付録 A

Phenomena Identification and Ranking Tables (PIRT) for Fukushima-daiichi Accident

Table of Contents

List of Tables

List of Figures

1. Introduction

In fiscal year 2011, this national project carried out analyses to estimate accident scenarios which occurred in Fukushima daiichi nuclear power plants in March 2011 using MAAP and SAMPSON of severe accident analysis code. Those analysis results were compared to actual measured data in each plant and evaluated based on experiences and knowledge as engineer which has ever gained. As a result, some problems of each code were pointed out, and improvement points for each problem were listed.

In fiscal year 2012, this national project confirmed whether improvement points listed were valid to improve or not using an objective way. Specifically, Phenomena Identification and Ranking Table (PIRT) were developed to make up for objectivity of the validity, and it is confirmed by the table.

This appendix summarizes the outline of the development process for the PIRT and result derived from the PIRT effort.

The objectives of the PIRT are as follows:
- Classify the phenomena expected in the Fukushima daiichi accident by the level of importance and state of knowledge (SoK).
- From the categories above, clarify what phenomena are modeled at present, and set the priority of ones that should be modeled in the future.

This PIRT focuses on identifying the relative importance and SoK of phenomena related to location estimation of molten core in Fukushima daiichi accident.

To benefit from significant of prior PIRT development and applications, this project has consulted with the research committee on severe accident in Atomic Energy Society of Japan (AESJ) with extensive knowledge and experience.

In fact, this project had eight meetings with the research committee of sever accident from August through October to improve the accuracy of PIRT after this project established the initial preliminary PIRT by July.

This appendix report describes establishment of the PIRT process, PIRT results, and candidates of phenomena to be modeled.

2. PIRT procedure

Figure 2-1 shows specific PIRT development process applied this time. This process is made by improving the process by Wilson [2-1], and consists of ten steps. The followings are contents of each step.

Step1: Definition of the issues for PIRT
Here, this step defines issues to develop PIRT. The issue for the PIRT developed in this project is as follows.

> Fukushima daiichi nuclear power plants are under environment of high radiation by molten core and fission products generated in the accident. Hence, those plants are in difficult situation to measure various parameters in reactor vessels (RV). However, it is necessary to predict damage situation in core, and location and distribution of molten core using severe accident code, in order to tackle decommissioning in medium and long term under the environment including finding-out of accident cause and removing of molten fuel.
>
> In fiscal year 2011, analysis results by MAAP and measured data in actual plants were compared, and phenomena which are modeled in current MAAP are listed for evaluation in relocation behavior of molten core. In fiscal year 2012, whether there are any phenomena else to be improve or not should be confirmed.

Step 2: Definition of objectives
This step defines objective of PIRT development. The objective of the PIRT is as follows.

- Pick out important phenomena to be considered in order to estimate location and distribution of molten core in the accident by analysis
- Confirm the validity, and necessity and sufficiency by comparing important phenomena picked out by PIRT and improvement point for analysis code listed in fiscal year 2011.

Step 3: Definition of scenario
This step defines representative scenario addressed in the PIRT covering wide range of scenario from a lot of accident scenarios and initiating events.

This PIRT basically selects accident progression scenario based on one of unit 3. However, specific scenarios and events in unit 1 and 2 are also dealt with. Chapter 4 describes about detail of the scenario.

Step 4: Partition of accident scenario into time phases
This step partitions accident scenario defined in step 3 into some time phases to clarify relative importance of phenomena changing with progression of accident scenario. Chapter 4 describes about detail of the partition.

Step 5: Partition of plant system into multiple components
This step partitions whole plant system into multiple components to enhance plausible phenomena identification carried out in step 7. Chapter 5 describes about detail of the partition.

Step 6: Definition of Figures of Merit
This step defines Figures of Merit (FoM). Here, FoM are the criteria with which the relative importance of each phenomenon is judged. Chapter 6 describes about detail of FoM.

Step 7: Identification of plausible phenomena
This step identifies plausible phenomena using all currently available knowledge, including expert opinion. In the context of the PIRT process, “plausible phenomena” means those that may have some influence on the FoM. Chapter 7 describes about detail of identification of plausible phenomena.

Step 8: Ranking of relative importance for phenomena
This step ranks relative importance of plausible phenomena identified in step 7 that have an influence on FoM. This PIRT uses four classifications of ranking according to influence on FoM, which are High (H), Medium (M), Low (L), and Not Applicable (N/A). Chapter 8 describes about detail of relative importance ranking of phenomena.

Step 9: Ranking of SoK for phenomena
This step ranks state of knowledge (SoK) for plausible phenomena identified in step 7 that impact FoM. This PIRT uses three classifications of ranking according to

knowledge level, which are Known (K), Partially-known (P), and Unknown (U). Chapter 8 describes about detail of knowledge level ranking of phenomena.

Step 10: Picking out of phenomena to be modeled

This step picks out important phenomena for FoM, and identifies phenomena to be newly modeled or to be enhanced out of those. Chapter 8 describes about detail of picking out of phenomena to be modeled.

Reference

[2-1] G. E. Wilson and B. E. Boyack, “The Role of the PIRT Process in Experiments, Code Development and Code Applications Associated with Reactor Safety Analysis,” *Nuclear Engineering and Design*, 186, pp. 23–37, 1998.

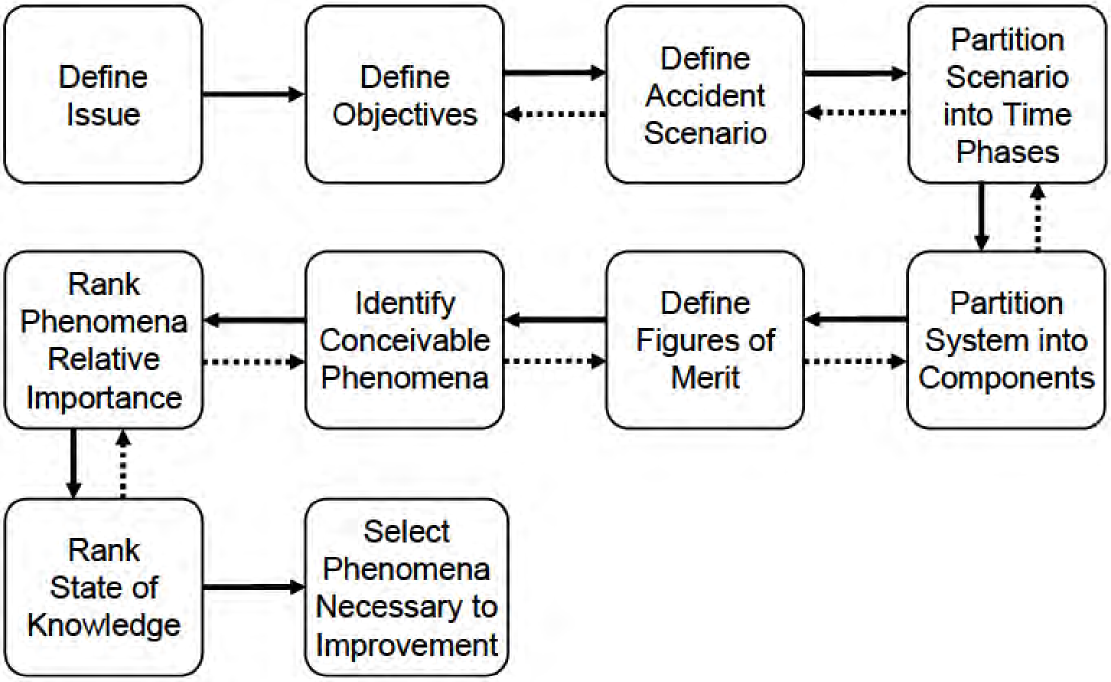


Fig. 2-1 Steps for PIRT Process

3. Description of Plant System

As shown in Table 3-1, there are six Nuclear Power Plants (NPPs) in the Fukushima Daiichi Nuclear Power Station. Among these, Unit1 to 3 were in operation at rated power, and Unit4 to 6 were outage as of Mar. 11, 2011.

Unit1 is BWR-3 reactor type plant, and which electric power is 460 MWe. Unit 2 and 3 is BWR-4 reactor type plant, and compared with Unit1, the electric power is large, which power is 784 MWe. The basic reactor design of Unit 2 and 3 is same, and as to containment, Unit 1 to 3 is also same design what is called Mark-I type.
The Outline of the nuclear power plant (Unit1 to 5) is shown in Fig.3-1.

Table 3-1 Plant specifications of the Fukushima Daiichi Nuclear Power Station

Site	**unit**	**Reactor Type**	**Containment Type**	**Commercial Operation Start**	**Rated MWe**
Fukushima Daiichi	**1**	**BWR/3**	**Mark-I**	**1971**	**460**
	2	**BWR/4**	**Mark-I**	**1974**	**784**
	3	**BWR/4**	**Mark-I**	**1976**	**784**
	4	**BWR/4**	**Mark-I**	**1976**	**784**
	5	**BWR/4**	**Mark-I**	**1978**	**784**
	6	**BWR/5**	**Mark-II**	**1979**	**1100**

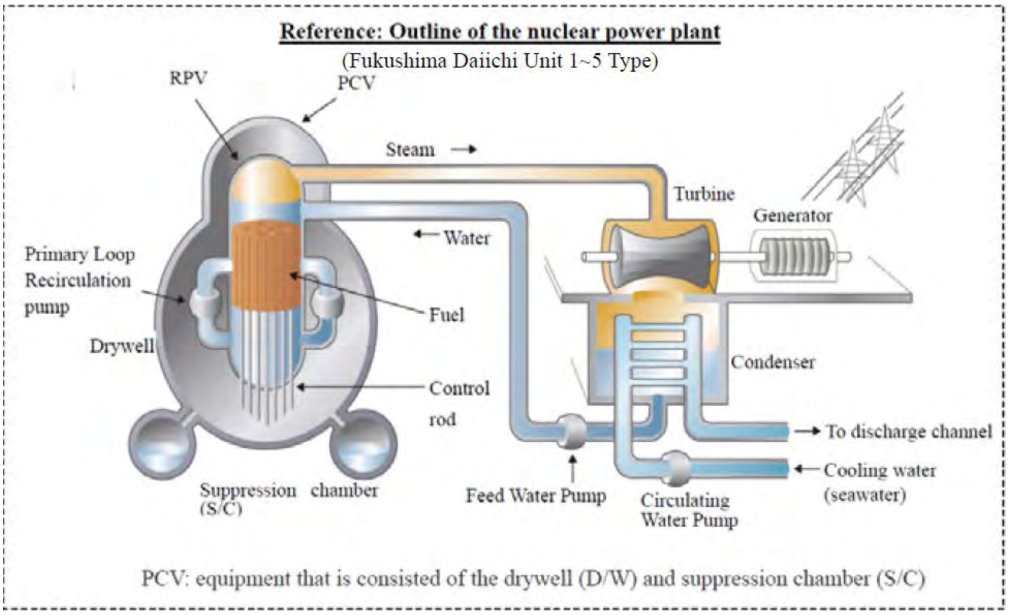


Fig.3-1 Outline of the nuclear power plant (Unit1 to 5) [3-1]

3.1 Primary System and Containment System

The schematic drawing of the typical Mark-I type containment with primary system is shown in Fig.3-2. In Unit1 to 3, the coolant in the primary system is supplied by the feedwater Line and the Primary Loop Recirculation System (PLR) which is external loop. The coolant which is supplied to downcomer region from feedwater line is supplied to Jet Pumps through the PLR. The part of downcomer water is also drawn into the Jet Pumps directly with the coolant supplied through the PLR pumps, and the coolant is supplied to the lower plenum region through the Jet Pumps. And then, the coolant is supplied to the core region and cools the fuels. The steam generated at the core region by the core cooling is supplied to the main turbine through the separators and dryer. In the case of Unit 2 and 3, there are 548 fuel bundles in the core at the normal operation mode. In addition, the MOX fuels were loading in the core for Unit3.

When the Loss of Coolant Accident (LOCA) is occurred, the blowdown steam from the primary system pressurizes the drywell (D/W) region. In the BWR containment, since the steam in the D/W region flows to the Suppression Chamber (S/C) region through the vent pipes, the steam is condensed in the S/C water, the containment pressurization is suppressed at the LOCA conditions. For Mark-I type containment, D/W region is connected to the S/C region shaped torus configuration by 8 vent pipes and 96 downcomers branched from vent pipes.

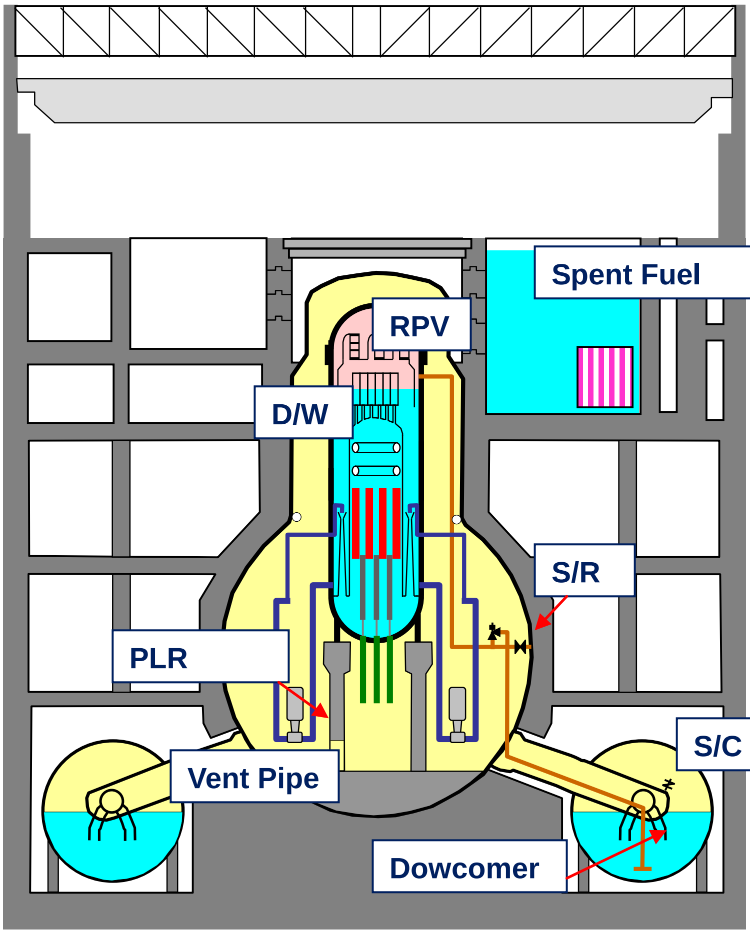


Fig.3-2 Schematic drawing of the typical Mark-I type containment with primary system

[3-1] TEPCO Press release, Release of the Fukushima Nuclear Accidents Investigation Report, Attachment Fukushima Nuclear Accidents Investigation Report: Main body, Jun 20, 2012.

3.2 Safety Systems

The RPV and connected systems of BWR-4 are shown in Fig.3-3. Also, the concept of the Emergency Core Cooling System (ECCS) is shown in Fig.3-4. In the BWR-4 plant, Low Pressure Core Injection System (LPCI) and the Core Spray System (CS) are multiply equipped for re-flooding function and spray function respectively against LOCA. Also High Pressure Coolant Injection System (HPCI) is equipped against intermediate LOCA. In addition, Reactor Core Isolation Cooling (RCIC), not the ECCS, is equipped for feed the coolant at high reactor pressure condition against the anticipated transient. HPCI is also functioned as a backup system for RCIC. The RCIC and HPCI can be operated without AC power, so these systems were functioned for core cooling at the Fukushima Daiichi accident. For Unit1, the Isolation Condenser (IC) is equipped for same function as RCIC.

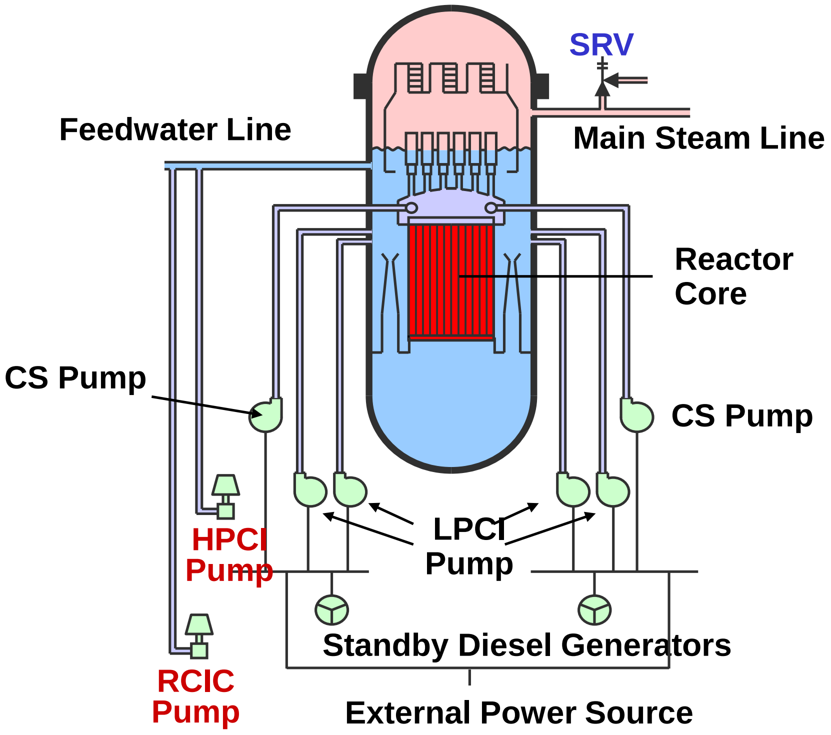


Fig.3-3 RPV and Connected systems (BWR-4)

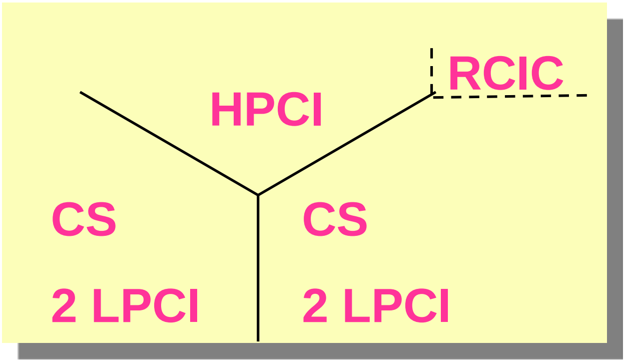


Fig.3-4 Concept of ECCS (BWR-4)

3.3 RCIC and HPCI

The Outline of the RCIC system is shown in Fig.3-5. The RCIC is the injection system to the primary systems with turbine driven pump. The RCIC turbine extracts the steam from the main steam line, and then the RCIC pump is operated by the RCIC turbine drive. The RCIC pumps up the water from CST or S/C. The RCIC system starts up by getting the low water level signal (L-2), and also trips by the high water level (L-8). Normally, the operator will control the flow rate with monitoring the reactor water level to be near the normal water level. The RCIC flow capacity is designed about 90 ton/h not to decrease the water level extremely in the case of loss of feed water event.

The HPCI is also functioned to backup for the RCIC systems, so the outline of the system is almost the same design. Since the HPCI is one of the ECCS against the LOCA, the rated flow rate is about ten times as the RCIC.

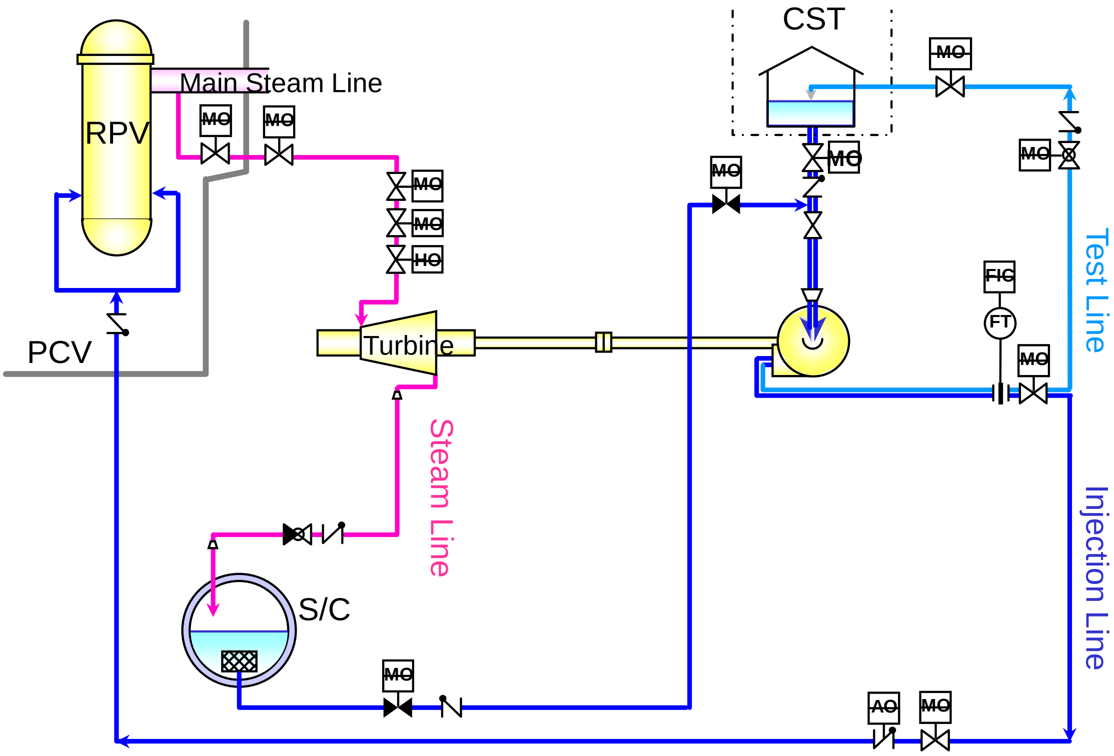


Fig.3-5 Outline for the RCIC system

4. Event Definition

Fukushima Dai-ichi Nuclear Power Station was hit by Tsunami as a consequence of the Great East Japan Earthquake on March 11th, 2011. The disasters caused the Station Blackout (SBO) and Loss of Ultimate Heat Sink (LUHS) events that eventually led to the core damage, releasing radioactivity to the environment.

Fukushima Dai-ichi has six nuclear plants, and three of them (Unit1, 2, 3) suffered the most severe core damage. In this Fukushima PIRT for MAAP enhancement, the scenario is selected in terms of covering dominant events that are thought to have happened in the three units. It is considered that the typical severe accident phenomena were observed in unit3, including accident management operation. So, the accident scenario of unit3 is selected for this PIRT as base scenario.

The following is the accident scenario in the unit3 Hitachi GE and Toshiba assumes, and the summary of it is shown in Fig. 4-1

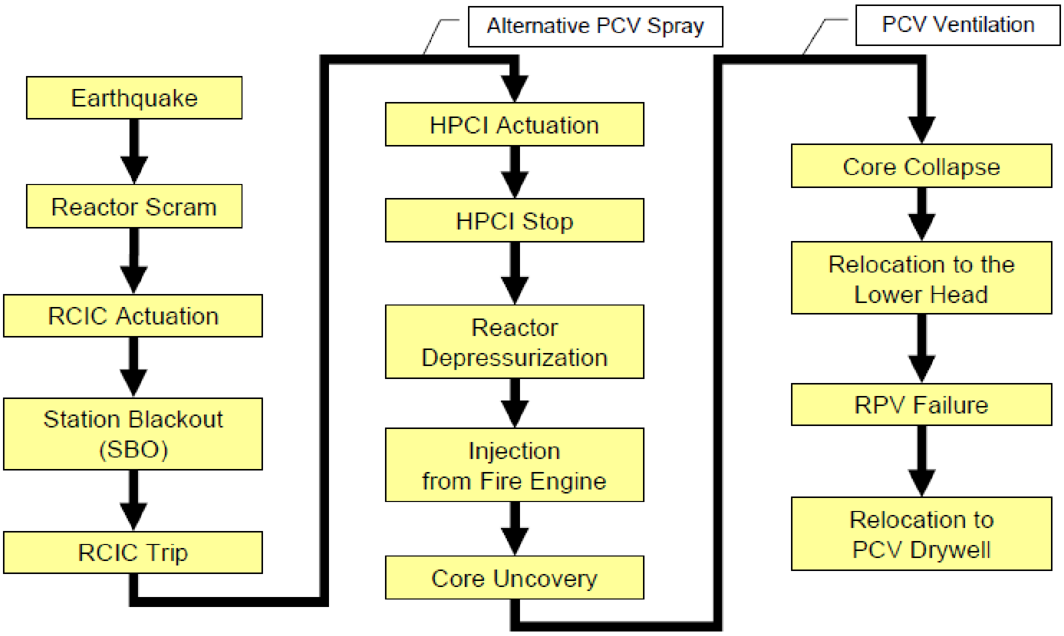


Fig. 4-1 Summary of accident scenario of Unit 3

4.1 Event Description

On March 11th, 2011 Great East Japan Earthquake was occurred. The reactor of unit 3 was scrammed within 1 minute after earthquake by receiving the scram signal. Since the reactor water level had decreased, operator manually activated RCIC (Reactor Core Isolation Cooling) system. About 1 hour after the earthquake occurrence, tsunami was hit to Fukushima Dai-ichi nuclear power station. In unit 3, all AC power was lost by flooding of tsunami, what is called Station Blackout.

Since RCIC is available by DC power, even if there is no AC power supply, the reactor core was continuously cooled by RCIC operation. After loss of battery for DC power supplied to RCIC, RCIC was tripped. In unit 1, there are no water injection systems such as RCIC with DC power supply. Hence, accident progress of unit 1 is earlier than unit 2 and unit 3.

Though the reactor water level had decreased to L-2 after RCIC trip, HPCI (High Pressure Coolant Injection) system was also available by DC power supplied to HPCI. By receiving the signal of low water level, HPCI system was activated automatically. During this period, alternate containment spray started by diesel driven fire protection pumps.

As is the case with RCIC, HPCI was tripped by loss of battery for HPCI. Water was injected through a fire engine to lower reactor pressure, since core cooling system did not work because of high reactor pressure conditions by RCIC and HPCI trip. In unit 2, although HPCI was not available, RCIC worked for about three days. After RCIC trip in unit 2, the accident scenario is similar to unit 3 roughly.

Due to reactor depressurization, reactor water level had rapidly decreased by flashing. Because water injection flow rate from fire engine was not sufficient to core cooling, reactor water level was not increased. As a result, the reactor core began to be exposed. Additionally, since the injection flow rate was small, the reactor core began to collapse. After depletion of fresh water pit, operator changed injection water source from fresh water to sea water. But sea water injection flow rate was also small. During this period, containment was vented to the outside reactor building, because the containment pressure was increased by reactor depressurization and hydrogen generation associated with core collapse.

Then, the core started to melt because of small water injection. After core was melted, pool by molten material was formed in the core region and a molten core was surrounded by fuel crust. After that, the molten core broke the crust, and flew down to the core support plates. In addition, it relocated to another region such as lower plenum, because the core support plate was melted. When the molten core relocated to lower plenum region, it reacted with water in the lower plenum and evaporated the water. Moreover, the molten core reacted with structures in the lower plenum such as CRD housing, and instrument housing. As a result, it also formed the pool by molten material. When the molten core melted such as structures' penetration, the reactor pressure vessel failed. In unit 3, it is considered that reactor pressure vessel is failed by melt-through.

After reactor failed, the molten core fell to the pedestal region and ablated the concrete floor and side wall in it. A part of the molten core remained in the pedestal region, but others relocated to drywell region from access pass between pedestal and drywell. The molten core in drywell region speeded on the drywell floor and also ablated the floor. In general, the containment fails, because the containment pressure and temperature increases to ultimate capability by non-condensable gas generation or radiation heating of molten core, however, in the unit 3, though the containment was vented, the containment didn't failed. In fact, it might have a leak from containment vessel by containment failure.

The event timeline for accident progress analysis by MAAP is shown in Table 4-1. And the analytical results of MAAP analysis are shown in Fig. 4-2 to Fig. 4-5.

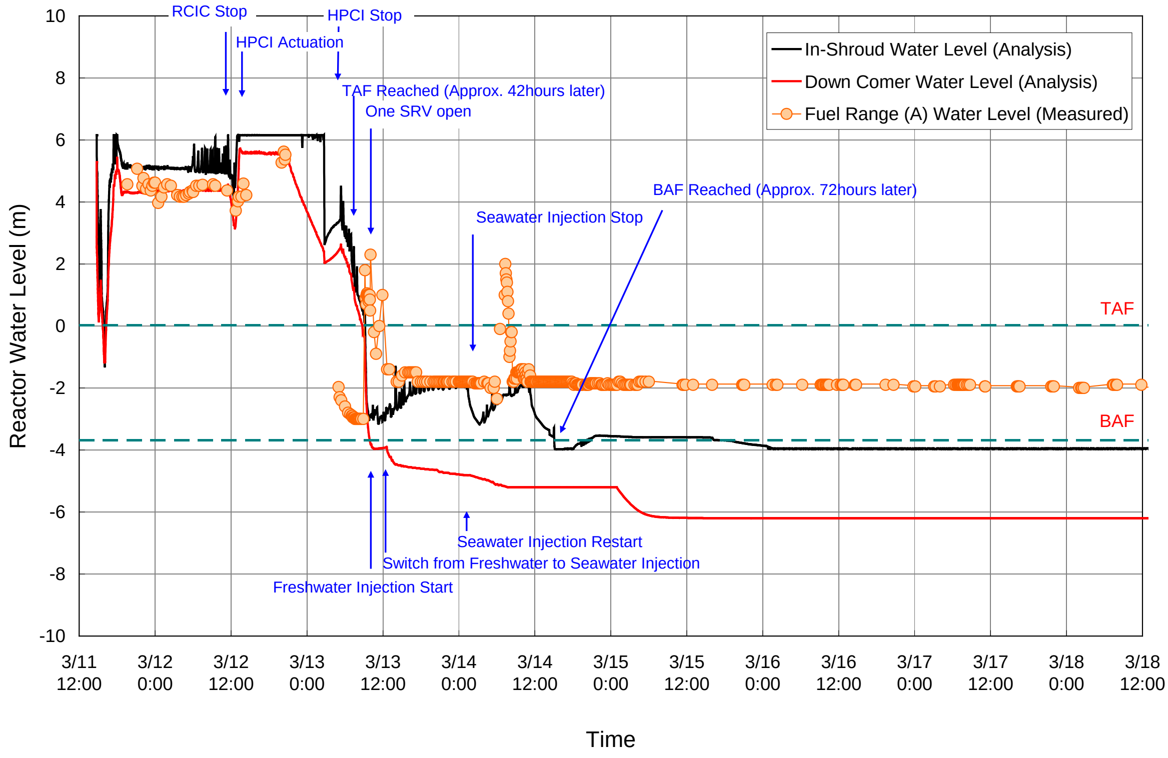


Fig. 4-2 Unit 3 Reactor Water Level

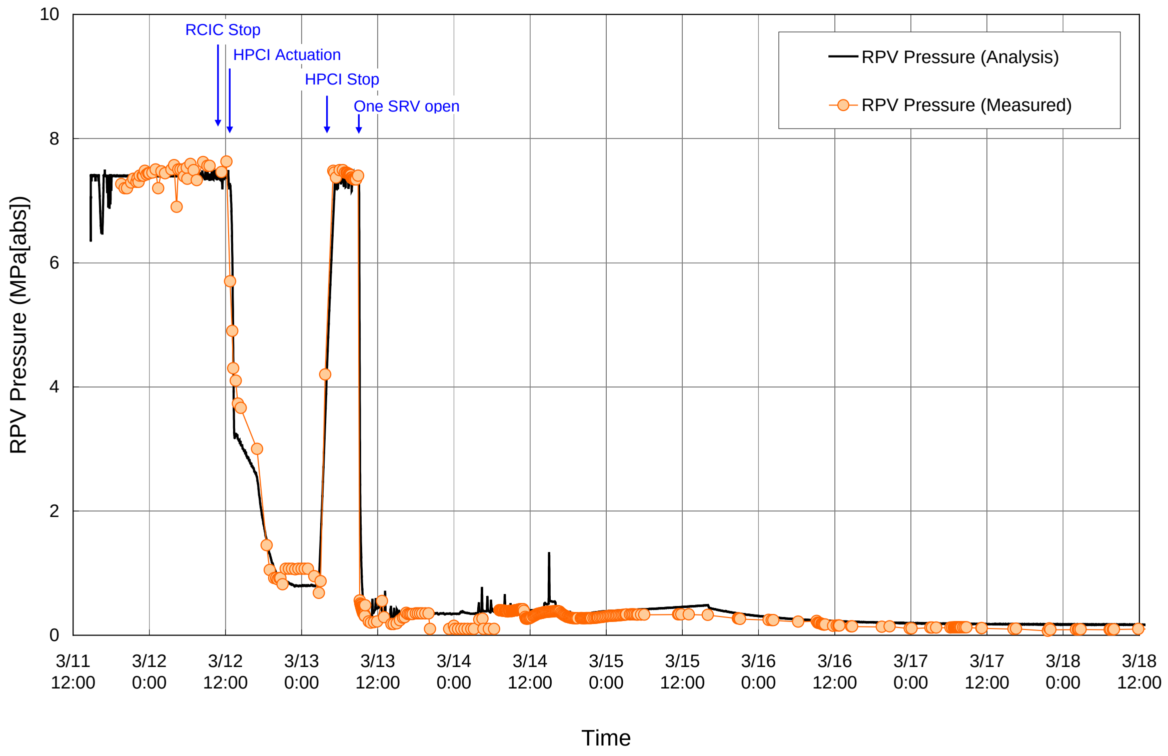


Fig. 4-3 Unit 3 Reactor Pressure

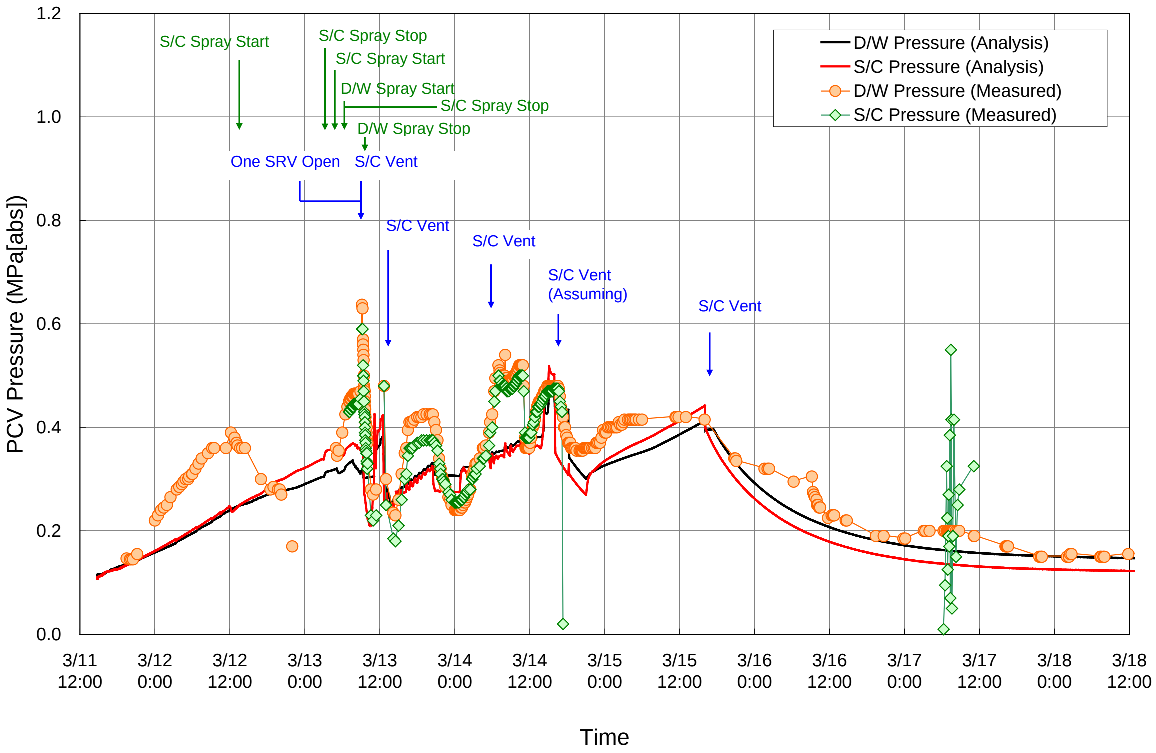


Fig. 4-4 Unit 3 Containment Pressure

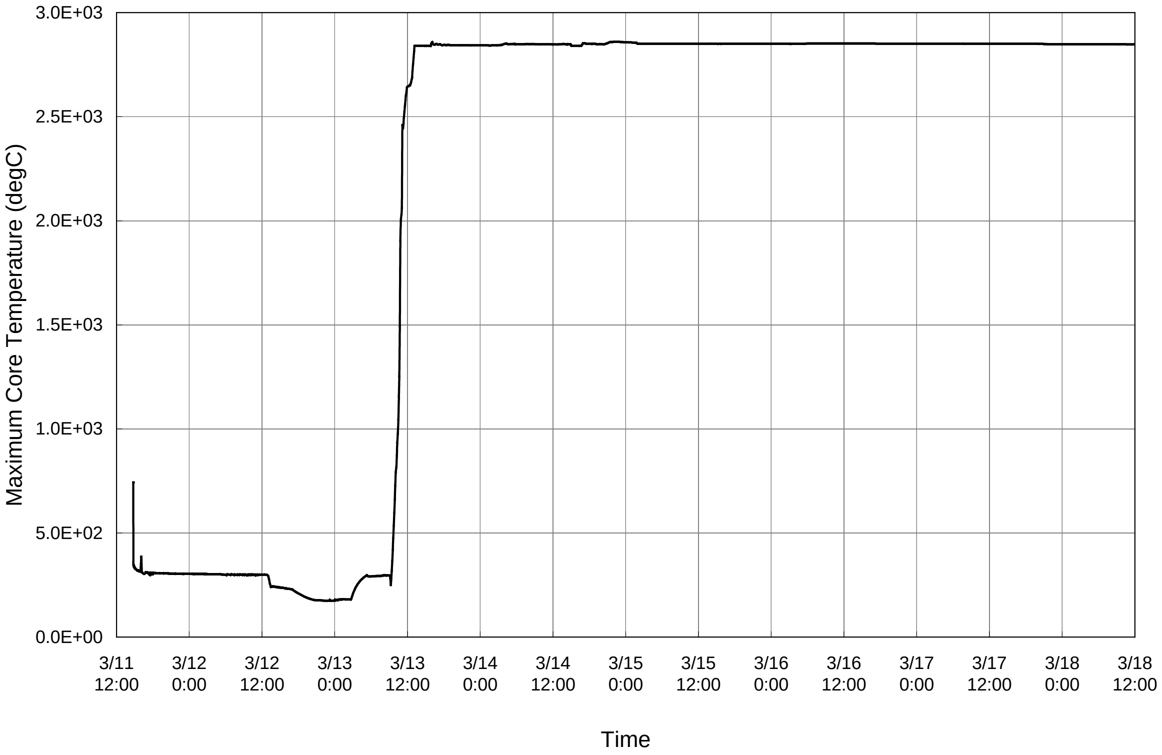


Fig. 4-5 Unit 3 Reactor Core Temperature

Table 4-1 Unit 3 Event Timeline

Legend: ○ indicates actual records; △indicates assumptions based on available records.

Time sequence				Classification	Remarks
No.	Date/time		Event		
1	March 11	14:46	Earthquake occurred.	○	
2		14:47	Reactor scrammed.	○	
3		15:05	RCIC manually activated.	○	
4		15:25	RCIC tripped (L-8).	○	
5		15:38	All AC power was lost.	○	
6		16:03	RCIC manually activated.	○	
7	March 12	11:36	RCIC tripped.	○	
8		12:06	Alternate S/C Spray Started.	○	
9		12:35	HPCI activated (L-2).	○	
10	March 13	2:42	HPCI tripped.	○	
11		3:05	Alternate S/C Spray Stopped. (Switched the Line to reactor.)	○	DD FP
12		5:08	Alternate S/C Spray Started.	○	DD FP
13		7:39	Alternate D/W Spray Started. (Switched the Line from reactor.)	○	DD FP
14		7:43	Alternate S/C Spray Stopped.	○	DD FP
15		8:40 - around 9:10	Alternate D/W Spray Stopped. (Switched the Line to reactor.)	○	The time was set at 8:55 on the same day for the purpose of analysis.
16		Around 9:08	SRV 1 valve opened.	○	
17		9:20	Containment vent valve opened. (S/C)	○	
18		9:25	Freshwater injections started.	○	
19		11:17	Containment vent valve closed. (S/C)	○	
20		12:20	Freshwater injections stopped.	○	Continued to inject the fresh water by DD FP
21		12:30	Containment vent valve opened. (S/C)	○	

Table 4-1 Unit 3 Event Timeline (cont.)

Legend: ○ indicates actual records; △indicates assumptions based on available records.

Time sequence				Classification	Remarks
No.	Date/time		Event		
22		13:12	Seawater injections started.	○	Assumed that freshwater injections by DD FP stopped.
23		14:10	Closed containment vent valve (S/C).	△	Assumption based on the behaviors of containment pressure.
24		21:10	Opened containment vent valve (S/C).	○	The time is set at 20:30 on the same day for the purpose of analysis. (assumed based on the behaviors of containment pressure)
25	March 14	0:50	Closed containment vent valve. (S/C)	△	Assumption based on the behaviors of containment pressure.
26		1:10	Seawater injections stopped.	○	
27		3:20	Seawater injections restarted.	○	
28		5:20	Containment vent valve opened. (S/C)	○	
29		11:01	Seawater injections stopped.	○	Explosion of Reactor Building
30		12:00	Containment vent valve closed. (S/C)	△	Assumption based on the behaviors of containment pressure.
31		16:00	Containment vent valve opened. (S/C)	△	Assumption based on the behaviors of containment pressure.
32		16:30	Seawater injections restarted.	○	
33		21:04	Containment vent valve closed. (S/C)	△	Assumption based on the behaviors of containment pressure.
34	March 15	16:05	Containment vent valve opened. (S/C)	○	
35	March 16	1:55	Containment vent valve opened. (S/C)	△	Based on the assumption that the vent valve continue to be open.
36	March 17	21:00	Containment vent valve closed. (S/C)	△	Based on the assumption that the vent valve continue to be open.
37		21:30	Containment vent valve opened. (S/C)	△	Based on the assumption that the vent valve continue to be open.

5. Partitioning of Plant System

In the PIRT process, to make the selection of plausible phenomena easier, the overall plant system is divided into subsystems. Here, “plant system” means the whole plant system, and “subsystem” means individual plant system, such as “Core”, “Wetwell” and so on

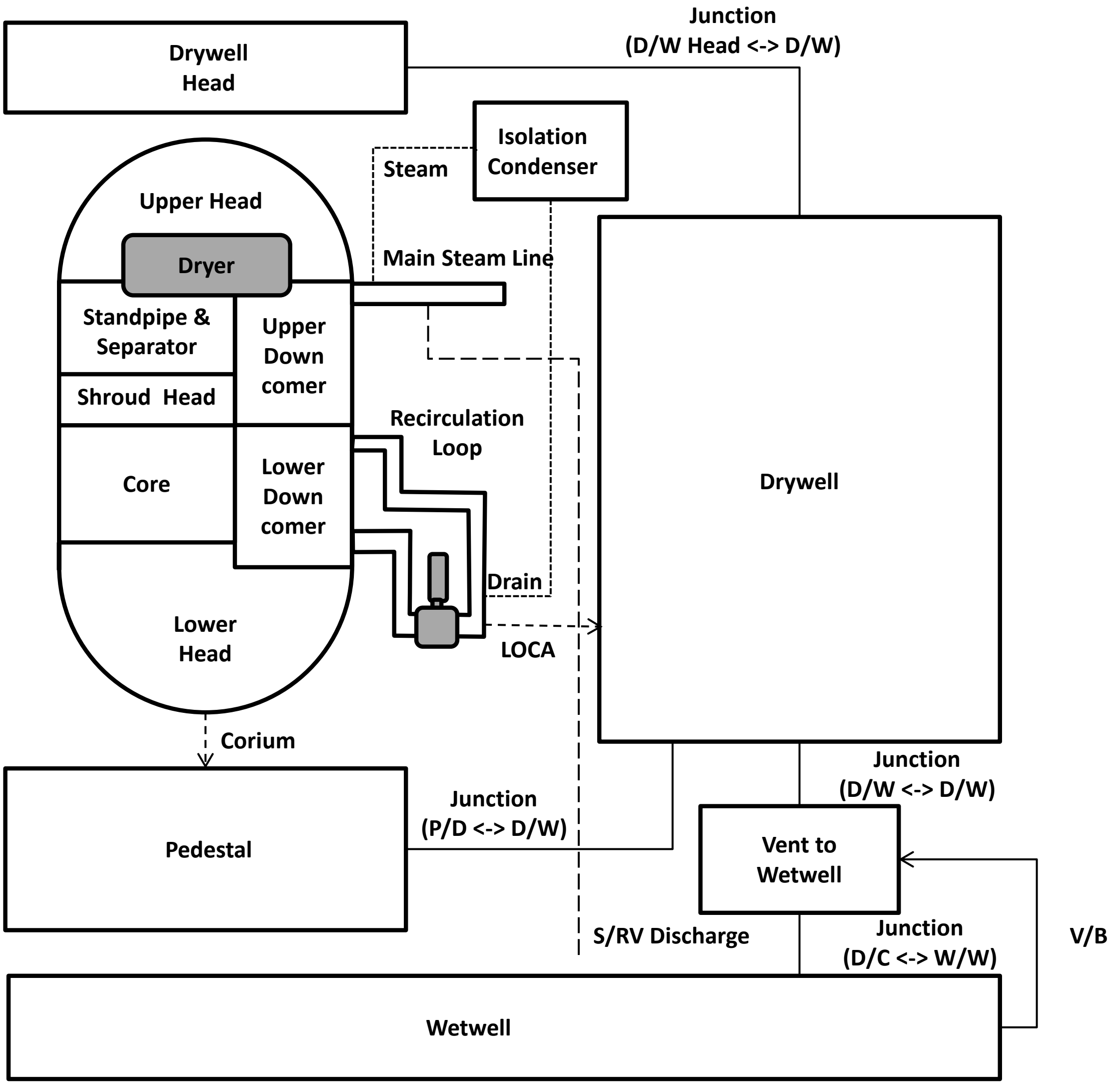
The overall plant system is divided into 16 subsystems based on control volume of the MAAP code.

The following subsystems are considered for PIRT construction.

- Primary System
  - Upper Head
  - Upper Downcomer
  - Lower Downcomer
  - Recirculation Loop
  - Lower Head
  - Core
  - Shroud Head
  - Standpipe & Separator
  - Dryer
  - Main Steam Line
  - Isolation Condenser

- Primary Containment Vessel
  - Drywell
  - Drywell Head
  - Vent to Wetwell
  - Pedestal / Cavity
  - Wetwell

The typical outline of RPV and PCV noding for MAAP code is shown in Fig.5-1. In MAAP code, containment noding can be arbitrary defined by code user. So the noding shown in Fig.5-1 is just the example of typical containment noding.



*D/W: drywerll, P/D: Pedestal, W/W: wetwell, D/C: downcomer, S/RV: safety relief valve, V/B: vacuum breaker

Fig.5-1 Outline of RPV and PCV noding for MAAP code
(Jet Pump Plant & Mark-I Containment)

Table 5-1 Description of Subsystem

RPV/PCV	Subsystem	Description
RPV	Core	The core is composed of the fuels and bypass region. In Unit2 and 3, there are 548 fuel bundles. The fuel bundle is composed of the fuel and channel box. The major component of the fuel is UO_2 in the form of pellet, and covered the Zr cladding rod. In the fuel bundle, a number of the fuel rods are arranged with water rod; the fuel rod array is 8x8 or 9x9 formation. In Unit3, the MOX fuel bundles were loaded as the part of the fuels.
	Shroud Head	The shroud head is the region formed by the shroud head and top guide and two phase fluid flows into this region from the core. In this region, the core spray sparger is located in Unit 2 and 3.
	Standpipe & Separator	The standpipe is the region connects the separator and shroud head region. In this region, two phase fluid also flow from the shroud head. The separator can separate the steam and the water from two phase fluid by the swirl flow. The separated water flows into upper downcomer region, and the separated steam flows to the dryer. In the separated steam, a small amount of water is carried.
	Dryer	The dryer is the equipment for removing the water drop supplied from separators. The pure steam which is removed the drop flows to the main turbine through the main steam line.
	Upper Head	The upper head is the region formed by reactor vessel wall above the RPV flange level. This region is filled with steam in principle under normal operation condition.

Table 5-1 Description of Subsystem (cont.)

RPV/PCV	Subsystem	Description
RPV	Main Steam Line	The main steam line is the pipe connected to main turbine from RPV for steam supply. In this PIRT, the scope of the main steam line is from connecting point of RPV to first Main Steam Isolation Valve (MSIV).
	Upper Downcomer	The upper downcomer is the region formed by reactor vessel wall and shroud head. The scope of this region is from RPV flange level to top of the core level. The water separated by separators is supplied in this region and flows to lower downcomer region. In normal operation, the coolant from the feedwater line is supplied in this region.
	Lower Downcomer	The lower downcomer is the region formed by the reactor vessel wall and shroud. The scope of this region is from top of the core level to jet pump baffle plate. In this region, the jet pumps are located as the pass to the lower plenum. The water in this region is suctioned by the PLR pumps, and recirculates to this region.
	Lower Head	The lower head is the region formed by the reactor vessel wall and the core support plate. In this region, there are many structures such as CR guide tube, CRD housing, ICM guide tube etc. These structures are penetrate the lower part of the reactor vessel wall.
	Recirculation Loop	The recirculation loop is composed of the pipe and the PLR pumps. The PLR pumps suction the water from lower downcomer region, and recirculate the coolant to in the jet pumps.

Table 5-1 Description of Subsystem (cont.)

RPV/PCV	Subsystem	Description
RPV	Isolation Condenser	The isolation condenser is the equipment for feed water function at the reactor isolation event. When reactor is isolated, by opening the isolation condenser valve, the steam in the main steam line is supplied to the isolation condenser heat exchanger. In the heat exchanger, the steam is condensed, and then condensate water returns to the RPV from feedwater line or PLR line.
PCV	Pedestal / Cavity	The pedestal/cavity is the region formed by the RPV lower head and the inside of the pedestal wall which supports the RPV. When RPV is failed by the corium, it is considered that the corium is falling from the RPV to this region.
	Drywell	The drywell is one of the regions of the PCV including the drywell head and the pedestal. In this PIRT scope, the drywell is defined the region formed by the outside of the pedestal region and the drywell shell excluding the drywell head.
	Drywell Head	The drywell head is the region of one of the drywell region above the PCV flange. This region is partitioned in terms of the overetemperature of the PCV at the severe accident conditions.
	Vent to Wetwell	The “Vent to Wetwell” means vent pipes to wetwell region from drywell region for suppression function of BWR containment. It is the region connects to the drywell and wetwell. A part of the downcomer is submerged in the wetwell pool in normal operation.
	Wetwell	The wetwell is the region for suppression of the containment pressure by condensation of the steam generated by LOCA or other event. The wetwell pool scrabbling is considered effective when wetwell vent performed at the severe accident.

6. Figure of Merit

The selection of the FoM is a very important step in the overall PIRT process. Relative importance of phenomena picked out in each component is discussed in four time phases which are determined in step 4. Hence, FoM to judge relative importance of phenomena is also set in each time phase. Each FoM is as follows.

The 1st phase: Maximum cladding temperature and enthalpy of fuel rod are selected as FoM in order to pick out important phenomena related to transition to fuel melting because this time phase is before fuel rod is failed.

The 2nd phase: Enthalpy and average temperature in core are selected as FoM in order to appropriately estimate temperature situation in core because melting of fuel rod is progressing in core in this time phase.

The 3rd phase: One of molten core relocates to the lower head in this time phase, because creep failure due to thermal interaction between molten core and RPV and failure of penetrations including instrumentation piping occurs. Hence, Maximum temperatures of RPV and corium in the lower head are selected as FoM.

The 4th phase: In this time phase, one of molten core relocates to PCV, and gas generated by MCCI and metal-water reaction fails PCV by pressurization and heating. Hence, Maximum pressure and temperature in PCV are selected as FoM.

7. Phenomena Identification

In this chapter, plausible phenomena in defined accident scenario are identified for each component. The identification of plausible phenomena before ranking their relative importance is a primary means to help ensure that the full phenomena spectrum is identified.

In this identification, the way of two-stage brainstorming was used. First, engineers of Hitachi-GE and Toshiba who are members of the national project developed the preliminary PIRT through brainstorming. After that, the preliminary PIRT is revised by brainstorming between the above engineers and experts in research committee on severe accident of AESJ. In the latter brainstorming, whether or not phenomena listed to be modeled was enough was discussed.

In addition to the above, division of nuclear fuel of AESJ reviewed phenomena related to core fuel as experts for fuel, and U.S. EPRI and FAI reviewed the whole PIRT as experts for MAAP.

As a result, 1047 phenomena were picked out eventually. Table 7-1 shows specification for each component. The table states that there are phenomena over 100 in the regions including Core, Lower head, and Pedestal cavity which have high possibility of being molten core because this PIRT focuses on estimation of location of molten core.

Table 7-2 shows names of phenomena listed and what they mean.

Table 7-1 Number of selected phenomena by PIRT

Component	Number of selected phenomena
Core	178
Shroud Head	32
Standpipe & Separator	32
Dryer	24
Upper Head	24
Main Steam Line	32
Upper Downcomer	31
Lower Downcomer	121
Lower Head	163
Recirculation Loop	36
Pedestal Cavity	140
Drywell	105
Drywell Head	33
Vent to Wetwell	40
Wetwell	40
Isolation Condenser (*only unit 1)	16
Total	1047

