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TOKYO, JAPAN

March 10, 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-09079

Subject: MHI's Responses to US-APWR DCD RAI No.199-2073

Reference: 1) "Request for Additional Information No. 199-2073 Revision 1, SRP Section: 10.02.03 – Turbine Rotor Integrity, Application section Tier 2 FSAR Section 10.2.3," dated February 9, 2009.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 199-2073 Revision 1"

Enclosed is the responses to 7 RAIs contained within Reference 1.

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 with the information identified as proprietary redacted and replaced by the designation "[ ]".

This letter includes a copy of the proprietary version (Enclosure 2), a copy of the non-proprietary version (Enclosure 3), and the Affidavit of Yoshiki Ogata (Enclosure 1) which identifies the reasons MHI respectfully requests that all materials designated as "Proprietary" in Enclosure 2 be withheld from public 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 the submittals. His contact information is below.

Sincerely,

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

D081
NRO

Enclosure:

1. Affidavit of Yoshiki Ogata

2. Responses to Request for Additional Information No. 199-2073 Revision 1 (proprietary version)

3. Responses to Request for Additional Information No. 199-2073 Revision 1 (non-proprietary version)

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

Contact Information
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Enclosure 1

Docket No. 52-021
MHI Ref: UAP-HF-09079

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

I, Yoshiki Ogata, 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 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.

2. In accordance with my responsibilities, I have reviewed the enclosed document entitled "Responses to Request for Additional Information No. 199-2073 Revision 1" dated March 2009, and have determined that portions of the document contain 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 information identified as proprietary in the enclosed document has in the past been, and will continue to be, held in confidence by MHI and its disclosure outside the company is limited to regulatory bodies, customers and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and is always subject to suitable measures to protect it from unauthorized use or disclosure.

4. The basis for holding the referenced information confidential is that it describes the unique design by MHI for performing the turbine rotors design of the US-APWR.

5. The referenced information is being furnished to the Nuclear Regulatory Commission ("NRC") in confidence and solely for the purpose of information to the NRC staff.

6. The referenced information is not available in public sources and could not be gathered readily from other publicly available information. Other than through the provisions in paragraph 3 above, MHI knows of no way the information could be lawfully acquired by organizations or individuals outside of MHI.

7. Public disclosure of the referenced information would assist competitors of MHI in their design of new nuclear power plants without incurring the costs or risks associated with the design of the subject systems. Therefore, disclosure of the information contained in the referenced document would have the following negative impacts on the competitive position of MHI in the U.S. nuclear plant market:

A. Loss of competitive advantage due to the costs associated with development of turbine rotor materials.

B. Loss of competitive advantage of the US-APWR created by benefits of information of turbine rotor materials specification.

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 10th day of March, 2009.

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

QUESTION NO.: 10.02.03-6, RAI 10.2.3-6

The US APWR DCD, Tier 2, FSAR Section 10.2.3.5 states the ultrasonic inspection is performed on both the high and low-pressure turbine rotors "at intervals of about 10 years." Clarify the inspection interval of "about 10 years," to a more specific value or range, such as "every 10 years" or "10 year intervals," etc..

ANSWER:

Each rotor, stationary and rotating blade path components shall be inspected at the interval equal or less than 10 years

Impact on DCD

DCD Subsection 10.2.3.5, first bullet, first item shall be revised as follows,

- Each rotor, stationary and the rotating blade path component is inspected visually and by magnetic particle testing on its accessible surfaces. Ultrasonic inspection of the side entry blade grooves is conducted. These inspections are conducted at intervals equal or less than ~~of about~~ 10 years for both high-pressure and low-pressure turbines.

