MITSUBISHI HEAVY INDUSTRIES, LTD.
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TOKYO, JAPAN

July 3, 2009

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-09346

Subject: MHI's Response to US-APWR DCD RAI No. 313-2361 Revision 2

Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") the document entitled "MHI's Response to US-APWR DCD RAI No. 313-2361 Revision 2". The enclosed materials provide MHI's response to the NRC's "Request for Additional Information (RAI) 313-2361 Revision 2," dated May 4, 2009.

As indicated in the enclosed materials, this document contains information that MHI considers proprietary, and therefore should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential. A non-proprietary version of the document is also being submitted in this package (Enclosure 3). In the non-proprietary version, the proprietary information, bracketed in the proprietary version, is replaced by the designation "[ ]".

This letter includes a copy of the proprietary version of the RAI response (Enclosure 2), a copy of the non-proprietary version of the RAI response (Enclosure 3), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the reasons MHI respectfully requests that all material designated as "Proprietary" in Enclosure 2 be withheld from disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

Please contact Dr. C. Keith Paulson, Senior Technical Manager, 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
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, Ltd.

D081
NRO

Enclosures:

1. Affidavit of Yoshiki Ogata
2. MHI's Response to US-APWR DCD RAI No. 313-2361 Revision 2 (proprietary)
3. MHI's Response to US-APWR DCD RAI No. 313-2361 Revision 2 (non-proprietary)

CC: J. A. Ciocco
C. K. Paulson

Contact Information

C. Keith Paulson, Senior Technical Manager
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ENCLOSURE 1

Docket No. 52-021

MHI Ref: UAP-HF-09346

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, being duly sworn according to law, depose and state as follows:

1. I am General Manager, APWR Promoting Department, of Mitsubishi Heavy Industries, Ltd. ("MHI"), and have been delegated the function of reviewing MHI's US-APWR documentation to determine whether it contains information that should be withheld from disclosure pursuant to 10 C.F.R. § 2.390 (a)(4) as trade secrets and commercial or financial information which is privileged or confidential.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled "MHI's Response to US-APWR DCD RAI No. 313-2361 Revision 2" dated July 3, 2009, and have determined that the document contains proprietary information that should be withheld from public disclosure. Those pages containing proprietary information are identified with the label "Proprietary" on the top of the page and the proprietary information has been bracketed with an open and closed bracket as shown here "[ ]". The first page of the document indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a)(4).

3. The basis for holding the referenced information confidential is that it describes the unique design of the safety analysis, developed by MHI (the "MHI Information").

4. The MHI Information is not used in the exact form by any of MHI's competitors. This information was developed at significant cost to MHI, since it required the performance of research and development and detailed design for its software and hardware extending over several years. Therefore public disclosure of the materials would adversely affect MHI's competitive position.

5. The referenced information has in the past been, and will continue to be, held in confidence by MHI and is always subject to suitable measures to protect it from unauthorized use or disclosure.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information.

7. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of supporting the NRC staff's review of MHI's application for certification of its US-APWR Standard Plant Design.

8. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without the costs or risks associated with the design and testing of new systems and components. Disclosure of the information identified as proprietary would therefore have negative impacts on the competitive position of MHI in the U.S. nuclear plant market.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 3rd day of July, 2009.

Y. Ogata

Yoshiki Ogata

ENCLOSURE 3

UAP-HF-09346
Docket No. 52-021

MHI's Response to US-APWR DCD RAI No. 313-2361 Revision 2

July 2009

(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/03/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.: **NO. 313-2361 REVISION 2**

SRP SECTION: **15.04.08 – SPECTRUM OF ROD EJECTION ACCIDENTS (PWR)**

APPLICATION SECTION: **15.4.8**

DATE OF RAI ISSUE: **5/04/2009**

QUESTION NO.: 15.4.8-1

In the rod ejection accident (REA) analysis the neglect of the high power range neutron flux rate trip is conservative. Discuss how much of a difference this assumption makes in the calculated peak fuel enthalpy?

ANSWER:

The high neutron flux and high neutron flux rate trips occur at almost the same time. A sensitivity analysis has been performed in which the trip time has been increased by approximately the amount of the expected difference in the two signals as shown in Table 15.4.8-1.1 below. The effect on peak fuel enthalpy is presented in Table 15.4.8-1.2 below. The base cases are the HFP EOC and HZP EOC cases described in DCD Subsection 15.4.8. As shown in the table, the sensitivity to the trip signal is very small and less than 1%.

