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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-12161

Subject: MHI's Response to the Questions at the US-APWR ACRS Subcommittee Meeting on August 17, 2011 Regarding DCD Chapter 10 (STEAM AND POWER CONVERSION SYSTEM)

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") the responses to the questions that were discussed during the US-APWR ACRS Subcommittee meeting on August 17, 2011 regarding DCD Chapter 10 (STEAM AND POWER CONVERSION SYSTEM).

Please contact Mr. Joseph Tapia, General Manager of Licensing Department, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of this submittal. His contact information is provided below.

Sincerely,

Y. Ogata

Yoshiki Ogata,
Director- APWR Promoting Department
Mitsubishi Heavy Industries, Ltd.

Enclosure:

1. MHI's Response to the Questions at the US-APWR ACRS Subcommittee Meeting on August 17, 2011 Regarding DCD Chapter 10 (STEAM AND POWER CONVERSION SYSTEM)

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CC: J. A. Ciocco
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Enclosure 1

UAP-HF-12161
Docket No. 52-021

MHI's Response to the Questions at the US-APWR ACRS Subcommittee Meeting on August 17, 2011 Regarding DCD Chapter 10 (STEAM AND POWER CONVERSION SYSTEM)

June 2012

RESPONSE FOR ACRS SUBCOMMITTEE MEETING

06/08/2012

US-APWR Design Control Document

Mitsubishi Heavy Industries, Ltd.

CHAPTER: 10

CHAPTER TITLE: STEAM AND POWER CONVERSION SYSTEM

DATE OF MEETING: 08/17/11

QUESTION NO.: Item 1

Subsection 10.4.4 is about turbine bypass system, and MHI states that it handles 100 percent load rejection without tripping the reactor or actuating any main steam relief valves, safety valves or the pressurizer safety valves. Has MHI actually had a load rejection trip at a Japanese plant, or is this an update to the control and plant design for the US-APWR? Has there been any experience with 100% load rejection in operation in Japan? Does it work half of the time or all of the time? (i.e., If MHI had 1,000 load rejections, has it worked 999 times out of 1,000, or two times out of 1,000, or if MHI has only had one load rejection, did it work or didn't it work, or have you had zero load rejections?)

ANSWER:

The turbine bypass control system of US-APWR is designed the same as the plants in Japan.

In Japan, MHI has seven plants which can always handle a 100% load rejection from 100% power operation without tripping the reactor or actuating any main steam relief valves, main steam safety valves, or pressurizer safety valves (i.e. the same design as the US-APWR). These plants actually succeeded in handling a 100% load rejection without tripping the reactor or actuating the previously listed valves during the startup test performed for each plant.

US-APWR is also designed for 100% load rejection, the results above indicate that the US-APWR will be very successful in handling a 100% load rejection without tripping the reactor or actuating any main steam relief valves, main steam safety valves, or pressurizer safety valves.

06/08/2012

US-APWR Design Control Document

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CHAPTER: 10

CHAPTER TITLE: STEAM AND POWER CONVERSION SYSTEM

DATE OF MEETING: 08/17/11

QUESTION NO.: Item 2

Regarding steam bypass valves, there are 15 of them, which are controlled in four banks. Because they are controlled in banks, if there is a control signal malfunction that tells an entire bank to stick open for whatever reason, that is a failure mode that could cause an over-cooling transmission [sic transient]. Although MHI has analyzed one valve in Chapter 15, one valve sticking open is rather innocuous. However, if four valves sticks open, that is 15 to 17 or 18 percent. What is the cool-down rate and depressurization rate for that transient compared to the design basis steam line break event, and what is the relative time? Is there a signal to close the MSIV's? If there is, when does it occur, and what happens in the interim, in terms of automatic system responses, that is, pressure temperature responses? However, if MHI has something to justify the fact that single bank effect is bounded in some way, by the steam line break analysis, that is fine.

ANSWER:

The turbine bypass system has two operating modes: Tavg control mode and steam header pressure control mode.

The turbine bypass valves are normally closed by the block turbine bypass function when the Tavg control mode is selected. These valves open only when both the turbine bypass control signal (open signal) and the interlock signal for open (i.e. loss of load interlock or turbine trip interlock) are initiated. Therefore, the inadvertent opening of multiple turbine bypass valves can not occur due to a turbine bypass control signal malfunction alone when the Tavg control mode is selected.

