**MITSUBISHI HEAVY INDUSTRIES, LTD.**
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**TOKYO, JAPAN**

July 7, 2011

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

Attention: Mr. Jeffery A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-11210

**Subject:** MHI's Responses to US-APWR DCD RAI No. 762-5749 Revision 3 (SRP 05.04.12)

**Reference:** 1) "REQUEST FOR ADDITIONAL INFORMATION 762-5749 REVISION 3, SRP Section: 05.04.12 - Reactor Coolant System High Point Vents, Application Section: 5.4.12" dated 5/26/2011.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Response to Request for Additional Information No. 762-5749, Revision 3."

Enclosed are the responses to one RAI contained within Reference 1. This transmittal completes the response to this RAI.

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.

Enclosure:

1. Response to Request for Additional Information No. 762-5749, Revision 3

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NRO

CC: J. A. Ciocco
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Enclosure 1

UAP-HF-11210
Docket No. 52-021

# Response to Request for Additional Information No. 762-5749, Revision 3

July, 2011

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**7/7/2011**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No. 52-021**

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|---|---|
| **RAI NO.:** | **NO. 762-5749 REVISION 3** |
| **SRP SECTION:** | **05.04.12 – Reactor Coolant System High Point Vents–** |
| **APPLICATION SECTION:** | **05.04.12** |
| **DATE OF RAI ISSUE:** | **5/26/2011** |

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**QUESTION NO.:** 05.04.12-2

a) The acceptance criteria in SRP Section 5.4.12 states that reactors with U-tube steam generators should develop procedures to remove sufficient gas from the U-tubes to ensure continued core cooling. Provide these procedures or propose an alternative method of complying with the regulations identified in SRP Section 5.4.12.
b)The acceptance criteria in SRP Section 5.4.12 states that procedures (or detailed DCD descriptions of these procedures) to effectively operate the vent system should consider when venting is needed, when it is not needed and the variety of initial conditions for which venting is required. Procedures (or DCD descriptions of procedures) should also include operator actions and the necessary instrumentation. While some of this information is provided in DCD 5.4.12.3 and the response to RAI 5.4.12-5, neither document fully explains the operation of the venting system. Provide the procedures (or proposed DCD revisions) to meet the above criteria being sure to include which vents (reactor vessel head vent, safety depressurization valve, depressurization valve) are used for each procedure, and if the procedure is intended for normal operation, accident mitigation, and severe accident mitigation. Regarding the DCD 5.4.12.3(B) description of the safety depressurization valve, explain what is meant by "operation is needed when heat removal from the SG fails and SG water level is lowered with respect to the wide range" and identify which transients from Chapter 15 need this operation.

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**ANSWER:**

US-APWR DCD Tier2,Section 5.4.12,states:
"The reactor vessel head vent, the safety depressurization valve (SDV), and the depressurization valve (DV) could be used for high point vents. The SDV and DV are connected to the pressurizer. The US-APWR does not require elimination of noncondensable gases for core cooling following design based accidents using high point vents."
"The reactor vessel head vent is used to enhance natural circulation of the reactor coolant by eliminating non-condensable gases in the upper plenum of the reactor vessel."

"The SDVs are used to cool the reactor core by feed and bleed operation when loss of heat removal from the SGs occurs."

"The DVs are used to prevent high pressure melt ejection (HPME) at vessel failure and temperature induced steam generator tube rupture (TI-SGTR) by depressurizing the reactor coolant system."

And the response to RAI 5.4.12-5 (RAI No.48-840 dated Sept.22,2008) states:

"The RCS high point vents of non-condensable gases are implemented when in-vessel retention(IVR) is achieved for transient sequence in severe accidents."

The following provides the response to RAI 762-5749 for removing noncondensable gases from the reactor coolant system and reactor vessel.

a) If a gas accumulation is detected in the RV head by the RV water level instrumentation and natural circulation of the reactor coolant can not be confirmed by core exit temperature, then noncondensable gas could accumulate in the SG tubes. In this situation the removal of the noncondensable gas would follow the procedure outlined below:

a-1) Open the RV head vent valve to vent the noncondensable gas accumulating in the RV head to the pressurizer relief tank (PRT). Monitor and confirm that the noncondensable gas is vented from the RV head by monitoring the RV water level instrumentation. Supply makeup water to the RCS using the charging pumps or SI umps to fill the reactor vessel, as needed.

a-2) Close the RV head vent valve, start an RCP in each steam generator loop and run the RCP for a period of time, and then stop the pump; this will allow any noncondensable gases accumulating in the SG U-tubes to be transferred to the RV head.

a-3) Open the RV head vent valve to vent the noncondensable gas accumulating in the RV head to the PRT and again supply makeup water to the RCS using the charging pumps or SI pumps, as needed. Confirm that the noncondensable gas is vented from the RV head by monitoring the RV water level instrumentation.