Table 15.4.8-1.1 Reactor Trip Time

	HFP EOC	HZP EOC
DCD Case	0.06 sec	0.15 sec
Delayed Trip Case	0.1 sec	0.2 sec

Table 15.4.8-1.2 Peak Fuel Enthalpy Sensitivity

	HFP EOC	HZP EOC
DCD Case	148.2 cal/g	72.7 cal/g
Delayed Trip Case	(	)

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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SRP SECTION:	**15.04.08 – SPECTRUM OF ROD EJECTION ACCIDENTS (PWR)**
APPLICATION SECTION:	**15.4.8**
DATE OF RAI ISSUE:	**5/04/2009**

QUESTION NO.: 15.4.8-2

Values of ejected rod worth and hot channel factors used in the REA analysis are stated to be conservative. What are realistic values for these quantities for the events from zero and full power for both beginning- and end-of-cycle?

ANSWER:

Realistic values for ejected rod worth and hot channel factors for the first cycle described in Section 4.3 of the US-APWR DCD are shown in Table 15.4.8-2.1 below.

Ejected rod worths and hot channel factors become more severe if the axial power distribution is higher in the upper part of the core than in the lower part. Therefore, to take into account the worst condition caused during normal operation, it is conservatively assumed for the initial condition that the axial power distribution at HFP reaches the upper limit of the allowable operational band although control banks are inserted to the insertion limits.

Realistic ejected rod worths and hot channel factors in Table 15.4.8-2.1, which include[ ] margin for conservatism, are bounded by the values used in the REA analysis with sufficient margin.

Table 15.4.8-2.1 Results of Rod Ejection Analysis Under Realistic Conditions (First Cycle)

	Power	Ejected Rod Worth (pcm)		Hot Channel Factor	
		Realistic Case	DCD Case	Realistic Case	DCD Case
BOC	HFP		110		5
	HZP		600		14
EOC	HFP		120		6
	HZP		800		35

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION:	**15.4.8**
DATE OF RAI ISSUE:	**5/04/2009**

QUESTION NO.: 15.4.8-3

It is stated that the moderator reactivity is conservatively estimated by multiplying the moderator slowing down density by a conservative multiplier. Since the moderator temperature coefficient may be positive or negative depending on power level and time in cycle, is a single multiplier used? What is the multiplier and how does that relate to the statement in Table 15.0-1 that the MTC is *reduced* by 20%?

ANSWER:

The moderator temperature coefficient (MTC) is always negative in MODE1 and MODE2 with keff ≥ 1.0 for the following reasons:

1. The US-APWR core is designed so that the MTC is negative in MODE1 and MODE2 with keff ≥ 1.0.
2. It is required by the Technical Specifications that the MTC must be confirmed to be negative by measurement before reaching MODE1.
3. It is also required by the Technical Specifications that, if the measured MTC is not negative, administrative withdrawal limits for the control banks must be established so that the MTC becomes negative.

Since the MTC is always negative during power operation, including zero power, the reduction of the absolute value of the MTC is conservative for this event. The MTC is adjusted towards zero by 20% (or more) from the design value as shown in DCD Table 15.0-1. As described in DCD Subsection 15.4.8.3.2, a conservative multiplier is applied to the moderator slowing down cross section in order to achieve the 20% (or more) reduction in the MTC. As a result, this conservative multiplier varies by case.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION:	**15.4.8**
DATE OF RAI ISSUE:	**5/04/2009**

QUESTION NO.: 15.4.8-4

The void fraction is adjusted in the analysis of pressure during the REA. State what conservative multiplier is used?

ANSWER:

A conservative multiplier of[ ]is applied to the calculated void fraction. An analysis to determine sensitivity to void fraction has been performed. The peak RCS pressure increases as void fraction increases as shown below in Figure 15.4.8-4.1. The peak RCS pressure and void fraction are almost proportional. As a result, MHI conservatively adjusts the void fraction by a factor of[ ].

Figure 15.4.8-4.1 RCP Outlet Pressure versus Time Void Fraction Sensitivity Analysis

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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SRP SECTION: **15.04.08 – SPECTRUM OF ROD EJECTION ACCIDENTS (PWR)**

APPLICATION SECTION: **15.4.8**

DATE OF RAI ISSUE: **5/04/2009**

QUESTION NO.: 15.4.8-5

Per Regulatory Guide 1.77, perform rod ejection analyses for both Beginning of Cycle and End of Cycle starting from a low-power condition and provide analysis results.