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

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

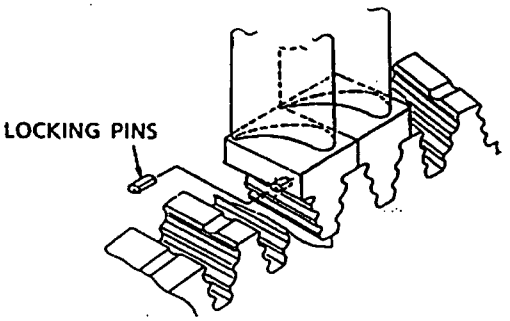
RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

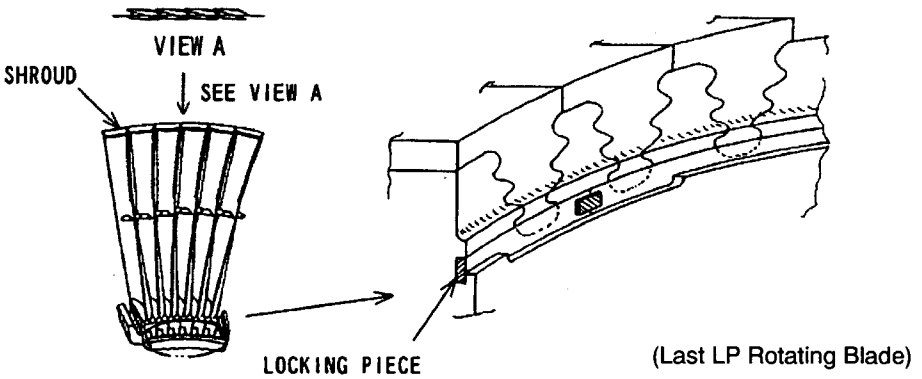
QUESTION NO.: 10.02.03-7, RAI 10.2.3-7

Provide a sketch of the christmas tree side entry type root attachment referenced in US APWR DCD, Tier 2, FSAR Section 10.2.3.4 for connecting the turbine blades to the rotor. Discuss how ultrasonic inspection performed during inservice inspection in accordance with US APWR DCD, Tier 2, FSAR Section 10.2.3.5 will be performed and whether 100% coverage of the area can be achieved for the christmas tree side entry type root attachment.

ANSWER:

The sketch of christmas tree side entry type root is as follows.





(Last LP Rotating Blade)

In regard to ultrasonic inspection during inservice inspection for the chrstmas tree side entry root attachment, we made some mistake and need to revise DCD Subsection 10.2.3.5, the first bullet, the first item. "Magnetic particle inspection" on both inlet and outlet side will be conducted for every rows instead of "Ultrasonic inspection". In case of side entry structure as you see in the previous sketches, end-surface of rotor grooves are directly observed and visual and magnetic particle inspection are good enough to verify the existence of cracks.

Impact on DCD

DCD Subsection 10.2.3.5, the first bullet, the first item therefore shall be replaced by the following sentences.

- Each rotor, stationary and the rotating blade path component is inspected visually and by magnetic particle testing on its accessible surfaces. Magnetic Particle ~~Ultrasonic~~ inspection of the side entry blade grooves is conducted. These inspections are conducted at intervals equal or less than 10 years for both high-pressure and low-pressure turbines.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.

Docket No. 52-021
MHI Ref: UAP-HF-09079

Enclosure 3

UAP-HF-09079
Docket Number 52-021

Responses to Request for Additional Information
No. 199-2073 Revision 1

March 2009
(Non Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

QUESTION NO.: 10.02.03-1, RAI 10.2.3-1

The US APWR DCD, Tier 2, FSAR Section 10.2.3.1 specifies that the turbine rotor material complies with the chemical properties of ASTM A470, Classes 5, 6, and 7, but the specification for the rotor has lower limitations for phosphorous, sulfur, aluminum, antimony, tin, argon and copper than ASTM A470. In addition the US APWR DCD, Tier 2, FSAR Section 10.2.3.2 states that the impact energy and transition temperature requirements are more rigorous than those given in ASTM A470 Class 6 or 7. The above does not provide sufficient information concerning the material used for the LP and HP turbine rotors in accordance with SRP Section 10.2.3 to assess its acceptability on the turbine rotor integrity. Therefore, the NRC staff requests the following information be provided in the US APWR DCD FSAR:

a) The chemical composition ranges, including maximum levels of trace elements, and the corresponding mechanical properties (yield strength, impact energy, transition temperature, etc.) of the materials that differ from the ASTM A470 specification.

b) Discuss how these material properties relate to those used in the turbine missile analysis (Mitsubishi Report MUAP-07028, Revision 0).