On the other hand, when the steam header control mode is selected, the inadvertent opening of multiple turbine bypass valves can occur due to a turbine bypass control signal malfunction alone. If the inadvertent opening of multiple valves occurs, an RCS cooldown begins. However, when the RCS temperature reaches the low-low Tavg setpoint, all of the turbine bypass valves are closed by the low-low Tavg turbine bypass valve block interlock. The low-low Tavg turbine bypass valve block interlock is a safety grade function with two trains. A single failure would not prevent the valves from being closed. Therefore, even if the inadvertent opening of multiple valves occurs, it only results in multiple valves being open for a very brief time. The cooldown caused by this transient is relatively minor since it is

terminated so quickly. If a valve were to stick upon automatic closure after reaching the low-low Tavg setpoint, it is not anticipated that more than one valve would stick. The analysis of a stuck valve has been analyzed in Ch.15, and to assume more valves fail would be inconsistent with Ch. 15 analytical methods.

Instead, MHI assumes that one turbine bypass valve is inadvertently opened and then fails (stuck open) as the initiating event. Since the valve is stuck-open, the low-low Tavg turbine bypass valve block interlock does not mitigate the event. As a result, a continuous cooldown occurs. This cooldown is much more severe than the brief transient caused by the inadvertent opening of multiple turbine bypass valves due to a control system failure. Therefore, the safety analysis in Chapter 15 assumes one valve sticking open rather than the inadvertent opening of multiple turbine bypass valves due to a control system failure.

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CHAPTER:	**10**
CHAPTER TITLE:	**STEAM AND POWER CONVERSION SYSTEM**
DATE OF MEETING:	**08/17/11**

QUESTION NO.: Item 3

If the EPRI secondary water chemistry program is different from the steam generator water chemistry program that is typically followed in Japan for these types of steam generators, are there differences in the EPRI secondary water chemistry program that could make the Japanese operating experience worse? In other words, is the commitment to conform to the EPRI secondary water chemistry program perhaps, indicative of something because of the nature of your steam materials, or your operating experience, is that not necessarily a good thing to do? What is the difference between EPRI guidelines and Japanese domestic experience?

ANSWER:

There are some differences in detail between EPRI guidelines and Japanese PWRs operating experiences. The differences mainly originated from the differences of plant location (coolant of condenser), installation of Deaerator, and pH agent. The both ideas are fundamentally the same and the both standard values are not so far each other. Comparison tables to the secondary water chemistry guidelines of EPRI and for operating Japanese PWRs are shown in Table 1, Table 2, and Table 3, formatted according to the tables in the EPRI guidelines. Following describes major differences for control parameters and diagnostic parameters between the EPRI guidelines and Japanese PWRs experiences:

Table 1 shows control parameters and diagnostic parameters of feedwater sample. Control values of the pH and pH agent of feedwater sample are defined by a plant specific plan. Ammonia or ethanolamine (ETA) is used as pH agent in Japanese PWRs and the pH agent concentration can be calculated from pH value easily. That brings saving the measurement of pH agent concentration and simplifies the definition of pH control value. On the other hand, mixed amine application including ammonia and ETA is executed in US PWRs. The pH and pH agent control cannot be performed easily in this case and the measurement of pH agent concentration is required due to complexity of the definition of pH control value.
With regard to the hydrazine control, Japanese PWRs have not experienced any trouble on loss of hydrazine feed, and the Deaerator prevents the transportation of oxidant during loss of hydrazine. Therefore, there is no necessity of definition of Action Level 2 and 3 for deaerator equipped plant. On the other hand, Deaerator is not installed in almost all US PWRs and the definition of Action Level 2 and 3 is more important than those for Japanese PWRs.
Total iron concentration in Japanese PWRs is measured to be usually less than 5ppb. But it principally changes by the pH and plant aging. The pH control is restricted by the materials of plant equipment. Initial stage of the commercial operation, surface of piping is not sufficiently coated with protective oxide layer, and iron is easily corroded. Thus, the total iron concentration should be a site-specific parameter, and is a diagnostic parameter in Japanese PWRs.
Total copper concentration is measured to be sufficiently lower than 1 ppb and copper alloy is being reduced by the copper alloy heater tube replacement in Japanese PWRs. Then, total copper concentration is not a control parameter or a diagnostic parameter in Japanese PWRs.
Cation conductivity in feedwater is an indicator of amine decomposition and is not a diagnostic parameter in Japanese PWRs. As stated above, ammonia or ETA is used as the pH agent in Japanese PWRs. Organic acid generation due to simple ETA operation is not so much and is not complicated, thus, cation conductivity is only measured at blowdown sample to measure inorganic impurities and generated organic acid at a time.
Metal oxide species are also not a diagnostic parameter in Japanese PWRs. Magnetite and FeOOH are major and effective oxidative species as hematite is sufficiently low in Deaerator equipped plant of Japanese PWRs. Then, there is no definition about metal oxide species.
Lead concentration does not reach detective level in Japanese PWRs because use of lead is prohibited in secondary system materials in Japan.