a-4) Repeat the steps a-2 and a-3 until the noncondensable gas is vented completely from the RCS. If the PRT rupture disk is broken, the noncondensable gas in the PRT would be vented to the containment.

a-5) If the natural circulation of the reactor coolant can not be confirmed by the indications of the core exit temperature instruments, the noncondensable gas could still accumulate in the SG tubes, and steps a-2 and a-3 will need to be repeated, to remove the gases, until natural circulation can be confirmed.

b) The RCS high point vents are used for the venting of noncondensable gas during plant startup and severe accident. The RCS high point vent procedures for these two scenarios are as follows:

b-1) RCS venting during plant startup:

After the RV head is installed, fill the RV head by opening the RV head vent valve and supply reactor coolant makeup using the charging pump. To remove any accumulated noncondensable gas from the SG U-tubes and to allow for it to be vented by the RV head vent ,repeat the RCP short term operation as described in item a above.

b-2) RCS venting for severe accident mitigation:

The reactor vessel head vent system is implemented when in-vessel retention (IVR) is achieved for the transient sequence in severe accidents.

If noncondensable gas accumulation is detected in the RV head by observing RV water level instrumentation and natural circulation of the reactor coolant is not confirmed by core exit temperature instruments, then, the procedure to remove the noncondensable gas is applied. This procedure is the same as that provided in item a above.

The RV head vent system, SDV, and DV are used in the following events:

RV head vent: The RV head vent is used for the RCS venting during plant startup and for accomplishing the RCS natural circulation during severe accident mitigation.

SDV: The Safety Depressurization Valve (SDV) is provided to cool the RCS by feed (by SI pump) and bleed (by SDV) operation in the unlikely event that heat removal from secondary system is unavailable.*

DV: The DVs are used to prevent high pressure melt ejection (HPME) at vessel failure and temperature induced steam generator tube rupture (TI-SGTR) by depressurizing the RCS.

* Heat removal from the secondary system is secured considering a single failure in the accident analysis in Chapter 15; therefore, the SDV is not used in the Chapter 15 transient analyses.

**Impact on DCD**

See Attachment 1 for the mark-up of DCD Section5.4.12, Revision 3, changes to be incorporated.

- Add the following sentence after the first paragraph of Section 5.4.12.2.
  " The reactor vessel head vent is used for the air vent path during plant startup to fill the reactor coolant system and reactor vessel head."
- Add the following sentence after the last paragraph of Section 5.4.12.2.
  "The noncondensable gases accumulating in the SG U-tubes are transferred to the RV head by operating the RCP's."
- Add the following sentence after the last paragraph of Section5.4.12.3.
  "The noncondensable gases accumulating in the SG U-tubes are transferred to the RV head by using a procedure that operates a RCP in each SG for a short time to purge the gases from the SG to the reactor vessel, and then the RCP is stopped."

**Impact on R-COLA**

There is no impact on the COLA.

**Impact on S-COLA**

There is no impact on the S-COLA.

**Impact on PRA**

There is no impact on the PRA.

**Attachment 1**

**US-APWR DCD Section 5.4.12 Mark-up**

**Response to RAI No.762-5749 Revision 3**

### 5.4.12 Reactor Coolant System High Point Vents

The reactor vessel head vent, the safety depressurization valve (SDV), and the depressurization valve (DV) could be used for high point vents. The SDV and DV are connected to the pressurizer. The US-APWR does not require elimination of non-condensable gases for core cooling following design based accidents using high point vents. RCS piping and instrumentation diagram (Figure 5.1-2) shows the system arrangements.

#### 5.4.12.1 Design Bases

The high point vents system is designed to provide the vent path which is used to enhance natural circulation of reactor coolant by eliminating non-condensable gases.

The high point vents system satisfies applicable requirements and industry standards, including ASME Code classifications, 10 CFR 50.34(f) (2)(vi) (Ref. 5.4-2), 10 CFR 50.44 (Ref. 5.4-3), 10 CFR 50.46 (Ref. 5.4-4), 10 CFR 50.46a (Ref. 5.4-5), 10 CFR 50.49 (Ref. 5.4-6), 10 CFR 50.55a (Ref. 5.4-7), safety classifications and environmental qualification.

The piping and equipment from the reactor vessel head vent up to and including the second vent valve, and from the pressurizer up to and including SDV and DV are designed and fabricated according to ASME Codes Section III, Class 1 requirements.

The Class 1 piping used for the reactor vessel head vent is 1-inch schedule 160 pipe. The piping analysis is following the procedures of NC-3600 for Class 2 piping in accordance with ASME Section III.