ANSWER:

The turbine rotor material basically complies the chemical property limits of ASTM A470, Classes 5, 6 and 7 and we believe that ASTM A470 gives enough information for review. But some minor differences from ASTM A470 exist in the LP rotor material and these differences are listed in this reply to NRC. Designation of ASTM A470 and additional information which shows the difference from ASTM A470 therefore will be satisfy the requirement of SRP and DCD subsection 10.2.3.1 will be not modified.

a) Table 1 and Table 2.shows the chemical composition ranges, including maximum levels of trace elements, and the corresponding mechanical properties (yield strength, impact energy, transition temperature, etc.) of the materials that differ from the ASTM A470 specification.

As there are not specified chemical compositions of tin (Sn), argon and copper (Cu) by ASTM A470 Grade C, these elements shall be deleted from 1ST paragraph of DCD Subsection 10.2.3.1.

b) The yield strength is used in the turbine missile analysis. The evaluation value of yield strength is [621MPa], which is the minimum strength required for purchasing rotor material.

Table 1 Comparison of the chemical composition ranges

	Purchase Specification of LP Rotor Forging			ASTM A470 Grade C
	Heat Analysis	Allowable Deviation for Product Analysis		
		For Minimum	For Maximum	
C *	[ ]	[ ]	[ ]	0.28%
Mn	[ ]	[ ]	[ ]	0.20 - 0.60%
P	[ ] Desired Value : Less than [ ]	[ ]	[ ]	0.012%
S	[ ] Desired Value : Less than [ ]	[ ]	[ ]	0.015%
Si	[ ]	[ ]	[ ]	(B,C)
Ni	[ ]	[ ]	[ ]	3.25 - 4.00%
Cr	[ ]	[ ]	[ ]	1.25 - 2.00%
Mo	[ ]	[ ]	[ ]	0.25 - 0.60%
V	[ ]	[ ]	[ ]	0.05 - 0.15%
Sb **	[ ]	[ ]	[ ]	(E)
Al **	[ ]	[ ]	[ ]	0.015%
Cu **	[ ]	[ ]	[ ]	Not Specified
Sn **	[ ]	[ ]	[ ]	Not Specified
As **	[ ]	[ ]	[ ]	Not Specified

* It is desirable that carbon content shall be held to as low a level as possible.
** These are the desired values.

(B) 0.10% max, unless an alternative value, not in excess of 0.30%, is specified in the purchase order.
(C) 0.15 to 0.30% silicon is permitted for material that is subsequently VAR Processed.
(E) To be reported for information only on all Grades.

Table 2 Comparison of the mechanical properties

Test	Item	Purchase Specification of LP Rotor Forging	ASTM A470 Grade C (Class 6)
Tensile Test	Tensile Strength	[ ]	725 - 860 MPa
	Yield Strength (0.2% offset)	[ ]	Min.620 MPa
	Elongation	[ ]	Min.17%
	Reduction of Area	[ ]	Min.50%
Impact Test	Impact Strength at 21-27 deg C	[ ]	Min.61J
	50% FATT	[ ]	Max.-7 deg C
	Upper Shelf Energy Level	[ ]	-

Impact on DCD

1st paragraph in DCD Subsection 10.2.3.1 will be revised as follows, because there are no specific requirement for tin, argon and copper in the ASTM standards.

10.2.3.1 Materials Selection

Fully integral turbine rotors are made from ladle refined, vacuum deoxidized Ni-Cr-Mo-V alloy steel by processes that maximize the cleanliness and toughness of the steel. The lowest practical concentrations of residual elements are obtained through the melting process. The turbine rotor material complies with the chemical property limits of ASTM A470 (Reference 10.2-5), Classes 5, 6, and 7. The specification for the rotor steel has lower limitations than indicated in the ASTM standard (Reference 10.2-5) for phosphorous, sulphur, aluminum and antimony~~, tin, argon, and copper~~.