Table 1 Control Parameters and Diagnostic Parameters of Feedwater Sample
(Extracted from EPRI secondary water chemistry guidelines Rev.7 Table5-6)

	EPRI			Japanese PWRs		
	Action Level			Action Level		
	1	2	3	1	2	3
pH agent	(a)	-	-	—(1)		
pH	Diagnostic Parameters) Continuous indicator of pH additive concentration			(2)	< 8.5	< 8.0
Hydrazine, ppb	< 8 X CPD[O_2] or < 20, whichever number is larger	(b)	(b)	< 50	-	-
Oxygen, ppb	> 5	> 10	-	> 5	> 20	
Total Iron, ppb	> 5	-	-	Diagnostic Parameter		
Total Copper, ppb	> 1	-	-	-		
Cation Conductivity, mS/m	Diagnostic Parameter) Semi-quantitative indicator of organic acid concentration			-		
Metal oxide species ECP	Assessment of corrosion product impact on steam generator tubing.			-		
Integrated Corrosion Product Transport	Periodic assessment of corrosion product mass transport to the steam generator using integrated samples.			Diagnostic Parameter		
Lead	As obtained on a plant-specific intermittent basis from integrated samples.			-		

a. Per plant specific pH optimization plan as described in the Strategic Water Chemistry in the EPRI guideline.
b. If the ratio of feedwater hydrazine to feedwater oxygen decreases to a value < 2 and is not restored to a value > 2 within 8 hours, commence shutdown as quickly as safe plant operation permits. If this ratio is restored to a value > 2, the plant may return to full power as consistent with Table 5-3 on EPRI secondary water chemistry guidelines Rev. 7, if applicable, and Action Level of this table.
1. Ammonia or ETA is simply used as pH agent.
2. Plant specific value.

Table 2 shows control and diagnostic parameters of blowdown sample. The action level 1 of cation conductivity of blowdown sample in Japanese PWRs is defined as shown in Table 2. Ammonia or ETA is used as pH agent in Japanese PWRs so that a slight change of cation conductivity can be detected. If the mixed variety amines are used like operating US plants, it would be difficult to detect slight change of cation conductivity because of high level of baseline.

Action level 2 for chloride, sulfate is different between EPRI guideline and Japanese PWRs, but the values are not so far.

Silica is measured in many Japanese PWRs. Silica concentration in Japanese raw water is low, because the Japanese fresh water is soft. A significant concentration of silica for detective level has not ever been detected, so silica is not a control parameter or diagnostic parameter.

Table 2 Control Parameters and Diagnostic Parameters of Blowdown Sample
(Extracted from EPRI secondary water chemistry guidelines Rev.7 Table5-7)

	EPRI			Japanese PWRs		
	Action Level			Action Level		
	1	2	3	1	2	3
Cation Conductivity, mS/m	-	> 0.1[a]	> 0.4[a]	> 0.05[1]	> 0.2	> 30
Sodium, ppb	> 5	> 50	> 250	> 5	> 50	-[2]
Chloride, ppb	> 10	> 50	> 250[b]	> 10	> 100	-[2]
Sulfate, ppb	> 10	> 50	> 250[b]	> 10	> 100	-[2]
Crevice condition	Diagnostic Parameter) Molar ratio monitoring. As specified in site-specific chemistry program. Hideout Return Evaluation is also evaluated.			Diagnostic Parameter) Crevice pHt monitoring with pHt estimation code.		
Boron	Diagnostic Parameter) Molar ration monitoring. As specified in site-specific chemistry program.			- (Boron is not used at present)		
pH @ 25°C	Diagnostic Parameter) Continuously monitored.			-	-	< 8.0
Specific Conductivity and pH Agent	Diagnostic Parameter) Reasonable consistency between values of pH, ammonia, amine, boric acid, conductivity, etc, should be achieved.			-[3]		
Silica	Diagnostic Parameter) Crevice chemistry, steam quality, and impurity source consideration			-		