As discussed in Subsection 3.9.3, the discharge piping and support arrangement is designed considering the effect of thrust forces on the piping system from valve operations.

Vent areas should provide good mixing with containment air.

Venting does not adversely affect the performance of safety-related SSCs, and does not aggravate the challenge to containment or the course of an accident.

Pursuant to the quality assurance program discussed in Chapter 17, the high point vent system is designed.

#### 5.4.12.2 System Design

(A) Reactor Vessel Head Vent

The reactor vessel head vent is used to enhance natural circulation of the reactor coolant by eliminating non-condensable gases in the upper plenum of the reactor vessel. The reactor vessel head vent design parameter is shown in Table 5.4.12-1.

And the reactor vessel head vent is used for the air vent path during plant startup to fill the reactor coolant system and reactor vessel head.

The reactor vessel head vent arrangement consists of a flow path that diverges into two parallel paths each with two redundant 1-inch motor-operated remote manual valves connected in series. A 1-inch vent pipe is located near the center of the reactor vessel head. The reactor vessel head vent discharge line is connected to PRT.

The noncondensable gases accumulating in the SG U-tubes are transferred to the RV head by operating the RCP's.

The valve arrangement of two normally closed valves in series in each flow path minimizes the possibility of inadvertent actuation. The motor-operated valves are controlled from the MCR. Open and closed indication of the valves is provided and monitored from MCR. Each valve connected in series is powered by the independent Class 1E power supply. And these valves could be also powered by alternate alternating current power supplies which are available under station blackout conditions. The valves are qualified to IEEE 344.

Information available to the operator for initiating and terminating system operation is as follows:

- Information available for initiating system operation: core damage
- Information available for terminating system operation: reactor vessel water level

"Core damage" is judged from dose rate in the containment and core exit temperature.

(B) Safety depressurization valve

The SDVs are used to cool the reactor core by feed and bleed operation when loss of heat removal from the SGs occurs. The SDVs are the motor-operated remote manual valves. SDV design parameter is shown in Table 5.4.12-2.

The SDVs arrangement consists of two flow paths with the motor-operated remote manual block valve located at the upstream of each SDV. The block valves are used in case the SDVs are stuck open or leak excessively. The SDVs and the block valves are controlled from MCR. Open and closed indication of the valves is provided and monitored from MCR. The SDVs and the block valves are respectively powered by the independent Class 1E power supply. And these valves could be also powered by alternate alternating current power supplies which are available under the station blackout condition. The valves are qualified to IEEE 344.

Information available to the operator for initiating and terminating the SDVs operation at severe accident is as follows:

- Information available for initiating system operation: SG secondary side water level (wide range)
- Information available for terminating system operation: SG secondary side water level (wide range)

(C) Depressurization valve

The DVs are used to prevent high pressure melt ejection (HPME) at vessel failure and temperature induced steam generator tube rupture (TI-SGTR) by depressurizing the reactor coolant system. The DVs design parameters are shown in Table 5.4.12-3.

The DVs arrangement consists of a flow path with two redundant motor-operated remote manual valves connected in series. Non-condensed gas or steam is directly discharged to the containment vessel.

- The operation requires instruments for dose rate in containment, core exit temperature and RV water level.

The operations are initiated and terminated manually in accordance with the above-described conditions.

The noncondensable gases accumulating in the SG U-tubes are transferred to the RV head by using a procedure that operates a RCP in each SG for a short time to purge the gases from the SG to the reactor vessel,and then the RCP is stopped.

(B) Safety depressurization valve

lock valve is provided at the upstream of each SDV in series so that a single failure remotely operated vent valves, power supply, or control system does not prevent on of the flow path.

verview of system operation is as follows:

- The operation is needed when heat removal from the SG fails and SG water level is lowered with respect to wide range.
- Core damage does not occur in the assumed conditions so that non-condensable bubbles must not be generated in the RCS.
- The operation is started when decay heat is not removed from the core due to low SG water level but the core is still intact.
- The operation requires instruments for SG water level (wide range).
- The operations are initiated and terminated manually in accordance with the above-described conditions.

(C) Depressurization valve

The DVs are two normally closed valves in series in a flow path. This arrangement eliminates the possibility of opening a flow path due to the spurious opening of one valve.

The overview of the DVs operation is as follows:

- The operation is needed when RCS is higher than the pressure in which HPME probably occurs after onset of core damage.
- The size of a non-condensable bubble is estimated from reading of RV water level indication.
- The operation is started when the heat removal from the core fails after onset of core damage.
- The operation requires instruments for dose rate in containment, core exit temperature, and RCS pressure, and information on success and failure of both vessel head vent valves and reactor core coolant injection.

The operations are initiated and terminated manually in accordance with the above-described conditions.