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

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

QUESTION NO.: 10.02.03-2, RAI 10.2.3-2

The US APWR DCD, Tier 2, FSAR Section 10.2.3.1 specifies that charpy tests and tensile tests in accordance with ASTM A370 and /or the equivalent are required from the forging supplier. This does not provide specifics about the tests in order for the staff to review it with. The guidelines of SRP Section 10.2.3 has specific guidelines for the staff to use in reviewing the acceptability of the material selection and fracture toughness of the rotor. Therefore, the NRC staff requests that the following information be provided:

a) Provide the specific tests (i.e., chemical analysis, Charpy V-notch – including fracture appearance temperature (FATT), tensile) to be performed, the acceptance criteria and the number of tests to be performed on the fabricated rotor. Also, specify the equivalent standards and provide the criteria used to determine that these standards are equivalent to ASTM A370 in order to ensure that the material properties are tested appropriately and consistently to prevent failure of the turbine rotor assemblies and the generation of potential missiles in accordance with GDC 4 of Appendix A to 10 CFR Part 50.

b) The US APWR DCD, Tier 2, FSAR Section 10.2.3.1 also implies that the rotor may or may not have a bored area. Discuss where the tests locations will be on the rotor, including the bore region. In addition, discuss how the material properties for the fabricated rotor will be homogeneous for the internal regions if the rotor is not bored.

ANSWER:

a) The chemical composition and the mechanical properties of rotor material shall be determined by performing the following tests.

Chemical Composition
- (1) Heat Analysis
- (2) Product Analysis

Mechanical Properties
- (3) Tensile Test
- (4) Impact Test (Charpy Impact Test)

The acceptance criteria are as follows, and these value shall be described in the purchase specification of rotor forging.

Table 1 Acceptance criteria of the chemical composition

	Heat Analysis	Allowable Deviation for Product Analysis	
		For Minimum	For Maximum
C *	[ ]	[ ]	[ ]
Mn	[ ]	[ ]	[ ]
P	[ ] Desired Value : Less than [ ]	[ ]	[ ]
S	[ ] Desired Value : Less than [ ]	[ ]	[ ]
Si	[ ]	[ ]	[ ]
Ni	[ ]	[ ]	[ ]
Cr	[ ]	[ ]	[ ]
Mo	[ ]	[ ]	[ ]
V	[ ]	[ ]	[ ]
Sb **	[ ]	[ ]	[ ]
Al **	[ ]	[ ]	[ ]
Cu **	[ ]	[ ]	[ ]
Sn **	[ ]	[ ]	[ ]
As **	[ ]	[ ]	[ ]

* It is desirable that carbon content shall be held to as low a level as possible.
** These are the desired values.

Table 2 Acceptance criteria of the mechanical properties

Test	Item	Purchase Specification of LP Rotor Forging
Tensile Test	Tensile Strength	[ ]
	Yield Strength (0.2% offset)	[ ]
	Elongation	[ ]
	Reduction of Area	[ ]
Impact Test	Impact Strength at 21-27 deg C	[ ]
	50% FATT	[ ]
	Upper Shelf Energy Level	[ ]

The number of each test is one (1) time through the manufacturing process of rotor.

In regard to the tensile test and the impact test, these are performed in accordance with ASTM A370, therefore, the equivalent standards will not be informed.

So, the related mention of "the equivalent standards" will be deleted from 1ST paragraph of DCD Subsection 10.2.3.1.

b) The locations of test specimens are shown in Figure 1.

