MITSUBISHI HEAVY INDUSTRIES, LTD.
16-5, KONAN 2-CHOME, MINATO-KU
TOKYO, JAPAN

July 10, 2012

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-12156

Subject: **MHI's Responses to US-APWR DCD RAI No.929-6380 REVISION 3 (SRP 04.02)**

Reference: 1) "REQUEST FOR ADDITIONAL INFORMATION 929-6380 REVISION 3" dated on May 14, 2012

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") documents entitled "Response to US-APWR DCD RAI No.929-6380 REVISION 3".

In the enclosed documents, MHI provides responses to Questions 04.02-53 through 04.02-57 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. The proprietary information is bracketed 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 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.

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NRO

Enclosures:

1. Affidavit of Yoshiki Ogata
2. Response to US-APWR DCD RAI No. 929-6380 REVISION 3 (Proprietary)
3. Response to US-APWR DCD RAI No. 929-6380 REVISION 3 (Non-Proprietary)

CC: J. A. Ciocco
J. Tapia

Contact Information
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Telephone: (703) 908 – 8055

ENCLOSURE 1

Docket No.52-021
MHI Ref: UAP-HF-12156

MITSUBISHI HEAVY INDUSTRIES, LTD.

AFFIDAVIT

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

1. I am Director, 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 "Response to US-APWR DCD RAI No.929-6380 REVISION 3" and have determined that portions of the report 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 technical report indicates that all information identified as "Proprietary" should be withheld from public disclosure pursuant to 10 C.F.R. § 2.390 (a).

3. The information in the report identified as proprietary by MHI 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 methodologies developed by MHI for the fuel of the US-APWR. These were developed at significant cost to MHI, since they required the performance of detailed calculations, analyses, and testing extending over several years. The referenced information is not available in public sources and could not be gathered readily from other publicly available information.

5. 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.

6. 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 of new fuel 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 10th day of July, 2012.

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

Docket No. 52-021
MHI Ref: UAP-HF-12156

Enclosure 3

UAP-HF-12156
Docket No. 52-021

Response to US-APWR DCD RAI No. 929-6380 REVISION 3

July 2012
(Non-Proprietary)

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/10/2012

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**929-6380 Revision 3**
SRP SECTION:	**04.02 - Fuel System Design**
APPLICATION SECTION:	**04.02**
DATE OF RAI ISSUE:	**05/14/2011**

QUESTION NO. : 04.02-53

In response to RAI 877-5918, Question 4.2-50, MHI makes an assumption that the burnable absorber (BA) released gas reaches its maximum value within one cycle of operation. From the information provided, the staff could not reach that conclusion as removal burnable absorbers are not prohibited from insertion into multiple duty cycles. Therefore, the staff is requesting that additional information be provided regarding the limiting BA internal pressure and whether internal or external pressure is limiting from a cladding strain perspective.

ANSWER:

In the evaluation of inner pressure of the BA, the amount of released helium is calculated from the total amount of ^{10}B in the borosilicate glass rod. It is assumed that all of the ^{10}B is consumed within the first cycle of operation and that the resulting released gas amount reaches its' maximum value during the first cycle. In subsequent cycles, there is no additional gas release because there is no additional ^{10}B available for consumption. Although the BA may be utilized in multiple cycles during actual operation, the design calculation is conservatively based on consumption of the total amount of ^{10}B during the first cycle; multiple cycle use will not affect the maximum helium pressure result.

With regards to cladding strain, the inner pressure of the BA is always lower than the primary coolant pressure when helium release due to ^{10}B reaction is taken into account. Therefore, the cladding is under compression, with no possibility for tensile strain to lead to cladding failure.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

This completes MHI's response to the NRC's question.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/10/2012

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**929-6380 Revision 3**
SRP SECTION:	**04.02 - Fuel System Design**
APPLICATION SECTION:	**04.02**
DATE OF RAI ISSUE:	**05/14/2011**

QUESTION NO. : 04.02-54

Table 4.6-1 of technical report MUAP-07016 provides data which supports the conclusion that assembly liftoff does not occur during normal operation and AOOs, but does not describe the limiting AOO or if the cold startup condition bounds the limiting AOO. Provide a description of the AOOs evaluated, the limiting AOO and details of how the limiting AOO was determined.

ANSWER:

AOO events are some of the limiting conditions for the safety analyses listed in DCD Chapter 15 Table 15.0-1, but not for the mechanical design of the fuel assembly and reactor internals. Since greater heat transfer (removal) from fuel rod surface to the reactor coolant occurs with increased coolant flow rate, there is no specific AOO event that is analyzed with increased coolant flow rate greater than from normal operational flow. An increase in the reactor coolant flow rate mitigates minimum DNBR, while it creates a larger hydraulic force for the fuel assembly. Therefore, under normal operation and AOO conditions, the most limiting condition in the assembly lift off evaluation is the Mechanical Design Flow (MDF), which is defined in DCD chapter 5 and is larger than Thermal Design Flow (TDF).