ANSWER:

A spectrum of rod ejection accidents for BOC/EOC from low power conditions are analyzed using TWINKLE-M (3-D model) static and transient calculations and VIPRE-01M. The best estimate analysis conditions are assumed for the ejected RCCA reactivity, feedback coefficient, peaking factor, and gap heat transfer coefficient. The ejected rod worth and peaking factor are key parameters for this event and the calculation results for this event are dominated by these two parameters. A spectrum of rod ejection accidents from HFP and HZP are also analyzed with best estimate and 3-D conditions for reference.

First, static calculations are done for the first cycle BOC, first cycle EOC, 24 month equilibrium core BOC, and 24 month equilibrium core EOC. The initial power is assumed to be 0%, 20%, 40%, 60%, 80%, and 100%. The ejected RCCA position is selected from 5 different positions within bank-C and bank-D. The results of the static calculations are shown below in Table 15.4.8-5.1 and Figures 15.4.8-5.1 to 15.4.8-5.8. The identifiers for the control rod locations are also shown in Figure 15.4.8-5.9. Uncertainty is also assumed in the ejected rod worth and F_Q.

Based on these cases, the first cycle BOC and 24 month equilibrium core EOC are selected for additional transient calculations. The transient calculation results are shown below in Figures 15.4.8-5.10 to 15.4.8-5.15. The ejected rod is selected in order to maximize the ejected rod worth. From Figures 15.4.8-5.14 and 15.4.8-5.15, it is clear that the calculation results for partial power with best estimate conditions are bounded by the DCD cases. Thus, by considering the proper conservatism for the HFP and HZP case, the DCD calculation results are bounding for all initial power conditions.

Table 15.4.8-5.1 Ejected RCCA Worth and F_Q of Each Case

		24 Month Equilibrium Core BOC		24 Month Equilibrium Core EOC		First Cycle BOC		First Cycle EOC	
	Initial Power	F_Q	Ejected RCCA Worth (%Δk/k)	F_Q	Ejected RCCA Worth (%Δk/k)	F_Q	Ejected RCCA Worth (%Δk/k)	F_Q	Ejected RCCA Worth (%Δk/k)
Bank D (J15)	0%								
	20%								
	40%								
	60%								
	80%								
	100%								
Bank D (D14)	0%								
	20%								
	40%								
	60%								
	80%								
	100%								
Bank D (J11)	0%								
	20%								
	40%								
	60%								
	80%								
	100%								
Bank C (G15)	0%								
	20%								
	40%								
	60%								
	80%								
	100%								
Bank C (E13)	0%								
	20%								
	40%								
	60%								
	80%								
	100%								

Figure 15.4.8-5.1 Ejected RCCA Worth versus Initial Power – 24 Month Equilibrium Core BOC

Figure 15.4.8-5.2 Ejected RCCA Worth versus Initial Power – 24 Month Equilibrium Core EOC

Figure 15.4.8-5.3 Ejected RCCA Worth versus Initial Power – First Cycle BOC

Figure 15.4.8-5.4 Ejected RCCA Worth versus Initial Power – First Cycle EOC

Figure 15.4.8-5.5 F_Q versus Initial Power – 24 Month Equilibrium Core BOC

Figure 15.4.8-5.6 F_Q versus Initial Power – 24 Month Equilibrium Core EOC

Figure 15.4.8-5.7 F_Q versus Initial Power – First Cycle BOC

Figure 15.4.8-5.8 F_Q versus Initial Power – First Cycle EOC

180˚

	T	S	R	P	N	M	L	K	J	H	G	F	E	D	C	B	A
1																	
2						SD		SB		SB		SD					
3			B		A		C		D		C		A		B		
4				D										D			
5			A		C		B		SA		B		C		A		
6		SD														SD	
7			C		B		SC		D		SC		B		C		
8		SB														SB	
9 (90˚ / 270˚)			D		SA		D		A		D		SA		D		
10		SB														SB	
11			C		B		SC		D		SC		B		C		
12		SD														SD	
13			A		C		B		SA		B		C		A		
14				D										D			
15			B		A		C		D		C		A		B		
16						SD		SB		SB		SD					
17																	