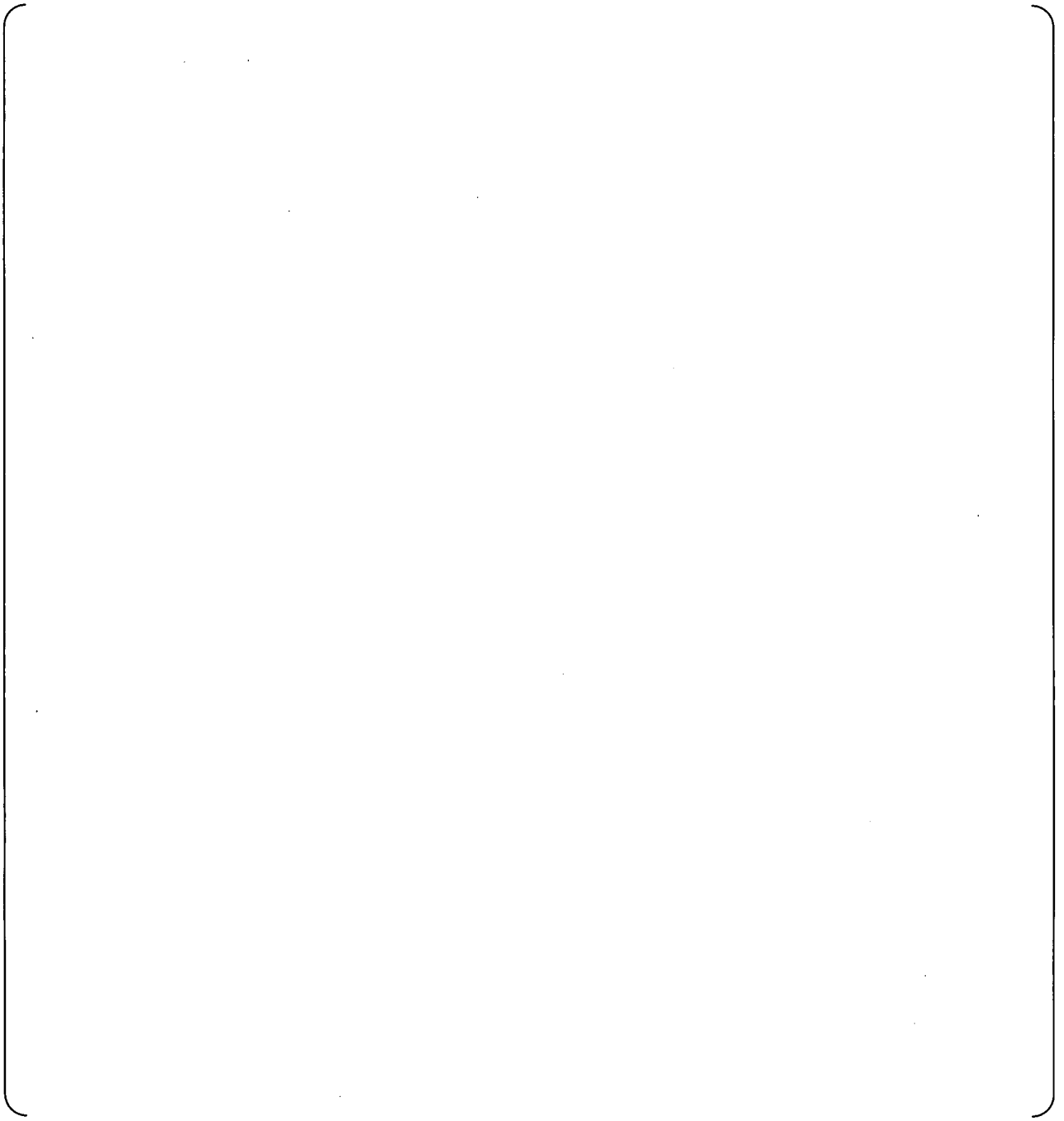


Figure 1 The locations of test specimens

The tensile properties shall be determined on standard round 0.500inch diameter (12.5mm), 2 inch gage (50mm) length test specimen. Charpy impact test specimens shall have the V-Notch of 2mm machined parallel to the forging axis.

The product analysis will be performed by using the test specimens from X-1 to X-5, in addition, from C-2 to C-4 in case the bored rotor.

Through the progress of steelmaking techniques, the homogeneity and quality of material specification at the center core of rotor can be ensured. The process of steelmaking is described in the US APWR DCD, Tier 2, FSAR Section 10.2.3.1.
Therefore, the chemical composition of rotor material is analyzed at the rotor peripheries only.

The mechanical properties at the center core of rotor are evaluated by the test result of material at the rotor periphery. Figure 1 shows the test result of mechanical properties for LP rotor.

Figure 1 Test result of mechanical properties (sample)

By a lot of comparative experience of material test result between the rotor periphery and the rotor center, the mechanical properties at the rotor center core can be evaluated by the test result of material at the rotor periphery.

Therefore, the additional test and/or evaluation will not be conducted for the rotor center core.