As described above, there is no AOO condition that has a larger flow rate than the MDF from normal operation. Therefore, the MDF is applied in evaluating the limiting hydraulic lift force on the fuel assembly for the lift off evaluation during normal operation and AOOs

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

This completes MHI's response to the NRC's question.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/10/2012

US-APWR Design Certification

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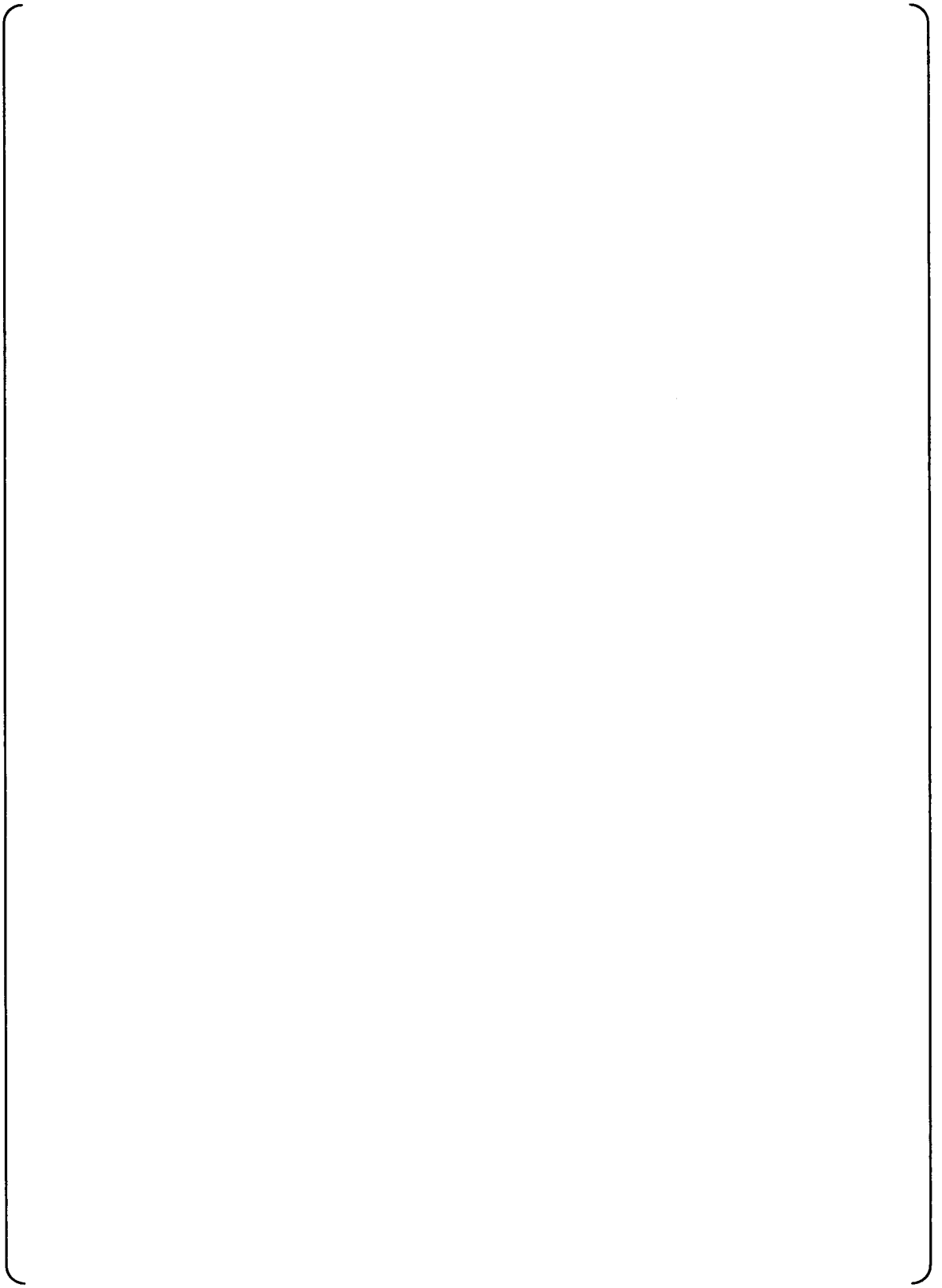
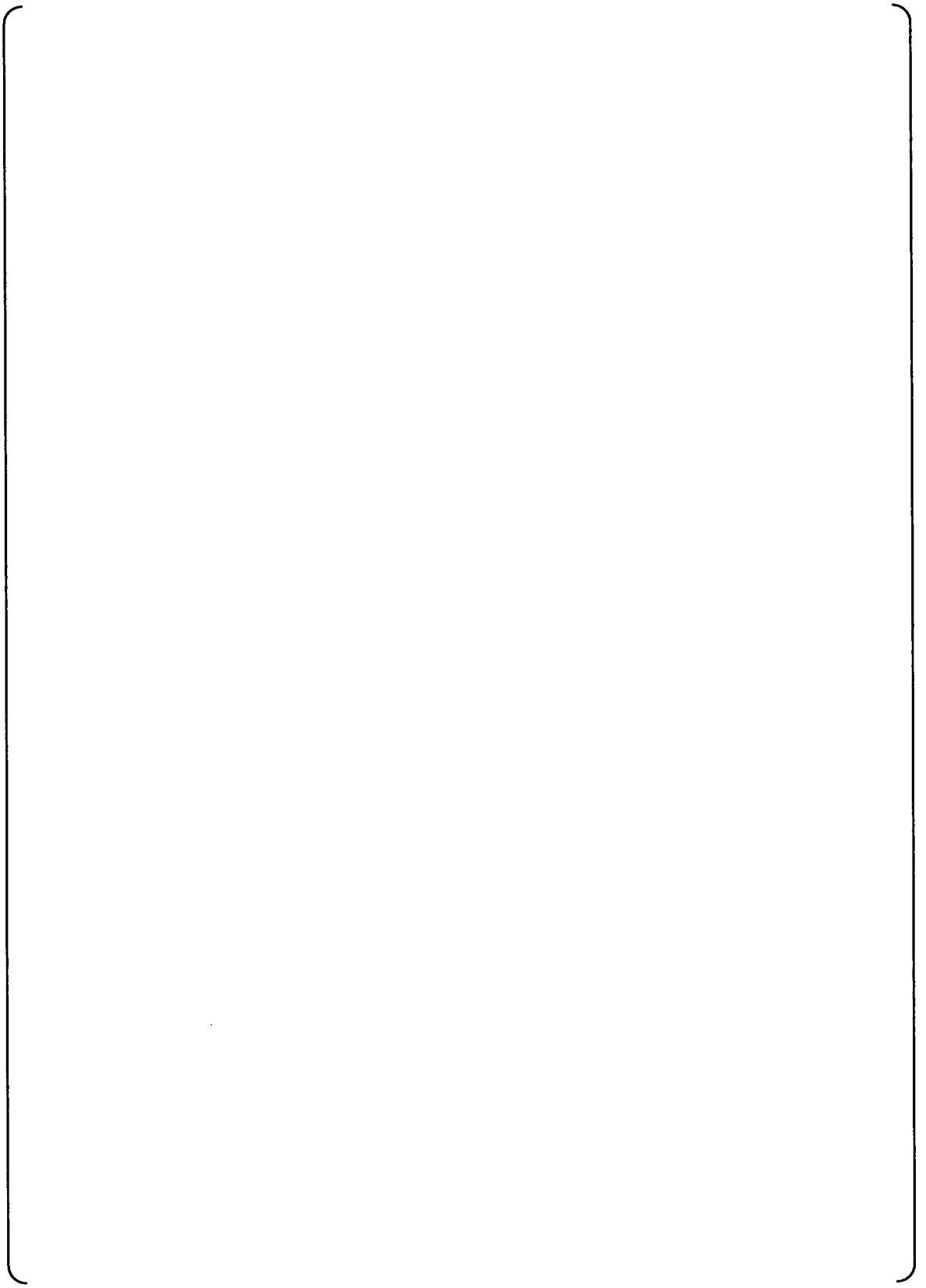
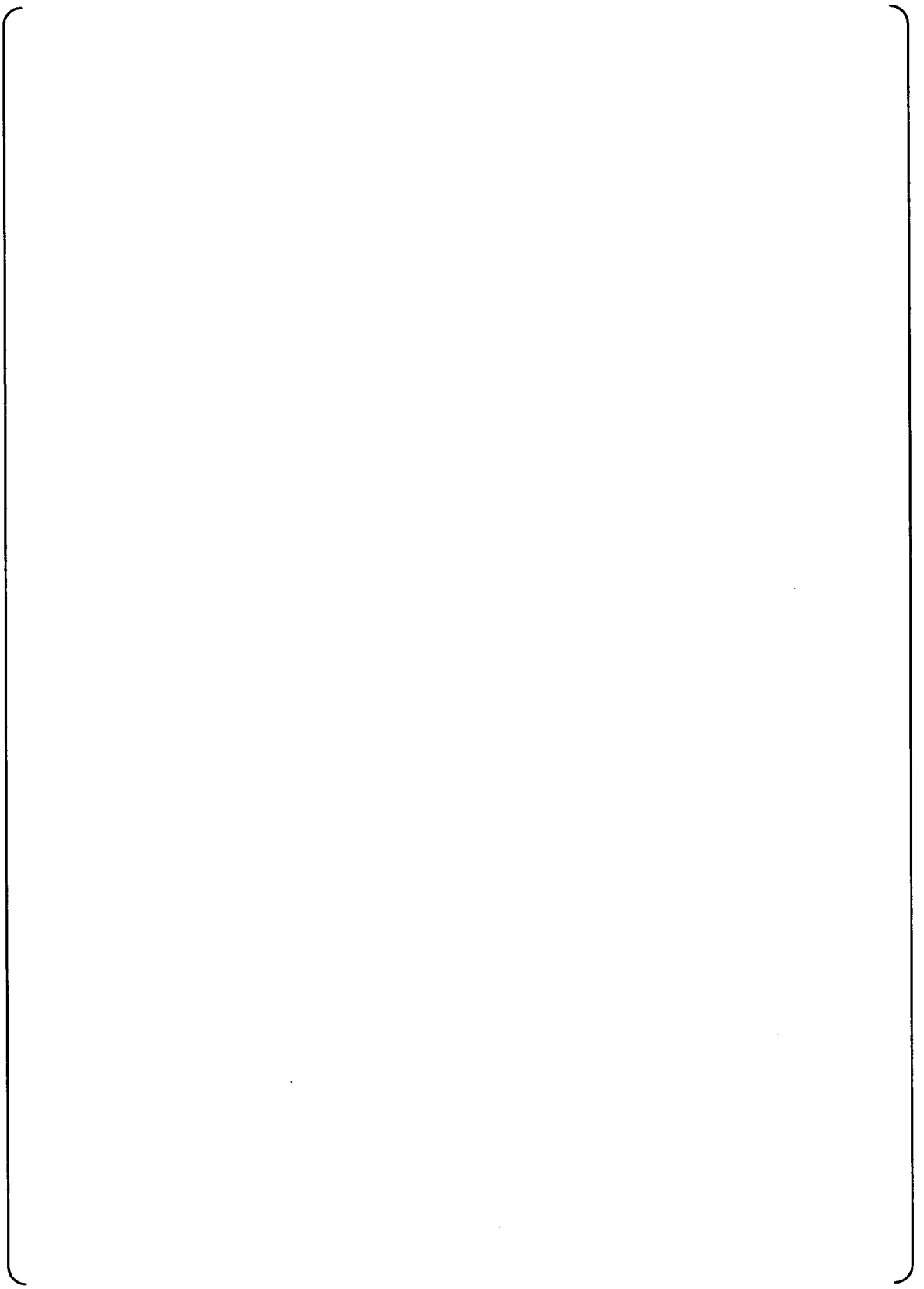
QUESTION NO. : 04.02-55