Table 7-2 Description for Plausible Phenomena

	Subsystem/Component	Core
No.	Phenomenon	Description
1	Core Water Level Change	- Core water level may rise or decline under the top of active fuel, according to safety injection, pressure and boiling.
2	Core Flowrate Change	- Core coolant (water) flow may increase or decrease according to safety injection and head difference.
3	Core Coolant Temperature Change	- Core coolant (water) temperature may rise or decline according to safety injection and heat transfer from the fuel rods or internals.
4	Core Pressure Change	- Core pressure may rise or decline due to boiling of coolants in th core region, boundary breaks, leakage flows, safety relief valve actuation and so on.
5	Boiling due to Depressurization	- Water in the core region including channels and bypasses boils due to system depressurization
6	Gap Conductance between Fuel Pellets and Cladding	- Thermal conductivity between fuel pellets and fuel claddings in the fuel rods changes according to the gap width and the status of fuel pellets and claddings
7	Gas (Condensable/Incondensable) Temperature Change in Channel Region	- Steam or incondensable gas temperature in the channel region changes due to heat transfer from fuel rods, channel boxes and other core internals.
8	Temperature Change in Fuel Cladding	- Fuel cladding temperature changes due to heat transfer from fuel pellets (through the gap), water or steam. - Oxidation also changes the cladding temperature.
9	Temperature Change in Fuel Pellets	- Temperature in fuel pellets changes due to heat transfer to the gap, decay heat generation, FP release, and so on.
10	Temperature Change in Control Rods	- Although control rods don’t basically generate heat, temperature in control rods changes according to temperature change in fuel rods adjacent to it.
11	Decay Heat in Intact Fuel Assemblies	- Decay heat must be generated from the fuel rods that keep normal shape after reactor scram.
12	Gamma Ray Heat Generation in Core Internals (Except Fuel Rods)	- Gamma ray is emitted from fission products in fuel rods or corium. - Gamma ray usually pass through the source materials and radiates and heats other core internals..
13	Temperature Change in Gaps between Fuel Pellets and Cladding	- Gas temperature in the gap between pellets and claddings changes due to heat transfer from the pellets or FP release.
14	Temperature Change in Channel Boxes	- Channel boxe temperature changes due to heat transfer from coolants inside or outside, or gamma ray deposition. - Radiation heat from the fuel rods also impacts the temperature in channel boxes when the core water level declines.
15	Temperature Change in Tie Plates	- Temperature in upper and lower tie plates changes due to heat transfer from coolants or fuel rods.
16	Temperature Change in Spacers	- Temperature in spacers changes due to heat transfer from coolants or fuel rods.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
17	Heat Transfer between Water and Fuel Cladding	- Heat generated in fuel rods may be transferred through the cladding surface to the coolant water. -The heat transfer rate depends on flow regimes, flow rate, temperature difference between coolant water and the fuel cladding surface, and cladding surface geometries.
18	Heat Transfer between Water and Channel Boxes	- In a BWR core, coolant water flows both inside and outside channel boxes. - Heat may be transferred between this coolant water and channel box surface, depending on flow regimes, flow rates, temperature difference on both sides, and channel box geometries.
19	Heat Transfer between Water and Control Rods	- In a BWR, coolant flowing in core touches with control rtods. - Heat with control rods is transferred to coolant mainly by forced heat transfer.
20	Heat Transfer between Water and Tie Plates	- Heat may be transferred between upper and lower tie plates and coolant water flowing among fuel rods. - Heat transfer rate depends on flow regimes, flow rate, temperature difference between coolant water and tie plate surfaces, and tie plate geometries.
21	Heat Transfer between Water and Spacers	- Heat may be transferred between spacers and coolant water flowing among fuel rods. - Heat transfer rate depends on flow regimes, flow rate, temperature difference between coolant water and spacer surfaces, and spacer geometries.
22	Heat Transfer between Fuel Cladding and Spacers	- As upper/lower tie plates and spacers are attached to fuel claddings, heat generated in fuel rods may be transferred through the cladding surface to them. -The heat transfer rate depends on temperature difference and contact areas.
23	Heat Transfer between Fuel Cladding and Gas	- Heat generated in fuel rods may be transferred through the cladding surface to gas phase including steam, non-condensables, and gaseous FP, when the core uncovers. -The heat transfer rate depends on gas flow rate, temperature difference between the gas phase and the fuel cladding surface, gas composition and cladding surface geometries.
24	Heat Transfer between Fuel Pellets and Gas	- Heat generated in fuel pellets should be transferred to surronding gas. -The heat transfer rate depends on temperature difference between the surrounding gas and the fuel pellet surface, gas composition and pellet surface geometries.
25	Heat Transfer between Channel Boxes and Gas	- When the core uncovers, channel boxes may contact with gaseous phase including steam, non-condensables and gaseous FPs on both sides. - In the condition stated above, heat may be transferred between the gaseous phase and channel box surface, depending on gas flow rates, gas composition, temperature difference on both sides, and channel box geometries.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
26	Heat Transfer between Control Rods and Gas	- When the core uncovers, control rods may contact with gaseous phase including steam, non-condensables and gaseous FPs on both sides. - In the condition stated above, heat may be transferred between the gaseous phase and control rods surface, depending on gas flow rates, gas composition, temperature difference on both sides, and control rods geometries.
27	Heat Transfer between Tie Plates and Gas	- When the core uncovers, upper/lower tie plates may contact with gaseous phase including steam, non-condensables and gaseous FPs. - In the condition stated above, heat may be transferred between the gaseous phase and upper/lower tie plates, depending on gas flow rates, temperature difference, and tie plate geometries.
28	Heat Transfer between Spacers and Gas	- When the core uncovers, spacers may contact with gaseous phase including steam, non-condensables and gaseous FPs. - In the condition stated above, heat may be transferred between the gaseous phase and spacers, depending on gas flow rates, temperature difference, and spacer geometries.
29	Hydrogen Absorption in Fuel Cladding	- Hydrogen generated from fuel claddings oxidation is likely to be absorbed into the cladding material, leading to embrittlement.
30	Fuel Pellets Composition (Including MOX Fuels)	- Chemical composition in fuel pellets changes depending on initial enrichment, exposure, power distribution, fuel design (including MOX fuels), fraction of burnable poisons.
31	Fuel Rod Growth (Cladding Irradiation Growth)	- Neutron irradiation may induce the fuel rod glowth. - When fuel cladding is irradiated, point defection is generated inside Zircaloy hexagonal crystal structure. - As this defection is likely to accumulate on the surface normal to 'c' axis in the hexagonal crystals, fuel cladding shrinks in the radial direction and stretches in the axial and circumferential direction.
32	Pressure Change in Gap between Fuel Pellets and Cladding	- Pressure inside the gap between fuel pellets and cladding changes, depending on gas temperature, composition, the amount of gaseous FPs released to the gap.
33	Gas Composition Change in Gap between Fuel Pellets and Cladding	- Composition inside the gap between fuel pellets and cladding changes, depending on the amount of gaseous FPs released to the gap.
34	Balooning of Fuel Cladding	- Over-pressure in the cladding may induce the balooning of zircaloy tube. - Fuel cladding may deform like a 'baloon' when the core uncovers and stress exceeds the elastic limit due to heat up and a lot of gaseous FP release.
35	Contraction of Fuel Cladding Outer Diameter（Creep Down）	- The diameter of fuel cladding decreases due to pressure difference between the inner and outer region. - The decrease of the diameter could make the fuel cladding contact with the fuel pellets inside, leading to thermodynamic and mechanical interaction.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
36	Fuel Cladding Rupture	- High temperature may induce fuel cladding rupture. - If fuel cladding get excessive stress due to heat up, it would rupture and make flow paths connecting the inner and outer region.
37	Changes in Bonding Status of Fuel Pellts to Cladding	- Fuel pellets are normally fixed with springs at the upper and lower plenum in the fuel cladding. - As reactor operation continues and exposure gets higher, fuel pellets would swell and displace the spring. -Creep deformation for the springs due to irradiation might also impact the damper function.
38	Pellet Cracks, Grains and Relocation in Cladding	- At higher exposure, fuel pellets are likely to swell and crack due to FP generation and release. - This may lead to generate pellet grains, making them relocate inside fuel cladding. The mechanical and thermodynamic conditions between fuel pellets and cladding may be changed. - The pellet relocation may be driven by aftershock stress.
39	Water Flow into Gap between Fuel Pellets and Cladding	- If fuel cladding rupture occurs and the break position is in the reflooding condition, coolant water could flow into the gap between fuel pellets and cladding. - In this condition, cladding oxidatin on the inner surface, and chemical interaction between fuel pellets and water should be considered.
40	Steam Flow into Gap between Fuel Pellets and Cladding	- If fuel cladding rupture occurs and the break position is above the water level, steam could flow into the gap between fuel pellets and cladding. - In this condition, cladding oxidatin on the inner surface, and chemical interaction between fuel pellets and water should be considered.
41	Zr-Water Reaction Facilitation by Water Flow into Gap between Fuel Pellets and Cladding	-If water or steam flows into the gap between fuel pellets and cladding through the break, Zr-water reaction is facilitated on the inner surface of the cladding and additional hydrogen generation should be considered.
42	Core Axial Power Distribution Change	- Based on core design, exposure and power history, core axial power distribution changes. - Axial power distribution impacts fuel heat up behavior, initial position for fuel melting, cladding rupture, and FP inventory.
43	Core Radial Power Distribution Change	- Based on core design, control rod pattern, exposure and power history, core radial power distribution changes. - Radial power distribution impacts fuel heat up behavior, initial position for fuel melting, cladding rupture, FP inventory, flow distribution for core natural circulation.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
44	Fuel Axial Exposure(Burn-up) Distribution	- Based on core design and power history, core axial exposure distribution changes. - Axial exposure distribution impacts fuel heat up behavior, initial position for fuel melting, cladding rupture, pellet relocation behavior inside cladding, initial oxidation condition for fuel cladding, and FP inventory.
45	Fuel Radial Exposure(Burn-up) Distribution	- Based on core design, fuel shuffling and power history, core radial exposure distribution changes. - Radial exposure distribution impacts fuel heat up behavior, initial position for fuel melting, cladding rupture, pellet relocation behavior inside cladding, initial oxidation condition for fuel cladding, and FP inventory.
46	Pressure Loss Change for Core Flow Paths	- When core flow changes from forced convection to natural circulation due to recirculation pump trip, friction loss coefficient for the core flow path changes. - Changes in void fraction due to core flow rate may also influence the core pressure loss.
47	Changes in Flowrate Distribution between Fuel Channels and Bypasses	- Fraction of core flow into fuel channels or bypass region changes, depending on the difference in water level, pressure loss, void fraction between inside and outside channel boxes.
48	Changes in Flowrate Distribution in each Fuel Channel	- Each fuel channel may have different thermal-hydraulic conditions such as water level, void fraction, pressure loss. - In this condition, distribution of flow into each fuel channel may be different and change independently.
49	Changes in Pressure Loss at Core Inlet	- For core inlet region, there are several flow paths; a core inlet orifice to the channel region, a control rod guide tube flow path to the bypass region, a leakage hole in a core support plate, a side entry orifice on a fuel assembly. - When core flow changes from forced convection to natural circulation due to recirculation pump trip, geometry loss coefficient for each inlet flow path may be influenced.
50	Pressure Loss Increase by Fuel Cladding Swelling	- Pressure loss for channel region should be increased if fuel cladding swells and the cross sectional area for the channel flow path shrinks
51	Change in 2-Phase Flow Regime Status in Fuel Channels	- 2-phase flow regime in the fuel channel region changes from bubble flow to dispersed flow, depending on core water level and void fraction. - Flow regime influences the heat transfer rate from fuel cladding to coolant water or steam, including the critical heat flux.
52	Change in 2-Phase Flow Regime Status in Bypass Regions	- 2-phase flow regime in the bypass region changes from bubble flow to droplet flow, depending on the water level and void fraction. - Flow regime influences the heat transfer rate from channel boxes or control rods to coolant water or steam, especially when the core uncovers and structures in the bypass region are heated by radiation.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
53	Gas Natural Circulation above Water Level	- When the core uncovers, gaseous phase are heated up and natural flow patterns are formed above the water level. This natural circulation has an important role of conveying the decay heat in the core region to the upper part of the reactor vessel. - Eventually this flow impacts the temperature distribution for the core region as well as the upper core internals.
54	CCFL at Upper Tie Plate	- As the cross sectional flow path area for the position of the upper tie plate is relatively narrow, counter-current flow limitation might occur with strong steam upward flow and safety injection from the upper plenum.
55	CCFL at Bypass Region	- As the cross sectional flow path area for the position of the bypass region is relatively narrow, counter-current flow limitation might occur with strong steam upward flow and safety injection from the upper plenum.
56	CCFL at Core Inlet	- As the cross sectional flow path area for the core inlet region, including lower tie plate, debris filter, and leakage holes is relatively narrow, counter-current flow limitation might occur with strong steam upward flow and safety injection from the upper plenum.
57	Changes in Gas Composition in Core Region	- Gas composition in the core region changes due to the following phenomena: - steam generation (boiling) or condensation - non-condensables (inert gas) inflow after depressurization - herium release through ruptured fuel cladding - gaseous FPs release through ruptured fuel cladding - hydrogen generation due to fuel cladding oxidation - water radiolysis
58	Changes in Gas Spatial Distbution in Core Region	- As gaseous components released in the core region have different density, some components may be stratified until they are totally mixed. - For example, hydrogen due to oxidation is likely to flow upward and accumulate in the upper region.
59	Changes in Gas Mixture Properties in Core Region	- Thermal-hydraulic properties for the gaseous phase, such as density, specific heat, thermal conductivity, and viscosity etc, changes, depending on the gas component in the core region.
60	Changes in the Amount of Residual Burnable Poisons	- The amount of residual burnable poisons changes due to initial composition in fuel rods, exposure and power history. - This amount may influence the FP inventory to be released after core damage.
61	Changes in Properties of Fuel Materials	- High temperature may induce property change of fuel materials. - Thermal-hydraulic properties for mixture derived from fuel materials, such as density, specific heat, and thermal conductivity etc, changes according to the compositon and temperature of fuel pellets or cladding. - 'Fuel materials' means uranium, plutonium, minor actinides, and other FPs in fuel pellets, as well as Zircaloy and oxides in fuel cladding and channel boxes.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
62	Changes in Properties of Core Internals	- High temperature may induce property change of fuel materials. - Thermal-hydraulic properties for mixture derived from fuel materials, such as density, specific heat, and thermal conductivity etc, changes according to the composition and temperature of core internals. - 'Core internals' means steel, B4C and their oxides contained in control rods, instrumentation tubes, and core shrouds.
63	Zr-Water Reaction Including Oxidation and Hydrogen Production	- Zircaloy contained in fuel cladding or channel boxes may oxidize, generating hydrogen and reaction heat. - Oxidation is facilitated when the core water level decrease and fuel cladding heats up.
64	SUS-Water Reaction Including Oxidation and Hydrogen Production	- SUS contained in tie plates, spacers instrumentation tubes, and shrouds may oxidize, generating hydrogen and reaction heat. - Oxidation is facilitated when the core water level decrease and the structure heats up due to radiation.
65	Reaction between Water and Other Substances (e.g. B4C), Including Oxidation and Hydrogen Production	- B4C contained in control rods may oxidize, generating hydrogen and reaction heat. - Oxidation is facilitated when the core water level decrease and the structure heats up due to radiation.
66	Heat Transfer between Water(Liquid Phase) and Corium	- Heat generated in corium may be transferred to coolant water when it contacts with the corium surface due to safety injection or spray system, and the core water level rises. - Heat transfer rate depends on water flow around the corium surface, contact area, temperature difference, water level rising speed, boiling conditions, and critical heat flux.
67	Heat Transfer between Gaseous Phase and Corium	- Heat generated in corium may be transferred to gas phase including steam, non-condensables, and gaseous FPs when the corium is uncovered. - Heat transfer rate depends on gas flow around the corium surface (normally natural convection), contact area, temperature difference, gas composition, and critical heat flux.
68	Heat Transfer between Fuel Cladding and Corium	- Heat generated in corium may be transferred to fuel cladding when it contacts with the corium surface due to spatial growth of molten pool. - Heat transfer rate depends on contact area and temperature difference.
69	Heat Transfer between control rods and Corium	- Heat generated in corium may be transferred to control blades when they contact with the corium surface due to spatial growth of molten pool. - Heat transfer rate depends on contact area and temperature difference. If the temperature for the control blades exceeds the melting point, they start melting.
70	Heat Transfer between Channel Boxes and Corium	- Heat generated in corium may be transferred to channel boxes when they contacts with the corium surface due to spatial growth of molten pool. - Heat transfer rate depends on contact area and temperature difference.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
71	Heat Transfer between Core Shroud and Corium	- Heat generated in corium may be transferred to the core shroud when it contacts with the corium surface due to spatial growth of molten pool. - Heat transfer rate depends on contact area and temperature difference. If the temperature for the core shroud exceeds the melting point, it will be ablated, forming flow paths between the core region and the downcomer.
72	Heat Transfer between Water Rods (or Channels) and Corium	- Heat generated in corium may be transferred to water rods, normally located in BWR fuel assemblies, when they contacts with the corium surface due to spatial growth of molten pool. - Heat transfer rate depends on contact area, temperature difference.
73	Heat Transfer between Water(Liquid Phase) and Particulate Corium	- Heat generated in particulate corium, which consists of loose parts of fuel assemblies, or debris generated by corium 'break-up', may be transferred to coolant water when it contacts with the particle surface due to safety injection or spray system, and the core water level rises. - Heat transfer rate depends on water flow around the particles, contact area influenced by particle size distibution and porosity, temperature difference, water level rising speed, boiling conditions, and critical heat flux.
74	Heat Transfer between Gaseous Phase and Particulate Corium	- Heat generated in particulate corium, which consists of loose parts of fuel assemblies, or debris generated by corium 'break-up', may be transferred to gas phase including steam, non-condensables, and gaseous FPs when the particles are uncovered. - Heat transfer rate depends on gas flow around the particles (normally natural convection), contact area influenced by particle size distribution, temperature difference, gas composition, and critical heat flux.
75	Heat Transfer between Fuel Cladding and Particulate Corium	- Heat generated in particulate corium, which consists of loose parts of fuel assemblies, or debris generated by corium 'break-up', may be transferred to fuel cladding when it contacts with the particles. - Heat transfer rate depends on contact area influenced by particle size distribution, and temperature difference.
76	Heat Transfer between control rods and Particulate Corium	- Heat generated in particulate corium, which consists of loose parts of fuel assemblies, or debris generated by corium 'break-up', may be transferred to control blades when they contact with the particles. - Heat transfer rate depends on contact area influenced by particle size distribution, and temperature difference.
77	Heat Transfer between Channel Boxes and Particulate Corium	- Heat generated in particulate corium, which consists of loose parts of fuel assemblies, or debris generated by corium 'break-up', may be transferred to channel boxes when they contact with the particles. - Heat transfer rate depends on contact area influenced by particle size distribution, and temperature difference.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
78	Heat Transfer between Core Shroud and Particulate Corium	- Heat generated in particulate corium, which consists of loose parts of fuel assemblies, or debris generated by corium 'break-up', may be transferred to the core shroud when it contacts with the particles. - Heat transfer rate depends on contact area influenced by particle size distribution, and temperature difference.
79	Heat Transfer between Water Rods (or Channels) and Particulate Corium	- Heat generated in particulate corium, which consists of loose parts of fuel assemblies, or debris generated by corium 'break-up', may be transferred to the water rods when they contact with the particles. - Heat transfer rate depends on contact area influenced by particle size distribution, and temperature difference.
80	Heat Transfer between Water(Liquid Phase) and Crust	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred through the solidified crust layer. - Heat may be transferred to coolant water it contacts with the crust surface due to safety injection or spray system, and the core water level rises. - Heat transfer rate depends on water flow around the crust surface, contact area, temperature difference, water level rising speed, boiling conditions, and critical heat flux.
81	Heat Transfer between Gaseous Phase and Crust	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred through the solidified crust layer. - Heat may be transferred to gas phase including steam, non-condensables, and gaseous FPs when the crust surface is uncovered. - Heat transfer rate depends on gas flow around the crust surface (normally natural convection), contact area, temperature difference, gas composition, and critical heat flux.
82	Heat Transfer between Fuel Cladding and Crust	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred through the solidified crust layer. - Heat may be transferred to fuel cladding when it contacts with the crust surface. The Heat transfer rate depends on contact area and temperature difference.
83	Heat Transfer between control rods and Crust	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred through the solidified crust layer. - Heat may be transferred to control blades when they contact with the crust surface. Heat transfer rate depends on contact area and temperature difference.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
84	Heat Transfer between Channel Boxes and Crust	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred through the solidified crust layer. - Heat may be transferred to channel boxes when they contact with the crust surface. Heat transfer rate depends on contact area and temperature difference.
85	Heat Transfer between Core Shroud and Crust	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred through the solidified crust layer. - Heat may be transferred to the core shroud when it contacts with the crust surface. Heat transfer rate depends on contact area and temperature difference.
86	Heat Transfer between Water Rods (or Water Channels) and Crust	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred through the solidified crust layer. - Heat may be transferred to the water rods or channels when they contact with the crust surface. Heat transfer rate depends on contact area and temperature difference.
87	Heat Transfer between Crusts and Corium	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred from the molten pool to the solidified crust layer. - Heat transfer rate depends on contact area between the molten pool and solidified crust layer, natural convection inside the molten pool, and temperature difference.
88	Heat Transfer between Core Support Plate and Corium	- Heat generated inside the corium may transfer to core support plate. - Heat transfer rate depends on contact area between corium and core support plate, temperature differences, and so on.
89	Heat Transfer between Core Support Plate and Crusts	- When the corium is cooled and crust is formed on its surface, heat generated inside the corium should be transferred through the solidified crust layer. - Heat may be transferred to core fuel support coupling when it contacts with the crust surface. - Heat transfer rate depends on contact area and temperature difference.
90	Heat Transfer between Core Fuel Support Coupling and Corium	- Heat generated inside the corium may transferred to core fuel support coupling. - Heat transfer rate depends on contact area between corium and core fuel support coupling, temperature differences, and corium flow rate near the support coupling.
91	Radiation Heat Transfer among Fuel Rods	- When the core water level declines and the fuel assemblies are uncovered, radiation heat transfer to fuel rods facing each other occurs. -Radiation heat transfer rate is proportional to the difference in the fourth power of the temperatures for the fuel rod surfaces, as well as to the facing rod surface areas.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
92	Radiation Heat Transfer between Channel Boxes and Fuel Rods	- When the core water level declines and the fuel assemblies are uncovered, radiation heat transfer from fuel rods to surrounding channel boxes occurs. -Radiation heat transfer rate is proportional to the difference in the fourth power of the surface temperature for the fuel rods and channel boxes, as well as to the facing surface areas.
93	Radiation Heat Transfer between Water Rods (or Water Channels) and Fuel Rods	- When the core water level declines and the fuel assemblies are uncovered, radiation heat transfer from fuel rods to adjacent water rods (channels) occurs. -Radiation heat transfer rate is proportional to the difference in the fourth power of the surface temperatures for the fuel rods and water rods (channels), as well as to the facing surface areas.
94	Radiation Heat Transfer among Channel Boxes	- When channel boxes are uncovered and heated up due to heat transfer from fuel rods or corium, they are radiated further to adjacent channel boxes. -Radiation heat transfer rate is proportional to the difference in the fourth power of the channel box surface temperatures, as well as to the facing surface areas.
95	Radiation Heat Transfer between Channel Boxes and Core Shroud	- When the channel boxes of the core peripheral fuel assemblies are uncovered and heated up due to heat transfer from fuel rods or corium, they radiate further to the adjacent core shroud. -Radiation heat transfer rate is proportional to the difference in the fourth power of the temperatures for the channel box and core shroud surfaces, as well as to the facing surface areas.
96	Radiation Heat Transfer between control rods and Core Shroud	- When the control blades located among the core peripheral fuel assemblies are uncovered and heated up due to heat transfer from fuel rods or corium, they radiate further to the adjacent core shroud. -Radiation heat transfer rate is proportional to the difference in the fourth power of the temperatures for the control blade and core shroud surfaces, as well as to the facing surface areas.
97	Radiation Heat Transfer between control rods and Channel Boxes	- When the control blades located among the core peripheral fuel assemblies are uncovered and heated up due to heat transfer from fuel rods or corium, they radiate further to the adjacent core shroud. -Radiation heat transfer rate is proportional to the difference in the fourth power of the temperatures for the control blade and core shroud surfaces, as well as to the facing surface areas.
98	Radiation Heat Transfer between Corium and Shroud	- During the accident, radiation heat is transferred from corium to shroud. - Radiation heat transfer rate is proportional to the difference in the fourth power of the temperatures for corium and shroud surfaces, as well as to the facing surface areas.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
99	Radiation Heat Transfer between Crusts and Shroud	- When corium is reflooded, crust layer has formed on the surface of the water. - Radiation heat is transferred from crust to shroud and its rate is proportional to the difference in the fourth power of the temperatures for crusts and shroud surfaces, as well as to the facing surface areas.
100	Radiation Heat Transfer between Particulate Corium and Shroud	- When corium contacts water or cooled during the translation, particulate corium has formed. - Radiation heat is transferred from particulate corium to shroud and its rate is proportional to the difference in the fourth power of the temperatures for particulate corium and shroud surfaces, as well as to the facing surface areas.
101	Radiation Heat Transfer between Corium and Core Support Plate	- During the accident, radiation heat is transferred from corium to core support plate. - Radiation heat transfer rate is proportional to the difference in the fourth power of the temperatures for corium and core support plate surfaces, as well as to the facing surface areas.
102	Radiation Heat Transfer between Crusts and Core Support Plate	- When corium is reflooded, crust layer has formed on the surface of the water. - Radiation heat is transferred from crust to core support plate and its rate is proportional to the difference in the fourth power of the temperatures for crusts and core support plate surfaces, as well as to the facing surface areas.
103	Radiation Heat Transfer between Particulate Corium and Core Support Plate	- When corium contacts water or cooled during the translation, particulate corium has formed. - Radiation heat is transferred from particulate corium to core support plate and its rate is proportional to the difference in the fourth power of the temperatures for particulate corium and core support plate surfaces, as well as to the facing surface areas.
104	Fuel Pellet Expansion（Thermal Expansion, Gas Swelling, Solid Swelling）	- Fuel pellets are likely to expand due to thermal stress, pellet composition change, internal pressure change by gaseous FP generation. - The extent of the expansion or swelling depends on initial pellet composition, exposure, irradiation conditions, and power histories.
105	FP Absorption into Fuel Pellet	- Part of gaseous FPs generated through reactor operation may be absorbed into fuel pellets, rather than released into the gap between fuel pellets and fuel cladding. - This could impact the amount of FPs released outside the fuel cladding after its rupture.
106	FP Release from Pellet to Gap between Fuel Pellets and Cladding (Gap Release)	- Part of gaseous FPs generated through reactor operation may be released out of fuel pellets to the gap between fuel pellets and fuel cladding. - This could impact the gap internal pressure, temperature change, and the amount of FPs released outside the fuel cladding after its rupture.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
107	FP Release from Damaged Fuel Rods to Channel Region	- Once fuel cladding has ruptured or damaged due to excessive stress, gaseous FPs in the gap between fuel pellets and fuel cladding are released through the break to the core channel region. - Released FPs could be eventually diffused to the environment, if accident progression makes the boundaries damaged.
108	Melting of Fuel Cladding	- If fuel cladding heats up and its temperature exceeds the melting point, it starts melting. - Melted fuel cladding will be eventually taken into corium, contributing its spatial growth.
109	Melting of Fuel Pellet	- If fuel pellets heat up due to internal heat generation and their temperature exceeds the melting point, they start melting. - Melted fuel pellets will be eventually taken into corium, contributing its spatial growth.
110	Melting of control rod	- If control blades heat up and their temperature exceeds the melting point, they start melting. - As the melting point for the control blades is lower than that for Zircaloy in fuel cladding and channel boxes, melted control blades may collapse among the surrounding channel boxes, or may be eventually taken into corium, contributing its spatial growth.
111	Melting of Channel Box	- If channel boxes heat up and their temperature exceeds the melting point, they start melting. - Melted channel boxes will be eventually taken into corium, contributing its spatial growth.
112	Melting of Spacers	- If spacers heat up and their temperature exceeds the melting point, they start melting. - Melted spacers will be eventually taken into corium, contributing its spatial growth.
113	Melting of Tie Plates	- If lower/upper tie plates heat up and their temperature exceeds the melting point, they start melting. - Melted lower/upper tie plates will be eventually taken into corium, contributing to its spatial growth.
114	Phase change condition for core components (including eutectic)	- High tempereture may induce the eutectic reaction of core components including fuel pellets, zircaloy, SUS, B4C, and so on. - Once materials in core components are melted and mixed, they will form an eutectic compound, which melts at a lower temperature than the normal melting point for each component.
115	Fuel Rod Collapse and Moving to the Lower Region	- Once parts of fuel rods, tie plates or spacers are damaged and lose the mechanical support, the fuel rods will collapse as 'loose parts' and fall to the lower core region. - Fuel rod collapse and 'loose parts' falling to the lower core region may be initiated by after shock.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
116	Channel Blockage by Collapsed Fuel Rods	- Collapsed fuel rods, tie plates, spacers, or other loose parts may reduce the flow path areas, suspended in channel boxes. - This flow path blockage may change the channel gas/water flow distribution and fuel rod coolability. - Channel blockge as stated above may be initiated by aftershock.
117	Melted Fuel 'Candling'	- Mixture of melted fuel rods, tie plates, spacers and channel boxes moves downward, melting further the lower fuel assembly structures like candle burning.
118	Channel and Bypass Blockage by Melted Fuel	- If mixture of melted fuel rods ablates the surronding channel box, it flows out to the bypass region and reduces its flow path areas. - This flow path blockage may change the bypass gas/water flow condition and the coolability for channel boxes and control blades.
119	Corium Temperature Change	- Corium temperature changes due to inner decay heat generation, or heat transfer to surrondging gas/water, core structures, and the surface crust layer (if any). - Corium temperature influences its thermodynamic properties, spatial growth, molten pool geometries, and the time for relocation out of the core region,
120	Formation of Molten Pool	- Corium as mixture of melted fuel rods, channel boxes, control blades and other core stuructures will form molten core pool. Normally the shape of the molten core pool is spherical, and the surface is solidified forming the crust layer.
121	Natural Circulation in Molten Pool	- There is corium natural circulation inside molten pool, depending on heat transfer to gas/water through the surface crust layer.
122	Molten Core Flow out of Crust Crack	- If a crust layer formed on the surface of molten core pool is cracked, corium inside the pool flows through the crack. - Corium flow out of the crack will increase the contact areas between corium and gas/water, facilitating thermal and mechanical interaction with them.
123	Corium Transverse Flow above Blocked Flowpaths	- If core channel flow paths are blocked due to corium solidification by water cooling below, or collapsed loose debris, corium above the blocked paths may spread in the radial or circumferential direction, rather than flowing down.
124	Corium Spatial Distribution	- Corium will keep growing in the core region without cooling by reflooding. the size of molten core pool depends on its inner heat generation, coolability, composition, and thermodynamic properties - Depending on the initial position for corium generation, the time for reaching the core boundaries such as the lower core support plate or the core shroud changes.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
125	Vaporization inside Corium (including FP release)	- When core materials such as fuel rods, cladding, control blades and other structures are taken into corium, some consistuents may be heated up above the boiling point. These components must evaporate and flow out of the molten core pool. - Gaseous materials including FPs originally in the fuel rods (e.g. herium, xenon..) are also trapped in the growing corium, but they are likely to flow out of the molten pool.
126	Decay Heat Generation from Corium	- Decay heat is the main source for corium internal heat and its generation rate depends on the corium composition and reactor exposure.
127	Corium-Water Reaction (Including Oxidation and Hydrogen Production)	- If corium contains some metal components not oxidized and contacts with water by safety injection, spray or reflooding, metal oxidation on the corium surface occurs, generating hydrogen and reaction heat.
128	Changes in Corium Properties by Mixed Composition	- As corium grows and ablates core structures such as fuel rods, cladding, channel boxes and control blades, its thermodynamic properties such as density, viscosity, thermal conductivity and specific heat change, based on the corium chemical composition.
129	Crust generation by solidification of corium	- When corium is cooled enough and its surface temperature decreases below the melting point, the surface will be solidified, forming a crust layer. - Corium spatial growth slows down as the crust layer has been formed on the corium surface.
130	Corium relolcation type through breached core support plate	- Corium flows to lower downcomer through breached core support plate and slump to the lower plenum. - Corium type may be jet or agglomerate during relocation. - Relocation type may be influenced by aftershock.
131	Change in Ablated Area for Core Support Plate	- As corium keeps touching with the core support plate, the ablated area will be increasing.
132	Changes in Particle Corium (Debris) Composition	- Since particulate corium interacts with water to be generated and is likely to be oxidized, the chemical composition for particulate corium may be different from the original molten core pool. - Even after particles were generated, they have relatively large surface area, facilitating interaction with the surrounding gas/water.
133	Changes in Particle Corium Shape and Size	- Corium particle shape and size distribution must be different, depending on the initial conditions for interaction with water, such as water temperature, corium contact areas, composition for the original molten pool. - As the interaction between the particulate corium and surrounding gas/water continues, the particle shape and size distribution may change.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
134	Particulate Corium (Debris) Relocation	- Particulate corium can easily fall to the lower core region, or moves with the water flow if the particles are reflooded. - When there are flow paths on the lower core support plate or the shroud due to ablation or thermal failure, particulate corium could even relocate out of the core region through these breaches.
135	Particle Corium Non-uniform Distribution	- Since the generation of particulate corium is not uniform due to different corium contact positions with water and complicated geometries in the core region, corium particles are likely to accumulate at the specific position, rather than distributed uniformly on the upper crust layer.
136	Crust Formation on Fuel Cladding	- If corium is attached to the fuel cladding and cooled enough below the melting point, a crust layer will be formed on the fuel cladding surface. - In this condition, heat transfer from the fuel cladding will be influenced by the surface crust layer.
137	Void Generation inside Crust	- When corium is solidified with gaseous components trapped inside, a void region will be generated inside the crust layer.
138	Water Flow around Crust	- When corium is reflooded and a crust layer has formed on the surface, surrounding water flow influences heat transfer from the crust. - The water flow condition depends on the water level, safety injection flowrate, water temperature, and the geometries of the damaged core.
139	Gaseous Flow around Crust	- When corium is reflooded and a crust layer has formed on the surface, surrounding gas flow, which is normally natural convection, influences heat transfer from the crust. - The gas flow condition depends on the water level, safety injection flowrate, steam generation speed, gas temperature and composition, the geometries of the damaged core.
140	Formation of Crust Crack	- Cracks on the surface of a crust layer may be generated due to excessive thermal/mechanical stress with internal corium or external gas/water.
141	Crust Temperature Change	- Crust temperature changes due to inner decay heat generation, or heat transfer from inner corium or to surrondging gas/water, core structures. - Crust temperature influences its thermodynamic properties.
142	Changes in Crust Properties by Mixed Composition	- Crust thermodynamic properties such as density, thermal conductivity and specific heat changes based on the crust chemical composition.
143	Crust-Water Reaction (Including Oxidation and Hydrogen Production)	- If a crust layer contains some metal components not oxidized and contacts with water by safety injection, spray or reflooding, metal oxidation on the crust layer surface occurs, generating hydrogen and reaction heat.
144	Water Flow into Crust	- When a crust layer is reflooded and there are cracks in the crust layer, water will flow into the cracks, facilitating the heat transfer from the crust and oxidation with metal components.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
145	Crust remelting due to change in the heat transfer status to corium or water	-Normally corium is cooled and solidified on the surface, forming crust. -This crust may remelt due to change in heat transfer status, such as loss of cooling water on the surface, or change in heat transfer from inner corium with changing mixture conditions.
146	Particulate corium remelting due to change in the heat transfer status	-Particle corium (debris) in the particle bed may melt and transfer into molten pool again when the cooling water is lost and heat removal is not sufficient.
147	Decay Heat Generation from Crust	- Decay heat is part of heat source for crust internal heat as well as oxidation reaction heat. Its generation rate depends on the crust composition and reactor exposure.
148	Molten Core Re-Criticality	- As molten core pool contains residual fissile materials derived from fuel rods and the materials for neutron absorption derived from control blades are not always mixed well, it might reach the re-critical condition, generating fission power. - Mixing condition for fuel materials, control blade materials, boron concentration and other core structures as well as existence of water as moderator are crucial to determine the re-criticality. - Please note that re-critical condition is highly unlikely to occur. However the impact would be large and the feasibility cannot be denied perfectly. Then this item should be kept in the phenomena list.
149	Molten Core Reflooding by Injection Restart	- When the core water level starts to rise by safety injection or spray system, a molten core pool must be reflooded, starting thermal/chemical interaction with water on its surface. - Interaction with water changes the thermal, chemical, and mechanical conditions for the molten core pool.
150	FP deposition on core internals	- Volatile FPs released from the damaged fuel rods are likely to deposit on the surface of core internals such as control blades, channel boxes, instrumentation tubes and so on. - The deposition of these FPs cause to heat up for the core internals.
151	FP re-vaporization	- Volatile FPs once deposited on the surface of core internals is also likely to evaporate again, depending on the saturation pressure and temperature.
152	Decay heat generation from FP	- Decay heat must be generated from the volatile FP released from the damaged core. When FPs are deposited on the core internal surfaces, the temperature for the structure may rise without coolant water.
153	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
154	Adsorption and release of gaseous FP	- During the accident, FPs generated from core-heatup and melting. - Gaseous FP adsorped to core structure wall and release from the wall on the contrary.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
155	Corium Jet through Breached Core Support Plate	- When the core support plate is ablated due to contact with corium on the upper surface, coirum starts to fall down through the breach to the lower head. - Based on break size and pressure difference, Corium jet flow may occur in falling down to the lower head.
156	Corium Flow into control rod guide tubes through Breached Fuel Support Coupling	- If corium reaches and ablates the fuel support couplings at the bottom of fuel assemblies, it flows into CRD tubes through the breach.
157	Corium Flow to the Downcomer through Breached Core Shroud	- If corium reaches and ablates the core shroud, it flows out of the core region to the downcomer region through the breach.
158	Corium Flow out of the Core Inlet Orifice	- If corium reaches the fuel support couplings at the bottom of fuel assemblies, it may also flow through core inlet orifices on the side of the couplings to the lower head.
159	Corium Solidifcation inside Fuel Support Coupling	- If corium flowing into the fuel support coupling at the bottom of fuel assemblies is cooled by the water in the CRD tubes or lower head, it will be solidified in the couplings and flow paths are blocked.
160	Instrumentation Tube Break	- There are some instumentation tubes in the core region. - As the core uncovers, these instrumentation tubes are exposed excessive thermal stress or ablated by corium. - As these tubes form the containment boundary, their failure may lead to leakage of radioactive materials.
161	Corium Flow into Instrumentation Tube	- Once the core instrumentation tubes are ablated, corium may flow into the tubes. - Coirum flow behavior inside the tubes depends on heat transfer from the tubes to the core bypass region.
162	Water Flow into Instrumentation Tube	- If the core instrumentation tubes are ablated and the core water level is above the break, coolant water should flow into the tubes. - The water flow into the instrumentation tubes will impact corium coolability inside and FP leakage through them.
163	Corium Solidifcation inside Instrumentation Tube	- If corium flowing inside the instrumentation tubes is cooled and the corium temperature decreases below the melting point, it will be solidified inside the tubes. - If corium in the instrumentation tubes is solidified, the flow paths from core channel region to reactor building compartments are totally plugged, or the flow area shrinks a great deal.
164	Gas Leak Flow into Instrumentation Tube	- Once the instrumentation tubes in the core region are failed, gas mixture including steam, non-condensables, and gaseous FP will flow inside the tubes. - The instrumentation tubes form the containment boundary, gas flow into the tubes may leak out of the containment. It also impacts the reactor pressure change.
165	Water Radiolysis	- In the core region, which is under irradiated environment, water is resolved into hydrogen and oxygen due to irradiation.
166	Seasalt intake to corium	- Seawater is injected to RPV and deposited at the surface of core structure wall and dispersed into core region. - Then seasalt are mixed into corium.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
167	Seasalt impact for corium thermodynamic properties	- During the accident, seawater is injected to RPV. - Seasalt may be deposited on the core internal surfaces as water level decreases and mixed into corium. - Thermodynamic properties of corium including seasalt vary with composition ration of seasalt.
168	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enters into core. - Then seawater deposited at the surface of the wall and dispersed into core region. - Presence of seasalt may cause additional chemical reactions.
169	Corrosion of Core Internals by Seasalt (including Marine Lives)	- Seawater injection may induce salt corrosion of core materials. - The core internals such as fuel cladding, instrumentation tubes, control blades and support plates in the core region are susceptible to corrosion especially with the seawater including Na, Mg, Ca, and some organic materials (i.e. marine lives).
170	Impact of Seasalt Deposition on Heat Transfer	- If seawater is injected into the reactor core, seasalt may be deposited on the core internal surfaces with the water level decrease. - Seasalt deposition may impact the heat transfer from the core structures to gas/water phases.
171	Channel (Bypass) Flowpath Blockage by Seasalt Deposition	- When seasalt is deposited on the core structure surfaces, especially narrow regions such as debris filters and tie plates, flow path area may be reduced and gas flow distribution may be influenced.
172	Seasalt Dissolution by Reflooding	- When the core water level rises due to reflooding, seasalt deposited on the core structure surfaces will dissolve in water.
173	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt concentration may have an impact on seasalt deposition amount on core structures and therefore heat transfer between seawater and structures.
174	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
175	Corrosion of Core Internals by Boron	- If boric acid added water is condensed, water becomes to show acidity. - This acid water causes corrosion. - Characteristic of this corrosion is that metal is corroded as If metal is melted. - Also, position which corrosion appears is limited to one which boric acid is condensed.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Core
No.	Phenomenon	Description
176	Impact of Boron Deposition on Heat Transfer	- If borate acid is injected into the reactor core, solid borate may be deposited on the core internal surfaces with the water level decrease. - Boron carbide derived from control blades might also deposit on the core structure surfaces. - Boron deposition may impact the heat transfer from the core structures to gas/water phases.
177	Channel (Bypass) Flowpath Blockage by Boron Deposition	- When boron is deposited on the core structure surfaces, especially narrow regions such as debris filters and tie plates, flow path area may be reduced and gas flow distribution may be influenced.
178	Boron Dissolution by Reflooding	- When the core water level rises due to reflooding, boron deposited on the core structure surfaces will dissolve in water.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Shroud head
No.	Phenomenon	Description
179	Radiation Heat Transfer between Intact Fuel Rods and Shroud Head	- When the core water level declines and the fuel assemblies are uncovered, radiation heat transfer from the fuel rod upper region to the shroud head occurs. -Radiation heat transfer rate is proportional to the difference in the fourth power of the surface temperatures for the fuel rod and the shroud head, as well as to the facing rod surface areas.
180	Radiation Heat Transfer between Corium and Shroud Head	- After fuel assemblies collapsed and a molten core pool was formed, radiation heat transfer from the corium surface to the shroud head occurs. -Radiation heat transfer rate is proportional to the difference in the fourth power of the surface temperatures for the corium and the shroud head, as well as to the facing rod surface areas.
181	Radiation Heat Transfer between Crust and Shroud Head	- After a molten core pool was formed and it has been solidified on the surface, radiation heat transfer from the crust surface to the shroud head occurs. -Radiation heat transfer rate is proportional to the difference in the fourth power of the surface temperatures for the crust and the shroud head, as well as to the facing rod surface areas.
182	Radiation Heat Transfer between Shroud Sidewall and Shroud Head	- When the shroud head heated up due to heat transfer from fuel rods or corium, they are radiated further to adjacent shroud sidewalls. -Radiation heat transfer rate is proportional to the difference in the fourth power of the surface temperatures for the shroud head and sidewalls, as well as to the facing surface areas.
183	Radiation Heat Transfer between Particulate Corium and Shroud Head	- Corium is cooled to form particulate corium during the translation or contact to structure wall. - Radiation heat is transferred from particulate corium to shroud head. - Radiation heat transfer between particulate corium and shroud head is dependent on both temperature, geometry, and emissivity, and so on.
184	Heat Transfer between Gas and Shroud Head	- When the core uncovers, channel boxes may contact with gaseous phase including steam, non-condensables and gaseous FPs on both sides. - In the condition stated above, heat may be transferred between the gaseous phase and channel box surface, depending on gas flow rates, gas composition, temperature difference on both sides, and channel box geometries.
185	Shroud Head Break or Deformation by Thermal Stress	- Shroud head may be broken or deformed by excessive thermal stress. - Excessive heat up could be driven by the continuous radiation heat transfer from corium in the core region or FP deposition.
186	Shroud Head Oxidation with Steam (Including Reaction Heat and Hydrogen Production)	- SUS contained in the shroud head may oxidize, generating hydrogen and reaction heat by contacting with steam from the core region. - Oxidation is facilitated as steam temperature increases.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Shroud head
No.	Phenomenon	Description
187	Gamma Ray Heat Generation in Shroud Head	- Gamma ray is emitted from fission products in fuel rods or corium. - Gamma ray usually passes through the source materials and radiates and heats the shroud head.
188	Temperature Change in Shroud Head Structure	- Temperature in the shoroud head changes due to heat transfer from steam, deposited FP, and radiation heat.
189	Droplet Spray	- There are core sprays in the upper plenum region surrounded by the shroud head. - When the core spray system starts working, droplet water will fall down to the core region, with steam condensing on the droplet.
190	Droplet Deposition on Shroud Head Structure	- When the core spray system starts working, part of droplets will deposit on the surface of the shroud head structures. - The shroud head temperature will be decreased.
191	Condensation Heat Transfer on Shroud Head	- Steam injected from reactor cooling system to shroud head. - Most of the steam condensation is supposed to occur on the surface of shroud head and a few occurs in the bulk. - Condensation heat transfer occurs in these two ways and affects the gas transport within the shroud head.
192	Pressure Change in Shroud Head	- Pressure in shroud head may change due to pressure change in core region, SRV open, and reactor water level decline due to depressurization boiling.
193	Gas Flow in Shroud Head	- Gas flow caused by inertial forces and buoyant forces. - The inertial flow may be the flow of steam itself from the reactor cooling system, or the flow of other gas components in the shroud head. - The buoyant forces occurs due to the difference in density of different components. These differences in density may be due either to the intrinsic gas property or to the difference in gas temperature. - During an accident, hydrogen gas and so on are released as gases, then flow into shroud head by steam carrier.
194	Gas Composition Change in Shroud Head	- Steam is injected from the reactor cooling system. - During an accident, hydrogen must be produced in a fast process due to zirconium oxidation. - And also, fission products are released as gases or vapors from the degrading core into the reactor cooling system and swept by a steam-hydrogen gas mixture. - Gas composition in shroud head change with progress of the event. - This change may affect the gas flow.
195	Gas Temperature Change in Shroud Head	- Gas temperature change may occur due to injection of steam from the reactor cooling system. - During an accident, hydrogen and fission products are released as gases or vapors into the reactor cooling system and entered in shroud head with steam carrier. - Among the gas components, fission products contain decay heat and may affect the gas temperature change in shroud head.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Shroud head
No.	Phenomenon	Description
196	FP deposition on shroud head	- The core heat-up and melting releases the fission products. - The fission products form compounds with each other and swept by a steam-hydrogen gas mixture. - The fission products transported to the shroud head and resulted in the deposition of a sizable fraction of fission products on the surface of the shroud head wall.
197	FP re-vaporization	- The core heat-up and melting releases the fission products. - The fission products form compounds with each other and swept by a steam-hydrogen gas mixture. - The fission products are transported to shroud head and deposited on the surface of shroud head wall. - The decay heat contained in the fission products heat up the shroud head to revaporize the deposited fission product compounds.
198	Decay heat generation from FP	- The decay heat is generated from the fission products and may heat up the shroud head.
199	FP Leakage from Flange between Shroud Sidewall and Head	- The core heat-up and melting release the fission products and swept by a steam-hydrogen gas mixture into shroud head. - The FP leakage may occur as gas leak from flange between shroud sidewall and head.
200	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into shroud head. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
201	Gas Leakage from Flange between Shroud Sidewall and Head	- Gas components in the shroud head change with progress of the event and may be mixture of steam, hydrogen, and so on. - According to the pressure, temperature, and flange failure between shroud sidewall and head, gas may leak from the flange.
202	Corrosion of Shroud Head by Seasalt (Including Marine Lives)	- See water injection may induce the salt corrosion of shroud. - Characteristics of sea water property is as follows. (1) Sea water includes much dissolved oxygen. (2) Sea water includes much salt such as chloride ion. (3) Sea water has high electrical conductivity. (4) Others (marine life, polluted seawater, and so on) - SUS is extremely stable material for corrosion because SUS has passivation film on the surface of it. - However, in the sea water, much chloride ion, which is included in sea water, breaks passivation film locally, and might causes pitting corrosion, crevice corrosion, and SCC.
203	Influence for heat transfer by salt deposition	- Seawater is injected to RPV from the existing makeup water system using fire-extinguishing pump. - Seawater may be transported to the shroud head through the core and may deposit at the surface of the wall. - Seasalt deposition on shroud wall has an impact on heat transfer between water, gas and shroud wall.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Shroud head
No.	Phenomenon	Description
204	Spray Nozzle Blockage by Seasalt Deposition	- Seawater is injected to RPV from the existing makeup water system using fire-extinguishing pump. - Seasalt may deposit at the surface of the wall. - Seasalt deposition may cover a cross sectional surface in spray nozzle and affect the coolability on core.
205	Re-solution of salt by reflooding	- Salt precipitates on the surface of structures. - After water injection, boron precipitation may soluble in water.
206	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and may be transported to the shroud head through the core. - Then seawater deposited at the surface of the wall and dispersed into shroud head. - Presence of seasalt may cause additional chemical reactions.
207	Corrosion of Shroud Head by Boron	- If boric acid added water is condensed, water becomes to show acidity. - This acid water causes corrosion. - Characteristic of this corrosion is that metal is corroded as If metal is melted. - Also, position which corrosion appears is limited to one which boric acid is condensed.
208	Influence for heat transfer by boron deposition	- The high-temperature oxidation of B4C in steam is an exothermic reaction that produces boron-containing spieces. - Boron-containing spieces are transported to shroud head and may deposit at the surface of the wall. - Boron deposition on shroud wall have an impact on heat transfer between gas, water, and shroud wall.
209	Spray Nozzle Blockage by Boron Deposition	- The high-temperature oxidation of B4C in steam produces boron-containing spieces. - Boron-containing spieces flow into shroud head with steam carrier and may deposited at the surface of the wall. - Boron precipitation may cover a cross sectional surface in spray nozzle and affect the coolability on core.
210	Re-solution of boron by reflooding	- Boron precipitates on the surface of structures. - After water injection, boron precipitation may soluble in water.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Standpipe & Separator
No.	Phenomenon	Description
211	Radiation Heat Transfer between Intact Fuel Rods and Standpipe/Separator	- Radiation heat transfer is dependent on both temperature, geometry, and emissivities and so on. - Intact fuel rods release the decay heat. - Radiation heat is transferred from intact fuel rods and have an impact on temperature distribution in standpipe/separator temperature.
212	Radiation Heat Transfer between Corium and Standpipe/Separator	- Radiation heat transfer is dependent on both temperature, geometry, and emissivities and so on. - With progress of the event, fuel melt and corium, which creates heat flux, is formed. - Radiation heat is transferred from corium and have an impact on temperature distribution in standpipe/separator.
213	Radiation Heat Transfer between Crust and Standpipe/Separator	- Radiation heat transfer is dependent on both temperature, geometry, and emissivities and so on. - With progress of the event, fuel melt and corium pool is formed. - Corium crust is developed on its cooled surface which attached itself to the walls or water. - Radiation heat is transferred from corium crust and have an impact on temperature distribution in standpipe/separator.
214	Radiation Heat Transfer between Intact Control Rod and Standpipe/Separator	- Radiation heat transfer is dependent on both temperature, geometry, and emissivities and so on. - Radiation heat is transferred from intact control rod and have an impact on temperature distribution in standpipe/separator.
215	Radiation Heat Transfer between Shroud Structure and Standpipe/Separator	- Radiation heat transfer is dependent on both temperature, geometry, and emissivities and so on. - Radiation heat transfer between shroud structure and standpipe/sepatrator would have an effect on temperature distribution in both shroud and standpipe/separator.
216	Radiation Heat Transfer between Particulate Corium and Standpipe(Separator)	- Corium is cooled to form particulate corium during the translation or contact to structure wall. - Radiation heat is transferred from particulate corium to standpipe (separator). - Radiation heat transfer between particulate corium and standpipe (separator) is dependent on temperature, georetry, emissivity, and so on.
217	Heat Transfer between Gas and Standpipe/Separator	- Water and steam from the core transported to standpipe/separator. - As the event progression, hydrogen and fission product are also transported to standpipe/separator and gas components change. - Heat transfer between gases and standpipe/separator is dependent on gas composition, temperature, flow velocity, geometry, and so on.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Standpipe & Separator
No.	Phenomenon	Description
218	Standpipe/Separator Temperature Change	- Standpipe/separator temperature change due to temperature of water and steam from the core and gas components. - Gas components have an impact on heat transfer between gas and standpipe/separator. - With progress of the event, hydrogen gas and fission products generated from core region are transported to standpipe/separator. - Fission products create heat flux and would have an impact on standpipe/separator temperature.
219	Gamma Heat Generation in Standpipe/Separator	- Gamma ray is emitted from fission products transported to the standpipe.separator. - Gamma ray usually passes through the source materials and radiates and heats standpipe/separator.
220	Condensation Heat Transfer on Standpipe/Separator	- Water and steam from the core flow into standpipe/separator. - Most of the steam condensation is supposed to occur on the surface of the wall and a few occurs in the bulk. - Condensation heat transfer occurs at the surface of standpipe/separator and affects the gas transport within the standpipe/separator.
221	Pressure Change in Standpipe/Separator	- Pressure in standpipe/separator change due to pressure change in core region, according to boiling of coolant in core region, boundary breaks, leakage flows, and so on.
222	Gas Temperature Change in Standpipe/Separator	- Gas in standpipe/separator may be composed of water steam, fission products, and hydrogen gas. - These gas components change with progress of the event and have an impact on gas temperature.
223	Gas Flow in Standpipe/Separator	- Water steam from core region flow into standpipe/separator. - With progress of the event, fission products released by core-heatup and hydrogen gas generated by reaction between water and structure materials are transported into standpipe/separator. - Gas flow change with gas components and it effects on heat transfer.
224	Gas Composition Change in Standpipe/Separator	- Water steam from core region flow into standpipe/separator. - Gas composition change with progress of the event, for fission products released by core-heatup and hydrogen gas generated by reaction between water and structure materials are transported into standpipe/separator.
225	Standpipe/Separator Break or Deformation by Themal Stress	- High pressure and high temperature would create significant thermal stress on standpipe/separator. - Pressure and temperature would increase with progress of the event, and therefore thermal stress would cause break or deformation of the standpipe/separator.
226	Standpipe/Separator Oxidation with Steam (Including Reaction Heat and Hydrogen Production)	- Steel is used as a material of standpipe/separator. - Steel is oxidized with steam from core. Steel oxidization occurs with steam flow from core region and it is an exothermic reaction to produce hydrogen gas. - However, steel oxidation does not contribute much to the amount of hydrogen produced.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Standpipe & Separator
No.	Phenomenon	Description
227	FP deposition on standpipe/separator	- Fission products are released by core-heatup and melting, then transported to standpipe/separator with steam carrier. - The transported fission products resulted in deposition of a sizable fraction on the surface of standpipe/separator wall. - This phenomena would change heat transfer coefficient on standpipe/separator.
228	FP re-vaporization	- Fission products are released by core-heatup and melting and transported to standpipe/separator with steam carrier. - The transported fission products resulted in deposition of a sizable fraction on the surface of standpipe/separator wall. - Decay heat contained in the fissoin products heat up the standpipe/separator to revaporize the deposited product compounds.
229	Decay heat generation from FP	- Fission products are released by core-heatup and melting, then transported to standpipe/separator with steam carrier. - Decay heat contained in the fission products heat up standpipe/separator and would have an impact on the temperature.
230	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into standpipe and separator. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
231	Corrosion of Standpipe/Separator by Seasalt (Including Marine Lives)	- See water injection may induce the salt corrosion of standpipe/separator. - Characteristics of sea water property is as follows. (1) Sea water includes much dissolved oxygen. (2) Sea water includes much salt such as chloride ion. (3) Sea water has high electrical conductivity. (4) Others (marine life, polluted seawater, and so on) - SUS is extremely stable material for corrosion because SUS has passivation film on the surface of it. - However, in the sea water, much chloride ion, which is included in sea water, breaks passivation film locally, and might causes pitting corrosion, crevice corrosion, and SCC.
232	Influence for heat transfer by salt deposition	- Seawater is injected to RPV from the existing makeup water system using fire-extinguishing pump. - Seawater transferred to standpipe/separator through the core region and deposited at the surface of the wall. - Seasalt deposition on the wall would have an impact on heat trasnfer between water, gas, and standpipe/separator.
233	Pick-off Ring Flowpath Blockage by Seasalt Deposition	- Seawater is injected to RPV from the existing makeup water system using fire-extinguishing pump. - Seasalt may be transported to the separator through the core and deposited on the wall. - Seasalt suspended in separator may block up pick-off ring flowpath. - Pick-off ring flowpath, where water or gas flow, is blocked and this blockage may degrade the performance of separator.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Standpipe & Separator
No.	Phenomenon	Description
234	Separator Inlet Flowpath Blockage by Seasalt Deposition	- Seawater is injected to RPV from the existing makeup water system using fire-extinguishing pump. - Seawater flow into standpipe and deposited on the wall. - The seasalt transferred to the separator and may block the inlet flow path of the separator.
235	Re-solution of salt by reflooding	- Seasalt precipitates on the surface of structure. - After water injection, boron precipitation may soluble in water.
236	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enter the standpipe and separator through the core. - Then seawater deposited at the surface of the wall and dispersed into standpipe/separator. - Presence of seasalt may cause additional chemical reactions.
237	Corrosion of Standpipe/Separator by Boron	- If boric acid added water is condensed, water becomes to show acidity. - This acid water causes corrosion. - Characteristic of this corrosion is that metal is corroded as If metal is melted. - Also, position which corrosion appears is limited to one which boric acid is condensed.
238	Influence for heat transfer by boron deposition	- High temperature oxidation of B4C in steam is an exothermic reaction that produces boron-containing spieces. - Boron-containing spieces are transported to standpipe/separator and deposited at the surface of the wall. - Boron deposition on the wall would change the heat transfer between water, gas, and standpipe/separator.
239	Pick-off Ring Flowpath Blockage by Boron Deposition	- High temperature oxidation of B4C in steam produces boron-containing spieces. - Boron-containing speices are transported to separator and deposited on the wall. - Boron deposition may cover a cross sectional surface in pick-off ring and may degrade the perfomance of the separator.
240	Separator Inlet Flowpath Blockage by Boron Deposition	- High temperature oxidation of B4C in steam produces boron-containing spieces. - Boron-containing speices are transported to separator and deposited on the wall. - Boron deposition may cover a cross sectional surface and block the inlet flowpath of the separator.
241	Re-solution of boron by reflooding	- Boron precipitates on the surface of structures. - After water injection, boron precipitation may soluble in water.
242	Standpipe/Separator Tilt by Shroud Head Deformation	- During the accident, standpipe/separator may tilt by shroud head deformation due to high pressure and temperature.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Dryer
No.	Phenomenon	Description
243	Dryer Temperature Change	- Dryer temperature change with temperature and ratio of water and steam in two-phase flow from the separator.
244	Gamma Heat Generation in Dryer	- Gamma ray is emitted from fission products and transported to dryer with steam carrier. - Gamma ray usually passes through the source materials and radiates and heats the internals of the dryer.
245	Heat Transfer between Gas and Dryer	- Gas component in dryer may be steam, fission products, and hydrogen gas. - Gas components change with progress of the event and may change the heat transfer between gas and dryer.
246	Condensation Heat Transfer on Dryer	- Two-phase flow of steam and water, fission products, and hydrogen gas flow into dryer. - Most of the gas condensation is supposed to occur on the surface of the wall. - Condensation heat is transferred from gas to dryer wall and have an impact on temperature change.
247	Pressure Change in Dryer	- Pressure in dryer change due to pressure change in core region, according to boiling of coolant in core region, boundary breaks, leakage flows, and gas components.
248	Gas Flow in Dryer	- Gas passing through the separator flow into dryer. - Gas component fraction change during the accident and may be composed of steam, fission products, and hydrogen gas. - Gas components change the gas flow and have an impact on heat transfer between gas and the wall.
249	Gas Temperature Change in Dryer	- Gas temperature change according to the pressure and gas components. - Gas components change during the accident and it may be mixture of steam, fission products, and hydrogen gas. - Decay heat is contained in fission products and it would impact on temperature distribution.
250	Gas Composition Change in Dryer	- After fuel melt, fission products and hydrogen gas produced in core region and flow into dryer. - Gas components in dryer change during the accident, and may be steam, fission products, and hydrogen gas.
251	Dryer Break or Deformation by Thermal Stress	- High pressure and high temperature would create significant thermal stress on dryer. - Pressure and temperature may become high with progress of the event, and then thermal stress may cause break or deformation of the dryer.
252	Dryer Oxidation with steam (Including Reaction Heat and Hydrogen Production)	- High temperature steam may induce the oxdation of dryer. - Dryer consists of steel. - Steel ablation is generated in interface between dryer and steam. - The ablation phenomena such as corrosion process and formation of eutectics lead to corrosion of dryer at temperature which is significantly lower than melting temperature of steel.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Dryer
No.	Phenomenon	Description
253	FP deposition on dryer	- The core heat-up and melting release the fission products. - The fission products form compounds with each other. - Then transported to dryer and resulted in deposition of a sizable fraction of fission products on the surface of the wall.
254	FP re-vaporization	- Fission products are released by core-heatup and melting. - Then fission products transported to dryer and resulted in the deposition of a sizable fraction on the surface of the wall. - Decay heat contained in fission products heat up the dryer to revaporize the deposited product compounds.
255	Decay heat generation from FP	- Decay heat is generated from fission products which are released by core-heatup and melting, and transported to dryer with steam carrier..
256	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into dryer. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
257	Corrosion of Dryer by Seasalt (Including Marine Lives)	- See water injection may induce the salt corrosion of dryer. - Characteristics of sea water property is as follows. (1) Sea water includes much dissolved oxygen. (2) Sea water includes much salt such as chloride ion. (3) Sea water has high electrical conductivity. (4) Others (marine life, polluted seawater, and so on) - SUS is extremely stable material for corrosion because SUS has passivation film on the surface of it. - However, in the sea water, much chloride ion, which is included in sea water, breaks passivation film locally, and might causes pitting corrosion, crevice corrosion, and SCC.
258	Influence for heat transfer by salt deposition	- Seawater is injected to RPV from the existing makeup water system using fire-extingushing pump. - Seasalt may be transported with steam carrier to dryer and deposited at the surface of the wall. - Seasalt deposition on the wall would impact on heat transfer between gas and dryer.
259	Dryer Flowpath Blockage by Seasalt Deposition	- Seawater is injected to RPV from existing makeup water system using fire-extinguishing pump. - Seawater may be transported to the dryer with steam carrier and seasalt deposited at the surface of the wall. - As seasalt deposition grows up, dryer flowpath may be blocked up. - This phenomena may degrade the performance of dryer and impact on steam amount.
260	Re-solution of salt by reflooding	- Seasalt precipitates at the surface of structure wall. - With water injection, salt precipitation may soluble in water.
261	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enter the dryer through the core. - Then seawater deposited at the surface of the wall and dispersed into dryer. - Presence of seasalt may cause additional chemical reactions.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Dryer
No.	Phenomenon	Description
262	Corrosion of Dryer by Boron	- If boric acid added water is condensed, water becomes to show acidity. - This acid water causes corrosion. - Characteristic of this corrosion is that metal is corroded as If metal is melted. - Also, position which corrosion appears is limited to one which boric acid is condensed.
263	Impact of Boron Deposition on Heat Transfer	- High temperature oxidation of B4C in steam is an exothermic reaction that produces boron-containing spieces. - Boron spieces are transported to dryer by steam carrier and deposited on the surface of the wall. - Boron deposition on dryer wall may change the heat transfer between gas and dryer wall.
264	Dryer Flowpath Blockage by Boron Deposition	- High temperature oxidation of B4C in steam is an exothermic reaction that produces boron-containing spieces. - Boron spieces are transported to dryer by steam carrier and deposited on the surface of wall. - Seasalt deposition may cover a cross sectional surface and block the inlet flowpath of the dryer. - This phenomena may degree the performance of dryer and impact on steam flow.
265	Re-solution of boron by reflooding	- Boron precipitates on the surface of structures. - After water injection, boron precipitation may soluble in water.
266	Dryer Structure Tilt	- During the accident, dryer structure may tilt due to high pressure and temperature or deformation of the structure.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Upper head
No.	Phenomenon	Description
267	Heat Transfer between Gas and Upper Head Wall	- Gas components in upper head may be steam, fission products, and hydrogen gas during the accident. - Gas components change with progress of the event. - Also, gas components would change the heat transfer between gas and upper head wall.
268	Gamma Heat Generation in Upper Head	- Gamma ray is emitted from fission products in fuel rods or corium which transported to upper head. - Then upper head is also radiated and heated with fission products.
269	Upper Head Temperature Change	- Upper head temperature change due to steam temperature flow from dryer and temperature of drywell head.
270	Radiation Heat Transfer from Upper Head to Drywell Head	- Radiation heat transfer is dependent on temperature, geometry, and emissivities and so on. - Radiation heat transfer from upper head to drywell head would have an effect on temperature distribution in upper head.
271	Condensation Heat Transfer on Upper Head	- Mixture gas of steam, hydrogen gas, and so on, flow into upper head and most of the gas condensation is supposed to occur on the surface of the wall. - Condensation heat is transferred from gas to upper head wall and has an impact on temperature change.
272	Pressure Change in Steam Dome	- Pressure in steam dome change due to pressure change in core region, according to boiling of coolant in core region, boundary breaks, leakage flows, FP and hydrogen gas generation and so on.
273	Gas Flow in Steam Dome	- Steam is only the gas component in steam dome at rated operation. - During the accident, fission products and hydrogen gas are produced and may flow into steam dome. - Gas components change with progress of the event and may have an impact on gas flow and heat transfer between gas and the wall.
274	Gas Temperature Change in Steam Dome	- Gas in steam dome may be composed of water steam, fission products, and hydrogen gas. - Gas temperature in steam dome would change with these components change.
275	Gas Composition Change in Steam Dome	- Steam is only the gas component in steam dome at rated operation. - During the accident, fission products and hydrogen gas are produced and may flow into steam dome. - Gas components change with progress of the event.
276	Upper Head Oxidation with Steam (Including Reactin Heat and Hydrogen Production)	- Upper head is oxidized with steam from core region. - The oxidization is exothermic reaction and produces hydrogen gas. - However, this reaction does not contribute much to the amount of hydrogen production.
277	FP deposition on upper head	- The core heat-up and melting releases the fission products. - The fission products form compounds with each other. - Then transported to upper head and resulted in deposition of a sizable fraction of fission products on the surface of the wall.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Upper Head
No.	Phenomenon	Description
278	FP re-vaporization	- Fission products are released by core-heat-up and melting. - Then fission products transported to upper head and resulted in the deposition of a sizable fraction on the surface of the wall. - Decay heat contained in fission products heat up the upper head to revaporize the deposited product compounds.
279	Decay heat generation from FP	- Fission products are released by core-heatup and melting, and transported to upper head with steam. - Decay heat contained in fission products heat up the upper head and change the temperature.
280	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into upper head. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
281	Gas Leakage from RPV flange to Drywell Head	- Gas is composed of steam, hydrogen gas, and so on, flow from dryer. - Due to high temperature during the accident, RPV frange is reduced or loss, and causing leakage. - This phenomena impact on temperature and pressure of both upper head and drywell head.
282	Corrosion of Upper Head by Seasalt (Including Marine Lives)	- See water injection may induce the salt corrosion of upper head. - Characteristics of sea water property are as follows. (1) Sea water includes much dissolved oxygen. (2) Sea water includes much salt such as chloride ion. (3) Sea water has high electrical conductivity. (4) Others (marine life, polluted seawater, and so on) - SUS is extremely stable material for corrosion because SUS has passivation film on the surface of it. - However, in the sea water, much chloride ion, which is included in sea water, breaks passivation film locally, and might causes pitting corrosion, crevice corrosion, and SCC.
283	Influence for heat transfer by salt deposition	- Seawater is injected to RPV from the existing makeup water system using fire-extinguishing pump. - Seawater transported with steam carrier to upper head and deposited at the surface of the wall. - Seasalt deposition on the wall would have an impact on heat transfer between gas and upper head.
284	Re-solution of salt by droplet	- Seasalt precipitates on the surface of structure. - With water injection, salt precipitation may soluble in water.
285	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Upper Head
No.	Phenomenon	Description
286	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enters the upper head through the core. - Then seawater deposited at the surface of the wall and dispersed into upper head. - Presence of seasalt may cause additional chemical reactions.
287	Corrosion of Upper Head by Boron	- If boric acid added water is condensed, water becomes to show acidity. - This acid water causes corrosion. - Characteristic of this corrosion is that metal is corroded as If metal is melted. - Also, position which corrosion appears is limited to one which boric acid is condensed.
288	Influence for heat transfer by boron deposition	- High temperature oxidation of B4C in steam is an exothermic reaction that produces boron-containing spieces. - Boron spieces are transported to upper head by steam carrier and may deposit on the surface of the wall. - Boron deposition on dryer wall may change the heat transfer between gas and the wall.
289	Re-solution of boron by reflooding	- Boron precipitates on the surface of structure. - With water injection, boron precipitation may soluble in water.
290	Degradation or Falling of Lagging Material	- Lagging material is degraded by heat through RPV wall, when inside temperature of RPV is extremely high. - As a result of degradation, lagging material might fall down.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Main Steam Line
No.	Phenomenon	Description
291	Main Steam Line Creep Rupture	- During the accident, steam flows into main steam line become high temperature and high pressure condition. - This condition may lead to creep rupture of main steam line.
292	Break Flow from Main Steam Line Break	- When main steam line breaks due to high temperature, steam within the line flows out. - Break flow is changed by components, pressure, and temperature within the main steam line. - And it may also have an impact on temperature and pressure within main steam line.
293	Gas Flow in Main Steam Line	- Steam is only the gas component in main steam line at rated operation. - During the accident, fission products and hydrogen gas are produced and may carry into the main steam line. - Gas components change with progress of the event and it may have an impact on gas flow and heat transfer between gas and the wall.
294	Pressure Change in Main Steam Line	- Pressure in main steam line change due to pressure change in primary system, steam ejection through SRV, and so on.
295	Gas Temperature Change in Main Steam Line	- Gas temperature in main steam line change due to gas temperature flow from the core region. - Gas in main steam line may be composed of water steam, fission products, and hydrogen gas. - These gas components change with progress of the event and would have an impact on gas temperature.
296	Gas Composition Change in Main Steam Line	- Steam is only the gas component in main steam line at rated operation. - During the accident, fission products and hydrogen gas are produced and may carry into main steam line. - Gas components change with progress of the event.
297	Main Steam Line Temperature Change	- Main steam line temperature change as temperature change of inflow gas from primary system. - Also, heat transfer between gas and main steam line may have an impact on temperature of the main steam line.
298	Heat Transfer between Gas and Main Steam Line	- Gas component in main steam line is only steam at rated operation, and then hydrogen gas is mixed in as progress of the event. - Heat transfer between gas and main steam line change due to gas components in the line. - This phenomena would have an impact on temperature of the line.
299	Heat Transfer between water and Main Steam Line	- Water carried by steam is transported into main steam line. - Heat transfer coefficient between water and main steam line depends on water flow velocity.
300	Condensation Heat Transfer on Main Steam Line	-During the accident, mixture gas of steam, hydrogen gas, and so on, flow into upper head and most of the gas condensation is supposed to occur on the surface of the wall. - Condensation heat is transferred from gas to main steam line and has an impact on temperature change.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Main Steam Line
No.	Phenomenon	Description
301	Heat Transfer to Drywell through Lagging Material	- Heat transfer to drywell through lagging material depends on thickness of lagging material, gas velocity near the lagging material, and so on.
302	Safety Relief Valve Opening Characteristics	- Safety relief valve opening characteristics such as opening pressure has uncertainty width and may become incorrect during the accident. - Safety relief valve opening status may be changed by aftershock stress.
303	Leakage from Safety Relief Valve to Drywell	- When pressure of gases such as steam, fission products, and hydrogen gas flow from core region become high, gas leakage from safety relief valve to drywell may occur. - This phenomena would impact on pressure, temperature, and gas composition in main steam line.
304	Pressure Loss at Safety Relief Valve	- Pressure loss at safety relief valve would have an effect on gas flow rate from the valve.
305	Safety Relief Valve Temperature Change	- Gases flowing through safety relief valve include fission products which generate decay heat. - Safety relief valve temperature change with temperature of flowing gas in main steam line.
306	Heat Transfer between Gas and Safety Relief Valve Blowdown Piping	- When safety relief valve open, gases flow through the safety relief valve blowdown piping. - Heat transfer coefficient between gas and safety relief valve depends on gas flow velocity.
307	Safety Relief Valve Blowdown Piping Break	- When safety relief valve open during the accident, high temperature gas flow into blowdown piping. - In some cases, safety relief valve blowdown piping may break.
308	Safety Relief Valve Blowdown Piping Break Flow	- When safety relief valve open during the accident, steam and hydrogen gas flow into the blowdown piping. - If safety relief valve blowdown piping break occurs, gases flow out from the break. - The break flow is influenced by gas components, pressure and temperature of gases.
309	MSIV Closure	- MSIV closure generates a pressure wave and may have an impact on pressure change in the reactor.
310	Pressure Wave by MSIV Closure	- Due to the closure of MSIV, a wave of backpressure is generated.
311	Gas Leakage from MSIV	- During the accident, pressure in main steam line increase and gas may leak from MSIV. - Gas components in main steam line is steam at rated operation, and fission products and hydrogen gas are mixed into main steam line with progress of the event.
312	FP deposition on main steam line	- The core heat-up and melting release the fission products. - The fission products form compounds with each other. Then transported to main steam line and resulted in deposition of a sizable fraction of fission products on the surface of the line wall.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Main Steam Line
No.	Phenomenon	Description
313	FP re-vaporization	- Fission products are released by core-heat-up and melting. - Then fission products transported to main steam line and resulted in the deposition of a sizable fraction on the surface of the wall. - Decay heat contained in fission products heat up the main steam line to revaporize the deposited product compounds.
314	Decay heat generation from FP	- Fission products are released by core-heatup and melting, and transported to main steam line with steam. - Decay heat contained in fission products heat up the main steam line and change the temperature.
315	FP accumulation at leakage path	- During the accident, fission products generated from core-heatup and melting flow into main steam line. - When valves connected from main steam line are opened, FPs flow into leakage path and accumulate.
316	Radiation heat transfer to drywell	- Radiation heat transfer is dependent on temperature, geometry, and emissivity and so on. - Radiation heat transfer from main steam line to drywell would have an effect on temperature distribution in main steam line.
317	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV changes due to vaporization, injection amounts of real water, and so on. - Seasalt concentration may have impact on seasalt deposition amount on structures and therefore heat transfer between seawater and structures.
318	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
319	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enters into main steam line through the core. - Then seawater deposited at the surface of the wall and dispersed into main steam line. - Presence of seasalt may cause additional chemical reactions.
320	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into main steam line. - FP reaction occurs gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
321	Failure of RPV nozzle welding by thermal stress	- During the accident, temperature and pressure within RPV and main steam line become high. - Then thermal stress on RPV occurs and RPV nozzle welding may fail.
322	Degradation or Falling of Lagging Material	- Lagging material is degraded by heat through RPV wall, when temperature within RPV becomes extremely high. - As a result of degradation, lagging material might fall down.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Upper down comer
No.	Phenomenon	Description
323	Heat Transfer between Gas and Upper Downcomer Wall	- Gas exists in upper downcomer is steam only at rated operation, then fission products and hydrogen gas are mixed during the accident. - Heat is transferred from gas to upper downcomer wall. - Heat transfer rate depends on gas flow velocity near the downcomer wall and gas composition.
324	Gamma Heat Generation in Upper Downcomer Wall	- During the accident, gamma ray is emitted from fission products in fuel rods and transported to upper down comer. - Gamma ray usually passes through the source materials and radiates and heats upper downcomer wall.
325	Upper Downcomer Wall (and Feedwater Sparger) Temperature Change	- Upper downcomer wall (and feedwater sparger) temperature change by temperature of water and gases from core.
326	Condensation Heat Transfer on Upper Downcomer Wall (and Feedwater Sparger)	- Mixture gas of steam, fission products, and hydrogen gas flow into upper down comer and condensed when it contacts the wall. - Condensation heat is transferred from gas to upper downcomer wall (and feedwater sparger) and impacts on temperature change.
327	Pressure Change in Upper Downcomer	- Pressure in upper down comer change due to pressure change in primary system, according to boiling of coolant in core region, boundary breaks, leakage flows, FP and hydrogen gas generation and so on.
328	Change in water level in upper down comer	- Water level in upper downcomer change due to water level change in primary system, according to boiling of coolant in core region, boundary breaks, leakage flows, and so on.
329	Gas Flow in Upper Downcomer	- Steam is only the gas component in upper down comer in rated operation. - During the accident, fission products and hydrogen gas are produced and may flow into upper down comer. - Gas components, pressure, and temperature would change the gas flow in upper downcomer.
330	Gas Temperature Change in Upper Downcomer	- Gas in upper downcomer flows from core and the temperature is determined by gas temperature in core region.
331	Gas Composition Change in Upper Downcomer	- Steam is only the gas component in upper down comer in rated operation. - During the accident, fission products and hydrogen gas are produced and may carry into upper down comer. - Gas composition change as event progression.
332	Upper Downcomer Wall (and Feedwater Sparger) Break or Deformation by Thermal Stress	- High pressure and high temperature would create significant thermal stress on upper downcomer wall (and feedwater sparger). - Pressure and temperature in upper down comer may become high as the progress of event, so the thermal stress result in dryer break or deformation.
333	Upper Downcomer Wall (and Feedwater Sparger) Oxidation with Steam (Including Reaction Heat and Hydrogen Production)	- Upper down comer (and feedwater sparger) is oxidized with steam from core. - The oxidization is exothermic reaction and leads to hydrogen generation.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Upper down comer
No.	Phenomenon	Description
334	FP deposition on upper down comer	- The core heat-up and melting releases the fission products. - The fission products form compounds with each other. - Then transported to upper down comer and resulted in deposition of a sizable fraction of fission products on the surface of structure wall.
335	FP re-vaporization	- Fission products are released by core-heat-up and melting. - Then fission products transported to upper down comer and resulted in the deposition of a sizable fraction on the surface of the wall. - Decay heat contained in fission products heat up the upper down comer to revaporize the deposited product compounds.
336	Decay heat generation from FP	- Fission products are released by core-heatup and melting, and transported to upper down comer with steam. - Decay heat contained in fission products heat up the upper down comer and change the temperature.
337	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into upper downcomer. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
338	Radiation heat transfer to drywell	- Radiation heat transfer is dependent on temperature, geometry, and emissivities and so on. - Radiation heat transfer from upper downcomer to drywell would have an effect on temperature distribution in upper down comer.
339	Corrosion of Upper Head by Seasalt (Including Marine Lives)	- See water injection may induce the salt corrosion of upper down corner. - Characteristics of sea water property is as follows. (1) Sea water includes much dissolved oxygen. (2) Sea water includes much salt such as chloride ion. (3) Sea water has high electrical conductivity. (4) Others (marine life, polluted seawater, and so on) - SUS is extremely stable material for corrosion because SUS has passivation film on the surface of it. - However, in the sea water, much chloride ion, which is included in sea water, breaks passivation film locally, and might causes pitting corrosion, crevice corrosion, and SCC.
340	Influence for heat transfer by salt deposition	- Seawater is injected to RPV from the existing makeup water system using fire-extinguishing pump. - Seawater flows into upper down comer and deposited at the surface of the structure wall. - Seasalt deposition on the wall would have an impact on heat transfer between gas, water, and upper down comer.
341	Re-solution of salt by reflooding	- Seasalt precipitates at the surface of structure. - With water injection, salt precipitation may be soluble in water.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Upper down comer
No.	Phenomenon	Description
342	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
343	Corrosion of Upper Head by Boron	- If boric acid added water is condensed, water becomes to show acidity. - This acid water causes corrosion. - Characteristic of this corrosion is that metal is corroded as If metal is melted. - Also, position which corrosion appears is limited to one which boric acid is condensed.
344	Influence for heat transfer by boron deposition	- High temperature oxidation of B4C in steam is an exothermic reaction that produces boron-containing spieces. - Boron spieces are transported to upper down comer and deposited on the surface of the structure wall. - Boron deposition on upper down comer wall may change the heat transfer between gas and the wall.
345	Re-solution of boron by reflooding	- Boron precipitates at the surface of structure. - With water injection, boron precipitation may be soluble in water.
346	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enter the upper downcomer through the core. - Then seawater deposited at the surface of the wall and dispersed into upper downcomer. - Presence of seasalt may cause additional chemical reactions.
347	Gas Flow to Main Steam Line	- During the accident, gas components may be steam, hydrogen gas, and so on. - Gas flow to main steam line change as gas flow change in upper downcomer.
348	FP Flow to Main Steam Line	- Volatile fission products are released by core-heatup and melting. - Then volatile FP transported to upper downcomer and flow into main steam line. - Decay heat contained in FP may heat up the main steam line.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Upper down comer
No.	Phenomenon	Description
349	Gas Flow to Feedwater Line	- Steam is only the gas component in upper down comer in rated operation. - During the accident, hydrogen gas is produced and may flow into upper down comer. - Gas composition, pressure, and temperature change as event progression and they would impact on gas flow to feedwater line.
350	FP Flow to Feedwater Line	- Volatile fission products are released by core-heatup and melting. - Then volatile FP is transported to upper downcomer and flow into feedwater line. - Decay heat contained in FP may heat up the feedwater line.
351	Heat Transfer to Drywell through Lagging Material	- Heat transfer to drywell through lagging material is dependent on thickness of lagging material, gas velocity near lagging material and so on.
352	Failure of RPV nozzle welding by thermal stress	- During the accident, temperature and pressure within RPV and upper downcomer become high. - Then thermal stress on RPV occurs and RPV nozzle welding may fail.
353	Degradation or Falling of Lagging Material	- Lagging material is degraded by heat through RPV wall, when temperature within RPV becomes extremely high. - As a result of degradation, lagging material might fall down.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
354	Heat transfer between water and shroud wall	- Heat of the shroud wall which is heated by core transfers to the water in the lower down comer from the outer side of shroud wall. - Heat transfer rate is depends on water flow velocity.
355	Heat transfer between water and jet pump	- Heat transfer between water and jet pump is dependent on water flow velocity near the jet pump surface and the jet pump geometry.
356	Heat transfer between water and pump deck	- Heat transfer between water and pump deck is dependent on water flow velocity near the pump deck surface and the pump deck geometry.
357	Heat transfer between water and RPV wall	- Heat transfer between water and RPV wall is dependent on water flow velocity near the RPV wall surface.
358	Heat transfer between gas and shroud wall	- Heat of the shroud wall which is heated by core transfers to the gas in the lower down comer from the outer side of shroud wall. Gas mainly consists of steam in the case of normal operation, and hydrogen gas is mixed in the case of failure of fuel rods. - Heat transfer rate depends on gas flow velocity near the shroud wall.
359	Heat transfer between gas and jet pump	- Heat transfer between gas and jet pump is dependent on gas flow velocity near the jet pump surface and the jet pump geometry.
360	Heat transfer between gas and pump deck	- Heat transfer between gas and pump deck is dependent on gas flow velocity near the pump deck surface and the pump deck geometry.
361	Heat transfer between gas and RPV wall	- Heat transfer between gas and RPV wall is dependent on gas flow velocity near the RPV wall surface.
362	Heat transfer between water and corium	- Heat of the corium which flows out to the lower down comer through damaged parts of shoroud wall transfers to the water in the lower down comer. - Heat transfer rate is depends on flow velocity difference between both.
363	Heat transfer between gas and corium	- Heat of the corium which flows out to the lower down comer through damaged parts of shroud wall transfers to the gas in the lower down comer. - Heat transfer rate is depends on flow velocity difference between both.
364	Heat transfer between corium and shroud wall	- Heat of the corium, which flows out from damaged parts of shroud wall to the lower down comer, transfers to shroud wall. - Heat transfer rate depends on corium flow velocity near the shroud wall.
365	Heat transfer between corium and jet pump	- Heat of the corium, which flows out from damaged parts of shroud wall to the lower down comer, transfers to jet pump. - Heat transfer rate depends on corium flow velocity near the jet pump surface and its geometry.
366	Heat transfer between corium and pump deck	- Heat of the corium, which flows out from damaged parts of shroud wall to the lower down comer, transfers to pump deck. - Heat transfer rate depends on corium flow velocity near the pump deck surface and its geometry.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
367	Heat transfer between corium and RPV wall	- Heat of the corium, which flows out from damaged parts of shroud wall to the lower down comer, transfers to RPV wall. - Heat transfer rate depends on corium flow velocity near the RPV wall surface.
368	Heat transfer between water and crust	- When corium flows out from damaged parts of shroud wall to lower down comer and contacts the structure wall, corium is cooled and crust is formed at the surface of the wall. - Heat is transferred from crust to pooling water in the lower down comer. - Heat transfer rate depends on difference of flow vwlosity between water and crust.
369	Heat transfer between gas and crust	- When corium flows out from damaged parts of shroud wall to lower down comer and contacts with the structure wall, corium is cooled to form crust at the surface of the wall. - Heat is transferred from crust to gas in lower down comer and its rate depends on gas flow velocity near the crust.
370	Heat transfer between corium and crust	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with structure wall in lower down comer, corium is cooled to form crust at the surface of the wall. - Heat is transferred from corium to crust and its rate depends on corium flow velocity near the crust.
371	Heat transfer between crust and shroud wall	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with shroud wall in lower down comer, corium is cooled to form crust at the surface of the wall. - Heat is transferred from crust to shroud wall.
372	Heat transfer between crust and jet pump	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with jet pump in lower down comer, corium is cooled to form crust at the surface of the pump. - Heat is transferred from crust to jet pump.
373	Heat transfer between crust and pump deck	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with pump deck in lower down comer, corium is cooled to form crust at the surface of pump deck. - Heat is transferred from crust to pump deck.
374	Heat transfer between crust and RPV wall	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with RPV wall in lower down comer, corium is cooled to form crust at the surface of the wall. - Heat is transferred from crust to RPV wall.
375	Heat transfer between water and particulate corium	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during translation or contact to structure wall. - Heat transfer between water and particulate corium depends on their flow velocity difference.
376	Heat transfer between gas and particulate corium	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during the translation or contact to structure wall. - Heat transfer rate between gas and particulate corium depends on their flow velocity difference.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
377	Heat transfer between particulate corium and shroud wall	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during the translation or contact to structure wall. - Heat is transferred from particulate corium to shroud wall and its rate depends on particulate corium flow velocity near the shroud wall surface.
378	Heat transfer between particulate corium and jet pump	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during translation or contact to structure wall. - Heat is transferred from particulate corium to jet pump and its rate depends on particulate corium flow velocity near the pump surface and its geometry.
379	Heat transfer between particulate corium and pump deck	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during translation or contact to structure wall. - Heat is transferred from particulate corium to pump deck and its rate depends on particulate corium flow velocity near the pump deck surface and its geometry.
380	Heat transfer between particulate corium and RPV wall	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during translation or contact to structure wall. - Heat is transferred from particulate corium to RPV wall and its rate depends on particulate corium flow velocity near the RPV wall surface.
381	Heat Transfer to Drywell through Lagging Material	- Heat transfer to drywell through lagging material is dependent on thickness of lagging material, gas velocity near lagging material and so on.
382	Radiation heat transfer between corium and shroud wall	- Corium flows out from damaged parts of shroud wall in the form of jet and dispersed into lower down comer. - Radiation heat is transferred from corium to shroud wall.
383	Radiation heat transfer between corium and jet pump	- Corium flows out from damaged parts of shroud wall in the form of jet and dispersed into lower down comer. - Radiation heat is transferred from corium to jet pump.
384	Radiation heat transfer between corium and pump deck	- Corium flows out from damaged parts of shroud wall in the form of jet and dispersed into lower down comer. - Radiation heat is transferred from corium to pump deck.
385	Radiation heat transfer between corium and RPV wall	- Corium flows out from damaged parts of shroud wall in the form of jet and dispersed into lower down comer. - Radiation heat is transferred from corium to RPV wall.
386	Radiation heat transfer between particulate corium and shroud wall	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during the translation or contact to structure wall. - Radiation heat is transferred from particulate corium to shroud wall.
387	Radiation heat transfer between particulate corium and jet pump	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during the translation or contact to structure wall. - Radiation heat is transferred from particulate corium to jet pump.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
388	Radiation heat transfer between particulate corium and pump deck	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during the translation or contact to structure wall. - Radiation heat is transferred from particulate corium to pump deck.
389	Radiation heat transfer between particulate corium and RPV wall	- Corium that flows out from damaged parts of shroud wall to lower down comer is cooled to form particulate corium during the translation or contact to structure wall. - Radiation heat is transferred from particulate corium to RPV wall.
390	Radiation heat transfer between crust and shroud wall	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with structure wall in lower down comer, corium is cooled to form crust at the surface of the wall. - Radiation heat is transferred from crust to shroud wall.
391	Radiation heat transfer between crust and jet pump	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with structure wall in lower down comer, corium is cooled to form crust at the surface of the wall. - Radiation heat is transferred from crust to jet pumpl.
392	Radiation heat transfer between crust and pump deck	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with structure wall in lower down comer, corium is cooled to form crust at the surface of the wall. - Radiation heat is transferred from crust to pump deck.
393	Radiation heat transfer between crust and RPV wall	- Corium flows out from damaged parts of shroud wall to lower down comer and if it contacts with structure wall in lower down comer, corium is cooled to form crust at the surface of the wall. - Radiation heat is transferred from crust to RPV wall.
394	Radiation heat transfer to drywell	- Radiation heat transfer is dependent on temperature, geometry, and emissivities and so on. - Radiation heat transfer from lower downcomer to drywell would have an effect on temperature distribution in lower down comer.
395	Heat generation by gamma ray in lower down comer structure	- Corium flows out from damaged parts of shroud wall to lower down comer. - Gamma ray is emitted from fission products in corium. - Gamma ray usually passes through the source materials and radiates and heats lower down comer structure.
396	Failure of shroud wall by thermal stress	- Temperature in primary system increase and lower down comer is heated during the accident. - This cause thermal stress and shroud wall may break by thermal stress.
397	Failure of RPV nozzle welding by thermal stress	- During the accident, temperature and pressure within RPV and lower downcomer become high. - Then thermal stress on RPV occurs and RPV nozzle welding may fail.
398	CCFL in suction part in jet pump	- During the accident, steam blows up from jet pump and water suction is blocked by the countercurrent flow.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
399	Change in water level in lower down comer	- Water level decreases according to lowering of core water level by boiling or outflow of water through opening by failure in RPV wall, and increase according to rising of core water level or direct water injection into lower downcomer etc..
400	Change in pressure in lower down comer	- Pressure in the lower dwuncomer increases with boiling of water in RPV etc., and decreases by injection of water or flowout of gas including steam through opening including SR valve etc..
401	Change of flow regime in lower down comer	- In the case of normal operation, flow in the lower downcomer is single phase and has no flow regime. - In the case of that corium flows into the lower plenum or the lower downcomer, flow of water becomes to two-phase flow, because water in those area boils and bubbles are generated. - According to increasing of an amout of bubbles, flow regime changes bubbly flow to droplet flow.
402	Decompression boiling	- In the case of normal operation, water in lower down comer dosen't boil even if water temperature is high, because pressure in the RPV is kept high. - However, in the accident, when pressure in RPV rapidly decreases, water in lower plenum becomes to saturation water and water boils, which is called decompression boiling. - When decompression boiling occurs, pressure decreasing is relaxed temporarily.
403	Change in water temperature in lower down comer	- Water temperature in the lower dwuncomer changes with pressure. - Also, water temperature is affected by surrounding materials such as shoroud wall, jet pump, corium, and so on.
404	Change in gas temperature in lower down comer	- In the case of normal operation, gas temperature in the lower downcomer is almost saturation temperature. - Gas temperature becomes higher than saturation temperature, when corium directly touches gas after fuel rods are failed.
405	Change in gas composition in lower down comer	- In the case of normal operation, gas consists only of steam. - Gas consists of steam and hydrogen, because hydrogen gas is generated by metal-water reaction when wtaer level lowers.
406	Change in temperature in shroud wall	- Temperature in shroud wall increases if corium contacts shroud wall.
407	Change in temperature in jet pumps	- Temperature in jet pump increases if corium contacts jet pump or flows into jet pump. .
408	Change in temperature in pump deck	- Temperature in shroud deck increases if corium contacts pimp deck.
409	Change in temperature in RPV sidewall	- Temperature in RPV sidewall increases if corium flowed out lower downcomer contacts RPV sidewall.
410	Corium relocation type through breached core shroud to lower plenum	- Corium flows to lower downcomer through breached core shroud and slump to the lower plenum. - Corium type may be jet or agglomerate during relocation. - The relocation type may be changed by aftershock.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
411	Corium spreading in lower down comer	- Once corium has fallen to the lower downcomer, it wil spread on the pump deck.
412	Ablation of outer wall surface of shroud by corium	- Corium spreaded in the lower downcomer melts shroud wall from outer surface of it by heat, or erodes with metal-water reaction.
413	Change in area of failire opening in shroud	- Opening by failure in shroud wall enlarges by influence from in and out of it. - On the other hand, opening may shrink by freezing of corium around opening.
414	Flow of water and gas through failure opening in shroud	- Water in the lower downcomer flows into core through opening by failure in the shroud, and vice versa. - Gas in the lower downcomer flows into core through opening by failure in the shroud, and vice versa.
415	Corium submerged in water by water injection	- Water by injection covers corium, and cools it. - As a result, the surface of corium might become crust.
416	FCI pre-mixing by contact between corium and water pool	- When high-temperature liquid corium contacts with water, corium finely breaks up in water. - Each droplet of corium is covered by steam film, and droplets keep high-temperature state.
417	FCI triggering by vapor film collapse	- Corium flows to lower down comer through damaged parts of shroud wall and breaks up into water in a film boiling regime to creats a melt-water-steam mixture. - After a certain amount of melt has penetrated into water, steam explosion process starts. - The trigger induces vapor film collapse locally and melt-water contact occurs.
418	Atomization of corium in water pool and rapid steam generation (FCI)	- When steam film around corium droplet breaks by some reason and sorium droplets directly contact with water, droplets are broken up furthermore and contact area wbetween corium and water increases. - This is called "atomization". - As a result, thermal energy of corium rapidly transfers to water, and a lot of steam generates.
419	Pressure wave by FCI	- When "Atomization of corium in water pool and rapid steam generation (FCI)" of phenomenon occurs, pressure wave generates, because generated steam rapidly pushes water aside.
420	Temperature increas of water and gas by FCI	- Temperature of water and gas increases, thermal energy of corium transfers to water and gas.
421	Failure of RPV lower head by FCI	- Impact force generated by FCI has an influence on strength of RPV lower head, and cause damage to the reactor structures. - In some cases, RPV lower head is broken .

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
422	Scattering of corium, particulate corium and crust in lower down comer by FCI	- Impact force generated by FCI has an influence on strength not only of RPV lower head but also crust solidified on structures. - In some cases, crust is broken. - Pressure wave scatters corium, particulate corium, and broken crust.
423	Impact for FCI by seawater	- Seawater is injected to RPV and poured into lower downcomer. - Corium flows out from damaged parts of shroud wall to lower downcomer and breaks up into seawater. - Water presence could lead to energetic FCI, and its behavior is affected by density, viscosity of the materials, and so on. - Therefore existence of seasalt solute may have an impact on FCI behavior.
424	Change in corium temperature	- Water, gas, particulate corium, crust and structures in lower down comer have an influence on corium temperature..
425	Change in physical property by material mixing in corium	- Corium consists of a lot of components such as UO2, zircalloy, and SUS. - Hence, physical property is different due to ratios of each component, even if temperatures for each state are same.
426	Oxidation reaction between corium and water (steam) (including hydrogen generation and reaction heat)	- Corium includes zircaloy, and so on. - Metal-water interaction occurs between metalic components of corium and water in lower down comer, and hydrogen is produced. - However, an amount of hydrogen is much less than interaction between particulate corium and water, because reaction area is small than it of interaction between particulate corium and water.
427	Oxidation reaction between shroud and steam (including hydrogen generation and reaction heat)	- Shroud consists of steel. - Steel ablation is generated in interface between shroud and steam. - The ablation phenomena such as corrosion process and formation of eutectics lead to errosion of shroud at temperatures that are significantly lower than melting temperature of steel.
428	Oxidation reaction between jetpump and steam (including hydrogen generation and reaction heat)	- Jet pump consist of steel. - Steel ablation is generated in interface between jet pump and steam. - The ablation phenomena such as corrosion process and formation of eutectics lead to errosion of jet pump at temperatures that are significantly lower than melting temperature of steel.
429	Oxidation reaction between pump deck and steam (including hydrogen generation and reaction heat)	- Pump deck consist of steel. - Steel ablation is generated in interface between pump deck and steam. - The ablation phenomena such as corrosion process and formation of eutectics lead to errosion of pump deck at temperatures that are significantly lower than melting temperature of steel.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
430	Oxidation reaction between RPV sidewall and steam (including hydrogen generation and reaction heat)	- RPV consists of steel. - Steel ablation is generated in interface between RPV and steam. - The ablation phenomena such as corrosion process and formation of eutectics lead to errosion of RPV at temperatures that are significantly lower than melting temperature of steel.
431	Crust generation by solidification of corium	- Liquid corium is frozen by contact with low temperature material such as water, gas, structures, and so on. - Solidified corium becomes crust or particulate corium.
432	Crust remelting due to change in the heat transfer status to corium or water	-Normally corium is cooled and solidified on the surface, forming crust. -This crust may remelt due to change in heat transfer status, such as loss of cooling water on the surface, or change in heat transfer from inner corium with changing mixture conditions.
433	Particulate corium remelting due to change in the heat transfer status	-Particle corium (debris) in the particle bed may melt and transfer into molten pool again when the cooling water is lost and heat removal is not sufficient.
434	Corium spreading in circumferential direction in lower down comer	- Corium flowing out through failure opening in shroud spreads in circumferential direction.
435	Decay heat in corium	- Decay heat is the heat released as a result of radioactive decay. - Corium including fuel component and radioactivated material has decay heat.
436	Relocation of corium by failure of pump deck	- When pump deck is broken in the situation of that there is corium in lower down comer, corium flow down into lower head.
437	Relocation of corium by failure of jet pump	- When jet pump is broken in the situation of that there is corium in lower down comer, corium flow into lower recirculation loop piping.
438	Particulation of corium by contact with water	- Corium is frozen by contact with water. - Corium which is not by structure such as wall becomes to particulate corium.
439	Change in physical property of particulate corium	- Corium consists of a lot of components such as UO2, zircalloy, and SUS. - Hence, physical property is different due to ratios of each component, even if temperatures for each state are same.
440	Change in size and shape of particulate corium	- When corium which comes from adjacent regions such as core contacts with water, corium becomes to particulate corium. - Size and shape of particulate corium depend on falling velocity of corium and water temperature and so on.
441	Entrainmentof of particulate corium from corium falling into water	- When corium coming from adjacent regions such as core contacts with water, corium is broken down and small droplets are entrained. - Small droplets are frozen and get to particulate coriums.
442	Aggregation and bed formation of particulate corium	-Particulate corium accumulates at the lower point in case of no flow.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
443	Change in temperature of particulate corium	- Water, gas, corium, crust and structures in lower down comer have an influence on particulate corium temperature..
444	Decay heat in particulate corium	- Decay heat is the heat released as a result of radioactive decay. - Particulate corium including fuel component and radioactivated material has decay heat.
445	Change in temperature of crust	- Water, gas, corium, particulte corium and structures in lower down comer have an influence on crust temperature..
446	Bubble formation in crust	- Water infiltrating into crust boils, and steam bubbles are formed.
447	Water inflow into crust through crack on surface of crust	- Water infiltrates into cracks formed on the surface of crust.
448	Decay heat in crust	- Decay heat is the heat released as a result of radioactive decay. - Crust including fuel component and radioactivated material have decay heat.
449	Change in physical property by material mixing in crust	- Crust consists of a lot of components such as UO2, zircalloy, and SUS. - Hence, physical property is different due to ratios of each component, even if temperatures for each state are same.
450	Oxidation reaction between crust and water (steam) (including hydrogen generation and reaction heat)	- Crust includes zircaloy, and so on. - Metal-water interaction occurs between metalic components of crust and water in lower plenum, and hydrogen is produced. - However, An amount of hydrogen is much less than interaction between particulate corium and water, because reaction area is small than it of interaction between particulate corium and water.
451	Flow path blockage in lower down comer (including jet pump) by crust	- There is a possibility that corium flowing out into lower down comer is frozen by contact with water or structures in the lower down comer and becomes crust. - In some conditions, flow path would be blocked by crust.
452	Recriticality	- There is enough fuel in the core originally that makes crtical state kept. - In some conditions, though there is very small possibility, molten core fuel might cause critical state again. - Please note that re-critical condition is highly unlikely to occur. However the impact would be large and the feasibility cannot be denied perfectly. Then this item should be kept in the phenomena list.
453	Flow of corium (including particulate corium) out of RPV side wall	- Corium flowed out in lower down comer might melt RPV side wall by contact with it, in some conditions.
454	Flow of corium (including particulate corium) into recirculation loop piping	- Corium flowed out in lower down comer might melt wall of recirculation loop piping by contact with it, in some conditions. - As a result, corium flows into piping.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
455	Radiation decomposition of water	- Radiation affects water which is main constituent of biological body and cell. - As aresult, radiation causes ionization and excitation of water molecule.
456	FP deposition on lower downcomer	- FP suspended as aerosol attaches on the surface of structure such as piping in in-vessel or ex-vessel.
457	FP re-vaporization	- FP attached once on the surface of structure such as piping in in-vessel or ex-vessel could evaporate by heat of structure.
458	Decay heat generation from FP	- Decay heat is the heat released as a result of radioactive decay. - Volatile FP which generates as burnup of fuel have decay heat.
459	FP release from corium surface	- With core-heatup and melting, corium flows out from damaged parts of shroud wall into lower downcomer. - Fission products are released from the corium surface.
460	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into lower downcomer. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
461	Adsorption and release of gaseous FP	- During the accident, FPs generated from core-heatup and melting flow into lower downcomer. - Gaseous FP adsorped to structure wall and release from the wall on the contrary.
462	Corrosion of structure in lower down comer by salt content of seawater (including marine lives)	- Characteristics of sea water property are as follows. (1) Sea water includes much dissolved oxygen. (2) Sea water includes much salt such as chloride ion. (3) Sea water has high electrical conductivity. (4) Others (marine life, polluted seawater, and so on) - SUS is extremely stable material for corrosion because SUS has passivation film on the surface of it. - However, in the sea water, much chloride ion, which is included in sea water, breaks passivation film locally, and might causes pitting corrosion, crevice corrosion, and SCC.
463	Seasalt intake to corium	- Seawater is injected to RPV and poured into lower downcomer. - Seawater deposited at the surface of the wall and dispersed into lower downcomer. - Then seasalt are mixed into corium.
464	Influence for heat transfer by salt deposition	- Sea water injected in RPV probably evaporates by decay heat. - As a result, salt precipitates on the surface of structures such as piping. - Salt precipitated might have an influence on heat transfer.
465	Flow path blockage in jet pump by salt deposition	- Salt percipitaed on structures such as piping might cover a cross sectional surface in piping. - As a result, flow of water or gas is blocked.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower down comer
No.	Phenomenon	Description
466	Re-solution of salt by reflooding	- Water injection after precipitation of salt on the surface of structure probably solves it.
467	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt concentration may have impact on seasalt deposition amount on structures and therefore heat transfer between seawater and structures.
468	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
469	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enter the lower downcomer through the core. - Then seawater deposited at the surface of the wall and dispersed into lower downcomer. - Presence of seasalt may cause additional chemical reactions.
470	Corrosion of structure in lower down comer by boron	- If boracic acid added in water is condensed, water acicifies. - As a result, corrosion occurs in SUS. - This corrosion has a characteristic that metal is corroded as melt. - Occurrence point is limited to point where boracic acid is condensed.
471	Influence for heat transfer by boron deposition	- Sea water injected boron injected in RPV probably evaporates by decay heat. - As a result, boron precipitates on the surface of structures such as piping. - Boron precipitated might have an influence on heat transfer.
472	Flow path blockage in jet pump by boron deposition	- Boron percipitaed on structures such as piping might cover a cross sectional surface in piping. - As a result, flow of water or gas is blocked.
473	Re-solution of boron by reflooding	- Water injection after precipitation of boron on the surface of structure probably solves it.
474	Degradation or Falling of Lagging Material	- Lagging material is degraded by heat through RPV wall, when temperature within RPV becomes extremely high. - As a result of degradation, lagging material might fall down.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
475	Heat transfer between water and lower head including crack	- Heat transfer between water and lower head including crack is depedent on flow velocity, and geometry of structure in the lower head such as CRD housing.
476	Heat transfer between water and penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes)	- Heat transfer between water and penetration tubes is depedent on flow velocity, and geometry of penetration tube.
477	Heat transfer between gas and lower head including crack	- Heat transfer between gas and lower head including crack is depedent on flow velocity, and geometry of structure in the lower head such as CRD housing.
478	Heat transfer between gas and penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes)	- Heat transfer between gas and penetration tubes is depedent on flow velocity, and geometry of penetration tube.
479	Heat transfer between corium and water (including CHF)	- Heat transfer between corium and water is seen in interaction between water pool in the lower head and various forms of corium, such as corium jet falling from the above regions, dispersed corium from falling jet and corium pool in the lower head. - Heat transfer between corium and water is depedent on flow velocity of corium, and size of corium etc..
480	Heat transfer between corium and gas	- Heat transfer between corium and gas is seen in interaction between gas pool in the lower head and various forms of corium, such as corium jet falling from the above regions, dispersed corium from falling jet and corium pool in the lower head. - Heat transfer between corium and gas is depedent on flow velocity of corium, and size of corium and so on.
481	Heat transfer between corium and penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes)	- Heat transfer between corium and penetration tubes is depedent on temperature of both, flow velocity, geometry of penetration tube and so on.
482	Heat transfer between corium and lower head	- Heat transfer between corium and lower head is depedent on flow velocity, size and shape of corium and geometry of penetration tube and so on.
483	Heat transfer between particulate corium and water	- Heat transfer between particulate corium and water is seen in interaction between water pool in the lower head and various forms of particulate corium, such as particulate corium dispersed from falling jet and particulate corium accumulated on the lower head and so on. - Heat transfer between particulate corium and water is depedent on flow velocity of particulate corium, and size of particulate corium and so on.
484	Heat transfer between particulate corium and gas	- Heat transfer between particulate corium and gas is seen in interaction between gas pool in the lower head and various forms of particulate corium, such as particulate corium dispersed from falling jet and particulate corium accumulated on the lower head and so on. - Heat transfer between particulate corium and gas is depedent on flow velocity of particulate corium, and size of particulate corium and so on.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
485	Heat transfer between particulate corium and penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes)	- Heat transfer between particulate corium and penetration tubes is depedent on flow velocity, size and shape of particulate corium and geometry of penetration tube and so on.
486	Heat transfer between particulate corium and lower head	- Heat transfer between particulate corium and lower head is depedent on flow velocity, size and shape of particulate corium and geometry of penetration tube and so on.
487	Heat transfer between particulate corium and light metal layer	- Molten core falling from the above regions such as core accumulates on the lower head as corium pool. - Particulate corium is formed in the process of corium falling and falls from the above regions. - Particulate corium bed is formed on top of corium pool. - Molten steel phases (Fe, Ni, Cr) are not miscible with molten oxides (UO2, ZrO2), and the metalic phases are lighter than molten oxides. - Hence, stratified metal layers float on top of molten oxidic material. - This means that particulate corium bed is on top of light metal layer. - Heat transfer between particulate corium and light metal layer is basically done between the bottom of particulate corium bed and the top of light metal layer, and is depedent on size and shape of particulate corium, thickness of each layer and so on.
488	Heat transfer between crust and water (including CHF, inner crack and gap)	- Molten core falling from the above regions such as core accumulates on the lower head as corium pool. - The surface of molten core is frozen in some conditions and becomes to crust. - Heat transfer between crust and water appears upward, downward and sideward. - In particular, steam generated by downward heat transfer helps to prevent vessel failure. - Also, Water ingressing into crack on crust helps to cool crust and corium. - Heat transfer between crust and water is depedent on shape of surface of crust, thickness of crust and so on.
489	Heat transfer between crust and gas	- Molten core falling from the above regions such as core accumulates on the lower head as corium pool. - The surface of molten core is frozen in some conditions and becomes to crust. - Heat transfer between crust and gas measn heat transfer between crust and bubble, because there is water pool in lower head basically. - Heat transfer between crust and gas is depedent on shape of surface of crust, thickness of crust and so on.
490	Heat transfer between corium and crust	- Heat transfer between corium and crust means heat transfer between corium pool and crust formed around it. - Heat transfer between corium and crust is depedent on temperature of both, condition on the outer side of crust and so on. - In some condition, corium might melt crust, and in other conditions, crust might solidify corium.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
491	Heat transfer between crust and penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes)	- Heat transfer between crust and penetration tubes means heat transfer between penetration tubes and crust formed around it. - Heat transfer between crust and penetration tubes is depedent on temperature of both, condition on the outer side of crust, condition on contact surface and so on. - In some condition, crust mifgt melt penetration tubes.
492	Heat transfer between crust and lower head	- Heat transfer between crust and lower head means heat transfer between lower head and crust formed around it. - Heat transfer between crust and lower head is depedent on temperature of both, condition on the outer side of crust, condition on contact surface and so on. - In some condition, crust might melt lower head.
493	Heat transfer between crust and light metal layer	- When molten core falls down to lower plenum, crust is formed around molten pool, and lighter metal layer is formed on the crust. - Heat transfer between crust and light mrtal layer means heat transfer between lower head and crust formed around it. - Heat transfer between crust and light mrtal layer is depedent on temperature of both, condition on the outer side of crust, condition on contact surface and so on. - In some condition, crust might melt lower head.
494	Heat transfer between light metal layer and water (including CHF)	- When molten core falls down to lower plenum, crust is formed around molten pool, and lighter metal layer is formed on the crust. - Heat transfer between light metal layer and water is done between upper surface of light metal layer and under surface of water pool. - Heat transfer between light metal layer and water is depedent on temperature of botht, thickness of metal layer, water velocity and so on.
495	Heat transfer between light metal layer and gas	- When molten core falls down to lower plenum, crust is formed around molten pool, and lighter metal layer is formed on the crust. - There is usually water on top of the light metal laye. - This heat transfer is considered in the case of no water on top of the metal layer. - Heat transfer between light metal layer and gas is depedent on temperature of botht, thickness of metal layer, gas velocity and so on.
496	Heat transfer between light metal layer and penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes)	- Heat transfer between light metal layer and penetration tubes is depedent on temperature of both, flow velocity, geometry of penetration tube and so on.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
497	Heat transfer between light metal layer and lower head	- Molten light metal (mainly steel) layer forms on top of oxidic corium, because solubility of steel in the oxides is very limited, and the density of steel is lower than the density of core oxides. - Hnece, the vessel walls adjacent to the metal layer were subjected to increased heat fluxes, because crust is not formed between metal layer and vessel wall. - This leads to substantial localised melting of the walls. - Heat transfer between light metal layer and lower head is depedent on temperature of both, composition of metal layer and so on.
498	Heat transfer between heavy metal layer in corium pool and lower head	- In the presence of molten steel, Uranium may migrste from the oxidic melt into the molten metal layer. - As a resut, density of metal layer increases, and in some circumstances, the density of metal layer becomes greater than the density of molten oxide - This results in layer inversion, which heavy metal layer statifies under molten oxide. - Heat transfer between heavy metal layer and lower head is depedent on temperature of both, composition of metal layer and so on.
499	Heat transfer between heavy metal layer in corium pool and penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes)	- Heat transfer between heavy metal layer and penetration tubes is depedent on temperature of both, flow velocity, geometry of penetration tube and so on.
500	Heat transfer between heavy metal layer in corium pool and metal-oxide layer in corium	- Formation of heavy metal layer by transfer of uranium into molten metal layer requires direct caontact between molten materials. - This means no crust formation between molten materials, and this requires that metal layer comes to close to thermodynamic equilibrium with oxidic layer. - Heat transfer between heavy metal layer and oxide layer is basically done between the bottom of oxide layer and the top of heavy metal layer, and is depedent on temperature of both, flow velocity, geometry of penetration tube and so on.
501	Radiation heat transfer between particulate corium and core	- Radiation heat transfer between particulate corium and core is dependent on both temperatures, geometry, and both emissivities and so on.
502	Radiation heat transfer between light metal layer and core	- Radiation heat transfer between light metal layer and core is dependent on both temperatures, geometry, and both emissivities and so on.
503	Radiation heat transfer between corium and lower head	- Radiation heat transfer between corium and lower head is dependent on both temperatures, geometry, and both emissivities and so on.
504	Particulate Corium Bed Porosity	- Particlulate corium formes porous debris bed when it falls into lower plenum. - Ratio of space between particlute corium to unit volume is debris bed porosity.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
505	Change in temperature of penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes	– Heat transfers from materials around penetration tubes to penetration tube cause change in temperature of penetration tubes.
506	Change in temperature of RPV lower head	– Heat transfers from materials around lower head to lower head cause change in temperature of lower head.
507	Deformation of RPV lower head by thermal stress	- There are some causes having an influence on RPV lower head. - Thermal stress resulting from heat flow from corium pool in the lower head. - Internal pressure, if the primary system pressure cannot be released. - Deadweight of the vessel wall and the corium pool - Thermo-chemical attack of the corium (corrosion) - By the combination of those, deformation of RPV occurs.
508	Failure of RPV nozzle welding by thermal stress	- During the accident, temperature and pressure within RPV and lower head become high. - Then thermal stress on RPV occurs and RPV nozzle welding may fail.
509	Oxidation reaction between penetration tubes (control rod guide tubes, drain lines, and instrumetation tubes) and steam (including hydrogen generation and reaction heat)	- Penetration tubes consist of steel. - Steel ablation is generated in interface between penetrations and steam. - The ablation phenomena such as corrosion process and formation of eutectics lead to errosion of penetrations at temperatures that are significantly lower than melting temperature of steel.
510	Oxidation reaction between lower head and steam (including hydrogen generation and reaction heat)	- Lower head tubes consist of steel. - Steel ablation is generated in interface between Lower head and steam. - The ablation phenomena such as corrosion process and formation of eutectics lead to errosion of Lower head at temperatures that are significantly lower than melting temperature of steel.
511	Change in pressure in lower plenum	- Gas pressure in RPV is same everywhere above the water level. - In lower plenum, pressure below the water level is equal to sum of gas pressure and water head. - When the pressure in RPV increases, pressure is released by opening of safety relief valve or pressure relief valve.
512	Change in water temperature in lower plenum	- Water temperature in the lower plenum changes with pressure. - Also, water temperature is affected by surrounding materials such as shoroud wall, jet pump, corium, and so on.
513	Change in gas temperature in lower plenum	- In the case of normal operation, gas temperature in the lower plenum is almost saturation temperature. - Gas temperature becomes higher than saturation temperature, when corium directly touches gas after fuel rods are failed.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
514	Change in gas composition in lower plenum	- In the case of normal operation, gas consists only of steam. - Gas consists of steam and hydrogen, because hydrogen gas is generated by metal-water reaction when wtaer level lowers.
515	Decompression boiling	- In the case of normal operation, water in lower plenum dosen't boil even if water temperature is high, because pressure in the RPV is kept high. - However, in the accident, when pressure in RPV rapidly decreases, water in lower plenum becomes to saturation water and water boils, which is called decompression boiling. - When decompression boiling occurs, pressure decreasing is relaxed temporarily.
516	Change in temperature inside corium	- Temperature in corium changes according to heat transfer with surrounding materials such as crust, internal structure in lower plenum, and thermal conduction within corium.
517	Non-uniform corium spreading in lower head	- There are lots of structures such as CRD housing in lower plenum. - Hence, when corium and particulte corium falls down from the upper side, corium cannot spread evenly in lower plenum, and some corium is frozen. - Also, particulate corium might accumulate near internal structure by being blocked the monement.
518	Evaporation of materials from inside corium (including FP)	- Corium includes steel, zircaloy and so on except UO2 composing fuel. - If state of corium is liquid, materials can evaporate from corium.
519	Corium jet into water pool	- When corium consisting of molten core, falls down to lower plenum from the above parts such as core, corium contacts with water in lower plenum. - At the time, breakup of corium, generation of particulte corium is seen
520	Formation of corium pool	- When corium consisting of molten core, falls down to lower plenum from the above parts such as core, corium contacts with water in lower plenum. - At the time, lots of corium accumulate on the wall of lower head and form corium pool.
521	Stratification of corium pool	- Depending on the difference of density of materials and miscibility, liquid phases in corium, such as metalic and ceramic materials, may separate and form different layers. - Metals may come atop from corium. - Under the Metals, upper crust formed around melting corium may come. - Under the upper crust, pool of melting corium may come. - Under the melting corium, lower crust may come. - Under the lower crust, heavy Metals may come.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
522	Atomization of corium by contanct with water (jet breakup)	- When a bulk of hot molten metal or oxidic corium falls into water in the lower head, three scenarios are considered. 1) Hot metl sinks calmly down to the bottom of lower head. 2) Some of hot melt jet is entrained and breaks up into particulate corium, and causes violent boiling. 3) Steam explosion occurs, spraying steam, boiling water, and hot melt particulates in the upward direction. (see No.479)
523	Change in temperature in light metal layer	- Water, particulate corium, crust and so on around light metal layer in lower plenum have an influence on light metal layer temperature.
524	Change in temperature in heavy metal layer	- Water, crust, corium and so on around heavy metal layer in lower plenum have an influence on heavy metal layer temperature.
525	Change in composition of particulate corium	- Particulate corium consists of core materials and others. - The composition depends on condition when it is formed.
526	Change in size and shape of particulate corium	- Size and shape of pariticulate corium depends on condition when it is formed, such as temperature.
527	Crust generation by solidification of corium	- When temperature of bulk corium drops below the melting point, corium freezes to become to crust.
528	Accumulation and bed formation of particulate corium	- Particulate corium accumulates on the upper crust or light metal layer, and forms particulate corium bed.
529	Non-uniform spreading of particulate corium bed	- There are lots of structures such as CRD housing in lower plenum. - Hence, when particulte corium is generated, it cannot spread evenly in lower head, and might accumulate near internal structure by being blocked the monement.
530	Change in temperature of particulate corium bed	- Water, crust, ligh metal layer and so on around particulate corium in lower plenum have an influence on particulate corium temperature.
531	Decay heat in particulate corium	- Decay heat is the heat released as a result of radioactive decay. - Particulate corium including fuel component and radioactivated material has decay heat.
532	Oxidation reaction between light metal layer and water (steam) (including hydrogen generation and reaction heat)	- Light metal layer includes zircaloy, steel and so on. - Metal-water interaction occurs between metalic components of light metal layer and water in lower plenum, and hydrogen is produced. - However, An amount of hydrogen is much less than interaction between particulate corium and water, because reaction area is small than it of interaction between particulate corium and water.
533	FCI pre-mixing by contact between corium and water pool	- When a bulk of hot molten metal or oxidic corium falls into water in the lower head, FCI occurs in some condition. - When high-temperature liquid corium contacts with water, corium finely breaks up in water. - Each droplet of corium is covered by steam film, and droplets keep high-temperature state.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
534	FCI triggering by vapor film collapse	- Corium flows to lower head and breaks up into water in a film boiling regime to creats a melt-water-steam mixture. - After a certain amount of melt has penetrated into water, steam explosion process starts. - The trigger induces vapor film collapse locally and melt-water contact occurs.
535	Atomization of corium in water pool and rapid steam generation (FCI)	- When steam film around corium droplet breaks by some reason and sorium droplets directly contact with water, droplets are broken up furthermore and contact area wbetween corium and water increases. - This is called "atomization". - As a result, thermal energy of corium rapidly transfers to water, and a lot of steam generates.
536	Pressure wave by FCI	- When "Atomization of corium in water pool and rapid steam generation (FCI)" of phenomenon occurs, pressure wave generates, because generated steam rapidly pushes water aside.
537	Temperature increase by FCI	- Temperature of water and gas increases, thermal energy of corium transfers to water and gas.
538	Failure of RPV lower head by FCI	- Impact force generated by FCI has an influence on strength of RPV lower head, and cuases damage to the reactor structures. - In some cases, RPV lower head is broken.
539	Scattering of corium and material in lower plenum by FCI	- Impact force generated by FCI has an influence on strength not only of RPV lower head but also crust solidified on structures. - In some cases, crust is broken. - Pressure wave scatters corium, particulate corium, and broken crust.
540	Impact for FCI by seawater	- Seawater is injected to RPV and poured into lower head. - Corium flows out from damaged parts of shroud wall to lower head and breaks up into seawater. - Water presence could lead to energetic FCI, and its behavior is affected by density, viscosity of the materials, and so on. - Therefore existence of seasalt solute may have an impact on FCI behavior.
541	Mixing state and physical property of corium	- Corium is the mixture made up from molten core materials. - Bsically, molten steel phases (Fe, Ni, Cr) are not miscible with molten oxides (UO2, ZrO2), and metallic phases are lighter. - However, zirconium is miscible in oxides (UO2, ZrO2). - Basic property is as follows; 1) Solidus-liquidus temperature: 1800 - 3100K 2) Density: 7e3 to 10e3 kg/m3