Impact on DCD

1st paragraph in DCD Subsection 10.2.3.1 will be revised as follows:

10.2.3.1 Materials Selection

Fully integral turbine rotors are made from ladle refined, vacuum deoxidized Ni-Cr-Mo-V alloy steel by processes that maximize the cleanliness and toughness of the steel. The lowest practical concentrations of residual elements are obtained through the melting process. The turbine rotor material complies with the chemical property limits of ASTM A470 (Reference 10.2-5), Classes 5, 6, and 7. The specification for the rotor steel has lower limitations than indicated in the ASTM standard (Reference 10.2-5) for phosphorous, sulphur, aluminum and antimony~~, tin, argon, and copper~~. This material has the lowest fracture appearance transit temperatures (FATT) and the highest Charpy V-notch energies obtainable on a consistent basis from water-quenched Ni-Cr-Mo-V material at the sizes and strength levels used. Charpy tests and tensile tests in accordance with ASTM, A370 (Reference 10.2-6) ~~and/or the equivalent are required from the forging supplier~~.

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

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

QUESTION NO.: 10.02.03-3, RAI 10.2.3-3

Table 2.7.1.1-1 in US APWR DCD, Revision 1, Tier 1, Section 2.7.1.1, provides an ITAAC (commitment 2) for the inspections and tests of the as-built turbine rotors. The acceptance criteria for the ITAAC states, "the as-built LP rotor material conforms to the specified requirements as described in Subsection 2.7.1.1.1." However, the NRC staff notes that FSAR Section 2.7.1.1.1 does not provide requirements for the turbine rotor.
Therefore, the ITAAC should specify acceptance criteria, which determines that the asbuilt turbine material properties, turbine rotor and blade designs, pre-service inspection and testing results, and in-service inspection and testing plans meet the requirements of the turbine missile probability analysis (Mitsubishi Technical Reports MUAP-07028, and MUAP-07029).

It should be noted that USAPWR DCD, Revision 0, Tier 2, FSAR Section 10.2.5 discussed this issue by stating the following:

"The program ISI be consistent with the maintenance and inspection program plan activities and inspection intervals identified in Subsection 10.2.3.5. The Combined License holder has available plant-specific turbine rotor test data and calculated toughness curves that support the material properties assumptions in the turbine rotor analysis. Plant start-up procedure including warm-up time is to be verified based on the specific material property."

However, this statement was removed from COL information item 10.2(1). Confirm that this information was to be addressed in the ITAAC (commitment 2) to verify that the actual material properties (once the turbine is fabricated) are within the bounding turbine missile probability analysis, which determines the inspections and testing intervals of the turbine generator and overspeed protection systems for meeting the requirements of GDC 4 of 10 CFR Part 50 in protecting safety-related equipment from turbine missiles.
In addition, the applicable ITAAC should be revised to include this information.

ANSWER:
Inspections and tests of the as-built LP rotors shall be performed to confirm that LP rotor material properties (chemical composition, mechanical properties) satisfy acceptable criteria prescribed in the purchase specification, because the missile analysis had been carried out based on the requirement specified in the purchase specification.
Acceptance criteria is described in the reply to 10.02.03-1, RAI 10.2.3-1 and 10.02.03-2, RAI

10.2.3-2.

Impact on DCD

DCD Tier 1, 2.7.1.1.1 Design Description, Key Design Features shall be replaced as follows:

"Key Design Features

The turbine is an 1800rpm, tandem compound, six exhaust flow, reheat unit. Two external moisture separator/reheaters (MS/R) with two stages of reheating are located on each side of the T/G centerline. The generator is a direct-driven, three-phase, 60 Hz, four-pole synchronous generator with water-cooled stator and hydrogen-cooled rotor.

The turbine rotors, valves and control/protection system are designed to minimize the possibility of turbine missile generation less than 1.0E-05 per year. Orientation of the T/G is such that a high-energy missile to be directed at an approximately 90 degree angle away from safety-related structures, systems, and components. For the purpose to keep the probability equal or less than the above, turbine rotor integrity is provided by the integrated combination of rotor design, facture toughness requirements, tests, and inspections.

Inspections and tests of the as-built LP rotors shall be conducted to verify that as-built test data and calculated toughness curves satisfy the material properties assumptions in the turbine rotor analysis, which determines the turbine maintenance program and inspection interval to meet the requirements of the turbine missile probability analysis (Mitsubishi Technical Reports MUAP-07028, and MUAP-07029).

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

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

QUESTION NO.: 10.02.03-4, RAI 10.2.3-4

Confirm that terminology "subsurface sonic indications" should be "subsurface ultrasonic indications" in the US APWR DCD, Tier 2, FSAR Section 10.2.3.3.