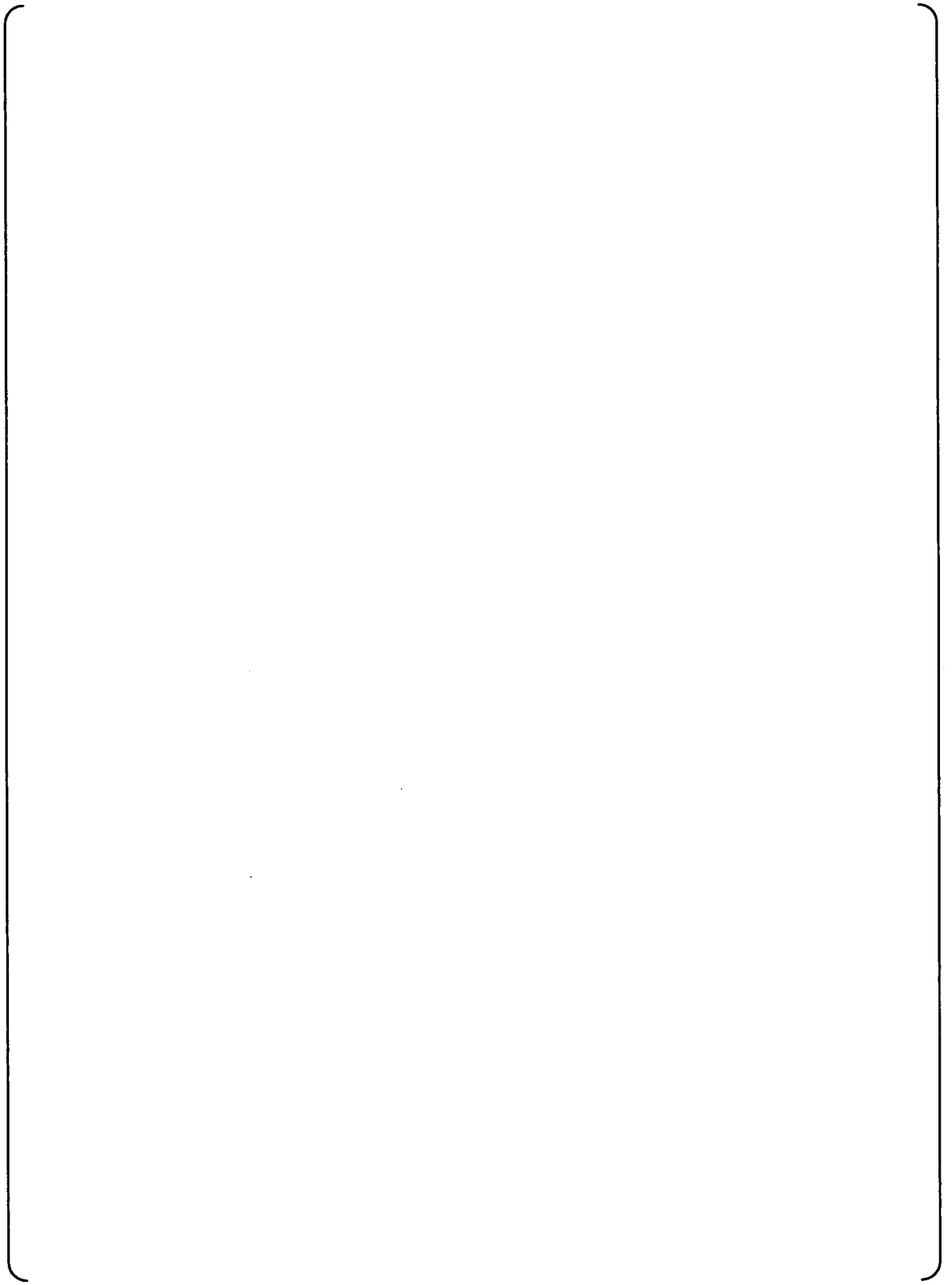
In technical report MUAP-07016, Appendix C, MHI presents a predictive grid to rod fretting model. This model is used to predict the end of life cladding wear due to fretting. A model would need to consider the effects of complex local flow characteristics (e.g., caused by spacer grid vane design and associated manufacturing tolerances) which can cause fuel rod vibrations, as well as other contributing factors. SRP 4.2 discusses the use of information gained from operational experience and prototype testing as a guide for review of the effects of fretting wear. The staff has previously accepted conservative extrapolations based on test or operating information to predict wear effects. Using the1000 hour fretting data gathered as part of the full-scale hydraulic testing of the USAPWR fuel assembly (MUAP-11017) provide a conservative extrapolation of the cladding wear for a conservative end of fuel assembly lifetime. Provide the basis for the extrapolation method used and explain how the extrapolated results compare to the acceptance criteria.