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
542	Oxidation reaction between corium and water (steam) (including hydrogen generation and reaction heat)	- Corium includes zircaloy, and so on. - Metal-water interaction occurs between metalic components of corium and water in lower plenum, and hydrogen is produced. - However, An amount of hydrogen is much less than interaction between particulate corium and water, because reaction area is small than it of interaction between particulate corium and water.
543	Natural convection in corium pool	- Corium pool is surrounded by crust of which top is thinner and bottom is thicker, and there is water on the upper crust. - As a result, temperature difference between thhe center of corium pool and the upper boundary is larger, larger heat flux is generated in the direction. - Hence, this causes natural convection in corium pool.
544	Decay heat of corium	- Decay heat is the heat released as a result of radioactive decay. - Corium including fuel component and radioactivated material have decay heat.
545	Solidification of corium	- Liquid corium is frozen by contact with low temperature material such as water, gas, structures and so on. - Solidified corium becomes crust or particulate corium.
546	Flow of water in lower plenum	- In the normal operation, water in the lower plenum flows upward to core. - In the accident where pumps stop, water flows upward by natrual convection. - In the case of that molten core falls down to lower plenum and there is water in the lower plenum, water is the lightest material of other ones, which corium, crust, and so on.
547	Reflooding of molten material in lower plenum by water injection	- In the condition of no water or small amount of water in the lower plenum, when water is injected, molten material which is dry is refooded. - As a result, temperature of molten material drops, and steam is generated.
548	Flow of gas in lower plenum	- In the normal operation, there is no gas in the lower plenum. - In the accident, when level of water lowers to within lower plenum, gas phase appears in lower plenum. - Gas heated by corium and others flows upward.
549	Change in an amount of purge water in CRD guide tube	- When molten material falls down from the core and so on, purge water in CRD guide tube is heated by molten material and evaporates.
550	Change in water level in lower plenum	- When the accident occurs, level of water in the core lowers and finally to within lower plenum. - The level of water lowers further, when water is heated by corium and others.
551	Radiation decomposition of water	- Radiation affects water which is main constituent of biological body and cell. - As aresult, radiation causes ionization and excitation of water molecule.
552	Bubble formation in crust	- Water infiltrating into crust boils, and steam bubbles are formed.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
553	Water inflow into crust through crack on surface of crust	- Water infiltrates into cracks formed on the surface of crust.
554	Oxidation reaction between crust and water (steam) (including hydrogen generation and reaction heat)	- Crust includes zircaloy, and so on. - Metal-water interaction occurs between metalic components of crust and water in lower plenum, and hydrogen is produced. - However, An amount of hydrogen is much less than interaction between particulate corium and water, because reaction area is small than it of interaction between particulate corium and water.
555	Change in physical property by material mixing in crust	- Corium consists of a lot of components such as UO2, zircalloy, and SUS. - Hence, physical property is different due to ratios of each component, even if temperatures for each state are same.
556	Change in temperature of crust	- Water, corium, ligh metal layer and so on around crust in lower plenum have an influence on crust temperature.
557	Decay heat in crust	- Decay heat is the heat released as a result of radioactive decay. - Corium including fuel component and radioactivated material have decay heat.
558	Recriticality	- There is enough fuel in the core originally that makes crtical state kept. - In some conditions, though there is very small possibility, molten core fuel might cause critical state again. - Please note that re-critical condition is highly unlikely to occur. However the impact would be large and the feasibility cannot be denied perfectly. Then this item should be kept in the phenomena list.
559	Gap formation between corium and lower head	- As corium is frozen, corium shrinks, - As lower head is heated, vessel wall expands. - As a result, gap is formed between corium and lower head.
560	Inflow of coolant into gap between corium and lower head	- When gap between corium and lower head is formed, water flows into the gap. - This prevents direct contact between corium and lower head. - Also, water boils up and steam is generated, - Hence, vessel wall and corium are cooled.
561	Crack formation on lower head	- There are some causes having an influence on RPV lower head. - Thermal stress resulting from heat flow from corium pool in the lower head. - Internal pressure, if the primary system pressure cannot be released. - Deadweight of the vessel wall and the corium pool - Thermo-chemical attack of the corium (corrosion) - By the combination of those, crack might occur on the surface of vessel wall. - In fact, in the TMI accident, crack was seen in the surface of vessel wall.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
562	Inflow of coolant into crack on lower head	- When gap between corium and lower head is formed, water flows into the gap. - This causes inflow of water into crack.
563	Corrosion of lower head by corium pool	- When corium jet falling down from core impinges on vessel wall, steel ablation is seen at the interface between corium and vessel wall steel. - This is a thermo-chemical attack by corium and is corrosion. - This corrosion process and formation of eutectics lead to erosion of vessel wall.
564	Erosion of lower head by corium jet	- When corium spreads on vessel wall, steel ablation is seen at the interface between corium and vessel wall steel. - This is a thermo-chemical attack by corium. - This process and formation of eutectics lead to erosion of vessel wall.
565	Flow of corium out of lower head bottom section by lower head failure	- There are some causes having an influence on RPV lower head. - Thermal stress resulting from heat flow from corium pool in the lower head. - Internal pressure, if the primary system pressure cannot be released. - Deadweight of the vessel wall and the corium pool - Thermo-chemical attack of the corium (corrosion) - When lower head is failed, corium in the lower head flows out to pedestal from the failure opening.
566	Crust remelting due to change in the heat transfer status to corium or water	-Normally corium is cooled and solidified on the surface, forming crust. -This crust may remelt due to change in heat transfer status, such as loss of cooling water on the surface, or change in heat transfer from inner corium with changing mixture conditions.
567	Particulate corium remelting due to change in the heat transfer status	-Particle corium (debris) in the particle bed may melt and transfer into molten pool again when the cooling water is lost and heat removal is not sufficient.
568	Change in area of failure opening in lower head bottom section	- After vessel failure, when corium passes through failure opening, corium flows out with ablation of vessel wall. - As a result, area of failure opening becomes larger.
569	Formation of flow path by ablation between control rod guide tubes and lower plenum	- When outer surface of CRD tube is failed by corrosion with corium, opening which corium can flow out is created.
570	Formation of flow path by jet impingement to control rod guide tubes	- Corium jet falling from core could impinges on penetration tubes. - If momentum of the corium is larger, penetration tubes migh be failed by the impact.
571	Flow of corium through failed control rod guide tubes from/to lower plenum	- When penetration tubes are failed in core, corium might flows into CRD ubes. - When the corium goes down to lower plenum through inside of CRD tube, corium might flow out through a point of failure in CRD tube.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
572	Flow of water through failed control rod guide tubes from/to lower plenum	- When penetration tubes are failed in core, water might flows into CRD tubes. - When the water goes down to lower plenum through inside of CRD tube, water might flow out through a point of failure in CRD tube.
573	Flow of gas through failed control rod guide tubes from/to lower plenum	- When penetration tubes are failed in core, gas might flows into penetration tubes. - When the gas goes down to lower plenum through inside of penetration tube, gas might flow out through a point of failure in penetration tube.
574	Purge water steaming in control rod guide tubes due to corium inflow	- Purge water which CRD tubes hold vaporizes due to heat of corium.
575	Formation of flow path to pedestal by ablation of control rod guide tube internals	- Corium flowing in CRD tubes creates opening in the inner wall of CRD tube to corrode with it.
576	Changes in breached area in control rod guide tubes to pedestal (including blockage)	- Corium flowing in CRD tube might be freezed in it depending on condition. - As a result, flow path in the CRD tube is blocked.
577	Ejection of control rod guide tubes	- Hounsing storing penetration tubes is welded with stub tube on the vessel wall. - When corium contacts with weld section, weld is deteriorated and penetration tubes migh be ejected. - Guide tubes may be ejected due to thermal expansion for lower head connections. - The ejection may be initiated by aftershock.
578	Flow of corium out of control rod guide tubes into pedestal	- Corium flowing in penetration tube might melt a boundary with ex-vessel, which is outer surface of penetration tube sticking out in pedestal region. - If the boudary is failed, corium might flows out of penetration tube into pedestal.
579	Flow of water out of control rod guide tubes into pedestal	- If a boundary with ex-vessel, which is outer surface of penetration tube sticking out in pedestal region, is failed, water might flows out of penetration tube into pedestal.
580	Flow of gas out of control rod guide tubes into pedestal	- If a boundary with ex-vessel, which is outer surface of penetration tube sticking out in pedestal region, is failed, gas might flows out of penetration tube into pedestal.
581	Formation of flow path between SRM/IRM tubes and lower plenum	- When outer surface of SRM/IRM tube is failed by corrosion with corium, opening which corium can flow out is created.
582	Formation of flow path by jet impingement to SRM/IRM tubes	- Corium jet falling from core could impinges on SRM/IRM tubes. - If momentum of the corium is larger, SRM/IRM tubes migh be failed by the impact.
583	Flow of corium through failed SRM/IRM tubes from/to lower plenum	- When penetration tubes are failed in core, corium might flows into SRM/IRM tubes. - When the corium goes down to lower plenum through inside of SRM/IRM tube, corium might flow out through a point of failure in SRM/IRM tube.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
584	Flow of water through failed SRM/IRM tubes from/to lower plenum	- When penetration tubes are failed in core, water might flows into SRM/IRM tubes. - When the water goes down to lower plenum through inside of SRM/IRM tube, water might flow out through a point of failure in SRM/IRM tube.
585	Flow of gas through failed SRM/IRM tubes from/to lower plenum	- When penetration tubes are failed in core, gas might flows into SRM/IRM tubes. - When the gas goes down to lower plenum through inside of SRM/IRM tube, gas might flow out through a point of failure in SRM/IRM tube.
586	Ejection of SRM/IRM tubes	- Hounsing storing SRM/IRM tubes is welded with stub tube on the vessel wall. - When corium contacts with weld section, weld is deteriorated and SRM/IRM tubes migh be ejected. - Instrumentation tubes may be ejected due to thermal expansion for lower head connections. - The ejection may be initiated by aftershock.
587	Flow of corium out of SRM/IRM tubes into pedestal	- Corium flowing in SRM/IRM tube might melt a boundary with ex-vessel, which is outer surface of penetration tube sticking out in pedestal region. - If the boudary is failed, corium might flows out of SRM/IRM tube into pedestal.
588	Flow of water out of SRM/IRM tubes into pedestal	- If a boundary with ex-vessel, which is outer surface of SRM/IRM tube sticking out in pedestal region, is failed, water might flows out of SRM/IRM tube into pedestal.
589	Flow of gas out of SRM/IRM tubes into pedestal	- If a boundary with ex-vessel, which is outer surface of SRM/IRM tube sticking out in pedestal region, is failed, gas might flows out of SRM/IRM tube into pedestal.
590	Formation of flow path between TIP/ICM tubes and lower plenum	- When outer surface ofTIP/ICM tube is failed by corrosion with corium, opening which corium can flow out is created.
591	Formation of flow path by jet impingement to TIP/ICM tubes	- Corium jet falling from core could impinges on TIP/ICM tubes. - If momentum of the corium is larger, SRM/IRM tubes migh be failed by the impact.
592	Flow of corium through failed TIP/ICM tubes from/to lower plenum	- When penetration tubes are failed in core, corium might flows into TIP/ICM tubes. - When the corium goes down to lower plenum through inside of TIP/ICM tube, corium might flow out through a point of failure in TIP/ICM tube.
593	Flow of water through failed TIP/ICM tubes from/to lower plenum	- When penetration tubes are failed in core, water might flows into TIP/ICM tubes. - When the water goes down to lower plenum through inside of SRM/IRM tube, water might flow out through a point of failure in TIP/ICM tube.
594	Flow of gas through failed TIP/ICM tubes from/to lower plenum	- When penetration tubes are failed in core, gas might flows into TIP/ICM tubes. - When the gas goes down to lower plenum through inside of SRM/IRM tube, gas might flow out through a point of failure in TIP/ICM tube.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
595	Formation of flow path to Pedestal by ablation of TIP/ICM tube internals	- Corium flowing in TIP/ICM tubes creates opening in the inner wall of TIP/ICM tube to corrode with it.
596	Ejection of TIP/ICM tubes	- Hounsing storing TIP/ICM tubes is welded with stub tube on the vessel wall. - When corium contacts with weld section, weld is deteriorated and TIP/ICM tubes migh be ejected. - Instrumentation tubes may be ejected due to thermal expansion for lower head connections. - The ejection may be initiated by aftershock.
597	Flow of corium out of TIP/ICM tubes into pedestal	- Corium flowing in TIP/ICM tube might melt a boundary with ex-vessel, which is outer surface of penetration tube sticking out in pedestal region. - If the boudary is failed, corium might flows out of TIP/ICM tube into pedestal.
598	Flow of water out of TIP/ICM tubes into pedestal	- If a boundary with ex-vessel, which is outer surface of TIP/ICM tube sticking out in pedestal region, is failed, water might flows out of TIP/ICM tube into pedestal.
599	Flow of gas out of TIP/ICM tubes into pedestal	- If a boundary with ex-vessel, which is outer surface of TIP/ICM tube sticking out in pedestal region, is failed, gas might flows out of TIP/ICM tube into pedestal.
600	Flow of gas out of TIP tubes into PCV	- TIP tubes connect to PCV. - As a result, gas flowing in TIP tubes might goes out to PCV.
601	Formation of flow path to Pedestal by ablation of RPV drain lines	- When outer surface of RPV drain lines is failed by corrosion with corium, opening which corium can flow out is created.
602	Changes in breached area in RPV drain lines to pedestal (including blockage)	- Flow path area changes due to extent of influence of ablation or heat by corium. '- Corium flowing in RPV drain lines might be freezed in it depending on condition. - As a result, flow path in the RPV drain lines is blocked.
603	Flow of corium out of RPV drain lines into pedestal	- When penetration tubes are failed in core, corium might flows into RPV drain lines. - When the corium goes down to lower plenum through inside of RPV drain lines, corium might flow out through a point of failure in RPV drain lines.
604	Flow of water out of RPV drain lines into pedestal	- When penetration tubes are failed in core, water might flows into RPV drain lines. - When the water goes down to lower plenum through inside of SRM/IRM tube, water might flow out through a point of failure in RPV drain lines.
605	Flow of gas out of RPV drain lines into pedestal	- When penetration tubes are failed in core, gas might flows into RPV drain lines. - When the gas goes down to lower plenum through inside of RPV drain lines, gas might flow out through a point of failure in RPV drain lines.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
606	Deformation of lower head	- The main deformation mechanisms of the RPV wall are creep and plasticity. - Plasticity is not a time-dependent phenomenon, and is due to such as corium jet impingement and so on. - Creep is a time-dependent phenomenon. - As material temperature is higher, creep velocity is faster.
607	Corium focusing effect on Lower Head Sidewall	- Molten light metal (mainly steel) layer forms on top of oxidic corium, because solubility of steel in the oxides is very limited, and the density of steel is lower than the density of core oxides. - Hnece, the vessel walls adjacent to the metal layer were subjected to increased heat fluxes, because crust is not formed between metal layer and vessel wall. - This leads to substantial localised melting of the walls. - Heat transfer between light metal layer and lower head is depedent on temperature of both, composition of metal layer and so on.
608	Change in area of failure opening in lower head side section	- After vessel failure, when corium passes through failure opening, corium flows out with ablation of vessel wall. - As a result, area of failure opening becomes larger.
609	Flow of corium out of lower head side section by lower head failure	- After failure of lower head side section, corium flows out through failure opening in it.
610	Failure of shroud support leg	- Shroud support leg in lower plenum is subjected to heat of corium. - Hence, in some condition, shroud support leg might be melted or cause buckling.
611	Change in flow resistance in shroud support leg	- If shroud support leg is failed, flow resistance might be decreased.
612	FP deposition on lower head	- FP suspended as aerosol attaches on the surface of structure such as piping in in-vessel or ex-vessel.
613	FP re-vaporization	- FP attached once on the surface of structure such as piping in in-vessel or ex-vessel could evaporate by heat of structure.
614	Decay heat generation from FP	- Decay heat is the heat released as a result of radioactive decay. - Volatile FP which generates as burnup of fuel have decay heat.
615	FP release from corium surface	- With core-heatup and melting, corium flows out from damaged parts of shroud wall into lower head. - Fission products are released from the corium surface.
616	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into lower head. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
617	Adsorption and release of gaseous FP	- During the accident, FPs generated from core-heatup and melting flow into lower head. - Gaseous FP adsorped to structure wall and release from the wall on the contrary.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
618	Buckling of Control Rod Guide Tubes	- If CRGT is affected by heat of corium, strength of CRGT is weakened. - As a result, CRGT become not to be able to withstand against deadweight of CRGT.
619	Radiation heat transfer between corium and pump deck bottom surface	- When corium drops into lower head, radiation heat transfer between corium and pump deck bottom surface occurs. -Radiation heat transfer rate is proportional to the difference in the fourth power of the corium temperature and pump deck bottom surface.
620	Corrosion of structure in lower plenum by salt content of seawater (including marine lives)	- Characteristics of sea water property is as follows. (1) Sea water includes much dissolved oxygen. (2) Sea water includes much salt such as chloride ion. (3) Sea water has high electrical conductivity. (4) Others (marine life, polluted seawater, and so on) - SUS is extremely stable material for corrosion because SUS has passivation film on the surface of it. - However, in the sea water, much chloride ion, which is included in sea water, breaks passivation film locally, and might causes pitting corrosion, crevice corrosion, and SCC.
621	Melting point change for lower head materials	- According to mixing ratio of material in lower head, melting point changes.
622	Eutectic (Corium and lower head materials)	- Once materials contained in fuel pellets and Zircaloy in fuel cladding are melted and mixed, they will form a eutectic compound, which melts at a lower temperature than the normal melting point for each component. - Fuel and zircaloy components which is not involved in eutectic in the core might be involved in eutectic in lower head.
623	Melting of lower head penetration lines	- During the accident, temperature in lower head become high and penetration lines start melting. - Then melted penetration lines are mixed into corium.
624	Melting of lower head wall	- During the accident, temperature in lower head becomes high and lower head wall start melting. - Then melted lower head wall is mixed into corium.
625	Melting of jet pump	- During the accident, temperature in lower downcomer becomes high and jet pump start melting. - Then melted jet pump are mixed into corium.
626	Melting of pump deck	- During the accident, temperature in lower downcomer become high and pumps deck start melting. - Then melted pump deck are mixed into corium.
627	Melting of shroud	- During the accident, temperature in lower downcomer become high and shroud start melting. - Then melted shroud are mixed into corium.
628	Influence for heat transfer by salt deposition	- Sea water injected in RPV probably evaporate by decay heat. - As a result, salt precipitates on the surface of structures such as piping. - Salt precipitated might have an influence on heat transfer.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Lower head
No.	Phenomenon	Description
629	Seasalt intake to corium	- Seawater is injected to RPV and poured into lower head. - Seawater deposited at the surface of the wall and dispersed into lower head. - Then seasalt are mixed into corium.
630	Seasalt impact for corium thermodynamic properties	- Thermodynamic properties of corium including seasalt vary with composition ratio of salt.
631	Re-solution of salt by reflooding	- Water injection after precipitation of salt on the surface of structure probably solves it.
632	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV changes due to vaporization, injection amounts of real water, and so on.
633	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
634	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enter the lower head through the core. - Then seawater deposited at the surface of the wall and dispersed into lower head. - Presence of seasalt may cause additional chemical reactions.
635	Corrosion of structure in lower plenum by boron	- If boracic acid added in water is condensed, water acicifies. - As a result, corrosion occurs in SUS. - This corrosion has a characteristic that metal is corroded as melt. - Occurrence point is limited to point where boracic acid is condensed.
636	Influence for heat transfer by boron deposition	- Sea water injected boron injected in RPV probably evaporates by decay heat. - As a result, boron precipitates on the surface of structures such as piping. - Boron precipitated might have an influence on heat transfer.
637	Re-solution of boron by reflooding	- Water injection after precipitation of boron on the surface of structure probably solves it.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Recirculation Loop
No.	Phenomenon	Description
638	Heat transfer between recirculation loop piping and water	- Heat transfer between recirculation loop piping and water is dependent on water flow velocity in the recirculation loop piping.
639	Heat transfer between recirculation loop piping and gas	- Heat transfer between recirculation loop piping and gas is dependent on gas flow velocity in the recirculation loop piping.
640	Heat Transfer to Drywell through Lagging Material	- Heat transfer to drywell through lagging material is dependent on thickness of lagging material, gas velocity near lagging material and so on.
641	Radiation heat transfer to drywell	- Radiation heat transfer is dependent on both temperature, geometry, and emissivity and so on. - Radiation heat transfer from recirculation loop to drywell would have an effect on temperature distribution in recirculation loop.
642	Change in temperature of recirculation loop piping	- Change in temperature of recirculation loop piping is dependent on temperature inside RPV.
643	Change in pressure in recirculation loop piping	- Change in pressure of recirculation loop piping is dependent on pressure inside RPV.
644	Change in water level in recirculation loop piping	-Water level in recirculation loop piping stays the top of recirculation loop piping when water level inside RPV stays higher than PLR suction nozzle. -Water level in recirculation loop is the same as water level inside RPV when water level inside RPV is between PLR suction nozzle and PLR drive nozzle. -Water level in recirculation loop piping may stay the same after water level inside RPV falls below PLR drive nozzle.
645	Change in water temperature in recirculation loop piping	-Water temperature in recirculation loop piping stays the same as that inside RPV when water level inside RPV stays higher than PLR drive nozzle. -Water temperature in recirculation loop piping may stay the same after water level inside RPV falls below PLR drive nozzle.
646	Change in flow of water and/or steam in in recirculation loop piping (including flow regime)	-Steam generated in recirculation loop goes out of higher junction of recirculation loop.
647	Change in gas temperature in recirculation loop piping	-Gas temperature in recirculation loop piping changes to temperature in RPV.
648	Change in gas composition in recirculation loop piping	-In case corium is not inside recirculation loop piping, gas composition in recirculation loop piping may remain the same. -In case corium is inside recirculation loop piping, FP gas concentration in recirculation loop piping may increase.
649	Change in flow of corium in recirculation loop piping	-When pressure inside RPV decreases by water injection, corium may be washed away from recirculation loop.
650	Oxidation reaction between recirculation loop piping and steam (including hydrogen generation and reaction heat)	-Oxidation reaction between recirculation loop piping and steam is dependent on steam temperature and pressure.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Recirculation Loop
No.	Phenomenon	Description
651	Leakage of gas from breached gasket or PLR pump seal	-Gasket or seal breaches due to heat and pressure, and gas leaks.
652	Leakage of water from breached gasket or PLR pump seal	-Gasket or seal breaches due to heat and pressure, and water leaks.
653	Water Radiolysis	-Decomposition of water by radiation occurs due to radiation from corium.
654	Flow path blockage in recirculation loop piping by solidification of corium	-Relatively large solidified corium blocks recirculation loop piping.
655	Corrosion of structure in recirculation loop piping by salt content of seawater (including marine lives)	-Corrosion of structure occurs due to reduction reaction by sodium.
656	Influence for heat transfer by salt deposition	-Thermal conductivity decreases due to deposition of salt at recirculation loop piping.
657	Seasalt intake to corium	- Seawater is injected to RPV and flows into recirculation loop. - Seawater deposited at the surface of the wall and dispersed into the loop. - Then seasalt are mixed into corium transported to the recirculation loop.
658	Re-solution of salt by reflooding	-Thermal conductivity increases due to removal of salt from recirculation loop piping.
659	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV changes due to vaporization, injection amounts of real water, and so on. - Seasalt concentration may have impact on seasalt deposition amount on structures and therefore heat transfer between seawater and structures.
660	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
661	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and enter into recirculation loop through the core. - Then seawater deposited at the surface of the wall and dispersed into the loop. - Presence of seasalt may cause additional chemical reactions.
662	Corrosion of structure in recirculation loop piping by boron	-Corrosion of structure occurs due to reduction reaction by boron.
663	Influence for heat transfer by boron deposition	-Thermal conductivity decreases due to deposition of boron at recirculation loop piping.
664	Re-solution of boron by reflooding	-Thermal conductivity increases due to removal of boron from recirculation loop piping.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Recirculation Loop
No.	Phenomenon	Description
665	FP deposition on recirculation loop	- FP accumulates at the low point in recirculation loop.
666	FP re-vaporization	- Iodine gas goes off when accumulated FP becomes exposed.
667	Decay heat generation from FP	- Decay heat is dependent on the time after scram, mass and composition of FP.
668	Leakage of FP from recirculation loop piping	- Leakage occurs from gasket and/or PLR pump seal.
669	FP release from corium surface	- With core-heatup and melting, corium flows out from damaged parts of shroud wall and transfers to recirculation loop. - Fission products are released from the corium surface.
670	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into recirculation loop. - FP reaction occurs gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
671	Adsorption and release of gaseous FP	- During the accident, FPs generated from core-heatup and melting flow into recirculation loop. - Gaseous FP adsorped to structure wall and release from the wall on the contrary.
672	Melting of recirculation piping	- During the accident, temperature in recirculation loop become high and recirculation piping start melting.
673	Degradation or Falling of Lagging Material	- Lagging material is degraded by heat through RPV wall, when temperature within RPV becomes extremely high. - As a result of degradation, lagging material might fall down.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
674	Liquid film flow of corium at outer surface of penetration pipes (control rod guide tube, drain line, instrumentation tube) sticking out from RPV bottom(<-- Liquid film flow of corium at protrusion surface of penetration pipes (control rod guide tube, drain line, instrumentation tube))	- Corium streaming down the outer surface of penetration pipes (CRD tube, drain line, instrumentation tube) sticked out from the RPV bottom, and leak into pedestal region.- Liquid film flow of corium streaming down the outer surface of penetration pipes.
675	Thermal conduction of penetration pipes (control rod guide tube, drain line, instrumentation tube) sticking out from RPV bottom (<-- Thermal conduction on protrusion surface of penetration pipes (control rod guide tube, drain line, instrumentation tube))	- Thermal conduction of penetration pipes (CRD tube, drain line, instrumentation tube) sticked out to pedestal region. - Temperature of penetration pipes would change due to the thermal conduction.
676	Heat transfer between corium and outer surface of penetration pipes (control rod guide tube, drain line, instrumentation tube) sticking out from RPV bottom (<-- Heat transfer between corium and outer surface of protrusion on penetration pipes (control rod guide tube, drain line, instrumentation tube))	- Corium streaming down the outer surface of penetration pipes (CRD tube, drain line, instrumentation tube) sticked out from the RPV bottom, and leak into pedestal region. - Heat is transferred from corium to outer surface of penetration pipes (CRD tube, drain line, instrumentation tube).
677	Heat transfer between corium and water (including CHF)	- Heat is transferred from corium to water falling along with corium.
678	Heat transfer between corium and gas	- Pedestal region is filled with inert gas (N2) at rated operation. - With progression of the event, water falling along with the corium evaporates and mixed into the inert gas (N2). - Heat is transferred from corium to inert gas (N2) or mixture gas of N2 and water steam.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
679	Heat transfer between crust and water (including CHF)	- When corium contact with water layer at the bottom of pedestal, corium is cooled by water and crust is formed at the surface of the water layer. - Heat is transferred from corium crust to water.
680	Heat transfer between crust and gas	- When corium contact with water layer at the bottom of pedestal, corium is cooled by water and crust is formed at the surface of water layer. - Pedestal region is filled with inert gas (N2) at rated operation. - Heat is transferred from corium crust to the inert gas (N2). - With progression of the event, water layer evaporates and water steam is mixed into the inert gas. - Heat is transferred from corium crust to the mixture gas.
681	Heat transfer between crust and corium (including heat transfer enhancement at gas generation due to MCCI)	- With progression of the event, a lot of corium accumulate in pedestal bottom and cooled with water layer to form corium crust at the surface of corium. - Heat is transferred from corium to corium crust. - Gases produced by molten core concrete interaction are vented through the crust to the water layer above. - At that time, heat transfer between crust and corium would be influenced by the gas generation.
682	Heat transfer between corium particle and water	- Corium is cooled to form corium particle during falling through the pedestal region or contact to pedestal floor. - Heat is transferred from corium particle to water layer.
683	Heat transfer between corium particle and gas	- Corium is cooled to form corium particle during falling through the pedestal region or contact to pedestal floor. - Pedestal region is filled with inert gas (N2) at rated operation. - Heat is transferred from corium particle to the inert gas (N2). - With progression of the event, water layer evaporates and water steam is mixed into the inert gas. - Heat is transferred from corium particle to the mixture gas.
684	Heat transfer between corium particle and pedestal floor/wall	- Heat transfer between corium particle and pedestal floor/wall is dependent on area of contact between corium particle and pedestal floor/wall.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
685	Heat transfer between pedestal floor/wall and corium	- Heat transfer between pedestal floor/wall and corium is dependent on area of contact between pedestal floor/wall and corium
686	Heat transfer between pedestal floor/wall and crust	- Heat transfer between pedestal floor/wall and crust is dependent on area of contact between pedestal floor/wall and crust
687	Heat transfer between pedestal floor/wall and water	- Heat transfer between pedestal floor/wall and water is dependent on area of contact between pedestal floor/wall and water. - Heat transfer between pedestal floor/wall and water is also dependent on water flow velocity near the pedestal floor/wall surface.
688	Heat transfer between pedestal floor/wall and gas	- Heat transfer between pedestal floor/wall and water is dependent on area of contact between pedestal floor/wall and gas. - Heat transfer between pedestal floor/wall and gas is also dependent on gas flow velocity near the pedestal floor/wall surface.
689	Heat transfer from lower head to gas in pedestal region	- Heat transfer from lower head to gas in pedestal region is dependent on area of lower head surface. - Heat transfer from lower head to gas in pedestal region is also dependent on gas flow velocity near the lower head surface.
690	Heat transfer from protrusion of penetration pipes (control rod guide tube, drain line, instrumentation tube) to water (leak flow)	- Heat transfer from protrusion of penetration pipes to water (leak flow) is dependent on area of protrusion of penetration pipes surface. - Heat transfer from protrusion of penetration pipes to water is also dependent on water flow velocity near the protrusion of penetration pipes.
691	Heat transfer from protrusion of penetration pipes (control rod guide tube, drain line, instrumentation tube) to gas	- Heat transfer from protrusion of penetration pipes to gas is dependent on area of protrusion of penetration pipes surface. - Heat transfer from protrusion of penetration pipes to gas is also dependent on gas flow velocity near the protrusion of penetration pipes.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
692	Radiation between lower head and pedestal floor/wall	- Radiation heat transfer between lower head and pedestal floor/wall is dependent on lower head temperature and surface area of lower head. - Radiation heat transfer between lower head and pedestal floor/wall is also dependent on distance from lower head to pedestal floor/wall and surface area of pedestal floor/wall.
693	Radiation between lower head and pedestal internal structure	- Radiation heat transfer between lower head and pedestal internal structure is dependent on lower head temperature and surface area of lower head. - Radiation heat transfer between lower head and pedestal internal structure is also dependent on distance from lower head to pedestal internal structure and surface area of pedestal internal structure.
694	Radiation between corium and pedestal wall	- Radiation heat transfer between corium and pedestal wall is dependent on corium temperature and surface area of corium. - Radiation heat transfer between corium and pedestal wall is also dependent on distance from corium to pedestal wall and surface area of pedestal wall.
695	Radiation between corium and RPV wall	- Radiation heat transfer between corium and RPV wall is dependent on corium temperature and surface area of corium. - Radiation heat transfer between corium and RPV wall is also dependent on distance from corium to RPV wall and surface area of pedestal wall.
696	Radiation between corium and pedestal internal structure	- Radiation heat transfer between corium and pedestal internal structure is dependent on corium temperature and surface area of corium. - Radiation heat transfer between corium and pedestal internal structure is also dependent on distance from corium to pedestal internal structure and surface area of pedestal internal structure.
697	Radiation between crust and pedestal wall	- Radiation heat transfer between crust and pedestal wall is dependent on crust temperature and surface area of crust. - Radiation heat transfer between crust and pedestal wall is also dependent on distance from crust to pedestal wall and surface area of pedestal wall.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
698	Radiation between crust and RPV wall	- Radiation heat transfer between crust and RPV wall is dependent on crust temperature and surface area of crust. - Radiation heat transfer between crust and RPV wall is also dependent on distance from crust to RPV wall and surface area of pedestal wall.
699	Radiation between crust and pedestal internal structure	- Radiation heat transfer between crust and pedestal internal structure is dependent on crust temperature and surface area of crust. - Radiation heat transfer between crust and pedestal internal structure is also dependent on distance from crust to pedestal internal structure and surface area of pedestal internal structure.
700	Radiation between corium particle and pedestal wall	- Radiation heat transfer between corium particle and pedestal wall is dependent on corium particle temperature and surface area of corium particle. - Radiation heat transfer between corium particle and pedestal wall is also dependent on distance from corium particle to pedestal wall and surface area of pedestal wall.
701	Radiation between corium particle and RPV wall	- Radiation heat transfer between corium particle and RPV wall is dependent on corium particle temperature and surface area of corium particle. - Radiation heat transfer between corium particle and RPV wall is also dependent on distance from corium particle to RPV wall and surface area of pedestal wall.
702	Radiation between corium particle and pedestal internal structure	- Radiation heat transfer between corium particle and pedestal internal structure is dependent on corium particle temperature and surface area of corium particle. - Radiation heat transfer between corium particle and pedestal internal structure is also dependent on distance from corium particle to pedestal internal structure and surface area of pedestal internal structure.
703	Particulate Corium Bed Porosity	- Particlulate corium formes porous debris bed when it falls into pedestal / cavity. - Ratio of space between particlute corium to unit volume is debris bed porosity.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
704	Pedestal deformation/failure due to thermal stress	- Pedestal deformation/failure may be wreaked by heat from corium, crust and lower head of RPV.
705	Pedestal wall heatup due to corium adhesion to pedestal wall	- Pedestal wall temperature rise due to heat transfer from corium, crust and lower head to pedestal wall.
706	Pressure change in pedestal	- Pressure in pedestal may rise due to steam generation which is induced by heat transfer between corium and water in pedestal. - Pressure in pedestal may decline due to condensation of vapor which is induced by water injection.
707	Gas temperature change in pedestal	- Gas temperature in pedestal may rise due to heat transfer from corium, crust and lower head. - Gas temperature in pedestal may decline due to injection of water.
708	Water temperature change in pedestal	- Water temperature in pedestal may rise due to heat transfer from corium and crust and injection of water. - Water temperature in pedestal may decline due to injection of water.
709	Thermal conduction / Temperature change of corium	- Thermal conduction / Temperature of corium may change due to change of composition of corium and decreasing of decay heat.
710	Thermal conduction / Temperature change of crust	- Thermal conduction / Temperature of crust may change due to change of composition of crust and decreasing of decay heat.
711	Thermal conduction / Temperature change of pedestal floor/wall	- Thermal conduction / Temperature of pedestal floor/wall may change due to oxidation of pedestal floor/wall surface and evaporation of water in concrete.
712	Gas flow in pedestal internal space	- Gas flow in pedestal internal space is dependent on thermal gradient of gas between pedestal and drywell and generation/condensation of vapor.
713	Local gas flow and turbulence	- There are some structures in pedestal. - Local gas flow which pass through spaces of structures generates except main flow. - Also, local gas flow might become turbulent flow.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
714	Water flow on pedestal floor	- Water flow on pedestal floor is dependent on thermal gradient of Water in pedestal.
715	Ejection conditions (corium, mixture state of water/steam) of corium jet	- Ejection conditions (corium, mixture state of water/steam) of corium jet is dependent on the state in lower plenum at the last minute of RPV failure.
716	Oxidation of grating due to collision of corium jet with grating and oxidation	- Collision of high temperature corium jet and grating cause oxidation of grating. It is dependent on ejection conditions of corium jet and material of grating.
717	Splash of corium towards pedestal floor by collision of corium with grating	- Splash of corium by collision of corium with grating is dependent on the shape of grating and ejection conditions of corium jet.
718	Gas composition change in pedestal	- Gas composition in pedestal changes due to inflow of corium, water, and steam and hydrogen generation.
719	Erosion of pedestal floor / wall	-Since erosion of pedestal floor/wall means MCCI occurrence, generation of hydrogen and carbon monoxide directly affect PCV pressure, PCV temperature, and hydrogen concentration.
720	Physical properties of concrete ingredients (C, Si, etc.)	- Physical properties of concrete is dependent on concrete ingredients. It effects that chemical reaction between corium and concrete.
721	Mass transfer of concrete ingredients into corium	- Concrete is melt by heat from corium and mixed into corium at the surface of contact between corium and concrete.
722	Water evaporation from concrete by concrete heating	- Water in concrete evaporates due to heat transfer from corium.
723	Gas generation (H2, CO, CO2, etc.) from concrete-corium interaction (reaction)	- Gases.(H2, CO, CO2, etc) are generated by decomposition of concrete. Amount of generated gas is dependent on the ingredient content of concrete.
724	Aerosol generation from concrete-corium interaction (reaction)	- Aerosol may be taken with gas generated by MCCI and flows through corium and leave from at a surface of corium or crust. An amount of aerosol directly affects PCV pressure and temperature. Aerosol also directly affects an amount of FP release from PCV.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
725	Heat generation from chemical reaction between corium and concrete ingredients	- Deoxidization of water and CO2 is exothermic reaction. Heat release from this chemical reaction directly affects PCV pressure, PCV temperature. An amount of chemical reaction affects the hydrogen concentration.
726	Corium flow / spread in pedestal	- Corium flow / spread in pedestal is dependent on viscosity of corium and shape of pedestal (floor) surface.
727	Corium flow into drywel by spread in pedestal (Mark-I)	- Corium flow into drywell by spread in pedestal is dependent on the shape of opening area which is set on pedestal floor.
728	Corium entrainment in pedestal by sparging gas	- When concrete is heated by corium, gas is sparged from concrete and sparging gases entrain corium through perforations in the crust. (Then, corium particle is made.)
729	Generation of corium particle due to breakup at jet drop	- Generation of corium particle due to breakup at jet drop is dependent on condition of jet drop and heat removal from corium particle(depends on temperature of water of floor in pedestal)
730	Corium ejection from crack in the crust (includion generation of corium particle)	- Corium ejection from crack in the crust is dependent on thickness of crust and difference temperature between crust surface and water on the crust.
731	Outflow of corium particle with water flow	- Outflow of corium particle with water flow is dependent on the size of corium particle and flow ratio of water in pedestal.
732	Composition of corium particle	- Composition of corium particle may change due to oxidation of corium and mixing with molten materials in pedestal (mainly concrete).
733	Size / configuration of corium particle	- Size / configuration of corium particle may change due to association of particles each other and mixing with molten materials in pedestal (mainly concrete).
734	Aggregation / debris bed formation of corium particle	- Aggregation / debris bed formation of corium particle is dependent on shape of pedestal floor surface and flow of water in pedestal.
735	Generation / attenuation of decay heat from corium particle	- Decay heat is dependent on the time after scram, mass and composition of corium particle.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
736	Temperature change of corium particle bed	- Temperature of corium particle bed may change due to heat transfer to the water, decay heat generation, FP release and so on.
737	Corium solidification	- Corium is solidified when corium temperature is lower than solidification temperature by heat transfer to the water or pedestal internal materials.
738	Generation / attenuation of decay heat from corium	- Decay heat from corium may affect corium temperature, heat transfer, and corium condition change (melting and solidification).
739	Oxidation reaction (including generation of hydrogen and reaction heat) between corium ingredients and water (steam)	- Metal components in the corium react with water to oxidation.
740	Mixture state (fuel, structure, concrete, etc.) and physical properties of corium ingredients	- Mixture state and physical properties may change due to corium composition, corium temperature, and so on.
741	Corium stratification	- Depending on the relative density of the different materials and their relative miscibility (existence of miscibility gaps), liquid phases such as metallic and ceramic materials may separate and form different layers.
742	Remixing of corium stratification associated with corium flow and internal gas generation	- Corium is remixed by natural circulation and internal generated gasses. - Internal gasses are generated by decomposition of concrete or FP gasses released.
743	Change in corium deposit conditions on the pedestal floor	- Corium deposit condition depends on corium condition falling down from RPV. - If main component of corium consists of liquid phase, corium forms pool on the pedestal floor. - If main component of corium consists of solid such as particulate corium, corium forms deposition like mountain.
744	Crust segregation and waftage	-Crust formed on top of corium are floated in molten pool.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
745	Crust generation on the surface of penetration pipes sticking out of RPV lower head	- During the accident, corium may fall into pedestal/cavity with streaming down the penetration pipings sticking out of RPV lower head. - When corium contact with the wall, corium is cooled to generate crust at the surface of the pipes.
746	Crust remelting due to change in the heat transfer status to corium or water	- Normally corium is cooled and solidified on the surface, forming crust. - This crust may remelt due to change in heat transfer status, such as loss of cooling water on the surface, or change in heat transfer from inner corium with changing mixture conditions.
747	Particulate corium remelting due to change in the heat transfer status	-Particle corium (debris) in the particle bed may melt and transfer into molten pool again when the cooling water is lost and heat removal is not sufficient.
748	Water flow into crust	- Overlying water is into crust via a crack. - Crack is generated by internal generated gassed or weight of the crust itself and overlying water.
749	Bubble formation in crust	- Bubble formation in upper crust may affect the crust porosity.
750	Crack generation in crust	- Crack in crust is generated by internal generated gassed or weight of the crust itself and overlying water.
751	Generation / attenuation of decay heat from crust	- Decay heat is dependent on the time after scram, mass and composition of corium particle.
752	Oxidation reaction (including generation of hydrogen and reaction heat) between crust ingredients and water (steam)	- Metal components in the crust react with water to oxidation.
753	Mixture state (fuel, structure, concrete, etc.) and physical properties of crust	- Mixture state and physical properties may change due to crust composition, crust temperature, and so on.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
754	Recriticality	- Probability of recriticality in pedestal is depends on corium composition, shape of deposited corium, water presence or not, and so on. - Please note that re-critical condition is highly unlikely to occur. However the impact would be large and the feasibility cannot be denied perfectly. Then this item should be kept in the phenomena list.
755	Oxidation (including generation of hydrogen and reaction heat) of pedestal wall by steam	- Pedestal wall may oxidize due to steam generated by injection water or overlying water of corium. - Degree of oxidization of pedestal wall is depends on atmosphere temperature.
756	Radiation decomposition of water	- Radiation decomposition (radiolysis) of water is caused by radiation from FP, and so on in corium.
757	FCI's premixing due to corium contact to water pool	- Debris jet is broken up and mixed by contacted and penetrated to water pool. - Created coarse fragments are thermally insulated by a vapor film. - Debris break- up depends on water depth and so on.
758	FCI triggering by vapor film collapse	- Corium flows to pedestal/cavity and breaks up into water in a film boiling regime to creats a melt-water-steam mixture. - After a certain amount of melt has penetrated into water, steam explosion process starts. - The trigger induces vapor film collapse locally and melt-water contact occurs.
759	Corium atomization and rapid steam generation (FCI) in water pool	- Corium atomization and rapid steam generation in water pool is caused by destabilization of vapor film and contact of corium and water - The vapor film is became destabilization by triggering. - Destabilization of vapor film depends on water temperature and so on.
760	Pressure wave due to FCI	- Pressure wave is caused by corium atomization and rapid steam generation. - Vapor film of surrounding fragments becomes unstable by pressure wave - Fine fragmentation of corium and rapid heat transfer is associated with a propagating pressure wave.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
761	Temperature increas of water and gas by FCI	- Temperature of water and gas increases, thermal energy of corium transfers to water and gas.
762	Pedestal failure due to FCI	- FCI generate the pressure wave and dynamic loading for pedestal wall.
763	Dispersion of corium and pedestal internal material due to FCI	- Pressure wave by FCI might blow off corium and pedestal internal material depending on the level of pressure wave.
764	Impact for FCI by seawater	- Seawater is injected to RPV and poured into lower downcomer. - Corium flows to pedestal/cavity and breaks up into seawater. - Water presence could lead to energetic FCI, and its behavior is affected by density, viscosity of the materials, and so on. - Therefore existence of seasalt solute may have an impact on FCI behavior.
765	Droplet behavior in the pedestal free space	- Droplets move due to diffusion, settling, or interaction with other droplets.
766	Condensation heat transfer on the pedestal wall and internal surfaces	- During the accident, various components, such as corium, water, steam, gases, and so on, are flow into pedestal/cavity region and most of the gas condensation is supposed to occur on the surface of the wall. - Condensation heat is transferred from gas to pedestal/cavity wall and have an impact on temperature change.
767	Interaction between gas and water film flow on the pedestal wall and internal surfaces	- Gas flow and water film flow, which is condensed on the wall surface, interacts with each other due to some processes such as interfacila shear, surface instability, droplet re-entrainment, and so on.
768	FP particle transport by gas in the pedestal	- FPs released from the damaged fuel rods are transported into pedestal/cavity and deposited at the surface of wall to generate FP particle. - FP particle are dispersed and transport by gas in the pedestal/cavity.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
769	FP particle agglomeration/fragmentation in the pedestal	- FPs released from the damaged fuel rods are transported into pedestal/cavity. - FPs might agglomerate or is fragmentated in the pedestal.
770	FP particle deposition on the pedestal wall and internal surfaces	- FPs released from the damaged fuel rods are transported into pedestal/cavity and deposited at pedestal wall and internal surfaces to generate FP particle.
771	FP transport by water flow on the pedestal wall and internal surfaces	- FPs released from the damaged fuel rods are transported into pedestal/cavity. - FPs might be transported by water flow on the pedestal wall and internal surfaces.
772	FP re-entrainment	- FPs released from the damaged fuel rods are transported into pedestal/cavity. - During the accident, water and corium pool may be generated in the pedestal/cavity. - Re-entrainment of fission products can occur at water and corium pools.
773	FP deposition on pedestal wall	- Aerosolized FP releases from corium and it deposits on pedestal walls.
774	FP re-vaporization	- Deposited FP may be re-vaporization due to increased pedestal atmosphere temperature.
775	Decay heat generation from FP	- Decay heat is generated by radiation from FP that is radiated by decay of FP(α, βand γ decay)
776	FP release from corium surface	- With core-heatup and melting, corium falls down from RPV lower head into pedestal/cavity. - Fission products are released from the corium surface.
777	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into pedestal/cavity. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
778	Adsorption and release of gaseous FP	- During the accident, FPs generated from core-heatup and melting flow into pedestal/cavity. - Gaseous FP adsorped to structure wall and release from the wall on the contrary.
779	Direct Containment Heating (DCH)	- Corium flows from core region and dispersed into pedestal/cavity. - Fragmentation and dispersal of corium may cause sudden heatup and pressurization of pedestal/cavity region.
780	Pedestal water level change	- There is no water in pedestal in the noraml operation. - When RPV is failed, water remaining in RPV drops down to pedestal region with corium. - Then, pedestal water evaporates by heat of corium. - Change rate of pedestal water depends on an amount of corium.
781	Thermal stratification	- Depending on the difference of density of materials and miscibility, liquid phases in corium, such as metalic and ceramic materials may separate and form different layers. - Metals may come atop from corium. - Under the Metals, upper crust formed around melting corium may come. - Under the upper crust, pool of melting corium may come. - Under the melting corium, lower crust may come. - Under the lower crust, heavy Metals may come.
782	Collision of corium with penetration tube support beams and oxidation	- Penetration tube support beams are set laterally under RPV in the pedestal. - Corium falling down form RPV collides with penetration tube support beams. - As a result, penetration tube support beams are corroded by corium.
783	Collision of corium with CRD purge lines and oxidation	- CRD purge lines are set laterally under RPV in the pedestal. - Corium falling down form RPV collides with CRD purge lines. - As a result, CRD purge lines are corroded by corium.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
784	Collision of corium with other structures in the pedestal and oxidation	- Other structures in the pedestal are set laterally under RPV in the pedestal. - Corium falling down form RPV collides with other structures in the pedestal. - As a result, other structures in the pedestal are corroded by corium.
785	Melting point change for penetration pipings sticking out of RPV lower head	- During the accident, corium may fall into pedestal/cavity with streaming down the penetration pipings sticking out of RPV lower head. - Contact between corium and piping surface may cause eutectic between corium and metal, then melting point of the penetration pipings may change.
786	Eutectic (Corium and metal in pedestal internals)	- Once materials contained in corium and metal in pedestal internals are melted and mixed, they will form an eutectic compound, which melts at a lower temperature than the normal melting point for each component.
787	Melting of penetration pipes sticking out of RPV lower head	- During the accident, corium falls down to pedestal/cavity with streaming down the penetration pipes sticking out of RPV lower head. - Then temperature of the pipes become high and pipes sticking out of RPV lower head start melting.
788	Melting of gratings	- Grating in pedestal melts, when corium drops down from RPV.
789	Melting of penetration tube support beams	- Penetration tube support beams in pedestal melts, when corium drops down from RPV.
790	Melting of CRD purge lines	- CRD purge lines in pedestal melts, when corium drops down from RPV.
791	Melting of other structures in the pedestal	- Other structures in pedestal melt, when corium drops down from RPV.
792	Seasalt intake to corium	- Seawater is injected to RPV and flows into pedestal/cavity. - Seawater deposited at the surface of the wall and dispersed into pedestal/cavity. - Then seasalt are mixed into corium which falls down topedestal/cavity.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
793	Seasalt impact for corium thermodynamic properties	- During the accident, seawater is injected to RPV and flows into pedestal/cavity. - Seasalt may be deposited on the wall surfaces and mixed into corium. - Thermodynamic properties of corium including seasalt varies with composition ration of seasalt.
794	Corrosion of pedestal internals by seasalt (including marine lives)	- The pedestal internals are susceptible to corrosion especially with the seawater including Na, Mg, Ca, and some organic materials (i.e. marine lives).
795	Salt effects on heat transfer	- Salt may disturb heat transfer between pedestal structures and others (water pool, atmosphere gasses and so on).
796	Salt remelting from flood	- The deposition of salt on the surface may disturb heat transfer.
797	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV changes due to vaporization, injection amounts of real water, and so on. - Seasalt concentration may have impact on seasalt deposition amount on structures and therefore heat transfer between seawater and structures.
798	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and flows into pedestal/cavity through the core. - Then seawater deposited at the surface of the wall and dispersed into pedestal/cavity. - Presence of seasalt may cause additional chemical reactions.
799	Boron corrosion of pedestal internal structure	- The pedestal internals are susceptible to corrosion especially with the boron.
800	Boron effects on heat transfer	- Boron may disturb heat transfer between pedestal structures and others (water pool, atmosphere gasses and so on).
801	Boron remelting from flood	- The deposition of boron on the surface may disturb heat transfer.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
802	FP aerosol absorption in water pool at upper surface of corium	- The overlying water of corium is heated up by decay heat of absorbed FP aerosol in pool water.
803	FP release from water pool at upper surface of corium	- An amount of aerosol directly affects PCV pressure and temperature. Aerosol also directly affects an amount of FP release from PCV.
804	Corium flow into sump pit (drainage pit) and reaction	- The dropped corium from RPV spread on the pedestal floor and flow into sump pit. -Because of small floor area, the flowed corium in sump pit is difficult to cool and to prevent MCCI.
805	Heat transfer between sump floor/wall and corium	- Heat transfer between sump floor/wall and corium influence the PCV pressure and temperature and amount of generated hydrogen. If sump floor or wall is melted by corium, non-condensable gases are released from concrete.
806	Heat transfer between sump floor/wall and crust	- Heat transfer between sump floor/wall and crust influence the PCV pressure and temperature and amount of non-condensable gases. If sump floor or wall is melted by crust, non-condensable gases are released from concrete.
807	Heat transfer between sump floor/wall and corium particle	- Heat transfer between sump floor/wall and corium particle influence the PCV pressure and temperature and amount of non-condensable gases. If sump floor or wall is melted by crust, non-condensable gases are released from concrete.
808	Heat transfer between sump cover and corium	- Sump cover may be melted by corium. If sump cover melted, debris may flow into sump.
809	Heat transfer between sump cover and crust	- Sump cover may be melted by crust. If sump cover melted, debris may flow into sump.
810	Heat transfer between sump cover and corium particle	- Sump cover may be melted by corium particle. If sump cover melted, debris may flow into sump.
811	Heat capacity of structure inside sump	- Heat capacity of structure inside sump influences the amount of melting.
812	Deposition situation of corium on pedestal floor	- Deposition situation of corium influence the behavior of debris spreading, debris coolability and so on.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Pedestal/Cavity
No.	Phenomenon	Description
813	Corium leak into connecting piping inside sump	- If corium flow into connecting piping (i.e. RCW system piping), FP may spread to whole plant.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
814	Attack on containment vessel shell (interaction between metal and corium)	- Melted corium may flow into D/W from pedestal and spread on D/W floor. Corium may contact and attack D/W vessel shell.
815	Containment vessel penetration seal degradation (Seal degradation at containment vessel penetration)	- High D/W ambient temperature due to decay heat from corium, crust, and FP aerosol may cause the penetration seal degradation.
816	Water leak from deteriorated part of containment vessel penetration	- Water may leak from D/W to outside through the degradated penetration seal (leak path). If water flows out from the leak path, corium in PCV may not cool because of a lack of water, and PCV ambient temperature and pressure may increase.
817	Gas leak from deteriorated part of containment vessel penetration	- Gas may leak from D/W to outside through the degradated penetration seal (leak path). Gas leak directly affects temperature and pressure of inside and outside of PCV.
818	Deformation / failure of drywell internal equipment due to thermal stress	- D/W internal equipment may be thermally attacked by the contact corium or crust, radiation from the corium or crust, and FP attachment on the surface of it.
819	Deformation / failure of drywell wall by thermal stress	- Temperature in primary system increase and drywell wall is heated during the accident. - This cause thermal stress and drywell wall may break by thermal stress.
820	Heat transfer between corium and water (including CHF)	- Corium, crust, and corium particle are considered as heat source. D/W wall, D/W floor, D/W internal structures, gas and water in D/W, and heat sources may transfer heat each other. In this part, all combination for heat exchange are considered. Heat exchange between heat sources and the others is the most important phenomenon because it determines heat source coolability and MCCI occurrence. If heat fluxes from heat sources are larger than the critical heat flux (CHF), the maximum of heat transfer capability is limited by the CHF because heat transfer mode is changed from nucleate boiling heat transfer to transition boiling heat transfer.
821	Heat transfer between corium and gas	- same as above.
822	Heat transfer between crust and water (including CHF)	- same as above.
823	Heat transfer between crust and gas	- same as above.
824	Heat transfer between crust and corium	- same as above.
825	Heat transfer between corium particle and water	- same as above.
826	Heat transfer between corium particle and gas	- same as above.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
827	Heat transfer between corium particle and drywell floor/wall	- same as above.
828	Heat transfer between drywell floor/wall and corium	- same as above.
829	Heat transfer between drywell floor/wall and crust	- same as above.
830	Heat transfer between drywell floor/wall and water	- same as above.
831	Heat transfer between drywell floor/wall and gas	- same as above.
832	Heat transfer from drywell internal structure (lagging material, biological shield wall) to water	- same as above.
833	Heat transfer from drywell internal structure (lagging material, biological shield wall) to gas	- same as above.
834	Radiation between corium and drywell wall	- Radiation from heat sources to the structures is important for evaluating the heat source coolability. All combinations between heat sources and D/W structures are considered. Corium, crust, and corium particle are considered as heat sources, and D/W wall, flow, and internal structure are selected as D/W structures, as described in No.706-719.
835	Radiation between corium and drywell internal structure	- same as above.
836	Radiation between crust and drywell wall	- same as above.
837	Radiation between crust and drywell internal structure	- same as above.
838	Radiation between corium particle and drywell wall	- same as above.
839	Radiation between corium particle and drywell internal structure	- same as above.
840	Particulate Corium Bed Porosity	- Particlulate corium formes porous debris bed when it falls into drywell. - Ratio of space between particlute corium to unit volume is debris bed porosity.
841	Gas stratification in drywell	- If the natural or forced convections are not insufficient for gas mixing in D/W, gas stratification in D/W may occur. As described in No.703 and 704, temperature increase at local area may cause D/W leak by penetration seal degradation.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
842	Jet/plume gas interaction and entrainment effects	- Seawater is injected into RPV and transfers into drywell. - Then seawater deposited at the surface of the wall and dispersed into drywell. - Presence of seasalt may cause additional chemical reactions.
843	Pressure change in drywell	- Pressure change in D/W is caused by several phenomena, such as steam generation, D/W gas temperature increase, MCCI gas generation, etc. PCV may deform or fail because of high pressure.
844	Gas temperature change in drywell	- Gas temperature change in D/W is caused by several phenomena, such as direct heating by corium, MCCI gas generation, FP aerosol generation, etc. PCV may deform or fail because of high temperature.
845	Gas composition change in drywell	- Gas composition change in D/W is caused by several phenomena, such as steam generation, steam condensation, MCCI gas generation, etc. Gas composition does not directly affect D/W pressure and temperature, and an amount of total gas (mole) affects them. Hydrogen concentration directly affects hydrogen leak and explosion in R/B.
846	Thermal conduction / temperature change of corium	- Thermal conduction and temperature change is important for evaluating MCCI. From MCCI evaluation, heat exchange from heat sources (crust, corium) to D/W concrete (D/W floor/wall) is important. If MCCI occurs, hydrogen and carbon monoxide generates in D/W. On the other hand, D/W internal structure does not affect MCCI directly. Heat storage capability of D/W internal structure affects PCV pressure and temperature.
847	Thermal conduction / temperature change of crust	- same as above.
848	Thermal conduction / temperature change of drywell floor/wall	- same as above.
849	Thermal conduction / temperature change of drywell internal structure	- same as above.
850	Water temperature change in drywell	- Water temperature change in D/W is caused by several phenomena, such as heating by corium, water injection from outside, etc. Water temperature change affects heat source coolability.
851	Gas flow in drywell	- This directly affects No.726, so phenomena and ranking are the same as No.726
852	Local gas flow and turbulence	- There are some structures in drywell. - Local gas flow which pass through spaces of structures generates except main flow. - Also, local gas flow might become turbulent flow.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
853	Water flow in drywell	- Multi-dimensional flow pattern and velocities within the pool of D/W floor must be considered. It includes free-surface (vertical) velocity profile and turbulent mixing (circulation) flows.
854	Drywell water level change	- There is no water in drywell in the noraml operation. - When RPV is failed, water remaining in RPV drops down to pedestal region with corium. - After that, water spreads to drywell. - Then, drywell water evaporates by heat of corium. - Change rate of drywell water depends on an amount of corium.
855	Thermal stratification	- Depending on the difference of density of materials and miscibility, liquid phases in corium, such as metalic and ceramic materials, may separate and form different layers. - Metals may come atop from corium. - Under the Metals, upper crust formed around melting corium may come. - Under the upper crust, pool of melting corium may come. - Under the melting corium, lower crust may come. - Under the lower crust, heavy Metals may come.
856	Erosion of drywell floor (concrete)	- Since erosion of D/W floor/wall means MCCI occurrence, generation of hydrogen and carbon monoxide directly affect PCV pressure, PCV temperature, and hydrogen concentration.
857	Physical properties of concrete ingredients (C, Si, etc.)	- Physical properties of concrete ingredients such as heat capacity affects MCCI erosion progression.
858	Transition of concrete ingredients into corium	- Physical properties of corium change due to transition of concrete into it. Property change of the corium such as solidus temperature and thermal conductivity affects corium coolability, so it affects MCCI progression.
859	Water evaporation from concrete by concrete heating	- Water and CO2 included in concrete are released from concrete by heating. If these gases go into corium and flow out at surface of corium by buoyancy force, water and CO2 may be partially deoxidized by Zr in corium and be changed into H2 and CO. These gases directly affect PCV pressure, PCV temperature, and hydrogen concentration.
860	Gas generation (H2, CO, CO2, etc.) from concrete-corium interaction (reaction)	- Gases.(H2, CO, CO2, etc) are generated by decomposition of concrete. Amount of generated gas is dependent on the ingredient content of concrete.
861	Aerosol generation from concrete-corium interaction (reaction)	- Aerosol may be taken with gas generated by MCCI and flows through corium and leave from at a surface of corium or crust. An amount of aerosol directly affect PCV pressure and temperature. Aerosol also directly affects an amount of FP release from PCV.
862	Heat generation from chemical reaction between corium and concrete ingredients	- Deoxidization of water and CO2 is exothermic reaction. Heat release from this chemical reaction directly affects PCV pressure, PCV temperature. An amount of chemical reaction affects the hydrogen concentration.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
863	Reaction (including generation of hydrogen and reaction heat) between corium ingredients and water (steam)	Water included in concrete is released from concrete by heating. If steam go into corium and flow out at surface of corium by buoyancy force, steam may be partially deoxidized by Zr in corium and be changed into H2. Steam and H2 directly affect PCV pressure, PCV temperature, and hydrogen concentration. Chemical heat generation of exothermic reaction is also important.
864	Corium flow / spread in drywell	- Spread area of corium is very important for corium coolability. Corium coolability directly affected MCCI.
865	Outflow of corium particle with water flow	- Amount of corium particles in D/W may be removed to S/C by water flow.
866	Composition of corium particle	- Composition of corium particles affects heat generation and heat transfer.
867	Size / configuration of corium particle	- Debris particle diameter and porosity affect the cooling. Intrusion of water into debris bed is affected by debris particle diameter and porosity.
868	Aggregation / debris bed formation of corium particle	- Two or more small particles may combine to form a larger conglomerate particle by mechanical or chemical interaction among debris particles.
869	Generation / attenuation of decay heat from corium particle	- Decay heat from corium particle may affect corium particle temperature, heat transfer, and corium particle condition change (melting).
870	Temperature change of corium particle bed	- Temperature change of corium particle bed affects solidification, melting and corium spread area.
871	Corium solidification	- Corium solidification affects corium spread area and heat flux to pedestal.
872	Generation / attenuation of decay heat from corium	- Decay heat from corium may affect corium temperature, heat transfer, and corium condition change (melting and solidification).
873	Mixture state (fuel, structure, concrete, etc.) and physical properties of corium ingredients	- Mixture state and physical properties of corium (such as density, thermal conductivity, viscosity, etc.) affect heat transfer and heat flux.
874	Corium stratification	- Depending on the relative density of the different materials and their relative miscibility (existence of miscibility gaps), liquid phases such as metallic and ceramic materials may separate and form different layers.
875	Direct Containment Heating (DCH)	- Corium flows from core region and dispersed into drywell. - Fragmentation and dispersal of corium may cause sudden heatup and pressurization of pedestal/cavity region.
876	Water flow into crust	- When cracks are formed in upper crust, water may penetrate the cracks and improve the heat transfer.
877	Bubble formation in crust	- Bubble formation in upper crust may affect the crust porosity.
878	Crack formation in crust	- Cracks formation in upper crust due to thermal constraint applied, water may penetrate the cracks and improve the heat transfer.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
879	Crust composition	- Crust composition affects the crust properties (density, thermal conductivity, viscosity, yield stress, etc).
880	Generation / attenuation of decay heat from crust	- Decay heat from crust may affect crust temperature, heat transfer, and crust condition change (melting).
881	Crust remelting due to change in the heat transfer status to corium or water	-Normally corium is cooled and solidified on the surface, forming crust. -This crust may remelt due to change in heat transfer status, such as loss of cooling water on the surface, or change in heat transfer from inner corium with changing mixture conditions.
882	Particulate corium remelting due to change in the heat transfer status	- Particle corium (debris) in the particle bed may melt and transfer into molten pool again when the cooling water is lost and heat removal is not sufficient.
883	Oxidation reaction (including generation of hydrogen and reaction heat) between crust ingredients and water (steam)	- Oxidation reaction between crust ingredients and water (steam) affects D/W pressure and temperature by heat generation and hydrogen generation.
884	Mixture state (fuel, structure, concrete, etc.) and physical properties of crust	- Mixture state and physical properties of crust affect heat transfer and heat flux.
885	Recriticality	- The recriticality in D/W cavity is influenced by dispersion behavior of molten fuel, filling water condition in cavity, debris accumulation character, and water immersion behavior into debris. - Please note that re-critical condition is highly unlikely to occur. However the impact would be large and the feasibility cannot be denied perfectly. Then this item should be kept in the phenomena list.
886	Oxidation (including generation of hydrogen and reaction heat) of drywell wall by steam	- Oxidation of D/W wall may affect D/W pressure and temperature.
887	Oxidation (including generation of hydrogen and reaction heat) of drywell internal structure by steam	- Oxidation of D/W internals may affect D/W pressure and temperature.
888	Radiation decomposition of water	- Radioactive decomposition water makes hydrogen and oxygen.
889	FP aerosolization	- FP in the form of aerosol may move from D/W by the carrier gas medium.
890	FP deposition on drywell wall	- FP deposition on D/W wall may affect D/W pressure and temperature.
891	FP re-vaporization	- FP re-vaporization may affect D/W pressure and temperature.
892	Decay heat generation from FP	- Decay heat from FP that attached D/W wall may affect D/W pressure and temperature.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
893	FP removal from drywell internal space by spray	- When FPs contact with water droplets by spray, they fall down to floor in drywell. - As aresult, FPs suspending in the drywell space are removed.
894	FP particle transport by gas in the drywell	- FPs released from the damaged fuel rods are transported into drywell and deposited at the surface of wall to generate FP particle. - FP particle are dispersed and transport by gas in the drywell.
895	FP particle agglomeration/fragmentation in the drywell	- FPs released from the damaged fuel rods are transported into drywell - FPs might agglomerate or is fragmentated in the drywell.
896	FP particle deposition on the drywell wall and internal surfaces	- FPs released from the damaged fuel rods are transported into drywell and deposited at drywell wall and internal surfaces to generate FP particle.
897	FP transport by water flow on the drywell wall and internal surfaces	- FPs released from the damaged fuel rods are transported into drywell. - FPs might be transported by water flow on the drywell wall and internal surfaces.
898	FP re-entrainment	- FPs released from the damaged fuel rods are transported into drywell. - During the accident, water and corium pool may be generated in the drywell. - Re-entrainment of fission products can occur at water and corium pools.
899	FP release from corium surface	- With core-heatup and melting, corium falls down from RPV lower head to pedestal and transported into drywell. - Fission products are released from the corium surface.
900	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into drywell. - FP reaction occurs gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
901	Adsorption and release of gaseous FP	- During the accident, FPs generated from core-heatup and melting flow into drywell. - Gaseous FP adsorped to structure wall and release from the wall on the contrary.
902	Eutectic (Corium and metal in pedestal internals)	- Once materials contained in corium and metal in drywell are melted and mixed, they will form an eutectic compound, which melts at a lower temperature than the normal melting point for each component.
903	Droplet behavior in the drywell free space	- Droplets move due to diffusion, settling, or interaction with other droplets.
904	Condensatiion heat transfer on the drywell wall	- During the accident, various components, such as corium, water, steam, gases, and so on, are flow into drywell and most of the gas condensation is supposed to occur on the surface of the wall. - Condensation heat is transferred from gas to drywell wall and have an impact on temperature change.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
905	Interaction between gas and water film flow on the drywell wall and internal surfaces	- Gas flow and water film flow, which is condensed on the wall surface, interacts with each other due to some processes such as interfacila shear, surface instability, droplet re-entrainment, and so on.
906	Seasalt intake to corium	- Seawater is injected to RPV and flows into drywell. - Seawater deposited at the surface of the wall and dispersed into drywell. - Then seasalt are mixed into corium transported to the drywell.
907	Seasalt impact for corium thermodynamic properties	- During the accident, seawater is injected to RPV and flows into drywell. - Seasalt may be deposited on the wall surfaces and mixed into corium. - Thermodynamic properties of corium including seasalt varies with composition ration of seasalt.
908	Corrosion of drywell internals by seasalt (including marine lives)	Seawater including Na, Mg, Ca and some organic materials(i.e. marine lives) may affect corrosion of D/W internals.
909	Salt effects on heat transfer	Deposited salt from seawater may decrease heat transfer to D/W wall.
910	Salt remelting from flood	Deposited salt may resolve into water.
911	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV changes due to vaporization, injection amounts of real water, and so on. - Seasalt concentration may have impact on seasalt deposition amount on structures and therefore heat transfer between seawater and structures.
912	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
913	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and transfers into drywell through the core. - Then seawater deposited at the surface of the wall and dispersed into drywell. - Presence of seasalt may cause additional chemical reactions.
914	Boron corrosion of drywell internal structure	Boron from control rods or standby liquid control system (SLC) may affect corrosion of D/W internals.
915	Boron effects on heat transfer	Melted boron is cooled and may deposit in D/W wall and floor.
916	Boron remelting from flood	Deposited boron may resolve into water.
917	Heat release from drywell wall	Heat release from D/W wall affects D/W pressure and temperature.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell
No.	Phenomenon	Description
918	Steam condensation by PCV spray	Steam condensation affects D/W pressure and temperature.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell Head
No.	Phenomenon	Description
919	Heat transfer between D/W head inner wall and gas	- D/W head atmosphere is cooled by heat transfer to D/W wall.
920	Heat transfer between D/W head inner wall and water	- D/W head atmosphere is cooled by heat transfer to D/W wall.
921	Gas stratification in D/W head internal space	- Mixing or stratification of noncondensable gases in D/W head affects gas concentration distribution.
922	Gas composition in D/W head internal space	- Gas composition in D/W head affect mixing and stratification.
923	Steam condensation in D/W head	- Steam condensation affects D/W pressure and temperature.
924	Gas flow in D/W head	- Gas flow in D/W head may affect D/W temperature distribution.
925	Pressure change in D/W head internal space	- Pressure change in D/W head may cause D/W gas flow.
926	Temperature change in D/W head internal space	- D/W head temperature is affected by the heat transfer and thermal radiation from the high temperature RPV.
927	Thermal conduction / Temperature change of D/W head	- Containment failure may occur under excessively high temperature conditions.
928	Deformation / failure of drywell head by thermal stress	- Temperature in primary system increase and drywell head is heated during the accident. - This cause thermal stress and drywell head may break by thermal stress.
929	Seal failure of D/W head flange	- Degradation of seal at flange may occur due to excessive pressure and high temperature.
930	Gas flow from D/W head flange	- Degradation of seal at flange may occur due to excessive pressure and high temperature.
931	Pressure loss of bulk head plate in head (including air duct)	- Pressure loss of bulk head plate may affect gas flow rate and D/W temperature distribution.
932	Gas flow through air conditioner duct	- There is an air conditioner duct in the drywell head. - Gas flow passing through that generates.
933	Local gas flow and turbulence	- There are some structures in drywell head. - Local gas flow which pass through spaces of structures generates except main flow. - Also, local gas flow might become turbulent flow.
934	Jet/plume gas interaction and entrainment effects	- Seawater is injected into RPV and transfers into drywell head. - Then seawater deposited at the surface of the wall and dispersed into drywell head. - Presence of seasalt may cause additional chemical reactions.
935	Droplet behavior in the drywell head free space	- Droplets move due to diffusion, settling, or interaction with other droplets.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell Head
No.	Phenomenon	Description
936	Condensatiion heat transfer on the drywell head wall	- During the accident, various components, such as corium, water, steam, gases, and so on, are flow into drywell head and most of the gas condensation is supposed to occur on the surface of the wall. - Condensation heat is transferred from gas to drywell head wall and have an impact on temperature change.
937	Interaction between gas and water film flow on the drywell head wall	- Gas flow and water film flow, which is condensed on the wall surface, interacts with each other due to some processes such as interfacila shear, surface instability, droplet re-entrainment, and so on.
938	FP attachment	FP deposition on D/W head wall may affect D/W head pressure and temperature.
939	FP reevaporation	FP re-vaporization may affect D/W head pressure and temperature.
940	Generation / attenuation of FP decay heat	Decay heat from FP may affect D/W head pressure and temperature.
941	FP particle transport by gas in the drywell head	- FPs released from the damaged fuel rods are transported into drywell head and deposited at the surface of wall to generate FP particle. - FP particle are dispersed and transport by gas in the drywell head.
942	FP particle agglomeration/fragmentation in the drywell head	- FPs released from the damaged fuel rods are transported into drywell head. - FPs might agglomerate or is fragmentated in the drywell head.
943	FP particle deposition on the drywell head wall	- FPs released from the damaged fuel rods are transported into drywell head and deposited at drywell head wall to generate FP particle.
944	FP transport by water flow on the drywell head wall	- FPs released from the damaged fuel rods are transported into drywell head. - FPs might be transported by water flow on the drywell head wall and internal surfaces.
945	FP re-entrainment	- FPs released from the damaged fuel rods are transported into drywell. - During the accident, water and corium pool may be generated in the drywell. - Re-entrainment of fission products can occur at water and corium pools.
946	FP accumulation at leakage path	- During the accident, fission products generated from core-heatup and melting flow into drywell head. - When drywell head occurs leakage, FPs flow into leakage path and accumulate.
947	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into drywell head. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Drywell Head
No.	Phenomenon	Description
948	Thermal stratification	- Depending on the difference of density of materials and miscibility, liquid phases in corium, such as metalic and ceramic materials may separate and form different layers. - Metals may come atop from corium. - Under the Metals, upper crust formed around melting corium may come. - Under the upper crust, pool of melting corium may come. - Under the melting corium, lower crust may come. - Under the lower crust, heavy Metals may come.
949	Direct Containment Heating (DCH)	- Corium flows from core region and dispersed into drywell head. - Fragmentation and dispersal of corium may cause sudden heatup and pressurization of pedestal/cavity region.
950	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
951	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and transfers into drywell head through the core. - Then seawater deposited at the surface of the wall and dispersed into drywell head. - Presence of seasalt may cause additional chemical reactions.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Vent to Wetwell
No.	Phenomenon	Description
952	Deformation / failure of pipe line due to thermal stress	- Pipe lines may be deformed or failed by thermal stress.
953	Flow resistance	- Pressure in D/W may change when steam rapidly generates.
954	Heat transfer between vent pipe and water	- Heat transfer between vent pipes and water may affect temperature and natural circulation in S/C.
955	Heat transfer between vent pipe and gas	- Heat transfer between vent pipes and gas may affect W/W pressure and temperature.
956	Pressure change in vent line	- Pressure change in vent lines is caused by several phenomena, such as steam generation, gas temperature change, MCCI gas generation, etc.
957	Gas temperature change in vent line	- Temperature in vent lines is affected by heat transfer and thermal radiation from high temperature D/W.
958	Water temperature change in vent line	- Hot water may come from D/W to vent lines .
959	Temperature change of vent pipe	- Hot water may come from D/W to vent lines and the temperature of vent lines goes up.
960	Gas flow in vent line	- Gas flow in vent lines may affect vent lines temperature distribution.
961	Local gas flow and turbulence	- There are some structures in drywell vent line and downcomer to wetwell. - Local gas flow which pass through spaces of structures generates except main flow. - Also, local gas flow might become turbulent flow.
962	Water flow in vent line	- Hot water may come from D/W to vent lines .
963	Gas composition change in vent line	- Mixing (or stratification) of non-condensable gases in vent line atmosphere may change with time.
964	Corium particle entrainment by gas / water	- Corium particles may relocate from D/W to vent lines.
965	Heat transfer between entrainment corium particle and vent pipe	- Vent line atmosphere is heated by heat transfer from corium particles.
966	Heat transfer between entrainment corium particle and water	Water temperature in vent lines is heated by heat transfer from corium particles.
967	Droplet behavior in the drywell vent line free space	- Droplets move due to diffusion, settling, or interaction with other droplets.
968	Condensation heat transfer on the drywell vent line inner surface	- During the accident, various components, such as corium, water, steam, gases, and so on, are flow into drywell vent line and most of the gas condensation is supposed to occur on the surface of the wall. - Condensation heat is transferred from gas to drywell vent line inner surface and has an impact on temperature change.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Vent to Wetwell
No.	Phenomenon	Description
969	FP particle transport by gas in the drywell vent line and downcomer	- FPs released from the damaged fuel rods are transported into drywell vent line and downcomer and deposited at the surface of wall to generate FP particle. - FP particle are dispersed and transport by gas in the drywell vent line and downcomer.
970	FP particle agglomeration/fragmentation in the drywell vent line	- FPs released from the damaged fuel rods are transported into drywell vent line. - FPs might agglomerate or is fragmentated in the drywell vent line.
971	FP particle deposition on the drywell vent line	- FPs released from the damaged fuel rods are transported into drywell vent line and deposited at drywell vent line to generate FP particle.
972	FP deposition on vent line	- FP deposition on vent lines may affect vent line temperature and pressure.
973	FP re-vaporization	- FP re-vaporization may affect vent line temperature and pressure.
974	Decay heat generation from FP	-Decay heat from FP may affect vent line pressure and temperature.
975	FP transport by water flow on the drywell vent line and downcomer	- FPs released from the damaged fuel rods are transported into drywell vent line and downcomer. - FPs might be transported by water flow on thedrywell vent line and downcomer walls and internal surfaces.
976	FP re-entrainment	- FPs released from the damaged fuel rods are transported into drywell vent line and downcomer to wetwell. - During the accident, water and corium pool may be generated in the drywell vent line and downcomer to wetwell. - Re-entrainment of fission products can occur at water and corium pools.
977	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into drywell vent line and downcomer to wetwell. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
978	Local water flow in the drywell vent line and downcomer	- There are a lot of holes in drywell vent line and downcomer to wetwell. - Local water flow which passes through those generates except main flow.
979	Direct Containment Heating (DCH)	- Corium flows from core region and dispersed into drywell vent line and downcomer to wetwell. - Fragmentation and dispersal of corium may cause sudden heatup and pressurization of pedestal/cavity region.
980	Change of failure crack area on bellows	- The leak rate is dependent on the area of hole on bellows.
981	Water leak from failure crack on bellows	- Change of temperature and coolant inventory is caused by water leak.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Vent to Wetwell
No.	Phenomenon	Description
982	Gas leak from failure crack on bellows	- Change of temperature and coolant inventory is caused by gas leak.
983	Corrosion of piping by seasalt (including marine lives)	- Seawater including Na, Mg, Ca and some organic materials (i.e. marine lives) may affect corrosion of pipes.
984	Water level change in Drywell/Wetwell vantilation line	- During the accident, water level in RPV decreases and steam pressure grows up. - Water level in drywell/wetwell ventilation line change due to steam pressure in RPV.
985	Salt effects on heat transfer	- Deposited salt from seawater may decrease heat transfer to vent pipes.
986	Salt remelting from flood	- Deposited salt may resolve into water.
987	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV changes due to vaporization, injection amounts of real water, and so on. - Seasalt concentration may have impact on seasalt deposition amount on structures and therefore heat transfer between seawater and structures.
988	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and transfers into drywell vent line and downcomer to wetwell. - Then seawater deposited at the surface of the wall and dispersed into drywell vent line and downcomer to wetwell. - Presence of seasalt may cause additional chemical reactions.
989	Boron corrosion of vent pipe	- Boron from control rods or standby liquid control system (SLC) may affect corrosion of vent pipes.
990	Boron effects on heat transfer	- Melted boron is cooled and deposited in vent pipes and it may decrease heat transfer to vent pipes.
991	Boron remelting from flood	- Deposited boron may resolve into water.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Wetwell
No.	Phenomenon	Description
992	Deformation / failure of Wetwell by thermal stress	- W/W may be deformed or failed by thermal stress
993	Pressure change in wetwell	- Pressure change in W/W is caused by several phenomena, such as steam generation, gas temperature change, MCCI gas generation, etc.
994	Water flow in wetwell	- Hot water may come from D/W to W/W.
995	Temperature change in wetwell structure	- Hot water may come from D/W and temperature of W/W structures may change.
996	Gas composition change in wetwell	- Mixing (or stratification) of non-condensable gases in W/W atmosphere may change with time.
997	Corium particle entrainment by gas / water	- Small corium particles may move from D/W to W/W.
998	Corium particle waftage	- Small corium particles may make water heat up in W/W.
999	Corium particle deposition / accumulation	- Small corium particles may deposit or accumulate on W/W wall.
1000	Heat transfer between pool water in wetwell and corium particle	- Water temperature in W/W is heated by heat transfer from corium particles.
1001	Gas ejection	- W/W is subjected to the load when SRV operates after core damage.
1002	Steam condensation (with/without non-condensable gases)	- Non-condensable gas which contains FP may release into the liquid phase. And it may be considered as isothermalized with the liquid phase and released into the gas phase.
1003	Temperature stratification (three-dimensional temperature distribution)	- PCV pressure may rise due to steam when the condensation mechanism decays by temperature stratification of W/W.
1004	Stratification of gas composition	- W/W vent may be affected by gas composition in W/W.
1005	Dynamic load on wetwell wall (with/without non-condensable gases)	- Non-condensable gas temperature has an insignificant effect due to heat transfer coefficient is smaller than steam.
1006	Scrubbing	- Aerosols in highly superheated gas may flow into W/W with low subcooling.
1007	Gas flow at vacuum breaker valve	- Gas may return to D/W from W/W if vacuum breaker valves open.
1008	Local gas flow and turbulence	- There are some structures in wetwell. - Local gas flow which pass through spaces of structures generates except main flow. - Also, local gas flow might become turbulent flow.
1009	Water level change	The amount of heat transfer to outside may change if the water level changes.
1010	Droplet behavior in the wetwell above water level	- Droplets move due to diffusion, settling, or interaction with other droplets.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Wetwell
No.	Phenomenon	Description
1011	Condensation heat transfer on the wetwell wall above water level	- During the accident, various components, such as corium, water, steam, gases, and so on, are flow into wetwell and most of the gas condensation is supposed to occur on the surface of the wall. - Condensation heat is transferred from gas to wetwell wall and have an impact on temperature change.
1012	Interaction between gas and water film flow on the wetwell wall above water level	- Gas flow and water film flow, which is condensed on the wall surface, interacts with each other due to some processes such as interfacila shear, surface instability, droplet re-entrainment, and so on.
1013	FP particle transport by gas in the wetwell	- FPs released from the damaged fuel rods are transported into wetwell and deposited at the surface of wall to generate FP particle. - FP particle are dispersed and transport by gas in the wetwell.
1014	FP particle agglomeration/fragmentation in the wetwell	- FPs released from the damaged fuel rods are transported into wetwell. - FPs might agglomerate or is fragmentated in the wetwell.
1015	FP particle deposition on the wetwell wall above water level	- FPs released from the damaged fuel rods are transported into wetwell and deposited at wetwell wall above water level to generate FP particle.
1016	FP transport by water flow on the wetwell wall above water wall	- FPs released from the damaged fuel rods are transported into wetwell. - FPs might be transported by water flow on the wetwell wall and internal surfaces.
1017	FP re-entrainment	- FPs released from the damaged fuel rods are transported into wetwell. - During the accident, water and corium pool may be generated in the wetwell. - Re-entrainment of fission products can occur at water and corium pools.
1018	FP reaction including iodine chemistry	- During the accident, fission products generated from core-heatup and melting flow into wetwell head. - FP reaction occurs based on gas phase chemistry. - Chemical reactions between various species depending on temperature, carrier fluid composition and concentration of species.
1019	Corrosion of wetwell by seasalt (including marine lives)	- Deposited salt from seawater may decrease heat transfer to W/W wall.
1020	Adsorption and release of gaseous FP	- During the accident, FPs generated from core-heatup and melting flow into wetwell. - Gaseous FP adsorped to structure wall and release from the wall on the contrary.
1021	Salt remelting from flood	- Deposited salt may resolve into water.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Wetwell
No.	Phenomenon	Description
1022	Influence on Heat Transfer by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV changes due to vaporization, injection amounts of real water, and so on. - Seasalt concentration may have impact on seasalt deposition amount on structures and therefore heat transfer between seawater and structures.
1023	Influence for heat transfer between wetwell and torus room by seawater	- Seawater is injected to RPV from the existing makeup water system using fire-extinguishing pump. - Seawater flows into wetwell and torus room and deposited at the surface of the structure wall. - Seasalt deposition on the wall would have an impact on heat transfer between wetwell and torus room
1024	Influence on Instrumentation and Measurements by Seasalt Concentration Change	- Concentration of salt in sea water injected into RPV change due to vaporization, injected amount of real water, and so on. - Seasalt deposited on structures including instrumentation and the precipitation amount is dependent on salt concentration. - Due to salt precipitation amount on instrumentation, measuring precision may change.
1025	Seasalt impact for FP reaction and composition	- Seawater is injected into RPV and transfers into wetwell. - Then seawater deposited at the surface of the wall and dispersed into wetwell. - Presence of seasalt may cause additional chemical reactions.
1026	Boron corrosion of wetwell wall	- Boron from control rods or standby liquid control system (SLC) may affect corrosion of W/W wall.
1027	Boron effects on heat transfer	- Melted boron is cooled and deposited in W/W wall and it may decrease heat transfer to W/W wall vent.
1028	Boron remelting from flood	- Deposited boron may resolve into water.
1029	Heat release from wetwell wall to torus room	- The temperature of PCV may be changed by heat release rate from W/W wall to torus room.
1030	Gas leak from wetwell (vacuum breaker)	- Wetwell inner gasses may leak from vacuum breaker.
1031	Water leak from wetwell (vacuum breaker)	- Wetwell inner water may leak from vacuum breaker.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Isolation Condenser
No.	Phenomenon	Description
1032	Heat transfer between steam and inner wall of IC heat transfer tube	- Heat transfer between steam and inner wall of IC heat transfer tube depend on RPV pressure , steam flow rate , concentration of non-condensable gas in the fluid within IC and so on.
1033	Heat transfer between condensate and inner wall of IC heat transfer tube	- Heat transfer between steam and inner wall of IC heat transfer tube depend on RPV pressure , condensate flow rate, concentration of non-condensable gas in the fluid within IC and so on.
1034	Heat transfer between pool water and outer wall of IC heat transfer tube	- Heat transfer between pool water and outer wall of IC heat transfer tube depend on pool water temperature, boiling state at tube surface(nuclear boiling or film boiling) and so on.
1035	Heat transfer between air and IC heat transfer tube in case of low pool water level	- Heat transfer between air and IC heat transfer tube depend on elapsed time after scram (decay heat level), air temperature and so on.
1036	Fouling factor of heat transfer tube (inner/outer surface)	- Increasing of fouling factor degrade the heat transfer rate. Fouling factor depend on quality of water (retained water of RPV/pool water) and elapsed time after maintenance.
1037	Degradation of condensation heat transfer coefficient due to non-condensable gas (Hydrogen, Noble gas)	- Hydrogen is generated by metal-water interaction in RPV, when IC is temporarily stopped by some transient (i.e. unintended closed the isolation valve and so on). In this case, even if IC is restarted, heat transfer rate is degraded.
1038	Volatile FP attachment into IC heat transfer tube	- In case of fuel cladding failed, volatile FP is released from fuel and attached inner surface of IC tube.
1039	Volatile FP reevaporation from IC heat transfer tube	- If IC tube is ruptured, reevaporated FP is released to out of PCV.
1040	Heat generation of volatile FP attached inside IC heat transfer tube	- IC tube may be ruptured by decay heat of volatile FP.
1041	Pressure change(pressure loss) along IC system	- Pressure change along IC system may be occurred by changed steam generation rate in RPV, changed pool condition and so on. Pressure change along IC system influence the heat transfer rate of IC.
1042	Pressure of IC heat transfer tube	- Pressure of IC influence the heat transfer rate.
1043	Water level in IC tank (shell side)	- If water level in IC tank below than IC tube, heat transfer rate is significantly degraded.
1044	Gas leak inside PCV boundary	- If gas leaking inside PCV boundary is occurred, core cooling function of IC is lost by depressurization of RPV or closed isolation valve. And leaked gas or steam from IC tube is influenced the PCV pressure and temperature.
1045	Water leak inside PCV boundary	- If water leaking inside PCV boundary is occurred, core cooling function of IC is lost by depressurization of RPV or closed isolation valve. And leaked steam from IC tube is influenced the PCV pressure and temperature.
1046	Gas leak outside PCV boundary	- If gas leaking outside PCV boundary is occurred, core cooling function of IC is lost by depressurization of RPV or closed isolation valve. And leaked gas or steam from IC tube is discharged to reactor building.

Table 7-2 Description for Plausible Phenomena (cont.)

	Subsystem/Component	Isolation Condenser
No.	Phenomenon	Description
1047	Water leak outside PCV boundary	- If water leaking outside PCV boundary is occurred, core cooling function of IC is lost by depressurization of RPV or closed isolation valve. And leaked water from IC tube is discharged to reactor building.

8. PIRT Ranking Results

This chapter shows relative importance and state of knowledge (SoK) of phenomena selected in chapter 7.

8.1 Relative importance of phenomena

This section describes ranking for relative importance of phenomena for FoM in each time phase.

Ranking scale used in this PIRT is as follows. This PIRT uses four classifications of ranking according to influence on FoM

- High (H): Phenomenon which has a large influence on FoM, and modeling in code is strongly recommended.
- Medium (M): Phenomenon which has a medium influence on FoM, and modeling in code is recommended.
- Low (L): Phenomenon which has a small influence on FoM, and modeling in code is not required especially.
- Not Applicable (N/A): Phenomenon which has little or nothing to do with FoM.

The procedure to determine relative importance of phenomena is same as one of phenomena identification in chapter 7. First, Hitachi-GE and Toshiba developed the preliminary PIRT. After that, PIRT was revised based on discussion with research committee on severe accident of AESJ, division of nuclear fuel of AESJ, U.S. EPRI and FAI and review by them

The process for the preliminary PIRT is as follows.
(1) Each engineer of Hitachi-GE and Toshiba independently made a ranking for phenomena according to the above ranking scale.

(2) After compiling of the above results, the preliminary ranking of PIRT was determined. In the compiling, two kinds of importance are used, which are the importance got the most votes and the one determined by the method EURSAFE used. If two kinds of importance are in accordance with each other, the importance ranking is accepted, and if not, importance ranking is determined by discussion. Here, the method EURSAFE used is the one determining by the average point of votes. Specifically, 3 point is given

to “High”, 2 point is given to “Medium”, 1 point is given to “Low”, and “N/A” is out of counting, and then the average point is counted for total points. If the average point is over 2.33, “High” is set, if over 1.66, “Medium” is set, and if below 1.66, “Low” is set.

Table 8-1 shows specification of relative importance of phenomena for each component. 386 phenomena are eventually selected as ones of importance “High”. As is the case with the number of selected phenomena in chapter 7, this table shows that the regions including Core, Lower head, and Pedestal cavity which have high possibility of being molten core have a lot of “High”.

The detail of the PIRT ranking is shown in Table 8-3.

8.2 State of knowledge of phenomena

This section describes ranking for SoK of phenomena in each time phase.

Ranking scale used in this PIRT is as follows. This PIRT uses three classifications of ranking according to knowledge level and uncertainty for phenomena evaluation.

- Known (K): Phenomenon is well-known, and test data has relatively small uncertainty. Evaluation model for relevant phenomenon is in level appropriate for design of actual plant.
- Partially known (P): Phenomenon is partially known, and test data has relatively large uncertainty. Evaluation model is not perfectly validated, and is in level which has technical issues yet.
- Unknown (U): There is little knowledge regarding the phenomenon. There is little knowledge for analysis model, and analysis model is made based on a lot of assumption. If phenomenon has importance “High”, it requires a lot of investigation.

The procedure to determine SoK is same as one of relative importance of phenomena in section 8.1. First, Hitachi-GE and Toshiba developed the preliminary PIRT. After that, PIRT was revised based on discussion with research committee on severe accident of AESJ, division of nuclear fuel of AESJ, U.S. EPRI and FAI and review by them

Table 8-2 shows specification of SoK of phenomena for each component. From this table, it is seen that phenomena with “Known” is about 30%, ones with “Partially known” is about 60%, and ones with “Unknown” is about 10%. A lot of phenomena with “Unknown” are ones related to injection of salt water to core in the accident.

The detail of the PIRT ranking is shown in Table 8-3.

8.3 Final ranking results

Table 8-3 shows the ranking results for the scenario that the PIRT treated. This table contains not only the ranking results but also an explanation of the results with rationales.