ANSWER:

We confirmed the terminology "subsurface sonic indications" is equivalent term as "subsurface ultrasonic indications.

Impact on DCD

1st paragraph in DCD Subsection 10.2.3.3 will be revised as follows:

10.2.3.3 Preservice Inspection

Preservice inspections for turbine rotors include the following:

- Rotor forgings are rough machined with a minimum stock allowance prior to heat treatment.
- Each rotor forging is subjected to a 100-percent volumetric (ultrasonic) examination. Each finish-machined rotor is subjected to a surface magnetic particle and visual examination. Results of the above examination are evaluated by use of criteria that are more restrictive than those specified for Class 1 components in ASME Code, Section III and V (Reference 10.2-7 and 10.2-8). These criteria include the requirement that subsurface ultrasonic ~~sonic~~ indications are either removed or evaluated to verify that they do not grow to a size which compromises the integrity of the unit during the service life of the unit.

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

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

QUESTION NO.: 10.02.03-5, RAI 10.2.3-5

The US APWR DCD, Tier 2, FSAR Section 10.2.3.4 specifies that the non-bored design of the high-pressure and low-pressure turbine rotor provide the necessary design margin by virtue of its inherently lower centerline stress. Also the use of solid rotor forgings was verified by an evaluation of the material removed from center-bored rotors for fossil power plants, and this evaluation demonstrated that the material at the center of the rotors satisfied the rotor material specification requirements. The NRC staff requests the following:

a) Discuss how the non-bored rotor will be 100% ultrasonically inspected in accordance with the US APWR DCD, Tier 2, FSAR Section 10.2.3.3 since there is no bore to gain access to perform the ultrasonic inspection.

b) Other sections in the US APWR DCD, Tier 2, including FSAR Section 10.2.3.3, state "in bores (if present)." This implies that there is an option for the rotor to either have a bore or not. Clarify whether the rotor will have a bore or not.

c) Typically each fabricated rotor has destructive testing performed at various locations to ensure homogeneity and acceptable material properties. Discuss how the material properties for each rotor fabricated will have the required material properties and homogeneity throughout the forged rotor, including the interior, which is normally bored out. Also, provide any supporting evaluations or tests.

ANSWER:

a) The ultrasonic inspection will be performed before gashing of rotor material (after periphery machining). In this stage, 100% ultrasonic inspection will be able to be performed because the rotor is drum shape.

As technology advances of ultrasonic test, the potential imperfection at the center core of rotor can be detected from the rotor periphery. The inspection procedures used for integral rotor forgings can reliably detect flaws [as small as 1.6mm] in length.

b) The non-bored design rotors of the high-pressure and the low-pressure turbine rotor are provided.

c) Through the progress of steelmaking technique, the homogeneity and quality of material specification at the center core of rotor can be ensured. The process of steelmaking is described in the US APWR DCD, Tier 2, FSAR Section 10.2.3.1.
Therefore, the chemical composition of rotor material is analyzed at the rotor peripheries only.

The mechanical properties at the center core of rotor are evaluated by the test result of material at the rotor periphery. Figure 1 shows the test result of mechanical properties for LP rotor.

Figure 1 Test result of mechanical properties (sample)

By a lot of comparative experience of material test result between the rotor periphery and the rotor center, the mechanical properties at the rotor center core can be evaluated by the test result of material at the rotor periphery.

Therefore, the additional test and/or evaluation will not be conducted for the rotor center core.

Impact on DCD

DCD Subsection 10.2.3.2.1, the third paragraph shall be replaced by the following sentence,

For rotor contour ~~or for flows near the rotor bore (for bored rotors)~~, a surface connected elliptical crack is assumed. The flaw is assumed to be orientated normal to the maximum principle stress direction.

DCD Subsection 10.2.3.3, the third bullet shall be replaced by the following sentence,

Finish-machined surfaces are subjected to a magnetic particle examination. No magnetic particle flaw indications are permissible in ~~bores (if present) or other~~ highly stressed regions.

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

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

QUESTION NO.: 10.02.03-6, RAI 10.2.3-6

The US APWR DCD, Tier 2, FSAR Section 10.2.3.5 states the ultrasonic inspection is performed on both the high and low-pressure turbine rotors "at intervals of about 10 years." Clarify the inspection interval of "about 10 years," to a more specific value or range, such as "every 10 years" or "10 year intervals," etc..