0˚

		Number of RCCAs
A:	Control group, Bank A	9
B:	Control group, Bank B	12
C:	Control group, Bank C	12
D:	Control group, Bank D	12
SA:	Shutdown group, Bank A	4
SB:	Shutdown group, Bank B	8
SC:	Shutdown group, Bank C	4
SD:	Shutdown group, Bank D	8

Figure 15.4.8-5.9 US-APWR RCCA Locations

Figure 15.4.8-5.10 Reactor Power versus Time – 24 Month Equilibrium Core EOC

Figure 15.4.8-5.11 Pellet Center Temperature versus Time – 24 Month Equilibrium Core EOC

Figure 15.4.8-5.12 Reactor Power versus Time – First Cycle BOC

Figure 15.4.8-5.13 Pellet Center Temperature versus Time – First Cycle BOC

Figure 15.4.8-5.14 Pellet Center Temperature versus Initial Power

Figure 15.4.8-5.15 Fuel Enthalpy Rise versus Initial Power

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

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DATE OF RAI ISSUE:	**5/04/2009**

QUESTION NO.: 15.4.8-6

Provide drawings of the missile shield which dissipates the ejected CRDM's kinetic energy. Also, provide analysis to demonstrate that the CRDM's resulting kinetic energy upon deflection is sufficiently low so as to not cause the failure of a neighboring housing.

ANSWER:

The missile shield is installed to the upper seismic support as shown below in Figure 15.4.8-6.1. Even if a CRDM missile occurs due to the failure of the CRDM nozzle welding, the collision of the top of rod travel housing with the missile shield can limit the uplift of the coil housing to approximately[ ] inches, even though the CRDM is uplifted. On the other hand, the radial gap between coil housings placed in the CRDM is narrow, around [ ] inches. The missile shield prevents a coil housing from passing through the narrow gap area and limits the radial movement, which results in nearly vertical missile energy. Therefore, the impact load applied to the neighboring CRDM housing is sufficiently low so as to not cause the failure of a neighboring housing.