Table 8-1 Relative importance of phenomena (Maximum point in 4 time phases)

Component	Relative importance of phenomena		
	High	Medium	Low
Core	73	75	30
Shroud Head	0	5	27
Standpipe & Separator	4	4	24
Dryer	4	1	19
Upper Head	5	5	14
Main Steam Line	7	9	16
Upper Downcomer	3	12	16
Lower Downcomer	49	43	29
Lower Head	91	53	19
Recirculation Loop	2	4	30
Pedestal Cavity	69	35	36
Drywell	46	31	28
Drywell Head	14	5	14
Vent to Wetwell	7	7	26
Wetwell	9	9	22
Isolation Condenser (* only unit 1)	3	9	4
Total	386	307	354

Table 8-2 SoK of phenomena (Maximum point in 4 time phases)

Component	State of knowledge (SoK)		
	Known	Partially known	Unknown
Core	60	108	10
Shroud Head	16	11	5
Standpipe & Separator	15	9	8
Dryer	10	6	8
Upper Head	10	9	5
Main Steam Line	22	8	2
Upper Downcomer	17	9	5
Lower Downcomer	24	83	14
Lower Head	23	128	12
Recirculation Loop	13	16	7
Pedestal Cavity	21	100	19
Drywell	16	74	15
Drywell Head	14	17	2
Vent to Wetwell	10	23	7
Wetwell	12	22	6
Isolation Condenser (* only unit 1)	7	9	0
Total	290	632	125

Table 8-3 Final PIRT results

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
1	Core	Core water level change	H	H	M	M	K	- If core water level is above the top of active fuel, fuel rods are cooled. Once the core water level is under the top of active fuel, fuel rods start to heat up, leading to core melt. - Therefore the importance is high for the 1st and 2nd phase. - It becomes less important after the 3rd phase because the part of melted fuel rods would relocate to the lower plenum.	-Core water level is one of the key parameters for safety analyses for LOCA, and transients, as well as severe accidents. -Water level changing behavior has been well-known through a lot of plant licensing analyses or various experiments for plant safety analysis code validation.
2		Core flowrate change	H	H	M	M	K	- Core flowrate change influences mass balance of core coolant, resulting in the water level change. It also changes coolant flow velocity, which impacts heat transfer characteristics from fuel rods to water. - Therefore the importance is high for the 1st and 2nd phase. - It becomes less important after 3rd phase because the part of melted fuel rods in the core relocates from the core to the lower plenum.	-Core flowrate change is usually evaluated for safety analyses for LOCA, and transients, as well as severe accidents. -Therefore, core flowrate change has been well-known through a lot of plant licensing analyses or various experiments (e.g. recirculation pump trip test)

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
3	Core	Core coolant temperature change	H	L	L	L	K	- Core coolant temperature change influences the temperature gradient between fuel rod surface and core coolant, as well as void fraction in core channels. These determines heat transfer rate from the fuel rods. - Therefore the importance is high for the 1st phase. - Since the 2nd phase, the water level has been low and core has uncovered. Coolant surrounding the fuel rods has become steam. In these conditions, heat transfer rate from the fuel rods has been very low regardless of the coolant temperature. Therefore the importance for these phases becomes less important than for the 1st phase.	-Core coolant temperature change is usually evaluated for safety analyses for LOCA, and transients, as well as severe accidents. -Therefore, core flowrate change has been well-known through a lot of plant licensing analyses or various experiments for safety analysis code validation.
4		Core pressure change	H	H	H	H	K	- Core pressure change influences water level swelling, coolant boiling behavior, the amount of safety injection. - After fuel rods have started to melt, differential pressure in the core region drives natural circulation gaseous flow, affecting molten core cooling behavior. - Also, pressure would affect RPV failure mode and subsequent corium release behavior. These would influence the containment pressure and temperature significantly. - Eventually, pressure change is highly important for all phases considered.	-core pressure is one of the key parameters for safety analyses for LOCA, and transients, as well as severe accidents. -Pressure changing behavior has been well-known through a lot of plant licensing analyses or various experiments for plant safety analysis code validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
5	Core	Boiling due to depressurization	H	L	L	L	K	- Due to depressurization boiling, the core water level drops, leading to core uncovery. It also changes the void fraction in the core channels and heat transfer rate. - Therefore, the importance for the 1st phase is high. - Since the 2nd phase, the core water level has dropped and the boiling effect will be limited.	-Depressurization boiling is usually considered in safety analyses for LOCA, and transients, as well as severe accidents. -Therefore, depressurization boiling has been well-known through a lot of plant licensing analyses or various experiments for safety analysis code validation.
6		Gap conductance between fuel pellets and cladding	H	L	L	L	K	- Gap conductance is one of the key parameter for the heat transfer behavior from pellets to claddings. - Therefore the importance for the 1st phase is high. - Since the 2nd phase, the fraction of intact fuel rods should be decreased and thus the gap conductance would be less important.	-Gap conductance is one of the key parameters for safety analyses for LOCA, and transients, as well as fuel rod design codes. -A lot of experiments to measure the heat resistance in the gap for fuel development were conducted, followed by validation analyses for fuel design codes and safety analysis codes.
7		Gas (condensable/incondensable) temperature change in channel region	M	L	L	M	K	- Since the heat transfer coefficient from the fuel rods to the gaseous phase is much lower than the liquid phase, it is less important but not entirely ignored. The importance should be medium for the 1st phase. - After fuel rods have started to melt, heat removal to the gaseous phase is degraded due to surface area decrease, and the impotence will be further low. - For the 4th phase, gas temperature in the core region influences the containment pressure and temperature.	-Gas temperature in the core region is usually evaluated for safety analyses for LOCA, and transients, as well as severe accidents. -Therefore, core flowrate change has been well-known through a lot of plant licensing analyses or various experiments for safety analysis code validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
8	Core	Temperature change in fuel cladding	H	H	L	L	K	- Fuel cladding temperature is one of the key parameters for the fuel rod integrity. It also influences molten core properties after core melt started. Thus the importance for the 1st and 2nd phase is high. - Since the 3rd phase, a quite part of fuel cladding has melted, being mixed with other fuel materials. Then the temperature for the intact fuel cladding itself is less important.	- Heat-up rate for the fuel cladding has been examined in a lot of experiments for the material development for higher burn-up (ex. Halden Reactor Project) - Also, cladding temperature has been evaluated through the LOCA analyses, because this is one of the plant licensing criteria.
9		Temperature change in fuel pellets	H	H	L	L	K	- Fuel pellet temperature is one of the key parameters for the fuel rod integrity as well as that of fuel cladding. It also influences molten core properties after core melt started. Thus the importance for the 1st and 2nd phase is high. - Since the 3rd phase, a quite part of fuel pellets have melted, being mixed with other fuel materials. Then the temperature for the intact fuel pellets itself is less important.	-Fuel pellet temperature has been evaluated for safety analyses for LOCA, and transients, as well as severe accidents. -Therefore, it has been well-known through a lot of experiences in plant licensing analyses or various experiments for safety analysis code validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
10	Core	Temperature change in control rods	L	M	L	L	P	- Since the control rods are in the bypass region in the core, direct heat transfer from the fuel rods does not occur, except gamma ray. - Thus the effect of the control rod temperature change on the fuel rod heat-up is limited. - For the 2nd phase, fuel rods have started to melt and the control rod could be contacted with the melted fuel. the control rod temperature determines the melting sequence and the molten core composition. Thus the importance becomes higher than the previous phase.	-As control rod temperature change is rarely evaluated in the safety analyses, knowledge for the phenomenon is not as much as that for fuel claddings. -Control rod heat-up has been evaluated in some studies such as DF-4 and XR2 experiments. -As seawater was injected into the core for Fukushima Dai-ichi accident, the effect of salt on the cladding temperature change remains unknown.
11		Decay heat in Intact fuel assemblies	H	M	L	L	K	- Since decay heat from fuel assemblies is the main source for fuel rod heat-up, the importance is high for the 1st phase. - After the core has started to melt, the importance was set lower because the fraction of intact fuel assemblies is decreasing.	- Decay heat in intact fuel assemblies has been evaluated in the fuel design codes and the design methodology has been established. - The evaluation model such as the ANS equation is well-known, even if it has some uncertainty ranges.
12		Gamma ray heat generation in core internals (except fuel rods)	L	L	L	L	K	- Since gamma ray heat generation other than the core internals contributes a relatively small fraction (a few percents) of the total heat source, the effect on the figures of merit is smaller.	- The fraction of gamma ray heat generation is evaluated in various fuel design codes or safety analysis codes as the 'gamma smearing' effects.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
13	Core	Temperature change in gaps between fuel pellets and cladding	M	L	L	L	K	- Gap gas temperature change influences indirectly the temperatures for the fuel rods and cladding as one of the parameter for the gap conductance. - Thus the importance is middle for the 1st phase. Since the 2nd phase, the amount of the intact fuel rods decreases due to core melt so that the importance for the gap becomes lower.	-The gap is modeled to evaluate the gap conductance in safety analyses for LOCA, and transients, as well as fuel rod design codes. -A lot of experiments to measure the heat resistance in the gap for fuel development was conducted, followed by validation analyses for fuel design codes and safety analysis codes.
14		Temperature change in channel boxes	M	H	L	L	P	- Radiation heat from the fuel rods impacts the temperature for channel boxes when the core water level declines. -For the 2nd phase, channel box temperature determines the time for the formation of flowpaths between the fuel channels and the bypass. This could change the coolant flow and the core cooling conditions, being more important than for the 1st phase.	-As channel box temperature change is rarely evaluated in the safety analyses, knowledge for the phenomenon is not as much as that for fuel claddings. -Channel box heat-up has been evaluated in some studies such as DF-4 and XR2 experiments. -As seawater was injected into the core for Fukushima Dai-ichi accident, the effect of salt on the channel box temperature change remains unknown.
15		Temperature change in tie plates	L	L	L	L	K	- Since the contribution of tie plates to the core materials is relatively small, the tie plate temperature change is less important than that for fuel rods and channel boxes	-Although tie plate temperature change is not independently evaluated, it is considered in some integrated tests (e.g. ROSA-III)
16		Temperature change in spacers	L	L	L	L	K	- Since the contribution of spacers to the core materials is relatively small, the spacer temperature change is less important than that for fuel rods and channel boxes.	-Although spacer temperature change is not independently evaluated, it is considered in some integrated tests (e.g. ROSA-III)

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
17	Core	Heat transfer between water and fuel cladding	H	H	L	L	K	- Heat transfer from the fuel cladding to water determines the rod cooling conditions. Thus it is one of the key parameters to evaluate the initiation of fuel rod damage. The importance should be set to 'high' up to the 2nd phase.	- Heat transfer from the heated rod to water has been extensively experimented and analyzed in nuclear safety studies, fuel development projects, as well as other general thermal-hydraulic studies.
18		Heat transfer between water and channel boxes	M	M	L	L	K	- Since channel boxes surround fuel rods in an assembly, heat transfer from the channel boxes to water influences indirectly the rod cooling conditions by changing the water temperature. The importance should be set to 'medium' up to the 2nd phase.	- Heat transfer from rectangle flowpaths such as channel boxes to water has been extensively experimented and analyzed in nuclear safety studies, fuel development projects, as well as other general thermal-hydraulic studies.
19		Heat transfer between water and control rods	L	M	L	L	P	- During the 1st phase, channel boxes are still intact and the heat transfer from the control rods to water in the bypass region does not really influence the fuel rod temperature. - For the 2nd phase, fuel assemblies start melting, and the control rods could be mixed into the molten core, changing its behavior. Thus the control rod heat removal would be more important than the previous phase.	-As control rod temperature change is rarely evaluated in the safety analyses, knowledge for the phenomenon is not as much as that for fuel claddings. -Control rod heat-up has been evaluated in some studies such as DF-4 and XR2 experiments. -As seawater was injected into the core for Fukushima Dai-ichi accident, the effect of salt on the cladding temperature change remains unknown.
20		Heat transfer between water and tie plates	L	L	L	L	P	- Since the contribution of tie plates to the core materials is relatively small, heat transfer from the tie plates to water is less important than that from fuel rods and channel boxes	- Although heat transfer from tie plates is not independently evaluated, it is considered in some integrated tests (e.g. ROSA-III)

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
21	Core	Heat transfer between water and spacers	M	L	L	L	P	- Since the contribution of spacers to the core materials is relatively small, heat transfer from the spacers to water is less important than that from fuel rods and channel boxes	- Although heat transfer from spacers is not independently evaluated, it is considered in some integrated tests (e.g. ROSA-III)
22		Heat transfer between fuel cladding and spacers	L	L	L	L	P	- Since the contact area between the spacers and the fuel cladding is relatively small, heat transfer from the fuel cladding to spacers is less important than that to water or gas.	- Although heat transfer from fuel cladding to spacers is not independently evaluated, it is considered in some integrated tests (e.g. ROSA-III)
23		Heat transfer between fuel cladding and gas	H	H	L	L	K	- Heat transfer from the fuel cladding to gas determines the rod cooling conditions. Thus it is one of the key parameters to evaluate the initiation of fuel rod damage and melting The importance should be set to 'high' up to the 2nd phase.	- Heat transfer from the heated rod to gas has been extensively experimented and analyzed in nuclear safety studies, fuel development projects, as well as other general thermal-hydraulic studies.
24		Heat transfer between fuel pellets and gas	M	L	L	L	K	- Heat transfer from fuel pellets to gas is not neglected for the 1st phase, but this effect is rather considered in gap conductance. - Since the 2nd phase, fuel rods have already damaged and the fraction of intact rods decreases. Thus the heat transfer from the fuel pellets is less important.	-Heat transfer from the fuel pellet to gas is evaluated as gap conductance for safety analyses for LOCA, and transients, as well as fuel rod design codes. -A lot of experiments to measure the heat resistance in the gap for fuel development was conducted, followed by validation analyses for fuel design codes and safety analysis codes.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
25	Core	Heat transfer between channel boxes and gas	L	M	L	L	K	- Since channel boxes surround fuel rods in an assembly, heat transfer from the channel boxes to gas influences indirectly the rod cooling conditions by changing the gas temperature. It also influences the initiation of channel box melting. The imporatance should be set to 'medium' for the 2nd phase.	- Heat transfer from rectangle flowpaths such as channel boxes to gas has been extensively experimented and analyzed in nuclear safety studies, fuel development projects, as well as other general thermal-hydraulic studies.
26		Heat transfer between control rods and gas	L	M	L	L	P	- During the 1st phase, channel boxes are still intact and the heat transfer from the control rods to gas in the bypass region does not really occur and influence the fuel rod temperature. - For the 2nd phase, fuel assemblies start melting, and the control rods could be mixed into the molten core, changing its behavior. Thus the control rod heat removal would determine the rod damage and be more important than the previous phase.	-As control rod temperature change is rarely evaluated in the safety analyses, knowledge for the phenomenon is not as much as that for fuel claddings. -Control rod heat-up has been evaluated in some studies such as DF-4 and XR2 experiments. -As seawater was injected into the core for Fukushima Dai-ichi accident, the effect of salt on the cladding temperature change remains unknown.
27		Heat transfer between tie plates and gas	L	L	L	L	P	- Since the contribution of tie plates to the core materials is relatively small, heat transfer from the tie plates is less important than that for fuel rods and channel boxes	- Although heat tarnsfer from tie plates is not independently evaluated, it is considered in some integrated tests (e.g. ROSA-III)
28		Heat transfer between spacers and gas	L	L	L	L	P	- Since the contribution of spacers to the core materials is relatively small, heat transfer from the spacers is less important than that for fuel rods and channel boxes.	- Although heat transfer from spacers is not independently evaluated, it is considered in some integrated tests (e.g. ROSA-III)

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
29	Core	Hydrogen absorption in fuel cladding	M	M	L	L	K	-Zirconium-hydride forms in fuel cladding by hydrogen absorption. The reaction of $Zr+H_2 \rightarrow ZrH_2$ is exothermal. -The hydride formation changes the cladding thermal and mechanical properties.	-Hydrogen absorption in cladding in LOCA phase is studied in LOCA tests, for example, performed by JAEA -Residual moisture in fuel rod caused excess hydride called sunburst in fuel cladding. Fuel rod failure due to the sunburst happened at early time when pellet dry process after surface polishing was insufficient. -Since the embrittlement by the hydride formation is a cause of cladding failure, the phenomenon of hydrogen absorption by zirconium is studied well.
30		Fuel pellets composition (including MOX fuels and Gd_2O_3)	M	M	L	L	K	-Since the thermal properties such as specific heat and thermal conductivity somewhat depends on fuel pellet composition, it should be considered in heat-up assessment until melting phase.	-Composition of irradiated fuel pellet including MOX pellet and Gd_2O_3 content pellet is usually calculated with ORIGEN code.
31		Fuel rod growth (cladding irradiation growth)	M	L	L	L	K	-Axial configuration of fuel rods would give an effect on heat up in the 1st phase where the fuel rods keep their geometry.	-The fuel rod design is based on sufficient data base for cladding irradiation growth
32		Pressure change in gap between fuel pellets and cladding	M	M	L	L	K	-Pressure change gives an effect on cladding ballooning. Heat conductance from fuel pellet to cladding depends on gap size between fuel pellet and cladding. The pressure should be considered until melting phase in order to predict fuel temperature.	-Rod internal pressure is well modeled in fuel rod performance codes based on PIE data.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
33	Core	Gas composition change in gap between fuel pellets and cladding	M	L	L	L	K	-Gas composition in fuel rod gives an effect on heat conductance. -After the gas is released from burst rapture opening, water or steam can flow into the fuel rod.	-Main components of the gas are helium charged at fabrication, xenon and krypton of fission gas released from fuel pellet.
34		Balooning of fuel cladding	M	L	L	L	P	-Heat flow from fuel pellet to cladding depends on gap size between fuel pellet and cladding. -The ballooning of a fuel cladding toward surrounding fuel claddings may change lateral heat flow condition among the fuel cladding and axial heat flow by steam flow.	-Ballooning of fuel cladding is studied as a part of LOCA tests and summarized in NUREG-2121, for example. - The condition of fuel cladding contact to fuel pellets depends on the accident progression with some uncertainties.
35		Contraction of fuel cladding outer diameter（creep down）	M	M	L	L	K	-Contact of cladding with fuel pellet due to cladding creep down gives effects on fuel rod behavior in terms of thermal, mechanical and chemical aspects. The thermal effect is to change gap heat conductance. The mechanical effect is pellet-cladding mechanical interaction (PCMI). The chemical effect is bonding reaction between fuel pellet and cladding. It is considered that these somewhat influence fuel rod heat up and melting.	-Cladding creep down is well modeled in fuel rod performance codes based on PIE data.
36		Fuel cladding rupture	L	L	L	L	K	- The phenomenon of fuel cladding rapture does not directly influence fuel heat up and melting.	-Fuel cladding rupture is well studied in LOCA tests and some of the results are summarized in NUREG-2121, for example.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
37	Core	Changes in bonding status of fuel pellets to cladding	L	L	L	L	P	-Change in chemical bonding status does not give remarkable effects on fuel heat up and melting.	-Bonding of fuel pellets to cladding is observed at post-irradiation-examinations of high burnup fuel rod and ramp tested fuel rod. The phenomenon itself is well known however the bonding reaction mechanism is partly known.
38		Pellet cracks, grains and relocation in cladding	M	L	L	L	P	-Radial relocation of fuel pellet influences heat conductance between fuel pellet and cladding. -Axial relocation of fuel pellet to a ballooning part increases local heat generation at the balooning part. -These give some effects on fuel rod heat up behavior.	-Fragmentation and relocation of fuel pellets are observed at post-irradiation-examinations after normal operation, ramp tests, RIA tests and LOCA tests. The phenomenon itself is well known however it is not modeled enough.
39		Water flow into gap between fuel pellets and cladding	N/A	N/A	N/A	L	P	-Fuel rods keep their geometry until melting, although they are degraded by excess oxidation, rupture etc. of the cladding. Water flowing into the gap between fuel pellet and cladding from a breach of the cladding such as rapture can change heat conductance between fuel pellet and cladding. - After 3rd phase, most of the fuel rods do not keep their geometry due to collapse resulting from excess oxidation and melting, consideration of water flow into gap between fuel pellet and cladding would not be necessary.	-The effect of water flow into gap on fuel pellet is studied to understand fuel pellet dissolution from leak fuel rod. Some studies are reported in IAEA-TECDOC-1654. -The effect of water flow into gap on cladding oxidation and hydrogen absorption is studied in LOCA tests, performed at JAEA for example. -The effect of it on thermal behavior for example how much gap heat conductance is improved is not known quantitatively.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
40	Core	Steam flow into gap between fuel pellets and cladding	M	M	L	L	P	-Fuel rods keep their geometry until melting, although they are degraded by excess oxidation, rupture etc. of the cladding. Steam flowing into the gap between fuel pellet and cladding from a breach of the cladding such as rapture can change heat conductance between fuel pellet and cladding. - After 3rd phase, most of the fuel rods do not keep their geometry due to collapse resulting from excess oxidation and melting, consideration of steam flow into gap between fuel pellet and cladding would not be necessary.	-The effect of water/steam into gap on cladding oxidation and hydrogen absorption is studied in LOCA tests, performed at JAEA for example
41		Zr-Water reaction facilitation by water flow into gap between fuel pellets and cladding	N/A	N/A	N/A	L	P	-During fuel rod heat-up, gas pressure in the gap is higher than that outside the fuel rods. In this condition, injected water can not flow into the gap even if the cladding has ruptured and some flow paths has been generated. Thus this phenomenon should not take place up to the 3rd phase. - For 4th phase, the pressure is relatively decreased and water could flow into the gap. But in this phase, most of the fuel rods have been degraded, thus the contribution is not important.	-The effect of water/steam into gap on cladding oxidation and hydrogen absorption is studied in LOCA tests, performed at JAEA for example
42		Core axial power distribution change	H	H	L	L	K	-Axial power distribution influences the decay heat generation distribution initial position of fuel damage in core uncovery. - In the 2nd phase, the power distribution also contributes to the fuel melting and collapsing sequences.	- Axial power distribution in the core is normally assessed in core design with various core design codes. - Axial power distribution changes are being measured in actual operating BWRs with the neutron detector system in the core such as LPRM and TIP

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
43	Core	Core radial power distribution change	H	H	L	L	K	-Radial power distribution influences the decay heat generation distribution initial position of fuel damage in core uncovery. - In the 2nd phase, the radial power distribution also contributes to the fuel melting and collapsing sequences.	- Radial power distribution in the core is normally assessed in core design with various core design codes. - Radial power distribution changes are being measured in actual operating BWRs with the neutron detector system in the core such as LPRM and TIP
44		Fuel axial exposure(burn-up) distribution	M	H	L	L	K	- Axial exposure distribution has an influence on the axial composition changes in the fuel cladding, gap gases and pellets. - The fuel composition changes may have influences on the fuel melting initiation. It has more impact fuel melting sequence, in which various materials are mixed up.	- Once initial fuel rod composition, core axial power distribution and plant operation time are known, axial burn-up distribution can be assessed.
45		Fuel radial exposure(burn-up) distribution	M	H	L	L	K	- Radial exposure distribution has an influence on the radial composition changes in the fuel cladding, gap gases and pellets. - The fuel composition changes may have influences on the fuel melting initiation. It has more impact fuel melting sequence, in which various materials are mixed up.	- Once initial fuel rod composition, core radial (bundle-wise) power distribution and plant operation time are known, radial burn-up distribution can be assessed. - This distribution should be used in refueling.

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Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Rationale**	**State of Knowledge**
			1st	**2nd**	**3rd**	**4th**			
46	Core	Pressure loss change for core flow paths	M	M	L	L	K	- Pressure loss change in core flow paths impacts the core water/gas flow-rate, 2-phase flow regimes, and heat transfer rate just after a reactor scram. Once the flow characteristics changes to natural convection, the pressure loss change becomes small. - In the 2nd phase, pressure loss change due to fuel rod melting followed by geometry collapse may have some influences on heat transfer from heated rods to gas phase.	- Friction loss coefficient in the coolant flow around fuel assemblies are evaluated in fuel design and transient analysis models. - Friction loss correlation equations are available in various fluid dynamics handbooks.
47		Changes in flowrate distribution between fuel channels and bypasses	M	M	L	L	K	- Flow distribution change between fuel channels and bypasses may impact the 2-phase flow regimes, and heat transfer rate in the channel region just after a reactor scram or recirculation pump trips. - In the 2nd phase, difference change in flow-rates between fuel channels and bypasses may have some impact on the cooling behavior for melting rods.	- The flow distribution change between channels and bypasses are evaluated in core design and transient analyses models.
48		Changes in flowrate distribution in each fuel channel	M	M	L	L	K	- Flow distribution change in each channel may impact the 2-phase flow regimes and heat transfer rate in each channel just after a reactor scram or recirculation pump trips. Once the flow characteristics changes to natural convection, the pressure loss change becomes small. - In the 2nd phase, difference change in flow-rates in each channel may have some impact on the cooling behavior for melting rods in the different position (i.e. the center region or the peripheral region)	- The flow distribution change for each channel is evaluated in core design and transient analyses models (especially by using the full 3-dimensional core model such as TRACT)

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
49	Core	Changes in pressure loss at core inlet	M	L	L	L	K	- Pressure loss change in the core may impact the 2-phase flow regimes and heat transfer rate in each channel just after a reactor scram or recirculation pump trips. Once the flow characteristics changes to natural convection, the pressure loss change becomes small. - Since the 2nd phase, core flow becomes almost gas-phase and based on natural circulation, making the pressure loss in the inlet smaller.	Geometry loss coefficient has been evaluated in core design, transient analyses, and BWR particular thermal-neutronic stability analyses models.
50		Pressure loss increase by fuel cladding balooning	M	L	L	L	K	-In the 1st phase, there would be an effect of pressure loss change through fuel assembly on fuel heat up while there would be little effect in the 2nd phase and the following phases.	-Ballooning of fuel cladding is well studied in LOCA tests and summarized in NUREG-2121, for example. -Pressure loss due to fuel cladding ballooning can be calculated with analysis code such as CFD code, if the dimensions of ballooning are known.
51		Change in 2-phase flow regime status in fuel channels	M	M	L	L	K	- Although 2-phase flow regime in the core channel region is important and has been evaluated in LOCA analyses, it is less important in the SBO accident scenario like the Fukushima accident. - The 2-phase level, rather than 2-phase regimes is the key metric for evaluation of cooling behavior for both intact and damaged fuel rods, as the water level declines much more slowly in the SBO scenario than the DBAs. - After molten core has started to relocate in the 3rd phase, the geometries for the channel are almost collapsed and flow regime for the channel region does no longer have any impact.	- 2-phase flow regime is usually evaluated for safety analyses for LOCA, and transients. - Flow regime maps are installed in the various safety analysis codes such as RELAP5, TRACT, and COBRA/TRAC. - Flow regime has been studied by Mandhane (experimentally) and Taitel-Duker (theoretically).

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
52	Core	Change in 2-phase flow regime status in bypass regions	M	L	L	L	K	- 2-phase flow regime in the bypass region is less important in the SBO accident scenario like the Fukushima accident. - The 2-phase level, rather than 2-phase regimes is the key metric for evaluation of cooling behavior for both intact and damaged fuel rods, as the water level declines much more slowly in the SBO scenario than the DBAs. - In addition, bypass region flow conditions are less important than that in the channel region.	- 2-phase flow regime is usually evaluated for safety analyses for LOCA, and transients. - Flow regime maps are installed in the various safety analysis codes such as RELAP5, TRACT, and COBRA/TRAC. - Flow regime has been studied by Mandhane (experimentally) and Taitel-Duker (theoretically).
53		Gas natural circulation above water level	H	H	H	L	K	- Gas natural circulation is a major mechanism to remove decay heat from the fuel rod, molten core or debris in the core region. - Eventually this flow impacts the temperature distribution and starting time for core melting in the core region. - Thus this phenomenon should be 'High' until most of the molten core moves to the lower head or pedestal.	- The natural circulation flow rate can be assessed by evaluating temperature distribution and density difference for the gaseous phase and heat transfer rate from the fuel rods or molten core with general natural heat transfer correlations.
54		CCFL at upper tie plate	M	M	L	L	K	- CCFL at the upper tie plate could limit the safety injection from the core upper region (e.g. core spray, condensed flow). - In the Fukushima accident progression, core spray started working much later than core melting. Thus the importance for the CCFL is not so high. - Eventually the importance is set to 'Medium' on the basis of CCFL due to gas stratification until the 2nd phase. The importance is lowered after the molten core has relocated.	- CCFL has been considered especially in the LOCA analyses. This phenomenon is modeled in various safety analysis codes such as TRACT, RELAP5, and COBRA/TRAC. - These models are basically derived from Wallis or Kutateladze correlations. - CCFL at the upper tie plate was evaluated in the Toshiba's ESTA experiment. This experiment was used to validate the CCFL model including above correlations in the TRACT code.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
55	Core	CCFL at bypass region	M	M	L	L	K	- CCFL at the bypass region could limit the safety injection from the core upper region (e.g. core spray, condensed flow). - CCFL may influence the bypass flow when the lower plenum flashing occurs. In the Fukushima accident, depressurization rate is not as rapid as the flashing may happen. - Eventually the importance is set to 'Medium' on the basis of CCFL due to gas stratification until the 2nd phase. The importance is lowered after the molten core has relocated.	- CCFL has been considered especially in the LOCA analyses. This phenomenon is modeled in various safety analysis codes such as TRACT, RELAP5, and COBRA/TRAC. - These models are basically derived from Wallis or Kutateladze correlations.
56		CCFL at core inlet	L	L	L	L	K	- CCFL at the bypass region could limit the safety injection from the core upper region (e.g. core spray, condensed flow). - CCFL may influence the core inlet flow when the lower plenum flashing occurs. In the Fukushima accident, depressurization rate is not as rapid as the flashing may happen. - In the Fukushima accident progression, core spray started working much later than the core degradation and water level decline was much slower than the typical LOCA conditions.	- CCFL has been considered especially in the LOCA analyses. This phenomenon is modeled in various safety analysis codes such as TRACT, RELAP5, and COBRA/TRAC. - These models are basically derived from Wallis or Kutateladze correlations.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
57	Core	Changes in gas composition in core region	M	M	L	L	P	- Gas composition may have impact on core temperature change by steam condensation degradation behavior. - In the Fukushima accident, safety injection did not work and heat transfer from the fuel rods or molten core to the gas phase is a major heat removal path, and steam condensation is not expected to occur. - Thus, the importance level is 'Medium' for the 1st and 2nd phase, considering only the influence of gas composition on the heat transfer rate to the gas phase, rather than condensation.	- Candidate gas components that could exist in the core region during the accident and their source are known, as is described in the 'Phenomena Description' column. - But the fraction of each component and its changing behavior depend largely on the accident progression with some uncertainties.
58		Changes in gas spatial distribution in core region	M	M	L	L	K	- Since spatial distribution for each gas components could change gas circulation flow in the core region with different elevations, core temperature is influenced indirectly. - It may also change local heat transfer rate from the fuel rods or debris, but the changing rate is probably not larger than that for other factors, such as gas natural circulation flow or 2-phase level changes. - Thus the importance level is 'Medium' for the 1st and 2nd phase. Influences on the lower head corium temperature and the containment system responses are smaller and indirect.	- Spatial distribution for each gas component can be evaluated by the fluid dynamics and diffusion equations - Note that the release rate and source position for each component depend largely on the accident progression with some uncertainties, as described above.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
59	Core	Changes in gas mixture properties in core region	M	M	L	L	K	- Local heat transfer rate from the fuel rods or debris may be influenced by the mixture properties, but the changing rate is probably not larger than that for other factors, such as gas natural circulation flow or 2-phase level changes. - Thus the importance level is 'Medium' for the 1st and 2nd phase. Influences on the lower head corium temperature and the containment system responses are smaller and indirect.	- Properties for gas mixture can be evaluated once fraction for each component is determined. - Note that the gas composition depend largely on the accident progression with some uncertainties, as described above.
60		Changes in the amount of residual burnable poisons	L	L	L	L	K	-Thermal properties of fuel pellets depend on the amount of residual burnable poison. However, the amount of residual burnable poison is one of the factors that influence the thermal properties fuel pellet and it is minor.	-Changes in the amount of residual burnable poisons are calculated in neutronics codes for fuel and core design.
61		Changes in properties of fuel materials	M	M	L	L	K	-Although the changes or uncertainties for fuel rod properties mentioned here may not be neglected during the fuel rod heat-up and melting sequence, the influence on the behaviors is not so large as other thermal-hydraulic phenomena. Thus the importance is set 'medium' up to the 2nd phase.	-Changes in properties of fuel materials are well modeled in fuel performance codes, transient codes and safety analysis codes based on sufficient data base.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
62	Core	Changes in properties of core internals	L	M	M	L	K	- The property changes in the core material have less influence on the core temperature change than other factors such as water level and coolant flow rates. - After fuel rods start to melt, the thermal properties for the core materials have more influence to determine the core melting speed, though not critical.	- Properties for core material mixture can be evaluated once fraction for each component is determined. - Note that the composition (especially after core has melted) depends largely on the accident progression with some uncertainties.
63		Zr-Water reaction including oxidation and hydrogen production	H	H	M	L	P	-The heat generation from oxidation of Zr is one of the main heat sources to heat up the core in loss of coolant accident. -When oxidation of Zr is almost completed after the melting phase, the effect of the Zr-water reaction is less important.	-Zr-water reaction is investigated well in LOCA study (Halden project). The reaction rate is calculated by using Baker-Just equation. -However, influence by atmosphere such as partial pressures of oxygen, hydrogen and nitrogen on the oxidation is not known.
64		SUS-Water reaction including oxidation and hydrogen production	M	M	L	L	K	- Steel oxidation may contribute to the total hydrogen production, resulting in the gas natural convection in the 1st and 2nd phase. But the amount of hydrogen is expected to be smaller than that by the Zr-water reaction, as Zr is more contained in the core region and steel tends to melt earlier. - The reaction heat also contributes to the core heat-up. This is also less than that for Zr-water reaction. - Thus the importance level is set 'Medium' for the 1st and 2nd phase.	- Steel-water (steam) reaction can be represented by a simple chemical equation. The reaction heat is also well-known - Reaction speed can be generally assessed by the Arrhenius formulation. Steel corrosion mechanism has been also extensively studied in material science. - MAAP code adopts ANL data to evaluate the steel-water reaction.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
65	Core	Reaction between water (steam) and other substances (e.g. B4C in BWR core), including heat generation and hydrogen production	M	M	L	L	P	- B4C oxidation may contribute to the total hydrogen production, resulting in the gas natural convection in the 1st and 2nd phase. But the amount of hydrogen is expected to be smaller than that by the Zr-water reaction, as Zr is more contained in the core region and control rods that contain B4C tends to melt earlier. - The reaction heat also contributes to the core heat-up. This is also less than that for Zr-water reaction. - Thus the importance level is set 'Medium' for the 1st and 2nd phase.	- The number of experiments for B4C oxidation is limited (COLOSS project). - SNL conducted the DF-4 experiment, in which a control rod including B4C are heated and melted. CORA and QUENCH experiments also include B4C as a control rod material in the test sections.
66		Heat transfer between water(liquid phase) and corium	N/A	H	H	M	P	- Heat transfer rate from corium to water should be very large, - The contact between corium and water is instantaneous, as corium immediately cools down and crust will be generated on the surface. - Thus the heat transfer from corium to water determines corium mobility and crust generation. The importance level should be 'High' for the 2nd and 3rd phase.	- Heat transfer rate can be calculated by standard correlations once corium shape and thermal boundary conditions are determined. - Since corium shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and surface area, resulting in uncertainties in the selection of the appropriate correlation for evaluation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
67	Core	Heat transfer between gaseous phase and corium	N/A	H	H	H	P	- Heat transfer from corium to gaseous phase is a major heat removal process. It contributes largely to the molten core temperature change and melt progression. It also impacts the gas temperature change at the same time. - Thus the importance level should be 'High' after fuel rods have started to melt. - Heat transfer to gas would be important even in the 4th phase, since this is one of the major heat sources for the gaseous phase that could be released into the containment.	- Heat transfer rate can be calculated by standard correlations once corium shape and thermal boundary conditions are determined. - Since corium shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and surface area, resulting in uncertainties in the selection of the appropriate correlation for evaluation.
68		Heat transfer between fuel cladding and corium	N/A	H	H	L	P	- Heat transfer from corium to fuel cladding is an essential process to melt intact fuel rods and bring them into growing molten core. - After the core has relocated to the lower head, most of fuel cladding has melted and the phenomenon will be diminished. - Thus the importance level is set 'High' for the 2nd and 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once corium contact area to fuel cladding is determined. - Since corium shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to the fuel cladding, resulting in uncertainties in the appropriate formulation.
69		Heat transfer between control rods and corium	N/A	H	H	L	P	- Heat transfer from corium to control rods is an essential process to melt and bring them into growing molten core. - After the core has relocated to the lower head, most of control rods have melted and the phenomenon will be diminished. - Thus the importance level is set 'High' for the 2nd and 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once corium contact area to control rods is determined. - Since corium shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to the control rods, resulting in uncertainties in the appropriate formulation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
70	Core	Heat transfer between channel boxes and corium	N/A	H	H	L	P	- Heat transfer from corium to channel boxes is an essential process to melt and bring them into growing molten core. - When the channel boxes melt, corium can flow into the bypass region. This flow path is also important to the melting progression. - After the core has relocated to the lower head, most of channel boxes have melted and the phenomenon will be diminished. - Thus the importance level is set 'High' for the 2nd and 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once corium contact area to channel boxes is determined. - Since corium shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to the channel boxes, resulting in uncertainties in the appropriate formulation.
71		Heat transfer between core shroud and corium	N/A	H	H	L	P	- Heat transfer from corium to the shroud wall is an essential process to melt the wall. - When the shroud wall melts, molten core can flow out of the core region to the downcomer. This flow path is critical to the melting progression and the evaluation of core debris distribution. - After the core has relocated to the lower head, the phenomenon will be diminished. - Thus the importance level is set 'High' for the 2nd and 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once corium contact area to the shroud wall is determined. - Since corium shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to the shroud wall, resulting in uncertainties in the appropriate formulation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
72	Core	Heat transfer between water rods (or channels) and corium	N/A	M	M	L	P	- Heat transfer from corium to water rods is an essential process to melt and bring them into growing molten core. - However the amount of water rods is smaller than other structures such as fuel rods, channel boxes and control rods. - After the core has relocated to the lower head, the phenomenon will be diminished. - Thus the importance level is set 'Medium' for the 2nd and 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once corium contact area to water rods is determined. - Since corium shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to water rods, resulting in uncertainties in the appropriate formulation.
73		Heat transfer between water (liquid phase) and particulate corium	N/A	H	H	M	P	- Since some of fuel assemblies collapse and turn into loose parts or debris before melting, this is an important process to form the molten core pool. - Since heat transfer from debris to water could delay the molten core growth, it should be considered in core melting phases.	- Heat transfer rate from particulate corium to water can be partly predicted by the correlations with porous media. - In reality, particulate corium distribution, accumulation and property variations have some uncertainties and are not uniform as modeled.
74		Heat transfer between gaseous phase and particulate corium	N/A	H	H	H	P	- Since some of fuel assemblies collapse and turn into loose parts or debris before melting, this is an important process to form the molten core pool. - Since heat transfer from debris to gas is a main heat removal path for particulate corium and debris, it should be considered in core melting phases. - Heat transfer to gas would be important even in the 4th phase, since this is one of the major heat sources for the gaseous phase that could be released into the containment.	- Heat transfer rate from particulate corium to gas can be partly predicted by the correlations with porous media. - In reality, particulate corium distribution, accumulation and property variations have some uncertainties and are not uniform either as modeled.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
75	Core	Heat transfer between fuel cladding and particulate corium	N/A	M	M	L	P	- Since some of fuel assemblies collapse and turn into loose parts or debris before melting, this is an important process to form the molten core pool. - However heat transfer rate from particulate corium to fuel cladding is not as large as that to gas or water (in reflooding), since the contact area is likely to be smaller due to porosity. - Thus the importance level is set to lower one, 'Medium'.	- Heat transfer rate from particulate corium to intact fuel cladding can be partly predicted once the contact area is determined. - In reality, particulate corium distribution, accumulation and property variations make difficulty in evaluating the contact area between particulate corium and fuel cladding in the accident.
76		Heat transfer between control rods and particulate corium	N/A	M	M	L	P	- Since some of fuel assemblies collapse and turn into loose parts or debris before melting, this is an important process to form the molten core pool. - However heat transfer rate from particulate corium to control rods is not as large as that to gas or water (in reflooding), since the contact area is likely to be smaller due to porosity. - Thus the importance level is set to lower one, 'Medium'.	- Heat transfer rate from particulate corium to intact control rods can be partly predicted once the contact area is determined. - In reality, particulate corium distribution, accumulation and property variations make difficulty in evaluating the contact area between particulate corium and control rods in the accident.
77		Heat transfer between channel boxes and particulate corium	N/A	M	M	L	P	- Since some of fuel assemblies collapse and turn into loose parts or debris before melting, this is an important process to form the molten core pool. - However heat transfer rate from particulate corium to channel boxes is not as large as that to gas or water (in reflooding), since the contact area is likely to be smaller due to porosity. - Thus the importance level is set to lower one, 'Medium'.	- Heat transfer rate from particulate corium to intact channel boxes can be partly predicted once the contact area is determined. - In reality, particulate corium distribution, accumulation and property variations make difficulty in evaluating the contact area between particulate corium and channel boxes in the accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Rationale**	**State of Knowledge**
			1st	**2nd**	**3rd**	**4th**			
78	Core	Heat transfer between core shroud and particulate corium	N/A	L	M	L	P	- Since some of fuel assemblies collapse and turn into loose parts or debris before melting, this is an important process to form the molten core pool. - However heat transfer rate from particulate corium to the shroud wall is not so large as that to gas or water (in reflooding), since the contact area is likely to be smaller due to porosity. - The debris bed is likely to contact to the shroud wall in the 3rd phase, in which the debris bed has grown radially. Thus the importance level is set to 'Medium' in that phase.	- Heat transfer rate from particulate corium to the shroud wall can be partly predicted once the contact area is determined. - In reality, particulate corium distribution, accumulation and property variations make difficulty in evaluating the contact area between particulate corium and the shroud wall in the accident.
79		Heat transfer between water rods (or channels) and particulate corium	N/A	L	L	L	P	- Since some of fuel assemblies collapse and turn into loose parts or debris before melting, this is an important process to form the molten core pool. - However heat transfer rate from particulate corium to water rods is not as large as that to gas or water (in reflooding), since the contact area is likely to be smaller due to porosity. - The number of water rods is also smaller than other structures, thus the importance level is set to 'Low'.	- Heat transfer rate from particulate corium to intact water rods can be partly predicted once the contact area is determined. - In reality, particulate corium distribution, accumulation and property variations make difficulty in evaluating the contact area between particulate corium and water rods in the accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
80	Core	Heat transfer between water(liquid phase) and crust	N/A	H	H	M	P	- Heat transfer rate from crust to water should be large due to boiling. - It could determine heat removal from corium inside and crust thickness growth, influencing the core temperature. - Thus The importance level should be 'High' for the 2nd and 3rd phase.	- Heat transfer rate can be calculated by standard correlations once crust shape and thermal boundary conditions are determined. - Since crust shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and surface area, resulting in uncertainties in the selection of the appropriate correlation for evaluation.
81		Heat transfer between gaseous phase and crust	N/A	H	H	H	P	- Heat transfer from crust to gaseous phase is a major heat removel process during the core uncovery period. It contributes largely to the core temperature change and melting progression. It also impacts the gas temperature change at the same time. - Thus the importance level should be 'High' after fuel rods have started to melt. - Heat transfer to gas would be important even in the 4th phase, since this is one of the major heat sources for the gaseous phase that could be released into the containment.	- Heat transfer rate can be calculated by standard correlations once crust shape and thermal boundary conditions are determined. - Since crust shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and surface area, resulting in uncertainties in the selection of the appropriate correlation for evaluation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
82	Core	Heat transfer between fuel cladding and crust	N/A	M	H	L	P	- Heat transfer from crust to fuel cladding is an important process to determine the crust thickness, resulting in the molten core boundary formation. - When the molten core starts to relocate out of the core region, the size of molten core determined by crust could influence corium relocation rate. - Thus the importance level is set to 'High' for the 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once crust contact area to fuel cladding and thermal boundary conditions are determined. - Since crust shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to the fuel cladding, resulting in uncertainties in the appropriate formulation.
83		Heat transfer between control rods and crust	N/A	M	H	L	P	- Heat transfer from crust to control rods is an important process to determine the crust thickness, resulting in the molten core boundary formation. - When the molten core starts to relocate out of the core region, the size of molten core determined by crust could influence corium relocation rate. - Thus the importance level is set to 'High' for the 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once crust contact area to control rods and thermal boundary conditions are determined. - Since crust shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to the control rods. - These crust shape variations result in uncertainties in the appropriate formulation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
84	Core	Heat transfer between channel boxes and crust	N/A	M	H	L	P	- Heat transfer from crust to channel boxes is an important process to determine the crust thickness, resulting in the molten core boundary formation. - When the molten core starts to relocate out of the core region, the size of molten core determined by crust could influence corium relocation rate. - Thus the importance level is set to 'High' for the 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once crust contact area to channel boxes and thermal boundary conditions are determined. - Since crust shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to the channel boxes. - These crust shape variations result in uncertainties in the appropriate formulation.
85		Heat transfer between core shroud and crust	N/A	M	H	L	P	- Heat transfer from crust to the shroud is an important process to determine the crust thickness, resulting in the molten core boundary formation. - When the molten core starts to relocate out of the core region, the heat transfer from crust to the shroud wall could influence corium relocation rate, especially to the downcomer. - Thus the importance level is set to 'High' for the 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once crust contact area to the shroud wall and thermal boundary conditions are determined. - Since crust shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to the shroud wall. - These crust shape variations result in uncertainties in the appropriate formulation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
86	Core	Heat transfer between water rods (or water channels) and crust	N/A	M	M	L	P	- Heat transfer from crust to water rods may contribute to determination of the crust thickness, resulting in the molten core boundary formation. - The amount of water rods, however, is smaller than other structures such as channel boxes and fuel cladding. - Thus the importance level is set to 'Medium' in the 3rd phase.	- Heat transfer rate can be calculated by standard heat conduction equations once crust contact area to water rods and thermal boundary conditions are determined. - Since crust shape in the core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and contact area to water rods. - These crust shape variations result in uncertainties in the appropriate formulation.
87		Heat transfer between crusts and corium	N/A	H	H	L	P	- Heat transfer from molten core to crust is a major mechanism for corium decay heat removal after crust layer has been formed on the molten core surface. - It determines corium growth as well as crust layer thickness and influences the time for core relocation.	- A natural circulation regime is expected to establish and the heat transfer rate depends on the internal Rayleigh number. - CFD codes may be used to evaluate corium natural convection and heat transfer at the interface, even if the regime could be changing according to the accident progression.
88		Heat transfer between core support plate and corium	N/A	H	H	L	P	- Heat transfer from corium to core support plate is a major process to heat up and ablate the plate steel. - Thus it could determine the time for initiation of molten core relocation out of the core region.	- Heat transfer rate can be calculated by standard heat conduction equations once corium contact area to the core support plate and thermal boundary conditions are determined. - Since corium contact to the core support plate depends largely on accident progression and complex geometries, it is difficult to predict the exact contact area. - These variations result in uncertainties in the appropriate formulation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
89	Core	Heat transfer between core support plate and crusts	N/A	H	H	L	P	- Heat transfer from crust to core support plate is an important process to heat up and ablate the plate steel. - It could change the area for relocation path and determine the relocation rate out of the core region.	- Heat transfer rate can be calculated by standard heat conduction equations once crust contact area to the core support plate and thermal boundary conditions are determined. - Since crust contact to the core support plate depends largely on accident progression and complex geometries, it is difficult to predict the exact contact area. - These variations result in uncertainties in the appropriate formulation.
90		Heat transfer between core fuel support coupling and corium	N/A	H	H	L	P	- If heat transfer rate is high, corium flowing into the fuel support coupling will be solidified, blocking the flow path to the lower head. - Thus the heat transfer from corium to the fuel support coupling determines the core relocation path and the relocation rate in the 2nd and 3rd phase.	- Heat transfer from corium to fuel support coupling was indirectly evaluated in the XR-2 experiment at SNL, in which the corium relocation through the fuel support coupling was experimented. - The results that considerable corium passed through the test coupling and accumulated on the fuel can below indicates the heat transfer rate is not so large enough to freeze corium inside the coupling.
91		Radiation heat transfer among fuel rods	H	H	L	L	K	- Before fuel rods are damaged, radiation heat transfer is a main heat removal mechanism from fuel rods under uncovered conditions. - After fuel rods collapsed the heat radiation among the fuel rods decreases along with the number of the intact fuel rods. - Thus the importance level is high for up to the 2nd phase.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of intact fuel rods are known clearly. - Radiation heat transfer is considered in various DBA safety analysis codes such as TRACT and SAFER. It is also considered in the MAAP and MELCOR code.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
92	Core	Radiation heat transfer between channel boxes and fuel rods	M	M	L	L	K	- Before fuel rods are damaged, radiation heat transfer is a main heat removal path from fuel rods under uncovered conditions. - Since the surface area for channel boxes facing to the heated fuel rods is smaller than that among fuel rods themselves, the importance level is set to lower. - After fuel rods collapsed the heat radiation among the fuel rods decreases along with the number of the intact ones.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of intact fuel rods and channel boxes are known clearly. - Radiation heat transfer is considered in various DBA safety analysis codes such as TRACT and SAFER. It is also considered in the MAAP and MELCOR code.
93		Radiation heat transfer between water rods (or water channels) and fuel rods	L	M	L	L	K	- Since the surface area for water rods facing to the heated fuel rods is smaller than that among fuel rods themselves, the importance level is lower than the radiation to other structures. - In the Fukushima accident, the core spray did not work and radiation heat transfer rate to the water rods was not so large, since the temperature for water rods is expected to be immediately close to that for fuel cladding. - After fuel rods collapsed the heat radiation among the fuel rods decreases along with the number of the intact ones.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of intact fuel rods and water rods are known clearly. - Radiation heat transfer is considered in various DBA safety analysis codes such as TRAC and SAFER. It is also considered in the MAAP and MELCOR code.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
94	Core	Radiation heat transfer among channel boxes	M	M	L	L	K	- When fuel assemblies keep their shape, radiation heat transfer among channel boxes is a main mechanism for heat transfer from one assembly to another. - Although this is not direct heat transfer from fuel rods or corium, it has some influence on the fuel temperature changes. Thus the importance level is medium for the 1st and 2nd phase. - After fuel assemblies collapsed, the heat radiation among the channel boxes decreases along with their number.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of intact channel boxes are known clearly. - Radiation heat transfer is considered in various DBA safety analysis codes such as TRAC and SAFER. It is also considered in the MAAP and MELCOR code.
95		Radiation heat transfer between channel boxes and core shroud	M	M	L	L	K	- When fuel assemblies keep their shape, radiation heat transfer is a main mechanism for heat transfer from the core region to the shroud wall. - Although this is not direct heat transfer from fuel rods or corium, it has some influence on the fuel temperature changes. Thus the importance level is medium for the 1st and 2nd phase. - After fuel assemblies collapsed, the heat radiation from the channel boxes decreases along with their number.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of intact channel boxes and the shroud wall are known clearly. - Radiation heat transfer is considered in various DBA safety analysis codes such as TRAC and SAFER. It is also considered in the MAAP and MELCOR code.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
96	Core	Radiation heat transfer between control rods and core shroud	L	M	L	L	K	- Since the surface area for control rods facing to the shroud wall is smaller than that for channel boxes, radiation heat transfer from control rods to the shroud wall is less important. - After control rods collapsed, the radiation heat from decreases along with their number.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of intact control rods and the shroud wall are known clearly. - Radiation heat transfer is considered in various DBA safety analysis codes such as TRAC and SAFER. It is also considered in the MAAP and MELCOR code.
97		Radiation heat transfer between control rods and channel boxes	H	M	L	L	K	- When fuel assemblies keep their shape, radiation heat transfer is a main mechanism for heat transfer from the core region to the shroud wall. - Although this is not direct heat transfer from fuel rods or corium, it determines the initiation of control rod melting, which results in the influence on the initiation for fuel rod melting. Thus the importance level is high for the 1st phase. - After fuel assemblies collapsed, the radiation heat decreases along with their number.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of intact control rods and channel boxes are known clearly. - Radiation heat transfer is considered in various DBA safety analysis codes such as TRAC and SAFER. It is also considered in the MAAP and MELCOR code.
98		Radiation heat transfer between corium and shroud	N/A	H	H	L	P	- The shroud wall could fail due to the radiation heat from corium. It could determine the initiation for the molten core relocation to the downcomer region. - Thus the importance level is set to 'High'	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of corium depend largely on the accident progression. - The corium surface area facing to the shroud also has some uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
99	Core	Radiation heat transfer between crusts and shroud	N/A	M	M	L	P	- The shroud wall could fail due to the radiation heat from crust. It could determine the progression for the molten core relocation to the downcomer region. - Since the crust surface temperature is lower than corium, the importance level is set to 'Medium', lower than for corium.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of crust depend largely on the accident progression. - The crust surface area facing to the shroud also has some uncertainty.
100		Radiation heat transfer between particulate corium and shroud	N/A	M	M	L	P	- The shroud wall could fail due to the radiation heat from particulate corium. It could determine the progression for the molten core relocation to the downcomer region. - Since the particulate corium surface temperature is lower than corium, the importance level is set to 'Medium', lower than for corium.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The distribution of particulate corium depends largely on the accident progression. - The particulate corium bed's equivalent surface area facing to the shroud also has some uncertainty, even if it can be evaluated roughly by assuming a simple distribution shape.
101		Radiation heat transfer between corium and core support plate	N/A	H	H	L	P	- The radiation heat from corium to the core support plate could contribute to the support plate failure, resulting in the initiation for corium relocation. - Thus the importance level is set to 'High'.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of corium depend largely on the accident progression. - The corium surface area facing to the core support plate also has some uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
102	Core	Radiation heat transfer between crusts and core support plate	N/A	M	M	L	P	- The radiation heat from crust to the core support plate could contribute to the support plate failure, resulting in the initiation for corium relocation. - Since the temperature on the crust surface is lower than corium, the importance level is set to 'Medium'.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometries of crust depend largely on the accident progression. - The crust surface area facing to the core support plate also has some uncertainty.
103		Radiation heat transfer between particulate corium and core support plate	N/A	L	L	L	P	- Particulate corium, especially 'loose parts' is likely to accumulate above the molten core, according to the observation in the TMI-2 accident. - Therefore fraction of particulate corium facing directly to the core support plate is small. The importance level is set to 'Low'.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The distribution of particulate corium depends largely on the accident progression. - The particulate corium bed's equivalent surface area facing to the core support plate also has some uncertainty, even if it can be evaluated roughly by assuming a simple distribution shape.
104		Fuel pellet expansion（thermal expansion, gas swelling, solid swelling）	M	M	L	L	K	- Fuel pellet swelling gives effects on mechanical and thermal behaviors of fuel rod. Large swelling makes the gap between fuel pellet and cladding narrow. That improves gap conductance.	- Fuel pellet expansion is studied well and modeled in fuel performance code based on PIE data.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
105	Core	FP absorption into fuel pellet	L	L	L	L	P	- The phenomenon of the retaining of FP itself has small impact on the heat-up, melting and the followings in phases discussed here. - It influences thermal properties of fuel pellet in terms of composition change while the fuel pellet composition is separately considered in the other line.	- Most of FPs are retained in fuel pellets as metal or oxide. Chemical form of the FPs in the fuel pellets is known to depend on atmosphere such as oxygen partial pressure. - The chemical form in the fuel pellet under accident condition is not known well.
106		FP release from pellet to gap between fuel pellets and cladding (gap release)	M	M	L	L	P	- FP released from fuel pellet to the free volume (gap) inside fuel rod gives effects on mechanical and thermal behaviors of fuel rod, for example ballooning and degradation of thermal conductivity of gap gas. - After melting, the phenomenon of FP release from fuel pellet to gap has a less importance.	- FP released from fuel pellet to the free volume of fuel rod before rupture is investigated to predict rod internal pressure. It is calculated using fuel performance code based on PIE data. - After rupture, atmosphere in the fuel rod is changed due to water/steam ingress. Chemical form of FP is controlled by atmosphere and then the FP release depends on the chemical form. The effect of atmosphere on the FP release is not known well.
107		FP release from damaged fuel rods to channel region	M	M	L	L	P	- Volatile FP release from the damaged core could change the heat source remained in the fuel rods. - The fraction of heat from gaseous FP is about 10%. It should not be ignored, but not enough to change totally fuel rod melting progression. - Therefore the importance level is set to 'Medium' up to 2nd phase. - Since the 3rd phase, the amount of FP release decreases along with the number of fuel rods keeping their shape.	- Gaseous FP inventory in fuel rods can be evaluated by ORIGEN code, though the calculation is based on the point approximation kinetics. - The amount of gaseous FPs depends on temperature, oxidation conditions, burnup, and fuel types. It is difficult to evaluate all these parameters precisely. - Various experiments have been conducted (e.g. SASCHA, VERCORS, VEGA, and Phebus-FP etc) to evaluate the FP release from fuel rods.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
108	Core	Melting of fuel cladding	N/A	H	H	L	K	- Fuel cladding is one of major components for fuel assemblies, and its melting is a key phenomenon that determines fuel melting and molten core formation. The influence on core enthalpy and importance level is evidently 'High' for the phases related to melting.	- As fuel cladding is basically made from Zr-alloy, the melting point for Zr is known (2100K). - Although Zr in actual fuel cladding changes to ZrO2 much higher melting point than Zr before melting, its behavior has been extensively experimented with CORA, Phebus-FP, PBF-SFD, and QUENCH etc. - Note that eutectic and mixture phase change are referred to independently.
109		Melting of fuel pellet	N/A	H	H	L	K	- Fuel pellets are major components for fuel assemblies, and their melting is a key phenomenon that determines fuel melting and molten core formation. The influence on core enthalpy change and importance level is evidently 'High' for the phases related to melting.	- As fuel pellets are basically made from UO2, the melting point for UO2 is known (about 3100K). - Although UO2 in the actual fuel rods is mixed with FP, the melting behavior for fuel pellets has been extensively experimented with CORA, Phebus-FP, PBF-SFD, and QUENCH etc. - Note that eutectic and phase change for mixture are referred to independently
110		Melting of control rod	N/A	H	H	L	P	- Control rods are major components in the core region, and their melting is a key phenomenon that determines molten core formation. - Actually, control rods would start to melt with much lower temperature than B4C and SS due to chemical interaction (eutectic) before fuel assembly melting, resulting in influence on the initiation for fuel assembly collapse. - Therefore importance level is 'High' for the phases related to melting and relocation.	- As control rods are basically made of B4C and stainless-steel, the melting point for each material is known (about 2700K and 1700K, respectively). -Control rod melting behavior has been experimented with CORA, DF-4, and XR-2 tests, though the control rods were modeled in a sector model, not in full scale. - Although the actual control rod melting point is much lower than each component material, note that eutectic and phase change for mixture are referred to independently.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
111	Core	Melting of channel box	N/A	H	H	L	P	- Channel boxes are major components for fuel assemblies, and its melting is a key phenomenon that determines fuel melting and molten core formation. The influence on core enthalpy and importance level is evidently 'High' for the phases related to melting.	- As fuel cladding is basically made from Zr-alloy, the melting point for Zr is known (2100K). - Channel boxes melting behavior has been experimented with DF-4 and XR2 tests, though the channel boxes were modeled in a sector model, not in full scale. - Although the actual channel box melting point is much lower than normal Zr due to chemical interaction, note that eutectic and phase change for mixture are referred to independently.
112		Melting of spacers	N/A	M	L	L	P	- Although spacer melting behavior may change the overall fuel assembly melting progression through flow path blockage. - However, the total mass of spacers is smaller than other fuel assembly components. - Thus the influence on the core temperature change is relatively small, resulting in the 'Medium' importance.	- There are fewer experiments that consider spacer effects; The Phebus-FP test apparatus includes spacer grids. They model the AFA spacer grids. CORA test bundle also includes grid spacers. - Although the actual channel box melting point is much lower than normal Zr due to chemical interaction, note that eutectic and phase change for mixture are referred to independently.
113		Melting of tie plates	N/A	M	L	L	P	- Although tie plate melting behavior may change the overall fuel assembly melting progression through flow path blockage. - However, the total mass of tie plates is smaller than other fuel assembly components. - Thus the influence on the core temperature change is relatively small, resulting in the 'Medium' importance.	- There are fewer experiments that consider the effects of tie plate geometry; The XR2 test focuses on the lower region for fuel assemblies including tie plates. - Although the actual tie plate melting point is much lower than normal stainless steel due to chemical interaction (eutectic), note that eutectic and phase change for mixture are referred to independently.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
114	Core	Phase changing condition change for core components (including eutectic)	N/A	H	H	M	P	-Since core melting and relocation behavior considerably depends on the phase transformation conditions, this is an important phenomenon to evaluate the core temperature and the molten core relocation in the 2nd and the 3rd phase.	-Simple binary phase diagrams for core materials are studied well in order to predict what phase exists, however multi phase diagrams under the actual condition where a variety of elements exist is partly known, for example from thermodynamic equilibrium calculation. - Oxygen potential also influences the phase-changing behavior.
115		Fuel rod collapse and moving to the lower region	N/A	H	H	L	P	- Fuel rod collapse initiates flow path blockage, heat removal degradation, and results in molten core spatial growth and changes in the core temperature distribution. - It also influences the progression of core relocation to the lower plenum by adding the mass accumulating on the core support plate. Therefore the importance level should be high for the 2nd and 3rd phase.	- Fuel rod collapse has been studied in the experiments such as CORA, Phebus, Sandia DF-4, and QUENCH etc. The fundamental process for fuel rod collapse has been characterized. - A partial or single fuel assembly was modeled in these test apparatus: The number of fuel rods is limited. Fuel rod collapse and moving process for full-scale multiple BWR fuel assemblies including control rods and channel boxes are not experimented.
116		Channel blockage by collapsed fuel rods	N/A	H	M	L	P	- Channel blockage by collapsed fuel rods changes steam flow distribution in the channel region, resulting in the degradation of heat transfer from the damaged fuel. - It facilitates the core melt progression and could initiate the melt relocation.	- Channel blockage has been studied in the experiments such as CORA, Phebus, Sandia DF-4, and QUENCH etc. The fundamental process for fuel rod collapse and blockage has been characterized. - A partial or single fuel assembly was modeled in these test apparatus: The number of fuel rods is limited. The flow path blockage for full-scale BWR fuel assemblies including control rods and channel boxes are not experimented.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
117	Core	Melted fuel 'candling'	N/A	H	M	L	P	- 'Candling' film flow for Zr cladding is a major mechanism for the initial stage of fuel melting progression downward. - The flow rate and contact area with the lower fuel rods determines the pellet collapse and melting initiation through UO2 dissolution. - The importance level for the 2nd phase should be 'High'	- Candling has been studied in the experiments such as CORA, Phebus, Sandia DF-4, and QUENCH etc. The fundamental process to melting progression due to cladding film flow has been characterized. - A partial or single fuel assembly was modeled in these test apparatus: The number of fuel rods is limited. The flow path blockage for full-scale BWR fuel assemblies including control rods and channel boxes are not experimented.
118		Channel and bypass blockage by melted fuel	N/A	H	M	L	P	- Channel and bypass blockage by melted fuel rods changes steam flow distribution, resulting in the degradation of heat transfer from the damaged fuel. - It determines the core melt progression in the radial direction, resulting in the spatial growth of the molten core.	- Channel blockage has been studied in the experiments such as CORA, Phebus, Sandia DF-4, and QUENCH etc. The fundamental process for fuel rod collapse and blockage has been characterized. - Only a part of fuel assemblies, control rods and channel boxes was modeled in these test apparatus: The number of fuel rods is limited. The flow path blockage in full-scale BWR fuel assemblies including the bypass region are not experimented.
119		Corium temperature change	N/A	H	H	L	P	- Corium temperature change is a fundamental phenomenon that determines the core liquefaction, melting progression, molten core spatial growth, and initiation of the relocation to the lower head, - The importance level should be evidently 'High' for the 2nd and 3rd phase.	- Corium temperature change has been extensively studied through various test projects such as CORA, Phebus, and QUENCH etc. - It is thought through the experiments that at 2500-2600K fuel rod can melt, forming the molten core, but measuring the corium temperature directly is difficult.

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No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
120	Core	Formation of molten pool	N/A	H	H	L	P	- Molten pool formation influences the heat transfer characteristics from the melted fuel, and determines the spatial growth, resulting in the initiation of the relocation to the lower plenum.	- Based on the post accident observation of TMI-2, the molten pool was likely to form in the core central region. - Molten core formation was observed in the ACRR-MP tests. - Since the BWR core has more Zr than PWR due to channel boxes, molten pool formation characteristics may be different from that for TMI-2.
121		Natural circulation in molten pool	N/A	H	H	L	P	- Natural circulation in molten pool is a major mechanism for heat removal from the core. It determines molten core spatial growth to the shroud or the core support plate, resulting in the initiation of relocation to the lower plenum	- The natural circulation flow rate can be assessed by evaluating internal Rayleigh number and using the relevant heat transfer correlations. - The uncertainties for the precise molten pool shape and internal temperature distribution remain.
122		Molten core flow out of crust failure	N/A	H	H	L	P	- Molten core flow out of crust failure increases heat transfer rates from the molten core in the 2nd phase, impacting the melting progression. - Molten core flow could also determine the initiation of core relocation to the downcomer or lower plenum, depending on the failure position.	- Based on the post accident observation of TMI-2, the crust remelting and the following core flow is a feasible scenario for the molten core relocation. - Thus the molten core flow due to crust failure can be postulated as one of the accident progression scenario, though it is not studied directly.
123		Corium transverse flow above blocked flowpaths	N/A	H	H	L	P	- Corium transverse flow influences the molten pool radial growth. It could change the surface area of the melted fuel, changing the heat transfer characteristics.	- Corium transverse flow characteristics may be predicted by the post accident observation of TMI-2, in which some of the melted fuel relocation was initiated by the penetration of the molten pool to the peripheral crust layer. - Molten core transverse flow is considered in severe accident codes to simulate molten pool spatial growth.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
124	Core	Corium spatial distribution	N/A	L	H	L	P	- Corium spatial distribution determines the initiation of molten core relocation. Depending on the corium position, the molten core penetrates through the core support plate, or the shroud wall.	- In severe accident codes such as MAAP and MELCOR, the core region is usually nodalized in the radial and axial direction to evaluate molten core distribution. - Since corium distribution in The core region depends largely on accident progression, it is difficult to predict the exact shape including volumes and surface area.
125		Vaporization inside corium (including FP release)	N/A	M	M	L	P	- Vaporization of volatile materials in the molten pool may have influences corium composition. The fraction of materials that could be vaporized is not expected to be large enough to change the melting progression, though it may be important to evaluate the FP inventory in the core region. - Since it might impact molten core natural flow regime, the importance level is set to 'Medium' up to the relocation phase.	- FP volatility was experimented through VERCORS5 tests, illustrating four volatility classes. Volatile and semi-volatile FP materials are expected to remain in the damaged fuel rods, and it is easy to assume that they would vaporize in the core melting phase, though the exact FP composition is not clearly identified.
126		Decay heat generation from corium	N/A	H	H	L	K	- Decay heat from corium is an essential heat source to consider the core melting progression, molten pool spatial growth and relocation out of the core region. - The importance level should evidently 'High' for the melting and relocation phase.	- Decay heat calculation is based on the ANS standard equation, depending on the burnup and operating time. - Various severe accident codes adopt the formulation like the ANS standard to evaluate decay heat from corium. - Calculating the corium decay heat exactly is difficult due to the uncertainty in the corium composition

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
127	Core	Corium-Water reaction (including oxidation and hydrogen production)	N/A	L	H	L	U	- In the core melting phase, there is little water in the core region and the corium-water interaction is not significant. - When the phase changes to the relocation, corium would be exposed to more water or steam, since some of the melted fuel has fallen to the lower plenum and steam would flow from the lower head into the core region. - Water or steam may oxidize the unreacted metal materials in the corium. More hydrogen may be generated, impacting the relocation process. - Thus the importance level is set to 'High ' for the 3rd phase.	- Although the Zr-water interaction has been extensively studied in various test projects, the oxidation or hydrogen production characteristics after fuel rods have melted have never been focused on. - The interaction depends largely on the corium surface condition, composition, shape, and temperature. All these parameters have large uncertainties during the accident progression.
128		Changes in corium properties by mixed composition	N/A	H	H	L	P	- Corium spatial growth behavior, heat transfer rates and initiation of relocation depend largely on the thermodynamic properties. Therefore the importance level should be 'High' for the 2nd and 3rd phase.	- Properties for corium mixture can be predicted by fraction for each component. - Actually the composition depends largely on the accident progression with some uncertainties. Also, the chemical form for each compound makes exact simulation difficult.
129		Crust generation by solidification of corium	N/A	H	H	L	P	- The crust layer on the surface of molten pool determines the heat transfer characteristics from melted fuel to the intact fuel rods or coolant, the molten core spatial growth, and initiation for core relocation. - Thus the crust layer should be considered in the 2nd and 3rd phase.	- Crust generation has been observed in the post-accident investigation for the TMI-2. - There are few experiments that cover the late-phase accident progression including the crust generation. The layer thickness depends largely on the accident progression.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
130	Core	Corium relolcation type through breached core support plate	N/A	N/A	H	M	P	- The relocation type determines the corium flow to the lower plenum and the corium-water reaction rate there, resulting in the influence on the lower head temperature change. - Steam generation rate due to the relocation may also impact the containment pressure change.	- The corium relocation type (jet or slumping) depends largely on the accident progression. - It is determined by the corium contact area to the core support plate, the mass of the corium above the contact area, and the time for initiation of the relocation.
131		Change in ablated area for core support plate	N/A	N/A	H	L	P	- The ablated area change determines the corium relocation flow rates, resulting in the influence on the lower head temperature change.	- The ablating area change should depend largely on corium temperature, the accumulated mass on the core support plate, according to accident progression.
132		Changes in particle corium (debris) composition	N/A	L	L	L	P	- Particulate corium or debris in the core region mainly consists of 'loose parts' and collapsed fuel pellets. - They tend to accumulate above the molten pool, being less likely to react with water in the core melting phase. - Therefore the chemical composition change in the particulate corium has little influence on the core heat transfer or the relocation behavior.	- 'Loose parts' composition change may be predicted by assuming the equivalent shape and surface area to the intact fuel rods and cladding, though the exact prediction is difficult. - Debris composition may also be inferred from the post accident investigation for the TMI-2 core region.
133		Changes in particle corium shape and size	N/A	L	L	L	P	- Particulate corium or debris in the core region mainly consists of 'loose parts' and collapsed fuel pellets. - The particle size in the core region is larger than what reacted in the lower plenum. The heat transfer rates and impact on the core relocation process is not as large as the molten pool. - Since they also tend to accumulate above the molten pool, the influence on the relocation process is small.	- Debris shape and size distribution may be inferred from the post accident investigation for the TMI-2 core region.

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No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
134	Core	Particulate corium (debris) relocation	N/A	L	M	L	P	- Although some debris may relocate out of the core region, its mass fraction and impact on the vessel temperature change is not as large as the molten pool relocation. - Thus the importance level is set to 'Medium' for the 3rd phase.	- Based on the post accident investigation for the TMI-2, it is found that some debris had relocated to the lower head. - Relocation behavior may be different between BWR and PWR, resulting in the uncertainties.
135		Particle corium non-uniform distribution	N/A	L	L	L	P	- Since particulate corium tends to accumulate on the upper surface of the molten core, the effect of accumulation shape on the downward melting progression is small. - Since the debris relocation also has little impact on the vessel temperature change, the debris non-uniform distribution is also not important.	- Particulate corium non-uniform distribution can be observed by the post accident investigation for the TMI-2, though there may be some difference from the Fukushima accident, a BWR severe accident.
136		Crust formation on fuel cladding	N/A	M	M	L	P	- Crust on the cladding surface may change the heat transfer rate from the fuel rods in the early phase. - Since the crust layer on the surface of the molten pool will eventually be formed in the core central region in the melting phase, the local crust on the fuel cladding becomes less important for the overall core temperature change and relocation behavior. - The importance level results in 'Medium'.	- Local crust formation was observed in some fuel degradation tests such as QUENCH.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
137	Core	Void generation inside crust	N/A	M	M	L	P	- Void in the crust layer may change the equivalent density and thermal conductivity. - Since the void fraction is not expected to be large, the sensitivity to the core heat transfer is limited. - The importance level is set to 'Medium', lower than for the crust composition.	- Volatile and semi-volatile FP or other volatile materials are expected to form voids in the crust layer, though the exact composition is not clearly identified.
138		Water flow around crust	N/A	M	M	L	P	- When the crust layer is formed, the channel flow path has collapsed. In this condition, the heat removal from the crust layer is close to pool boiling as long as the crust is covered with water. - Thus the evaluation for detailed water flow regime around the crust surface is not as important as the water level evaluation. The importance level should be 'Medium'	- Crust generation has been observed in the post-accident investigation for the TMI-2. - There are few experiments that cover the late-phase accident progression including the crust cooling with water. LOFT-FP and PBF-SFD tests include the water cooling phase.
139		Gaseous flow around crust	N/A	M	M	L	P	- The heat transfer rate for the natural circulation can be predicted by the temperature and density difference, without knowing the detailed flow rate. - Thus the importance for the gas flow around the crust layer is set to 'Medium'.	- Crust generation has been observed in the post-accident investigation for the TMI-2. It is a reactor-scale reference for the crust cooling down. - There are a few experiments that cover the late-phase accident progression: Phebus FP, ACRR, LOFT-FP and PBF-SFD.
140		Formation of crust crack	N/A	M	M	L	P	- Crack on the crust layer may change the thermal conductivity for the crust layer. - The influence on the core temperature change is not so large, as long as the molten core is kept inside the crust layer.	- Crust has been observed in the post-accident investigation for the TMI-2. It is a reactor-scale reference for the crust cooling down. - There are a few experiments that cover the late-phase accident progression: Phebus FP, ACRR, LOFT-FP and PBF-SFD.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
141	Core	Crust temperature change	N/A	M	M	L	P	- Since the crust has solidified and could not move from the core region, its temperature change is not as critical as that for corium, which determines the molten pool growth and relocation. - The crust temperature determines, however, the layer remelting, followed by the corium flow out of the molten pool.	- Crust has been observed in the post-accident investigation for the TMI-2. It is a reactor-scale reference for the crust cooling down. - There are a few experiments that cover the late-phase accident progression: Phebus FP, ACRR, LOFT-FP and PBF-SFD.
142		Changes in crust properties by mixed composition	N/A	M	M	L	P	- Crust thermal properties may change the temperature change, heat transfer rate from the crust layer, though it is not critical as corium to evaluate the molten pool spatial growth and relocation. - The crust thermal properties influence indirectly the layer remelting.	- Properties for crust layer can be predicted by fraction for each component, as it is for corium. - Actually the composition depends largely on the accident progression with some uncertainties. Also, the chemical form for each compound makes exact simulation difficult.
143		Crust-Water reaction (including oxidation and hydrogen production)	N/A	M	M	L	P	- In the core melting phase, there is little water in the core region and the corium-water interaction is not significant. - Although some metal components on the surface of the crust layer may react with water or steam, the oxidation is limited on the layer surface, the influence on the core temperature and relocation behavior is not very large.	- Although the Zr-water interaction has been extensively studied in various test projects, the oxidation or hydrogen production characteristics after fuel rods have melted have never been focused on. - The interaction depends largely on the corium surface condition, composition, shape, and temperature. All these parameters have large uncertainties during the accident progression.

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Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Rationale**	**State of Knowledge**
			1st	**2nd**	**3rd**	**4th**			
144	Core	Water flow into crust	N/A	M	M	L	P	- Water flow into crust cracks may facilitate the heat transfer from the crust layer, but the surface area for the crack should be small and the effect is limited.	- Water ingression into the crust crack may be evaluated by the way similar to the corium heat transfer to water in the pedestal.
145		Crust remelting due to change in the heat transfer status to corium or water	N/A	H	H	L	P	- The mass of remelted crust and resulting 'break' area determines the molten pool spatial growth. Thus the remelting changes the core temperature distribution. - Crust remelting could initiate the process of the molten core relocation.	- Crust remelting may be assessed by calculating the heat transfer from corium and crust temperature. - Actually it is difficult to predict the exact crust melting point, depending on the crust composition,
146		Particulate corium remelting due to change in the heat transfer status	N/A	H	H	L	P	- Particulate debris remelt could add the mass of the molten pool, resulting in its spatial growth and the molten core relocation out of the core region.	- Debris remelting may be assessed by calculating the heat transfer from corium and debris bed temperature. - Actually it is difficult to predict the exact debris melting, due to the uncertainty in composition and porosity,
147		Decay heat generation from crust	N/A	M	H	L	P	- Decay heat from crust is an important heat source to consider the crust condition, though the temperature is lower than that of the molten pool. - It could determine the crust remelting in combination with the heat transfer from the molten pool inside it, resulting in the molten core relocation.	- Decay heat calculation is based on the ANS standard equation, depending on the burnup and operating time. - Various severe accident codes adopt the formulation like the ANS standard to evaluate decay heat from corium. - Calculating the crust decay heat exactly is difficult due to the uncertainty in the crust composition.
148		Molten core re-criticality	N/A	H	H	L	P	- The re-critical condition is highly unlikely to occur. However the impact would be large and the feasibility cannot be denied perfectly. Then this item should be kept in the phenomena list.	- The recriticality may be evaluated by some fuel design codes or transient analysis codes if a simple shape is assumed for the molten pool or debris. - FP with short half-life can be a tracer material to determine the re-criticality.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
149	Core	Molten core reflooding by injection restart	N/A	H	M	M	K	- Molten core reflooding could change its temperature immediately, influencing the molten pool growth and crust layer formation. - Therefore the importance level is set to 'High' for the 2nd phase. After the molten core started to relocate, the mass of the melted fuel is decreasing, and the importance level should be lowered.	- Note that the state of knowledge is set to 'known', since the reflooding itself can be judged only by whether the water level is above the molten pool or not.
150		FP deposition on core internals	L	L	M	L	P	- FP deposition on the core internal has less influence on the core temperature change than the molten pool. - Since the temperature of gaseous FP in the core is still high, it is hard to deposit on the surface in the core region, and the FP tends to flow upward.	- According to the Sehgal's book, FP aerosols are likely to deposit on structure surfaces as they cool down. Thus the deposition process is inferred through the basic aerosol theories. - Brownial diffusion, thermophoresis, sedimentation are main processes for deposition.
151		FP re-vaporization	L	L	M	L	P	- The effect of FP re-vaporization on the core temperature change is smaller than that of the molten core and fuel rod temperature changes.	- FP volatility was experimented through VERCORS5 tests, illustrating four volatility classes. - The fraction of each class in the Fukushima accident should be further studied.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
152	Core	Decay heat generation from FP	L	L	M	L	P	- Since the contribution of gaseous FP decay heat to the core temperature change is smaller than that of the molten pool and fuel rods, the importance level should be set lower.	- Decay heat generation can be predicted by FP inventory in the shroud head. - FP inventory can be evaluated by ORIGEN code, though the calculation is based on the point approximation kinetics. - The amount of deposited FPs depends on temperature, oxidation conditions, burnup, fuel types, and surface conditions. It is difficult to evaluate all these parameters precisely.
153		FP reaction including iodine chemistry	L	L	L	L	P	- FP reaction in the shroud head does not influence directly the core enthalpy change. - The impact on the containment system responses is expected to be small, since FP in the shroud head flows upward shortly.	- Although FP chemical form was studied in the OECD workshops in 80 to 90's, RTF project in Canada, Phebus-FP, and OECD/BIP, there are still technical challenges such as gaseous-aerosol reactions.
154		Adsorption and release of gaseous FP	L	L	L	L	P	- Since adsorbed FP mass is expected to be smaller than the mass of fuel rods and molten core, its sensitivity to the core temperature change and relocation behavior should be small.	- Although FP chemical form was studied in the OECD workshops in 80 to 90's, RTF project in Canada, Phebus-FP, and OECD/BIP, there are still technical challenges such as gaseous-aerosol reactions.
155		Corium jet through breached core support plate	N/A	N/A	H	M	P	- Corium jet characteristics determine the relocation behavior, resulting in the impact on the temperature change in the lower head.	- Corium jet is considered as one of the important relocation paths to the lower head, and modeled in severe accident codes such as MAAP and MELCOR. - Modeling is based on the post accident investigation for the TMI-2, though there is difference from the Fukushima accident.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
156	Core	Corium flow into control rod guide tubes through breached fuel support coupling	N/A	N/A	H	L	P	- Since the BWR fuel assemblies are supported by the control rod guide tubes, the corium flow into the guide tubes may impact their integrity, possibly resulting in the molten pool slumping.	- Whether the corium flows into the control rod guide tube or not depends on the corium temperature, viscosity, and the control rod velocity limiter that forms the narrow flow paths between the control rods and the guide tubes. - Core relocation mechanism for BWR fuel assemblies has been experimented in the XR-2 tests, though they are conducted in a scale model with electric heating.
157		Corium flow to the downcomer through breached core shroud	N/A	N/A	H	L	P	- Core flow to through the shroud impacts significantly on the vessel temperature change and the may delay the time for corium reaching the lower head, since the relocation path is totally different from the path through the core support plate or couplings to the lower head.	- Based on the post accident investigation for the TMI-2, The corium might have flowed through the core peripheral region. - Although the BWR shroud geometry is different from the PWR core bypass region, the observation indicates that the molten core might penetrate through the shroud and flow to the downcomer.
158		Corium flow out of the core Inlet orifice	N/A	N/A	H	L	P	- Whether the molten core in the core support coupling could flow out of the inlet orifice or not determines the core relocation path and the relocation flow rate. - It evidently influences the vessel temperature change in the lower head.	- Core relocation mechanism including the fuel support coupling and the control rod velocity limiter for BWR fuel assemblies has been experimented in the XR-2 tests, though they are conducted in a scale model with electric heating.
159		Corium solidification inside fuel support coupling	N/A	N/A	H	L	P	- Whether the molten core in the core support coupling could be solidified or not determines the core relocation path and the relocation flow rate. - It evidently influences the vessel temperature change in the lower head.	- Core relocation mechanism including the fuel support coupling and the control rod velocity limiter for BWR fuel assemblies has been experimented in the XR-2 tests, though they are conducted in a scale model with electric heating.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
160	Core	Instrumentation tube break	N/A	M	H	L	P	- Instrumentation tube break initiates gas leakage from the core region, has some influence on the core temperature in the 2nd phase, though the break area is not large. - Instrumentation tube break at the 3rd phase may determine the relocation path, as the instrumentation tubes penetrate the core support plate. - Since the vessel has failed in the 4th phase, the impact on the containment system responses becomes smaller than in the previous phase.	- Based on the accident progression data for the radiation monitor in the TMI-2, the instrumentation tube break was expected to have occurred. - Instrumentation tubes are normally made of stainless steel, lower melting point than the fuel rods (Zr and UO2). They are likely to break before the fuel rod melting. - BWR TIP, or IRM/SRM tubes are a little different from those in the TMI-2, but the similar tube break is probable.
161		Corium flow into instrumentation tube	N/A	M	H	L	P	- Corium flow into breached instrumentation tube break could stop gas leakage and plug the tube. It has some influences on the in-vessel pressure change before the vessel failure, though the break area is not large. - Instrumentation tube break at the 3rd phase would determine the relocation path, as the instrumentation tubes penetrate the core support plate to the lower plenum. The importance level is 'High' for the 3rd phase. - Since the vessel has failed in the 4th phase, the impact on the containment system responses becomes smaller than in the previous phase.	- Based on the accident progression data for the radiation monitor in the TMI-2, the instrumentation tube break was expected to have occurred. - Corium flow followed by the tube plugging due to solidification may be calculated by simple head difference and heat conduction, though the thermal corium properties have some uncertainties.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
162	Core	Water flow into instrumentation tube	N/A	M	M	L	P	- Water flow into instrumentation tube break could stop the tube ablation by heat removal from the tubes. It has some influences on the in-vessel pressure change before the vessel failure, though water would boil up in the tube break. The importance level is 'Medium' for the 2nd and 3rd phase. - Since the vessel has failed in the 4th phase, the impact on the containment system responses becomes smaller than in the previous phase.	- Based on the accident progression data for the radiation monitor in the TMI-2, the instrumentation tube break was expected to have occurred. - Water flow into the tubes may be calculated by a simple head difference and heat conduction, though uncertainties due to 2-phase flow remain.
163		Corium solidification inside instrumentation tube	N/A	M	M	L	P	- Corium solidification could stop the gas leakage through the instrumentation tubes, resulting in some influences on the in-vessel pressure change before the vessel failure, though the tube break area could not be so large as the vessel failure. - Once the corium is solidified, the molten core could not relocate to the lower plenum. The influence on the core temperature is thus less important than the corium flow through the fuel coupling. - Since the vessel has failed in the 4th phase, the impact on the containment system responses becomes smaller than in the previous phase.	- Based on the accident progression data for the radiation monitor in the TMI-2, the instrumentation tube break was expected to have occurred. - The tube plugging due to corium solidification may be calculated by a simple heat conduction equation, though the thermal corium properties have some uncertainties.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
164	Core	Gas leak flow into instrumentation tube	N/A	M	M	L	P	- Gas leakage through instrumentation tubes has some influences on the in-vessel pressure change before the vessel failure, though the break area is not so large as the vessel failure. The importance level is 'Medium' for the 2nd and 3rd phase. - Since the vessel has failed in the 4th phase, the impact on the containment system responses becomes smaller than in the previous phase.	- Based on the accident progression data for the radiation monitor in the TMI-2, the instrumentation tube break was expected to have occurred. - Gas leak flow in the instrumentation tubes may be calculated by pressure difference between in-vessel and ex-vessel, and critical flow models. - The flow area changes tube ablation and gas temperature change should be considered.
165		Water radiolysis	L	L	L	L	K	- Hydrogen and oxygen generation rate is too slow and small to impact on the in-vessel and ex-vessel pressure and temperature changes during the accident progression.	- Hydrogen and oxygen generation due to water radiolysis is proportional to the FP mass and its dacay heat in the liquid phase. - The mass fraction of each FP composition, and the energy fraction of beta and gamma rays necessary to calculate the can be evaluated by ORIGEN code.
166		Seasalt intake to corium	N/A	M	M	M	U	- Seasalt may change the corium composition and mass. Seasalt may react with melted steel, Zr, B4C, UO2 etc, generating reaction heat. It may contribute the molten pool temperature change.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the core degradation with sea water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
167	Core	Seasalt impact for corium thermodynamic properties	N/A	M	M	L	U	- Although the mass of seasalt taken up by corium is smaller than metal or oxides derived from fuel assemblies, the effect of sea salt on the conductivity, specific heat may not be ignored. - Especially, the effect on the phase change should be paid attention, though it is not as large as the eutectic between the materials in fuel assemblies. - Thus the importance level is set to 'Medium' for the 2nd and 3rd phase.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the effect of core thermodynamic properties by sea salt.
168		Seasalt impact for FP reaction and composition	L	L	L	L	U	- Since FP chemical form has little influence on the core temperature change and the containment system responses, due to the small amount of total volatile and semi-volatile FP. the seasalt effects can be ignored.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the seasalt effects on FP reactions and compositions.
169		Corrosion of core Internals by seasalt (including marine lives)	L	L	L	L	U	- Since corrosion effects are expected to develop slowly, the influence on the core temperature from the core degradation to relocation should be small. - Corrosion of the core structures does not have direct influence on the containment system responses. -Thus the impact on the containment system responses in the 4th phase is also expected to be small.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the corrosion effects by sea salt or impurities in the core region. - The production characteristics of gases such as HCl, SOx and H2S, which could corrode metals in the core is also unknown.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
170	Core	Impact of seasalt deposition on heat transfer	M	M	M	L	U	- Since seasalt is expected to deposit on the fuel cladding, directly involved in the heat transfer from fuel rods. Therefore the salt layer may not be ignored - The importance level is set to 'Medium' in the core heat-up up to the relocation phases, as the amount of seasalt is expected to be small.	-Since there is no specific study for the heat transfer change by seasalt, the effect of salt on the temperature change for the fuel cladding, crusts, and core internals remains unknown.
171		Channel (bypass) flowpath blockage by seasalt deposition	L	M	L	L	U	- Since the amount of seasalt transported to the core region is expected to be small, flowpath blockage in the 1st phase is not likely to occur. - In the 2nd phase, some seasalt may segregate due to core uncovery and accumulate especially in the narrow flow paths (e.g spacers and tie plates). - Since the 3rd phase, the flowpaths have been damaged and the impact on the corium temperature change becomes small.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the flowpath blockage effects by sea salt or impurities in the core region.
172		Seasalt dissolution by reflooding	L	M	L	L	P	- If the flowpaths where seasalt is accumulating and blocking the area are reflooded, the seasalt will dissolve into the water and move to the other region. - This may change the flow distribution and the heat transfer characteristics from the damaged core.	- Seasalt solubility is known, though how much the damaged core is reflooded would have some uncertainties.
173		Influence on heat transfer by seasalt concentration change	L	L	L	L	P	- The effect of seasalt concentration on the heat transfer from fuel rods and corium is not so large as seasalt direct deposition. - It also does not have direct impact on the containment system responses.	-The effect of seasalt concentration on the heat transfer can be predicted by the operation experience of heat exchangers in which seawater is used.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
174	Core	Influence on instrumentation and measurements by seasalt concentration change	L	L	L	L	U	- The effect of seasalt on the performance of instrumentation does not have direct influence on the core temperature change and the containment system responses.	-There is no specific study for the effect on performance of instrumentation and measurements by seasalt concentration.
175		Corrosion of core internals by boron	L	L	L	L	U	- Since corrosion effects are expected to develop slowly, the influence on the core temperature in the core degradation and relocation phases should be small. - Corrosion of the core structures does not have direct influence on the containment system responses. -Thus the impact on the containment system responses in the 4th phase is also expected to be small.	- Although the upper head degradation at Davis Besse is known as a typical case due to corrosion by boron, the core internal corrosion with boron is not explicitly studied.
176		Impact of boron deposition on heat transfer	L	L	L	L	U	- Since SLC was not injected in the Fukushima accident, boron may not be deposited until the control rods collapse and boron carbide is released to the channels. - As the amount of boron deposited on the fuel cladding from boron carbide will be small, the importance level should be 'Low' for all phases.	- There are almost no studies or experiments focusing on the influence on heat transfer rate from the fuel cladding by boron, though boron precipitation are considered in the PWR LOCA long term cooling analyses. - The chemical form of boron derived from the control rods remains unknown.
177		Channel (bypass) flowpath blockage by boron deposition	L	L	L	L	P	- Since SLC was not injected in the Fukushima accident, boron is not released to the channles until the core degradation starts. - Even after the control rods have melted, the channel blockage is not so much due to boron only as molten core. - Therefore the importance level should be 'Low' for all phases.	- There are few experiments that cover reflooding with control rods: CORA, PBF-SFD etc.