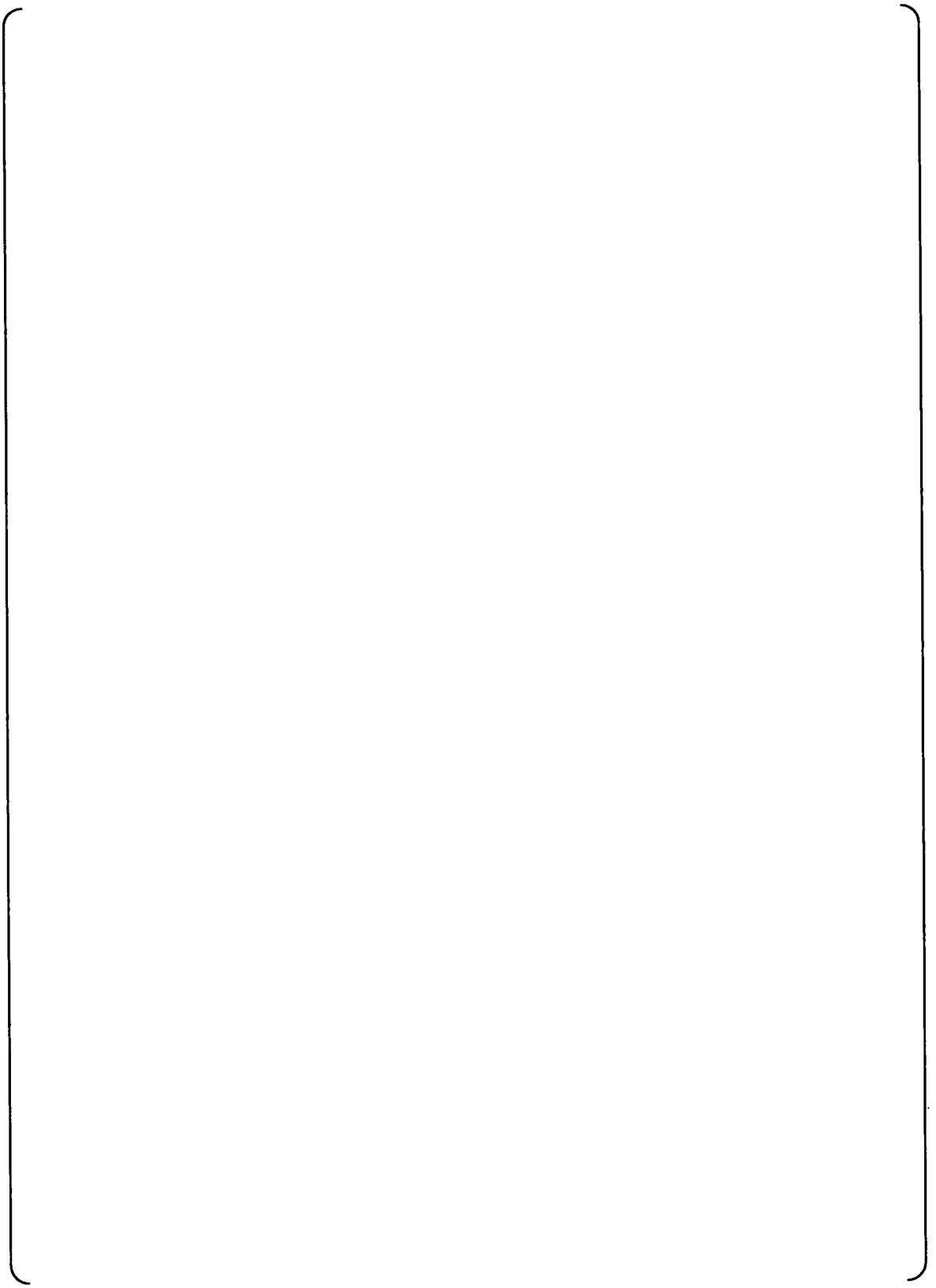
ANSWER:











6. References

(1) "Hydraulic Test of the Full Scale US-APWR Fuel Assembly", MUAP-11017-P (R0), May 2011

(2) R. D. Blevins, "Flow-Induced Vibrations in Nuclear Reactors: A Review", Progress in Nuclear Energy, Vol.4, pp.42, 1979