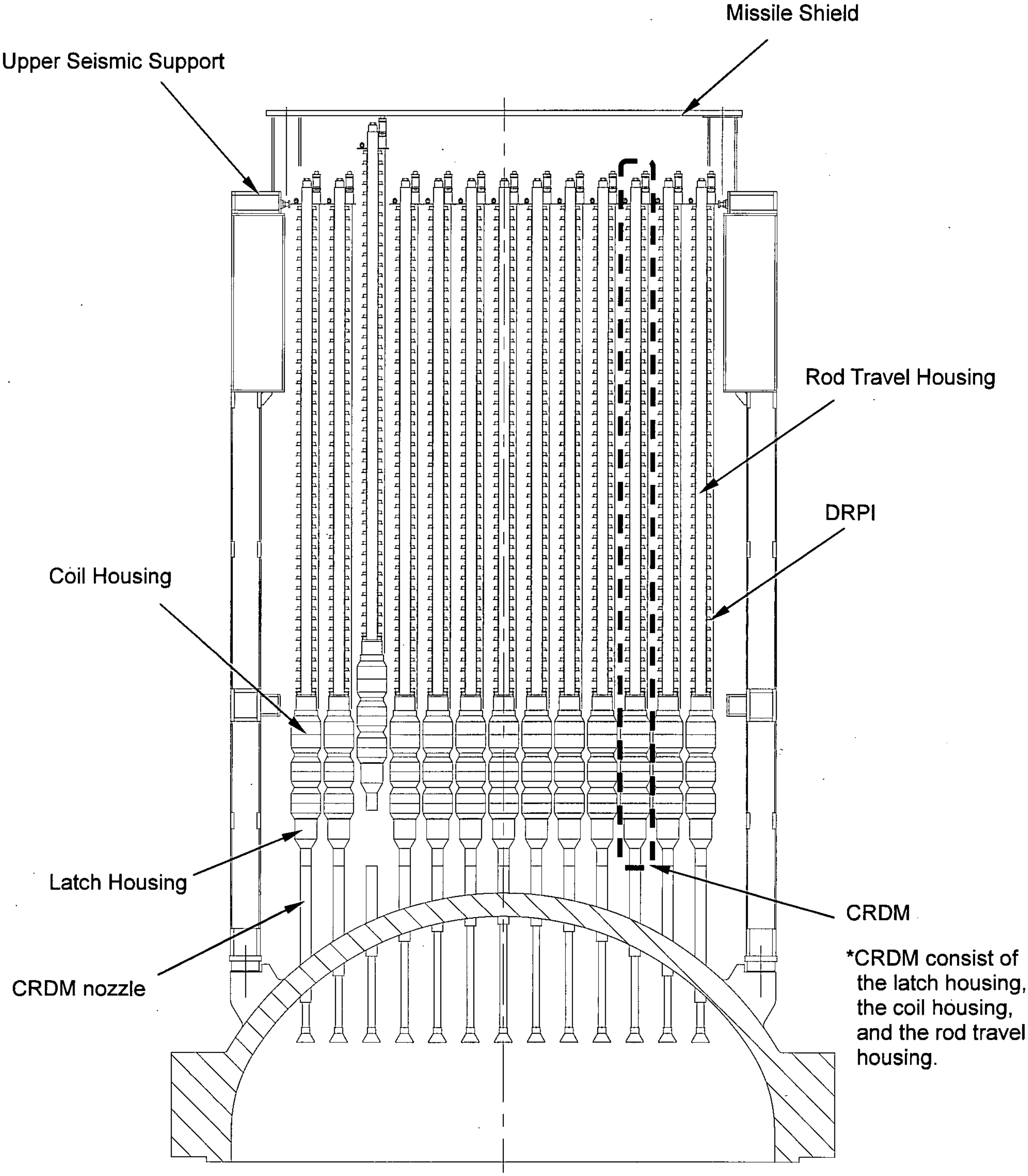

Figure 15.4.8-6.1 Missile Shield and CRDM

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO.: 15.4.8-7

In accordance with SRP Section 15.4.8 guidance found in Part III, "Review Procedures," include consideration of PCMI failure during the rod ejection analysis for at-power conditions.

ANSWER:

The enthalpy rise for the partial power case is shown in Figure 15.4.8-5.14 of the response to Question 15.4.8-5 of this RAI. The acceptance criteria for fuel enthalpy rise changes with cladding oxide thickness and the minimum value is 60 cal/g. The enthalpy rise for the partial power case is clearly less than 60 cal/g, and no PCMI failure occurs.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO.: 15.4.8-8

Provide the specific "realistic" gap conductance models employed for the DNB and RCS pressure analysis along with the justification for their applicability.

ANSWER:

Since the reactor power increases during the rod ejection event, the gap conductance increases due to the pellet thermal expansion and the consequent shrinking of the fuel pellet-to-cladding gap. This makes the DNBR and RCS pressure more severe due to the higher heat release and void generation. The "realistic" gap conductance model is used in the rod ejection analysis in order to account for the effect of the gap conductance increase.

The model used for the realistic gap conductance is originally incorporated in the VIPRE-01 code. This model is a simplified version of the one from the widely known fuel rod performance codes, GAPCON and FRAP, and is based on the Ross-Stoute model. The details and verifications of the VIPRE-01 fuel rod model are described in Ref. 15.4.8-8.1.

In the model, the width of the fuel pellet-to-cladding gap is calculated considering fuel deformation due to thermal expansion and elastic and thermal stresses. It can accurately model the gap conductance change during the transient. The input value of cold gap width is adjusted to match the gap conductance with that calculated by the fuel design code, FINE, to establish the proper initial condition.

Thus, the heat transferred from the fuel rods can be predicted realistically. The rod ejection analysis considers various conservative assumptions like the reactivity insertion and hot spot peaking factor to assure that the overall analysis is limiting.

Reference:

15.4.8-8.1 "VIPRE-01: A Thermal-Hydraulic Code for Reactor Cores," NP-2511-CCM-A Revision 4, Electric Power Research Institute (EPRI), February 2001.

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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QUESTION NO.: 15.4.8-9

Provide the specific number of fuel rods predicted to be in DNB for Beginning of Cycle and End of Cycle for HFP cases.

ANSWER:

The number of rods in DNB for the beginning of cycle HFP case is [ ]. The number of rods in DNB for the end of cycle HFP case is [ ].

Impact on DCD

There is no impact on the DCD.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

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APPLICATION SECTION:	**15.4.8**
DATE OF RAI ISSUE:	**5/04/2009**

QUESTION NO.: 15.4.8-10

Question has been deleted.

ANSWER:

NA

Impact on DCD

NA

Impact on COLA

NA

Impact on PRA

NA