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
178	Core	Boron dissolution by reflooding	L	L	L	L	P	- Since SLC was not injected in the Fukushima accident, boron re-dissolution is not likely to occur in the heat-up phase. - Even after the control rods have melted, most of boron carbide would be mixed with metals in the molten core. It may not dissolve in the reflooding phase.	- Boron solubility is known, though the deposition conditions and the chemical form have some uncertainties. - There are few experiments that cover reflooding with control rods: CORA, PBF-SFD etc.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale	State of Knowledge
			1st	2nd	3rd	4th			
179	Shroud head	Radiation heat transfer between intact fuel rods and shroud head	M	L	L	L	K	- Before fuel rods are damaged, the distance between the upper region of the rods and the shroud head is shorter. Thus, once the fuel rods are uncovered, the heat transferred to the shroud head may have some impact on the fuel rod temperature. - After fuel rods collapsed the heat radiation from the fuel rods to the shroud head decreases along with the number of the rods.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometry of the shroud head and intact fuel rods are known clearly.
180		Radiation heat transfer between corium and shroud head	N/A	L	L	L	K	- As corium tends to flow downward, the distance to the shroud head become longer. Also the surface area for the corium is smaller than that for the equivalent fuel rods. - Thus radiation heat from the corium to the shroud head is smaller than from the fuel rods.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The surface area for the corium facing the shroud head is expected to be close to the column top area with its diameter equivalent to that for crust.
181		Radiation heat transfer between crust and shroud head	N/A	L	L	L	K	- Since corium tends to flow downward, crust is likely to generate in the lower region of the core. The distance to the shroud head become longer. Also the surface area for the crust is smaller than that for the equivalent fuel rods. - Thus radiation heat from the crust to the shroud head is smaller than from the fuel rods.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The surface area for the crust facing the shroud head is expected to be close to the column top area with its diameter equivalent to that for the crust.
182		Radiation heat transfer between shroud sidewall and shroud head	L	L	L	L	K	- Since the facing area between the shroud sidewall and the shroud head is small, the radiation heat between them has little influence.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometry of the shroud head and the shroud sidewall are known clearly.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
183	Shroud head	Radiation heat transfer between particulate corium and shroud head	N/A	L	L	L	P	- The facing area for the particulate corium toward the shroud head is smaller than that for the intact fuel rods. - The fraction of the particulate corium is also small.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometry and distribution for the particulate corium is not perfectly understood. It would be depending on accident progression conditions.
184		Heat transfer between gas and shroud head	L	L	L	M	K	- Heat transfer between gas and the shroud head does not have direct influence on the fuel rod and corium temperature. - It may have some impact on the temperature change for the gases that could be released into the containment, but the surface area for the shroud head is smaller than the other in-vessel structures such as dryers and separators.	- Although the heat transfer from the shroud head is not directly experimented, it can be assessed through the general natural circulation correlations.
185		Shroud head break or deformation by thermal stress	L	L	L	L	K	- Even if the shroud head fails due to thermal stress, the flow path would connect the shroud upper region with the upper downcomer. This may not impact the overall natural circulation flow characteristics.	- Since the stress-strain characteristics for steel is well-known, the deformation or failure can be assessed by the general FEM methods.
186		Shroud head oxidation with steam including reaction heat and hydrogen production)	L	L	L	L	K	- The surface area for the shroud head that could be oxidized is smaller than the other in-vessel structures. - Oxidation reaction heat does not have direct impact on the core temperature change.	- Steel-water (steam) reaction can be represented by a simple chemical equation. The reaction heat is also well-known

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
187	Shroud head	Gamma ray heat generation in shroud head	L	L	L	L	K	- As the total mass and thickness for the shroud head is not as large as the other in-vessel structures, impact of gamma-ray heat generation inside the shroud head is small.	- Heat generation rate can be evaluated through the energy conservation and gamma ray spectrum analyses.
188		Temperature change in shroud head structure	L	L	L	L	K	- Temperature change in the shroud head does not have direct influence on the fuel rod and corium temperature. - It may have some impact on the temperature change for the gases that could be released into the containment, but the surface area for the shroud head is smaller than the other in-vessel structures such as dryers and separators.	- Temperature change in the shroud head can be evaluated by the heat conduction equation. - The conductivity for the shroud head is based on steel.
189		Droplet spray	N/A	L	L	L	K	- In the Fukushima accident progression, core spray was thought to succeed in working much later than the core relocation, thus the influence on the core temperature change and the containment condition is considered to be small.	- Spray system and flow-rate, droplet size are determined by the design specification. - Droplet size distribution is validated through nozzle tests.
190		Droplet deposition on shroud head structure	N/A	L	L	L	K	- As described above, core spray was not activated during the core degradation, There are few droplets deposited on the shroud head surface. - Even if some droplets are deposited on the surface due to steam condensation, they do not have direct influence on the core temperature change.	- Droplet deposition from the spray nozzles can be assessed by the general lagrangian model with CFD. - Condensed droplets are also able to be tracked by the lagrangian model with CFD.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
191	Shroud head	Condensation heat transfer on shroud head	L	L	L	L	K	- Condensation may influence the shroud head temperature, but it does not have any direct impact on the core temperature. - Since the surface area for the shroud head is smaller than the other in-vessel structures, shroud head condensation also has little influence on the containment.	- Condensation heat transfer can be well evaluated by the general correlation.
192		Pressure change in shroud head	L	M	M	L	K	- Pressure change in the shroud head influences on the pressure difference in the gas upward flow path from the core region to the upper head. - This is related to the core natural circulation that is important to core heat removal. Thus the importance is higher for the core melting and relocation phases.	-Pressure changing behavior in the shroud head has been evaluated in not just a lot of plant licensing analyses but also severe accident analysis codes.
193		Gas flow in shroud head	L	L	L	L	K	- Although gas flow in the shroud head may result from natural circulation in the core, the gas local flow itself in the shroud head has little influences on the core temperature change or containment responses.	- Gas flow in the shroud head can be evaluated with commercial CFD codes with buoyancy.
194		Gas composition change in shroud head	L	L	L	M	K	- Gas composition changes in the shroud head has little influence directly on the core temperature change. - Steam and hydrogen in the shroud head could be released to the containment through potential leak paths or safety release valves, thus the composition may affect containment pressure and temperature changes.	- Gas in the shroud head mostly consists of steam and hydrogen. - Thus the composition change mainly depends on steam condensation and hydrogen production from the core region, though a little gaseous fission products and oxygen due to water pyrolysis could be included.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
195	Shroud head	Gas temperature change in shroud head	L	L	L	M	K	- Gas temperature changes in the shroud head results from core damage. It does not result in the core temperature change. - Gas in the shroud head could be released to the containment through potential leak paths or safety release valves, thus the temperature change in this region may affect containment pressure and temperature changes.	-Gas temperature in the shroud head is usually evaluated for safety analyses for LOCA, and transients, as well as severe accidents.
196		FP deposition on shroud head	L	L	L	L	P	- FP deposition on the shroud head has little influence on the core temperature change, since the heated gas by deposited FP would flow to the upper region. - In addition, the surface area in the shroud head is smaller than the other in-vessel structures.	- According to the Sehgal's book, FP aerosols are likely to deposit on structure surfaces as they cool down. Thus the deposition process is inferred through the basic aerosol theories. - Brownial diffusion, thermophoresis, sedimentation are main processes for deposition.
197		FP re-vaporization	L	L	L	L	P	- Since the surface area in the shroud head is smaller than the other in-vessel structures, the amount of re-vaporized FP will be smaller.	- FP volatility was experimented through VERCORS5 tests, illustrating four volatility classes. - The fraction of each class in the Fukushima accident should be further studied.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
198	Shroud head	Decay heat generation from FP	L	L	L	L	P	- Since the fraction of FP in the shroud head is smaller than other in-vessel structures due to small the small surface area and volume, the decay heat from FP in the shroud head does not directly contribute to the core enthalpy change and containment system responses.	- Decay heat generation can be predicted by FP inventory in the shroud head. - FP inventory can be evaluated by ORIGEN code, though the calculation is based on the point approximation kinetics. - The amount of deposited FPs depends on temperature, oxidation conditions, burnup, fuel types, and surface conditions. It is difficult to evaluate all these parameters precisely.
199		FP leakage from flange between shroud sidewall and head	L	L	L	L	P	- Even if FP leaks from the shroud head to the downcomer, it eventually reaches the upper head and main steam line. The overall flow direction is not changed. - Thus it does not influence directly the core enthalpy change and the containment system responses.	- Once FP inventory in the shroud head, pressure difference, and the leakage path area in the shroud head flange are determined, FP leakage could be predicted. - Actually the FP inventory and leakage path area have some uncertainty.
200		FP reaction including iodine chemistry	L	L	L	L	P	- FP reaction in the shroud head does not influence directly the core enthalpy change. - The impact on the containment system responses is expected to be small, since FP in the shroud head flows upward shortly.	- Although FP chemical form was studied in the OECD workshops in 80 to 90's, RTF project in Canada, Phebus-FP, and OECD/BIP, there are still technical challenges such as gaseous-aerosol reactions.
201		Gas leakage from flange between shroud sidewall and head	L	L	L	L	P	- Even if gas leaks from the shroud head to the downcomer, it eventually reaches the upper head and main steam line. The overall flow direction is not changed. - Thus it does not influence directly the core enthalpy change and the containment system responses.	- Once the pressure difference and leakage path area in the shroud head flange are determined, gas leakage could be predicted. - Actually the leakage path area and pressure loss coefficient have some uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
202	Shroud head	Corrosion of shroud head by seasalt (including marine lives)	L	L	L	L	U	- Corrosion of the shroud head does not have direct influence on the core temperature change and relocation process. - Corrosion effects are expected to develop slowly except a case of extremely high temperature conditions. The surface area for the shroud head is smaller than other in-vessel structures. -Thus the impact on the containment system responses in the 4th phase is also expected to be small.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the corrosion effects on the shroud head by sea salt or impurities under the accident conditions.
203		Influence for heat transfer by salt deposition	L	L	L	L	U	- In the Fukushima accident, the core water level has not yet reached to the shroud head. Therefore only a small amount of sea salt derived from droplets could be deposited on the shroud head. The influence can be ignored.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the influence on heat transfer rate from the shroud head by sea salt or impurities.
204		Spray nozzle blockage by seasalt deposition	L	L	L	L	P	- In the Fukushima accident, the core water level has not yet reached to the shroud head. Therefore only a small amount of sea salt derived from droplets could be deposited on the shroud head. - In addition, core spray did not work during the core relocation to the pedestal, thus the influence on the core temperature change and the containment condition is considered to be small.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the influence on spray nozzle blockage due to sea salt deposition. - The phenomenon could be predicted by general spray nozzle blockages due to deposition.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
205	Shroud head	Re-dissolution of seasalt by reflooding	L	L	L	L	P	- In the Fukushima accident, the core water level has not yet reached to the shroud head. Therefore only a small amount of sea salt derived from droplets could be deposited on the shroud head. - In addition, core spray did not work during the core relocation to the pedestal. Thus the re-dissolution of seasalt on the shroud head can be ignored during the accident progression.	- Seasalt solubility is known, though the salt deposition conditions and the way spray water is dispersed have some uncertainties.
206		Seasalt impact for FP reaction and composition	L	L	L	L	U	- Since FP reaction itself has little influence on the core temperature change and the containment system responses, the seasalt effects can be ignored.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the seasalt effects on FP reactions and compositions.
207		Corrosion of shroud head by boron	L	L	L	L	U	- Corrosion of the shroud head does not have direct influence on the core temperature change and relocation process. - Corrosion effects are expected to develop slowly except a case of extremely high temperature conditions. The surface area for the shroud head is smaller than other in-vessel structures. -Thus the impact on the containment system responses in the 4th phase is also expected to be small.	- Although the upper head degradation at Davis Besse is known as a typical case due to corrosion by boron, the shroud head corrosion with boron has never been explicitly studied.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
208	Shroud head	Influence for heat transfer by boron deposition	L	L	L	L	U	- In the Fukushima accident, the core water level has not yet reached to the shroud head. Therefore only a very small amount of boron derived from control rods and transported by droplets could be deposited on the shroud head. The influence can be ignored.	- There is almost no studies or experiments focusing on the influence on heat transfer rate from the shroud head by boron, though boron precipitation are considered in the PWR LOCA long term cooling analyses.
209		Spray nozzle blockage by boron deposition	L	L	L	L	P	- In the Fukushima accident, the core water level has not yet reached to the shroud head. Therefore only a small amount of boron transported by droplets could be deposited on the shroud head and spray nozzles. - In addition, core spray did not work during the core relocation to the pedestal, thus the influence on the core temperature change and the containment condition is considered to be small.	- There are almost no studies or experiments focusing on the influence on spray nozzle blockage due to boron deposition. - The phenomenon could be predicted by general spray nozzle blockages due to deposition.
210		Re-dissolution of boron by reflooding	L	L	L	L	P	- In the Fukushima accident, the core water level has not yet reached to the shroud head. Therefore little amount of boron derived from control rods could be transported only by droplets. - In addition, core spray did not work during the core relocation to the pedestal. Thus the re-dissolution of boron on the shroud head can be ignored during the accident progression.	- Boron solubility is known, though the deposition conditions and the way spray water is dispersed have some uncertainties.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Rationale**	**State of Knowledge**
			1st	**2nd**	**3rd**	**4th**			
211	Standpipe & Separator	Radiation heat transfer between intact fuel rods and standpipe/separator	L	L	L	L	K	- Since the surface area of standpipe and separators facing the intact fuel rods is small, the influence on the FoM for each phase also should be small.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometry of the standpipe/separator and intact fuel rods are known clearly.
212		Radiation heat transfer between corium and standpipe/separator	N/A	L	L	L	K	- Since the surface area of standpipe and separators facing the corium is small, the influence on the FoM for each phase also should be small.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The surface area of the corium facing the standpipe/separator is expected to be close to the column top area with its diameter equivalent to that for crust.
213		Radiation heat transfer between crust and standpipe/separator	N/A	L	L	L	K	- Since the surface area of standpipe and separators facing the crust is small, the influence on the FoM for each phase also should be small.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The crust surface area facing the standpipe/separator is expected to be close to the column top area with its diameter equivalent to that for the crust.
214		Radiation heat transfer between intact control rod and standpipe/separator	L	L	L	L	K	- Since the surface area of standpipe and separators facing the intact control rods is small, the influence on the FoM for each phase also should be small.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometry of the standpipe/separator and intact control rods are known clearly.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
215	Standpipe & Separator	Radiation heat transfer between shroud structure and standpipe/separator	L	L	L	L	K	- Since the surface area of standpipe and separators facing the shroud structure is small, the influence on the FoM for each phase also should be small.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometry of the standpipe/separator and shroud structure are known clearly.
216		Radiation heat transfer between particulate corium and standpipe(separator)	N/A	L	L	L	P	- Since the surface area of standpipe and separators facing the particulate corium is small, the influence on the FoM for each phase also should be small.	- Radiation heat can be assessed by applying the Stefan Boltzmann's law, represented by the surface areas and temperature of interest. - The geometry and distribution for the particulate corium is not perfectly understood. It would be depending on accident progression conditions.
217		Heat transfer between gas and standpipe/separator	L	L	L	M	K	- Heat transfer between gas and the standpipe/separator does not have direct influence on the fuel rod and corium temperature. - It may have some impact on the temperature change for the gases that could be released into the containment. Therefore the importance level for the 4th phase is set to 'Medium'	- Although the heat transfer from the standpipe/separator is not directly experimented, it can be assessed through the general natural circulation correlations.
218		Standpipe/separator temperature change	L	L	L	L	K	- Temperature change in the standpipe/separator does not have direct influence on the fuel rod and corium temperature, neither on the containment system responses.	- Temperature change in the standpipe/separator can be evaluated by the heat conduction equation. - The conductivity for the standpipe/separator is based on steel.
219		Gamma heat generation in standpipe/separator	L	L	L	L	K	- As the thickness for the standpipe/separator is not thick, gamma rays would pass it through and impact of gamma-ray heat generation inside the standpipe/separator is small.	- Heat generation rate can be evaluated through the energy conservation and gamma ray spectrum analyses.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
220	Standpipe & Separator	Condensation heat transfer on standpipe/separator	L	L	L	L	K	- Condensation may influence the standpipe/separator temperature, but it does not have any direct impact on the core temperature. - Since the core spray was not activated during the core degradation, condensation in the standpipe/separator region is not likely to occur, bringing little influence on the containment system responses.	- Condensation heat transfer can be well evaluated by the general correlation.
221		Pressure change in standpipe/separator	L	M	M	M	K	- Pressure change in the standpipe/separator influences the pressure difference in the gas upward flow path from the core region to the upper head. - This is related to the core natural circulation that is important to core heat removal. Thus the importance is higher after the core degradation.	-Pressure changing behavior in the standpipe/separator has been evaluated in not just a lot of plant licensing analyses but also severe accident analysis codes.
222		Gas temperature change in standpipe/separator	L	L	L	H	K	- Gas temperature changes in the standpipe/separator results from core damage. It does not result in the core temperature change. - Gas in the standpipe/separator could be released to the containment through potential leak paths or safety release valves, thus the temperature change in this region affects containment pressure and temperature changes. Therefore, this phenomenon should be considered in the 4th phase.	-Gas temperature in the standpipe/separator is usually evaluated for safety analyses for LOCA, and transients, as well as severe accidents.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
223	Standpipe & Separator	Gas flow in standpipe/separator	L	L	L	L	K	- Although Gas flow in the standpipe/separator results from natural circulation in the core, it has little direct influences on the core temperature change or containment responses.	- Gas flow in the standpipe/separator can be evaluated with commercial CFD codes with buoyancy.
224		Gas composition change in standpipe/separator	L	L	L	M	K	- Gas composition changes in the standpipe/separator has little influence directly on the core temperature change. - Steam and hydrogen in the standpipe/separator could be released to the containment through potential leak paths or safety release valves, thus the composition may affect containment pressure and temperature changes.	- Gas in the standpipe/separator mostly consists of steam and hydrogen. - Thus the composition change mainly depends on steam condensation and hydrogen production from the core region, though a little gaseous fission products and oxygen due to water pyrolysis could be included.
225		standpipe/separator failure or deformation by thermal stress	L	L	L	L	K	- Even if the standpipe/separator fails due to thermal stress, the flow path would only connect with the upper downcomer. This may not impact the overall natural flow characteristics.	- Since the stress-strain characteristics for steel is well-known, the deformation or failure can be assessed by the general FEM methods.
226		Standpipe/separator oxidation with steam (including reaction heat and hydrogen production)	L	L	L	M	K	- The surface temperature for the standpipe/separator that could be oxidized is lower than the heat-up fuel rods. Therefore the influence on the containment system responses is not as large as in the core region. - Oxidation reaction heat does not have direct impact on the core temperature change.	- Steel-water (steam) reaction can be represented by a simple chemical equation. The reaction heat is also well-known

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
227	Standpipe & Separator	FP deposition on standpipe/separator	L	M	M	H	P	-Since the standpipe/separator surface area would be relatively large in the vessel, FP deposition on the standpipe/separator may have some influence on the core temperature change by influencing the natural circulation. - FP in the standpipe/separator could be a heat source for the gas to be released to the containment.	- According to the Sehgal's book, FP aerosols are likely to deposit on structure surfaces as they cool down. Thus the deposition process is inferred through the basic aerosol theories. - Brownial diffusion, thermophoresis, sedimentation are main processes for deposition.
228		FP re-vaporization	L	M	M	H	P	-Since the standpipe/separator surface area would be relatively large in the vessel, FP re-vaporization on the standpipe/separator may have some influence on the core temperature change by influencing the natural circulation. - FP amount in the standpipe/separator could be a heat source for the gas to be released to the containment.	- FP volatility was experimented through VERCORS5 tests, illustrating four volatility classes. - The fraction of each class in the Fukushima accident should be further studied.
229		Decay heat generation from FP	L	M	M	H	P	-Since the standpipe/separator surface area would be relatively large in the vessel, FP decay heat generation on the standpipe/separator may be a significant heat source influencing the natural circulation. - It also could be a heat source for the gas to be released to the containment.	- Decay heat generation can be predicted by FP inventory in the shroud head. - FP inventory can be evaluated by ORIGEN code, though the calculation is based on the point approximation kinetics. - The amount of deposited FPs depends on temperature, oxidation conditions, burnup, fuel types, and surface conditions. It is difficult to evaluate all these parameters precisely.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
230	Standpipe & Separator	FP reaction including iodine chemistry	L	L	L	L	U	- FP reaction in the standpipe/separator does not influence directly the core enthalpy change. - The impact on the containment system responses is expected to be small, since FP flows upward shortly.	- Although FP chemical form was studied in the OECD workshops in 80 to 90's, RTF project in Canada, Phebus-FP, and OECD/BIP, there are still technical challenges such as gaseous-aerosol reactions.
231		Corrosion of standpipe/separator by seasalt (iIncluding marine lives)	L	L	L	L	U	- Corrosion of the standpipe/separator does not have direct influence on the core temperature change and relocation process. - Corrosion effects are expected to develop slowly except a case of extremely high temperature conditions. -Thus the impact on the containment system responses in the 4th phase is also expected to be small.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the corrosion effects by sea salt or impurities under the accident conditions.
232		Influence for heat transfer by salt deposition	L	L	L	L	U	- In the Fukushima accident, the core water level has not yet reached to the standpipe/separator. Therefore only a small amount of sea salt derived from droplets could be deposited on the shroud head. The influence can be ignored.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the influence on heat transfer rate from the standpipe/separator by sea salt or impurities.
233		Pick-off ring flowpath blockage by seasalt deposition	L	L	L	L	U	- In the Fukushima accident, the core water level has not yet reached to the standpipe/separator. Only a small amount of sea salt derived from droplets could be deposited on the standpipe/separator. - Therefore the pick-off ring flowpath blockage by seasalt is not likely to occur. Even if it happens, there is no direct influence on the core temperature and the containment system responses.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the influence on the pick-off ring blockage due to sea salt deposition. - The phenomenon could be predicted by general flowpath blockages due to deposition.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
234	Standpipe & Separator	Separator inlet flowpath blockage by seasalt deposition	L	L	L	L	U	- In the Fukushima accident, the core water level has not yet reached to the standpipe/separator. Only a small amount of sea salt derived from droplets could be deposited on the standpipe/separator. - Therefore the pick-off ring flowpath blockage by seasalt is not likely to occur. Even if it happens, there is no direct influence on the core temperature and the containment system responses.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the influence on the pick-off ring blockage due to sea salt deposition. - The phenomenon could be predicted by general flowpath blockages due to deposition.
235		Re-dissolution of salt by reflooding	L	L	L	L	P	- In the Fukushima accident, the core water level has not yet reached to the standpipe/separator. - Only a small amount of sea salt derived from droplets could be deposited on the shroud head. - The re-dissolution of seasalt on the shroud head can be ignored during the accident progression.	- Seasalt solubility is known, though the salt deposition conditions and the way spray water is dispersed have some uncertainties.
236		Seasalt impact for FP reaction and composition	L	L	L	L	U	- Since FP reaction itself has little influence on the core temperature change and the containment system responses, the seasalt effects can be ignored.	- Since sea water injection has never been postulated, there are almost no studies or experiments focusing on the seasalt effects on FP reactions and compositions.
237		Corrosion of standpipe/separator by boron	L	L	L	L	U	- Corrosion of the standpipe/separator does not have direct influence on the core temperature change and relocation process. - Corrosion effects are expected to develop slowly except a case of extremely high temperature conditions. -Thus the impact on the containment system responses in the 4th phase is also expected to be small.	- Although the upper head degradation at Davis Besse is known as a typical case due to corrosion by boron, the shroud head corrosion with boron has never been explicitly studied.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
238	Standpipe & Separator	Influence for heat transfer by boron deposition	L	L	L	L	U	- In the Fukushima accident, the core water level has not yet reached to the shroud head. - Therefore only a very small amount of boron derived from control rods and transported by droplets could be deposited on the standpipe/separator. The influence can be ignored.	- There is almost no studies or experiments focusing on the influence on heat transfer rate from the standpipe/separator by boron, though boron precipitation are considered in the PWR LOCA long term cooling analyses.
239		Pick-off ring flowpath blockage by boron deposition	L	L	L	L	P	- In the Fukushima accident, SLC was not injected during the accident. Therefore only little amount of boron, which might be derived from the control rods could be deposited on the pick-off rings. - Also, even if pick-off rings are plugged, the overall natural circulation regimes do not change. Thus the importance level should be 'Low'.	- There are almost no studies or experiments focusing on the influence due to boron deposition. - The phenomenon could be predicted by general annulus flowpath blockages due to deposition.
240		Separator Inlet flowpath blockage by boron deposition	L	L	L	L	P	- In the Fukushima accident, SLC was not injected during the accident. Therefore only little amount of boron, which might be derived from the control rods, could be deposited on the standpipe/separators. - Thus the importance level should be 'Low'.	- There are almost no studies or experiments focusing on the influence due to boron deposition. - The phenomenon could be predicted by general flowpath blockages due to deposition.
241		Re-solution of boron by reflooding	L	L	L	L	P	- In the Fukushima accident, SLC was not injected during the accident. Therefore little amount of boron, which might derived from control rods, could be transported only by droplets and deposited on the surface. - Thus the re-dissolution of boron on the shroud head can be ignored during the accident progression.	- Boron solubility is known, though the deposition conditions and the steam condensation effect on the deposited boron have some uncertainties.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Rationale	State of Knowledge
			1st	2nd	3rd	4th			
242	Standpipe & Separator	Standpipe/Separator Tilt by Shroud Head Deformation	L	L	L	L	P	- Even if the standpipe/separator tilts due to shroud head deformation, the overall natural circulation regimes do not change. Thus the importance level should be 'Low'.	- Since the stress-strain characteristics for steel is well-known, the deformation or failure can be assessed by the general FEM methods.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
243	Dryer	Dryer Temperature Change	L	L	L	L	K	Dryer temperature change may affect the steam temperature released out from the dryer. However, the change is not so large and the effect on FoM may be small.	Temperature change of dryer can be estimated by solving heat conduction equation with assuming the steam temperature.
244		Gamma Heat Generation in Dryer	L	L	L	L	K	Gamma heat is generated from FP and its heat may raise the steam temperature released out from the dryer. However, the heat would not occur in the 1st phase. Since 2nd phase, the heat may decay with time, so the effect is small.	Gamma heat generated in dryer can be estimated with decay heat and FP transferred to the dryer based on established knowledge.
245		Heat Transfer between Gas and Dryer	L	L	L	L	K	Heat transfer between gas and dryer may have effect on steam temperature. However, the effect is not so large.	Since the correlation equation of Nu number between gas and dryer is investigated, there is sufficient knowledge.
246		Condensation Heat Transfer on Dryer	L	L	L	L	K	Gas condensation may occur on the surface of the dryer and would cause temperature change of the dryer. However, the temperature change only occurs in the local region of the surface of dryer, and its effect on FoM is small.	Condensation heat transfer on dryer can be estimated from physical properties of materials used for the dryer and established knowledge.
247		Pressure Change in Dryer	L	M	M	M	K	Pressure change in dryer is determined by the pressure change in core region. Therefore the effect on fuel rod is small. Since 2nd phase, the pressure change in dryer would change significantly and may affect the pressure and temperature of the boundary and steam released to PCV.	Pressure change in dryer can be estimated from temperature and pressure in other components with established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
248	Dryer	Gas Flow in Dryer	L	L	L	L	K	Gas flow may change the heat transfer between gas and dryer wall, and therefore the gas temperature. However, the change may be not so large and the effect on FoM is small.	Gas flow in dryer at normal operation can be evaluated analytically. Since gas component change in dryer can be estimated from the condition of core region in the accident, the flow can be also estimated based on established knowledge.
249		Gas Temperature Change in Dryer	L	L	L	H	K	Gas temperature in dryer may be changed by the condition of core region. Therefore, the effect of this change on FoM to 3rd phase is not so large. However, gas temperature change in dryer would directly have an effect on steam temperature, and therefore affects pressure and temperature in PCV directly.	Gas temperature change in dryer can be estimated from temperature and pressure in core region and other components with established knowledge.
250		Gas Composition Change in Dryer	L	L	L	L	K	Gas composition change would have an effect on gas flow and heat transfer between gas and dryer wall. However, the change of gas flow and temperature would small and the effect on FoM is small.	Gas composition change in dryer can be estimated from the condition of core region and established knowledge.
251		Dryer Break or Deformation by Thermal Stress	L	L	L	L	K	Dryer break or deformation has an effect on the quality of steam released out from the dryer. However, the effect on FoM is small.	The intensity to thermal stress on materials of the dryer has already investigated by the experiments. Therefore, sufficient knowledge exists.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
252	Dryer	Dryer Oxidation with steam (Including Reaction Heat and Hydrogen Production)	L	L	L	L	K	Oxidation would affect the capability of dryer and therefore quality of steam released out from the dryer. However, the oxidation progress slowly and the effect on FoM is not so large.	The effect of oxidation reaction with steam on materials of the dryer has investigated through the experiments. Therefore, there is sufficient knowledge of oxidation Also, the effects of reaction heat and hydrogen production can be estimated from the established knowledge.
253		FP deposition on dryer	L	M	M	H	P	In the 1st phase, FP has not transported to the dryer since the fuel has not yet started melting. FP released with fuel melting is likely to attach on structure which has a large surface area as dryer. FP attachment may raise the steam temperature. Therefore the pressure and temperature may affected by FP deposition on dryer.	Deposition behavior of FP has been studied. Therefore, FP deposition can be estimated based on established knowledge. There is insufficient knowledge of FP amounts transported into the dryer. Therefore, the evaluated value includes uncertainty.
254		FP re-vaporization	L	M	M	H	P	In the 1st phase, FP has not yet transported to the dryer since the fuel has not yet started melting. FP released with fuel melting is likely to attach on structure which has a large surface area as dryer. FP re-vaporization would raise the steam temperature and therefore the pressure and temperature may be affected.	FP re-vaporization behavior has been investigated in several studies. Therefore, FP re-vaporization can be estimated. There is insufficient knowledge of FP composition and quantity transported into the dryer. Therefore, the evaluated quantity of re-vaporization includes uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
255	Dryer	Decay heat generation from FP	L	M	M	H	P	In the 1st phase, FP has not yet transported to the dryer since the fuel has not yet started melting. FP released with fuel melting is likely to attach on structure which has a large surface area as dryer. Decay heat generated from FP would raise the steam temperature and therefore the pressure and temperature may be affected.	Decay heat generation can be predicted by FP inventory in the standpipe/separator. FP inventory can be evaluated by ORIGEN code, though the calculation is based on the point approximation kinetics. The amount of deposited FPs depends on temperature, oxidation conditions, burnup, fuel types, and surface conditions. It is difficult to evaluate all these parameters precisely.
256		FP reaction including iodine chemistry	L	L	L	L	P	FP released with fuel melting is likely to attach on structure which has a large surface area as dryer. Therefore, FP reaction including iodine may occur at the surface but the reaction effect on FoM is not so large.	FP reaction including iodine can be evaluated based on established knowledge. The reaction depending on temperature, composition, and so on is difficult to estimate definitely, and the data contain uncertainty.
257		Corrosion of Dryer by Seasalt (Including Marine Lives)	L	L	L	L	U	Seawater includes chloride ion and it may cause the corrosion of dryer. Since SUS used for dryer is an extremely stable material for corrosion, the effect of corrosion is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
258		Influence for heat transfer by salt deposition	L	L	L	L	U	Deposition of seasalt may be likely to occur in place with low flow rate such as water surface. Salt deposition may make a small difference on steam temperature due to the change of heat transfer. However, its effect on FoM is not so large.	The test to confirm the effect on heat transfer by seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
259	Dryer	Dryer Flowpath Blockage by Seasalt Deposition	L	L	L	L	U	Deposition of seasalt may be likely to occur in place with low flow rate. Therefore, the effect of blockage by the deposition is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
260		Re-solution of salt by reflooding	L	L	L	L	U	Deposition of seasalt may be likely to occur in place with low flow rate. Therefore, the effect of re-solution of salt is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
261		Seasalt impact for FP reaction and composition	L	L	L	L	U	Seawater may cause additional chemical reactions with FP gas and may generate additional reaction products. Additional reaction heat and products may have an effect on temperature and pressure of steam. However, reaction ratio of seasalt is less than that of FP reaction itself. Therefore, the effect on FoM is small.	The reaction between FP gas and seasalt components such as salt can be evaluated based on established knowledge. However, the effect of seasalt entered due to the injection of seawater has no knowledge in the past. The reaction depending on temperature, composition, and so on is difficult to estimate definitely, and the data contain uncertainty.
262		Corrosion of Dryer by Boron	L	L	L	L	U	Water containing boron becomes acid water and causes corrosion of dryer. Since SUS used for dryer is an extremely stable material for corrosion, the effect of corrosion is small.	Experiment to confirm the effect of boron has not conducted and there is almost no knowledge in the past.
263		Impact of Boron Deposition on Heat Transfer	L	L	L	L	U	Deposition of boron may be likely to occur in place with low flow rate such as water surface. Boron deposition may make a small difference on steam temperature due to the change of heat transfer. However, its effect on FoM is not so large.	Experiment to confirm the effect of boron has not conducted and there is no knowledge in the past.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
264	Dryer	Dryer Flowpath Blockage by Boron Deposition	L	L	L	L	U	Deposition of boron may be likely to occur in place with low flow rate. Therefore, the effect of blockage by the deposition is small.	Experiment to confirm the effect of boron has not conducted and there is no knowledge in the past.
265		Re-solution of boron by reflooding	L	L	L	L	P	Deposition of boron may be likely to occur in place with low flow rate. Therefore, the effect of re-solution of boron is small.	The effect of re-solution of boron has not evaluated in the past. However, the effect can be estimated based on established chemical knowledge.
266		Dryer Structure Tilt	L	L	L	L	P	Dryer structure tilt has an effect on the quality of steam released out from the dryer. However, the effect on FoM is small.	Stress on dryer structure due to temperature and pressure can be estimated based on established knowledge of structure materials. However, the pressure and temperature, which affect on stress, contain uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
267	Upper Head	Heat Transfer between Gas and Upper Head Wall	L	L	L	H	K	Heat transfer between gas and upper head wall would change the temperature in upper head. However the effect on FoM is small until 3rd phase. In 4th phase, temperature change of gas would directly affect the FoM. Therefore the effect is large.	Heat transfer coefficient between gas and upper head wall can be estimated from established knowledge.
268		Gamma Heat Generation in Upper Head	L	L	L	L	K	Gamma heat is generated from FP and its heat may raise the steam temperature in the upper head. However, the heat would not occur in the 1st phase. Since 2nd phase, the heat may decay with time, so the effect is small.	Gamma heat generated in upper head can be estimated with decay heat and FP transferred to the upper head based on established knowledge.
269		Upper Head Temperature Change	L	L	L	M	K	Upper head temperature change may be occurred due to temperature change in core region. However effect of the change may be small until 3rd phase. However, the change would directly affect the gas temperature which transferred into PCV.	Upper head temperature can be estimated from temperature in core region and established knowledge of material properties.
270		Radiation Heat Transfer from Upper Head to Drywell Head	M	M	M	H	K	Radiation heat transfer from upper head to drywell head may affect the temperature of core region and structure wall, so the FoM. Especially on 4th phase, temperature change due to this radiation heat transfer may affect the temperature and pressure of the gas which transferred into PCV. Therefore the effect is high.	Radiation heat transfer from upper head to drywell head can be estimated from established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
271	Upper Head	Condensation Heat Transfer on Upper Head	L	L	L	L	K	Gas condensation may occur on the surface of upper head wall and would cause temperature change of the upper head. However, the temperature change only occurs in the local region of the surface, and its effect on FoM is small.	Condensation heat transfer on upper head can be estimated from established knowledge on physical properties of materials.
272		Pressure Change in Steam Dome	L	M	M	H	K	Pressure change in steam dome is determined by the pressure change in core region. Therefore the effect on fuel rod is small in the 1st phase. Since 2nd phase, the pressure change in upper head would change significantly with coolant boiling and may affect the pressure and temperature of the RPV wall. Especially after 4th phase, pressure change in steam dome directly affects the steam flow rate transferred into the PCV. Therefore its effect on temperature and pressure in PCV may be large.	Pressure change in steam dome can be estimated from temperature and pressure in core region and in other components with established knowledge.
273		Gas Flow in Steam Dome	L	L	L	L	K	Gas flow may change the heat transfer between gas and steam dome, and therefore the gas temperature. However the change may be not so large and the effect on FoM is small.	Gas flow in steam dome at normal operation can be evaluated analytically. Since gas component change in steam dome can be estimated from the condition of core region in the accident, the flow can be estimated based on established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
274	Upper Head	Gas Temperature Change in Steam Dome	L	L	L	H	K	Gas temperature in steam dome may be changed by the condition of core region. Therefore, the effect of this change on FoM to 3rd phase is not so large. However, gas temperature change in steam dome would directly have an effect on steam temperature which flows into the PCV, and therefore it affects pressure and temperature in PCV directly.	Gas temperature change in steam dome can be estimated from temperature and pressure in core region and in other components with established knowledge.
275		Gas Composition Change in Steam Dome	L	L	L	L	K	Gas composition change would have an effect on gas flow and heat transfer between gas and steam dome wall. However, the change of gas flow and temperature would small and the effect on FoM is small.	Gas composition change in steam dome can be estimated from the condition of core region and established knowledge.
276		Upper Head Oxidation with Steam (Including Reaction Heat and Hydrogen Production)	L	L	L	L	K	Oxidation would affect the resistance properties of the upper head. However, the oxidation progress slowly and the effect on FoM is not so large.	The effect of oxidation reaction with steam on materials of the upper head has investigated through the experiments. Therefore, there is sufficient knowledge of oxidation Also, the effects of reaction heat and hydrogen production can be estimated from the established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
277	Upper Head	FP deposition on upper head	L	M	M	M	P	In the 1st phase, FP has not transported to upper head since the fuel has not yet started melting. FP released with fuel melting is likely to attach on the surface of upper head. FP attachment may raise the steam temperature. Therefore the pressure and temperature may affected by FP deposition on upper head.	Deposition behavior of FP has been studied. Therefore, FP deposition can be estimated based on established knowledge. There is insufficient knowledge of FP amounts transported into the upper head. Therefore, the evaluated value includes uncertainty.
278		FP re-vaporization	L	M	M	M	P	In the 1st phase, FP has not yet transported to upper head since the fuel has not yet started melting. FP released with fuel melting is likely to attach on the surface of upper head. FP re-vaporization would raise the steam temperature and therefore the pressure and temperature may be affected.	FP re-vaporization behavior has been investigated in several studies. Therefore, FP re-vaporization can be estimated. There is insufficient knowledge of FP composition and quantity transported into upper head. Therefore, the evaluated quantity of re-vaporization includes uncertainty.
279		Decay heat generation from FP	L	M	M	M	P	In the 1st phase, FP has not yet transported to upper head since the fuel has not yet started melting. FP released with fuel melting is likely to attach on the surface of upper head. Decay heat generated from FP would raise the steam temperature and therefore the pressure and temperature may be affected.	Decay heat generation can be predicted by FP inventory in the standpipe/separator. FP inventory can be evaluated by ORIGEN code, though the calculation is based on the point approximation kinetics. The amount of deposited FPs depends on temperature, oxidation conditions, burnup, fuel types, and surface conditions. It is difficult to evaluate all these parameters precisely.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
280	Upper Head	FP reaction including iodine chemistry	L	L	L	L	P	FP released with fuel melting is likely to attach on the surface of the upper head. Therefore, FP reaction including iodine may occur at the surface but the reaction effect on FoM is not so large.	FP reaction including iodine can be evaluated based on established knowledge. The reaction depending on temperature, composition, and so on is difficult to estimate definitely, and the data contain uncertainty.
281		Gas Leakage from RPV flange to Drywell Head	L	H	H	M	P	Since 2nd phase, leakage gas from RPV flange may include fission products which contain heat. Therefore the gas leakage may affect the FoM in 2nd and 3rd phase large. In the 4th phase, gas leakage may affect the gas which transferred into PCV. Therefore there exists effect on FoM.	Gas leakage from RPV flange to drywell head can be estimated from the established knowledge from some experiments. However the leakage rate is changed by condition of the gas, such as temperature and pressure, so the data contain uncertainty.
282		Corrosion of Upper Head by Seasalt (Including Marine Lives)	L	L	L	L	U	Seawater includes chloride ion and it may cause the corrosion of dryer. Since extremely stable material for the corrosion is used for the upper head structure, the effect of corrosion is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
283		Influence for heat transfer by salt deposition	L	L	L	L	U	Deposition of seasalt may be likely to occur locally in a small area of the upper head. Salt deposition may make a small difference on steam temperature due to the change of heat transfer. However, its effect on FoM is not so large.	The test to confirm the effect on heat transfer by seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
284	Upper Head	Re-solution of salt by droplet	L	L	L	L	P	Deposition of seasalt may be likely to occur locally in a small area of the upper head. Therefore, the effect of re-solution of salt is small.	Re-solution mechanism of salt has already known by the established knowledge. However, the test to confirm the effect of seasalt entered due to the injection of seawater has not conducted. Therefore the effect of the resolution on temperature and pressure of steam includes uncertainty.
285		Influence on Instrumentation and Measurements by Seasalt Concentration Change	L	L	L	L	U	High concentration of seasalt in water may deposited on the instruments and change the measurements. Therefore seasalt concentration change in water may make a small difference on temperature. However, its effect on FoM is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
286		Seasalt impact for FP reaction and composition	L	L	L	L	U	Seawater may cause additional chemical reactions with FP gas and may generate additional reaction products. Additional reaction heat and products may have an effect on temperature and pressure of steam. However, reaction ratio of seasalt is less than that of FP reaction itself. Therefore, the effect on FoM is small.	The reaction between FP gas and seasalt components such as salt can be evaluated based on established knowledge. However, the effect of seasalt entered due to the injection of seawater has no knowledge in the past. The reaction depending on temperature, composition, and so on is difficult to estimate definitely, and the data contain uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
287	Upper Head	Corrosion of Upper Head by Boron	L	L	L	L	P	Water containing boron becomes acid water and causes corrosion of upper head. Since materials used for upper head are extremely stable for the corrosion, the effect of corrosion is small.	Although the upper head degradation at Davis Besse is known as a typical case due to corrosion by boron, the shroud head corrosion with boron has never been explicitly studied.
288		Influence for heat transfer by boron deposition	L	L	L	L	U	Deposition of boron may be likely to occur locally in a small area of the upper head. Boron deposition may make a small difference on steam temperature due to the change of heat transfer. However, its effect on FoM is not so large.	Experiment to confirm the effect of boron has not conducted and there is no knowledge in the past.
289		Re-solution of boron by reflooding	L	L	L	L	P	Deposition of boron may be likely to occur locally in a small area of the upper head. Therefore, the effect of re-solution of boron is small.	The effect of re-solution of boron has not evaluated in the past. However, the effect can be estimated based on established chemical knowledge.
290		Degradation or Falling of Lagging Material	M	M	M	M	P	Degradation of lagging material would change the temperature of structure in upper head. As the degradation progresses, temperature of the structure may become high. Therefore there is an effect on FoM in each phase.	Stress on lagging material in upper head due to temperature and pressure can be estimated based on established knowledge of structure materials. However, the pressure and temperature, which affect on stress, contain uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
291	Main steam line	Main Steam Line Creep Rupture	N/A	M	M	L	K	- When Main Steam Line Creep Rupture occurs, Inventory of RPV is released quickly. Loss of coolant directly affects to fuel heat up. - Between fuel melting phase and relocation phase, most of steam in RPV has already lost, Impact of Main Steam Line Creep Rupture seems to be smaller than that of fuel heat up phase. - After PCV deposition occurs, most of gas in RPV already has been released to PCV. Main Steam Line Creep Rupture hardly affect to PCV temperature and pressure.	-Behavior of PCV and RPV gas temperature and pressure at Main Steam Line Break (MSLB) could be calculated analytically.
292		Break Flow from Main Steam Line Break	N/A	M	M	L	K	- When Main Steam Line Creep Rupture occurs, Inventory of RPV is released quickly. Loss of coolant directly affects to fuel heat up. - Between fuel melting phase and relocation phase, most of steam in RPV has already lost, Impact of Main Steam Line Creep Rupture seems to be smaller than that of fuel heat up phase. - After PCV deposition occurs, most of gas in RPV already has been released to PCV. Main Steam Line Creep Rupture hardly affect to PCV temperature and pressure.	-Behavior of PCV and RPV gas temperature and pressure at Main Steam Line Break (MSLB) could be calculated analytically.
293		Gas Flow in Main Steam Line	L	L	L	L	K	- As Main Steam Line has limited heat sink capacity, it is relatively less important than the other radiation phenomena.	- Temperature changes of Main Steam Line and pressure, water level, water temperature, gas temperature, gas composition, and flow of water and/or steam change in Main Steam Line could be evaluated by thermodynamic calculation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
294	Main steam line	Pressure Change in Main Steam Line	L	M	M	H	K	- Pressure Change in Main Steam Line has little impact on fuel heat up. - It affects RPV pressure and temperature. - It has large impact on PCV pressure and temperature.	- The same as No.293.
295		Gas Temperature Change in Main Steam Line	L	M	M	H	K	- Temperature Change in Main Steam Line has little impact on fuel heat up. - It affects RPV pressure and temperature. - It has large impact on PCV pressure and temperature.	- The same as No.293.
296		Gas Composition Change in Main Steam Line	L	L	L	L	K	- As the state quantities in Main Steam Line can be considered to be almost independent of those of core, gas composition change in Main Steam Line has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- The same as No. 293.
297		Main Steam Line Temperature Change	L	M	M	L	K	- Temperature Change of Main Steam Line has little impact on fuel heat up and PCV pressure and temperature. - It affects RPV pressure and temperature.	- The same as No. 293.
298		Heat Transfer between Gas and Main Steam Line	L	L	L	M	K	- As heat transfer between Main Steam Line and gas is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- General forced convection heat transfer coefficient could be applied inside of a pipe between pipe inner surface and gas.
299		Heat Transfer between water and Main Steam Line	L	L	L	L	K	- As heat transfer between Main Steam Line and water is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- General forced convection heat transfer coefficient could be applied inside of a pipe between pipe inner surface and water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
300	Main steam line	Condensation Heat Transfer on Main Steam Line	L	L	L	L	K	- As an amount of heat transfer due to condensation is limited due to relatively lower heat capacity in the MSL region, it affects little impact on RPV/PCV temperature and pressure on all categories.	- Steam condensation heat transfer coefficient could be applied.
301		Heat Transfer to Drywell through Lagging Material	L	L	L	L	K	- As heat transfer to Drywell through Lagging Material is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- General natural convection heat transfer coefficient between Lagging Material and gas could be evaluated by thermodynamic calculation.
302		Safety Relief Valve Opening Characteristics	M	H	H	L	K	- Safety Relief Valve opening characteristics affects fuel heatup. - It has large impact on RPV pressure and temperature. - After PCV deposition occurs, most of gas in RPV already has been released to PCV. Safety Relief Valve Opening hardly occurs.	- There is experimental data toward Characteristics of Safety Relief Valve.
303		Leakage from Safety Relief Valve to Drywell	M	H	H	L	K	- Safety relief valve opening characteristics affects fuel heatup. - It has large impact on RPV pressure and temperature. - After PCV deposition occurs, most of gas in RPV already has been released to PCV. Leakage from safety relief valve to drywell hardly occur.	- The same as No.302.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
304	Main steam line	Pressure Loss at Safety Relief Valve	M	H	H	L	K	- Safety Relief Valve opening characteristics affects fuel heatup. - It has large impact on RPV pressure and temperature. - After PCV deposition occur, most of gas in RPV already has been released to PCV. Gas flow in safety relief valve hardly occur.	- The same as No.302.
305		Safety Relief Valve Temperature Change	L	L	L	L	K	- As Safety Relief Valve temperature change is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- Temperature changes of Safety Relief Valve and heat transfer between gas and Safety Relief Valve blowdown piping could be evaluated by thermodynamic calculation.
306		Heat Transfer between Gas and Safety Relief Valve Blowdown Piping	L	L	L	L	K	- As heat transfer between gas and Safety Relief Valve blowdown piping is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- The same as No.305.
307		Safety Relief Valve Blowdown Piping Break	L	L	L	L	K	- As heat transfer between gas and Safety Relief Valve blowdown piping is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- The same as No.305.
308		Safety Relief Valve Blowdown Piping Break Flow	L	L	L	L	K	- Same as No.307.	- The same as No.307.
309		MSIV Closure	M	M	M	M	K	-The timing of MSIV closure affects to amount of steam release and decreasing of water level. It also affects to temperature in RPV and fuel heating. -After core melting phase, MSIV has already been closed.	- There is experimental data toward Characteristics of MSIV.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
310	Main steam line	Pressure Wave by MSIV Closure	L	N/A	N/A	N/A	K	-The timing of MSIV closure affects to amount of steam release and decreasing of water level. It also affects to temperature in RPV and fuel heating. -After core melting phase, MSIV has already been closed.	- The same as No.309.
311		Gas Leakage from MSIV	M	M	M	M	K	- Gas leakage from MSIV affects fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- The same as No.309.
312		FP deposition on main steam line	L	L	L	M	K	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much. - It affects PCV pressure and temperature.	- Main Steam Line heat-up would be affected by the amount of FP particle deposition. - FP particle deposition on Main Steam Line was examined in some tests. - However, there is not enough experimental data in pedestal for validation.
313		FP re-vaporization	L	L	L	M	K	-As deposited FP in Main Steam Line is sufficiently cooled, it cannot vaporize by its decay heat. - It affects PCV pressure and temperature.	- FP re-vaporization was examined in some tests. - There is enough data toward temperature of FP re-vaporization.
314		Decay heat generation from FP	M	H	H	M	K	- Decay heat generation from FP in Main Steam Line affects RPV/PCV pressure and temperature. - It has large impact on relocation and RPV failure.	- Decay heat generation from FP could be evaluated by using decay heat model. - There is enough data toward decay heat generation from FP.
315		FP accumulation at leakage path	M	H	H	H	U	- Decay heat generation from FP in Main Steam Line affects fuel melt. - It has large impact on RPV/PCV pressure and temperature.	- There is no experimental data toward FP accumulation at leakage path.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
316	Main steam line	Radiation heat transfer to drywell	L	L	L	L	K	- Because of existence of Lagging Material, radiation between Main Steam Line and drywell floor/wall has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- Radiation heat transfer between two surfaces could be theoretically evaluated by the temperatures, radiation factor, and radiation configuration factor.
317		Influence on Heat Transfer by Seasalt Concentration Change	L	L	L	L	P	- As the influence on heat transfer by seasalt concentration change in water is relatively small compared to that by water level change in MSL, it has little impact on PCV temperature and pressure.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
318		Influence on Instrumentation and Measurements by Seasalt Concentration Change	L	L	L	L	U	-As Influence on accident progress by change in instrumentation and measurements by seasalt concentration change is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
319		Seasalt impact for FP reaction and composition	L	L	L	L	P	- As an amount of heat generation from chemical reaction is small compared to that from decay heat, FP chemical reaction has little impact on RPV/PCV temperature and pressure. Change of FP chemical form due to seasalt may change the behavior of FP.	- The seasalt impact for FP reaction and composition have been examined after Fukushima Dai-Ichi Nuclear Power Plant accident. - However, there is not enough experimental data.
320		FP reaction including iodine chemistry	L	L	L	L	P	-As released energy from FP chemical reaction including iodine chemistry is relatively smaller than its decay heat, all categories are ranked “L”.	-FP reaction was examined in some tests. -Iodine chemistry was examined in some projects. -However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
321	Main steam line	Failure of RPV nozzle welding by thermal stress	N/A	M	M	M	P	- As temperature of RPV nozzle welding is not high until fuel heat up, 1st category is not applicable. - Failure of RPV nozzle welding by thermal stress affects RPV/PCV pressure and temperature.	- Thermal stress of RPV nozzle welding could be evaluated by thermodynamic calculation. -However, there is not enough experimental data for validation.
322		Degradation or Falling of Lagging Material	L	L	L	L	P	- As heat transfer between gas in Main Steam Line and gas in PCV after degradation or falling of Lagging Material of Main Steam Line is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	-Heat transfer between gas in Main Steam Line and gas in PCV could be evaluated by thermodynamic calculation. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
323	Upper down comer	Heat Transfer between Gas and Upper Downcomer Wall	L	L	L	M	K	Heat transfer between gas and upper downcomer wall would change the temperature in upper down comer. However the effect on FoM is small until 3rd phase. In 4th phase, temperature change of gas would directly affect the FoM. Therefore the effect on FoM is not so small.	Heat transfer coefficient between gas and upper downcomer wall can be estimated from established knowledge.
324		Gamma Heat Generation in Upper Downcomer Wall	L	L	L	L	K	Gamma heat is generated from FP and its heat may raise the steam temperature in the upper downcomer. However, the heat would not occur in the 1st phase. Since 2nd phase, the heat may decay with time, so the effect is small.	Gamma heat generated in upper downcomer can be estimated with decay heat and FP transferred and attached to the upper downcomer wall based on established knowledge.
325		Upper Downcomer Wall (and Feedwater Sparger) Temperature Change	L	L	L	L	K	Upper downcomer wall temperature change may be occurred due to temperature change in core region and heat transfer between water/steam and the wall. However effect of the change on FoM may be small.	Upper downcomer wall temperature can be estimated from temperature in core region and established knowledge of material properties.
326		Condensation Heat Transfer on Upper Downcomer Wall (and Feedwater Sparger)	L	L	L	L	K	Gas condensation may occur on the surface of upper downcomer wall and would cause temperature change of the upper downcomer. However, the temperature change only occurs in the local region of the surface, and its effect on FoM is small.	Condensation heat transfer on upper downcomer can be estimated from established knowledge on physical properties of materials.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
327	Upper down comer	Pressure Change in Upper Downcomer	L	M	M	H	K	Pressure change in upper downcomer is determined by the pressure change in core region. Therefore the effect on fuel rod is small in the 1st phase. Since 2nd phase, the pressure change in upper downcomer would change significantly with coolant boiling and may affect the pressure and temperature of the RPV wall. Especially after 4th phase, pressure change in upper doencomer directly affects the steam flow rate transferred into the PCV. Therefore its effect on temperature and pressure in PCV may be large.	Pressure change in upper downcomer can be estimated from temperature and pressure in core region and in other components with established knowledge.
328		Change in water level in upper down comer	H	L	L	L	K	In the 1st phase, water level in upper downcomer may directly affect on the temperature of core region and therefore the fuel heat up. The effect on FoM in 1st phase is large. On the other hand, fuel has already melted since 2nd phase. Therefore the effect of water level in upper down comer on FoM is small.	Water level change in upper downcomer can be estimated from temperature and pressure in core region and in other components with established knowledge.
329		Gas Flow in Upper Downcomer	L	L	L	L	K	Gas flow may change the heat transfer between gas and upper downcomer wall, and therefore the gas temperature in the downcomer. However the change may be not so large and the effect on FoM is small.	Gas flow in upper downcomer at normal operation can be evaluated analytically. Since gas component change in upper downcomer can be estimated from the condition of core region in the accident, the flow can be estimated based on established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
330	Upper down comer	Gas Temperature Change in Upper Downcomer	L	L	L	H	K	Gas temperature in upper downcomer may be changed by the condition of core region. Therefore, the effect of this change on FoM to 3rd phase is not so large. However, gas temperature change in upper downcomer would directly have an effect on steam temperature which flows into the PCV, and therefore it affects pressure and temperature in PCV directly.	Gas temperature change in upper downcomer can be estimated from temperature and pressure in core region and in other components with established knowledge.
331		Gas Composition Change in Upper Downcomer	L	L	L	L	K	Gas composition change would have an effect on gas flow and heat transfer between gas and upper downcomer wall. However, the change of gas flow and temperature would small and the effect on FoM is small.	Gas composition change in upper downcomer can be estimated from the condition of core region and established knowledge.
332		Upper Downcomer Wall (and Feedwater Sparger) Break or Deformation by Thermal Stress	L	L	L	L	K	Upper downcomer wall break or deformation has an effect on temperature and pressure in upper downcomer. However the effect on FoM is small.	The intensity to thermal stress on materials of the upper downcomer wall has already investigated by the experiments. Therefore, sufficient knowledge exists.
333		Upper Downcomer Wall (and Feedwater Sparger) Oxidation with Steam (Including Reaction Heat and Hydrogen Production)	L	L	L	L	K	Oxidation would affect the resistance properties of the upper downcomer. However, the oxidation progress slowly and the effect on FoM is not so large.	The effect of oxidation reaction with steam on materials of the upper downcomer has investigated through the experiments. Therefore, there is sufficient knowledge of oxidation Also, the effects of reaction heat and hydrogen production can be estimated from the established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
334	Upper down comer	FP deposition on upper down comer	L	L	L	M	P	In the 1st phase, FP has not transported to upper downcomer since the fuel has not yet started melting. FP released with fuel melting is likely to attach on the surface of upper downcomer. FP attachment may raise the steam temperature. Therefore the pressure and temperature may be affected by FP deposition on upper downcomer.	Deposition behavior of FP has been studied. Therefore, FP deposition can be estimated based on established knowledge. There is insufficient knowledge of FP amounts transported into the upper downcomer. Therefore, the evaluated value includes uncertainty.
335		FP re-vaporization	L	L	L	M	P	In the 1st phase, FP has not yet transported to upper downcomer since the fuel has not yet started melting. FP released with fuel melting is likely to attach on structure which has a large surface area as upper downcomer. FP re-vaporization would likely to occur in the 4th phase and raise the steam temperature. Therefore the pressure and temperature may be affected.	FP re-vaporization behavior has been investigated in several studies. Therefore, FP re-vaporization can be estimated. There is insufficient knowledge of FP composition and quantity transported into the upper downcomer. Therefore, the evaluated quantity of re-vaporization includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
336	Upper down comer	Decay heat generation from FP	L	L	L	M	P	In the 1st phase, FP has not yet transported to upper downcomer since the fuel has not yet started melting. FP released with fuel melting is likely to attach on structure which has a large surface area as upper down comer. However, locally attached FP would not have so large effect on FoM until 3rd phase. Since 4th phase, decay heat generated from FP would raise the temperature of steam directly which would transport into PCV, and therefore the pressure and temperature may be affected.	Decay heat generation can be predicted by FP inventory in the standpipe/separator. FP inventory can be evaluated by ORIGEN code, though the calculation is based on the point approximation kinetics. The amount of deposited FPs depends on temperature, oxidation conditions, burnup, fuel types, and surface conditions. It is difficult to evaluate all these parameters precisely.
337		FP reaction including iodine chemistry	L	L	L	L	P	FP released with fuel melting is likely to attach on structure which has a large surface area as upper downcomer. Therefore, FP reaction including iodine may occur at the surface but the reaction effect on FoM is not so large.	FP reaction including iodine can be evaluated based on established knowledge. The reaction depending on temperature, composition, and so on is difficult to estimate definitely, and the data contain uncertainty.
338		Radiation heat transfer to drywell	M	M	M	M	K	Radiation heat transfer to drywell may affect the temperature of water and steam within RPV. Therefore there exists effect on FoM.	Radiation heat transfer from upper downcomer to drywell can be estimated from established knowledge.
339		Corrosion of Upper Head by Seasalt (Including Marine Lives)	L	L	L	L	U	Seawater includes chloride ion and it may cause the corrosion of dryer. Since upper downcomer uses an extremely stable material for corrosion, the effect of corrosion is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
340	Upper down comer	Influence for heat transfer by salt deposition	L	L	L	L	U	Deposition of seasalt may be likely to occur in place with low flow rate such as water surface. Salt deposition may make a small difference on steam temperature due to the change of heat transfer. However, its effect on FoM is not so large.	The test to confirm the effect on heat transfer by seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
341		Re-solution of salt by reflooding	L	L	L	L	P	Deposition of seasalt may be likely to occur in place with low flow rate. Therefore, the effect of re-solution of salt is small.	Although the theoretical solubility for seasalt is known, the test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past
342		Influence on Instrumentation and Measurements by Seasalt Concentration Change	L	L	L	L	U	High concentration of seasalt in water may deposited on the instruments and change the measurements. Therefore seasalt concentration change in water may make a small difference on temperature. However, its effect on FoM is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
343		Corrosion of upper downcomer by Boron	L	L	L	L	P	Water containing boron becomes acid water and causes corrosion of dryer. Since upper downcomer uses an extremely stable material for the corrosion, the effect of corrosion is small.	Although the upper head degradation at Davis Besse is known as a typical case due to corrosion by boron, the shroud head corrosion with boron has never been explicitly studied.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
344	Upper down comer	Influence for heat transfer by boron deposition	L	L	L	L	U	Deposition of boron may be likely to occur in place with low flow rate such as water surface. Boron deposition may make a small difference on steam temperature due to the change of heat transfer. However, its effect on FoM is not so large.	Experiment to confirm the effect of boron has not conducted and there is no knowledge in the past.
345		Re-solution of boron by reflooding	L	L	L	L	P	Deposition of boron may be likely to occur in place with low flow rate. Therefore, the effect of re-solution of boron is small.	The effect of re-solution of boron has not evaluated in the past. However, the effect can be estimated based on established chemical knowledge.
346		Seasalt impact for FP reaction and composition	L	L	L	L	U	Seawater may cause additional chemical reactions with FP gas and may generate additional reaction products. Additional reaction heat and products may have an effect on temperature and pressure of steam. However, reaction ratio of seasalt is less than that of FP reaction itself. Therefore, the effect on FoM is small.	The reaction between FP gas and seasalt components such as salt can be evaluated based on established knowledge. However, the effect of seasalt entered due to the injection of seawater has no knowledge in the past. The reaction depending on temperature, composition, and so on is difficult to estimate definitely, and the data contain uncertainty.
347		Gas Flow to Main Steam Line	L	L	L	M	K	Gas flow to main steam line directly affects the condition in PCV. Therefore the effect on FoM in 4th phase is ranked to “M”. On the other hand, the effect on FoM until 3rd phase is small.	Gas flow to main steam line can be estimated from temperature and pressure in core region and in other components with established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
348	Upper down comer	FP Flow to Main Steam Line	L	L	L	M	K	FP flow to main steam line directly affects the condition in PCV. FP generates heat and the effect on FoM in 4th phase is ranked to "M". On the other hand, the effect on FoM until 3rd phase is small.	FP included in the gas and the gas quantity which flows into main steam line can be estimated from temperature and pressure in core region and in other components with established knowledge.
349		Gas Flow to Feedwater Line	L	L	L	M	K	Gas flow to feedwater line directly affects the condition in PCV. Therefore the effect on FoM in 4th phase is ranked to "M". On the other hand, the effect on FoM until 3rd phase is small.	Gas flow to feedwater line can be estimated from temperature and pressure in core region and in other components with established knowledge.
350		FP Flow to Feedwater Line	L	L	L	M	K	FP flow to feedwater line directly affects the condition in PCV. FP generates heat and the effect on FoM in 4th phase is ranked to "M". On the other hand, the effect on FoM until 3rd phase is small.	FP included in the gas and the gas quantity which flows into feedwater line can be estimated from temperature and pressure in core region and in other components with established knowledge.
351		Heat Transfer to Drywell through Lagging Material	M	M	M	M	K	Heat transfer to drywell may affect the temperature of steam and water within RPV. Therefore the phenomenon would have an effect on FoM.	Heat transfer to drywell can be estimated from established knowledge of property of the materials.
352		Failure of RPV nozzle welding by thermal stress	N/A	M	M	M	P	In the 1st phase, temperature of RPV would not increased up so high to cause the failure of RPV nozzle welding. Since 2nd phase, failure of RPV would have an effect on water/steam flow through RPV and therefore the temperature within core region, RPV and PCV. Therefore the effect on FoM is ranked to "M".	Thermal stress affect on RPV can be estimated from established knowledge of properties of the material. However the probability of failure of RPV nozzle welding by thermal stress, which is estimated with established knowledge, includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
353	Upper down comer	Degradation or Falling of Lagging Material	M	M	M	M	P	Degradation of lagging material would change the temperature of structure in upper down comer. As the degradation progresses, temperature of the structure may become high. Therefore there is an effect on FoM in each phase.	Stress on lagging material in upper downcomer due to temperature and pressure can be estimated based on established knowledge of structure materials. However, the pressure and temperature, which affect on stress, contain uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
354	Lower down comer	Heat transfer between water and shroud wall	L	H	H	L	K	Shroud wall is heated by core which transfers to the lower down comer. Therefore, the effect of this phenomenon on FoM is small in the 1st phase. In 2nd and 3rd phase, shroud wall would be heated by fuel melting. Therefore the heat transfers to the water would become large and have an effect on cooling capacity of core region and RPV wall. The effect of this phenomenon on FoM is large. Heat transfer would have an effect on temperature of water in the lower down comer. However its effect on steam temperature which transfers into PCV is not so large. Therefore the effect on FoM is small in the 4th phase.	Heat transfer coefficient between water and shroud wall can be estimated from established knowledge.
355		Heat transfer between water and jet pump	L	L	L	L	K	Jet pump is heated by core which transfers to the lower down comer and attached to the surface of jet pump. However surface of jet pump is small. Therefore the effect of heat transfer on FoM is not so large.	Heat transfer coefficient between water and jet pump can be estimated from established knowledge.
356		Heat transfer between water and pump deck	L	L	L	L	K	Pump deck is heated by core which transfers to the lower down comer and attached to the surface of the pump deck. However surface of pump deck is small. Therefore the effect of heat transfer on FoM is not so large.	Heat transfer coefficient between water and pump deck can be estimated from established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
357	Lower down comer	Heat transfer between water and RPV wall	L	L	M	L	K	Water and RPV wall would be heated by core transferred into the lower down comer. Therefore, the effect of this phenomenon on FoM is small in the 1st and 2nd phase. In the 3rd phase, heat transfer between water and RPV wall would have an effect on temperature of RPV wall directly. Therefore there has an effect on FoM. The effect of this phenomenon on steam transferred into PCV is not so large. Therefore the effect on FoM is small in the 4th phase.	Heat transfer coefficient between water and RPV wall can be estimated from established knowledge.
358		Heat transfer between gas and shroud wall	L	L	L	M	K	Shroud wall is heated by core which transfers to the lower down comer. Therefore, heat transfer between gas and shroud wall would not change so much and the effect of this phenomenon on FoM is small in the 1st phase. This phenomenon would change the gas temperature in lower down comer directly. Therefore it would have an effect on gas temperature transfers into PCV. There has an effect on FoM of 4th phase. On the other hand, the effect on FoM in 2nd and 3rd phase is small.	Heat transfer coefficient between gas and shroud wall can be estimated from established knowledge.
359		Heat transfer between gas and jet pump	L	L	L	L	K	Jet pump is heated by core which transfers to the lower down comer and attached to the surface of jet pump. However surface of jet pump is small. Therefore the effect of heat transfer on FoM is not so large.	Heat transfer coefficient between gas and jet pump can be estimated from established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
360	Lower down comer	Heat transfer between gas and pump deck	L	L	L	L	K	Pump deck is heated by core which transfers to the lower down comer and attached to the surface of the pump deck. However surface of pump deck is small. Therefore the effect of heat transfer on FoM is not so large.	Heat transfer coefficient between gas and pump deck can be estimated from established knowledge.
361		Heat transfer between gas and RPV wall	L	L	L	M	K	RPV wall is heated by core transferred into lower down comer. Heat transfer between gas and RPV wall would have an effect on gas temperature. Therefore the effect on FoM until 3rd phase is small. On the other hand, gas temperature in PCV would directly be changed by this phenomenon. Therefore there has an effect on FoM in the 4th phase.	Heat transfer coefficient between gas and RPV wall can be estimated from established knowledge.
362		Heat transfer between water and corium	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not formed. In the 3rd phase, corium flows out to the lower down comer and its heat is transferred to water. Therefore water temperature in lower down comer would be changed prominently due to the heat transfer between water and corium. The effect on FoM is large. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between water and corium can be estimated from established knowledge and experiment results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
363	Lower down comer	Heat transfer between gas and corium	N/A	N/A	M	M	P	In the 1st and 2nd phase, corium has not formed. Since 3rd phase, corium flows out to the lower down comer and its heat is transferred to the gas. Therefore gas temperature in lower down comer would be changed due to the heat transfer between gas and corium. There has an effect on FoM.	Heat transfer between gas and corium can be estimated from established knowledge and experiment results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.
364		Heat transfer between corium and shroud wall	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not formed. In the 3rd phase, corium flows out to the lower down comer through damaged parts of the shroud wall. Therefore this phenomenon has a large effect on temperature of corium directly. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between shroud wall and corium can be estimated from established knowledge and experiment results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.
365		Heat transfer between corium and jet pump	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not formed. In the 3rd phase, corium flows out from the core region. Heat transfer between corium and jet pump would have an effect on temperature of pump and corium directly. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between jet pump and corium can be estimated from established knowledge and experiment results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
366	Lower down comer	Heat transfer between corium and pump deck	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not formed. In the 3rd phase, corium flows out from the core region. Heat transfer between corium and pump deck would have an effect on temperature of pump deck and corium directly. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between pump deck and corium can be estimated from established knowledge and experiment results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.
367		Heat transfer between corium and RPV wall	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not formed. In the 3rd phase, corium flows out to the lower down comer and this phenomenon would have a large effect on temperature of corium and RPV wall directly. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between RPV wall and corium can be estimated from established knowledge and experiment results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.
368		Heat transfer between water and crust	N/A	N/A	M	L	P	In the 1st and 2nd phase, crust has not formed. In the 3rd phase, crust formed at the surface of the wall. Therefore heat transfer between water and crust may have an effect on water temperature and thus on RPV wall. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between water and crust can be estimated from established knowledge and experiment results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
369	Lower down comer	Heat transfer between gas and crust	N/A	N/A	M	L	P	In the 1st and 2nd phase, crust has not formed. Since 3rd phase, crust formed at the surface of water and structure wall. This heat transfer change may affect the temperature of gas and crust. According to this change, corium temperature formed into crust and RPV wall are also changed. Therefore there is an effect on FoM. Temperature of crust is lower than that of corium and crust sticks to the structure wall. Therefore effect on gas temperature which transported into PCV is small.	Heat transfer between gas and crust can be estimated from established knowledge and experiment results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.
370		Heat transfer between corium and crust	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium and crust have not formed. Heat transfer between corium and crust would directly affect the temperature of corium and therefore on the FoM in 3rd phase. In the 4th phase, this phenomenon would not directly affect the condition on PCV.	Heat transfer between corium and crust can be estimated from established knowledge and experiment results. However components and compositions of both corium and crust would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
371	Lower down comer	Heat transfer between crust and shroud wall	N/A	N/A	H	L	P	In the 1st and 2nd phase, crust has not formed. In the 3rd phase, corium flows out to the lower down comer through damaged parts of the shroud wall and form crust at the surface. Heat transfer between crust and shroud wall would change the temperature of shroud wall and therefore water and RPV wall. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between shroud wall and crust can be estimated from established knowledge and experiment results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.
372		Heat transfer between crust and jet pump	N/A	N/A	H	L	P	In the 1st and 2nd phase, crust has not formed. In the 3rd phase, corium flows out from the core region and form crust at the surface. Heat transfer between crust and jet pump would have an effect on temperature of pump and crust. Therefore temperature of corium and water would be changed and also of RPV wall. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between jet pump and crust can be estimated from established knowledge and experiment results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
373	Lower down comer	Heat transfer between crust and pump deck	N/A	N/A	H	L	P	In the 1st and 2nd phase, crust has not formed. In the 3rd phase, corium flows out from the core region and form crust at the surface. Heat transfer between crust and pump deck would have an effect on temperature of pump deck and crust. Therefore temperature of corium and water would be changed and also of RPV wall. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between pump deck and crust can be estimated from established knowledge and experiment results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.
374		Heat transfer between crust and RPV wall	N/A	N/A	H	L	P	In the 1st and 2nd phase, crust has not formed. In the 3rd phase, corium flows out from the core region and form crust at the surface of the structure. Heat transfer between crust and RPV wall would have an large effect on temperature of crust and RPV wall directly. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between RPV wall and crust can be estimated from established knowledge and experiment results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
375	Lower down comer	Heat transfer between water and particulate corium	N/A	N/A	H	L	P	In the 1st and 2nd phase, particulate corium has not formed. In the 3rd phase, corium flows out to the lower down comer and form particulate corium in the water. Its heat is transferred to water. Therefore water temperature in lower down comer would be changed prominently due to the heat transfer between water and particulate corium. The effect on FoM is large. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between water and particulate corium can be estimated from established knowledge and experiment results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.
376		Heat transfer between gas and particulate corium	N/A	N/A	H	M	P	In the 1st and 2nd phase, particulate corium has not formed. In the 3rd phase, corium flows out to the lower down comer and form particulate corium in the water or at the surface of the structure. Particulate corium would be suspended in the water and the heat is transferred to the gas. Therefore gas temperature in lower down comer would be changed due to the heat transfer between gas and particulate corium. There has a large effect on FoM. In the 4th phase, gas of which temperature is changed with heat transfer between gas and particulate corium is transferred into PCV and affects FoM.	Heat transfer between gas and particulate corium can be estimated from established knowledge and experiment results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
377	Lower down comer	Heat transfer between particulate corium and shroud wall	N/A	N/A	H	L	P	In the 1st and 2nd phase, particulate corium has not formed. In the 3rd phase, particulate corium is formed in the water or at the surface of structure. Particle corium, which temperature is changed by heat transfer, would be suspended in the water and affect the water temperature. Therefore RPV wall and corium temperature are also affected largely. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between shroud wall and particulate corium can be estimated from established knowledge and experiment results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.
378		Heat transfer between particulate corium and jet pump	N/A	N/A	H	L	P	In the 1st and 2nd phase, particulate corium has not formed. In the 3rd phase, particulate corium is formed in the water or at the surface of jet pump. Particulate corium, which temperature is changed by heat transfer, is suspended in the water and affects the water temperature. Also it could attach on RPV wall. Therefore RPV wall and corium temperature are also affected. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between jet pump and particulate corium can be estimated from established knowledge and experiment results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
379	Lower down comer	Heat transfer between particulate corium and pump deck	N/A	N/A	H	L	P	In the 1st and 2nd phase, particulate corium has not formed. In the 3rd phase, particulate corium is formed in the water or at the surface of pump deck. Particulate corium, which temperature is changed by heat transfer, is suspended in the water and affects the water temperature. Also it could attach on RPV wall. Therefore RPV wall and corium temperature are also affected. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between pump deck and particulate corium can be estimated from established knowledge and experimental results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.
380		Heat transfer between particulate corium and RPV wall	N/A	N/A	H	L	P	In the 1st and 2nd phase, particulate corium has not formed. In the 3rd phase, particulate corium is formed at the surface of structure or in water. Heat transfer between particulate corium and RPV wall would have a large effect on temperature of RPV wall directly. This phenomenon would not affect gas temperature directly. Therefore the effect on FoM in the 4th phase is small.	Heat transfer between RPV wall and particulate corium can be estimated from established knowledge and experimental results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.
381		Heat Transfer to Drywell through Lagging Material	M	M	M	M	K	Heat transfer to drywell from lower down comer would change the temperature within the reactor. Therefore there is an effect on FoM in each phase.	Heat transfer to drywell through lagging material can be estimated from established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
382	Lower down comer	Radiation heat transfer between corium and shroud wall	N/A	N/A	M	L	P	In the 1st and 2nd phase, corium has not transported to lower down comer. In the 3rd phase, corium temperature would be changed by radiation heat transferred to shroud wall. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between corium and shroud wall can be estimated from established knowledge and experimental results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.
383		Radiation heat transfer between corium and jet pump	N/A	N/A	M	L	P	In the 1st and 2nd phase, corium has not transported to lower down comer. In the 3rd phase, corium temperature would be changed by radiation heat transferred to jet pump. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between corium and jet pump can be estimated from established knowledge and experimental results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.
384		Radiation heat transfer between corium and pump deck	N/A	N/A	M	L	P	In the 1st and 2nd phase, corium has not transported to lower down comer. In the 3rd phase, corium temperature would be changed by radiation heat transferred to pump deck. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between corium and pump deck can be estimated from established knowledge and experimental results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
385	Lower down comer	Radiation heat transfer between corium and RPV wall	N/A	N/A	M	L	P	In the 1st and 2nd phase, corium has not transported to lower down comer. In the 3rd phase, corium temperature would be changed by radiation heat transferred to RPV wall. Therefore temperature of RPV wall would also change. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between corium and RPV wall can be estimated from established knowledge and experimental results. However components and compositions of the corium would change with event progression and therefore the heat transfer includes uncertainty.
376		Radiation heat transfer between particulate corium and shroud wall	N/A	N/A	M	L	P	In the 1st and 2nd phase, particulate corium has not formed in lower down comer. In the 3rd phase, particulate corium temperature would be changed by radiation heat transferred to shroud wall. Since particulate corium is suspended in the water, temperature of water and RPV wall would be changed. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between particulate corium and shroud wall can be estimated from established knowledge and experimental results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.
387		Radiation heat transfer between particulate corium and jet pump	N/A	N/A	M	L	P	In the 1st and 2nd phase, particulate corium has not formed in lower down comer. In the 3rd phase, particulate corium temperature would be changed by radiation heat transferred to jet pump. Since particulate corium is suspended in the water, temperature of water and RPV wall would be changed. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between particulate corium and jet pump can be estimated from established knowledge and experimental results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
388	Lower down comer	Radiation heat transfer between particulate corium and pump deck	N/A	N/A	M	L	P	In the 1st and 2nd phase, particulate corium has not formed in lower down comer. In the 3rd phase, particulate corium temperature would be changed by radiation heat transferred to pump deck. Since particulate corium is suspended in the water, temperature of water and RPV wall would be changed. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between particulate corium and pump deck can be estimated from established knowledge and experimental results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.
389		Radiation heat transfer between particulate corium and RPV wall	N/A	N/A	M	L	P	In the 1st and 2nd phase, particulate corium has not formed in lower down comer. In the 3rd phase, temperature of particulate corium and RPV wall is changed by radiation heat. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between particulate corium and RPV wall can be estimated from established knowledge and experimental results. However components and compositions of the particulate corium would change with event progression and therefore the heat transfer includes uncertainty.
390		Radiation heat transfer between crust and shroud wall	N/A	N/A	M	L	P	In the 1st and 2nd phase, crust has not formed in lower down comer. In the 3rd phase, crust is formed at structure surface. Temperature of crust and shroud wall is changed by radiation heat and so the temperature of corium and RPV wall. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between crust and shroud wall can be estimated from established knowledge and experimental results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
391	Lower down comer	Radiation heat transfer between crust and jet pump	N/A	N/A	L	L	P	In the 1st and 2nd phase, crust has not formed in lower down comer. In the 3rd and 4th phase, crust is formed at structure surface. Since surface area of jet pump is small and also crust is likely to be formed at the jet pump surface, the effect on FoM is small.	Radiation heat transfer between crust and jet pump can be estimated from established knowledge and experimental results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.
392		Radiation heat transfer between crust and pump deck	N/A	N/A	M	L	P	In the 1st and 2nd phase, crust has not formed in lower down comer. In the 3rd phase, crust is formed at structure surface. Temperature of crust and pump deck is changed by radiation heat and so the temperature of RPV wall. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between crust and pump deck can be estimated from established knowledge and experimental results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.
393		Radiation heat transfer between crust and RPV wall	N/A	N/A	M	L	P	In the 1st and 2nd phase, crust has not formed in lower down comer. In the 3rd phase, temperature of crust and RPV wall is changed by radiation heat. Radiation heat would not change the gas temperature directly. Therefore the effect on PCV is small.	Radiation heat transfer between crust and RPV wall can be estimated from established knowledge and experimental results. However components and compositions of the crust would change with event progression and therefore the heat transfer includes uncertainty.
394		Radiation heat transfer to drywell	M	M	M	M	K	Radiation heat transfer to drywell from lower down comer would change the temperature within the reactor. Therefore there is an effect on FoM in each phase.	Radiation heat transfer to drywell can be estimated from established knowledge.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
395	Lower down comer	Heat generation by gamma ray in lower down comer structure	L	L	M	L	K	Gamma heat is generated from FP and corium. The heat would not occur in the 1st and 2nd phase. In the 3rd phase, corium is transferred into lower down comer. Therefore FoM is affected by the heat. Since 4th phase, gas temperature may be not affected directly and the heat may also decay with time, so the effect is small.	Gamma heat generated in lower down comer can be estimated with decay heat and FP transferred to the lower down comer based on established knowledge.
396		Failure of shroud wall by thermal stress	L	L	M	L	P	In the 1st and 2nd phase, corium is stayed within the shroud wall and would not affect FoM. In the 3rd phase, failure of shroud wall would change the quantity of corium which transferred into lower down comer. Therefore the temperature RPV wall is affected. Since 4th phase, gas temperature may be not affected directly and the effect is small.	Thermal stress affect on shroud wall can be estimated from established knowledge of properties of the material. However the probability of failure on shroud wall by thermal stress, which is estimated with established knowledge, includes uncertainty.
397		Failure of RPV nozzle welding by thermal stress	N/A	N/A	M	M	P	In the 1st and 2nd phase, pressure and temperature within RPV would not become so high to fail the nozzle welding. Since 3rd phase, pressure and temperature within RPV become high. Therefore failure of RPV nozzle welding would change the temperature and pressure in RPV and so in PCV.	Thermal stress affect on RPV nozzle welding can be estimated from established knowledge of properties of the material. However the probability of failure on RPV nozzle welding by thermal stress, which is estimated with established knowledge, includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
398	Lower down comer	CCFL in suction part in jet pump	L	L	L	L	K	CCFL in jet pump would affect the circulation in jet pump and therefore the coolability of water. However the phenomenon would not occur continuously and the effect on FoM is small.	Phenomena of CCFL can be estimated from established knowledge.
399		Change in water level in lower down comer	H	H	M	L	K	Water level in lower down comer would affect the cool ability of core region. Therefore the effect on temperature of core region is large. In the 3rd phase, temperature within RPV is also affected by this phenomenon. This phenomenon would not affect directly on PCV conditions.	Water level change in lower downcomer can be estimated from temperature and pressure in core region and in other components with established knowledge.
400		Change in pressure in lower down comer	L	M	M	M	K	Pressure in lower down comer may change prominently since 2nd phase. Pressure change in lower down comer may change the temperature and pressure within RPV and PCV.	Pressure change in lower downcomer can be estimated from temperature and pressure in core region and in other components with established knowledge.
401		Change of flow regime in lower down comer	L	L	L	L	K	Flow regime may change the heat transfer between water and structure wall, and therefore the water temperature. However the change may be not so large and the effect on FoM is small.	Gas flow in lower down comer at normal operation can be evaluated analytically. Since flow regime change in lower down comer can be estimated from the condition of core region in the accident, the flow can be estimated based on established knowledge.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
402	Lower down comer	Depressurization boiling	H	L	M	L	K	Decompression boiling may affect the water temperature and water level in core region and within RPV. It affects the temperature of fuel directly and has an influence on the probability of fuel melt. Therefore the effect on FoM in 1st phase is large. In the 3rd phase, decompression boiling may affect the temperature of corium and therefore FoM.	The mechanism of decompression boiling has known with experimental results. Therefore the decompressing boiling can be estimated with established knowledge.
403		Change in water temperature in lower down comer	M	L	M	L	K	Water temperature in lower down comer would affect the cool ability of core region. Therefore the change would affect on FoM in the 1st phase. In the 3rd phase, temperature within RPV is also affected by water temperature in lower down comer directly, because it is effective to the cooling. This phenomenon would not affect directly on PCV conditions.	Water temperature change in lower downcomer can be estimated from temperature and pressure in core region and in other components with established knowledge.
404		Change in gas temperature in lower down comer	L	L	M	L	K	In the 1st and 2nd phase, gas temperature in lower down comer would not change from the saturation temperature and would not affect FoM. In the 3rd phase, gas temperature would change by transferred corium, and affect the temperature of RPV wall and corium. The effect of this phenomenon on PCV conditions is small.	Gas temperature change in lower downcomer can be estimated from temperature and pressure in core region and in other components with established knowledge.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
405	Lower down comer	Change in gas composition in lower down comer	L	L	L	L	K	Gas composition in lower down comer would change the gas temperature. However, the effect is small.	Gas composition change in lower downcomer can be estimated from temperature and pressure in core region and in other components with established knowledge.
406		Change in temperature in shroud wall	M	M	H	L	K	Temperature change in shroud wall may have an effect on temperature and pressure in core region. Especially in 3rd phase, this phenomenon have an large effect on corium and RPV wall temperature, since corium transferred through shroud wall to the lower down comer.	Temperature change in shroud wall can be estimated from temperature and pressure in core region and in other components with established knowledge.
407		Change in temperature in jet pumps	L	L	H	L	K	Temperature change in jet pump may not affect the conditions in core region in 1st and 2nd phase. In the 3rd phase, temperature and pressure in lower down comer may increase and the temperature change in jet pump may also have a large effect on temperature of RPV wall and corium which transfers into the lower down comer. The effect of this phenomenon on PCV conditions is small.	Temperature change in jet pumps can be estimated from temperature and pressure in core region and in other components with established knowledge.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
408	Lower down comer	Change in temperature in pump deck	L	L	H	L	K	Temperature change in pump deck may not affect the conditions in core region in 1st and 2nd phase. In the 3rd phase, temperature and pressure in lower down comer may increase and the temperature change in pump deck may also have a large effect on temperature of RPV wall and corium which transfers into the lower down comer. The effect of this phenomenon on PCV conditions is small.	Temperature change in pump deck can be estimated from temperature and pressure in core region and in other components with established knowledge.
409		Change in temperature in RPV sidewall	M	M	H	M	K	Since RPV wall have a large surface area, temperature change in RPV sidewall may have an effect on temperature and pressure within RPV and PCV. Especially in 3rd phase, temperature change in RPV sidewall has direct effect on RPV wall temperature.	Temperature change in RPV sidewall can be estimated from temperature and pressure in core region and in other components with established knowledge.
410		Corium relocation type through breached core shroud to lower plenum	N/A	N/A	H	M	P	In the 1st and 2nd phase, relocation has not started. Since 3rd phase, corium relocation type such as jet or agglomerate may have an effect on corium state in lower down comer and the place of corium attachment. Therefore FoMs are greatly influenced by corium relocation type. The effect on PCV conditions is not as large as that on RPV.	Corium relocation type can be estimated from established knowledge. However the type would change with temperature and pressure condition where corium exists and so it includes uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
411	Lower down comer	Corium spreading in lower down comer	N/A	N/A	H	L	U	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, corium spreading may have an effect on corium cooling and surface area of heating element which exist in lower down comer. Therefore the effect on FoM is large. The effect of corium spreading on PCV conditions is small.	The experiments which confirm and determined the corium spreading has not conducted in the past and there is no knowledge in the past.
412		Ablation of outer wall surface of shroud by corium	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, since corium flows into lower down comer through shroud wall, ablation of outer wall surface of shroud wall may enlarge the failure area of shroud wall. Therefore the quantity of corium flow into lower down comer may be affected. Also, temperature of shroud wall may change as thinning by the ablation. Therefore the effect on FoM is large. The direct effect of ablation on PCV conditions is small.	Ablation by corium can be estimated with established knowledge. However the compositions and components of corium include uncertainty and this would change the ablation behavior.
413		Change in area of failure opening in shroud	N/A	N/A	H	M	P	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, change in failure area in shroud may change the quantity of corium which flows into lower down comer. Therefore the effect on FoM is large. Also in 4th phase, large change of corium quantity flows into lower down comer may have an effect on PCV conditions.	As the area of failure opening in shroud depends on the accident progression, it is difficult to predict the area change.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
414	Lower down comer	Flow of water and gas through failure opening in shroud	N/A	N/A	M	M	P	In the 1st and 2nd phase, shroud has not failed. Since 3rd phase, flow of water and gas through shroud may change the temperature and pressure in RPV and PCV.	Flow of water and gas through failure opening in shroud depends on the pressure difference, loss coefficients and break size.
415		Corium reflood by water injection	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, corium which flows into lower down comer may cooled by water injection and its surface would be covered by crust. Therefore corium temperature and conditions within RPV wall may be affected largely. Corium submerge in water may not affect PCV conditions directly.	Corium will be reflooded when the downcomer water level is higher than the corium height. In reality, it is difficult to predict the corium height, which depends on the accident progression.
416		FCI pre-mixing by contact between corium and water pool	N/A	N/A	H	M	P	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, corium which flows into lower down comer contacts with water and breaks up. Since the high temperature corium droplets flow into water, the effect on FoM is large. Steam is generated in FCI pre-mixing, the effect on PCV conditions exist.	FCI pre-mixing by contact between corium and water pool can be estimated from established knowledge. However the components and compositions of corium include uncertainty and it would affect the mixing behavior.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
417	Lower down comer	FCI triggering by vapor film collapse	N/A	N/A	H	M	P	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, corium flows into lower down comer penetrated into water and corium-water contact occurs after steam explosion. This may have a large effect on FoM. Steam generated through FCI in lower down comer may have an effect on PCV conditions.	FCI triggering can be estimated from established knowledge. However the components and compositions of corium include uncertainty and it would affect the FCI behavior.
418		Atomization of corium in water pool and rapid steam generation (FCI)	N/A	N/A	H	M	P	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, corium fines are cooled by water and steam is generated in stead. Therefore the effect on RPV conditions and corium temperature is large. In the 4th phase, steam generated by FCI may have an effect on temperature and pressure in PCV.	Atomization of corium can be estimated from established knowledge. However the components and compositions of corium include uncertainty and it would affect the FCI behavior.
419		Pressure wave by FCI	N/A	N/A	H	M	P	In the 1st and 2nd phase, FCI has not occurred. In the 3rd phase, steam generated by FCI pushes the water. This may affect the coolability of water and corium temperature. Therefore the effect on FoM is large. In the 4th phase, pressure wave within RPV may have an effect on pressure in PCV.	Pressure wave by FCI can be estimated from established knowledge. However the components and compositions of corium include uncertainty and it would affect the FCI behavior.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
420	Lower down comer	Gas/water temperature increase by FCI	N/A	N/A	H	M	P	In the 1st and 2nd phase, FCI has not occurred. In the 3rd phase, temperature increase of water may affect the cool ability within RPV and corium. Therefore the effect on FoM is large. In the 4th phase, gas temperature change in RPV may directly affect the PCV temperature.	Temperature increase of water and gas by FCI can be estimated from established knowledge. However the components and compositions of corium include uncertainty and it would affect the FCI behavior.
421		Failure of RPV sidewall by FCI	N/A	N/A	H	M	P	In the 1st and 2nd phase, FCI has not occurred. In the 3rd phase, failure of RPV may suggest that the impact of FCI is large. Therefore the effect on RPV wall and corium may be large. As larger the impact of FCI, the steam generated by FCI would increase. Therefore the effect of FCI on pressure in PCV may be not small.	Failure of RPV lower head by FCI can be estimated from established knowledge. However the components and compositions of corium include uncertainty and it would affect the FCI behavior.
422		Scattering of corium, particulate corium and crust in lower down comer by FCI	N/A	N/A	H	M	P	In the 1st and 2nd phase, FCI has not occurred. In the 3rd phase, scattering of corium may be occurred through atomization by FCI and its effect on corium temperature and RPV wall temperature may large. The steam generated by FCI may effect on PCV pressure in the 4th phase.	Scattering of corium, particulate corium and crust by FCI can be estimated from established knowledge. However the components and compositions of corium, particulate corium and crust include uncertainty and it would affect the FCI behavior.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
423	Lower down comer	Impact for FCI by seawater	N/A	N/A	L	L	U	In the 1st and 2nd phase, FCI has not occurred. Since 3rd phase, existence of seasalt solute in water may have an effect on FCI behavior. However the effect would be small and the effect on FoM is also small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
424		Change in corium temperature	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not flowed into lower down comer. Change in corium temperature would directly affect FoM largely in the 3rd phase.	Corium temperature change can be estimated from established knowledge. However the components and compositions of corium, particulate corium and crust include uncertainty and it would affect the temperature change.
425		Change in physical property by material mixing in corium	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not flowed into lower down comer. In the 3rd phase, physical property change in corium may affect the cooling rate and mixing of corium in water. Therefore the effect on FoM may be large. The effect of physical properties in corium on PCV conditions is small.	Change in physical property by material mixing in corium can be estimated from established knowledge. However the components and compositions of corium include uncertainty and it would affect the physical property.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
426	Lower down comer	Oxidation reaction between corium and water (steam) (including hydrogen generation and reaction heat)	N/A	N/A	M	L	U	In the 1st and 2nd phase, corium has not flowed into lower down comer. Oxidation reaction between corium and water may generate reaction heat. Then the temperature of existing corium around reaction area and water may increase. There is an effect on FoM. Since reaction area of corium is small and generation of hydrogen and reaction heat is not large enough to affect PCV conditions.	The test to confirm the behavior of oxidation reaction between corium and water has not conducted in the past and there is no knowledge.
427		Oxidation reaction between shroud and steam (including hydrogen generation and reaction heat)	L	M	M	L	P	Shroud which consists of steel can be oxidized with water and steam. With the reaction, reaction heat is generated and it would affect the temperature around shroud. Therefore the effect on core and RPV exists.	Oxidation reaction behavior between shroud and steam can be estimated from established knowledge. However the definite condition such as reaction rate includes uncertainty..
428		Oxidation reaction between jet pump and steam (including hydrogen generation and reaction heat)	L	L	L	L	P	Jet pump which consists of steel can be oxidized with steam. However the surface area of jet pump is not so large and its reaction rate is small. Therefore the effect on FoM is small.	Oxidation reaction behavior between jet pump and steam can be estimated from established knowledge. However the definite condition such as reaction rate includes uncertainty..
429		Oxidation reaction between pump deck and steam (including hydrogen generation and reaction heat)	L	L	L	L	P	Pump deck which consists of steel can be oxidized with steam. However the surface area of jet pump is not so large and its reaction rate is small. Therefore the effect on FoM is small.	Oxidation reaction behavior between pump deck and steam can be estimated from established knowledge. However the definite condition such as reaction rate includes uncertainty..