ANSWER:

Each rotor, stationary and rotating blade path components shall be inspected at the interval equal or less than 10 years

Impact on DCD

DCD Subsection 10.2.3.5, first bullet, first item shall be revised as follows,

- Each rotor, stationary and the rotating blade path component is inspected visually and by magnetic particle testing on its accessible surfaces. Ultrasonic inspection of the side entry blade grooves is conducted. These inspections are conducted at intervals equal or less than ~~of about~~ 10 years for both high-pressure and low-pressure turbines.

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

03/10/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

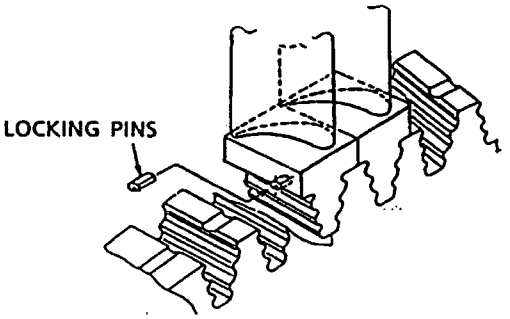
RAI NO.:	**NO. 199-2073**
SRP SECTION:	**10.02.03 – Turbine Rotor Integrity**
APPLICATION SECTION:	**Application Section: Tier 2 FSAR Section 10.2.3**
DATE OF RAI ISSUE:	**02/09/2009**

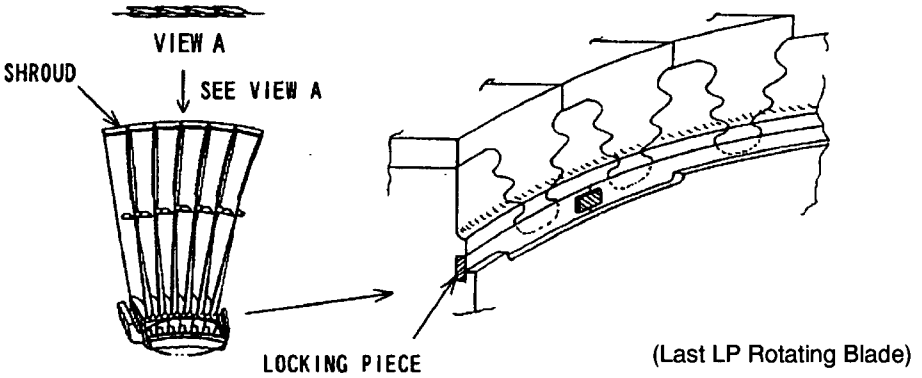
QUESTION NO.: 10.02.03-7, RAI 10.2.3-7

Provide a sketch of the christmas tree side entry type root attachment referenced in US APWR DCD, Tier 2, FSAR Section 10.2.3.4 for connecting the turbine blades to the rotor. Discuss how ultrasonic inspection performed during inservice inspection in accordance with US APWR DCD, Tier 2, FSAR Section 10.2.3.5 will be performed and whether 100% coverage of the area can be achieved for the christmas tree side entry type root attachment.

ANSWER:

The sketch of christmas tree side entry type root is as follows.





In regard to ultrasonic inspection during inservice inspection for the chrstmas tree side entry root attachment, we made some mistake and need to revise DCD Subsection 10.2.3.5, the first bullet, the first item. "Magnetic particle inspection" on both inlet and outlet side will be conducted for every rows instead of "Ultrasonic inspection". In case of side entry structure as you see in the previous sketches, end-surface of rotor grooves are directly observed and visual and magnetic particle inspection are good enough to verify the existence of cracks.

Impact on DCD

DCD Subsection 10.2.3.5, the first bullet, the first item therefore shall be replaced by the following sentences.

- Each rotor, stationary and the rotating blade path component is inspected visually and by magnetic particle testing on its accessible surfaces. Magnetic Particle ~~Ultrasonic~~ inspection of the side entry blade grooves is conducted. These inspections are conducted at intervals equal or less than 10 years for both high-pressure and low-pressure turbines.

Impact on COLA

There is no impact on the COLA.

Impact on PRA

There is no impact on the PRA.