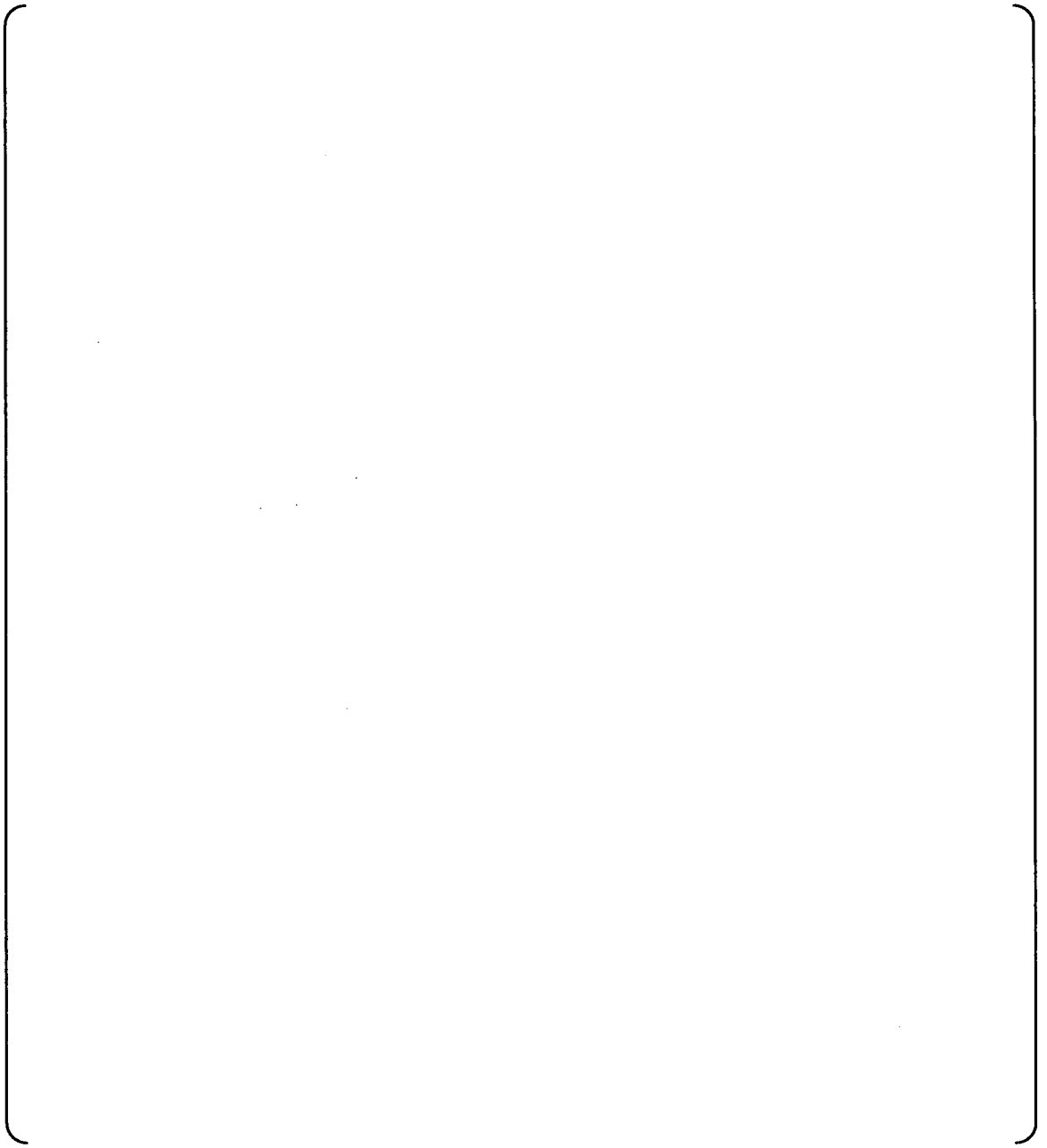
(3) R. D. Blevins, "Flow Induced Vibration", Van Nostrand Reinhold, New York, 1977, p.163

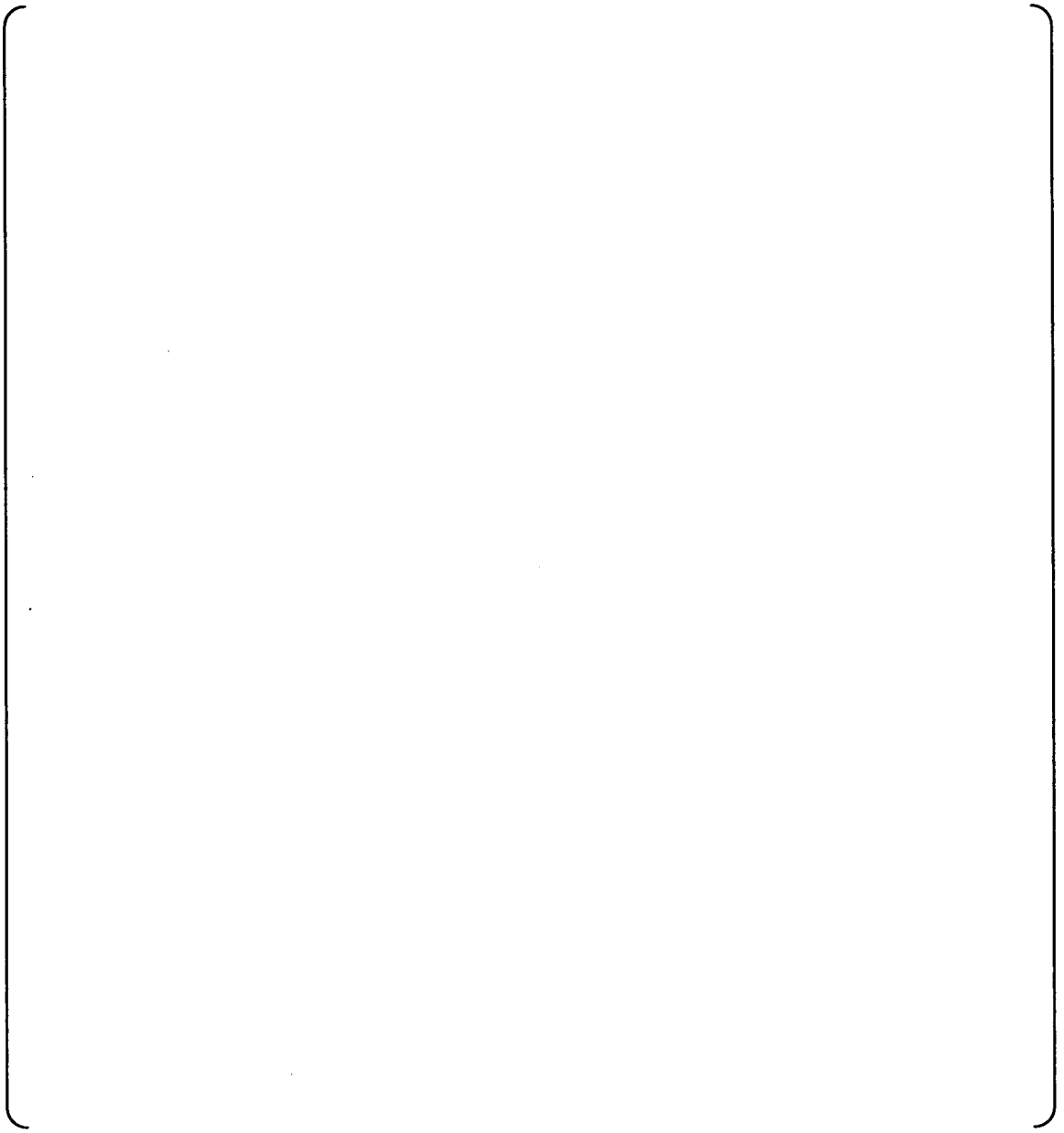
(4) H. J. Connors, S. J. Savorelli and F. A. Kramer, "Hydrodynamic Damping of Rod Bundles in Axial Flow", PVP-Vol.63 (ASME), pp.122-124