a. At plants operating with organic amines, cation conductivity values will be elevated as a result of organic acids. In such cases, identification of a possible Action Level 2 or 3 excursion can bases on increases of 0.1 or 0.4 mS/m, respectively, above the normal baseline value. The 0.1 mS/m value corresponds to a maximum chloride concentration of 80 ppb or a maximum sulfate concentration of 110 ppb. The 0.4 mS/m value corresponds to maximum chloride concentration of 330 ppb or a maximum sulfate concentration of 445 ppb. If these action Level 2 or Action Level 3 threshold values for cation conductivity increase above baseline are exceeded, the site has 4 hours to obtain a blowdown sample and analyze it to confirm both chloride and sulfate concentrations before being required to enter the appropriate Action Level based solely on cation conductivity increase above baseline. Once the blowdown sample is obtained and analyzed for both chloride and sulfate concentrations, action can be based on the measured chloride and sulfate concentrations and not on the cation conductivity increase above baseline. See Chapter 7 in EPRI secondary water chemistry guidelines Rev.7 for guidance regarding calculating cation conductivity.

b. It is recognized that these parameters are not continuously monitored at many plants. Since this is required for a parameter with an Action Level 3 limit, cation conductivity may be substituted in lieu of imposing AL 3 values for chloride and sulfate.

1. At plants operating with organic amines, cation conductivity values will be elevated as a result of organic acids.
2. In this emergency case, cation conductivity is a limitation for Action Level 3.
3. Specific conductivity is measured as a diagnostic parameter.

Table 3 shows control and diagnostic parameters of condensate sample. Japanese PWRs control the cation conductivity of condensate sample in addition to blowdown sample for early detection of sea water leak. US plants generally do not use sea water for cooling. Japanese PWRs constantly control oxygen under Action Level 1 concentration, and the Deaerator prevents oxygen transportation into the SG. Then there is no urgent necessity to define Action Level 2 and 3.
pH is controlled at feedwater sample. Because the Japanese plants control pH at feedwater using ammonia or simple ETA which simply distributed into condensate water, pH of condensate is simply defined by feed water pH. So there is no need to control the condensate sample pH.

Table 3 Control Parameters and Diagnostic Parameters of Condensate Sample
(Extracted from EPRI secondary water chemistry guidelines Rev.7 Table5-8)

	EPRI			Japanese PWRs		
	Action Level			Action Level		
	1	2	3	1	2	3
Oxygen, ppb	> 10[a, b]	-	-	> 15	-	-
Cation Conductivity, mS/m	-			> 0.03	-	-
pH @ 25°C (copper alloy systems only)	Daily[c]			-		

a. If an appropriate feedwater oxygen monitoring approach is in use, and if there are no copper alloy tubed condenser and no copper alloy feedwater heaters, condensate oxygen can be considered a diagnostic (and thus a recommendation and not a "shall" requirement) rather than a control parameter.
b. If the condensate oxygen concentration exceeds 10 ppb, the reason for the elevated concentration should be determined, negative effects on secondary cycle components should be assessed and possible corrective actions should be identified.
c. Daily determination of pH @ 25 °C can be satisfied by calculation using specific conductivity subject to development of a correlation between specific conductivity and pH @ 25 °C, consistent with theoretical calculations and confirmation that specific conductivity remains within the normal range for the target pH @ 25 °C. Under these conditions, measurement of pH @ 25 °C may be performed on a weekly basis.

As explained above, there are some differences in detail between EPRI guidelines and Japanese PWRs experiences. The differences are mainly based on Deaerator, pH agent and location like use of sea water for condenser cooling. The ideas of both guidelines are fundamentally same and the both standard values are not so far each other. Application of the EPRI guidelines to the US-APWR does not affect the plant safety and reliability. The EPRI guidelines can be applied to adjust US PWRs which does not have Deaerator to Japanese condition.

In addition, EPRI initiates to assess the applicability of their EPRI Water Chemistry Guidelines to the design and operation of new nuclear power plants including the US-APWR. A new advanced guideline based on EPRI and other PWRs experiences will be published by the APWR commercial operation. MHI plans to apply the new guideline to US-APWR.

References:

1. EPRI, "Pressurized Water Reactor Secondary Water Chemistry Guidelines – Revision 7", EPRI TR-1016555, 2009