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
430	Lower down comer	Oxidation reaction between RPV sidewall and steam (including hydrogen generation and reaction heat)	L	L	L	L	P	Since reaction rate of the oxidation between RPV and steam is small, the effect on FoM is small.	Oxidation reaction behavior between RPV sidewall and steam can be estimated from established knowledge. However the definite condition such as reaction rate includes uncertainty..
431		Crust generation by solidification of corium	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not flowed into lower down comer. In the 3rd phase, solidification of corium would affect the temperature of corium and quantity of high temperature corium exists in lower down comer. Therefore the effect on FoM is large. Crust generation may not affect PCV conditions directly.	The behavior of crust generation by solidification of corium can be estimated from established knowledge. However the compositions and components of corium would change by the conditions and it includes uncertainty.
432		Crust remelting due to change in the heat transfer status to corium or water	N/A	N/A	M	L	P	In the 1st and 2nd phase, corium has not flowed into lower down comer. In the 3rd phase, crust remelting would affect the corium temperature and temperature within RPV. Therefore there is an effect on FoM. Crust remelting may not affect PCV conditions directly.	The behavior of crust remelting can be estimated from established knowledge. However the compositions and components of corium would change by the conditions and it includes uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
433	Lower down comer	Particulate corium remelting due to change in the heat transfer status	N/A	N/A	M	L	P	In the 1st and 2nd phase, corium has not flowed into lower down comer. In the 3rd phase, particle remelting would affect the temperature of corium and molten pool. Therefore there is an effect on FoM. Particle corium remelting would change the temperature within RPV. However the change would not enough to affect the conditions within PCV.	The melting behavior of particulate corium can be estimated from established knowledge. The behavior is affected by the particulate corium conditions. However the compositions and components of particulate corium would change by the conditions and it includes uncertainty.
434		Recrticality	N/A	N/A	H	M	P	The re-critical condition is highly unlikely to occur. However the impact would be large and the feasibility cannot be denied perfectly. Then this item should be kept in the phenomena list.	The recriticality may be evaluated by some fuel design codes or transient analysis codes if a simple shape is assumed for the molten pool or debris. FP with short half-life can be a tracer material to determine the re-criticality.
435		Decay heat in corium	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, decay heat generated from corium would raise the temperature within RPV and therefore the pressure and temperature may be affected. In the 4th phase, the heat may decay with time, so the effect is small.	Decay heat in corium can be estimated from established knowledge. However the compositions and components of corium would change by the conditions and it includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
436	Lower down comer	Relocation of corium by failure of pump deck	N/A	N/A	M	L	P	Until 2nd phase, corium has not flow into lower down comer. In 3rd phase, corium would flow down into lower head with pump deck failing. Then the corium cooling and temperature and pressure within RPV would change. In the 4th phase, change of RPV conditions would not affect PCV largely.	Relocation of corium can be estimated from established knowledge. The behavior is affected by the corium conditions. However the compositions and components of corium would change by the conditions and it includes uncertainty.
437		Relocation of corium by failure of jet pump	N/A	N/A	M	L	P	Until 2nd phase, corium has not flow into lower down comer. In 3rd phase, corium would flow down into lower recirculation loop piping. Then corium would lower the performance of recirculation loop. Therefore conditions within RPV would change. In the 4th phase, change of RPV conditions would not affect PCV largely.	Relocation of corium can be estimated from established knowledge. The behavior is affected by the corium conditions. However the compositions and components of corium would change by the conditions and it includes uncertainty.
438		Break-up of corium by contact with water	N/A	N/A	H	L	P	Until 2nd phase, corium has not flow into lower down comer. In 3rd phase, corium is broken up by contact with water, so the cooling of corium by water would be promoted due to increase of surface area. Therefore the effect on FoM is large. This phenomenon would not affect FoM in the 4th phase.	Break-up of corium can be estimated from established knowledge. The behavior is affected by the corium conditions. However the compositions and components of corium would change by the conditions and it includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
439	Lower down comer	Change in physical property of particulate corium	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not flowed into lower down comer. In the 3rd phase, physical property change in corium may affect the cooling rate and mixing of corium in water. Therefore the effect on FoM may be large. The effect of physical properties in corium on PCV conditions is small.	Physical property change of particulate corium can be estimated from established knowledge. However the compositions and components of particulate corium would change by the conditions and it includes uncertainty.
440		Change in size and shape of particulate corium	N/A	N/A	M	L	P	Until 2nd phase, corium has not flow into lower down comer. In 3rd phase, size and shape of particulate corium would affect the cooling rate and mixing of corium in water. Therefore this would have an effect on FoM. The effect on PCV conditions is small.	Change in size and shape of particulate corium can be estimated from established knowledge. The behavior is affected by the particulate corium conditions. However the compositions and components of particulate corium would change by the conditions and it includes uncertainty.
441		Entrainment of particulate corium from corium falling into water	N/A	N/A	H	L	P	Until 2nd phase, corium has not flow into lower down comer. In 3rd phase, corium is particulated by contact with water, so the cooling and mixing of corium by water would change due to the increase of surface area. Therefore the effect on FoM is large. This phenomenon would not affect FoM in the 4th phase.	Entrainment of particulate corium can be estimated from established knowledge. The behavior is affected by the particulate corium conditions. However the compositions and components of particulate corium would change by the conditions and it includes uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
442	Lower down comer	Aggregation and bed formation of particulate corium	N/A	N/A	H	L	P	Until 2nd phase, corium has not flow into lower down comer. In 3rd phase, particulate corium accumulates at the point with no flow. Therefore accumulated particulate corium would raise the temperature of water and corium in lower down comer. The effect on FoM is high. The effect of this phenomenon on PCV conditions is small.	Aggregation and bed formation of particulate corium can be estimated from established knowledge. The behavior is affected by the particulate corium conditions. However the compositions and components of particulate corium would change by the conditions and it includes uncertainty.
443		Change in temperature of particulate corium	N/A	N/A	H	L	P	Until 2nd phase, corium has not flow into lower down comer. In 3rd phase, particulate corium temperature would affect the temperature of water and structure on lower down comer. Therefore the effect on FoM is large. The effect of this phenomenon on PCV conditions is small.	Temperature change of particulate corium can be estimated from established knowledge. However the compositions and components of particulate corium would change by the conditions and it includes uncertainty.
444		Decay heat in particulate corium	N/A	N/A	H	L	P	In the 1st and 2nd phase, corium has not flow into lower down comer. In the 3rd phase, decay heat generated from particulate corium would raise the temperature within lower down comer and therefore the pressure and temperature in RPV may be affected. In the 4th phase, the heat may decay with time, so the effect is small.	Decay heat in particulate corium can be estimated by established knowledge. However the compositions and components of particulate corium would be changed by the conditions and it includes uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
445	Lower down comer	Change in temperature of crust	N/A	N/A	H	L	P	Until 2nd phase, crust has not formed in lower down comer. In 3rd phase, since crust is formed at the surface of structure wall, crust temperature change would affect the temperature of water and structure on lower down comer. Therefore the effect on FoM is large. The effect of this phenomenon on PCV conditions is small.	Temperature change of crust can be estimated from established knowledge. However the compositions and components of crust would be changed by the conditions and it includes uncertainty.
446		Bubble formation in crust	N/A	N/A	M	L	P	Until 2nd phase, crust has not formed in lower down comer. In 3rd phase, bubble formation in crust may change the temperature and pressure in lower down comer. This would affect FoM. Pressure generated with bubble formation in crust may not so large to contribute to the pressure in PCV.	The behavior of bubble formation in crust can be estimated with established knowledge. The behavior is changed by the crust conditions. However the composition and components of crust would be changed by the conditions of water/steam and it includes uncertainty.
447		Water inflow into crust through crack on surface of crust	N/A	N/A	M	L	P	In 1st and 2nd phase, crust has not formed in lower down comer. In 3rd phase, water inflow in crust may promote the cooling of crust and therefore the corium which accumulates on the crust and temperature in lower down comer may change. This would affect FoM. The conditions change in lower down comer by this phenomenon would not large enough to affect FoM in 4th phase.	The behavior of water inflow into crust can be estimated with established knowledge. The behavior is changed by the crust conditions. However the composition and components of crust would be changed by the conditions of water/steam and it includes uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
448	Lower down comer	Decay heat in crust	N/A	N/A	H	L	P	In the 1st and 2nd phase, crust has not formed in lower down comer. In the 3rd phase, decay heat generated from crust would raise the temperature within lower down comer and therefore the pressure and temperature in RPV may be affected. In the 4th phase, the heat may decay with time, so the effect is small.	Decay heat in crust can be estimated by established knowledge. However the compositions and components of crust would be changed by the conditions and it includes uncertainty.
449		Change in physical property by material mixing in crust	N/A	N/A	M	L	P	In the 1st and 2nd phase, crust has not formed in lower down comer. In the 3rd phase, physical property change in crust may affect the cooling rate in water and temperature of structure where the crust is attached. Therefore the effect on FoM may be large. The effect of physical properties in corium is not large enough to change the conditions of PCV large.	Change in physical property by material mixing in crust can be estimated by established knowledge. However the compositions and components of crust would be changed by the conditions and it includes uncertainty.
450		Oxidation reaction between crust and water (steam) (including hydrogen generation and reaction heat)	N/A	N/A	M	L	U	In the 1st and 2nd phase, crust has not formed in lower down comer. Oxidation reaction between crust and water may generate reaction heat. Then the temperature of crust and corium existing around reaction area and water may increase. There is an effect on FoM. Since reaction area of crust is small and generation of hydrogen and reaction heat is not large enough to affect PCV conditions.	The test to confirm the behavior of oxidation reaction between crust and water has not conducted in the past and there is no knowledge.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
451	Lower down comer	Flow path blockage in lower down comer (including jet pump) by crust	N/A	N/A	H	L	P	Until 2nd phase, crust has not formed in lower down comer. In 3rd phase, flow path blockage may affect the coolability of water in lower down comer. Then temperature and pressure in lower down comer may change significantly. Therefore the effect on FoM is large. Since temperature and pressure in lower down comer may affect the PCV conditions in 4th phase, the change may be small.	The behavior of flow path blockage by crust can be estimated with established knowledge. The behavior is changed by the crust conditions. However the composition and components of crust would be changed by the conditions of water/steam and it includes uncertainty.
452		Recriticality	N/A	N/A	M	L	P	Until 2nd phase, molten core which has possibility to cause recriticality has not flowed into lower down comer. In 3rd phase, recriticality would generate large heat and FP gas. Therefore the impact on conditions in lower down comer may be large and so the FoM is affected. The effect on PCV conditions generated with impact of recriticality may be small in the 4th phase.	The investigation to cause re-critical condition has already conducted definitely and has estimated knowledge. Re-critical condition is highly unlikely to occur. However the impact would be large and the feasibility cannot be denied perfectly.
453		Flow of corium (including particulate corium) out of RPV side wall	N/A	N/A	N/A	M	P	Until 3rd phase, RPV has not failed and corium would not flow through RPV wall. In the 4th phase, corium flows out of RPV wall may transfer into PCV and affect the temperature and pressure.	The behavior of corium flow can be estimated with established knowledge. The behavior is changed by the crust conditions. However the composition and components of crust would be changed by the conditions of water/steam and it includes uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
454	Lower down comer	Flow of corium (including particulate corium) into recirculation loop piping	N/A	N/A	M	L	P	Until 2nd phase, corium has not flowed into lower down comer. In 3rd phase, corium in recirculation loop piping would lower the performance of the loop. This may affect the coolability of water in lower down comer and therefore temperature and pressure in RPV would be affected. However the effect is not so large to change the conditions in PCV.	The behavior of corium flow can be estimated with established knowledge. The behavior is changed by the crust conditions. However the composition and components of crust would be changed by the conditions of water/steam and it includes uncertainty.
455		Radiation decomposition of water	L	L	L	L	K	Radiation on water would cause ionization and excitation of molecules. However decomposition ratio may not so large and the rate is suspended to be small. Therefore the effect on FoM is small.	Radiation decomposition of water can be estimated by established knowledge.
456		FP deposition on lower downcomer	L	L	L	L	P	FP is likely to attach on the structure and deposited on the surface. This would affect the water temperature in lower down comer. However the deposition occurs locally and the effect on FoM is small.	Deposition behavior of FP has been studied. Therefore, FP deposition can be estimated based on established knowledge. There is insufficient knowledge of FP amounts transported into the lower down comer. Therefore, the evaluated value includes uncertainty.
457		FP re-vaporization	L	L	L	L	P	FP is likely to attach on the structure and deposited on the surface. Since FP re-vaporization would raise the temperature, the place where occurs re-vaporization may be locally and the effect on FoM is small.	FP re-vaporization behavior has been investigated in several studies. Therefore, FP re-vaporization can be estimated. There is insufficient knowledge of FP composition and quantity transported into the lower down comer. Therefore, the evaluated quantity of re-vaporization includes uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
458	Lower down comer	Decay heat generation from FP	L	L	L	L	P	FP is likely to attach on the structure and deposited on the surface. Since decay heat generated from FP would raise the temperature, the attached FP may be small and the effect on FoM is small.	Decay heat generation from FP can be estimated by established knowledge. However the FP quantity which transfers to lower downcomer is changed by conditions of lower downcomer and includes uncertainty.
459		FP release from corium surface	N/A	N/A	M	M	U	In 1st and 2nd phase, corium has not flowed into lower down comer. In 3rd phase, FP released from corium surface would raise the temperature of water and structures in lower down comer. In 4th phase, FP can transfer into PCV through failed RPV wall. Therefore temperature and pressure in PCV may be affected.	The test to confirm the behavior of FP release from corium surface has not conducted in the past and there is no knowledge.
460		FP reaction including iodine chemistry	L	L	L	L	P	FP released with fuel melting is likely to attach on structure. Therefore, FP reaction including iodine may occur at the surface but the reaction effect on FoM is small.	FP reaction including iodine can be evaluated based on established knowledge. The reaction depending on temperature, composition, and so on is difficult to estimate definitely, and the data contain uncertainty.
461		Adsorption and release of gaseous FP	L	L	L	L	P	Adsorption and release of gaseous FP on the surface of structure wall would be occurred locally and repeatedly. Therefore the effect on FoM is small.	The behavior of adsorption and release of gaseous FP can be estimated by established knowledge. However the FP quantity which transfers to lower downcomer is changed by conditions of lower downcomer and includes uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
462	Lower down comer	Corrosion of structure in lower down comer by salt content of seawater (including marine lives)	L	L	L	L	U	Seawater includes chloride ion and it may cause the corrosion of dryer. Since extremely stable material for the corrosion is used for the lower down comer structure, the effect of corrosion is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
463		Seasalt intake to corium	N/A	N/A	M	M	U	In 1st and 2nd phase, corium has not transferred into lower down comer. Since 3rd phase, seasalt may cause reaction with corium and generate reaction heat. And also cooling rate and mixture into water of corium may be affected. Therefore there is an effect on FoM.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
464		Influence for heat transfer by salt deposition	L	L	L	L	U	Deposition of seasalt may be likely to occur locally in a small area of the lower down comer. Salt deposition may make a small difference on steam temperature due to the change of heat transfer. However, its effect on FoM is not so large.	The test to confirm the effect on heat transfer by seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.
465		Flow path blockage in jet pump by salt deposition	L	L	L	L	U	Deposition of seasalt may be likely to occur in place with low flow rate. Therefore, the effect of blockage by the deposition is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
466	Lower down comer	Re-solution of salt by reflooding	L	L	L	L	P	Deposition of seasalt may be likely to occur locally in a small area of the lower down comer. Therefore, the effect of re-solution of salt is small.	Re-solution mechanism of salt has already known by the established knowledge. However, the test to confirm the effect of seasalt entered due to the injection of seawater has not conducted. Therefore the effect of the resolution on temperature and pressure of steam includes uncertainty.
467		Influence on Heat Transfer by Seasalt Concentration Change	L	L	L	L	P	Seasalt concentration in water may make a small difference on water temperature due to the change of heat transfer. However, its effect on FoM is small.	The effect of seasalt concentration on the heat transfer can be predicted by the operation experience of heat exchangers in which seawater is used. However, the test to confirm the effect of seasalt entered due to the injection of seawater has not conducted. Therefore the effect on temperature and pressure in lower down comer includes uncertainty.
468		Influence on Instrumentation and Measurements by Seasalt Concentration Change	L	L	L	L	U	High concentration of seasalt in water may deposited on the instruments and change the measurements. Therefore seasalt concentration change in water may make a small difference on temperature. However, its effect on FoM is small.	The test to confirm the effect of seasalt entered due to the injection of seawater has not conducted and there is no knowledge in the past.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
469	Lower down comer	Seasalt impact for FP reaction and composition	L	L	L	L	U	Seawater may cause additional chemical reactions with FP gas and may generate additional reaction products. Additional reaction heat and products may have an effect on temperature and pressure of steam. However, reaction ratio of seasalt is less than that of FP reaction itself. Therefore, the effect on FoM is small.	The reaction between FP gas and seasalt components such as salt can be evaluated based on established knowledge. However, the effect of seasalt entered due to the injection of seawater has no knowledge in the past. The reaction depending on temperature, composition, and so on is difficult to estimate definitely, and the data contain uncertainty.
470		Corrosion of structure in lower down comer by boron	L	L	L	L	U	Water containing boron becomes acid water and causes corrosion of lower down comer. Since materials used for lower down comer are extremely stable for the corrosion, the effect of corrosion is small.	Experiment to confirm the effect of boron has not conducted and there is no knowledge in the past.
471		Influence for heat transfer by boron deposition	L	L	L	L	U	Deposition of boron may be likely to occur locally in a small area of the lower down comer. Boron deposition may make a small difference on water and steam temperature due to the change of heat transfer. However, its effect on FoM is not so large.	The effect of boron deposition on heat transfer can be estimated from established knowledge. However, experiment to confirm the effect of boron has not conducted and there exists uncertainty.
472		Flow path blockage in jet pump by boron deposition	L	L	L	L	U	Deposition of boron may be likely to occur in place with low flow rate. Therefore, the effect of blockage by the deposition is small.	Experiment to confirm the effect of boron has not conducted and there is no knowledge in the past.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
473	Lower down comer	Re-solution of boron by reflooding	L	L	L	L	P	Deposition of boron may be likely to occur locally in a small area of the lower down comer. Therefore, the effect of re-solution of boron is small.	The effect of re-solution of boron has not evaluated in the past. However, the effect can be estimated based on established chemical knowledge.
474		Degradation or Falling of Lagging Material	M	M	M	M	P	Degradation of lagging material would change the temperature of structure in lower down comer. As the degradation progresses, temperature of the structure may become high. Therefore there is an effect on FoM in each phase.	Stress on lagging material in lower down comer due to temperature and pressure can be estimated based on established knowledge of structure materials. However, the pressure and temperature, which affect on stress, contain uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
475	Lower head	Heat transfer between water and lower head including crack	L	L	H	M	K	- In the 3rd phase, heat transfer between water and lower head has a large influence on temperature of RPV wall, which is one of FoM, because there is still a lot of water in the lower head. - In the 4th phase, a lot of steam generated by this heat transfer goes out to pedestal. - Hence, this results in pressure increase in PCV. - In the 1st and 2nd phases, heat transfer between water and lower head does not have influence on each FoM.	- There is sufficient knowledge of heat transfer between water and lower head.
476		Heat transfer between water and penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes)	L	L	H	M	K	- In the 3rd phase, heat transfer between water and penetration tubes has an influence on temperature of RPV wall, because there is still a lot of water in the lower head. - In the 4th phase, a lot of steam generated by this heat transfer goes out to pedestal. - Hence, this results in pressure increase in PCV. - In the 1st and 2nd phases, heat transfer between water and penetration tubes does not have influence on each FoM.	- There is sufficient knowledge of heat transfer between water and penetration tubes.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
477	Lower head	Heat transfer between gas and lower head including crack	N/A	L	H	L	K	- In the 3rd phase, heat transfer between gas and lower head has an influence on temperature of RPV wall, because gas is one of coolant to cool RPV wall although the cooling capability is not higher than water. - In the 4th phase, a lot of steam heated by this heat transfer goes out to pedestal. - Although this results in gas temperature increase in PCV, the contribution is not so large. - In the 2nd phase, heat transfer between gas and penetration tubes does not have influence on each FoM. In the 1st phase, there is no heat transfer between gas and penetration tubes because there is no gas in lower head.	- There is sufficient knowledge of heat transfer between gas and lower head.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
478	Lower head	Heat transfer between gas and penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes)	N/A	L	M	L	K	- In the 3rd phase, heat transfer between gas and penetration tubes has a relatively large influence on temperature of RPV wall, because gas is one of coolant to cool RPV wall although the cooling capability is not higher than water. - In the 4th phase, a lot of steam heated by this heat transfer goes out to pedestal. - Although this results in gas temperature increase in PCV, the contribution is not so large. - In the 2nd phase, heat transfer between gas and penetration tubes does not have an influence on each FoM. - In the 1st phase, there is no heat transfer between gas and penetration tubes because there is no gas in lower head.	- There is sufficient knowledge of heat transfer between gas and penetration tubes.
479		Heat transfer between corium and water (including CHF)	N/A	N/A	H	M	P	- In the 3rd phase, heat transfer between water and corium has a direct influence on corium temperature, which is one of FoM, because there is still a lot of water in the lower head and corium is high temperature. - In the 4th phase, a lot of steam generated by this heat transfer goes out to pedestal. - Hence, this results in pressure increase in PCV. - In the 1st and 2nd phases, heat transfer between water and corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between water and corium because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between corium and water.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
480	Lower head	Heat transfer between corium and gas	N/A	N/A	H	M	P	- In the 3rd phase, heat transfer between gas and corium has a direct influence on corium temperature, because gas is one of coolant to cool RPV wall although the cooling capability is not higher than water. - In the 4th phase, a lot of steam heated by this heat transfer goes out to pedestal. - Although this results in gas temperature increase in PCV, the contribution is not so large. - In the 1st and 2nd phases, heat transfer between gas and corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between gas and corium because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between corium and gas.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
481	Lower head	Heat transfer between corium and penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes)	N/A	N/A	H	M	P	- In the 3rd phase, heat transfer between corium and penetration tubes has a direct influence on corium temperature. - In the 4th phase, as RPV wall heated by this heat transfer heats gas in PCV, gas temperature in PCV increases. - In the 1st and 2nd phases, heat transfer between corium and penetration tubes has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between corium and penetration tubes because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between corium and penetration tubes.
482		Heat transfer between corium and lower head	N/A	N/A	H	M	P	- In the 3rd phase, heat transfer between corium and lower head has a direct influence on both corium temperature and temperature of RPV wall, which are FoM. - In the 4th phase, as RPV wall by this heat transfer heats gas in PCV, gas temperature in PCV increases. - In the 1st and 2nd phases, heat transfer between corium and lower head has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between corium and lower head because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between corium and lower head.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
483	Lower head	Heat transfer between particulate corium and water	N/A	N/A	H	L	P	- In the 3rd phase, heat transfer between water and particulate corium has a direct influence on corium temperature. - In the 4th phase, although steam is generated by this heat transfer, the contribution is smaller than heat transfer between corium and water (No.479). - In the 1st and 2nd phases, heat transfer between water and particulate corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data [1] related to heat transfer between water and particulate corium because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between particulate corium and water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
484	Lower head	Heat transfer between particulate corium and gas	N/A	N/A	H	M	P	- In the 3rd phase, heat transfer between gas and particulate corium has a direct influence on corium temperature. - In the 4th phase, a lot of steam heated by this heat transfer goes out to pedestal. - Although this results in gas temperature increase in PCV. - In the 1st and 2nd phases, heat transfer between gas and particulate corium has no influence on each FoM, because there is still no corium in these phases.	- There is little data related to heat transfer between gas and particulate corium because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is too difficult to accurately estimate heat transfer coefficient between particulate corium and gas.
485		Heat transfer between particulate corium and penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes)	N/A	N/A	H	L	P	- In the 3rd phase, heat transfer between particulate corium and penetration tubes has a direct influence on corium temperature. - In the 4th phase, as RPV wall indirectly heated by this heat transfer heats gas in PCV, gas temperature in PCV increases. - In the 1st and 2nd phases, heat transfer between particulate corium and penetration tubes has no influence on each FoM, because there is still no corium in these phases.	- There is little data related to heat transfer between particulate corium and penetration tubes because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is too difficult to accurately estimate heat transfer coefficient between particulate corium and penetration tubes.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
486	Lower head	Heat transfer between particulate corium and lower head	N/A	N/A	H	L	P	- In the 3rd phase, heat transfer between particulate corium and lower head has a direct influence on corium temperature and temperature of RPV wall. - In the 4th phase, as RPV wall directly heated by this heat transfer heats gas in PCV, gas temperature in PCV increases. - In the 1st and 2nd phases, heat transfer between particulate corium and lower head has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between particulate corium and lower head because heat transfer related to particulate corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between particulate corium and lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
487	Lower head	Heat transfer between particulate corium and light metal layer	N/A	N/A	H	L	P	- Whole corium is classified into some kinds of corium such as particulate corium, crust, and so on, and those temperatures have a distribution. - Maximum corium temperature depends on the extent of heat transfer between those. - Hence, in the 3rd phase, this heat transfer has a large influence on corium temperature. - In the 4th phase, this heat transfer does not have a direct influence on temperature in PCV, because this heat transfer does not affect steam generation. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between particulate corium and light metal layer because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer between particulate corium and light metal layer.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
488	Lower head	Heat transfer between crust and water (including CHF, inner crack and gap)	N/A	N/A	H	L	P	- If there is water between RPV wall and crust, water can cool RPV wall by convective heat transfer and boiling driven by heat of crust. - In the 3rd phase, heat transfer between crust and water has an influence on temperature of RPV wall, because there is still a lot of water in the lower head. - In the 4th phase, although steam is generated by this heat transfer, the contribution is smaller than heat transfer between corium and water (No.490). - Hence, this does not have large influence on pressure increase in PCV. - In the 1st and 2nd phases, heat transfer between crust and water does not have influence on each FoM, because there exist no crust in these phases.	- There is sufficient knowledge of heat transfer between crust and water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
489	Lower head	Heat transfer between crust and gas	N/A	N/A	M	L	P	- In the 3rd phase, heat transfer between crust and gas has a relatively large influence on temperature of RPV wall, because gas generated by heat transfer between crust and water directly cools RPV wall. - In the 4th phase, gas heated by this heat transfer goes out to PCV. - However, the effect is relatively smaller than that of heat transfer between corium and gas (No.480). - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there exist still no corium in these phases.	- There are limited data related to heat transfer between crust and gas because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between crust and gas.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
490	Lower head	Heat transfer between corium and crust	N/A	N/A	H	M	P	- In the 3rd phase, heat transfer between corium and crust has a direct influence on corium temperature. - This heat transfer does not directly affect gas temperature and gas generation. - Hence, this heat transfer does not between corium and crust has an effect on an amount of steam generation, because an amount of steam generation depends on corium and crust temperatures. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between corium and crust because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between corium and crust.
491		Heat transfer between crust and penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes)	N/A	N/A	H	M	P	- In the 3rd phase, heat transfer between crust and penetration tubes has an influence on temperature of RPV wall, because heat transferred from crust to penetration tubes directly heats RPV wall. - Penetration tubes heated by this heat transfer heats gas in PCV. - Hence, in the 4the phase, this heat transfer has an influence on gas temperature in PCV. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between crust and penetration tubes because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between crust and penetration tubes.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
492	Lower head	Heat transfer between crust and lower head	N/A	N/A	H	M	P	- In the 3rd phase, heat transfer between crust and lower head has a direct influence on temperature of RPV wall. - Lower head heated by this heat transfer heats gas in PCV. - Hence, in the 4the phase, this heat transfer has an influence on gas temperature in PCV. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between crust and lower head because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between crust and lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
493	Lower head	Heat transfer between crust and light metal layer	N/A	N/A	M	L	P	- Whole corium is classified into some kinds of corium such as particulate corium, crust, and so on, and those temperatures have a distribution. - Maximum corium temperature depends on the extent of heat transfer between those. - Hence, in the 3rd phase, this heat transfer has a relatively large influence on corium temperature. - In the 4th phase, this heat transfer does not have a direct influence on gas temperature in PCV, because this heat transfer does not affect steam generation. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between crust and light metal layer because heat transfer related to corium depends on configuration and composition of crust. - Hence, it is difficult to accurately estimate heat transfer coefficient between crust and light metal layer.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
494	Lower head	Heat transfer between light metal layer and water (including CHF)	N/A	N/A	M	L	P	- In the 3rd phase, RPV wall is failed before light metal layer is fully stratified, because BWR has a lot of penetration tubes being thermally weak. - Hence, heat transfer between light metal layer and water does not have a large influence on temperature of RPV wall. - In the 4th phase, this heat transfer does not have a direct influence on gas temperature in PCV, because this heat transfer does not affect steam generation. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between light metal layer and water because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between light metal layer and water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
495	Lower head	Heat transfer between light metal layer and gas	N/A	N/A	L	L	P	- In the 3rd phase, RPV wall is failed before light metal layer is fully stratified, because BWR has a lot of penetration tubes being thermally weak. - Influence by heat transfer between light metal layer and gas is smaller than heat transfer between light metal layer and water. - Hence, this heat transfer does not have an almost large effect on temperature of RPV wall and corium temperature. - In the 4th phase, this heat transfer does not have a direct influence on gas temperature in PCV, because this heat transfer does not affect steam generation. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between light metal layer and gas because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between light metal layer and gas.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
496	Lower head	Heat transfer between light metal layer and penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes)	N/A	N/A	M	L	P	- In the 3rd phase, heat transfer between light metal layer and penetration tubes has an influence on temperature of RPV wall, because heat transferred from light metal layer to penetration tubes directly heats RPV wall. - In the 4th phase, this heat transfer does not have a direct influence on gas temperature in PCV, because this heat transfer does not affect steam generation. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between light metal layer and penetration tubes because heat transfer related to corium depends on configuration and composition of crust. - Hence, it is difficult to accurately estimate heat transfer coefficient between light metal layer and penetration tubes.
497		Heat transfer between light metal layer and lower head	N/A	N/A	M	M	P	- In the 3rd phase, heat transfer between light metal layer and lower head has a direct influence on temperature of RPV wall. - Lower head heated by this heat transfer heats gas in PCV. - In the 4th phase, this heat transfer does not have a direct influence on gas temperature in PCV, because this heat transfer does not affect steam generation. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between light metal layer and lower head because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between light metal layer and lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
498	Lower head	Heat transfer between heavy metal layer in corium pool and lower head	N/A	N/A	L	L	P	- In BWR, RPV wall is failed in around penetration part, before heavy metal layer in corium pool is fully stratified, because BWR has a lot of penetration tubes being thermally weak. - Hence, in the 3rd phase, heat transfer between heavy metal layer in corium pool and lower head does not have an influence on temperature of RPV wall. - In the 4th phase, this heat transfer does not have a direct influence on gas temperature in PCV, because this heat transfer does not affect steam generation. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between heavy metal layer in corium pool and lower head because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between heavy metal layer in corium pool and lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
499	Lower head	Heat transfer between heavy metal layer in corium pool and penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes)	N/A	N/A	L	L	P	- In BWR, RPV wall is failed in around penetration part, before heavy metal layer in corium pool is fully stratified, because BWR has a lot of penetration tubes being thermally weak. - Hence, in the 3rd phase, heat transfer between heavy metal layer in corium pool and penetration tubes does not have an influence on temperature of RPV wall. - In the 4th phase, this heat transfer does not have a direct influence on gas temperature in PCV, because this heat transfer does not affect steam generation. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between heavy metal layer in corium pool and penetration tubes because heat transfer related to corium depends on configuration and composition of crust. - Hence, it is difficult to accurately estimate heat transfer coefficient between I heavy metal layer in corium pool and penetration tubes.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
500	Lower head	Heat transfer between heavy metal layer in corium pool and metal-oxide layer in corium	N/A	N/A	L	L	P	- In BWR, RPV wall is failed in around penetration part, before heavy metal layer in corium pool is fully stratified, because BWR has a lot of penetration tubes being thermally weak. - Hence, in the 3rd phase, heat transfer between heavy metal layer in corium pool and metal-oxide layer in corium does not have an influence on temperature of RPV wall. - In the 4th phase, this heat transfer does not have a direct influence on gas temperature in PCV, because this heat transfer does not affect steam generation. . - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to heat transfer between heavy metal layer in corium pool and metal-oxide layer in corium because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate heat transfer coefficient between heavy metal layer in corium pool and metal-oxide layer in corium.
501		Radiation heat transfer between particulate corium and core	N/A	N/A	M	L	K	- In the 3rd phase, radiation heat transfer between particulate corium and core has a relatively large influence on corium temperature because temperature difference between particulate corium and core is large - In the 4th phase, this radiation heat transfer does not have as a large influence on gas temperature or pressure as general heat transfer. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are sufficient data related to radiation heat transfer between particulate corium and core.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
502	Lower head	Radiation heat transfer between light metal layer and core	N/A	N/A	L	L	K	- In the 3rd phase, RPV wall is failed before light metal layer is fully stratified, because BWR has a lot of penetration tubes being thermally weak. - Hence, radiation heat transfer between light metal layer and core does not have a large influence on temperature of RPV wall. - In the 4th phase, this radiation heat transfer does not have as a large influence on gas temperature or pressure as general heat transfer. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are sufficient data related to radiation heat transfer between light metal layer and core.
503		Radiation heat transfer between corium and lower head	N/A	N/A	H	L	K	- In the 3rd phase, radiation heat transfer between corium and lower head has a large influence on temperature of RPV wall, because temperature difference between both is large and distance between both is very short. - In the 4th phase, although this radiation heat transfer has a direct influence by thermal absorption on gas temperature, its influence is smaller than convective heat transfer because heat is directly transferred by steam through gap between corium and lower head. - In the 1st and 2nd phases, this heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are sufficient data related to radiation heat transfer between corium and lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
504	Lower head	Particulate corium bed porosity	N/A	N/A	H	M	P	- In the 3rd phase, particulate corium bed porosity has a directly large influence on corium temperature because size of porosity has an effect on corium temperature. - Contact between particulate corium and water produces a lot of steam, because particulate corium has larger contact area with water than single body with same volume. - Hence, this has relatively large influence on pressure increase in PCV in the 4th phase. - In the 1st and 2nd phases, particulate corium bed porosity has no influence on each FoM, because there is still no corium in these phases.	- There are limited data (e.g. [2]) related to particulate corium bed porosity because porosity depends on test condition including composition of corium. - Hence, it is difficult to accurately estimate particulate corium bed porosity.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
505	Lower head	Change in temperature of penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes	L	L	H	L	K	- Penetration tubes directly connect to RPV wall - Also, change in temperature of penetration tubes is the result of various kinds of heat transfer such as No.487, 489, 492, and so on. - Hence, in the 3rd phase, change in temperature of penetration tubes has a large influence on RPV wall temperature due to thermal conduction. - Also in the 4th phase, change in temperature of penetration tubes does not have a large influence on gas temperature or pressure due to same reason with the above. - In the 1st and 2nd phases, change in temperature of penetration tubes which is appeared in lower plenum where there is still water has almost no effect on each FoM for core part.	- Change in temperature of penetration tubes is the result of various kinds of heat transfer such as No.487, 489, 492, and so on. - Hence, this SoK is in accordance with those SoK, and here is “partially known” as a result of average ranking.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
506	Lower head	Change in temperature of RPV lower head	L	L	H	M	K	- Change in temperature of RPV lower head is the result of various kinds of heat transfer such as No.477, 482, 486, and so on. - This phenomenon is FoM itself. - Hence, in the 3rd phase, this phenomenon has high ranking as a result of average ranking of the above phenomena. - Also in the 4th phase, this phenomenon has medium ranking as a result of average ranking of the above phenomena. - In the 1st and 2nd phases, ranking of this phenomenon is in accordance with the above phenomena.	- Change in temperature of penetration tubes is the result of various kinds of heat transfer such as No.488, 493, 497, and so on. - Hence, this SoK is in accordance with those SoK, and here is “partially known” as a result of average ranking.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
507	Lower head	Deformation of RPV lower head by thermal stress	L	L	H	M	K	- One of reasons of deformation is thermal stress. - As a result, deformation of RPV lower head has an influence on contact configuration between RPV lower head and corium, crust, and so on. - Hence, this deformation has a large influence on RPV wall temperature in the 3rd phase. - This deformation makes gap between crust and RPV lower head, and size of gap depends on extent of deformation. - A lot of steam is generated in the gap. - Hence, in the 4th phase, deformation of RPV lower head by thermal stress has a relatively large effect on gas temperature or pressure. - In the 1st and 2nd phases, deformation of RPV lower head by thermal stress which is appeared in lower plenum where there is still water has almost no effect on each FoM for core part.	- There are sufficient data related to deformation of RPV lower head by thermal stress.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
508	Lower head	Failure of RPV nozzle welding by thermal stress	N/A	N/A	M	M	P	- Failure of RPV nozzle welding itself has almost no influence on RPV wall temperature because failure of RPV nozzle welding means end of the 3rd phase. - In the 4th phase, corium discharged by failure of RPV nozzle welding heats gas in PCV. - Hence, this failure has a relatively large influence on gas temperature or pressure in PCV. - In the 1st and 2nd phases, failure of RPV nozzle welding by thermal stress has no effect on each FoM, because there is still no corium in these phases.	- There are limited data related to failure of RPV nozzle welding by thermal stress because configuration of failure depends on thermal condition. - Hence, it is difficult to accurately estimate failure of RPV nozzle welding by thermal stress.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
509	Lower head	Oxidation reaction between penetration tubes (control rod guide tubes, drain lines, and instrumentation tubes) and steam (including hydrogen generation and reaction heat)	N/A	L	M	L	P	- In the 2nd phase, there is a lot of water still in lower plenum. - Hence, there is almost no oxidation reaction in the 2nd phase because temperature of penetration tubes is kept low. - Oxidation reaction between penetration tubes and steam is exothermal reaction. - Hence, in the 3rd phase, this oxidation reaction has an influence on RPV wall temperature because heat produced by oxidation reaction heats penetration tubes, and as a result, heats RPV wall to which penetration tubes are connected. - In the 4th phase, after failure of RPV wall, oxidation reaction becomes inactive. - Hence, this oxidation reaction does not have a large influence on RPV wall temperature in the 4th phase. - In the 1st phase, this oxidation reaction has no effect on each FoM for core part.	- There are limited data related to oxidation reaction between penetration tubes and steam because oxidation reaction depends on condition. - Hence, it is difficult to accurately estimate failure of oxidation reaction between penetration tubes and steam.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
510	Lower head	Oxidation reaction between lower head and steam (including hydrogen generation and reaction heat)	N/A	L	M	L	P	- In the 2nd phase, there is a lot of water still in lower plenum. - Hence, there is almost no oxidation reaction in the 2nd phase because temperature of penetration tubes is kept low. - Oxidation reaction between lower head and steam is exothermal reaction. - Hence, this oxidation has an influence on RPV wall temperature. - In the 4th phase, after failure of RPV wall, this oxidation reaction becomes inactive. - Hence, this oxidation reaction does not have a large effect on RPV wall temperature in the 4th phase. - In the 1st phase, this oxidation reaction has no effect on each FoM for core part.	- There are limited data related to oxidation reaction between lower head and steam because oxidation reaction depends on condition. - Hence, it is difficult to accurately estimate failure of oxidation reaction between lower head and steam.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
511	Lower head	Change in pressure in lower plenum	L	L	H	H	K	- Difference between pressures in lower plenum and core region is hydraulic head. - If pressure in lower plenum changes, pressure in core region just changes and it has little to do with fuel rod temperature and enthalpy in core region, which are FoM - Hence, change in pressure in lower plenum has almost no effect on fuel rod temperature and enthalpy in core region in the 1st and the 2nd phases. - In the 3rd phase, lower head is deformed by increase in pressure in lower plenum. - Deformation of lower head makes gap between corium and lower head, and as a result, enhances cooling of lower head. - Hence, change in pressure in lower plenum has a large effect on RPV wall temperature. - In the 4th phase, change in pressure in lower plenum has a large effect on pressure in PCV because it results in change in pressure in PCV.	- There are sufficient data related to change in pressure in lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
512	Lower head	Change in water temperature in lower plenum	L	L	M	L	K	- If water temperature in lower plenum changes, it causes in changes in water temperature in core region and it leads to change in fuel rod temperature and enthalpy in core region. - However, in the 1st and the 2nd phases, change in water temperature in lower plenum is small. - Hence, change in water temperature in lower plenum does not have influence on fuel rod and enthalpy in core region in the 1st and the 2nd phases. - In the 3rd phase, change in water temperature in lower plenum has a relatively large influence on RPV wall temperature because water temperature directly has an influence on heat removal of RPV wall. - Change in water temperature in lower plenum is the result of various kinds of heat transfer such as No.490, 494, and so on. - Hence, in the 4th phase, change in water temperature in lower plenum does not have a large influence on temperature in PCV.	- There are sufficient data related to change in water temperature in lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
513	Lower head	Change in gas temperature in lower plenum	L	L	M	M	K	- If gas temperature in lower plenum changes, it causes in changes in gas temperature in core region and it leads to change in fuel rod temperature and enthalpy in core region. - However, in the 1st and the 2nd phases, change in gas temperature in lower plenum is small. - Hence, change in gas temperature in lower plenum does not have influence on fuel rod and enthalpy in core region in the 1st and the 2nd phases. - In the 3rd phase, change in gas temperature in lower plenum has a relatively large influence on RPV wall temperature because gas temperature directly has an influence on heat removal of RPV wall. - Change in gas temperature in lower plenum is the result of various kinds of heat transfer such as No.491, 495, and so on. - Hence, in the 4th phase, change in i gas temperature in lower plenum has a relatively large influence on temperature in PCV.	- There are sufficient data related to change in gas temperature in lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
514	Lower head	Change in gas composition in lower plenum	L	L	L	L	K	- Gas composition has little to do with fuel rod temperature. - Gas composition has little to do with melted fuel temperature. - Gas composition has little to do with RPV wall temperature. - Gas composition has little to do with pressure and temperature in PCV.	- There are sufficient data related to change in gas composition in in lower plenum.
515		Decompression boiling	M	L	M	L	K	- In the 1st phase, decompression boiling in lower plenum produces a lot of steam and has a relatively large influence on fuel rod temperature. - In the 2nd phase, probability of decomposition boiling is low, and even if it happens, its influence is small. - In the 3rd phase, as a result of failure of piping or flange connected to RPV, pressure in RPV might decrease and decompression boiling might happen by gas leakage. - As a result, decompression boiling has a relatively large influence on RPV wall temperature because decompression boiling causes production of steam. - In the 4th phase, probability of decomposition boiling is low and even if it happens, its influence is small because this phase is after failure of RPV wall. - Hence, In the 4th phase, decompression boiling does not have an influence on RPV wall.	- There are sufficient data related to decompression boiling.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
516	Lower head	Change in temperature inside corium	N/A	N/A	H	M	P	- Change in temperature inside corium means corium temperature which is one of FoM in the 3rd phase. - Change in temperature inside corium is the result of various kinds of heat transfer such as No.491, 495, and so on. - Hence, in the 4th phase, change in inside corium has a relatively large influence on temperature in PCV. - In the 1st and 2nd phases, change in temperature inside corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to change in temperature inside corium because corium temperature depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate change in temperature inside corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
517	Lower head	Non-uniform corium spreading in lower head	N/A	N/A	H	M	P	- In the 3rd phase, non-uniform corium spreading in lower head heats RPV wall to locally high temperature. - Hence, this non-uniform corium spreading has large influence on RPV wall temperature. - Whether corium locally is located or not has little to do with gas temperature in lower plenum, and change in gas temperature depends on corium enthalpy. - As is the case with No.513, this non-uniform corium spreading has relatively large influence on RPV wall temperature. - In the 1st and 2nd phases, non-uniform corium spreading in lower head has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to non-uniform corium spreading in lower head because uneven distribution of corium depends on condition. - Hence, it is difficult to accurately non-uniform corium spreading in lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
518	Lower head	Evaporation of materials from inside corium (including FP)	N/A	N/A	M	L	P	- In the 3rd phase, if hotter material evaporates out of corium, it heats RPV wall. - Hence, although its contribution depends on an amount of evaporation, this evaporation of materials has a relatively influence on RPV wall temperature. - In the 4th phase, although evaporation of materials from inside corium has an influence on gas temperature, an amount of evaporation is not so large. - Hence, its influence on gas temperature is not large. - In the 1st and 2nd phases, change in evaporation of materials from inside corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to evaporation of materials from inside corium because evaporarion of materials depends on condition. - Hence, it is difficult to accurately evaporation of materials from inside corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
519	Lower head	Corium jet into water pool	N/A	N/A	H	M	P	- In the 3rd phase, corium jet into water pool produces a lot of steam. - As a result, steam enhances heat removal from RPV wall. - Hence, corium jet into water pool has a large influence on RPV wall temperature. - In the 4th phase, an amount of corium jet is less than the 3rd phase. - Hence, an amount of steam generated is also less than the 3rd phase. - Therefore, corium jet into water pool does not have a large influence on RPV temperature. - In the 1st and 2nd phases, corium jet into water pool has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to corium jet into water pool because detail of the phenomenon depends on condition. - Hence, it is difficult to accurately estimate corium jet into water pool.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
520	Lower head	Formation of corium pool	N/A	N/A	H	M	P	- In the 3rd phase, corium is divided into some kinds of layer, such as corium pool, particulate corium, and so on. - The ratio of those layers has a large influence on corium temperature. - Hence, formation of corium pool has a large influence on corium temperature. - In the 4th phase, hotter corium pool produces a lot of steam. - Hence, formation of corium pool has a relatively large influence on gas temperature or pressure, because the ratio of those layers affects an amount of generated steam. - In the 1st and 2nd phases, formation of corium pool has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to formation of corium pool because it depends on condition. - Hence, it is difficult to accurately formation of corium pool.
521		Stratification of corium pool	N/A	N/A	H	M	P	- In the 3rd phase, as stratification of corium pool makes progress, hotter part becomes much hotter. - Hence, stratification of corium pool has a large influence on corium temperature. - In the 4th phase, hotter corium pool produces a lot of steam. - Hence, stratification of corium pool has a relatively large influence on gas temperature or pressure. - In the 1st and 2nd phases, stratification of corium pool has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to stratification of corium pool because it depends on condition. - Hence, it is difficult to accurately stratification of corium pool.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
522	Lower head	Atomization of corium by contact with water (jet breakup)	N/A	N/A	H	M	P	- In the 3rd and 4th phases, an amount of corium pool depends on ratio of corium atomized because this atomization is strongly linked to formation of corium pool of No.520. - Hence, the rankings in the 3rd and 4th phases are same as No.520. - In the 1st and 2nd phases, atomization of corium by contact with water has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to atomization of corium by contact with water because detail of the phenomenon depends on condition. - Hence, it is difficult to accurately estimate atomization of corium by contact with water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
523	Lower head	Change in temperature in light metal layer	N/A	N/A	M	L	P	- Change in temperature in light metal layer is the result of various kinds of heat transfer such as No.487, 493, 494, and so on. - Hence, in the 3rd phase, change in temperature in light metal layer has a relatively large influence on RPV wall temperature. - Also In the 4th phase, ranking of change in temperature in light metal layer is in accordance with the above. - Hence, change in temperature in light metal layer does not have a large influence on RPV wall temperature. - In the 1st and 2nd phases, change in temperature in light metal layer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to change in temperature in light metal layer because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate change in temperature in light metal layer.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
524	Lower head	Change in temperature in heavy metal layer	N/A	N/A	M	M	P	- Change in temperature in heavy metal layer is the result of various kinds of heat transfer such as No.498, 499, and 500. - Hence, in the 3rd phase, change in temperature in light metal layer does not have a large influence on RPV wall temperature. - Also In the 4th phase, ranking of change in temperature in heavy metal layer is in accordance with the above. - Hence, change in temperature in light metal layer does not have a large influence on RPV wall temperature. - In the 1st and 2nd phases, change in temperature in heavy metal layer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to change in temperature in heavy metal layer because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate change in temperature in heavy metal layer.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
525	Lower head	Change in composition of particulate corium	N/A	N/A	H	M	P	- In the 3rd and 4th phases, an amount of particulate corium depends on ratio of corium pool because this change in composition is strongly linked to phenomena of No.520, No.521 and No.522. - Hence, the rankings in the 3rd and 4th phases are same as those phenomena. - In the 1st and 2nd phases, atomization of corium by contact with water has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to change in composition of particulate corium because detail of the phenomenon depends on condition. - Hence, it is difficult to accurately estimate change in composition of particulate corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
526	Lower head	Change in size and shape of particulate corium	N/A	N/A	H	L	P	- In the 3rd phase, particulate corium is formed when corium jet drops down from core. - The size and shape is determined by condition of corium dropping. - The temperature of particulate corium depends on size and shape of it. - Hence, change in size and shape of particulate corium has a large influence on corium temperature. - In the 4th phase, an amount of steam which has an effect on steam temperature and pressure depends on corium temperature. - Hence, change in size and shape of particulate corium which affects corium temperature has a relatively large effect on gas temperature or pressure. - In the 1st and 2nd phases, atomization of corium by contact with water has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to change in size and shape of particulate corium because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate change in size and shape of particulate corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
527	Lower head	Crust generation by solidification of corium	N/A	N/A	H	L	P	- In the 3rd phase, crust formed around corium pool is thermal resistance between hotter corium pool and colder RPV wall. - RPV wall temperature and corium temperature depends on the thickness. - Hence, crust generation by solidification of corium has a large influence on temperature of RPV wall and corium temperature. - In the 4th phase, an amount of steam which has an influence on steam temperature and pressure depends on corium temperature. - Hence, crust generation by solidification of corium has a relatively large effect on gas temperature or pressure. - In the 1st and 2nd phases, crust generation by solidification of corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to crust generation by solidification of corium because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate crust generation by solidification of corium
528		Accumulation and bed formation of particulate corium	N/A	N/A	H	L	P	- In the 3rd and 4th phases, accumulation and bed formation of particulate corium depends on composition of particulate corium of No.525. - Hence, the rankings in the 3rd and 4th phases are same as those phenomena. - In the 1st and 2nd phases, atomization of corium by contact with water has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to accumulation and bed formation of particulate corium because detail of the phenomenon depends on condition. - Hence, it is difficult to accurately estimate accumulation and bed formation of particulate corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
529	Lower head	Non-uniform spreading of particulate corium bed	N/A	N/A	H	M	P	- In the 3rd and 4th phases, this phenomenon is almost same as non-uniform corium spreading in lower head of No.528 in effect bringing to FOMs. - Hence, rankings of this phenomenon are same as No.517. - In the 1st and 2nd phases, non-uniform corium spreading in lower head has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to non-uniform spreading of particulate corium bed because heat transfer related to corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate non-uniform spreading of particulate corium bed.
530		Change in temperature of particulate corium bed	N/A	N/A	H	M	P	- Change in temperature of particulate corium bed means including particulate corium temperature which is one of FoM in the 3rd phase. - Change in temperature of particulate corium bed is the result of various kinds of heat transfer such as No.483, 484, and so on. - Hence, in the 4th phase, change in inside corium does not have a large influence on temperature in PCV. - In the 1st and 2nd phases, change in temperature of particulate corium bed has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to change in temperature of particulate corium bed because corium temperature depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate change in temperature of particulate corium bed.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
531	Lower head	Decay heat in particulate corium	N/A	N/A	H	M	P	- Decay heat is heat source for corium itself. - Hence, decay heat in particulate corium has a large influence on corium temperature. - In the 4th phase, although particulate corium temperature has an influence on gas temperature, the 4th phase is one after RPV wall failure. - Hence, its influence on gas temperature is small. - In the 1st and 2nd phases, change in temperature of particulate corium bed has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to decay heat in particulate corium because detail of the phenomenon depends on condition. - Hence, it is difficult to accurately estimate decay heat in particulate corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
532	Lower head	Oxidation reaction between light metal layer and water (steam) (including hydrogen generation and reaction heat)	N/A	N/A	M	L	P	- In the 3rd phase, RPV wall is failed before light metal layer is fully stratified, because BWR has a lot of penetration tubes being thermally weak. - As a result, although oxidation reaction between light metal layer including zircaloy and water is severe under normal circumstances, this reaction in this accident scenario is not so active. - Hence, oxidation reaction between light metal layer and water does not have a large influence on temperature of RPV wall. - In the 4th phase, after failure of RPV wall oxidation reaction becomes inactive, because corium and water does down to pedestal. - Hence, this oxidation reaction does not have a large influence on RPV wall temperature in the 4th phase. - In the 1st and 2nd phases, this oxidation reaction has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to oxidation reaction between light metal layer and water because oxidation reaction depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate oxidation reaction between light metal layers.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
533	Lower head	FCI pre-mixing by contact between corium and water pool	N/A	N/A	H	L	P	- Whether contact between corium and water results in FCI depends on corium temperature and initial water temperature. - In the 3rd phase, pre-mixing and triggering cause severe FCI because corium temperature is enough high and water temperature is enough low in the lower plenum. - Hence, occurrence of FCI has large influence on RPV wall temperature, because a lot of water vaporizes. - In the 4th phase, contact between corium and water doesn’t leads to severe FCI because corium temperature is not enough high and water temperature is not enough low in the pedestal compared to the 3rd phase. - Hence, FCI pre-mixing doesn’t have a large influence on PCV pressure. - In the 1st and 2nd phases, FCI pre-mixing by contact between corium and water pool has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to FCI pre-mixing by contact between corium and water pool because FCI pre-mixing depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate FCI pre-mixing by contact between corium and water pool

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
534	Lower head	FCI triggering by vapor film collapse	N/A	N/A	H	M	P	- Whether contact between corium and water results in FCI depends on corium temperature and initial water temperature. - In the 3rd phase, pre-mixing and triggering cause severe FCI because corium temperature is enough high and water temperature is enough low in the lower plenum. - Hence, occurrence of FCI has large influence on RPV wall temperature, because a lot of water vaporizes. - In the 4th phase, contact between corium and water doesn't leads to severe FCI because corium temperature is not enough high and water temperature is not enough low in the pedestal. - Hence, FCI triggering doesn't have a large influence on PCV pressure. - In the 1st and 2nd phases, FCI triggering by vapor film collapse has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to FCI triggering by vapor film collapse because FCI triggering depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate FCI triggering by vapor film collapse

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
535	Lower head	Atomization of corium in water pool and rapid steam generation (FCI)	N/A	N/A	H	M	P	- Whether contact between corium and water results in FCI depends on corium temperature and initial water temperature. - In the 3rd phase, pre-mixing and triggering cause severe FCI because corium temperature is enough high and water temperature is enough low in the lower plenum. - Atomization of corium and rapid steam generation are a result of pre-mixing and triggering. - Hence, occurrence of FCI has large influence on RPV wall temperature, because a lot of water vaporizes. - In the 4th phase, contact between corium and water doesn't leads to severe FCI because corium temperature is not enough high and water temperature is not enough low in the pedestal. - Hence, atomization of corium in water pool and rapid steam generation doesn't have a large influence on PCV pressure. - In the 1st and 2nd phases, atomization of corium in water pool and rapid steam generation has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to atomization of corium in water pool and rapid steam generation because atomization and rapid steam generation depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate atomization of corium in water pool and rapid steam generation

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
536	Lower head	Pressure wave by FCI	N/A	N/A	L	M	P	- In the 3rd phase, pre-mixing and triggering cause severe FCI because corium temperature is enough high and water temperature is enough low in the lower plenum. - Although pressure wave by FCI is a result of pre-mixing and triggering, it is unlikely that pressure wave itself has an influence on corium and RPV wall temperature. - In the 4th phase, contact between corium and water doesn’t leads to severe FCI because corium temperature is not enough high and water temperature is not enough low in the pedestal. - Hence, pressure wave by FCI doesn’t have a large influence on PCV pressure. - In the 1st and 2nd phases, pressure wave by FCI has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to pressure wave by FCI because pressure wave by FCI depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate pressure wave by FCI

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
537	Lower head	Gas temperature increase by FCI	N/A	N/A	H	M	P	- Whether contact between corium and water results in FCI depends on corium temperature and initial water temperature. - In the 3rd phase, pre-mixing and triggering cause severe FCI because corium temperature is enough high and water temperature is enough low in the lower plenum. - Gas temperature increase by FCI heats RPV wall. - Hence, occurrence of FCI has large influence on RPV wall temperature, because gas of high temperature heats RPV wall. - In the 4th phase, contact between corium and water doesn’t leads to severe FCI because corium temperature is not enough high and water temperature is not enough low in the pedestal. - Hence, temperature increase by FCI doesn’t have a large influence on PCV pressure. - In the 1st and 2nd phases, temperature increase by FCI has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to temperature increase by FCI because temperature increase by FCI depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate temperature increase by FCI

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
538	Lower head	Failure of RPV lower head by FCI	N/A	N/A	N/A	M	P	- This phenomenon is one only in the 4th phase because failure of RPV lower head means the end of the 3rd phase and the beginning of the 4th phase. - In the 4th phase, as a result of failure of RPV lower head, it brings increase of gas temperature because a lot of high temperature steam goes out to PCV. - Hence, failure of RPV lower head by FCI has an influence on PCV pressure. - In the 1st and 2nd phases, failure of RPV lower head by FCI has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to failure of RPV lower head by FCI because failure of RPV lower head by FCI depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate failure of RPV lower head by FCI.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
539	Lower head	Scattering of corium and material in lower plenum by FCI	N/A	N/A	H	M	P	- Whether contact between corium and water results in FCI on corium temperature and initial water temperature. - In the 3rd phase, pre-mixing and triggering cause severe FCI because corium temperature is enough high and water temperature is enough low in the lower plenum. - As a result of pre-mixing and triggering, corium and material scatter in lower plenum. - Hence, scattering of corium and material has large influence on RPV wall temperature because it causes more vaporization of water. - More vaporization of water causes gas temperature increase in PCV in the 4th phase. - Hence, scattering of corium and material doesn't have a large influence on PCV pressure. - In the 1st and 2nd phases, scattering of corium and material in lower plenum by FCI has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to scattering of corium and material in lower plenum by FCI because scattering of corium and material in lower plenum by FCI depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate scattering of corium and material in lower plenum by FCI

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
540	Lower head	Impact for FCI by seawater	N/A	N/A	L	L	U	- A lot of seawater is injected to cool temperature in RPV in Fukushima daiichi accident. - Salt content in seawater might have some influence on collapse mechanism of vapor film. - However, it is unlikely that salt itself has an influence on scale of FCI. - Hence, in the 3rd phase, impact for FCI by seawater has only small influence on RPV wall temperature. - Also in the 4th phase, impact for FCI by seawater has only small influence on RPV wall temperature because of the above reason. - In the 1st and 2nd phases, impact for FCI by seawater has no influence on each FoM, because there is still no corium in these phases.	- There are little data related to impact for FCI by seawater because seawater injection into RPV was not supposed. - Hence, it is difficult to estimate impact for FCI by seawater

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
541	Lower head	Mixing state and physical property of corium	N/A	N/A	H	M	P	- Corium in the lower plenum is the mixture made up from molten core materials, and the mixing-state has an effect on heat transfer between structures in lower plenum and corium including crust, light metal, and so on. - Also, physical property such as solidus-liquidus temperature largely depends on the composition. - Hence, in the 3rd phase in which fluidity of corium is high because of relatively high corium temperature, mixing-state and physical property of corium has a large influence on corium temperature. - In the 4th phase, mixing-state and physical property in lower plenum has an influence on stem generation. - However, the influence on PCV temperature and pressure is not so large because the 4th phase is one that corium goes down to pedestal. - In the 1st and 2nd phases, mixing state and physical property of corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to mixing state and physical property because mixing state and physical property depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate mixing state and physical property.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
542	Lower head	Oxidation reaction between corium and water (steam) (including hydrogen generation and reaction heat)	N/A	N/A	M	L	P	- In the 3rd phase, corium including zircaloy dropped in lower plenum causes violent metal-water reaction. - As a result, corium temperature increases because metal-water reaction is exothermal one. - Hence, this oxidation reaction has a large influence on corium temperature. - This oxidation reaction is not active because most of water in lower plenum goes down to pedestal in the 4th phase. - Hence, this oxidation reaction does not have a large influence on temperature in PCV in the 4th phase. - In the 1st and 2nd phases, this oxidation reaction has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to oxidation reaction between corium and water because oxidation reaction depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate oxidation reaction between corium and water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
543	Lower head	Natural convection in corium pool	N/A	N/A	H	L	P	- In the 3rd phase, natural convection is caused by temperature difference between center of corium and surrounding material. - There is most of water in the top of corium. - This natural convection is important to heat removal from corium because temperature difference between corium and water is large. - Hence, this natural convection has a large influence on corium temperatures. - Most of water in lower plenum goes down to pedestal in the 4th phase. - Hence, extent of natural convection becomes small. - Thus, in the 4th phase, natural convection in corium pool has only small influence on PCV temperature and pressure. - In the 1st and 2nd phases, natural convection in corium pool by seawater has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to natural convection in corium pool because natural convection in corium pool depends on configuration and composition of corium [3], [4]. - Hence, it is difficult to accurately estimate natural convection in corium pool.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
544	Lower head	Decay heat of corium	N/A	N/A	H	L	P	- Decay heat of corium is only heat source after scram. - Hence, in the 3rd phase, decay heat of corium has a large influence on corium temperature. -The 4the phase is one corium going down to pedestal. - Hence, influence of decay heat of corium in lower plenum is small. - In the 1st and 2nd phases, decay heat of corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to decay heat of corium because decay heat of corium depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate decay heat of corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
545	Lower head	Solidification of corium	N/A	N/A	H	M	P	- Solidification of corium results in decrease of whole corium energy because it involves release of latent heat. - Also, because solidification makes corium lose fluidity, effect of heat transfer becomes smaller. - Hence, in the 3rd phase, solidification of corium has a large influence on corium temperature. - An amount of steam generation is restricted in pedestal, because solidification of corium, namely becoming crust, makes contact area between corium and water smaller. - Hence, in the 4th phase, solidification of corium has relatively and indirectly large influence on steam temperature and pressure. - In the 1st and 2nd phases, solidification of corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to solidification of corium because solidification of corium depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate solidification of corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
546	Lower head	Flow of water in lower plenum	L	L	H	L	K	- In the 3rd phase, there is no circulation of water in RPV and there is natural convection of remaining water in lower plenum. - Flow of water, which means heat removal by water, depends on an amount of water in lower plenum. - Hence, in the 3rd phase, flow of water in lower plenum has a large influence on RPV temperature. - In the 4th phase, there is almost no flow of water, because water in lower plenum goes down to pedestal. - Hence, in the 4th phase, flow of water has little effect on PCV temperature and pressure. - In the 1st and 2nd phases, flow of water in ore has an influence on FoMs. - However, solidification does not has direct influence on FoMs.	- There are a lot of data related to flow of water in lower plenum. - Hence, it is easy to accurately estimate flow of water in lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
547	Lower head	Re-flooding of molten material in lower plenum by water injection	N/A	N/A	H	M	K	- When water is injected in RPV in the 3rd phase, molten material in lower plenum and RPV wall are cooled and the temperatures decrease. - Hence, in the 3rd phase, re-flooding of molten material has a large influence on RPV temperature. - Re-flooding itself is phenomenon in the 3rd phase. - However, re-flooding makes more steam and has an influence on steam temperature and pressure in PCV after RPV fail. - Hence, in the 4th phase, re-flooding of molten material has a relatively large influence on temperature and pressure in PCV. - In the 1st and 2nd phases, re-flooding of molten material has no influence on each FoM, because there is still no corium in these phases.	- There are a lot of data related to re-flooding of molten material in lower plenum by water injection. - Hence, it is easy to accurately estimate re-flooding of molten material in lower plenum by water injection.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
548	Lower head	Flow of gas in lower plenum	L	L	M	L	K	- In the 1st and 2nd phases there is almost no gas flow in lower plenum because lower plenum is filled with water. - Hence, in the 1st phase, flow gas in lower plenum has little effect on corium temperature. - In the 3rd phase, although water takes precedence in heat removal from corium, when water infiltrates into corium or gap between crust and RPV wall, steam generates and it removes heat from corium. - Hence, in the 3rd phase, flow of gas has a relatively large influence on RPV temperature. - In the 4th phase, it is unlikely that flow of gas itself has an influence on temperature and pressure in PCV.	- There are a lot of data related to flow of gas in lower plenum. - Hence, it is easy to accurately estimate flow of gas in lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
549	Lower head	Change in an amount of purge water in CRD guide tube	M	L	H	L	K	- In the 1st phase, purge water in CRD guide tube is used to mitigate heat-up of fuel rods. - Hence, purge water has a relatively large influence on corium temperature because there is a lot of CRD guide tube. - In the 2nd phase, purge water has a small influence on temperature in core region because purge water in core part is vaporized. - In the 3rd phase, purge water in CRD guide tube is used to cool corium in lower plenum. - Purge water has a large effect on corium temperature because there is a lot of CRD guide tube. - In the 4th phase, purge water has little effect on PCV temperature pressure because most of purge water seems to be vaporized.	- There are a lot of data related to an amount of purge water in CRD guide tube. - Hence, it is easy to accurately estimate change in an amount of purge water in CRD guide tube.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
550	Lower head	Change in water level in lower plenum	L	M	H	L	K	- In the 1st phase, lower plenum is filled with water, and water level is above core support plate. - Hence, in the 1st phase, change in water level in lower plenum has little effect on corium temperature. - Also In the 2nd phase, lower plenum is almost filled with water. - Hence, also in the 2nd phase, change in water level has little effect on corium temperature. - In the 3rd phase, water level in lower plenum changes with vaporization of water by getting in touch with corium fallen from core. - Namely, water level means an amount of water, and an amount of water has an direct influence on corium temperature. - Hence, in the 3rd phase, change in water level has a large influence on corium temperature. - In the 4th phase, water in lower plenum goes down to pedestal. - Hence, in the 4th phase, change in water level has little effect on PCV temperature pressure.	- There are a lot of data related to change in water level in lower plenum. - Hence, it is easy to accurately estimate re-flooding of change in water level in lower plenum.
551		Radiation decomposition of water	L	L	L	L	K	- Radiation decomposition of water is always generated, even in normal operation. - However, an amount of heat generation is low. - Hence, in all the phases, radiation decomposition of water has a small influence on RPV wall.	- There are a lot of data related to radiation decomposition of water. - Hence, it is easy to accurately estimate radiation decomposition of water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
552	Lower head	Bubble formation in crust	N/A	N/A	M	L	P	- In the 3rd phase, a lot of bubbles are generated by ingression of water into crust. - Also, heat transfer coefficient by boiling is larger than general one between single-phase fluid and structure. - Hence, in the 3rd phase, bubble formation in crust has a relatively large influence on corium temperature because heat removal of crust causes heat removal of corium itself. - In the 4th phase, bubble formation in crust is not seen because water in plenum goes down to pedestal. - Hence, in the 4th phase, bubble formation in crust has little influence on PCV temperature pressure. - In the 1st and 2nd phases, bubble formation in crust has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to bubble formation in crust because bubble formation in crust depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate bubble formation in crust.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
553	Lower head	Water inflow into crust through crack on surface of crust	N/A	N/A	M	M	P	- In the 3rd phase, water inflow into crust through crack on surface of crust causes heat removal of corium by a lot of steam generation. - Hence, in the 3rd phase, this water inflow has a relatively large influence on corium temperature. - In the 4th phase, steam generation becomes smaller than the 3rd phase because most of water goes down to pedestal. - Hence, in the 4th phase, this water inflow has little influence on PCV temperature and pressure. - In the 1st and 2nd phases, this water inflow has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to water inflow into crust through crack on surface of crust because water inflow into crust through crack on surface of crust depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate water inflow into crust through crack on surface of crust.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
554	Lower head	Oxidation reaction between crust and water (steam) (including hydrogen generation and reaction heat)	N/A	N/A	M	L	P	- In the 3rd phase, crust including zircaloy dropped in lower plenum causes metal-water reaction. - However, an amount of zircaloy in crust is smaller than corium. - Hence, influence of this metal-water reaction on corium temperature is milder than phenomenon of No.553. - Thus, this oxidation reaction has a relatively large influence on corium temperature. - This oxidation reaction is not active because most of water in lower plenum goes down to pedestal in the 4th phase. - Hence, this oxidation reaction does not have a large influence on temperature in PCV in the 4th phase. - In the 1st and 2nd phases, this oxidation reaction has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to oxidation reaction between crust and water because oxidation reaction depends on configuration and composition of corium. - Hence, it is difficult to accurately estimate oxidation reaction between crust and water.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
555	Lower head	Change in physical property by material mixing in crust	N/A	N/A	H	L	U	- In the 3rd phase, physical property of crust changes by a degree of mixing of material. - In the 3rd phase, change in physical property by material mixing in crust has a large influence on corium temperature because physical property of crust is important to heat transfer between crust and water. - In the 4th phase, influence by crust on steam generation because most of water goes down to pedestal. - Hence, in the 4th phase, change in physical property by material mixing in crust does not have an influence on PCV temperature and pressure. - In the 1st and 2nd phases, this changes in physical property have no influence on each FoM, because there is still no corium in these phases.	- There is little data related to Change in physical property. - Hence, it is difficult to accurately estimate change in physical property.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
556	Lower head	Change in temperature of crust	N/A	N/A	H	M	P	- Change in temperature of crust means corium temperature which is one of FoM in the 3rd phase. - Change in temperature of crust is the result of various kinds of heat transfer such as No.499, 500, and so on. - Hence, in the 4th phase, change in of crust has a relatively large influence on temperature in PCV. - In the 1st and 2nd phases, change in temperature inside corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to change in temperature of crust because change in temperature of crust depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate change in temperature of crust.
557		Decay heat in crust	N/A	N/A	H	L	P	- Decay heat is only heat source after scram. - Hence, in the 3rd phase, decay heat of corium has a large influence on corium temperature. -The 4the phase is one corium going down to pedestal. - Hence, influence of decay heat of corium in lower plenum is small. - In the 1st and 2nd phases, decay heat in crust has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to decay heat in crust because detail of the phenomenon depends on condition. - Hence, it is difficult to accurately estimate decay heat in crust.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
558	Lower head	Re-criticality	N/A	N/A	H	M	P	- Re-criticality is considered to be very unlikely in this accident scenario. - However, if re-criticality occurs in the 3rd phases, the influence on corium temperature is considered to be very large. - In the 4th phase, re-criticality has a relatively effect on PCV temperature and pressure, because gas in PCV is heated, If re-criticality occurs. - In the 1st and 2nd phases, re-criticality has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to re-criticality because detail of the phenomenon depends on condition. - Hence, it is difficult to accurately estimate re-criticality.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
559	Lower head	Gap formation between corium and lower head	N/A	N/A	H	M	P	- In the 3rd phase, when crust is formed between corium and lower head, crust is shrunk and narrow gap is formed between crust and lower head. - Water goes into the gap, steam is generated and corium and lower head are cooled. - Also, the gap plays a part as insulator. - Hence, this gap formation has a large influence on RPV wall temperature. - Also, formation of gap causes more steam generation. - Hence, in the 4th phase, this gap formation has a relatively and indirectly large influence on PCV temperature and pressure. - In the 1st and 2nd phases, this gap formation has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to gap formation between corium and lower head because gap formation between corium and lower head depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate gap formation between corium and lower head.
560		Inflow of coolant into gap between corium and lower head	N/A	N/A	H	M	P	- This phenomenon is almost synonymous with one of No.559. - That is, gap formation between corium and lower head and inflow of coolant should be considered together. – Hence, rationales are same as No.559.	- There are limited data related to inflow of coolant into gap between corium and lower head because inflow of coolant into gap between corium and lower head depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate inflow of coolant into gap between corium and lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
561	Lower head	Crack formation on lower head	N/A	N/A	H	L	P	- In the 3rd phase, when crack is formed on lower head, water goes into the crack, and steam is generated. - As a result, lower head is cooled. - Hence, crack formation on lower head has a large effect on RPV wall temperature. - Also in the 4th phase, although steam is generated in the crack, an amount of that is not much as to have an influence on PCV temperature and pressure. - In the 1st and 2nd phases, crack formation on lower head has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to crack formation on lower head because crack formation on lower head depends on factors including some partially known ones. [5] - Hence, it is difficult to accurately estimate crack formation on lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
562	Lower head	Inflow of coolant into crack on lower head	N/A	N/A	H	L	P	- This phenomenon is almost synonymous with one of No.561. - That is, crack formation on lower head and inflow of coolant should be considered together. - Hence, rationales are same as No.561.	- There are limited data related to crack formation on lower head because crack formation on lower head depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate crack formation on lower head.
563		Corrosion of lower head by corium pool	N/A	N/A	H	M	P	- In the 3rd phase, when corium jet falling down from core impinges on vessel wall, steel ablation by thermo-chemical attack and corrosion is seen at the interface between corium and vessel wall. - A large amount of mass of lower plenum is ablated by corrosion and eutectics are also formed. - As a result, melting temperature is decreased and it affects both corium and RPV wall temperatures. - Hence, corrosion of lower head by corium pool has a large influence on RPV wall temperature. - Also, as a result of corrosion, lower head becomes easy to be broken. - As a result, early flow-out of gas affects gas temperature and pressure. - Hence, this corrosion has a relatively large influence on PCV temperature and pressure. - In the 1st and 2nd phases, this corrosion has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to corrosion of lower head by corium pool because corrosion of lower head by corium pool depends on factors including some partially known ones. [6] - Hence, it is difficult to accurately estimate corrosion of lower head by corium pool.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
564	Lower head	Erosion of lower head by corium jet	N/A	N/A	H	M	P	- In the 3rd phase, when corium jet falls down from core to lower plenum, corium itself and particulate corium attacks on surface of lower head and erode surface of lower head. - However, erosion itself is mechanical phenomenon on surface of lower head. - Hence, erosion of lower head by corium jet has only a small influence on corium and RPV wall temperatures. - As is the case with the 3rd phase, in the 4th phase, the influence of erosion of lower head by corium jet has a small influence on steam generation, which leads to PCV temperature and pressure. - In the 1st and 2nd phases, erosion of lower head by corium jet has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to erosion of lower head by corium pool because erosion of lower head by corium pool depends on factors including some partially known ones. [7] - Hence, it is difficult to accurately estimate erosion of lower head by corium pool.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
565	Lower head	Flow of corium out of lower head bottom section by lower head failure	N/A	N/A	N/A	H	P	- Flow of corium out of lower head bottom section by lower head failure is phenomenon that is seen in the 4th phase after vessel failure. - Flow of corium enhances steam generation due to contact with water on pedestal. - Hence, in the 4th phase, this flow of corium has a large influence on PCV temperature and pressure. - In the 1st, 2nd, and the 3rd phases, this flow of corium has no influence on each FoM, because this phenomenon is one after vessel failure. .	- There are limited data related to flow of corium out of lower head bottom section by lower head because c flow of corium out of lower head bottom section by lower head depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium out of lower head bottom section by lower head.
566		Crust re-melting due to change in the heat transfer status to corium or water	N/A	N/A	H	L	P	- In the 3rd phase, when crust is re-melted, it means increase of corium temperature. - Hence, in the 3rd phase, this crust re-melting has a large influence on corium temperature, although depending on an amount of crust re-melted. - It seems that effect of crust re-melted on steam generation is large. - However, in the 4th phase, an amount of crust re-melted does not seem to be much because a lot of corium falls down to pedestal. - Hence, in the 4th phase, this crust re-melting has a small influence on PCV temperature and pressure. - In the 1st and 2nd phases, this crust re-melting has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to crust re-melting due to change in the heat transfer status to corium or water because crust re-melting due to change in the heat transfer status to corium or water depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate crust re-melting due to change in the heat transfer status to corium or water

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
567	Lower head	Particulate corium re-melting due to change in the heat transfer status	N/A	N/A	H	L	P	- In the 3rd phase, when particulate corium is re-melted, it means increase of corium temperature. - Hence, in the 3rd phase, this particulate corium re-melting has a large influence on corium temperature, although depending on an amount of particulate corium re-melted. - It seems that effect of particulate corium re-melted on steam generation is large. - However, in the 4th phase, an amount of particulate corium re-melted does not seem to be much because a lot of corium falls down to pedestal. - Hence, in the 4th phase, this particulate corium re-melting has a small influence on PCV temperature and pressure. - In the 1st and 2nd phases, this particulate corium re-melting has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to particulate corium re-melting due to change in the heat transfer status to corium or water because particulate corium re-melting due to change in the heat transfer status to corium or water depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate particulate corium re-melting due to change in the heat transfer status to corium or water

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
568	Lower head	Change in area of failure opening in lower head bottom section	N/A	N/A	N/A	H	P	- Change in area of failure opening in lower head bottom section is phenomenon that is seen in the 4th phase after vessel failure. - If change in area of failure opening is fast, corium rapidly goes down to pedestal, and steam generation in pedestal is severe. - On the other hand, if change in area is slow, steam generation is mild. - Hence, in the 4th phase, this change in area of failure opening has a large influence on PCV temperature and pressure. - In the 1st, 2nd, and the 3rd phases, this change in area of failure opening has no influence on each FoM, because this phenomenon is one after vessel failure.	- There are limited data related to change in area of failure opening in lower head bottom section because change in area of failure opening in lower head bottom section depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate change in area of failure opening in lower head bottom section.
569		Formation of flow path by ablation between control rod guide tubes and lower plenum	N/A	N/A	H	M	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - Hence, rationale of this phenomenon is same as one of No.565.	- There are limited data related to formation of flow path by ablation between CRGTs and lower plenum because formation of flow path by ablation between CRGTs and lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path by ablation between CRGTs and lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
570	Lower head	Formation of flow path by jet impingement to control rod guide tubes	N/A	N/A	H	M	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 "Flow of corium out of lower head bottom section by lower head failure". - Hence, rationale of this phenomenon is same as one of No.565.	- There are limited data related to formation of flow path by jet impingement to CRGTs because formation of flow path by jet impingement to CRGT depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path by jet impingement to CRGT.s
571		Flow of corium through failed control rod guide tubes from/to lower plenum	N/A	N/A	H	M	P	- Corium flown out of side wall of control rods guide tubes (CRGTs) mixes with corium in lower plenum, and causes a change in corium temperature in lower plenum. - Hence, this flow of corium has a large influence on corium temperature. - Change in corium temperature causes a change in amount of stem generation. - Hence, in the 4th phase, this flow of corium has a relatively large influence on PCV temperature and pressure. - In the 1st and 2nd phases, this flow of corium has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to flow of corium through failed CRGTs from/to lower plenum because flow of corium through failed CRGTs from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium through failed CRGTs from/to lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
572	Lower head	Flow of water through failed control rod guide tubes from/to lower plenum	N/A	N/A	H	M	P	- Water flown out of side wall of control rods guide tubes (CRGTs) contacts with corium in lower plenum, and causes a change in corium temperature in lower plenum. - Hence, this flow of water has a large influence on corium temperature. - Change in corium temperature causes a change in amount of stem generation. - Hence, in the 4th phase, this flow of water has a relatively large influence on PCV temperature and pressure. - In the 1st and 2nd phases, this flow of water has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to flow of water through failed CRGTs from/to lower plenum because flow of water through failed CRGTs from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of water through failed CRGTs from/to lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
573	Lower head	Flow of gas through failed control rod guide tubes from/to lower plenum	N/A	N/A	**H**	H	P	- Gas flown out of side wall of control rods guide tubes (CRGTs) contacts with corium in lower plenum, and causes a change in corium temperature in lower plenum, although the contribution is smaller than water. - Hence, this flow of gas has a relatively large influence on corium temperature. - Gas flown out of CRGTs increases volume of gas in lower plenum. - Hence, in the 4th phase, this flow of gas has a large influence on PCV temperature and pressure. - In the 1st and 2nd phases, this flow of gas has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to flow of gas through failed CRGTs from/to lower plenum because flow of gas through failed CRGTs from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of gas through failed CRGTs from/to lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
574	Lower head	Purge water steaming in control rod guide tubes due to corium inflow	N/A	N/A	M	M	P	- Corium flown down from core part contacts water in control rod guide tubes (CRGTs), and makes water vaporize. -However, the corium does not directly contact corium in lower plenum. - Hence, purge water steaming in CRGTs does not have a large influence on corium temperature. - An amount of water in CRGTs is less than one in lower plenum. - Hence, in the 4th phase, purge water steaming in CRGTs does not have a large influence on PCV temperature and pressure because steam generation is milder than direct contact between corium and water in lower plenum. - In the 1st and 2nd phases, purge water steaming in CRGTs from/to lower plenum has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to purge water steaming in CRGTs because purge water steaming in CRGTs depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate purge water steaming in CRGTs.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
575	Lower head	Formation of flow path to pedestal by ablation of control rod guide tube internals	N/A	N/A	N/A	H	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - Hence, rationale of this phenomenon is same as one of No.565.	- There are limited data related to formation of flow path to pedestal by ablation of control rod guide tube internals because formation of flow path to pedestal by ablation of control rod guide tube internals depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path to pedestal by ablation of control rod guide tube internals.
576		Changes in breached area in control rod guide tubes to pedestal (including blockage)	N/A	N/A	N/A	M	P	- This change in breached area is one of causes for phenomenon of No.576 “Flow of corium out of lower head bottom section by lower head failure”. - Flow of corium and water appeared as a result of it is phenomenon of No.565. - Hence, rationale of this phenomenon is same as one of No.565.	- There are limited data related to changes in breached area in CRGTs to pedestal because changes in breached area in CRGTs to pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate changes in breached area in CRGTs to pedestal.
577		Ejection of control rod guide tubes	N/A	N/A	N/A	H	P	- Ejection of control rod guide tubes (CRGTs) is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This ejection of CRGTs is one of causes for phenomenon of No.576 “Flow of corium out of lower head bottom section by lower head failure”. - Flow of corium and water appeared as a result of it is phenomenon of No.565. - Hence, rationale of this phenomenon is same as one of No.565.	- There are limited data related to ejection of CRGTs because ejection of CRGTs depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate ejection of CRGTs