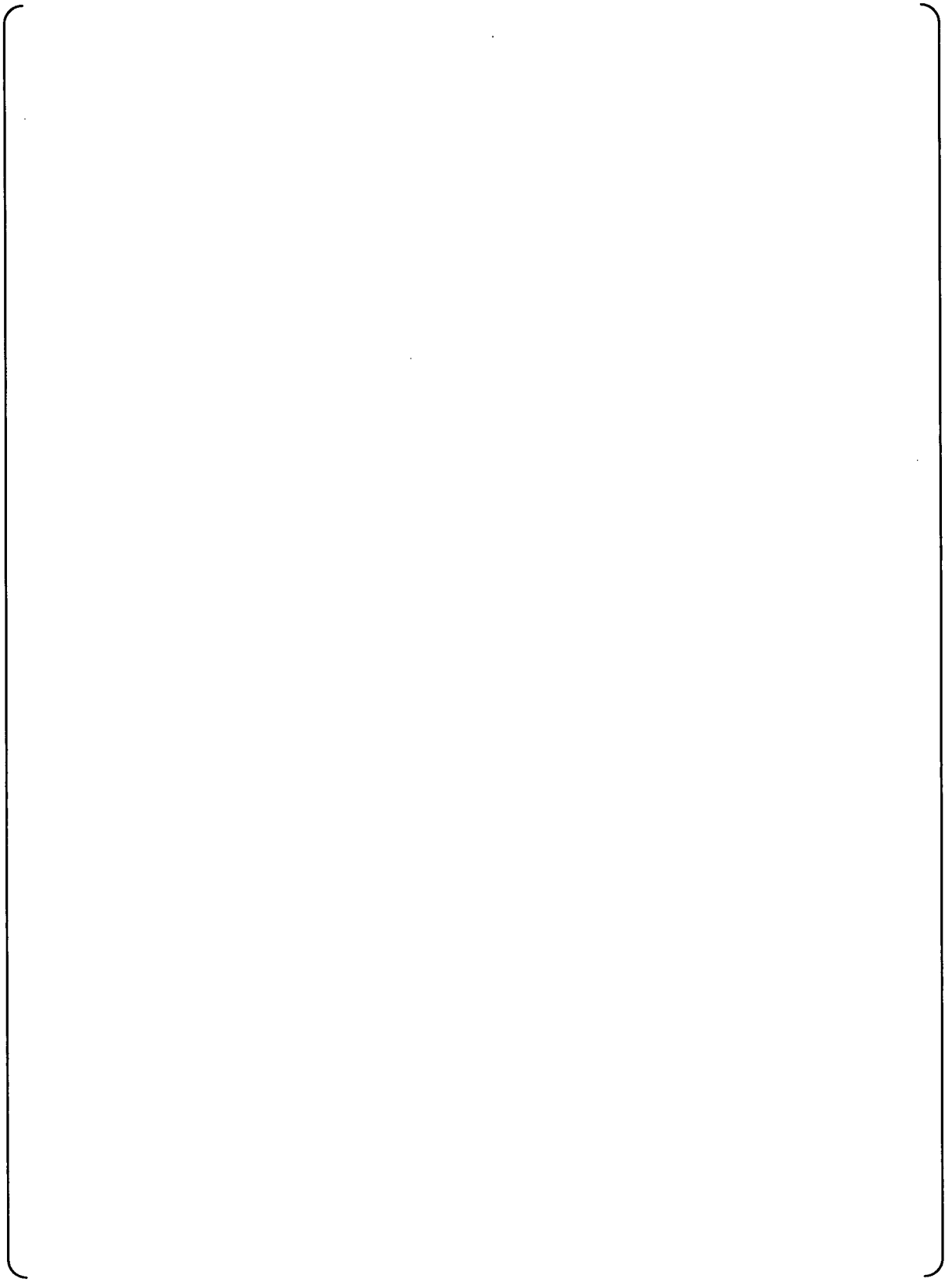
(5) "US-APWR Fuel System Design Evaluation", MUAP-07016-P(R3), August 2010

(6) JSME, "JSME Steam Tables", 1997

(7) R. E. Odeh and D. B. Owen, "Tables for Nominal Tolerance Limits, Sampling Plans, and Screening", 1980







Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

This completes MHI's response to the NRC's question.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/10/2012

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**929-6380 Revision 3**
SRP SECTION:	**04.02 - Fuel System Design**
APPLICATION SECTION:	**04.02**
DATE OF RAI ISSUE:	**05/14/2011**

QUESTION NO. : 04.02-56

Provide a concise explanation of how MUAP-011017, "Hydraulic Test of the Full Scale US-APWR Fuel Assembly" demonstrates that no additional holddown spring plastic deformation occurs under pump overspeed conditions.