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
578	Lower head	Flow of corium out of control rod guide tubes into pedestal	N/A	N/A	N/A	H	P	- Flow of corium out of control rod guide tubes into pedestal is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This flow of corium is one factor of phenomenon of No.5656 “Flow of corium out of lower head bottom section by lower head failure”, and is the biggest factors because total area of CRGTs is large. - Hence, rationale of this phenomenon is same as one of No.565.	- There are limited data related to flow of corium out of CRGTs into pedestal because flow of corium out of CRGTs into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium out of CRGTs into pedestal.
579		Flow of water out of control rod guide tubes into pedestal	N/A	N/A	N/A	H	P	- Flow of water out of control rod guide tubes into pedestal is phenomenon that is seen in the 4th phase. - This flow of water enhances steam generation due to contact with water on pedestal. - Hence, in the 4th phase, this flow of water has a large influence on PCV temperature and pressure. - In the 1st, 2nd, and the 3rd phases, this flow of corium has no influence on each FoM, because this phenomenon is one after vessel failure. .	- There are limited data related to flow of water out of CRGTs into pedestal because flow of water out of CRGTs into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of water out of CRGTs into pedestal.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
580	Lower head	Flow of gas out of control rod guide tubes into pedestal	N/A	N/A	N/A	H	P	- Flow of gas out of control rod guide tubes into pedestal is phenomenon that is seen in the 4th phase. - This flow of gas directly contributes to steam temperature increase and pressure increase in PCV. - Hence, in the 4th phase, this flow of water has a large influence on PCV temperature and pressure. - In the 1st, 2nd, and the 3rd phases, this flow of corium has no influence on each FoM, because this phenomenon is one after vessel failure. .	- There are limited data related to flow of gas out of CRGTs into pedestal because flow of gas out of CRGTs into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of gas out of CRGTs into pedestal.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
581	Lower head	Formation of flow path between SRM/IRM tubes and lower plenum	N/A	N/A	M	M	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs because total area of SRM/IRM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this formation of flow path does not have a large influence on PCV temperature and pressure.	- There are limited data related to formation of flow path between SRM/IRM tubes and lower plenum because formation of flow path between SRM/IRM tubes and lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path between SRM/IRM tubes and lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
582	Lower head	Formation of flow path by jet impingement to SRM/IRM tubes	N/A	N/A	M	M	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs because total area of SRM/IRM tubes is smaller than that of CRGTs. - Also, this formation of flow path is similar to phenomenon of No.594. - Hence, rationale of this phenomenon is same as one of No.594.	- There are limited data related to formation of flow path by jet impingement to SRM/IRM tubes because formation of flow path by jet impingement to SRM/IRM tubes depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path by jet impingement to SRM/IRM tubes.
583		Flow of corium through failed SRM/IRM tubes from/to lower plenum	N/A	N/A	M	M	P	- Flow of corium is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This flow of corium is one factor of phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs (No.578) because total area of SRM/IRM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of corium does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of corium through failed SRM/IRM from/to lower plenum because flow of corium through failed SRM/IRM from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium through failed SRM/IRM from/to lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
584	Lower head	Flow of water through failed SRM/IRM tubes from/to lower plenum	N/A	N/A	M	M	P	- Flow of water is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.579) because total area of SRM/IRM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of water does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of water through failed SRM/IRM from/to lower plenum because flow of water through failed SRM/IRM from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of water through failed SRM/IRM from/to lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
585	Lower head	Flow of gas through failed SRM/IRM tubes from/to lower plenum	N/A	N/A	M	H	P	- Flow of gas is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.580) because total area of SRM/IRM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of gas does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of gas through failed SRM/IRM from/to lower plenum because flow of gas through failed SRM/IRM from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of gas through failed SRM/IRM from/to lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
586	Lower head	Ejection of SRM/IRM tubes	N/A	N/A	N/A	H	P	- Ejection of SRM/IRM tubes is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This ejection of SRM/IRM tubes is one of causes for phenomenon of No.576 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs (No.578) because total area of SRM/IRM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this ejection of SRM/IRM tubes does not have a large influence on PCV temperature and pressure.	- There are limited data related to ejection of SRM/IRM because ejection of SRM/IRM depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate ejection of SRM/IRM.
587		Flow of corium out of SRM/IRM tubes into pedestal	N/A	N/A	N/A	M	P	- Flow of corium is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This flow of corium is one factor of phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs (No.578) because total area of SRM/IRM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of corium does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of corium out of SRM/IRM into pedestal because flow of corium out of SRM/IRM into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium out of SRM/IRM into pedestal.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
588	Lower head	Flow of water out of SRM/IRM tubes into pedestal	N/A	N/A	N/A	M	P	- Flow of water is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.579) because total area of SRM/IRM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of water does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of water out of SRM/IRM into pedestal because flow of water out of SRM/IRM into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of water out of SRM/IRM into pedestal.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
589	Lower head	Flow of gas out of SRM/IRM tubes into pedestal	N/A	N/A	N/A	H	P	- Flow of gas is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.580) because total area of SRM/IRM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of gas does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of gas out of SRM/IRM into pedestal because flow of gas out of SRM/IRM into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of gas out of SRM/IRM into pedestal.
590		Formation of flow path between TIP/ICM tubes and lower plenum	N/A	N/A	H	H	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this formation of flow path does not have a large influence on PCV temperature and pressure.	- There are limited data related to formation of flow path between TIP/ICM tubes and lower plenum because formation of flow path between TIP/ICM tubes and lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path between TIP/ICM tubes and lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
591	Lower head	Formation of flow path by jet impingement to TIP/ICM tubes	N/A	N/A	M	M	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs because total area of TIP/ICM tubes is smaller than that of CRGTs. - Also, this formation of flow path is similar to phenomenon of No.607. - Hence, rationale of this phenomenon is same as one of No.607.	- There are limited data related to formation of flow path by jet impingement to TIP/ICM tubes because formation of flow path by jet impingement to TIP/ICM tubes depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path by jet impingement to TIP/ICM tubes.
592		Flow of corium through failed TIP/ICM tubes from/to lower plenum	N/A	N/A	M	M	P	- Flow of corium is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This flow of corium is one factor of phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs (No.578) because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of corium does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of corium through failed TIP/ICM from/to lower plenum because flow of corium through failed TIP/ICM from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium through failed TIP/ICM from/to lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
593	Lower head	Flow of water through failed TIP/ICM tubes from/to lower plenum	N/A	N/A	M	M	P	- Flow of water is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.579) because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of water does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of water through failed TIP/ICM from/to lower plenum because flow of water through failed TIP/ICM from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of water through failed TIP/ICM from/to lower plenum.
594		Flow of gas through failed TIP/ICM tubes from/to lower plenum	N/A	N/A	M	H	P	- Flow of water is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.580 because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of water does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of gas through failed TIP/ICM from/to lower plenum because flow of gas through failed TIP/ICM from/to lower plenum depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of gas through failed TIP/ICM from/to lower plenum.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
595	Lower head	Formation of flow path to Pedestal by ablation of TIP/ICM tube internals	N/A	N/A	N/A	H	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs because total area of TIP/ICM tubes is smaller than that of CRGTs. - Also, this formation of flow path is similar to phenomenon of No.590. - Hence, rationale of this phenomenon is same as one of No.590.	- There are limited data related to formation of flow path to pedestal by ablation of TIP/ICM tube internals because formation of flow path to pedestal by ablation of TIP/ICM tube internals depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path to pedestal by ablation of TIP/ICM tube internals.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
596	Lower head	Ejection of TIP/ICM tubes	N/A	N/A	N/A	H	P	- Ejection of TIP/ICM tubes is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This ejection of TIP/ICM tubes is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs (No.578) because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this ejection of TIP/ICM tubes does not have a large influence on PCV temperature and pressure.	- There are limited data related to ejection of TIP/ICM because ejection of TIP/ICM depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate ejection of TIP/ICM.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
597	Lower head	Flow of corium out of TIP/ICM tubes into pedestal	N/A	N/A	N/A	M	P	- Flow of corium is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This flow of corium is one factor of phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs (No.578) because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of corium does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of corium out of TIP/ICM into pedestal because flow of corium out of TIP/ICM into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium out of TIP/ICM into pedestal.
598		Flow of water out of TIP/ICM tubes into pedestal	N/A	N/A	N/A	M	P	- Flow of water is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.579) because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of water does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of water out of TIP/ICM into pedestal because flow of water out of TIP/ICM into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of water out of TIP/ICM into pedestal.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
599	Lower head	Flow of gas out of TIP/ICM tubes into pedestal	N/A	N/A	N/A	H	P	- Flow of gas is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.580) because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of gas does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of gas out of TIP/ICM into pedestal because flow of gas out of TIP/ICM into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of gas out of TIP/ICM into pedestal.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
600	Lower head	Flow of gas out of TIP tubes into PCV	N/A	N/A	N/A	H	P	- Flow of gas is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.580) because total area of TIP/ICM tubes is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of gas does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of gas out of TIP into PCV because flow of gas out of TIP into PCV depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of gas out of TIP into PCV.
601		Formation of flow path to pedestal by ablation of RPV drain lines	N/A	N/A	N/A	M	P	- Formation of flow path is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This formation of flow path is one of causes for phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs because total area of RPV drain lines is smaller than that of CRGTs. - Hence, in the 4th phase, this formation of flow path does not have a large influence on PCV temperature and pressure.	- There are limited data related to formation of flow path to pedestal by ablation of RPV drain lines because formation of flow path to pedestal by ablation of RPV drain lines depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path to pedestal by ablation of RPV drain lines.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
602	Lower head	Changes in breached area in RPV drain lines to pedestal (including blockage)	N/A	N/A	N/A	M	P	- This phenomenon occurs after phenomenon of No.622. So, importance for each time phase and SoK is same as No.622. Also, this phenomenon is similar to the cases of No.590 and No.595.	- There are limited data related to formation of flow path to pedestal by ablation of RPV drain lines because formation of flow path to pedestal by ablation of RPV drain lines depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate formation of flow path to pedestal by ablation of RPV drain lines.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
603	Lower head	Flow of corium out of RPV drain lines into pedestal	N/A	N/A	N/A	M	P	- Flow of corium is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - This flow of corium is one factor of phenomenon of No.565 “Flow of corium out of lower head bottom section by lower head failure”. - However, this influence is smaller than that by CRGTs (No.578) because total area of RPV drain lines is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of corium does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of corium out of RPV drain lines into pedestal because flow of corium out of RPV drain lines into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium out of RPV drain lines into pedestal.
604		Flow of water out of RPV drain lines into pedestal	N/A	N/A	N/A	M	P	- Flow of water is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.579) because total area of RPV drain lines is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of water does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of water out of RPV drain lines into pedestal because flow of water out of RPV drain lines into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of water out of RPV drain lines into pedestal.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
605	Lower head	Flow of gas out of RPV drain lines into pedestal	N/A	N/A	N/A	M	P	- Flow of gas is phenomenon seen in the end of 3rd phase and the beginning of the 4th phase. - However, this influence is smaller than that by CRGTs (No.580) because total area of RPV drain lines is smaller than that of CRGTs. - Hence, in the 4th phase, this flow of gas does not have a large influence on PCV temperature and pressure.	- There are limited data related to flow of gas out of RPV drain lines into pedestal because flow of gas out of RPV drain lines into pedestal depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of gas out of RPV drain lines into pedestal.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
606	Lower head	Deformation of lower head	N/A	N/A	H	L	P	- Main deformation mechanisms of lower head wall are creep which is a time-dependent process and plasticity which occurs promptly with load. - In the 3rd phase, lower head wall temperature is as high as creep becomes notable because lower head wall contacts with high temperature corium and crust. - Hence, lower head wall becomes mechanically weak, and easier to deform. - As a result, this deformation makes crust difficult to contact with lower head wall. - Therefore, deformation of lower head has a large influence on RPV wall temperature. - The 4th phase is one after lower head failure. - Hence, deformation of lower head it self does not have an influence on PCV temperature and pressure. - In the 1st and 2nd phases, deformation of lower head has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to deformation of lower head because deformation of lower head depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate deformation of lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
607	Lower head	Corium focusing effect on lower head sidewall	N/A	N/A	L	L	P	- Corium focusing effect is important phenomenon to PWR lower head. - However, it is not so important to BWR because BWR lower head has larger coolability, - Namely, this means that the diameter of BWR lower head is larger than that of PWR. - Hence, this corium focusing effect does not have an influence on RPV wall temperature. - In the 4th phase in which lower head is already failed, most of corium goes down to pedestal. - Hence, this corium focusing effect it self does not have an influence on PCV temperature and pressure. - In the 1st and 2nd phases, this corium focusing effect has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to corium focusing effect on lower head sidewall because corium focusing effect on lower head sidewall depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate corium focusing effect on lower head sidewall

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
608	Lower head	Change in area of failure opening in lower head side section	N/A	N/A	N/A	M	P	- Change in area of failure opening in lower head side section is phenomenon that is seen in the 4th phase after vessel failure. - This phenomenon is similar to one in No.568. - However, in BWR, an amount of corium flowing out of lower head side section is less than that in bottom section which is stated in No.579 because BWR has a lot of penetrations in lower head bottom section which are easy to fail. - Hence, in the 4th phase, change in area of failure opening in lower head side section has a relatively large effect on PCV temperature and pressure. - In the 1st, 2nd, and the 3rd phases, flow of corium out of lower head side section by lower head has no influence on each FoM, because this phenomenon is one after vessel failure.	- There are limited data related to change in area of failure opening in lower head side section because change in area of failure opening in lower head side section depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate change in area of failure opening in lower head side section.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
609	Lower head	Flow of corium out of lower head side section by lower head failure	N/A	N/A	N/A	H	P	- Flow of corium enhances steam generation due to contact with water on pedestal. - Hence, in the 4th phase, this flow of corium has a large influence on PCV temperature and pressure. - In the 1st, 2nd, and the 3rd phases, this flow of corium has no influence on each FoM, because this phenomenon is one after vessel failure. . - This phenomenon is similar to one in No.565. - Flow of corium out of lower head side section by lower head failure is phenomenon that is seen in the 4th phase after vessel failure. - Flow of corium enhances steam generation due to contact with water on pedestal. - However, opening formed in side section of lower head is smaller than that in bottom section. - Hence, in the 4th phase, this flow of corium does not have a large influence on PCV temperature and pressure. - In the 1st, 2nd, and the 3rd phases, this flow of corium has no influence on each FoM, because this phenomenon is one after vessel failure. .	- There are limited data related to flow of corium out of lower head side section by lower head because flow of corium out of lower head side section by lower head depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate flow of corium out of lower head side section by lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
610	Lower head	Failure of shroud support leg	N/A	N/A	L	L	P	- Even if one or two of shroud support leg are melted, shroud would not collapse. - Failure of shroud support leg results in just mixing of melted support leg into corium. - Hence, failure of shroud support leg does not have an influence on corium temperature because an amount of melted support leg is smaller than that of corium. - In the 4th phase, failure of shroud support leg does not have a direct influence on PCV temperature and pressure. - In the 1st and 2nd phases, failure of shroud support leg has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to failure of shroud support leg because failure of shroud support leg depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate failure of shroud support leg.
611		Change in flow resistance in shroud support leg	N/A	N/A	L	L	K	- Failure of shroud support leg would leads to change in flow resistance in shroud support leg. - However, it is unlikely that change in this flow resistance has an influence on corium and RPV wall temperature in the 3rd phase. - Also in the 4th phase, it is more unlikely that this change in flow resistance has an influence on PCV temperature and pressure. - In the 1st, and 2nd phases, this change has no influence on each FoM, because this phenomenon is one after vessel failure.	- There are a lot of data related to change in flow resistance in shroud support leg. - Hence, it is easy to accurately estimate change in flow resistance in shroud support leg.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
612	Lower head	FP deposition on lower head	L	L	L	L	P	- In the 1st phase, it is unlikely that FP deposits on lower head because fuel rod is not failed yet. - Hence, it has almost no influence on fuel rod enthalpy which is FoM. - In the 2nd phase, a small amount of FP might deposit on lower head. - Hence, it has almost no influence on core region temperature which is FoM. - In the 3rd phase, a lot of FP would deposit on lower head. - However, it has just small influence on RPV wall temperature which is FoM - Also in the 4th phase, a lot of FP would deposit on lower head. - However, effect on PCV temperature and pressure by FP deposition is small because dominant factor of PCV temperature and pressure is given by steam or corium itself.	- There are limited data related to FP deposition on lower head because FP deposition on lower head depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate FP deposition on lower head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
613	Lower head	FP re-vaporization	L	L	L	L	P	- In the 1st phase, it is unlikely that FP re-vaporizes on lower head because fuel rod is not failed yet. - Hence, it has almost no influence on fuel rod enthalpy which is FoM. - In the 2nd phase, a small amount of FP might re-vaporize. - Hence, it has almost no influence on core region temperature which is FoM. - In the 3rd phase, a lot of FP would re-vaporize. - However, it has just small influence on RPV wall temperature which is FoM - Also in the 4th phase, a lot of FP would re-vaporize. - However, effect on PCV temperature and pressure by FP re-vaporization is small because dominant factor of PCV temperature and pressure is given by steam or corium.	- There are a lot of data related to FP re-vaporization. - Hence, it is easy to accurately estimate FP re-vaporization.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
614	Lower head	Decay heat generation from FP	L	L	M	L	P	- In the 1st phase, it is unlikely that decay heat generates from FP in lower head. - Hence, it has almost no influence on fuel rod enthalpy which is FoM. - In the 2nd phase, a small amount of decay heat might generate from FP in lower head. - However, it has almost no influence on core region temperature which is FoM. - In the 3rd phase, a lot of decay heat might generate from FP in lower head. - However, heat of FP is smaller than that of corium. - Hence, decay heat generation from FP does not have large effect on RPV temperature. - Also in the 4th phase, a lot of decay heat might generate from FP in lower head. - However, effect on PCV temperature and pressure by decay heat from FP in lower head is small because dominant factor of PCV temperature and pressure is given by steam or corium.	- There are a lot of data related to decay heat generation from FP. - Hence, it is easy to accurately estimate decay heat generation from FP.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
615	Lower head	FP release from corium surface	N/A	N/A	M	M	U	- In the 3rd phase, when FP is released from corium surface, corium temperature decreases because FP is one of heat source. - Hence, FP release from corium surface has an influence on RPV wall temperature. - In the 4th phase, FP migrated into PCV in which FP heats gas. - Hence, FP release from corium surface has an influence on PCV temperature and pressure. - In the 1st and 2nd phases, FP release from corium surface has no influence on each FoM, because there is still no corium in these phases.	- There is little data related to FP release from corium surface because FP release from corium surface depends on configuration and composition of corium. - Hence, it is too difficult to accurately estimate FP release from corium surface.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
616	Lower head	FP reaction including iodine chemistry	L	L	L	L	P	- In the 1st phase, it is unlikely that FP reacts on lower head because fuel rod is not failed yet. - Hence, it has almost no influence on fuel rod enthalpy which is FoM. - In the 2nd phase, a small amount of FP might react. - Hence, it has almost no influence on core region temperature which is FoM. - In the 3rd phase, a lot of FP would react. - However, it has just small influence on RPV wall temperature which is FoM - Also in the 4th phase, a lot of FP would react. - However, effect on PCV temperature and pressure by FP reaction including iodine chemistry is small because dominant factor of PCV temperature and pressure is given by steam or corium.	- There are limited data related to FP reaction including iodine chemistry because FP reaction including iodine chemistry depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate FP reaction including iodine chemistry.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
617	Lower head	Adsorption and release of gaseous FP	L	L	L	L	P	- In the 1st phase, it is unlikely that FP is absorbed and released on lower head because fuel rod is not failed yet. - Hence, it has almost no influence on fuel rod enthalpy which is FoM. - In the 2nd phase, a small amount of gaseous FP might be absorbed and released. - Hence, it has almost no influence on core region temperature which is FoM. - In the 3rd phase, a lot of gaseous FP might be absorbed and released. - However, heat of FP is smaller than that of corium. - Hence, adsorption and release of gaseous FP does not have large effect on RPV temperature. - Also in the 4th phase, a lot of gaseous FP might be absorbed and released. - However, effect on PCV temperature and pressure by adsorption and release of gaseous FP is small because dominant factor of PCV temperature and pressure is given by steam or corium.	- There are limited data related to adsorption and release of gaseous FP because adsorption and release of gaseous FP depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate adsorption and release of gaseous FP.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
618	Lower head	Buckling of control rod guide tubes	N/A	H	L	L	K	- In the 2nd phase, when CRGTs are buckled, corium in core region flows out of core region. - Hence, it has a large influence on enthalpy for core region which is FoM. - In the 3rd phase, even if CRGTs are buckled, buckling itself does not give thermal effect to corium in lower plenum. - Hence, buckling of CRGTs does not have a large influence on corium temperature. - As is the case with the 3rd phase, also in the 4th phase, buckling itself does not an influence on PCV temperature and pressure. - In the 1st phase, buckling of control rod guide tubes has no influence on each FoM, because it is unlikely that buckling occurs.	- There are a lot of data related to buckling of control rod guide tubes. - Hence, it is easy to accurately estimate buckling of control rod guide tubes.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
619	Lower head	Radiation heat transfer between corium and pump deck bottom surface	N/A	N/A	H	L	P	- In the 3rd phase, if water cannot cover whole corium, radiation between corium and pump deck bottom surface is important. - Although this phenomenon depends on water level, severer condition should be assumed. - Hence, this radiation heat transfer has a large influence on corium temperature. - In the 4th phase, corium in lower head goes down to PCV - Hence, this radiation heat transfer has little effect on PCV temperature and pressure. - In the 1st phase and the 2nd phase, this radiation heat transfer has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to radiation heat transfer between corium and pump deck bottom surface because radiation heat transfer between corium and pump deck bottom surface depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate radiation heat transfer between corium and pump deck bottom surface
620		Corrosion of structure in lower plenum by salt content of seawater (including marine lives)	L	L	L	L	U	- Corrosion by seawater takes long time by appearance of effect, which is over some days. - Hence, in every phase, corrosion of structure in lower plenum by salt content of seawater has little effect on each FoM.	- There is little data related to corrosion of structure in lower plenum by salt content of seawater. - Hence, it is too difficult to accurately estimate corrosion of structure in lower plenum by salt content of seawater.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
621	Lower head	Melting point change for lower head materials	N/A	N/A	H	M	P	- Melting point of lower head materials can change due to eutectics with corium. - Melting point is important to failure of RPV wall. - Hence, melting point change for lower head materials has a large influence on corium temperature. - In the 4th phase, moment of failure of RPV wall depends on melting point. - According to the moment, gas temperature going out of in-vessel is different. - Hence, melting point change for lower head materials has a relatively large influence on corium temperature. - In the 1st phase and the 2nd phase, melting point change for lower head materials has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to melting point change for lower head materials because melting point change for lower head materials depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate melting point change for lower head materials.
622		Eutectic (Corium and lower head materials)	N/A	N/A	H	M	P	- This phenomenon is cause of one of No.642. - Hence, the reasons of ranking are same as ones of No.621.	- There are limited data related to eutectic because eutectic depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate eutectic.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
623	Lower head	Melting of lower head penetration lines	N/A	N/A	H	H	P	- In the 3rd phase, lower head penetration melted is added to corium and affects enthalpy of corium. - Hence, melting of lower head penetration lines has a large influence on corium temperature. - Melting of lower head penetration lines in the 4th phase is same as some phenomena of No.569, 570, 5758, and so on. - Hence, the ranking and rationale are same as those. - In the 1st phase and the 2nd phase, melting of lower head penetration lines has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to melting of lower head penetration lines because melting of lower head penetration lines depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate melting of lower head penetration lines.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
624	Lower head	Melting of lower head wall	N/A	N/A	H	M	P	- In the 3rd phase, lower head wall melted is added to corium and affects enthalpy of corium. - Hence, melting of lower head wall has a large influence on corium temperature. - Melting of lower head wall in the 4th phase is same as phenomena of No.565 and 568. - Hence, the ranking and rationale are same as those. - In the 1st phase and the 2nd phase, melting of lower head wall has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to melting of lower head wall because melting of lower head wall depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate melting of lower head wall.
625		Melting of jet pump	N/A	N/A	M	L	P	- In the 3rd phase, jet pump melted is added to corium and affects enthalpy of corium. - Hence, melting of jet pump has a large ionfluence on corium temperature. - In the 4th phase, melting of jet pump does not directly affects flow-out of gas in in-vessel unlike No.623 and No.624. - Hence, melting of jet pump does not have a large influence on PCV temperature and pressure. - In the 1st phase and the 2nd phase, melting of jet pump has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to melting of jet pump because melting of jet pump depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate melting of jet pump.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
626	Lower head	Melting of pump deck	N/A	N/A	M	L	P	- In the 3rd phase, pump deck melted is added to corium and affects enthalpy of corium. - Hence, melting of pump deck has a large effect on corium temperature. - In the 4th phase, melting of pump deck does not directly affects flow-out of gas in in-vessel unlike No.623 and No.624. - Hence, melting of pump deck does not have a large effect on PCV temperature and pressure. - In the 1st phase and the 2nd phase, melting of pump deck has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to melting of pump deck because melting of pump deck depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate melting of pump deck.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
627	Lower head	Melting of shroud	N/A	N/A	M	L	P	- In the 3rd phase, shroud melted is added to corium and affects enthalpy of corium. - Hence, melting of shroud has a large influence on corium temperature. - In the 4th phase, melting of shroud does not directly affects flow-out of gas in in-vessel unlike No.623 and No.624. - Hence, melting of shroud does not have a large influence on PCV temperature and pressure. - In the 1st phase and the 2nd phase, melting of shroud has no influence on each FoM, because there is still no corium in these phases.	- There are limited data related to melting of shroud because melting of shroud depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate melting of shroud.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
628	Lower head	Influence for heat transfer by salt deposition	L	L	M	L	U	- In the 1st phase, it is unlikely that salt deposition in lower plenum affect fuel rod enthalpy in core region which is FoM. - Hence, influence for heat transfer by salt deposition has almost no influence on fuel rod enthalpy. - Also in the 2nd phase, an effect of heat transfer by salt deposition is same as the 1st phase. - Hence, influence for heat transfer by salt deposition has almost no influence on fuel enthalpy for core region. - In the 3rd phase, it is considered that salt deposition has some influence on heat transfer between materials, such as corium and RPV wall, because salt becomes thermal resistance. - Hence, influence for heat transfer by salt deposition has an influence on RPV wall temperature. - In the 4the phase, it is unlikely that salt deposition in lower plenum affect gas flow-out to ex-vessel. - Hence, influence for heat transfer by salt deposition has almost no influence on PCV temperature and pressure.	- There is little data related to influence for heat transfer by salt deposition. - Hence, it is too difficult to accurately estimate influence for heat transfer by salt deposition.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
629	Lower head	Seasalt intake to corium	N/A	N/A	H	H	U	- In the 3rd phase, seasalt taken in corium has impact on composition of corium. - Hence, seasalt intake to corium has a large influence on corium temperature. - In the 4th phase, seasalt intake to corium affects heat transfer between gas and corium. - Hence, seasalt intake to corium has a large influence on PCV temperature and pressure. - In the 1st phase and the 2nd phase, seasalt intake to corium has no influence on each FoM, because there is still no corium in these phases.	- There is little data related to seasalt intake to corium. - Hence, it is too difficult to accurately estimate seasalt intake to corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
630	Lower head	Seasalt impact for corium thermodynamic properties	N/A	N/A	H	L	U	- In the 3rd phase, seasalt taken in corium makes composition of corium change. - In the Fukushima accident, a lot of seasalt is added to in-vessel. - Hence, seasalt impact for corium thermodynamic properties has a large influence on corium temperature. - In the 4th phase, seasalt impact for corium thermodynamic properties itself does not give an impact on gas-flow to ex-vessel because it is not directly related to be gas. - Hence, seasalt impact for corium thermodynamic properties has little influence on PCV temperature and pressure. - In the 1st phase and the 2nd phase, seasalt impact for corium thermodynamic properties has no influence on each FoM, because there is still no corium in these phases.	- There is little data related to seasalt impact for corium thermodynamic properties. - Hence, it is too difficult to accurately estimate seasalt impact for corium thermodynamic properties.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
631	Lower head	Re-solution of salt by reflooding	L	L	M	L	U	- This phenomenon is opposite to one of No.649. - In the 1st phase, it is unlikely that re-solution of salt affect fuel rod enthalpy in core region which is FoM. - Hence, re-solution of salt by reflooding has almost no influence on fuel rod enthalpy. - Also in the 2nd phase, an effect of re-solution of salt is same as the 1st phase. - Hence, re-solution of salt by reflooding has almost no influence on fuel enthalpy for core region. - In the 3rd phase, it is considered that salt re-solution has some influence on heat transfer between materials, such as corium and RPV wall, because salt becomes thermal resistance. - Hence, re-solution of salt by reflooding has an influence on RPV wall temperature. - In the 4the phase, it is unlikely that salt re-solution in lower plenum affect gas flow-out to ex-vessel. - Hence, re-solution of salt by reflooding has almost no effect on PCV temperature and pressure.	- There is little data related to re-solution of salt by reflooding. - Hence, it is too difficult to accurately estimate re-solution of salt by reflooding.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
632	Lower head	Influence on heat transfer by seasalt concentration change	L	L	M	L	U	- This phenomenon is related to ones of No.649 and No.652. - In the 1st phase, it is unlikely that seasalt concentration change affect fuel rod enthalpy in core region which is FoM. - Hence, influence on heat transfer by seasalt concentration change has almost no influence on fuel rod enthalpy. - Also in the 2nd phase, an effect of seasalt concentration change is same as the 1st phase. - Hence, influence on heat transfer by seasalt concentration change has almost no influence on fuel enthalpy for core region. - In the 3rd phase, it is considered that seasalt concentration change has some influence on heat transfer between materials, such as corium and RPV wall, because salt becomes thermal resistance. - Hence, influence on heat transfer by seasalt concentration change has an effect on RPV wall temperature. - In the 4the phase, it is unlikely that seasalt concentration change affect gas flow-out to ex-vessel. - Hence, influence on heat transfer by seasalt concentration change has almost no influence on PCV temperature and pressure.	- There is little data related to influence on heat transfer by seasalt concentration change. - Hence, it is too difficult to accurately estimate influence on heat transfer by seasalt concentration change.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
633	Lower head	Influence on instrumentation and measurements by seasalt concentration change	L	L	L	L	U	- Influence this phenomenon means is corrosion by seasalt. - Hence, what this phenomenon means is same as one of No.620. - Corrosion by seawater takes long time by appearance of effect, which is over some days. - Hence, in every phase, influence on instrumentation and measurements by seasalt concentration change has little effect on each FoM.	- There are limited data related to influence on instrumentation and measurements by seasalt concentration change depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate influence on instrumentation and measurements by seasalt concentration change.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
634	Lower head	Seasalt impact for FP reaction and composition	L	L	L	L	P	- In the 1st phase, it is unlikely that seasalt impact for FP reaction and composition affect fuel rod enthalpy in core region which is FoM. - Hence, seasalt impact for FP reaction and composition has almost no influence on fuel rod enthalpy. - Also in the 2nd phase, an effect of seasalt impact for FP reaction and composition is same as the 1st phase. - Hence, seasalt impact for FP reaction and composition has almost no influence on fuel enthalpy for core region. - Also in the 3rd phase, it is unlikely that seasalt impact for FP reaction and composition affect corium temperature which is FoM. - Hence, seasalt impact for FP reaction and composition has an influence on RPV wall temperature. - Also in the 4the phase, it is unlikely that seasalt impact for FP reaction and composition affect gas flow-out to ex-vessel. - Hence, seasalt impact for FP reaction and composition has almost no influence on PCV temperature and pressure.	- There are limited data related to seasalt impact for FP reaction and composition because seasalt impact for FP reaction and composition depends on factors including some partially known ones. - Hence, it is difficult to accurately estimate seasalt impact for FP reaction and composition.
635	Lower head	Corrosion of structure in lower plenum by boron	L	L	L	L	U	- Corrosion by boron takes long time by appearance of effect, which is over some days. - Hence, in every phase, corrosion of structure in lower plenum by boron has little effect on each FoM.	- There is little data related to corrosion of structure in lower plenum by boron. - Hence, it is too difficult to accurately estimate corrosion of structure in lower plenum by boron.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
636	Lower head	Influence for heat transfer by boron deposition	L	L	M	L	U	- In the 1st phase, it is unlikely that boron deposition in lower plenum affect fuel rod enthalpy in core region which is FoM. - Hence, influence for heat transfer by boron deposition has almost no influence on fuel rod enthalpy. - Also in the 2nd phase, an effect of heat transfer by boron deposition is same as the 1st phase. - Hence, influence for heat transfer by boron deposition has almost no influence on fuel enthalpy for core region. - In the 3rd phase, it is considered that boron deposition has some influence on heat transfer between materials, such as corium and RPV wall, because boron is deposited on RPV wall and so on. - Hence, influence for heat transfer by boron deposition has an influence on RPV wall temperature. - In the 4the phase, it is unlikely that boron deposition in lower plenum affect gas flow-out to ex-vessel. - Hence, influence for heat transfer by boron deposition has almost no influence on PCV temperature and pressure.	- There is little data related to influence for heat transfer by boron deposition. - Hence, it is too difficult to accurately estimate influence for heat transfer by boron deposition.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
637	Lower head	Re-solution of boron by reflooding	L	L	M	L	P	- This phenomenon is opposite to one of No.649. - In the 1st phase, it is unlikely that re-solution of boron affect fuel rod enthalpy in core region which is FoM. - Hence, re-solution of boron by reflooding has almost no influence on fuel rod enthalpy. - Also in the 2nd phase, an effect of re-solution of boron is same as the 1st phase. - Hence, re-solution of boron by reflooding has almost no influence on fuel enthalpy for core region. - In the 3rd phase, it is considered that boron re-solution has some influence on heat transfer between materials, such as corium and RPV wall, because boron is deposited on RPV wall and so on. - Hence, re-solution of boron by reflooding has an influence on RPV wall temperature. - In the 4the phase, it is unlikely that boron re-solution in lower plenum affect gas flow-out to ex-vessel. - Hence, re-solution of boron by reflooding has almost no influence on PCV temperature and pressure.	- There is little data related to re-solution of boron by reflooding. - Hence, it is too difficult to accurately estimate re-solution of boron by reflooding.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
638	Recirculation loop	Heat transfer between recirculation loop piping and water	L	L	L	L	K	- As heat transfer between recirculation loop piping and water is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- General forced convection heat transfer coefficient could be applied inside of a pipe between pipe inner surface and water.
639		Heat transfer between recirculation loop piping and gas	L	L	L	L	K	- As heat transfer between recirculation loop piping and gas is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- General forced convection heat transfer coefficient could be applied inside of a pipe between pipe inner surface and gas.
640		Heat Transfer to Drywell through Lagging Material	L	L	L	L	K	- As heat transfer to Drywell through Lagging Material is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- General natural convection heat transfer coefficient between Lagging Material and gas could be evaluated by thermodynamic calculation.
641		Radiation heat transfer to drywell	L	L	L	L	K	- Because of existence of Lagging Material, radiation between recirculation loop piping and drywell floor/wall has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- Radiation heat transfer between two surfaces could be theoretically evaluated by the temperatures, radiation factor, and radiation configuration factor.
642		Change in temperature of recirculation loop piping	L	L	L	L	K	- As the state quantities of recirculation loop piping can be considered to be almost independent of those of core, temperature change of recirculation loop piping has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- Temperature changes of recirculation loop piping and pressure, water level, water temperature, gas temperature, gas composition, and flow of water and/or steam change in recirculation loop piping could be evaluated by thermodynamic calculation.
643		Change in pressure in recirculation loop piping	L	L	L	L	K	- As the state quantities in recirculation loop piping can be considered to be almost independent of those of core, pressure change in recirculation loop piping has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	The same as No.642.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
644	Recirculation loop	Change in water level in recirculation loop piping	L	L	L	L	K	- As the state quantities in recirculation loop piping can be considered to be almost independent of those of core, water level change in recirculation loop piping has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	The same as No.642.
645		Change in water temperature in recirculation loop piping	L	L	L	L	K	- As the state quantities in recirculation loop piping can be considered to be almost independent of those of core, water temperature change in recirculation loop piping has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	The same as No.642.
646		Change in flow of water and/or steam in recirculation loop piping (including flow regime)	L	L	L	L	K	- As the state quantities in recirculation loop piping can be considered to be almost independent of those of core, flow of water and/or steam change in recirculation loop piping has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	The same as No.642.
647		Change in gas temperature in recirculation loop piping	L	L	L	L	K	- As the state quantities in recirculation loop piping can be considered to be almost independent of those of core, gas temperature change in recirculation loop piping has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	The same as No.642.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
648	Recirculation loop	Change in gas composition in recirculation loop piping	L	L	L	L	K	- As the state quantities in recirculation loop piping can be considered to be almost independent of those of core, gas composition change in recirculation loop piping has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	The same as No.642.
649		Change in flow of corium in recirculation loop piping	N/A	N/A	L	L	P	- As corium does not exist in recirculation loop piping until relocation, 1st and 2nd categories are not applicable. - As the state quantities in recirculation loop piping can be considered to be almost independent of those of core, change in flow of corium in recirculation loop piping has little impact on RPV/PCV pressure and temperature.	- Corium properties are needed to be known in order to evaluate corium flow. - Corium properties were examined in the many tests[]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
650		Oxidation reaction between recirculation loop piping and steam (including hydrogen generation and reaction heat)	L	L	L	L	P	- As oxidation reaction between recirculation loop piping and steam is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- Oxidation reaction between pure substance in recirculation loop piping and steam could be evaluated by thermodynamic evaluation. - However, there is not enough experimental data toward oxidation reaction of recirculation loop piping.
651		Leakage of gas from breached gasket or PLR pump seal	N/A	M	H	M	P	- As gas temperature and water temperature in recirculation loop piping is not high until fuel heat up, 1st category is not applicable. - Leakage of gas and water in recirculation loop piping affects RPV/PCV pressure and temperature.	- Leakage of gas and water from recirculation loop piping could be evaluated by thermodynamic calculation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
652	Recirculation loop	Leakage of water from breached gasket or PLR pump seal	N/A	M	H	M	P	- As gas temperature and water temperature in recirculation loop piping is not high until fuel heat up, 1st category is not applicable. - Leakage of gas and water in recirculation loop piping affects RPV/PCV pressure and temperature.	The same as No.651.
653		Water Radiolysis	L	L	L	L	K	- As an amount of hydrogen generated by radiation decomposition of water is smaller than that by Water-Zr reaction, It is relatively less important than other phenomena.	- The phenomenon is well understood for pure water.
654		Flow path blockage in recirculation loop piping by solidification of corium	N/A	N/A	L	L	U	- As corium does not exist in recirculation loop piping until relocation, 1st and 2nd categories are not applicable. - As the state quantities in recirculation loop piping can be considered to be almost independent of those of core, flow path blockage by solidification of corium has little impact on RPV/PCV pressure and temperature.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
655		Corrosion of structure in recirculation loop piping by salt content of seawater (including marine lives)	L	L	L	L	U	- As corrosion rate of structure in recirculation loop piping by seasalt is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
656		Influence for heat transfer by salt deposition	L	L	M	L	U	- Deposited seasalt on RPV structure may decrease heat transfer to the others. However, as dissolution of seasalt occurs at lower temperatures, it has little impact on an amount of heat transfer to RPV and PCV structure/wall.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
657	Recirculation loop	Seasalt intake to corium	N/A	N/A	L	L	U	- As corium does not exist in recirculation loop piping until relocation, 1st and 2nd categories are not applicable. - As corium surface is cooled by seawater, generated crust on the surface of corium pool prevent seasalt intake to corium. Thus it has little impact on RPV/PCV pressure and temperature.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
658		Re-solution of salt by reflooding	L	L	L	L	P	- Deposited seasalt may decrease heat transfer from deposited surface to the others. However, as dissolution of seasalt occurs at lower temperatures, it has little impact on an amount of heat transfer to RPV and PCV structure/wall.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
659		Influence on Heat Transfer by Seasalt Concentration Change	L	L	L	L	P	- As the influence on heat transfer by seasalt concentration change in water is relatively small compared to that by water level change in RPV, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- Properties of normal or concentrated seawater are studied for seasalt making field.
660		Influence on Instrumentation and Measurements by Seasalt Concentration Change	L	L	L	L	U	-As Influence on accident progress by change in instrumentation and measurements by seasalt concentration change is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
661	Recirculation loop	Seasalt impact for FP reaction and composition	L	L	L	L	P	- As an amount of heat generation from chemical reaction is small compared to that from decay heat, FP chemical reaction has little impact on RPV/PCV temperature and pressure. Change of FP chemical form due to seasalt may change the behavior of FP.	- The seasalt impact for FP reaction and composition has been examined after Fukushima Dai-Ichi Nuclear Power Plant accident. - However, there is not enough experimental data.
662		Corrosion of structure in recirculation loop piping by boron	L	L	L	L	U	- As corrosion rate of structure in recirculation loop piping by boron is small, it has little impact on fuel heat up, fuel melting, relocation, and PCV pressure and temperature.	- There is no experimental data toward corrosion of structure in recirculation loop piping by boron.
663		Influence for heat transfer by boron deposition	L	L	L	L	P	- Deposited boron on the structure in recirculation loop piping may decrease heat transfer to the others. However, as dissolution of boron occurs at lower temperatures, it has little impact on an amount of heat transfer to RPV and PCV structure/wall.	- There is no experimental data toward boron effects on heat transfer.
664		Re-solution of boron by reflooding	L	L	L	L	P	- Deposited boron may decrease heat transfer from deposited surface to the others. However, as dissolution of boron occurs at lower temperatures, it has little impact on an amount of heat transfer to RPV and PCV structure/wall.	- Remelting and deposition behavior of boron might evaluated from flood. - However, there is not enough experimental data for validation.
665		FP deposition on recirculation loop	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- Recirculation loop piping heat-up would be affected by the amount of FP particle deposition. - FP particle deposition on recirculation loop piping was examined in some tests. - However, there is not enough experimental data for validation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
666	Recirculation loop	FP re-vaporization	L	L	L	L	P	-As deposited FP in recirculation loop piping is sufficiently cooled, it cannot vaporize by its decay heat.	- FP re-vaporization was examined in some tests. - However, there is not enough experimental data for validation..
667		Decay heat generation from FP	L	L	L	L	P	- As an amount of FP in recirculation loop piping is little, 1st to 4th categories are ranked “L”.	- Decay heat generation from FP could be evaluated by using decay heat model. - However, there is not enough experimental data for validation.
668		Leakage of FP from recirculation loop piping	L	L	M	L	K	-As an amount of FP in recirculation loop piping is little, 1st to 4th categories are ranked “L”.	- Leakage of FP from recirculation loop piping could be evaluated by thermodynamic calculation.
669		FP release from corium surface	N/A	N/A	M	M	U	- As corium does not exist in recirculation loop piping until relocation, 1st and 2nd categories are not applicable. - Released FP can impact on RPV/PCV pressure and temperature.	- There is no experimental data toward FP release from corium surface.
670		FP reaction including iodine chemistry	L	L	L	L	P	-As released energy from FP chemical reaction including iodine chemistry is relatively smaller than its decay heat, all categories are ranked “L”.	-FP reaction was examined in some tests. -Iodine chemistry was examined in some projects. -However, there is not enough experimental data for validation.
671		Adsorption and release of gaseous FP	L	L	L	L	P	- As an amount of adsorption and release of FP gas is little, all categories are ranked “L”.	- Adsorption and release of gaseous FP was examined in some tests. - However, there is not enough experimental data for validation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
672	Recirculation loop	Melting of recirculation piping	N/A	N/A	M	L	P	- As corium does not exist in recirculation loop piping until relocation, 1st and 2nd categories are not applicable. - Melting of recirculation loop piping affects RPV/PCV pressure and temperature.	- Melting point of recirculation loop piping could be calculated. - However, there is not enough experimental data for validation.
673		Degradation or Falling of Lagging Material	L	L	L	L	P	- Degradation or falling of Lagging Material of recirculation loop piping affects RPV/PCV pressure and temperature.	-Heat transfer between water in recirculation loop piping and gas in PCV could be evaluated by thermodynamic calculation. - However, there is not enough experimental data for validation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
674	Pedestal/Cavity	Liquid film flow of corium at outer surface of penetration pipes (control rod guide tube, drain line, instrumentation tube) sticking out from RPV bottom(<-- Liquid film flow of corium at protrusion surface of penetration pipes (control rod guide tube, drain line, instrumentation tube))	N/A	N/A	N/A	M	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Liquid film flow of corium at outer surface of penetration pipes may melt the pipes and increase leak flow area, or may freeze near the leak hole and decrease the leak flow area. It affects PCV pressure and temperature	- The behavior of liquid film flow of corium at outer surface of penetration pipes might be evaluated by present knowledge. - However, there is not enough experimental data for validation.
675		Thermal conduction of penetration pipes (control rod guide tube, drain line, instrumentation tube) sticking out from RPV bottom (<-- Thermal conduction on protrusion surface of penetration pipes (control rod guide tube, drain line, instrumentation tube))	L	L	L	M	P	- As heat release from RPV by the thermal conduction of penetration pipes is small, it has little impact on fuel heat up, fuel melting, and relocation. - Thermal conduction of penetration pipes may cause melting of the pipes and increase leak flow area, or may cause freezing of corium and decrease the leak flow area. It affects PCV pressure and temperature	- The thermal conductivity of materials for nuclear power plant could be calculated as a function of temperature [1].
676		Heat transfer between corium and outer surface of penetration pipes (control rod guide tube, drain line, instrumentation tube) sticking out from RPV bottom (<-- Heat transfer between corium and outer surface of protrusion on penetration pipes (control rod guide tube, drain line, instrumentation tube))	N/A	N/A	N/A	M	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between corium and outer surface of penetration pipes may cause melting of the pipes and increase leak flow area, or may cause freezing of corium and decrease the leak flow area. It affects PCV pressure and temperature	The same as No.674.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
677	Pedestal/Cavity	Heat transfer between corium and water (including CHF)	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between corium and water affects steam generation rate. It also affects corium temperature and MCCI progress. Those affect PCV pressure and temperature.	- Heat transfer between corium and water (including CHF) was examined in MCCI project [2], MACE experiment [3], and FARO experiment [4]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
678		Heat transfer between corium and gas	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between corium and gas affects PCV temperature change. It also affects corium temperature and MCCI progress. Those affect PCV pressure and temperature.	The same as No. 677.
679		Heat transfer between crust and water (including CHF)	N/A	N/A	N/A	H	P	- As crust does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between crust and water affects steam generation rate. It also affects corium temperature and MCCI progress. Those affect PCV pressure and temperature.	The same as No. 677.
680		Heat transfer between crust and gas	N/A	N/A	N/A	H	P	- As crust does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between crust and gas affects PCV temperature change. It also affects corium temperature and MCCI progress. Those affect PCV pressure and temperature.	The same as No. 677.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
681	Pedestal/Cavity	Heat transfer between crust and corium (including heat transfer enhancement at gas generation due to MCCI)	N/A	N/A	N/A	H	P	- As crust and corium do not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between crust and corium affects corium temperature and MCCI progress. Those affect PCV pressure and temperature.	The same as No. 677.
682		Heat transfer between corium particle and water	N/A	N/A	N/A	H	P	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between corium particle and water affects steam generation rate and leads PCV pressure change.	- Heat transfer between corium particle and water was examined in MCCI project [2] and heat transfer would be affected by the size of particle and the distribution of size. - However, there is not enough experimental data for validation.
683		Heat transfer between corium particle and gas	N/A	N/A	N/A	H	P	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between corium particle and gas affects PCV temperature change.	The same as No. 682.
684		Heat transfer between corium particle and pedestal floor/wall	N/A	N/A	N/A	H	P	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between corium particle and pedestal floor/wall affects heat release from PCV and MCCI progress. It affects PCV pressure and temperature.	The same as No. 682.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
685	Pedestal/Cavity	Heat transfer between pedestal floor/wall and corium	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between pedestal floor/wall and corium affects heat release from PCV and MCCI progress. It affects PCV pressure and temperature.	The same as No. 682.
686		Heat transfer between pedestal floor/wall and crust	N/A	N/A	N/A	H	P	- As crust does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between pedestal floor/wall and (lower) crust affects corium temperature and MCCI progress. It affects PCV pressure and temperature.	The same as No. 682.
687		Heat transfer between pedestal floor/wall and water	L	L	L	H	P	- Because of existence of RPV insulator, heat transfer between pedestal floor/wall and gas has little impact on fuel heat up, fuel melting, and relocation. - Heat transfer between pedestal floor/wall and water affects heat release from PCV. It affects PCV pressure and temperature.	- Heat transfer between floor/wall and water can be evaluated if water flow pattern is well known. However, water flow in the pedestal is complicated and it is difficult to evaluate an amount of heat transfer.
688		Heat transfer between pedestal floor/wall and gas	L	L	L	M	P	- Because of existence of RPV insulator, heat transfer between pedestal floor/wall and gas has little impact on fuel heat up, fuel melting, and relocation. - Heat transfer between pedestal floor/wall and gas affects heat release from PCV. It affects PCV pressure and temperature.	- Heat transfer between floor/wall and gas can be evaluated if gas flow pattern is well known. However, gas flow in the pedestal is complicated and it is difficult to evaluate an amount of heat transfer.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
689	Pedestal/Cavity	Heat transfer from lower head to gas in pedestal region	L	L	L	M	P	- Because of existence of RPV insulator, heat transfer from lower head to gas in pedestal region has little impact on fuel heat up, fuel melting, and relocation. - Since temperature of lower head may become high and part of decay heat of corium in RPV removes through the lower head to PCV, it affects PCV pressure and temperature	- Heat transfer between lower head and gas can be evaluated if gas flow pattern is well known. However, gas flow in the pedestal is complicated and it is difficult to evaluate an amount of heat transfer.
690		Heat transfer from protrusion of penetration pipes (control rod guide tube, drain line, instrumentation tube) to water (leak flow)	N/A	N/A	N/A	M	K	- As water does not exist in pedestal cavity until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer from protrusion of penetration pipes to water leak flow may cause freezing of corium in the pipe and decrease the leak flow area. It affects PCV pressure and temperature	- General forced convection heat transfer coefficient could be applied inside of a pipe between pipe inner surface and leaked water.
691		Heat transfer from protrusion of penetration pipes (control rod guide tube, drain line, instrumentation tube) to gas	L	L	L	M	K	- As heat transfer from protrusion of penetration pipes to PCV gas is small, it has little impact on fuel heat up, fuel melting, and relocation. - Heat transfer from protrusion of penetration pipes to gas may cause freezing of corium in the pipe and decrease the leak flow area. It affects PCV pressure and temperature	- General natural convection heat transfer coefficient could be applied outside of a pipe between pipe outer surface and gas.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
692	Pedestal/Cavity	Radiation between lower head and pedestal floor/wall	L	L	L	M	K	- Because of existence of RPV insulator, radiation between lower head and pedestal floor/wall has little impact on fuel heat up, fuel melting, and relocation. - Since temperature of lower head may become high due to remained corium in the lower head and it affects PCV pressure and temperature by radiation heat transfer from RPV to PCV.	- Radiation heat transfer between two surfaces could be theoretically evaluated by the temperatures, radiation factor, and radiation configuration factor.
693		Radiation between lower head and pedestal internal structure	L	L	L	M	K	- Because of existence of RPV insulator, radiation between lower head and pedestal internal structure has little impact on fuel heat up, fuel melting, and relocation. - Since pedestal internal structure has limited heat sink capacity, it is relatively less important than the other radiation phenomena.	The same as No.692.
694		Radiation between corium and pedestal wall	N/A	N/A	N/A	M	K	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since temperature of corium may become high and part of decay heat of corium in PCV removes through the pedestal wall by radiation, it affects PCV pressure and temperature.	The same as No.692.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
695	Pedestal/Cavity	Radiation between corium and RPV wall	N/A	N/A	N/A	M	K	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since temperature of RPV wall may become high and part of decay heat of debris in RPV removes through the RPV wall to PCV by radiation, it affects PCV pressure and temperature.	The same as No.692.
696		Radiation between corium and pedestal internal structure	N/A	N/A	N/A	M	K	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since pedestal internal structure has limited heat sink capacity, it is relatively less important than the other radiation phenomena.	The same as No.692.
697		Radiation between crust and pedestal wall	N/A	N/A	N/A	M	K	- As crust does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since temperature of crust may become high and part of decay heat of debris in PCV removes through the pedestal wall by radiation, it affects PCV pressure and temperature.	The same as No.692.
698		Radiation between crust and RPV wall	N/A	N/A	N/A	M	K	- As crust does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since temperature of RPV wall may become high and part of decay heat of corium in RPV removes through the RPV wall to PCV by radiation, it affects PCV pressure and temperature.	The same as No.692.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
699	Pedestal/Cavity	Radiation between crust and pedestal internal structure	N/A	N/A	N/A	M	K	- As crust does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since pedestal internal structure has limited heat sink capacity, it is relatively less important than the other radiation phenomena.	The same as No.692.
700		Radiation between corium particle and pedestal wall	N/A	N/A	N/A	M	K	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since temperature of corium particle may become high and part of decay heat of debris in PCV removes through the pedestal wall by radiation, it affects PCV pressure and temperature.	The same as No.692.
701		Radiation between corium particle and RPV wall	N/A	N/A	N/A	M	K	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since temperature of RPV wall may become high and part of decay heat of debris in RPV removes through the RPV wall to PCV by radiation, it affects PCV pressure and temperature.	The same as No.692.
702		Radiation between corium particle and pedestal internal structure	N/A	N/A	N/A	L	K	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since pedestal internal structure has limited heat sink capacity, it is relatively less important than the other radiation phenomena.	The same as No.692.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
703	Pedestal/Cavity	Particulate corium bed porosity	N/A	N/A	N/A	H	P	- As particulate corium bed does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Particulate corium bed porosity directly affects corium coolability from its upper surface via change of heat conductivity and change of water immersion possibility. Low corium coolability may cause MCCI.	- Corium bed porosity could be evaluated by the size of corium particles. - However, there are not enough data for the size of corium particles which are generated by entrainment with sparging gas (No.55) or jet breakup (No.56) .
704		Pedestal deformation / failure due to thermal stress	N/A	N/A	N/A	L	P	- As large thermal stress which can deform or fail pedestal does not occur if corium does not exist in pedestal. As corium does not exist in pedestal until RPV failure, categories from 1st to 3rd are not applicable. - Deformation / failure due to thermal stress in pedestal may occur, however, possibility is small because radiation heat transfer is relatively smaller than direct heat transfer to floor / wall of pedestal.	- Thermal stress on pedestal structure could be evaluated if heat source distribution is well known. - Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [19]. - However, there is uncertainty for heat source distribution, it is difficult to evaluate this phenomena.
705		Pedestal wall heatup due to corium adhesion to pedestal wall	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heatup of pedestal wall due to direct corium adhesion may occur. If it occurs, reaction between pedestal wall and corium (MCCI) occurs and non-condensable gas generates. It leads to change PCV pressure and temperature changes.	The same as No.704.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
706	Pedestal/Cavity	Pressure change in pedestal	L	L	L	H	K	- As the state quantities of pedestal can be considered to be almost independent of those of RPV because of existence of RPV insulator, pressure change in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Pressure change in pedestal directly leads to change of PCV pressure.	- Pressure, gas temperature, and water temperature changes in pedestal could be evaluated by thermodynamic calculation.
707		Gas temperature change in pedestal	L	L	L	H	K	- As the state quantities of pedestal can be considered to be almost independent of those of RPV because of existence of RPV insulator, gas temperature change in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Gas temperature change in pedestal directly leads to change of PCV temperature.	The same as No.706.
708		Water temperature change in pedestal	L	L	L	H	K	- As the state quantities of pedestal can be considered to be almost independent of those of RPV because of existence of RPV insulator, water temperature change in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Water temperature change in pedestal affects steam generation rate in pedestal, and the quantity of generated steam directly leads to change of PCV pressure.	The same as No.706.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
709	Pedestal/Cavity	Thermal conduction / temperature change of corium	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since thermal conduction change of corium directly affects corium coolability from upper surface, and temperature change of corium directly affects MCCI reaction rate, this affects an amount of MCCI reaction. An amount of chemical reaction heat and generated non-condensable gas directly affects PCV temperature and pressure.	- Temperature change could be evaluated by using heat conduction equation. - The corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - However, there is not enough experimental data of corium properties at high temperature.
710		Thermal conduction / temperature change of crust	N/A	N/A	N/A	H	P	- As crust does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since thermal conduction or temperature change of crust directly affects corium coolability from upper surface, this affects an amount of MCCI reaction. An amount of chemical reaction heat and generated non-condensable gas directly affects PCV temperature and pressure	- Thermal conduction and temperature would be affected by crust composition and porosity. - However, crust composition is not uniform and crust porosity is not well known (No.706). There is not enough experimental data.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
711	Pedestal/Cavity	Thermal conduction / temperature change of pedestal floor / wall	L	L	L	H	K	- As the state quantities of pedestal can be considered to be almost independent of those of RPV because of existence of RPV insulator, thermal conduction / temperature change of pedestal floor / wall has little impact on fuel heat up, fuel melting, and relocation. - Thermal conduction or temperature change of concrete floor / wall directly affects MCCI reaction rate when corium exists. An amount of chemical reaction heat and generated non-condensable gas directly affects PCV temperature and pressure.	- Temperature change could be evaluated by heat conduction equation and properties of concrete.
712		Gas flow in pedestal internal space	L	L	L	H	K	- As the state quantities of pedestal can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in pedestal has little impact on fuel heat up, fuel melting, and relocation. - The gas flow between pedestal and drywall affects temperature change in pedestal and drywell. Gas temperature change in pedestal directly leads to change of PCV temperature.	- Gas flow in pedestal internal space could be calculated by using density, temperature, and pressure gradient between pedestal and any other spaces.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
713	Pedestal/Cavity	Local gas flow and turbulence	L	L	L	L	P	- As the state quantities of pedestal can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Local gas flow and turbulence may affect heat transfer rate on inner surface of pedestal wall and upper surface of corium pool. However, it has a smaller impact than global flow induced by pressure difference between pedestal and drywell.	- This could be evaluated by using computational fluid dynamics code. However, as turbulent flow is complicated, there is uncertainty.
714		Water flow on pedestal floor	L	L	L	H	K	- As the state quantities of pedestal can be considered to be almost independent of those of RPV because of existence of RPV insulator, water flow on pedestal floor has little impact on fuel heat up, fuel melting, and relocation. - Water on pedestal wall is important for cooling corium deposited in pedestal because of large heat transfer rate between water and corium. Thus water flow on pedestal wall is also important.	The same as No.712.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
715	Pedestal/Cavity	Ejection conditions (corium, mixture state of water / steam) of corium jet	N/A	N/A	N/A	H	P	- As corium jet does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - An amount of corium jet affects an amount of ablation on pedestal floor if pedestal is dry, or an amount of particulate corium generation if pedestal is wet. Ablation means MCCI, and an amount of particulate corium affects corium coolability described in No.30. In any cases, ejection conditions affect an amount of MCCI. Thus this affects PCV temperature and pressure.	- RPV failure modes were examined in the past test [11]. Examined failure modes are tube heat up, tube ejection, global rupture due to creep, etc. - However, there is uncertainty in the experiment data because there are many influential factors.
716		Oxidation of grating due to collision of corium jet with grating and oxidation	N/A	N/A	N/A	L	U	- As corium jet does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since redox potential of corium materials such as Zr is relatively less than grating material such as Fe, Co, and Ni, an amount of oxidation of grating seems to be negligible.	- There is no experimental data for oxidation of grating due to collision with corium jet.
717		Splash of corium towards pedestal floor by collision of corium with grating	N/A	N/A	N/A	L	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since grating may melt by corium jet, an amount of corium splash seems to be small.	- Corium properties are needed to analyze splash of corium towards pedestal floor by collision of corium with grating by using computational fluid dynamics code. - Corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - However, there is not enough experimental data of corium properties at high temperature.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
718	Pedestal/Cavity	Gas composition change in pedestal	L	L	L	M	K	- As the state quantities of pedestal can be considered to be almost independent of those of RPV because of existence of RPV insulator, gas composition change in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Gas composition change in pedestal affects condensation of steam, which leads to change of PCV pressure.	The same as No.712.
719		Erosion of pedestal floor / wall	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - An amount of erosion of pedestal floor/wall directly corresponds to an amount of MCCI reaction and an amount of chemical reaction and an amount of non-condensable gas. Thus this affects PCV temperature and pressure.	- Erosion of pedestal floor / wall mainly depends on corium coolability. - Corium coolability was examined in MCCI project [2], MACE experiment [3], and FARO experiment [4]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
720		Physical properties of concrete ingredients (C, Si, etc.)	N/A	N/A	N/A	H	P	- As concrete property in the PCV has no effect on RPV, categories from 1st to 3rd are not applicable. - An amount of each concrete ingredient directly affects an amount of chemical reaction and an amount of non-condensable gas generated by MCCI. Thus this affects PCV temperature and pressure.	- Physical properties of concrete are well known at low temperature, however, there is not enough experimental data at high temperature near melting.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
721	Pedestal/Cavity	Mass transfer of concrete ingredients into corium	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - An amount of mass transfer of concrete into corium affects mechanical properties of corium and crust and it affects water ingression possibility into crust. Thus, this phenomenon directly affects corium coolability.	The same as No.719.
722		Water evaporation from concrete by concrete heating	N/A	N/A	N/A	H	P	- As water evaporation from concrete does not occur if corium does not exist in PCV, and corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - An amount of steam generation directly affects PCV pressure. Hydrogen generation due to steam deoxidation by Zr has large impact on PCV pressure.	The same as No.719.
723		Gas generation (H2, CO, CO2, etc.) from concrete-corium interaction (reaction)	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - An amount of non-condensable gas (H2, CO, CO2, etc.) generation directly affects PCV pressure.	- The amount of gas generation due to MCCI mainly depends on corium coolability. - Corium coolability was examined in MCCI project [2], MACE experiment [3], and FARO experiment [4]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
724	Pedestal/Cavity	Aerosol generation from concrete-corium interaction (reaction)	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - An amount of aerosol directly affects PCV pressure and temperature. Aerosol also directly affects an amount of FP released from PCV.	- The behavior of aerosols generation was examined in the 1990s in the ACE phase C and BETA tests and more recently in the OECD-MCCI and EC Framework Programmes (LPP and MP projects) [2,12]. - However, there is not enough experimental data for FP aerosol.
725		Heat generation from chemical reaction between corium and concrete ingredients	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Though heat generation from chemical reaction is commonly less than decay heat of corium, it leads to temperature increase in pedestal. Temperature increase in pedestal directly leads to change of PCV temperature. An amount of chemical reaction affects hydrogen concentration.	- The amount of chemical reaction due to MCCI mainly depends on corium coolability. - Corium coolability was examined in MCCI project [2], MACE experiment [3], and FARO experiment [4]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
726		Corium flow / spread in pedestal	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Coolability of corium is almost proportional to its upper surface area, thus flow and spread area of corium is important for its coolability.	- Ejection condition (No.42) and corium properties such as viscosity are needed to be known in order to evaluate corium flow and spread in pedestal [13]. - Ejection condition was examined in the past test [11] and Corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
727	Pedestal/Cavity	Corium flow into drywell by spread in pedestal (Mark-I)	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Coolability of corium is almost proportional to its upper surface area, thus flow and spread area of corium is important for its coolability	The same as No.726.
728		Corium entrainment in pedestal by sparging gas	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Entrainment corium by sparging gas generated from concrete wall may form particulate corium bed. Formation of particulate corium bed affects corium coolability described in No.30.	- The melt entrainment rate was obtained by the Melt Eruption Test (MET) as a function of the gas sparging rate. Gas sparging rate due to MCCI mainly depends on corium coolability. - Corium coolability was examined in MCCI project [2], MACE experiment [3], and FARO experiment [4]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
729		Generation of corium particle due to breakup at jet drop	N/A	N/A	N/A	H	P	- As corium jet does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Particulate corium forms porous debris bed. An amount and size of corium particle affect corium bed thickness and porosity. As stated in No.30, corium bed width and porosity is important for MCCI.	- The size of corium particles due to jet breakup was tested and evaluated [14]. - However, there is not enough experimental data of jet ejection conditions.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
730	Pedestal/Cavity	Corium ejection from crack in the crust (inclusion generation of corium particle)	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium ejection from crack in the crust enhances corium coolability and delays MCCI progress. It affects PCV pressure and temperature.	The same as No.728.
731		Outflow of corium particle with water flow	N/A	N/A	N/A	L	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since density of corium particle is larger than that of water, outflow of corium particle is limited. It is relatively less important than the other phenomenon.	- Outflow of corium particle with water flow was examined in LOFT test and TMI-2 Vessel Investigation Project [15,16,17]. - Larger density difference between corium particles and water prevents large amount of outflow of corium. - However, there is not enough experimental data toward behavior of outflow of corium particle.
732		Composition of corium particle	N/A	N/A	N/A	M	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Composition of corium particle affects its physical properties such as solidus and liquidus temperatures and then affects corium coolability. It may affect PCV pressure and temperature.	- The corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
733	Pedestal/Cavity	Size / configuration of corium particle	N/A	N/A	N/A	M	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Size / configuration of corium particle affect two-phase condition in debris beds and then affect corium coolability. It may affect PCV pressure and temperature.	- The corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - The effect of size of corium particle on coolability of corium could be evaluated analytically by using such as Lipinski model [18]. - However, there is not enough experimental data toward size / configuration of corium particle.
734		Aggregation / debris bed formation of corium particle	N/A	N/A	N/A	M	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Aggregation / debris bed formation of corium particle affects surface area interacting with water, and affects corium coolability. It may affect PCV pressure and temperature.	- Coolability of corium would be affected by corium thickness. - The effect of size of corium particle on coolability of corium could be evaluated analytically by using such as Lipinski model [18]. - However, there is not enough experimental data toward aggregation / debris bed formation.
735		Generation / attenuation of decay heat from corium particle	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since generation / attenuation of decay heat from corium particle affects its temperature and heat flux to water, it affects PCV pressure and temperature.	- Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [19] . - Decay heat density is affected by composition and weight density of corium particle. - However, there is not enough experimental data toward composition and density of corium particle.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
736	Pedestal/Cavity	Temperature change of corium particle bed	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since temperature change of corium particle bed affects heat flux to water, it affects PCV pressure and temperature.	- Temperature of corium can be evaluated analytically by using such as Lipinski model [18]. - However, there is not enough experimental data toward corium particle bed.
737		Corium solidification	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium solidification affects generation of crust surrounding outside of corium pool and then affects heat flux to water and MCCI progress. It affects PCV pressure and temperature.	- The corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - However, there is uncertainty for corium composition.
738		Generation / attenuation of decay heat from corium	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since generation / attenuation of decay heat from corium affects its temperature, heat flux to water, and MCCI progress, it affects PCV pressure and temperature.	- Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [19]. - Decay heat density is affected by composition and weight density of corium. - However, there is not enough experimental data toward composition and weight density of corium.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
739	Pedestal/Cavity	Oxidation reaction (including generation of hydrogen and reaction heat) between corium ingredients and water (steam)	N/A	N/A	N/A	H	U	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since oxidation reaction between corium ingredients and water (steam) generates hydrogen and chemical heat, it affects PCV pressure and temperature.	- Oxidation reaction between corium ingredients and water was examined in LOFT test and TMI-2 Vessel Investigation Project [15,16,17]. - Oxidation reaction between pure substance in corium and water (steam) could be evaluated by thermodynamic evaluation. - However, there is not enough experimental data toward oxidation behavior.
740		Mixture state (fuel, structure, concrete, etc.) and physical properties of corium ingredients	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Mixture state and physical property of corium ingredients affects crust formation and crust property affecting heat transfer to water and MCCI progress. It affects PCV pressure and temperature.	- The corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - However, there is uncertainty for mixture state, stratification, remixing of corium by corium flow and MCCI gas generation.
741		Corium stratification	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium stratification makes several liquid phases with different property in corium pool. They affect heat transfer to water and MCCI progress. It affects PCV pressure and temperature.	The same as No.740

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
742	Pedestal/Cavity	Remixing of corium stratification associated with corium flow and internal gas generation	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Remixing of corium affects heat transfer from corium pool and MCCI progress. It affects PCV pressure and temperature.	The same as No.740
743		Change in corium deposit conditions on the pedestal floor	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium deposit conditions on the pedestal floor affects surface area interacting with water and then affects corium coolability and MCCI progress. It affects PCV pressure and temperature.	- Corium spreading could be evaluated analytically [21]. - Corium deposition could be evaluated in pedestal flow [13]. - However, there is not enough experimental data toward corium deposit conditions on the pedestal floor.
744		Crust segregation and waftage	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Crust segregation and waftage affects heat transfer to water by water immersion and MCCI progress. It affects PCV pressure and temperature.	- Crust segregation and waftage might be affected by breaking crust. - Enhanced coolability of corium was examined in MCCI project [2] by breaking of crust. - However, there is not enough experimental data toward coolability of corium.
745		Crust generation on the surface of penetration pipes sticking out of RPV lower head	N/A	N/A	N/A	H	U	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Crust generation on the surface of penetration pipes sticking out of RPV lower head affects the amount of fallen corium to the PCV floor. It affects PCV pressure and temperature.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
746	Pedestal/Cavity	Crust remelting due to change in the heat transfer status to corium or water	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Crust remelting due to change in the heat transfer status to corium or water affects heat flux to water and MCCI progress. It affects PCV pressure and temperature.	- The corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - Crust remelting could be evaluated by heat balance between corium and crust. - However, there is not enough experimental data toward the heat transfer status to corium or water.
747		Particulate corium remelting due to change in the heat transfer status	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Particulate corium remelting due to change in the heat transfer status increase the amount of corium pool and affects heat flux to water and MCCI progress. It affects PCV pressure and temperature.	- Particulate corium remelting could be evaluated analytically by using such as Lipinski model [18]. - However, there is not enough experimental data toward the heat transfer status.
748		Water flow into crust	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Water flow into crust through cracks enhances coolability of corium pool and suppresses MCCI progress. It affects PCV pressure and temperature.	- The water flow into crust was examined in MCCI project [2]. - However, there is not enough experimental data for validation because there are many influential factors toward water flow in crust.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
749	Pedestal/Cavity	Bubble formation in crust	N/A	N/A	N/A	M	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Bubble formation in crust may cause water immersion and then enhance coolability of corium pool and suppresses MCCI progress. It may affect PCV pressure and temperature.	- Crust coolability was examined in MCCI project [2]. - Bubble formation in crust might be affected by the amount of gases from MCCI and water immersion. - However, there is not enough experimental data for validation because there are many influential factors toward bubble formation.
750		Crack generation in crust	N/A	N/A	N/A	H	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Crack generation in crust affects water immersion and then enhances coolability of corium pool and suppresses MCCI progress. It affects PCV pressure and temperature.	- Crust coolability was examined in MCCI project [2]. - Crack generation in crust could be affected by the amount of gases from MCCI and water immersion. - However, there is not enough experimental data for validation because there are many influential factors toward crack generation in the crust.
751		Generation / attenuation of decay heat from crust	N/A	N/A	N/A	H	K	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since generation / attenuation of decay heat from crust affects its temperature and heat flux to water, it affects PCV pressure and temperature.	- Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [19]. - Generation / attenuation of decay heat from crust are affected by composition and density of crust. - However, there is not enough experimental data toward composition and density of crust.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
752	Pedestal/Cavity	Oxidation reaction (including generation of hydrogen and reaction heat) between crust ingredients and water (steam)	N/A	N/A	N/A	M	U	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since oxidation reaction between crust ingredients and water (steam) generates hydrogen and heat, it affects PCV pressure and temperature. However, this effect is smaller than No.739 because of smaller reaction area.	- Oxidation reaction between pure substance in crust and water (steam) could be evaluated by thermodynamic evaluation. - However, there is not enough experimental data toward oxidation reaction between crust ingredients and water.
753		Mixture state (fuel, structure, concrete, etc.) and physical properties of crust	N/A	N/A	N/A	H	P	- As crust does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Mixture state and physical property of crust affects crack generation and water immersion and then affects corium coolability and MCCI progress. It affects PCV pressure and temperature	- Crust coolability was examined in MCCI project [2]. - Mixture state and physical properties of crust might affect crust coolability and gas generation. - However, there is not enough experimental data toward mixture state and physical properties of crust.
754		Recriticality	N/A	N/A	N/A	H	P	- As nuclear fuel does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Although re-critical condition is hardly occurs because of low concentration of uranium in the pedestal corium, it would affect PCV pressure and temperature if it were happened.	- Possibility of recriticality of reflood phase in the RPV was evaluated and it was very low [22]. - There is not enough experimental data toward recriticality.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
755	Pedestal/Cavity	Oxidation (including generation of hydrogen and reaction heat) of pedestal wall by steam	L	L	L	M	P	- As steam concentration in PCV is not large until RPV failure, the importance of oxidation of pedestal wall by steam is low in categories from 1st to 3rd. - Generated hydrogen and heat from oxidation reaction between pedestal wall and steam affects temperature and pressure of pedestal.	- Oxidation reaction between pure substance in pedestal wall and steam could be evaluated by thermodynamic evaluation. - However, there is not enough experimental data toward oxidation reaction of pedestal wall.
756		Radiation decomposition of water	L	L	L	L	K	- As an amount of hydrogen generated by radiation decomposition of water is smaller than that by Water-Zr reaction and by MCCI, It is relatively less important than other phenomena.	- The phenomenon is well understood for pure water [23].
757		FCI's premixing due to corium contact to water pool	N/A	N/A	N/A	M	P	- As FCI in the pedestal occurs after 3rd phase, categories from 1st to 3rd are not applicable. - FCI's premixing is one of the key processes for steam explosion. It affects energy transfer rate from heat to mechanical energy.	- There were some experimental data for FCI's premixing using corium [24]. - However, there is not enough experimental data from a real plant scale experiment.
758		FCI triggering by vapor film collapse	N/A	N/A	N/A	H	P	- As FCI in the pedestal occurs after 3rd phase, categories from 1st to 3rd are not applicable. - Since FCI occurs when triggering happens, this phenomenon is important for PCV pressure and temperature.	- Triggering was examined in some experiments [24,25]. - However, there is not enough experimental data from a real plant scale experiment, and there is also no enough experimental data for validation because there are many influential factors.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
759	Pedestal/Cavity	Corium atomization and rapid steam generation (FCI) in water pool	N/A	N/A	N/A	H	P	- As FCI in the pedestal occurs after 3rd phase, categories from 1st to 3rd are not applicable. - Since atomization rapidly increases interface area between corium and water, this phenomenon is important for PCV pressure and temperature.	- Corium atomization and rapid steam generation were examined in some tests [27,28]. - However, there is not enough experimental data from a real plant scale experiment.
760		Pressure wave due to FCI	N/A	N/A	N/A	H	P	- As FCI in the pedestal occurs after 3rd phase, categories from 1st to 3rd are not applicable. - Pressure wave affects to vapor film destabilization and enhances contact area between corium and water. It affects energy transfer rate from heat to mechanical energy.	- There are some experimental data measuring conversion ratio of thermal to mechanical energy [29]. -However, there is not enough experimental data for validation because there are many influential factors toward pressure wave due to FCI.
761		Temperature increase of water and gas by FCI	N/A	N/A	N/A	H	P	- As FCI in the pedestal occurs after 3rd phase, categories from 1st to 3rd are not applicable. - Temperature increases by heat transfer to water and gas from corium. Temperature increase of water and gas causes PCV pressurization.	- There were some experimental data for FCI using corium [24]. - However, there is not enough experimental data from a real plant scale experiment.
762		Pedestal failure due to FCI	N/A	N/A	N/A	H	P	- As FCI in the pedestal occurs after 3rd phase, categories from 1st to 3rd are not applicable. - Pedestal failure may occur with dynamic loading by FCI.	The same as No.88

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
763	Pedestal/Cavity	Dispersion of corium and pedestal internal material due to FCI	N/A	N/A	N/A	H	P	- As FCI in the pedestal occurs after 3rd phase, categories from 1st to 3rd are not applicable. - If corium is dispersed out from water pool, corium may thermally damage on PCV if it's not cooled. If broken pedestal internal material is dispersed, it may mechanically damage on PCV.	- There were some experimental data for FCI using corium [24]. - However, there is not enough experimental data for corium dispersion due to FCI.
764		Impact for FCI by seawater	N/A	N/A	N/A	L	U	- As FCI in the pedestal occurs after 3rd phase, categories from 1st to 3rd are not applicable. - Slight difference between water and sea water characteristics such as density, viscosity, etc. affects little impact on vapor film destabilization, triggering, pressure wave propagation and so on.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident
765		Droplet behavior in the pedestal free space	L	L	L	L	P	- As an amount of water droplet is limited, this phenomenon affects little impact on PCV temperature and pressure on all categories.	- Droplet behavior could be calculated using CFD analysis. - However, there is not enough experimental data for validation.
766		Condensation heat transfer on the pedestal wall and internal surfaces	L	L	L	L	P	- As an amount of heat transfer due to condensation is limited due to relatively lower heat capacity in the pedestal region, it affects little impact on PCV temperature and pressure on all categories.	- Condensation heat transfer on the pedestal wall and internal surfaces with a non-condensable gas was examined [31]. - However, there is not enough experimental data for validation.
767		Interaction between gas and water film flow on the pedestal wall and internal surfaces	L	L	L	L	P	- As an amount of heat transfer due to condensation is limited due to relatively lower heat capacity in the pedestal region, it affects little impact on PCV temperature and pressure on all categories.	- Interaction between gas and water film flow could be evaluated by using Kelvin-Helmholtz instability theory. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
768	Pedestal/Cavity	FP particle transport by gas in the pedestal	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- Direct Containment Heating (DCH) would be affected by the amount of FP particles. - FP particle transport by gas in the pedestal was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.
769		FP particle agglomeration/fragmentation in the pedestal	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- Direct Containment Heating (DCH) would be affected by the amount of FP particles. - FP agglomeration/fragmentation was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.
770		FP particle deposition on the pedestal wall and internal surfaces	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- PCV wall and internal structures heat-up would be affected by the amount of FP particle deposition. - FP particle deposition on the pedestal wall and internal surfaces was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
771	Pedestal/Cavity	FP transport by water flow on the pedestal wall and internal surfaces	L	L	L	L	P	- Relatively lower amount of transportation FP deposited on the surface of the pedestal wall and internal structure does not impact to temperature and pressure so much.	- PCV wall and internal structures heat-up would be affected by FP transport by water flow on the surface of pedestal wall and internal structures. - FP transport by water flow was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - FP in reflooding water was examined in LOFT test and TMI-2 Vessel Investigation Project [15,16,17]. - However, there is not enough experimental data for validation.
772		FP re-entrainment	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- FP re-entrainment was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.
773		FP deposition on the pedestal wall	L	L	L	M	P	- As an amount of FP deposition on the pedestal wall is little before RPV failure, 1st to 3rd categories are ranked “L”. - In case large amount FP deposits on the pedestal wall, FP decay heat may damage to the pedestal wall.	- Pedestal wall heat-up would be affected by the amount of FP particle deposition. - FP deposition was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.
774		FP re-vaporization	L	L	L	M	K	- As an amount of FP in the pedestal is little before RPV failure, 1st to 3rd categories are ranked “L”. - Deposited FP on the pedestal wall, floor, and internal structure can vaporize by its decay heat if it’s not sufficiently cooled. Vaporized FP may increase PCV temperature.	- FP re-vaporization was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
775	Pedestal/Cavity	Decay heat generation from FP	L	L	L	M	K	- As an amount of FP in the pedestal is little before RPV failure, 1st to 3rd categories are ranked “L”. - As decay heat is mainly generated from FP, this phenomenon can impact to PCV pressure and temperature directly.	- Decay heat generation from FP could be evaluated by using decay heat model such as ANS5.1 model [19]. - However, there is not enough experimental data for validation.
776		FP release from corium surface	N/A	N/A	N/A	M	U	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Released FP can impact on temperature and pressure in the PCV.	- There is no experimental data toward FP release from corium surface.
777		FP reaction including iodine chemistry	L	L	L	L	P	- As released energy from FP chemical reaction including iodine chemistry is relatively smaller than its decay heat, all categories are ranked “L”.	- FP reaction was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - Iodine chemistry was examined in ThAI, BIP and BIP2 projects[37-39]. - However, there is not enough experimental data for validation.
778		Adsorption and release of gaseous FP	L	L	L	L	P	- As an amount of adsorption and release of FP gas is little, all categories are ranked “L”.	- Adsorption and release of gaseous FP was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
779	Pedestal/Cavity	Direct Containment Heating (DCH)	N/A	N/A	N/A	H	P	- As corium is dispersed after 3rd phase, categories from 1st to 3rd are not applicable. - Corium can directly heat pedestal /cavity region by thermal conductivity and radiation.	- Direct Containment Heating (DCH) was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [13,41]. - However, there is not enough experimental data for validation.
780		Pedestal water level change	L	L	L	H	P	- As pedestal locates at outside of the RPV, pedestal water hardly affects to RPV inside cooling so much. - Heat flux from corium to water and gas depends on water level in the pedestal.	- Pedestal water level can be evaluated by the amount of injected water, heat transfer at wall surface and so on. - However, there is not enough experimental data for validation.
781		Thermal stratification	L	L	L	L	P	- As thermal stratification of corium occurs after 3rd phase, categories from 1st to 3rd are not applicable. - Thermal stratification of corium may affect to heat flux from corium to water or gas above the corium.	- Thermal stratification was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [13,41]. - However, there is not enough experimental data for validation.
782		Collision of corium with penetration tube support beams and oxidation	N/A	N/A	N/A	M	U	- As this phenomenon occurs after 3rd phase, categories from 1st to 3rd are not applicable. - As collision and oxidation may change corium flow from RPV to pedestal, it affects an amount of jet impingement and spreading behavior of corium on the pedestal.	- There is no experimental data toward collision and oxidation of corium with penetration tube support beams.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
783	Pedestal/Cavity	Collision of corium with CRD purge lines and oxidation	N/A	N/A	N/A	M	U	- As this phenomenon occurs after 3rd phase, categories from 1st to 3rd are not applicable. - As collision and oxidation may change corium flow from RPV to pedestal, it affects an amount of jet impingement and spreading behavior of corium on the pedestal.	- There is no experimental data toward collision and oxidation of corium with CRD purge lines.
784		Collision of corium with other structures in the pedestal and oxidation	N/A	N/A	N/A	M	U	- As this phenomenon occurs after 3rd phase, categories from 1st to 3rd are not applicable. - As collision and oxidation may change corium flow from RPV to pedestal, it affects an amount of jet impingement and spreading behavior of corium on the pedestal.	- There is no experimental data toward collision and oxidation of corium with other structures in the pedestal.
785		Melting point change for penetration pipings sticking out of RPV lower head	N/A	N/A	N/A	M	U	- As this phenomenon occurs after 3rd phase, categories from 1st to 3rd are not applicable. - Melting point change may affect a timing of corium dispersion into the pedestal region.	- There is no experimental data toward melting point change due to eutectic between penetration pipe and corium streaming outside of pipe.
786		Eutectic (Corium and metal in pedestal internals)	N/A	N/A	N/A	H	U	- As corium doesn't exist in the PCV until RPV failure, categories from 1st to 3rd are not applicable. - Eutectic affects corium properties such as solidus and liquidus temperature, viscosity, etc. It affects spreading behavior of corium on the pedestal floor.	- There is no experimental data toward eutectic (Corium and metal in pedestal internals).

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
787	Pedestal/Cavity	Melting of penetration pipes sticking out of RPV lower head	N/A	N/A	N/A	H	P	- As corium doesn't exist in the PCV until RPV failure, categories from 1st to 3rd are not applicable. - Melting of penetration pipes sticking out of RPV lower head affects corium composition and properties. It affects spreading behavior of corium on the pedestal.	- RPV failure mode was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [13,41]. - Melting point of penetration pipe could be calculated [1]. - However, there is not enough experimental data for validation.
788		Melting of gratings	N/A	N/A	N/A	L	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As an amount of grating structure is relatively small, melting of gratings has little impact on corium composition and properties and spreading behavior of corium due to change of properties.	- RPV failure mode was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [13,41]. - Melting point of gratings could be calculated [1]. - However, there is not enough experimental data for validation.
789		Melting of penetration tube support beams	N/A	N/A	N/A	L	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As an amount of penetration tube support beams structure is relatively small, melting of penetration tube support beams has little impact on corium composition and properties and spreading behavior of corium due to change of properties.	- RPV failure mode was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [13,41]. - Melting point of penetration tube support beams could be calculated [1]. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
790	Pedestal/Cavity	Melting of CRD purge lines	N/A	N/A	N/A	L	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As an amount of CRD purge lines structure is relatively small, melting of CRD purge lines has little impact on corium composition and properties and spreading behavior of corium due to change of properties.	- RPV failure mode was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [13,41]. - Melting point of CRD purge lines could be calculated [1]. - However, there is not enough experimental data for validation.
791		Melting of other structures in the pedestal	N/A	N/A	N/A	H	U	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As an amount of other structures in the pedestal is relatively large, melting of other structures in the pedestal affects corium composition and properties and spreading behavior of corium due to change of properties.	- There is no experimental data toward melting of other structures in the pedestal.
792		Seasalt intake to corium	N/A	N/A	N/A	L	U	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As corium surface cools by seawater, generated crust on the surface of corium pool prevent seasalt intake to corium. Thus it has little impact on PCV temperature and pressure.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
793	Pedestal/Cavity	Seasalt impact for corium thermodynamic properties	N/A	N/A	N/A	L	U	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As corium surface cools by seawater, generated crust on the surface of corium pool prevent seasalt intake to corium. Thus it has little impact on corium thermodynamic properties and also PCV temperature and pressure.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
794		Corrosion of pedestal internals by seasalt (including marine lives)	L	L	L	L	U	- As the pedestal is located outside of the PRV, corrosion of the pedestal internals by seasalt hardly affects categories from 1st to 3rd. - As corrosion rate of pedestal internals by seasalt is small, it has little impact on PCV temperature and pressure.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
795		Salt effects on heat transfer	L	L	L	L	U	- As the pedestal is located outside of the PRV, heat transfer characteristics change due to seasalt hardly affects categories from 1st to 3rd. - Deposited seasalt on the pedestal structure may decrease heat transfer to the others. However, as dissolution of seasalt occurs at lower temperatures, it has little impact on an amount of heat transfer to pedestal wall.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
796	Pedestal/Cavity	Salt remelting from flood	L	L	L	L	U	- As the pedestal is located outside of the PRV, seasalt remelting from flood hardly affects categories from 1st to 3rd. - Deposited seasalt may decrease heat transfer from deposited surface to the others. However, as dissolution of seasalt occurs at lower temperatures, it has little impact on an amount of heat transfer to pedestal wall.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
797		Influence on heat transfer by seasalt concentration change	L	L	L	L	P	- As the pedestal is located outside of the PRV, heat transfer characteristics change due to seasalt concentration hardly affects categories from 1st to 3rd. - As the influence on heat transfer by seasalt concentration change in water is relatively small compared to that by water level change in pedestal, it has little impact on PCV temperature and pressure.	- There is no experimental data under seasalt condition.
798		Seasalt impact for FP reaction and composition	L	L	L	L	P	- As the pedestal is located outside of the PRV, chemical reaction between FP and seasalt and FP composition hardly affects categories from 1st to 3rd. - As an amount of heat generation from chemical reaction is small compared to that from decay heat, FP chemical reaction has little impact on PCV temperature and pressure. Change of FP chemical form due to seasalt may change the behavior of FP.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
799	Pedestal/Cavity	Boron corrosion of pedestal internal structure	L	L	L	L	U	- As the pedestal is located outside of the PRV, corrosion of the pedestal internals by boron hardly affects categories from 1st to 3rd. - As corrosion rate of pedestal internals by boron is small, it has little impact on PCV temperature and pressure.	- There is no experimental data toward corrosion of pedestal internal structure by boron.
800		Boron effects on heat transfer	L	L	L	L	U	- As the pedestal is located outside of the PRV, heat transfer characteristics change due to boron hardly affects categories from 1st to 3rd. - Deposited boron on the pedestal structure may decrease heat transfer to the others. However, as dissolution of boron occurs at lower temperatures, it has little impact on an amount of heat transfer to pedestal wall.	- There is no experimental data toward boron effects on heat transfer.
801		Boron remelting from flood	L	L	L	L	P	- As the pedestal is located outside of the PRV, boron remelting from flood hardly affects categories from 1st to 3rd. - Deposited boron may decrease heat transfer from deposited surface to the others. However, as dissolution of boron occurs at lower temperatures, it has little impact on an amount of heat transfer to pedestal wall.	- Remelting and deposition behavior of boron might evaluate from flood. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
802	Pedestal/Cavity	FP aerosol absorption in water pool at upper surface of corium	N/A	N/A	N/A	L	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As FP aerosol can cool by water, FP aerosol absorption in water has little impact on PCV temperature and pressure.	- FP in reflooding water examined in LOFT test and TMI-2 Vessel Investigation Project [15,16,17]. - FP aerosol was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.
803		FP release from water pool at upper surface of corium	N/A	N/A	N/A	M	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - FP release from water pool has impact on PCV temperature and pressure due to direct heating of the PCV wall by FP adhesion or DCH rather than FP aerosol absorption in water pool.	- FP in reflooding water examined in LOFT test and TMI-2 Vessel Investigation Project [15,16,17]. - FP aerosol was examined in PHEBUS2K [32] and PHEBUS/FP test [33-36]. - However, there is not enough experimental data for validation.
804		Corium flow into sump pit (drainage pit) and reaction	N/A	N/A	N/A	H	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since sump pit has relatively large depth and narrow width, it is difficult to cool corium in the sump pit, and an amount of MCCI tends to increase. Non-condensable gases generated from MCCI affect PCV pressure and temperature.	- The corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - The mechanism of corium dropping was examined in FOREVER [44] test. - The mechanism of corium cooling was examined in OECD- MCCI project [2]. - However, there is not enough experimental data for validation in sump pit.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
805	Pedestal/Cavity	Heat transfer between sump floor/wall and corium	N/A	N/A	N/A	H	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between sump floor/wall and corium affects temperature of sump floor/wall and MCCI progression.	- The corium properties were examined in ENTHALPY project, MASCA [6,7]project, COLIMA [8] test and other tests [9,10]. - The heat transfer from corium was examined in OECD-MCCI [2] and VULCANO [45] test. - However, there is not enough experimental data for validation in sump pit.
806		Heat transfer between sump floor/wall and crust	N/A	N/A	N/A	H	P	- As crust doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between sump floor/wall and crust affects temperature of sump floor/wall and MCCI progression.	The same as No.805.
807		Heat transfer between sump floor/wall and corium particle	N/A	N/A	N/A	H	P	- As corium particles don't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between sump floor/wall and corium particles affects temperature of sump floor/wall and MCCI progression.	The same as No.805.
808		Heat transfer between sump cover and corium	N/A	N/A	N/A	L	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As heat capacity of the sump cover is small, heat transfer between sump cover and corium has little impact on PCV pressure and temperature. In addition, it also has little impact on timing of corium dropping into the sump.	The same as No.805.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
809	Pedestal/Cavity	Heat transfer between sump cover and crust	N/A	N/A	N/A	L	P	- As crust doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As heat capacity of the sump cover is small, heat transfer between sump cover and crust has little impact on PCV pressure and temperature. In addition, it also has little impact on timing of corium dropping into the sump.	The same as No.805.
810		Heat transfer between sump cover and corium particle	N/A	N/A	N/A	L	P	- As corium particles don't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - As heat capacity of the sump cover is small, heat transfer between sump cover and corium particles have little impact on PCV pressure and temperature. In addition, it also has little impact on timing of corium dropping into the sump.	The same as No.805.
811		Heat capacity of structure inside sump	N/A	N/A	N/A	M	P	- This item is chosen in consideration with interaction between corium and sump structure. As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat capacity means an amount of internal structure in the sump. An amount of structure affects an amount of corium in the sump after its melting. An amount of corium affects its coolability and MCCI progression.	The same as No.675.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
812	Pedestal/Cavity	Deposition situation of corium on pedestal floor	N/A	N/A	N/A	H	P	- As corium doesn't exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Deposition situation of corium on pedestal floor affects corium coolability and MCCI progress because this situation determines upper surface area of corium for coolability.	-The corium properties were examined in ENTHALPY project, MASCA [6,7] project, COLIMA [8] test and other tests [9,10]. - The mechanism of corium dropping was examined in FOREVER [44] test. - The mechanism of corium cooling was examined in OECD- MCCI project [2]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
813		Corium leak into connecting piping inside sump	N/A	N/A	N/A	H	P	- As corium leak does not occur until RPV failure, categories from 1st to 3rd are not applicable. - Corium leak into connecting piping inside sump may directly means PCV boundary failure, and this phenomenon is important for PCV.	- The mechanism of corium cooling was examined in OECD- MCCI project [2]. - However, there is not enough experimental data for validation in sump.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
814	Drywell	Attack on containment vessel shell (interaction between metal and corium)	N/A	N/A	N/A	H	U	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. -"Attack on containment vessel shell" affects PCV integrity, it has great a great impact on amount of released radioactive material.	- The behavior of spread of corium at pedestal and drywell might be evaluated by present knowledge. - However, there is not enough experimental data for validation. - The interaction between metal and corium is not enough experimental data for validation.
815		Containment vessel penetration seal degradation (Seal degradation at containment vessel penetration)	L	L	L	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Containment vessel penetration seal degradation" has a little impact on fuel heat up, fuel melting, and relocation -"Containment vessel penetration seal degradation" affects PCV integrity, it has great a great impact on amount of released radioactive material.	-The degradation of seal might be evaluated by temperature of drywell. -Some experimental data show that electrical penetration is not leak up to 265deg C at 1MPa.[1] -However, drywell temperature is affected by various factors. It is difficult to evaluate the drywell temperature.
816		Water leak from deteriorated part of containment vessel penetration	L	L	L	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Water leak from deteriorated part of containment vessel penetration" has a little impact on fuel heat up, fuel melting, and relocation -"Water leak from deteriorated part of containment vessel penetration" has great impact on amount of released radioactive material.	Water leak flow rate from drywell can be calculated analytically. However, limiting pressure and temperature of PCV failure has uncertain.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
817	Drywell	Gas leak from deteriorated part of containment vessel penetration	L	L	L	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Gas leak from deteriorated part of containment vessel penetration” has a little impact on fuel heat up, fuel melting, and relocation -“Gas leak from deteriorated part of containment vessel penetration” has great a great impact on amount of released radioactive material.	-Gas leak flow rate from drywell can be calculated analytically. However, limiting pressure and temperature of PCV failure has uncertain.
818		Deformation / failure of drywell internal equipment due to thermal stress	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Deformation / failure of drywell internal equipment due to thermal stress” has a little impact on fuel heat up, fuel melting, and relocation. - “Deformation/failure of drywell internal equipment due to thermal stress” has a little impact on PCV pressure and temperature.	- Thermal stress on drywell internal equipment could be evaluated if heat source distribution is well known. - Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [2]. - However, there is uncertainty for heat source distribution, it is difficult to evaluate this phenomena.
819		Deformation / failure of drywell wall by thermal stress	L	L	L	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Deformation / failure of drywell wall by thermal stress” has a little impact on fuel heat up, fuel melting, and relocation. -“Deformation / failure of drywell wall by thermal stress” affects PCV integrity, it has great a great impact on amount of released radioactive material.	- Thermal stress on deformation / failure of drywell wall by thermal stress equipment could be evaluated if heat source distribution is well known. - Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [2]. - However, there is uncertainty for heat source distribution, it is difficult to evaluate this phenomena.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
820	Drywell	Heat transfer between corium and water (including CHF)	N/A	N/A	N/A	H	P	-"Heat transfer between corium and water", categories from 1st to 3rd are not applicable. -"Heat transfer between corium and water "affects corium coolability, steam generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	- Heat transfer between corium and water (including CHF) was examined in MCCI project [3], MACE experiment [4], and FARO experiment [5]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
821		Heat transfer between corium and gas	N/A	N/A	N/A	H	P	-"Heat transfer between corium and gas", categories from 1st to 3rd are not applicable. -"Heat transfer between corium and gas" affects corium coolability, and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.
822		Heat transfer between crust and water (including CHF)	N/A	N/A	N/A	H	P	-"Heat transfer between corium and water", categories from 1st to 3rd are not applicable. -"Heat transfer between corium and water" affects corium coolability, steam generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.
823		Heat transfer between crust and gas	N/A	N/A	N/A	H	P	-"Heat transfer between crust and gas", categories from 1st to 3rd are not applicable. -"Heat transfer between crust and gas" affects corium coolability, and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
824	Drywell	Heat transfer between crust and corium	N/A	N/A	N/A	H	P	-"Heat transfer between crust and corium", categories from 1st to 3rd are not applicable. -"Heat transfer between crust and corium" affects corium coolability, steam generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.
825		Heat transfer between corium particle and water	N/A	N/A	N/A	H	P	-"Heat transfer between corium particle and water", categories from 1st to 3rd are not applicable. -"Heat transfer between corium particle and water" affects corium coolability, steam generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.
826		Heat transfer between corium particle and gas	N/A	N/A	N/A	H	P	-"Heat transfer between corium particle and gas", categories from 1st to 3rd are not applicable. -"Heat transfer between corium particle and gas" affects corium coolability, steam generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
827	Drywell	Heat transfer between corium particle and drywell floor/wall	N/A	N/A	N/A	H	P	-"Heat transfer between corium particle and drywell floor/wall", categories from 1st to 3rd are not applicable. -"Heat transfer between corium particle and drywell floor/wall" affects corium coolability, non-condensate gas generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.
828		Heat transfer between drywell floor/wall and corium	N/A	N/A	N/A	H	P	-"Heat transfer between drywell floor/wall and corium", categories from 1st to 3rd are not applicable. -"Heat transfer between drywell floor/wall and corium" affects corium coolability, non-condensate gas generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.
829		Heat transfer between drywell floor/wall and crust	N/A	N/A	N/A	H	P	-"Heat transfer between drywell floor/wall and crust", categories from 1st to 3rd are not applicable. -"Heat transfer between drywell floor/wall and crust" affects corium coolability, non-condensate gas generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 820.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
830	Drywell	Heat transfer between drywell floor/wall and water	L	L	L	H	P	-"Heat transfer between drywell floor/wall and crust", categories from 1st to 3rd are not applicable. -"Heat transfer between drywell floor/wall and crust" affects non-condensate gas generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	- Heat transfer between floor/wall and water can be evaluated if water flow pattern is well known. However, water flow in the pedestal is complicated and it is difficult to evaluate an amount of heat transfer.
831		Heat transfer between drywell floor/wall and gas	L	L	L	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Heat transfer between drywell floor/wall and gas" has a little impact on fuel heat up, fuel melting, and relocation. - "Heat transfer between drywell floor/wall and gas" may affect failure of D/W wall, which has a significant impact on PCV pressure.	- Heat transfer between floor/wall and gas can be evaluated if gas flow pattern is well known. - However, gas flow in the drywell is complicated and it is difficult to evaluate an amount of heat transfer.
832		Heat transfer from drywell internal structure (lagging material, biological shield wall) to water	L	L	L	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Heat transfer from drywell internal structure to water" has a little impact on fuel heat up, fuel melting, and relocation. - "Heat transfer from drywell internal structure to water" may affect PCV integrity.	- Heat transfer between floor/wall and gas can be evaluated if gas flow pattern is well known. - However, gas flow in the drywell is complicated and it is difficult to evaluate an amount of heat transfer.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
833	Drywell	Heat transfer from drywell internal structure (lagging material, biological shield wall) to gas	L	L	L	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Heat transfer from drywell internal structure to gas” has a little impact on fuel heat up, fuel melting, and relocation. - “Heat transfer from drywell internal structure to gas” may affect PCV integrity.	- Heat transfer between drywell internal structure and gas can be evaluated if gas flow pattern is well known. - However, gas flow in the drywell is complicated and it is difficult to evaluate an amount of heat transfer.
834		Radiation between corium and drywell wall	N/A	N/A	N/A	M	K	-“Radiation between corium and drywell wall”, categories from 1st to 3rd are not applicable. - “Radiation between corium and drywell wall” may affect failure of D/W wall, which has a significant impact on PCV pressure.	- Radiation heat transfer between two surfaces could be theoretically evaluated by the temperatures, radiation factor, and radiation configuration factor.
835		Radiation between corium and drywell internal structure	N/A	N/A	N/A	M	K	-“Radiation between corium and drywell internal structure”, categories from 1st to 3rd are not applicable. - “Radiation between corium and drywell internal structure” may affect PCV temperature.	The same as No. 834.
836		Radiation between crust and drywell wall	N/A	N/A	N/A	M	K	-“Radiation between crust and drywell wall”, categories from 1st to 3rd are not applicable. - “Radiation between crust and drywell wall may affect drywell temperature.	The same as No. 834.
837		Radiation between crust and drywell internal structure	N/A	N/A	N/A	M	K	-“Radiation between crust and drywell internal structure”, categories from 1st to 3rd are not applicable. - “Radiation between crust and drywell internal structure” may affect temperature of internal structure.	The same as No. 834

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
838	Drywell	Radiation between corium particle and drywell wall	N/A	N/A	N/A	M	K	-“Radiation between corium particle and drywell wall”, categories from 1st to 3rd are not applicable. - “Radiation between corium particle and drywell wall” may affect drywell wall temperature.	The same as No. 834
839		Radiation between corium particle and drywell internal structure	N/A	N/A	N/A	M	K	-“Radiation between corium particle and drywell internal structure”, categories from 1st to 3rd are not applicable. - “Radiation between corium particle and drywell internal structure” may affect temperature of internal structure..	The same as No. 834
840		Particulate Corium Bed Porosity	N/A	N/A	N/A	M	P	-“Particulate Corium Bed Porosity”, categories from 1st to 3rd is not applicable. - “Particulate Corium Bed Porosity” may affect coolability of corium and gas sparging from corium.	- Corium bed porosity could be evaluated by the size of corium particles. - However, there are not enough data for the size of corium particles which are generated by entrainment with sparging gas or jet breakup.
841		Gas stratification in drywell	L	L	L	H	K	-“Gas stratification in drywell”, categories from 1st to 3rd are not applicable. -“Gas stratification in drywell” affects PCV pressure and temperature, it has great impact on PCV integrity and amount of released radioactive material.	- Temperature stratification can be calculated from some correlations. - Stratification of gas composition can be calculated from some correlations.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
842	Drywell	Jet/plume gas interaction and entrainment effects	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Jet/plume gas interaction and entrainment effects” has a little impact on fuel heat up, fuel melting, and relocation. - “Jet/plume gas interaction and entrainment effects” has a little impact on PCV pressure and temperature.	- The entrainment rate can predict to use correlation equation. -However, “Jet/plume gas interaction and entrainment effects” is affected by various factors. Jet/plume is difficult to evaluate.
843		Pressure change in drywell	L	L	L	H	K	- As the state quantities of D/W can be considered to be independent of those of RPV, “Pressure change in drywell” has a little impact on fuel heat up, fuel melting, and relocation. -“Pressure change in drywell” has great impact on PCV integrity and amount of released radioactive material.	- Pressure, gas temperature, and water temperature changes in drywell could be evaluated by thermodynamic calculation.
844		Gas temperature change in drywell	L	L	L	H	K	- As the state quantities of D/W can be considered to be independent of those of RPV, “Pressure change in drywell” has a little impact on fuel heat up, fuel melting, and relocation. -“Pressure change in drywell” has great impact on PCV integrity and amount of released radioactive material.	The same as No.843.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
845	Drywell	Gas composition change in drywell	L	L	L	M	K	- As the state quantities of D/W can be considered to be independent of those of RPV, "Gas composition change in drywell" has a little impact on fuel heat up, fuel melting, and relocation. -"Gas composition change in drywell" may affect PCV integrity.	- Gas flow in drywell internal space could be calculated by using density, temperature, and pressure gradient between drywell and any other spaces.
846		Thermal conduction / temperature change of corium	N/A	N/A	N/A	M	P	-"Thermal conduction / temperature change of corium", categories from 1st to 3rd are not applicable. - "Thermal conduction / temperature change of corium" may affect PCV temperature.	- Thermal conduction and temperature would be affected by crust composition and porosity. - However, crust composition is not uniform and crust porosity is not well known. There is not enough experimental data.
847		Thermal conduction / temperature change of crust	N/A	N/A	N/A	M	P	-"Thermal conduction / temperature change of crust", categories from 1st to 3rd are not applicable. - "Thermal conduction / temperature change of crust" may affect PCV temperature.	The same as No. 820.
848		Thermal conduction / temperature change of drywell floor/wall	L	L	L	M	K	-"Thermal conduction / temperature change of drywell floor/wall", categories from 1st to 3rd are not applicable. - "Thermal conduction / temperature change of drywell floor/wall" may affect PCV temperature.	- Temperature change could be evaluated by heat conduction equation and properties of concrete.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
849	Drywell	Thermal conduction / temperature change of drywell internal structure	L	L	L	M	K	-"Thermal conduction / temperature change of drywell internal structure", categories from 1st to 3rd are not applicable. - "Thermal conduction / temperature change of drywell internal structure" may affect PCV temperature.	The same as No. 848.
850		Water temperature change in drywell	L	L	L	M	K	-"Water temperature change in drywell", categories from 1st to 3rd are not applicable. - "Water temperature change in drywell" may affect PCV temperature.	The same as No.843.
851		Gas flow in drywell	L	L	L	H	K	- As the state quantities of D/W can be considered to be independent of those of RPV, "Gas flow in drywell" has a little impact on fuel heat up, fuel melting, and relocation. -"Gas flow in drywell" has great impact on PCV integrity and amount of released radioactive material.	- Gas flow in drywell internal space could be calculated by using density, temperature, and pressure gradient between pedestal and any other spaces.
852		Local gas flow and turbulence	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Local gas flow and turbulence" has a little impact on fuel heat up, fuel melting, and relocation. - "Local gas flow and turbulence" has a little impact on PCV pressure and temperature.	- This could be evaluated by using computational fluid dynamics code. However, as turbulent flow is complicated, there is uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
853	Drywell	Water flow in drywell	L	L	L	H	K	- As the state quantities of D/W can be considered to be independent of those of RPV, “Water flow in drywell” has a little impact on fuel heat up, fuel melting, and relocation. -“Water flow in drywell” has great impact on PCV integrity and amount of released radioactive material.	- Water flow from P/D to D/W can be calculated based on the differential pressure between P/D and D/W.
854		Drywell water level change	L	L	L	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Drywell water level change” has a little impact on fuel heat up, fuel melting, and relocation. -“Drywell water level change” affects debris coolability and PCV pressure, it has great impact on PCV integrity and amount of released radioactive material.	- Water level change can be calculated by water mass, water density and lookup table of volume-level.
855		Thermal stratification	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Thermal stratification” has a little impact on fuel heat up, fuel melting, and relocation. - “Thermal stratification” has a little impact on PCV pressure and temperature.	- Thermal stratification was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [6,7]. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
856	Drywell	Erosion of drywell floor (concrete)	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Erosion of drywell floor (concrete)" has a no impact on fuel heat up, fuel melting, and relocation. -"Erosion of drywell floor (concrete)" affects non-condensate gas generation rate and base mat penetration rate, it has great impact on PCV integrity and amount of released radioactive material.	- Erosion of drywell floor / wall mainly depends on corium coolability. - Corium coolability was examined in MCCI project [3], MACE experiment [4], and FARO experiment [5].
857		Physical properties of concrete ingredients (C, Si, etc.)	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Physical properties of concrete ingredients" has a no impact on fuel heat up, fuel melting, and relocation. -"Physical properties of concrete ingredients" affects corium coolability, non-condensate gas generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	- Physical properties of concrete are well known at low temperature, however, there is not enough experimental data at high temperature near melting.
858		Transition of concrete ingredients into corium	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Transition of concrete ingredients into corium" has a no impact on fuel heat up, fuel melting, and relocation. -"Transition of concrete ingredients into corium" affects corium coolability, non-condensate gas generation rate and base mat penetration, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 856.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
859	Drywell	Water evaporation from concrete by concrete heating	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Water evaporation from concrete by concrete heating" has a no impact on fuel heat up, fuel melting, and relocation. -"Water evaporation from concrete by concrete heating" affects corium coolability and non-condensate gas generation rate, it has great impact on PCV integrity and amount of released radioactive material.	The same as No. 856.
860		Gas generation (H2, CO, CO2, etc.) from concrete-corium interaction (reaction)	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Gas generation (H2, CO, CO2, etc.) from concrete-corium interaction" has a no impact on fuel heat up, fuel melting, and relocation. -"Gas generation (H2, CO, CO2, etc.) from concrete-corium interaction" affects corium coolability and pressure change of PCV, it has great impact on PCV integrity and amount of released radioactive material.	- The amount of gas generation due to MCCI mainly depends on corium coolability. - Corium coolability was examined in MCCI project [3], MACE experiment [4], and FARO experiment [5].

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
861	Drywell	Aerosol generation from concrete-corium interaction (reaction)	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Aerosol generation from concrete-corium interaction" has a no impact on fuel heat up, fuel melting, and relocation. -"Aerosol generation from concrete-corium interaction" affects temperature and pressure change of PCV, it has great impact on PCV integrity and amount of released radioactive material.	- The behavior of aerosols generation was examined in the 1990s in the ACE phase C and BETA tests and more recently in the OECD-MCCI and EC Framework Programmes (LPP and MP projects) [3,8]. - However, there is not enough experimental data for FP aerosol.
862		Heat generation from chemical reaction between corium and concrete ingredients	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Heat generation from chemical reaction between corium and concrete ingredients" has a no impact on fuel heat up, fuel melting, and relocation. -"Heat generation from chemical reaction between corium and concrete ingredients" affects debris coolability and non-condensate gas generation rate, it has great impact on PCV integrity and amount of released radioactive material.	- The amount of chemical reaction due to MCCI mainly depends on corium coolability. - Corium coolability was examined in MCCI project [3], MACE experiment [4], and FARO experiment [5]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
863	Drywell	Reaction (including generation of hydrogen and reaction heat) between corium ingredients and water (steam)	N/A	N/A	N/A	H	U	- As the state quantities of D/W can be considered to be independent of those of RPV, "Reaction (including generation of hydrogen and reaction heat) between corium ingredients and water (steam)" has a no impact on fuel heat up, fuel melting, and relocation. -"Reaction (including generation of hydrogen and reaction heat) between corium ingredients and water (steam)" affects debris coolability and non-condensate gas generation rate, it has great impact on PCV integrity and amount of released radioactive material.	Oxidation reaction between corium ingredients and water was examined in LOFT test and TMI-2 Vessel Investigation Project [15-17]. - Oxidation reaction between pure substance in corium and water (steam) could be evaluated by thermodynamic evaluation. - However, there is not enough experimental data toward oxidation behavior.
864		Corium flow / spread in drywell	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Corium flow/spread in drywell" has a no impact on fuel heat up, fuel melting, and relocation. -"Corium flow/spread in drywell" affects debris coolability, non-condensate gas generation rate and attack D/W vessel shell, it has great impact on PCV integrity and amount of released radioactive material.	- Ejection condition (No.42) and corium properties such as viscosity are needed to be known in order to evaluate corium flow and spread in pedestal [6]. - Ejection condition was examined in the past test [14] and Corium properties were examined in ENTHALPY project, MASCA [9,10] project, COLIMA [11] test and other tests [12,13]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
865	Drywell	Outflow of corium particle with water flow	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Outflow of corium particle with water flow" has a no impact on fuel heat up, fuel melting, and relocation. -"Outflow of corium particle with water flow" affects water temperature of S/P, it has great impact on PCV pressure and temperature.	Outflow of corium particle with water flow was examined in LOFT test and TMI-2 Vessel Investigation Project [15-17]. - Larger density difference between corium particles and water prevents large amount of outflow of corium. - However, there is not enough experimental data toward behavior of outflow of corium particle.
866		Composition of corium particle	N/A	N/A	N/A	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Composition of corium particle" has a no impact on fuel heat up, fuel melting, and relocation. - "Composition of corium particle" may affect corium coolability and non-condensate gas generation rate.	- The corium properties were examined in ENTHALPY project, MASCA [9,10] project, COLIMA [11] test and other tests [12,13]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data. toward composition
867		Size / configuration of corium particle	N/A	N/A	N/A	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Size / configuration of corium particle" has a no impact on fuel heat up, fuel melting, and relocation. - As the size of corium particle does not affect the corium coolability, "Size / configuration of corium particle" has a little impact on PCV integrity.	- The corium properties were examined in ENTHALPY project, MASCA [9,10] project, COLIMA [11] test and other tests [12,13]. - The effect of size of corium particle on coolability of corium could be evaluated analytically by using such as Lipinski model [18]. - However, there is not enough experimental data toward size / configuration of corium particle.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
868	Drywell	Aggregation / debris bed formation of corium particle	N/A	N/A	N/A	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Aggregation / debris bed formation of corium particle" has a no impact on fuel heat up, fuel melting, and relocation. - As the aggregation of corium particle does not affect the corium coolability, "Aggregation / debris bed formation of corium particle" has a little impact on PCV integrity.	- Coolability of corium would be affected by corium thickness. - The effect of size of corium particle on coolability of corium could be evaluated analytically by using such as Lipinski model [18]. - However, there is not enough experimental data toward aggregation / debris bed formation.
869		Generation / attenuation of decay heat from corium particle	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Generation / attenuation of decay heat from corium particle" has a no impact on fuel heat up, fuel melting, and relocation. -"Generation/attenuation of decay heat from corium particle" affects debris coolability, it has great impact on PCV integrity and amount of released radioactive material.	- Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [2] . - Decay heat density is affected by composition and weight density of corium particle. - However, there is not enough experimental data toward composition and density of corium particle.
870		Temperature change of corium particle bed	N/A	N/A	N/A	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Temperature change of corium particle bed" has a no impact on fuel heat up, fuel melting, and relocation. - "Temperature change of corium particle bed" may affect corium coolability, non-condensate gas generation rate and base mat penetration.	- Temperature of corium can be evaluated analytically by using such as Lipinski model [18]. - However, there is not enough experimental data toward corium particle bed.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
871	Drywell	Corium solidification	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Corium solidification" has a no impact on fuel heat up, fuel melting, and relocation. -"Corium solidification" affects corium coolability, it has great impact on PCV integrity and amount of released radioactive material.	- The corium properties were examined in ENTHALPY project, MASCA [9,10] project, COLIMA [11] test and other tests [12,13]. - However, there is uncertainty for corium composition.
872		Generation / attenuation of decay heat from corium	N/A	N/A	N/A	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Generation / attenuation of decay heat from corium" has a no impact on fuel heat up, fuel melting, and relocation. - "Generation / attenuation of decay heat from corium" may affect corium coolability.	- Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [2]. - Decay heat density is affected by composition and weight density of corium. - However, there is not enough experimental data toward composition and weight density of corium.
873		Mixture state (fuel, structure, concrete, etc.) and physical properties of corium ingredients	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Mixture state (fuel, structure, concrete, etc.) and physical properties of corium ingredients" has a no impact on fuel heat up, fuel melting, and relocation. -"Mixture state (fuel, structure, concrete, etc.) and physical properties of corium ingredients" affects corium coolability, it has great impact on PCV integrity and amount of released radioactive material.	- The corium properties were examined in ENTHALPY project, MASCA [9,10] project, COLIMA [11] test and other tests [12,13]. - However, there is uncertainty for mixture state, stratification, remixing of corium by corium flow and MCCI gas generation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
874	Drywell	Corium stratification	N/A	N/A	N/A	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Corium stratification” has a no impact on fuel heat up, fuel melting, and relocation. - “Corium stratification” may affect corium coolability.	The same as No.873
875		Direct Containment Heating (DCH)	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Direct Containment Heating (DCH)” has a no impact on fuel heat up, fuel melting, and relocation. -“Direct Containment Heating (DCH)” affects temperature of D/W wall, it has great impact on PCV integrity and amount of released radioactive material.	- Thermal stratification was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [6,7]. - However, there is not enough experimental data for validation to apply BWR.
876		Water flow into crust	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Water flow into crust” has a no impact on fuel heat up, fuel melting, and relocation. -“Water flow into crust” affects corium coolability, it has great impact on PCV integrity and amount of released radioactive material.	- The water flow into crust was examined in MCCI project [3]. - However, there is not enough experimental data for validation because there are many influential factors toward water flow in crust.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
877	Drywell	Bubble formation in crust	N/A	N/A	N/A	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Bubble formation in crust" has a no impact on fuel heat up, fuel melting, and relocation. - "Bubble formation in crust" may affect corium coolability.	- Crust coolability was examined in MCCI project [3]. - Bubble formation in crust might be affected by the amount of gases from MCCI and water immersion. - However, there is not enough experimental data for validation because there are many influential factors toward bubble formation.
878		Crack formation in crust	N/A	N/A	N/A	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Crack formation in crust" has a no impact on fuel heat up, fuel melting, and relocation. - "Crack formation in crust" affects corium coolability, it has great impact on PCV integrity.	- Crust coolability was examined in MCCI project [3]. - Crack generation in crust could be affected by the amount of gases from MCCI and water immersion. - However, there is not enough experimental data for validation because there are many influential factors toward crack generation in the crust.
879		Crust composition	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Crust composition" has a no impact on fuel heat up, fuel melting, and relocation. - "Crust composition" affects corium coolability.	The same as No.862

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
880	Drywell	Generation / attenuation of decay heat from crust	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Generation / attenuation of decay heat from crust" has a no impact on fuel heat up, fuel melting, and relocation. - "Generation / attenuation of decay heat from crust" affects corium coolability.	- Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [2]. - Generation / attenuation of decay heat from crust are affected by composition and density of crust. - However, there is not enough experimental data toward composition and density of crust.
881		Crust remelting due to change in the heat transfer status to corium or water	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Crust remelting due to change in the heat transfer status to corium or water" has a no impact on fuel heat up, fuel melting, and relocation. - "Crust remelting due to change in the heat transfer status to corium or water" affects corium coolability.	- The corium properties were examined in ENTHALPY project, MASCA [9,10] project, COLIMA [11] test and other tests [12,13]. - Crust remelting could be evaluated by heat balance between corium and crust. - However, there is not enough experimental data toward the heat transfer status to corium or water.
882		Particulate corium remelting due to change in the heat transfer status	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Particulate corium remelting due to change in the heat transfer status" has a no impact on fuel heat up, fuel melting, and relocation. - "Particulate corium remelting due to change in the heat transfer status" affects corium coolability, non-condensate gas generation rate and base mat penetration.	- Particulate corium remelting could be evaluated analytically by using such as Lipinski model [18]. - However, there is not enough experimental data toward the heat transfer status.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
883	Drywell	Oxidation reaction (including generation of hydrogen and reaction heat) between crust ingredients and water (steam)	N/A	N/A	N/A	M	U	- As the state quantities of D/W can be considered to be independent of those of RPV, "Oxidation reaction (including generation of hydrogen and reaction heat) between crust" has a no impact on fuel heat up, fuel melting, and relocation. - "Oxidation reaction (including generation of hydrogen and reaction heat) between crust" may affect corium coolability.	- Oxidation reaction between pure substance in crust and water (steam) could be evaluated by thermodynamic evaluation. - However, there is not enough experimental data toward oxidation reaction between crust ingredients and water.
884		Mixture state (fuel, structure, concrete, etc.) and physical properties of crust	N/A	N/A	N/A	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Mixture state (fuel, structure, concrete, etc.) and physical properties of crust" has a no impact on fuel heat up, fuel melting, and relocation. - "Mixture state (fuel, structure, concrete, etc.) and physical properties of crust" may affect corium coolability.	- Crust coolability was examined in MCCI project [3]. - Mixture state and physical properties of crust might affect crust coolability and gas generation. - However, there is not enough experimental data toward mixture state and physical properties of crust.
885		Recriticality	N/A	N/A	N/A	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Recriticality" has a no impact on fuel heat up, fuel melting, and relocation. - "Recriticality" affects PCV pressure and temperature.	- Possibility of recriticality of reflood phase in the RPV was evaluated and it was very low [19]. - There is not enough experimental data toward recriticality.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
886	Drywell	Oxidation (including generation of hydrogen and reaction heat) of drywell wall by steam	L	L	L	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Oxidation (including generation of hydrogen and reaction heat) of drywell wall by steam" has a little impact on fuel heat up, fuel melting, and relocation. - "Oxidation (including generation of hydrogen and reaction heat) of drywell wall by steam" may affect PCV integrity.	- Oxidation reaction between pure substance in drywell wall and steam could be evaluated by thermodynamic evaluation.
887		Oxidation (including generation of hydrogen and reaction heat) of drywell internal structure by steam	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Oxidation (including generation of hydrogen and reaction heat) of drywell internal structure by steam" has a little impact on fuel heat up, fuel melting, and relocation. -Influence of "Oxidation (including generation of hydrogen and reaction heat) of drywell wall by steam" on D/W pressure and temperature is smaller than above item.	- Oxidation reaction between pure substance in drywell internal structure and steam could be evaluated by thermodynamic evaluation.
888		Radiation decomposition of water	L	L	L	L	K	- As the state quantities of D/W can be considered to be independent of those of RPV, "Radiation decomposition of water" has a little impact on fuel heat up, fuel melting, and relocation. -Hydrogen generation rate by radiation decomposition of water is smaller than metal-water interaction and MCCI.	- The phenomenon is well understood for pure water [20].

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
889	Drywell	FP aerosolization	L	L	L	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "FP aerosolization" has a little impact on fuel heat up, fuel melting, and relocation. - "FP aerosolization" may affect PCV pressure and temperature by its decay heat.	- FP aerosol was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25]. - However, there is not enough experimental data for validation.
890		FP deposition on drywell wall	L	L	L	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "FP deposition on drywell wall" has a little impact on fuel heat up, fuel melting, and relocation. - FP deposition on drywell wall" may affect PCV pressure and temperature by its decay heat.	- Pedestal wall heat-up would be affected by the amount of FP particle deposition. - FP deposition was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25]. - However, there is not enough experimental data in pedestal for validation.
891		FP re-vaporization	L	L	L	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "FP re-vaporization" has a little impact on fuel heat up, fuel melting, and relocation. - "FP re-vaporization" may affect PCV pressure and temperature by its decay heat.	- FP deposition was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25]. - There is enough data toward temperature of FP re-vaporization.
892		Decay heat generation from FP	L	L	L	M	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Decay heat generation from FP" has a little impact on fuel heat up, fuel melting, and relocation. - Decay heat generation from FP" affects PCV pressure and temperature by its decay heat.	- Decay heat generation from FP could be evaluated by using decay heat model such as ANS5.1 model [2]. - There is enough data toward decay heat generation from FP.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
893	Drywell	FP removal from drywell internal space by spray	N/A	N/A	N/A	M	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “FP removal from drywell internal space by spray” has a little impact on fuel heat up, fuel melting, and relocation. - FP removal from drywell internal space by spray” may affect PCV pressure and temperature.	- FP removal from drywell internal space by spray might be evaluated by present knowledge.[29,30] - However, there is not enough experimental data toward FP removal by spray.
894		FP particle transport by gas in the drywell	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “FP particle transport by gas in the drywell” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “FP particle transport by gas in the drywell” on D/W pressure and temperature is little.	- Direct Containment Heating (DCH) would be affected by the amount of FP particles. - FP deposition was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25]. - However, there is not enough experimental data in pedestal for validation.
895		FP particle agglomeration/fragmentation in the drywell	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “FP particle agglomeration/fragmentation in the drywell” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “FP particle agglomeration/fragmentation in the drywell” on D/W pressure and temperature is little.	- Direct Containment Heating (DCH) would be affected by the amount of FP particles. - FP deposition was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25]. - However, there is not enough experimental data in pedestal for validation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
896	Drywell	FP particle deposition on the drywell wall and internal surfaces	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “FP particle deposition on the drywell wall and internal surfaces” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “FP particle deposition on the drywell wall and internal surfaces” on D/W pressure and temperature is little.	- PCV wall and internal structures heat-up would be affected by the amount of FP particle deposition. - FP particle deposition on the pedestal wall and internal surfaces was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25]. - However, there is not enough experimental data in pedestal for validation.
897		FP transport by water flow on the drywell wall and internal surfaces	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “FP transport by water flow on the drywell wall and internal surfaces” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “FP transport by water flow on the drywell wall and internal surfaces” on D/W pressure and temperature is little.	- PCV wall and internal structures heat-up would be affected by FP transport by water flow on the surface of pedestal wall and internal structures. - FP transport by water flow was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25]. - FP in reflooding water was examined in LOFT test and TMI-2 Vessel Investigation Project [15-17]. - However, there is not enough experimental data in pedestal for validation.
898		FP re-entrainment	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “FP re-entrainment” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “FP re-entrainment” on D/W pressure and temperature is little.	- FP re-entrainment was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25]. FP in reflooding water was examined in LOFT test and TMI-2 Vessel Investigation Project [15-17].

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
899	Drywell	FP release from corium surface	N/A	N/A	N/A	M	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “FP release from corium surface” has a little impact on fuel heat up, fuel melting, and relocation. - “FP release from corium surface” may affect PCV pressure and temperature.	- There is no experimental data toward FP release from corium surface.
900		FP reaction including iodine chemistry	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “FP reaction including iodine chemistry” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “FP reaction including iodine chemistry” on D/W pressure and temperature is little.	- FP reaction was examined in PHEBUS2K [22] and PHEBUS/FP test [23-26]. - Iodine chemistry was examined in ThAI, BIP and BIP2 projects[32-34]. - However, there is not enough experimental data for validation.
901		Adsorption and release of gaseous FP	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Adsorption and release of gaseous FP” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Adsorption and release of gaseous FP” on D/W pressure and temperature is little.	- Adsorption and release of gaseous FP was examined in PHEBUS2K [21] and PHEBUS/FP test [22-25].. - However, there is not enough experimental data for validation.
902		Eutectic (Corium and metal in pedestal internals)	N/A	N/A	N/A	H	U	- As corium doesn’t exist in the PCV until RPV failure, categories from 1st to 3rd are not applicable. - Eutectic affects corium properties such as solidus and liquidus temperature, viscosity, etc. It affects spreading behavior of corium on the pedestal floor.	- There is no experimental data toward eutectic (Corium and metal in pedestal internals).

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
903	Drywell	Droplet behavior in the drywell free space	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Droplet behavior in the drywell free space" has a little impact on fuel heat up, fuel melting, and relocation. -Influence of "Droplet behavior in the drywell free space" on D/W pressure and temperature is little.	- Droplet behavior could be calculated using CFD analysis. - However, there is not enough experimental data for validation.
904		Condensation heat transfer on the drywell wall	L	L	L	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Condensation heat transfer on the drywell wall" has a no impact on fuel heat up, fuel melting, and relocation. - "Condensation heat transfer on the drywell wall" affects PCV pressure and temperature, it has great impact on PCV integrity.	- Condensation heat transfer on the pedestal wall and internal surfaces with a non-condensable gas was examined [26]. - However, there is not enough experimental data for validation.
905		Interaction between gas and water film flow on the drywell wall and internal surfaces	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, "Interaction between gas and water film flow on the drywell wall and internal surfaces" has a little impact on fuel heat up, fuel melting, and relocation. -Influence of "Interaction between gas and water film flow on the drywell wall and internal surfaces" on D/W pressure and temperature is little.	- Interaction between gas and water film flow could be evaluated by using Kelvin-Helmholtz instability theory. - However, there is not enough experimental data in drywell for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
906	Drywell	Seasalt intake to corium	N/A	N/A	N/A	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Seasalt intake to corium” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Seasalt intake to corium” on MCCI is little.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
907		Seasalt impact for corium thermodynamic properties	N/A	N/A	N/A	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Seasalt impact for corium thermodynamic properties” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Seasalt impact for corium thermodynamic properties” on MCCI is little.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
908		Corrosion of drywell internals by seasalt (including marine lives)	L	L	L	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Corrosion of drywell internals by seasalt” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Corrosion of drywell internals by seasalt” on PCV integrity (short term) is little.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
909		Salt effects on heat transfer	L	L	L	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Salt effects on heat transfer” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Salt effects on heat transfer” on PCV integrity (short term) is little.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
910	Drywell	Salt remelting from flood	L	L	L	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Salt remelting from flood” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Salt remelting from flood” on PCV integrity (short term) is little.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
911		Influence on heat transfer by seasalt concentration change	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Influence on Heat Transfer by Seasalt Concentration Change” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Influence on Heat Transfer by Seasalt Concentration Change” on PCV integrity (short term) is little.	- Properties of normal or concentrated seawater are studied for seasalt making field.
912		Influence on Instrumentation and Measurements by Seasalt Concentration Change	L	L	L	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Influence on Instrumentation and Measurements by Seasalt Concentration Change” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Influence on Instrumentation and Measurements by Seasalt Concentration Change” on PCV integrity may indirectly affect the SA management.	- There is no model or correlation to calculate seasalt deposition on the wall and its impact on heat transfer.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
913	Drywell	Seasalt impact for FP reaction and composition	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Seasalt impact for FP reaction and composition” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Seasalt impact for FP reaction and composition” on PCV integrity is little.	- The seasalt impact for FP reaction and composition has been examined after Fukushima Dai-Ichi Nuclear Power Plant accident [29,30]. - However, there is not enough experimental data.
914		Boron corrosion of drywell internal structure	L	L	L	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Boron corrosion of drywell internal structure” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Boron corrosion of drywell internal structure” on PCV integrity (short term) is little.	- There is no experimental data toward corrosion of drywell internal structure by boron.
915		Boron effects on heat transfer	L	L	L	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Boron effects on heat transfer” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of Boron effects on heat transfer” on PCV integrity is little.	- There is no experimental data toward boron effects on heat transfer.
916		Boron remelting from flood	L	L	L	L	U	- As the state quantities of D/W can be considered to be independent of those of RPV, “Boron remelting from flood” has a little impact on fuel heat up, fuel melting, and relocation. -Influence of “Boron remelting from flood” on PCV integrity is little.	- Remelting and deposition behavior of boron might evaluate from flood. - However, there is not enough experimental data for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
917	Drywell	Heat release from drywell wall	L	L	L	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Heat release from drywell wall” has a little impact on fuel heat up, fuel melting, and relocation. - “Heat release from drywell wall” affects PCV pressure and temperature, it has great impact on PCV integrity and amount of released radioactive material.	-Heat release from drywall wall to R/B can be calculated based on heat transfer correlations
918		Steam condensation by PCV spray	L	L	L	H	P	- As the state quantities of D/W can be considered to be independent of those of RPV, “Steam condensation by PCV spray” has a little impact on fuel heat up, fuel melting, and relocation. - “Steam condensation by PCV spray” affects PCV pressure and temperature, it has great impact on PCV integrity and amount of released radioactive material.	- Steam condensation by PCV can be calculated based on droplet diameter ,flow rate and water temperature.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
919	Drywell Head	Heat transfer between D/W head inner wall and gas	L	L	L	H	K	- As the state quantities of D/W can be considered to be independent of those of RPV, heat transfer between D/W head inner wall and gas has a little impact on fuel heat up, fuel melting, and relocation. - Heat transfer between D/W head inner wall and gas affects heat release from PCV. It affects PCV pressure and temperature.	- General natural convection heat transfer coefficient could be applied inside of D/W head between D/W head inner surface and gas.
920		Heat transfer between D/W head inner wall and water	L	L	L	H	K	- As the state quantities of D/W can be considered to be independent of those of RPV, heat transfer between D/W head inner wall and water has a little impact on fuel heat up, fuel melting, and relocation. - Heat transfer between D/W head inner wall and water (outside wall) affects heat release from PCV. It affects PCV pressure and temperature.	- Heat transfer between D/W head inner wall and water can be evaluated if water flow pattern is well known.
921		Gas stratification in D/W head internal space	L	L	L	H	K	- As the state quantities of D/W can be considered to be independent of those of RPV, gas stratification in D/W head internal space has a little impact on fuel heat up, fuel melting, and relocation. Gas stratification in D/W head internal space affect heat transfer between D/W head inner wall and gas. It affects PCV pressure and temperature.	- Stratification of gas can be calculated from some correlations.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
922	Drywell Head	Gas composition in D/W head internal space	L	L	L	M	K	- As the state quantities of D/W can be considered to be independent of those of RPV, gas composition in D/W head internal space has a little impact on fuel heat up, fuel melting, and relocation. - Gas composition change in D/W head internal space affects condensation of steam, which leads to change of PCV pressure.	- Gas flow in D/W head internal space could be calculated by using density, temperature and pressure gradient between D/W head internal space and any other spaces.
923		Steam condensation in D/W head	L	L	L	H	K	- As the state quantities of D/W can be considered to be independent of those of RPV, steam condensation in D/W head has a little impact on fuel heat up, fuel melting, and relocation. - Steam condensation in D/W head leads to change of PCV pressure.	- Condensation heat transfer on PCV wall with a non-condensable gas was examined[1] - Condensation heat transfer between D/W head inner wall and water could be evaluated with it.
924		Gas flow in D/W head	L	L	L	H	K	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, gas flow in D/W head has little impact on fuel heat up, fuel melting, and relocation. - Gas flow in D/W head and the other regions affects temperature change between D/W head. Gas temperature change in D/W head directly leads to change of PCV temperature.	- Gas flow in D/W head could be calculated by using density, temperature, and pressure gradient between pedestal and any other spaces.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
925	Drywell Head	Pressure change in D/W head internal space	L	L	L	H	K	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, pressure change in D/W head internal space has little impact on fuel heat up, fuel melting, and relocation. - Pressure change in D/W head internal space directly leads to change of PCV pressure.	- Pressure, gas temperature, and water temperature changes in D/W could be evaluated by thermodynamic calculation.
926		Temperature change in D/W head internal space	L	L	L	H	K	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, temperature change in D/W head internal space has little impact on fuel heat up, fuel melting, and relocation. - Temperature change in D/W head internal space directly leads to change of PCV temperature.	- Pressure, gas temperature, and water temperature changes in D/W could be evaluated by thermodynamic calculation.
927		Thermal conduction / Temperature change of D/W head	L	L	L	H	K	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, thermal conduction / temperature change of D/W head has little impact on fuel heat up, fuel melting, and relocation. -Since thermal conduction / temperature change of D/W head directly affects D/W head coolability from D/W head surface, this affects PCV temperature and pressure.	- Temperature change could be evaluated by heat conduction equation and properties of D/W head.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
928	Drywell Head	Deformation / failure of drywell head by thermal stress	L	L	L	H	P	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, deformation / failure of drywell head by thermal stress has little impact on fuel heat up, fuel melting, and relocation. - Deformation / failure of drywell head by thermal stress leads to gas leakage from D/W and this directly affects to PCV pressure.	- Thermal stress on drywell head could be evaluated if heat source distribution is well known. - Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [2]. - However, there is uncertainty for heat source distribution, it is difficult to evaluate this phenomena.
929		Seal failure of D/W head flange	L	L	L	H	K	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, seal failure of D/W head flange has little impact on fuel heat up, fuel melting, and relocation. - Seal failure of D/W head flange leads to gas leakage from D/W and this directly affects to PCV pressure.	- Condition of seal failure of D/W head flange is examined[19,20]
930		Gas flow from D/W head flange	L	L	L	H	K	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, gas flow from D/W head flange has little impact on fuel heat up, fuel melting, and relocation. - Gas flow from D/W head flange directly affects to PCV pressure.	- Correlation between displacement of D/W head flange and pressure is examined[19,20] - Gas flow from D/W head flange could be calculated analytically.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
931	Drywell Head	Pressure loss of bulk head plate in head (including air duct)	L	L	L	M	P	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, pressure loss of bulk head plate in head (including air duct) has little impact on fuel heat up, fuel melting, and relocation. - Pressure loss of bulk head plate in head (including air duct) may affect to PCV pressure when there is gas flow due to leakage from D/W head flange or the other reasons.	-Pressure loss of bulk head plate in head (including air duct) could be calculated analytically - However, there is not enough experimental data for pressure loss of bulk head plate for validation.
932		Gas flow through air conditioner duct	L	L	L	M	P	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, gas flow through air conditioner duct has little impact on fuel heat up, fuel melting, and relocation. - Gas flow through air conditioner duct may affect to PCV pressure and PCV temperature if heat exchanger of air conditioner (D/W cooler) can remove heat from gas.	- Pressure loss of bulk head plate could be calculated analytically. - However, there is not enough experimental data for gas flow through air conditioner duct for validation.
933		Local gas flow and turbulence	L	L	L	L	P	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in D/W head has little impact on fuel heat up, fuel melting, and relocation. - Local gas flow and turbulence may affect heat transfer rate on inner surface of D/W head and D/W gas. However, it has a smaller impact than global flow induced by pressure difference between D/W and the other regions.	- This could be evaluated by using computational fluid dynamics code. - However, as turbulent flow is complicated, there is uncertainty.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
934	Drywell Head	Jet/plume gas interaction and entrainment effects	L	L	L	L	P	Relatively lower amount of Jet/plume gas does not impact to temperature and pressure so much.	- Properties of normal or concentrated seawater are studied for seasalt making field.
935		Droplet behavior in the drywell head free space	L	L	L	L	P	- As an amount of water droplet is limited, this phenomenon affects little impact on PCV temperature and pressure on all categories.	- Droplet behavior could be calculated using CFD analysis. - However, there is not enough experimental data for validation.
936		Condensation heat transfer on the drywell head wall	L	L	L	L	P	- As the state quantities of D/W can be considered to be independent of those of RPV, steam condensation in D/W head has a little impact on fuel heat up, fuel melting, and relocation. - Unless D/W head external space is filled by water, there hardly occurs condensation heat transfer on the drywell head wall.	- Condensation heat transfer on PCV wall with a non-condensable gas was examined[1] - Condensation heat transfer between D/W head inner wall and water could be evaluated with it.
937		Interaction between gas and water film flow on the drywell head wall	L	L	L	L	P	- As an amount of heat transfer due to condensation is limited due to relatively lower heat capacity in the drywell head region, it affects little impact on PCV temperature and pressure on all categories.	- Interaction between gas and water film flow could be evaluated by using Kelvin-Helmholtz instability theory. - However, there is not enough experimental data for validation.
938		FP attachment	N/A	M	M	H	K	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, FP attachment in D/W head has little impact on fuel heat up, fuel melting, and relocation. - Heat-up of drywell head wall would be affected by the amount of FP attachment and reevaporation.	- FP particle deposition on the pedestal wall and internal surfaces was examined in PHEBUS2K [3] and PHEBUS/FP test [4-7].

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
939	Drywell Head	FP reevaporation	N/A	L	L	M	K	- As the state quantities of D/W can be considered to be almost independent of those of RPV because of existence of RPV insulator, FP reevaporation in D/W head has little impact on fuel heat up, fuel melting, and relocation. - Heat-up of drywell head wall would be affected by the amount of FP attachment and reevaporation.	- FP re-vaporization was examined in PHEBUS2K [3] and PHEBUS/FP test [4-7].
940		Generation / attenuation of FP decay heat	N/A	L	L	M	K	- As FP does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Since generation / attenuation of FP decay heat affects gas pressure and temperature in drywell head.	- Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [8]. -Amount of FP in drywell head region could be calculated analytically.
941		FP particle transport by gas in the drywell head	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- Direct Containment Heating (DCH) would be affected by the amount of FP particles. - FP particle transport by gas in the pedestal was examined in PHEBUS2K [3] and PHEBUS/FP test [4-7]. - However, there is not enough experimental data in drywell head for validation.
942		FP particle agglomeration/fragmentation in the drywell head	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- Direct Containment Heating (DCH) would be affected by the amount of FP particles. - FP agglomeration/fragmentation was examined in PHEBUS2K [3] and PHEBUS/FP test [4-7]. - However, there is not enough experimental data in drywell head for validation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
943	Drywell Head	FP particle deposition on the drywell head wall	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- PCV wall and internal structures heat-up would be affected by the amount of FP particle deposition. - FP transport by water flow on the drywell head wall was examined in PHEBUS2K [3] and PHEBUS/FP test [4-7]. - However, there is not enough experimental data in drywell head for validation.
944		FP transport by water flow on the drywell head wall	L	L	L	L	P	- Relatively lower amount of transportation FP deposited on the surface of the drywell head wall does not impact to temperature and pressure so much.	- PCV wall and internal structures heat-up would be affected by FP transport by water flow on the drywell head wall. - FP transport by water flow was examined in PHEBUS2K [3] and PHEBUS/FP test [4-7]. - FP in reflooding water was examined in LOFT test and TMI-2 Vessel Investigation Project [9,10,11]. - However, there is not enough experimental data in drywell head for validation.
945		FP re-entrainment	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- FP re-entrainment was examined in PHEBUS2K [3] and PHEBUS/FP test [4-7]. - FP in reflooding water was examined in LOFT test and TMI-2 Vessel Investigation Project [9,10,11].
946		FP accumulation at leakage path	L	H	H	H	U	FP accumulation at leakage path affects to gas flow of leakage, it also affects heat removal from drywell head region.	- There is no experimental data for FP accumulation at leakage path.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
947	Drywell Head	FP reaction including iodine chemistry	L	L	L	L	P	- As released energy from FP chemical reaction including iodine chemistry is relatively smaller than its decay heat, all categories are ranked “L”.	- FP reaction was examined in PHEBUS2K [3] and PHEBUS/FP test [4-7]. - Iodine chemistry was examined in ThAI, BIP and BIP2 projects[12~14]. - However, there is not enough experimental data for validation.
948		Thermal stratification	L	L	L	L	P	- Thermal stratification in drywell head may affect to heat flux from gas in drywell head to drywell head wall.	- Thermal stratification was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [15,16]. - However, there is not enough experimental data for validation.
949		Direct Containment Heating (DCH)	N/A	N/A	N/A	H	P	- As corium/FP is dispersed after 3rd phase, categories from 1st to 3rd are not applicable. - Corium particle and FP can directly heat drywell head wall by thermal conductivity and radiation.	- Direct Containment Heating (DCH) was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [15,16]. - However, there is not enough experimental data for validation.
950		Influence on Instrumentation and Measurements by Seasalt Concentration Change	L	L	L	L	U	- As the drywell head is located outside of the PRV, heat transfer characteristics change due to seasalt concentration hardly affects categories from 1st to 3rd. - Influence on instrumentation and measurements by seasalt concentration change in water is small.	- There is no experimental data under seasalt condition.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
951	Drywell Head	Seasalt impact for FP reaction and composition	L	L	L	L	P	- As the drywell head is located outside of the PRV, chemical reaction between FP and seasalt and FP composition hardly affects categories from 1st to 3rd. - As an amount of heat generation from chemical reaction is small compared to that from decay heat, FP chemical reaction has little impact on PCV temperature and pressure. Change of FP chemical form due to seasalt may change the behavior of FP.	- The seasalt impact for FP reaction and composition has been examined after Fukushima Dai-Ichi Nuclear Power Plant accident [17,18]. - However, there is not enough experimental data.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
952	Vent to wetwell	Deformation / failure of pipe line due to thermal stress	L	L	L	H	P	- As large thermal stress which can deform or fail pipe line does not occur if corium does not exist in drywell vent line and downcomer to wetwell. As corium does not exist in drywell vent line and downcomer to wetwell until RPV failure, categories from 1st to 3rd are not applicable. - If deformation / failure of pipe line due to thermal stress occur during large amount of steam are released, steam could not be condensed enough. It courses highly pressurization in PCV.	- Thermal stress on drywell vent line and downcomer to wetwell could be evaluated if heat source distribution is well known. - Total amount of decay heat could be evaluated by using decay heat model such as ANS5.1 model [1]. - However, there is uncertainty for heat source distribution, it is difficult to evaluate this phenomena.
953		Flow resistance	L	L	L	M	K	- As large thermal stress which can deform or fail pipe line does not occur if corium does not exist in drywell vent line and downcomer to wetwell. As corium does not exist in drywell vent line and downcomer to wetwell until RPV failure, categories from 1st to 3rd are not applicable. -Flow resistance affects to differential pressure between D/W and W/W. It also affects to peak pressure in D/W.	- Pressure suppression test is done enough, - Flow resistance is calculated by diameter and length of the vent pipe, pressure loss coefficient, and so on.
954		Heat transfer between vent pipe and water	L	L	L	L	K	As an amount of heat transfer between vent pipe and water is limited due to relatively lower heat capacity in the vent line, it affects little impact on PCV temperature and pressure on all categories.	- Natural convection heat transfer coefficient could be applied to heat transfer between vent pipe and water

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
955	Vent to wetwell	Heat transfer between vent pipe and gas	L	L	L	L	K	As an amount of heat transfer between vent pipe and gas is limited due to relatively lower heat capacity in the vent line, it affects little impact on PCV temperature and pressure on all categories.	- Natural convection heat transfer coefficient could be applied to heat transfer between vent pipe and gas
956		Pressure change in vent line	L	L	L	M	K	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, pressure change in vent line has little impact on fuel heat up, fuel melting, and relocation. - Pressure change in vent line leads to change of PCV pressure. - However, air space volume of vent line is smaller than volume of the other space in PCV (ex. D/W, W/W, Pedestal). The impact of pressure change in vent line is not so mach large.	- Pressure, gas temperature, and water temperature changes in vent line could be evaluated by thermodynamic calculation.
957		Gas temperature change in vent line	L	L	L	H	K	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, Gas temperature change in vent line has little impact on fuel heat up, fuel melting, and relocation. - Gas temperature change in vent line leads to change of PCV pressure.	- Pressure, gas temperature, and water temperature changes in vent line could be evaluated by thermodynamic calculation.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
958	Vent to wetwell	Water temperature change in vent line	L	L	L	L	K	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, water temperature change in vent line has little impact on fuel heat up, fuel melting, and relocation. - Water temperature change in vent line leads to change of PCV pressure. - However, air space volume of vent line is smaller than volume of the other space in PCV (ex. D/W, W/W, Pedestal). The impact of water temperature change in vent line is small.	- Pressure, gas temperature, and water temperature changes in vent line could be evaluated by thermodynamic calculation.
959		Temperature change of vent pipe	L	L	L	L	K	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, water temperature change in vent line has little impact on fuel heat up, fuel melting, and relocation. - Temperature change of vent pipe leads to change of PCV pressure and temperature. - However, volume of vent pipe is smaller than volume of the other space in PCV (ex. D/W, W/W, Pedestal). The impact of temperature change of vent pipe is small.	- Pressure, gas temperature, and water temperature changes in vent line could be evaluated by thermodynamic calculation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
960	Vent to wetwell	Gas flow in vent line	L	L	L	M	K	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in pedestal has little impact on fuel heat up, fuel melting, and relocation. - The gas flow in vent line affects temperature change in vent line. Gas temperature change in vent line leads to change of PCV temperature.	- Gas flow in vent line internal space could be calculated by using density, temperature, and pressure gradient between pedestal and any other spaces.
961		Local gas flow and turbulence	L	L	L	L	P	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Local gas flow and turbulence may affect heat transfer rate on inner surface of vent line and water. However, it has a smaller impact than global flow induced by pressure difference between vent line and drywell.	- This could be evaluated by using computational fluid dynamics code. However, as turbulent flow is complicated, there is uncertainty.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
962	Vent to wetwell	Water flow in vent line	L	L	L	L	K	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, water flow on pedestal floor has little impact on fuel heat up, fuel melting, and relocation. - When debris reach into water in vent line, soon debris go to S/P. Water flow in vent line is not important for cooling corium deposited in vent line. - If there is no debris, water flow in vent line hardly affects to PCV temperature and pressure.	- Water flow in vent line internal space could be calculated by using density, temperature, and pressure gradient between pedestal and any other spaces.
963		Gas composition change in vent line	L	L	L	M	K	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, gas composition change in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Gas composition change in vent line affects condensation of steam, which leads to change of PCV pressure.	- Gas composition in vent line evaluated by using computational fluid dynamics code..

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
964	Vent to wetwell	Corium particle entrainment by gas / water	N/A	N/A	N/A	L	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium particle entrainment by gas / water may form particulate corium bed. Formation of particulate corium bed affects corium coolability. But, particulate corium seems to fall into S/P soon. Therefore, corium particle entrainment by gas / water hardly affect to temperature and pressure in vent line.	- The melt entrainment rate was obtained by the Melt Eruption Test (MET) as a function of the gas sparging rate. - Corium coolability was examined in MCCI project [2], MACE experiment [3], and FARO experiment [4]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
965		Heat transfer between entrainment corium particle and vent pipe	N/A	N/A	N/A	L	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Entrainment corium particulate seems to fall into S/P soon. Therefore, corium particle entrainment by gas / water hardly affect to temperature and pressure in vent line.	- The melt entrainment rate was obtained by the Melt Eruption Test (MET) as a function of the gas sparging rate. - Corium coolability was examined in MCCI project [2], MACE experiment [3], and FARO experiment [4]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.
966		Heat transfer between entrainment corium particle and water	N/A	N/A	N/A	L	P	- As corium does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium particle entrainment by gas / water may form particulate corium bed. Formation of particulate corium bed affects corium coolability. But, particulate corium seems to fall into S/P soon. Therefore, corium particle entrainment by gas / water hardly affect to temperature and pressure in vent line.	- The melt entrainment rate was obtained by the Melt Eruption Test (MET) as a function of the gas sparging rate. - Corium coolability was examined in MCCI project [2], MACE experiment [3], and FARO experiment [4]. - However, there is not enough experimental data for validation because there are many influential factors toward experimental data.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
967	Vent to wetwell	Droplet behavior in the drywell vent line free space	L	L	L	L	P	- As an amount of water droplet is limited, this phenomenon affects little impact on PCV temperature and pressure on all categories.	- Droplet behavior could be calculated using CFD analysis. - However, there is not enough experimental data for validation.
968		Condensation heat transfer on the drywell vent line inner surface	L	L	L	L	P	- As an amount of heat transfer due to condensation is limited due to relatively lower heat capacity in the vent line, it affects little impact on PCV temperature and pressure on all categories.	- Condensation heat transfer on vent pipe with a non-condensable gas was examined [5]. - However, there is not enough experimental data for validation.
969		FP particle transport by gas in the drywell vent line and downcomer	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- Direct Containment Heating (DCH) would be affected by the amount of FP particles. - FP particle transport by gas in the pedestal was examined in PHEBUS2K [6] and PHEBUS/FP test [7-10]. - However, there is not enough experimental data in vent line for validation.
970		FP particle agglomeration/fragmentation in the drywell vent line	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- Direct Containment Heating (DCH) would be affected by the amount of FP particles. - FP agglomeration/fragmentation was examined in PHEBUS2K [6] and PHEBUS/FP test [7-10]. - However, there is not enough experimental data in vent line for validation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
971	Vent to wetwell	FP particle deposition on the drywell vent line	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- PCV wall and internal structures heat-up would be affected by the amount of FP particle deposition. - FP particle deposition on the pedestal wall and internal surfaces was examined in PHEBUS2K [6] and PHEBUS/FP test [7-10]. - However, there is not enough experimental data in vent line for validation.
972		FP deposition on vent line	L	L	L	M	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- PCV wall and internal structures heat-up would be affected by the amount of FP particle deposition. - FP particle deposition on the pedestal wall and internal surfaces was examined in PHEBUS2K [6] and PHEBUS/FP test [7-10]. - However, there is not enough experimental data in vent line for validation.
973		FP re-vaporization	L	L	L	M	P	- As an amount of FP in the pedestal is little before RPV failure, 1st to 3rd categories are ranked “L”. - Deposited FP on the vent line and downcomer can vaporize by its decay heat if it’s not sufficiently cooled. Vaporized FP may increase PCV temperature.	- FP re-vaporization was examined in PHEBUS2K [6] and PHEBUS/FP test [7-10]. - However, there is not enough experimental data in vent line for validation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
974	Vent to wetwell	Decay heat generation from FP	L	L	L	M	P	- As an amount of FP in the pedestal is little before RPV failure, 1st to 3rd categories are ranked “L”. - As decay heat is mainly generated from FP, this phenomenon can impact to PCV pressure and temperature directly. However, ratio of FP in vent line is lower than D/W or W/W region. Effect of decay heat generation from FP in vent line is smaller than that of D/W or that of W/W	- Decay heat generation from FP could be evaluated by using decay heat model such as ANS5.1 model [19]. − There is enough data toward decay heat generation from FP. - But, the deposition of FP in the vent pipe is uncertain.
975		FP transport by water flow on the drywell vent line and downcomer	L	L	L	L	P	- Relatively lower amount of transportation FP deposited on the surface of the pedestal wall and internal structure does not impact to temperature and pressure so much.	- PCV wall and internal structures heat-up would be affected by FP transport by water flow on the drywell vent line and downcomer. - FP transport by water flow was examined in PHEBUS2K [6] and PHEBUS/FP test [7-10]. - FP in reflooding water was examined in LOFT test and TMI-2 Vessel Investigation Project [11,12,13]. - However, there is not enough experimental data in vent line for validation.
976		FP re-entrainment	L	L	L	L	P	- Relatively lower amount of FP particle decay heat does not impact to temperature and pressure so much.	- FP re-entrainment was examined in PHEBUS2K [6] and PHEBUS/FP test [7-10]. - FP in reflooding water was examined in LOFT test and TMI-2 Vessel Investigation Project [11,12,13].

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
977	Vent to wetwell	FP reaction including iodine chemistry	L	L	L	L	P	- As released energy from FP chemical reaction including iodine chemistry is relatively smaller than its decay heat, all categories are ranked "L".	- FP reaction was examined in PHEBUS2K [6] and PHEBUS/FP test [7-10]. - Iodine chemistry was examined in ThAI, BIP and BIP2 projects[14-16]. - However, there is not enough experimental data for validation.
978		Local water flow in the drywell vent line and downcomer	L	L	L	L	P	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Local water flow in the drywell vent line and downcomer may affect heat transfer rate on inner surface of drywell vent line and downcomer. However, it has a smaller impact than global flow induced by pressure difference between vent line and drywell.	- This could be evaluated by using computational fluid dynamics code. However, as turbulent flow is complicated, there is uncertainty.
979		Direct Containment Heating (DCH)	N/A	N/A	N/A	H	P	- As corium is dispersed after 3rd phase, categories from 1st to 3rd are not applicable. - Corium can directly heat vent line region by thermal conductivity and radiation.	- Direct Containment Heating (DCH) was examined in the series of CSARP (Cooperative Severe Accident Research Program) and could be evaluated by severe accident analysis codes such as IMPACT and MELCOR [17,18]. - However, there is not enough experimental data for validation to apply BWR.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
980	Vent to wetwell	Change of failure crack area on bellows	L	L	L	H	P	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Change of failure crack area on bellows affects to gas and water leak from PCV. It also affects to change of pressure and temperature in PCV.	- Change of failure crack area on bellows could be calculated analytically. - However, there is not enough experimental data for validation.
981		Water leak from failure crack on bellows	L	L	L	H	P	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Water leak from failure crack on bellows directly affects to change of pressure and temperature in PCV.	- Water leak from failure crack on bellows could be calculated analytically. - However, there is not enough experimental data for validation.
982		Gas leak from failure crack on bellows	L	L	L	H	P	- As the state quantities of vent line can be considered to be almost independent of those of RPV because of existence of RPV insulator, local gas flow and turbulence in pedestal has little impact on fuel heat up, fuel melting, and relocation. - Gas leak from failure crack on bellows directly affects to change of pressure and temperature in PCV.	- Gas leak from failure crack on bellows could be calculated analytically. - However, there is not enough experimental data for validation.

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
983	Vent to wetwell	Corrosion of piping by seasalt (including marine lives)	L	L	L	L	U	- As the vent line is located outside of the PRV, corrosion of the pedestal internals by seasalt hardly affects categories from 1st to 3rd. - As corrosion rate of pedestal internals by seasalt is small, it has little impact on PCV temperature and pressure.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
984		Water level change in Drywell/Wetwell ventilation line	L	L	L	H	U	- As vent line locates at outside of the RPV, pedestal water hardly affects to RPV inside cooling so much. - If water level in vent line highly decrease and vent clear occur, it leads to depressurization in D/W. - If vent clear not occur, water level change in vent line hardly affects to PCV pressure and temperature.	- Water level in vent line could be calculated from S/P water level and pressure difference between D/W and W/W.
985		Salt effects on heat transfer	L	L	L	L	U	- As the vent line is located outside of the PRV, heat transfer characteristics change due to seasalt hardly affects categories from 1st to 3rd. - Deposited seasalt on the vent line structure may decrease heat transfer to the others. However, as dissolution of seasalt occurs at lower temperatures, it has little impact on an amount of heat transfer to pedestal wall.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
986	Vent to wetwell	Salt remelting from flood	L	L	L	L	U	- As the vent line is located outside of the PRV, seasalt remelting from flood hardly affects categories from 1st to 3rd. - Deposited seasalt may decrease heat transfer from deposited surface to the others. However, as dissolution of seasalt occurs at lower temperatures, it has little impact on an amount of heat transfer to pedestal wall.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
987		Influence on Heat Transfer by Seasalt concentration change	L	L	L	L	P	- As the vent line is located outside of the PRV, heat transfer characteristics change due to seasalt concentration hardly affects categories from 1st to 3rd. - As the influence on heat transfer by seasalt concentration change in water is relatively small compared to that by water level change in vent line, it has little impact on PCV temperature and pressure.	- This item hardly considered as research objects before Fukushima Dai-Ichi Nuclear Power Plant accident.
988		Seasalt impact for FP reaction and composition	L	L	L	L	P	- As the vent line is located outside of the PRV, chemical reaction between FP and seasalt and FP composition hardly affects categories from 1st to 3rd. - As an amount of heat generation from chemical reaction is small compared to that from decay heat, FP chemical reaction has little impact on PCV temperature and pressure. Change of FP chemical form due to seasalt may change the behavior of FP.	- The seasalt impact for FP reaction and composition has been examined after Fukushima Dai-Ichi Nuclear Power Plant accident [19,20]. - However, there is not enough experimental data.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
989	Vent to wetwell	Boron corrosion of vent pipe	L	L	L	L	U	- As the vent line is located outside of the PRV, corrosion of the vent line internals by boron hardly affects categories from 1st to 3rd. - As corrosion rate of vent line internals by boron is small, it has little impact on PCV temperature and pressure.	- There is no experimental data toward corrosion of vent line by boron.
990		Boron effects on heat transfer	L	L	L	L	U	- As the vent line is located outside of the PRV, heat transfer characteristics change due to boron hardly affects categories from 1st to 3rd. - Deposited boron in vent line may decrease heat transfer to the others. However, as dissolution of boron occurs at lower temperatures, it has little impact on an amount of heat transfer to vent line wall.	- There is no experimental data toward boron effects on heat transfer.
991		Boron remelting from flood	L	L	L	L	U	- As the vent line is located outside of the PRV, boron remelting from flood hardly affects categories from 1st to 3rd. - Deposited boron may decrease heat transfer from deposited surface to the others. However, as dissolution of boron occurs at lower temperatures, it has little impact on an amount of heat transfer to vent line wall.	− Remelting and deposition behavior of boron might evaluated from flood. - However, there is not enough experimental data for validation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
992	Wetwell	Deformation / failure of wetwell by thermal stress	L	L	L	H	P	- As the state quantities of W/W can be considered to be independent of those of RPV, failure of W/W has a little impact on fuel heat up, fuel melting, and relocation. - Failure of W/W significantly leads to depression of PCV pressure.	- Limiting pressure and temperature of W/W shell can be analytically predicted However, there are limited data to verify the results.
993		Pressure change in wetwell	L	L	L	H	K	- As the state quantities of W/W can be considered to be independent of those of RPV, pressure change in W/W has a little impact on fuel heat up, fuel melting, and relocation. - Pressure change in W/W affect gas flow through vacuum breaker and downcomer, which leads to change of PCV pressure and temperature.	- Pressure change in wetwell can be calculated based on the ideal gas law.
994		Water flow in wetwell	L	L	L	M	K	- As the state quantities of W/W can be considered to be independent of those of RPV, water flow in W/W has a little impact on fuel heat up, fuel melting, and relocation. - Water flow coming from D/W to W/W affects temperature of W/W pool, which leads to change of vapor pressure in W/W.	- Water flow from D/W to W/W can be calculated based on the differential pressure between D/W and W/W.
995		Temperature change in wetwell structure	L	L	L	M	K	- As the state quantities of W/W can be considered to be independent of those of RPV, temperature change in W/W structure has a little impact on fuel heat up, fuel melting, and relocation. - Temperature change in W/W structure affect temperature of W/W pool, which leads to change of vapor pressure in W/W.	-Temperature change in W/W structure can be calculated based on heat transfer between W/W gas/water and W/W structure.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
996	Wetwell	Gas composition change in wetwell	L	L	L	M	K	- As the state quantities of W/W can be considered to be independent of those of RPV, gas composition change in W/W has a little impact on fuel heat up, fuel melting, and relocation. - Gas composition change in W/W affect condensation of steam, which leads to change of pressure in W/W.	- Gas composition change in W/W can be calculated based on gas flow rate through SRV and downcomer .
997		Corium particle entrainment by gas / water	N/A	N/A	N/A	M	P	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium particle moving from D/W to W/W affects temperature of W/W pool, which leads to change of vapor pressure in W/W.	- DCH models are benchmarked with data from the integral effects tests (IET).
998		Corium particle waftage	N/A	N/A	N/A	M	P	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium particle moving from D/W to W/W affects temperature of W/W pool, which leads to change of vapor pressure in W/W.	- DCH models are benchmarked with data from the integral effects tests (IET).
999		Corium particle deposition / accumulation	N/A	N/A	N/A	M	P	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Corium particle moving from D/W to W/W affects temperature of W/W pool, which leads to change of vapor pressure in W/W.	- DCH models are benchmarked with data from the integral effects tests (IET).

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1000	Wetwell	Heat transfer between pool water in wetwell and corium particle	N/A	N/A	N/A	M	P	- As corium particle does not exist in PCV until RPV failure, categories from 1st to 3rd are not applicable. - Heat transfer between pool water and corium particle affects temperature of W/W gas and pool, which leads to change of vapor pressure in W/W.	- DCH models are benchmarked with data from the integral effects tests (IET).
1001		Gas ejection	L	L	L	L	K	- As the state quantities of W/W can be considered to be independent of those of RPV, gas ejection from SRV to W/W has a little impact on fuel heat up, fuel melting, and relocation. - Load caused by gas ejection from SRV to W/W has a little impact on PCV pressure and temperature.	- Gas ejection from SRV can be calculated based on critical flow equation and flow area.
1002		Steam condensation (with/without non-condensable gases)	L	L	L	H	K	- As the state quantities of W/W can be considered to be independent of those of RPV, steam condensation in W/W has a little impact on fuel heat up, fuel melting, and relocation. - As steam condensation directly affects vapor pressure in W/W, it has a great impact on PCV pressure and temperature.	- Steam condensation can be calculated from water pool temperature and steam temperature.
1003		Temperature stratification (three-dimensional temperature distribution)	L	L	L	H	K	- As the state quantities of W/W can be considered to be independent of those of RPV, temperature stratification in W/W has a little impact on fuel heat up, fuel melting, and relocation. - Temperature stratification of W/W pool increases surface temperature of W/W pool, which leads to change of vapor pressure in W/W.	- Temperature stratification can be calculated from some correlations.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1004	Wetwell	Stratification of gas composition	L	L	L	L	K	- As the state quantities of W/W can be considered to be independent of those of RPV, stratification of gas composition in W/W has a little impact on fuel heat up, fuel melting, and relocation. - As stratification of gas in W/W does not affect total mole number of gas, it has a small impact on PCV pressure and temperature.	- Stratification of gas composition can be calculated from some correlations.
1005		Dynamic load on wetwell wall (with/without non-condensable gases)	L	L	L	M	K	- As the state quantities of W/W can be considered to be independent of those of RPV, dynamic load on W/W wall has a little impact on fuel heat up, fuel melting, and relocation. - Dynamic load on W/W wall may lead to failure of W/W wall, which has a significant impact on PCV pressure.	- Dynamic load on W/W wall can be calculated from gas velocity.
1006		Scrubbing	N/A	L	L	M	P	- As FP aerosol does not exist in PCV until failure of fuel cladding, the first category is not applicable. - As the state quantities of W/W can be considered to be independent of those of RPV, scrubbing of FP aerosols has a little impact on fuel melting and relocation. - Scrubbing of FP aerosols affects aerosol mass included in gas phase, which leads to direct heating of gas and increasing of temperature and pressure in PCV.	- Scrubbing of FP aerosols can be calculated by SUPRA (SUpression Pool Retention Analysis) code. MAAP code uses the lookup-table calculated by the SUPRA code.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1007	Wetwell	Gas flow at vacuum breaker valve	L	L	L	H	K	- As the state quantities of W/W can be considered to be independent of those of RPV, gas flow at vacuum breaker valve has a little impact on fuel heat up, fuel melting, and relocation. - Gas flow at vacuum breaker valve significantly affects pressure of D/W and W/W.	-Gas flow at vacuum breaker valve can be calculated based on the differential pressure between D/W and W/W.
1008		Local gas flow and turbulence	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, local gas flow and turbulence in W/W has a little impact on fuel heat up, fuel melting, and relocation. - Local gas flow and turbulence may affect heat transfer rate on inner surface of W/W wall. However, it has a smaller impact than global gas flow induced by vacuum breaker valve.	-Local gas flow and turbulence can be calculated analytically. However, there are limited data to verify the results.
1009		Water level change	L	L	L	H	K	- As the state quantities of W/W can be considered to be independent of those of RPV, water level change in W/W has a little impact on fuel heat up, fuel melting, and relocation. - Water level change affects the amount of heat transfer from W/W to torus room especially when outer surface of W/W is submerged in floodwater.	- Water level change can be calculated by water mass, water density and lookup table of volume-level.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1010	Wetwell	Droplet behavior in the wetwell above water level	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, droplet behavior in W/W has a little impact on fuel heat up, fuel melting, and relocation. - As Humidity of W/W is very high and droplets return to the water pool immediately, droplet behavior has a little impact of PCV pressure and temperature.	-Droplet behavior in W/W above water level can be calculated by SUPRA (SUpression Pool Retention Analysis) code. However, there are limited data to verify the results.
1011		Condensation heat transfer on the wetwell wall above water level	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, condensation heat transfer on W/W wall has a little impact on fuel heat up, fuel melting, and relocation. - As outer shell surface of W/W is surrounded by air and condensation heat transfer on W/W wall is relatively small, condensation heat transfer has a little impact on PCV pressure and temperature.	- Condensation heat transfer on W/W wall can be calculated based on heat transfer between W/W gas and W/W structure. However, there are limited data to verify the results.
1012		Interaction between gas and water film flow on the wetwell wall above water level	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, interaction between gas and water film on W/W wall has a little impact on fuel heat up, fuel melting, and relocation. - Interaction between gas and water film flow may produce a lot of droplets. However, as humidity of W/W is very high and droplets return to the water pool immediately, droplet behavior has a little impact of PCV pressure and temperature.	- Interaction between gas and water film flow on the wetwell wall can be calculated analytically by using CFD codes. However, there are limited data to verify the results.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1013	Wetwell	FP particle transport by gas in the wetwell	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, FP particle transport by gas in W/W has a little impact on fuel heat up, fuel melting, and relocation. - As the location of FP particle does not affect the total energy released from FP to PCV, FP particle transport by gas in W/W has a little impact on PCV temperature and pressure.	- FP particle transport by gas can be calculated based on gas flow and FP particle density. However, there are limited data to verify the results.
1014		FP particle agglomeration/fragmentation in the wetwell	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, FP particle agglomeration and fragmentation in W/W has a little impact on fuel heat up, fuel melting, and relocation. - As the location of FP particle does not affect the total energy released from FP to PCV, FP particle agglomeration and fragmentation in W/W has a little impact on PCV temperature and pressure.	- FP particle agglomeration and fragmentation are considered in correlations of FP particle size distribution. However, there are limited data to verify the results.
1015		FP particle deposition on the wetwell wall above water level	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, FP particle deposition on W/W wall above water level has a little impact on fuel heat up, fuel melting, and relocation. - As the location of FP particle does not affect the total energy released from FP to PCV, FP particle deposition on W/W wall above water level has a little impact on PCV temperature and pressure.	- FP particle deposition on the wetwell wall is considered in correlations of FP particle size distribution. However, there are limited data to verify the results.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1016	Wetwell	FP transport by water flow on the wetwell wall above water wall	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, FP transport by water flow on W/W wall above water level has a little impact on fuel heat up, fuel melting, and relocation. - As the location of FP particle does not affect the total energy released from FP to PCV, FP transport by water flow on W/W wall above water level has a little impact on PCV temperature and pressure.	- FP particle transport by water flow can be calculated based on water flow and FP particle density. However, there are limited data to verify the results.
1017		FP re-entrainment	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, FP re-entrainment has a little impact on fuel heat up, fuel melting, and relocation. - As the location of FP particle does not affect the total energy released from FP to PCV, FP re-entrainment has a little impact on PCV temperature and pressure.	- FP re-entrainment can be calculated at water and corium pool. However, there are limited data to verify the results.
1018		FP reaction including iodine chemistry	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, FP reaction including iodine chemistry has a little impact on fuel heat up, fuel melting, and relocation. - As the location of FP particle does not affect the total energy released from FP to PCV, FP reaction including iodine chemistry has a little impact on PCV temperature and pressure.	- FP reaction such as iodine chemistry and pH control can be considered in the MAAP code. However, there are limited data to verify the results.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
1019	Wetwell	Corrosion of wetwell by seasalt (including marine lives)	L	L	L	L	U	- As the state quantities of W/W can be considered to be independent of those of RPV, corrosion of W/W by seasalt has a little impact on fuel heat up, fuel melting, and relocation. - As the corrosion failure of W/W wall requires long time, it has a little impact on PCV temperature and pressure.	- There are no model or correlation to calculate the corrosion of wetwell by seasalt
1020		Adsorption and release of gaseous FP	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, adsorption and release of gaseous FP has a little impact on fuel heat up, fuel melting, and relocation. - As the location of FP particle does not affect the total energy released from FP to PCV, adsorption and release of gaseous FP has a little impact on PCV temperature and pressure.	- FP adsorption and release of gaseous FP can be calculated based on vapor pressure and temperature. However, there are limited data to verify the results.
1021		Salt remelting from flood	L	L	L	L	U	- As the state quantities of W/W can be considered to be independent of those of RPV, salt remelting from flood has a little impact on fuel heat up, fuel melting, and relocation. - As the influence on heat transfer by salt remelting from flood is relatively small compared to that by water level change in W/W, it has a little impact on PCV temperature and pressure.	- There is no model or correlation to calculate salt remelting from flood.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1022	Wetwell	Influence on Heat Transfer by Seasalt Concentration Change	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, influence on heat transfer by seasalt concentration change has a little impact on fuel heat up, fuel melting, and relocation. - As the influence on heat transfer by seasalt concentration change is relatively small compared to that by water level change in W/W, it has a little impact on PCV temperature and pressure.	- Influence on heat transfer by seasalt concentration can be calculated by some correlations. However, there are limited data to verify the results.
1023		Influence for heat transfer between wetwell and torus room by seawater	L	L	L	L	U	- As the state quantities of W/W can be considered to be independent of those of RPV, influence for heat transfer between W/W and torus room by seawater has a little impact on fuel heat up, fuel melting, and relocation. - As the influence for heat transfer between wetwell and torus room by seasalt deposition is relatively small compared to that by submergence of outer surface of W/W, it has a little impact on PCV temperature and pressure.	- There is no model or correlation to calculate seasalt deposition on the wall and its impact on heat transfer between wetwell and torus room.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1024	Wetwell	Influence on Instrumentation and Measurements by Seasalt Concentration Change	L	L	L	L	U	- As the state quantities of W/W can be considered to be independent of those of RPV, influence on instrumentation and measurements by seasalt concentration change has a little impact on fuel heat up, fuel melting, and relocation. - Deposited salt from seawater may decrease heat transfer to W/W wall. However, as precipitation of salt occurs at lower temperatures, it has a little impact on heat transfer to W/W wall.	- There is no model or correlation to calculate seasalt deposition on the wall and its impact on heat transfer.
1025		Seasalt impact for FP reaction and composition	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, seasalt impact for FP reaction and composition has a little impact on fuel heat up, fuel melting, and relocation. - As the location of FP particle does not affect the total energy released from FP to PCV, seasalt impact for FP reaction and composition has a little impact on PCV temperature and pressure.	- There is no model or correlation to calculate seasalt impact for FP reaction and composition.
1026		Boron corrosion of wetwell wall	L	L	L	L	U	- As the state quantities of W/W can be considered to be independent of those of RPV, boron corrosion of W/W wall has a little impact on fuel heat up, fuel melting, and relocation. - As the corrosion failure of W/W wall requires long time, it has a little impact on PCV temperature and pressure.	- There is no model or correlation to calculate boron corrosion of wetwell wall.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1027	Wetwell	Boron effects on heat transfer	L	L	L	L	P	- As the state quantities of W/W can be considered to be independent of those of RPV, boron effects on heat transfer has a little impact on fuel heat up, fuel melting, and relocation. - Deposited boron may decrease heat transfer to W/W wall. However, as precipitation of boron occurs at lower temperatures, it has a little impact on heat transfer to W/W wall.	- Influence on heat transfer by boron concentration can be calculated by some correlations. However, there are limited data to verify the results.
1028		Boron remelting from flood	L	L	L	L	U	- As the state quantities of W/W can be considered to be independent of those of RPV, boron remelting from flood has a little impact on fuel heat up, fuel melting, and relocation. - As the influence on heat transfer by boron remelting from flood is relatively small compared to that by water level change in W/W, it has a little impact on PCV temperature and pressure.	- There is no model or correlation to calculate boron remelting from flood.
1029		Heat release from wetwell wall to torus room	L	L	L	H	K	- As the state quantities of W/W can be considered to be independent of those of RPV, heat release from W/W wall to torus room has a little impact on fuel heat up, fuel melting, and relocation. - As heat release from W/W wall to torus room directly affects the total amount of energy in PCV, it has a great impact on PCV pressure and temperature.	-Heat release from wetwell wall to torus room can be calculated based on heat transfer correlations

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1030	Wetwell	Gas leak from wetwell (vacuum breaker)	N/A	N/A	N/A	H	P	- As gas leak does not occur until PCV failure, categories from 1st to 3rd are not applicable. - Gas leak from W/W significantly leads to depression of PCV pressure.	-Gas leak flow rate from wetwell can be calculated analytically. However, limiting pressure and temperature of PCV failure has uncertain.
1031		Water leak from wetwell (vacuum breaker)	N/A	N/A	N/A	H	P	- As water leak does not occur until PCV failure, categories from 1st to 3rd are not applicable. - Water leak from W/W significantly leads to depression of PCV pressure.	-Water leak flow rate from wetwell can be calculated analytically. However, limiting pressure and temperature of PCV failure has uncertain.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1032	Isolation condenser	Heat transfer between steam and inner wall of IC heat transfer tube	M	L	L	L	K	- Heat transfer between steam and inner wall of IC heat transfer tube affects to ratio of water returning to the core. It affects to fuel heat up. - After fuel melting phase, there seems to be a little steam in RPV, it means heat transfer between steam and inner wall of IC heat transfer tube hardly occur.	- Steam condensation heat transfer coefficient could be applied.
1033		Heat transfer between condensate and inner wall of IC heat transfer tube	L	L	L	L	K	-Condensate temperature is approximately same as pool water temperature. There seems to be only a little heat transfer between condensate and inner wall of IC heat transfer tube.	- Convection heat transfer coefficient for condensate could be applied.
1034		Heat transfer between pool water and outer wall of IC heat transfer tube	M	L	L	L	K	- Heat transfer between pool water and outer wall of IC heat transfer tube affects to ratio of water returning to the core. It affects to fuel heat up. - After fuel melting phase, there seems to be a little steam in RPV, it means heat transfer between steam and inner wall of IC heat transfer tube hardly occur.	- Natural convection heat transfer coefficient could be applied to heat transfer between pool water and outer wall of IC heat transfer tube.
1035		Heat transfer between air and IC heat transfer tube in case of low pool water level	M	L	L	L	P	- Heat transfer between air and IC heat transfer tube in case of low pool water level affects to heat removal and ratio of water returning to the core. It affects to fuel heat up. - After fuel melting phase, there seems to be a little steam in RPV, it means heat transfer between steam and inner wall of IC heat transfer tube hardly occur.	- Natural convection heat transfer coefficient could be applied to heat transfer between air and IC heat transfer tube in case of low pool water level. - However, condition of outer side of IC heat transfer tube changes due to water level. It is difficult to evaluate an amount of heat transfer.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1036	Isolation condenser	Fouling factor of heat transfer tube (inner/outer surface)	M	L	L	L	K	-Degrade of heat transfer rate due to fouling affect to temperature change in RPV. It also affects to increase of fuel temperature. - After fuel melting phase, there seems to be a little steam in RPV, it means heat transfer between steam and inner wall of IC heat transfer tube hardly occur.	- Fouling factor of heat transfer tube could be applied to evaluate the heat transfer coefficient between steam/condensate and inner surface or between outer surface and pool water.
1037		Degradation of condensation heat transfer coefficient due to non-condensable gas (Hydrogen, Noble gas)	L	H	L	L	K	Non-condensable gas release occur due to fuel melting (during fuel melting hydrogen is released due to metal-water interaction), degradation of condensation heat transfer coefficient due to non-condensable gas (hydrogen, noble gas) affects to temperature change in RPV. Hydrogen generation occur mainly at 2nd phase (core melting). Hydrogen generation also occur at 3rd phase (relocation from core) and 4th phase (PCV deposition), however, as of 2nd phase, IC tube is already filled by non-condensable gas and additional gas generation seems to have no effect of degradation of condensation heat transfer coefficient. In the 1st phase(Fuel Heat Up), gas generation hardly occur.	- Condensation heat transfer in heat transfer tube with a non-condensable gas was examined.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1038	Isolation condenser	Volatile FP attachment into IC heat transfer tube	N/A	N/A	L	L	P	At the 1st phase (Fuel Heat Up), volatile FP is hardly released. Fuel melting is not affected whether Volatile FP attaches or doesn't attach into IC heat transfer tube. Volatile FP is one of heat source to heat up PCV, therefore, volatile FP attachment into IC heat transfer tube affect to temperature change of PCV. But, ratio of volatile FP attachment into IC heat transfer tube seems to be low and it has a little influence.	- Heat-up of IC heat transfer tube would be affected by the amount of volatile FP attachment. - FP particle deposition on the pedestal wall and internal surfaces was examined in PHEBUS2K [1] and PHEBUS/FP test [2-5]. - However, there is not enough experimental data in heat transfer tube for validation..
1039		Volatile FP reevaporation from IC heat transfer tube	N/A	N/A	L	L	P	At the 1st phase (Fuel Heat Up), volatile FP is hardly released. Fuel melting is not affected whether volatile FP attaches or doesn't attach into IC heat transfer tube. Volatile FP is one of heat source to heat up PCV, therefore, volatile FP reevaporation from IC heat transfer tube affects to temperature change of PCV. But, ratio of volatile FP attachment into IC heat transfer tube seems to be low and it has a relatively small effect.	- FP re-vaporization was examined in PHEBUS2K [1] and PHEBUS/FP test [2-5]. - However, there is not enough experimental data in heat transfer tube for validation.

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Table 8-3 Final PIRT results (cont.)

No.	Subsystem/ Component	Phenomenon	Importance				SoK	Ranking Rationale for Importance	Ranking Rationale for SoK
			1st	2nd	3rd	4th			
1040	Isolation condenser	Heat generation of volatile FP attached inside IC heat transfer tube	N/A	N/A	L	L	P	At the 1st phase (Fuel Heat Up), volatile FP is hardly released. Fuel melting is not affected whether volatile FP attaches or doesn't attach into IC heat transfer tube. Volatile FP is one of heat source to heat up PCV, therefore, volatile FP attachment into IC heat transfer tube affect to temperature change of PCV. But, ratio of volatile FP attachment into IC heat transfer tube seems to be low and it has a little influence.	- Heat-up of IC heat transfer tube would be affected by the amount of volatile FP attachment. - FP particle deposition on the pedestal wall and internal surfaces was examined in PHEBUS2K [1] and PHEBUS/FP test [2-5]. - However, there is not enough experimental data for validation..
1041		Pressure change(pressure loss) along IC system	M	L	L	N/A	P	Pressure change along IC system influence the heat transfer rate of IC. Change of heat transfer rate affects to ratio of water returning to the core. It affects to fuel heat up. After fuel melting phase, there seems to be a little steam in RPV, it means heat transfer between steam and inner wall of IC heat transfer tube hardly occur.	- Pressure change (pressure loss) along IC system could be calculated analytically . - However, pressure loss is affected by the state of IC system (ex. valve opening area, amount of water in IC heat transfer tube.)
1042		Pressure of IC heat transfer tube	M	L	L	N/A	K	Pressure change along IC system influence the heat transfer rate of IC. Change of heat transfer rate affects to ratio of water returning to the core. It affects to fuel heat up. After fuel melting phase, there seems to be a little steam in RPV, it means heat transfer between steam and inner wall of IC heat transfer tube hardly occur.	- Pressure in IC heat transfer tube could be calculated analytically from pressure in RPV.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

Table 8-3 Final PIRT results (cont.)

No.	**Subsystem/ Component**	**Phenomenon**	**Importance**				**SoK**	**Ranking Rationale for Importance**	**Ranking Rationale for SoK**
			1st	**2nd**	**3rd**	**4th**			
1043	Isolation condenser	Water level in IC tank (shell side)	M	L	L	N/A	K	If water level in IC tank is lower than top of heat transfer tube, it affect to Heat transfer between pool water and outer wall of IC heat transfer tube. After fuel melting phase, there seems to be a little steam in RPV, it means heat transfer between steam and inner wall of IC heat transfer tube hardly occur.	- Water level in IC tank (shell side) could be evaluated by initial condition of Water level in IC tank and amount of heat removal from RPV by IC.
1044		Gas leak inside PCV boundary	M	M	M	M	P	Gas leak inside PCV boundary causes RPV depressurization and PCV pressurization.	- Gas leak flow rate from IC to inside of PCV boundary could be calculated analytically. - However, limiting pressure and temperature that leakage occurs has uncertain.
1045		Water leak inside PCV boundary	M	M	M	M	P	Water leak inside PCV boundary causes RPV depressurization and PCV pressurization.	- Water leak flow rate from IC to inside of PCV boundary could be calculated analytically. - However, limiting pressure and temperature that leakage occurs has uncertain.
1046		Gas leak outside PCV boundary	L	H	H	N/A	P	Gas leak outside PCV boundary causes RPV depressurization. In case of gas leak outside of PCV, it doesn't affect to PCV temperature and pressure.	- Gas leak flow rate from IC to outside of PCV boundary could be calculated analytically. - However, limiting pressure and temperature that leakage occurs has uncertain.
1047		Water leak outside PCV boundary	L	H	H	N/A	P	Water leak outside PCV boundary causes RPV depressurization. In case of gas leak outside of PCV, it doesn't affect to PCV temperature and pressure.	- Water leak flow rate from IC to outside of PCV boundary could be calculated analytically. - However, limiting pressure and temperature that leakage occurs has uncertain.

Note: H: High, M: Medium, L: Low, N/A: Not applicable, K: Known, P: Partially known, U: Unknown

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- Isolation condenser

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9. Summary

PIRT has been developed in order to improve analysis accuracy of models in analysis codes using in analysis of Fukushima daiichi nuclear power plant accident.

The PIRT used accident progress scenario of unit 3 as the representative one.

The PIRT partitioned the accident scenario into four time phases to facilitate picking-out of phenomena, which is from plant scram to PCV failure.

The PIRT partitioned plant system into 16 components o facilitate picking-out of phenomena.

The PIRT picked out 1047 phenomena by discussion among member participating in the PIRT development.　386 phenomena are also selected as important ones.