ANSWER:

Background of the hydraulic test

The main purpose for the hydraulic test is to additionally confirm lift force evaluation in the hydraulic design of the US-APWR fuel assembly. In this test the holddown spring's design curve at cold condition is confirmed. (The test is performed at cold conditions, the result does not directly show that additional plastic deformation of the holddown spring will not occur during lift off during a hot pump-over-speed condition.)

Explanation of the result of the hydraulic test in the holddown spring design

In the Mitsubishi US-APWR fuel assembly design (Reference 1), the criterion for holddown spring design under pump-over-speed conditions is defined such that plastic deformation exceeding the maximum deformation at cold start up at beginning of life shall not occur during lifting of the fuel assembly from the hydraulic force occurring at the pump-over-speed condition.

In the design analysis, spring deformation was calculated using classical beam theory. The theory gives a load force versus deflection curve (the design curve) for the leaf spring such as the holddown spring. The design curve at hot conditions can be derived by accounting for the temperature condition in the elastic modulus for the design curve. From this method, the limiting force for no additional plastic deformation under pump-over-speed condition is calculated, and then it is concluded that no additional plastic deformation occurs even if the fuel assembly lifts off under hot pump-over-speed condition. The detail design analysis is provided in the subsection 4.6 of Reference 2.

For verification of the design curve based on classical beam theory, a mechanical test is conducted using a leaf spring and top nozzle mockup. This test is performed at cold

condition. The measured deflection curve shows very good agreement with the design curve at cold conditions, and then it is concluded that the design curve is applicable for holddown spring evaluation. Explanation of the verification is provided in the response RAI No.44 in Reference 3.

Furthermore, as an additional confirmation, the hydraulic test is performed with full scale US-APWR fuel assembly mockup at cold condition. The test results relating to holddown spring is shown in the subsection 4.3 and 4.4 of Reference 4 and summarized as follows;

I. Measured spring deflection

1) At assembling leaf springs with top nozzle (initial state) [ ] mm

2) At setting fuel assembly in the test loop (installed into the loop) [ ] mm

[ ] mm = [ ] mm (initial state) + [ ] mm (increment due to compression by upper plate)

3) After two lift off tests (at uninstalled from the loop) [ ] mm

(Ref: Subsection 4.4 Evaluation (4) to Reference 4)

II. Evaluation of additional spring deformation after lift off in the hydraulic test

In combination with the measured deflection curve from the mechanical test of holddown spring in Reference 3, [ ]mm of deflection will induce [ ] mm of plastic deformation after the force is released. However, in the hydraulic test, measured spring deformation after force release is [ ] mm. Therefore, plastic deformation due to the lift off in the hydraulic test can be evaluated as [ ] mm (= [ ] – [ ] mm).

(Ref: Subsection 4.4 Evaluation (4) & Figure 4.4-2 to Reference 4)

III. Evaluation of spring force reduction

From the results of the lift force measurement in the hydraulic test, holddown spring force after two lift off tests is evaluated as [ ] N. Since four sets of leaf springs are on the top nozzle, the spring force reduction per 1 set is calculated as [ ] N (= [ ] / 4).

(Ref: Subsection 4.3.3 Test Results (2) Holddown Spring Design Validation Test)

IV. Comparison between spring deformation and force reduction

After lift off testing, permanent deformation is measured as [ ] mm. This deflection value corresponds to about [ ] N from the measured deflection curve from the mechanical test. On the other hand, from the lift force measurement, spring force reduction per 1 set due to lift off is obtained as [ ] N. These spring force values, [ ] N (from the deflection curve) and [ ] N (from the lift force measurement in the hydraulic test) are fairly close. This means that the calculation based on measured deflection curve is applicable to evaluation of full scale mock-up assembly test results. Furthermore, the measured deflection curve obtained from the mechanical test shows good agreement with the design curve based on classical beam theory.

V. Conclusion

As described above, the hydraulic test data has demonstrated that the design curve is applicable to the full scale US-APWR fuel assembly spring force evaluation. Consequently, it is concluded that the design analysis results given in the Reference 2 is appropriate.

References:

[1] US-APWR Fuel System design Criteria and methodology, MUAP-07008-P/NP (R2), July 2010

[2] US-APWR Fuel System Design Evaluation MUAP-07016-P/NP (R3), August 2010

[3] MHI's Amended Responses to the NRC's Requests for Additional Information on Topical Report MUAP-07008-P(0), UAP-HF-09538, dated on November 30, 2009.

[4] Hydraulic Test of the Full Scale US-APWR Fuel Assembly, MUAP-11017-P/NP (R0), May 2011.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

This completes MHI's response to the NRC's question.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

7/10/2012

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**929-6380 Revision 3**
SRP SECTION:	**04.02 - Fuel System Design**
APPLICATION SECTION:	**04.02**
DATE OF RAI ISSUE:	**05/14/2011**

QUESTION NO. : 04.02-57

Evaluate the impact of up to 0.1 second delay in control rod insertion on the scram worth versus position or time curve used in the Chapter 15 analyses.

ANSWER:

The scram worth versus time curve used in the safety analysis is created based on the control rod insertion characteristic (relation between the control rod insertion distance and time). The control rod insertion time delay (up to 0.1 seconds) is included as design margin in the control rod insertion characteristic. Therefore there is no influence from the 0.1 second rod delay on the scram worth versus position or time curve in the safety analysis.

Additional explanation about creation of the scram worth versus time curve used in the safety analysis is provided below.

The characteristic scram worth curve versus time is set by integrating the scram worth, which is computed considering the control rod insertion characteristics (the relation between control rod insertion distance and time) and the relationship between control rod insertion in the active core and the power distribution of the reactor core.

Even if the reactor core length were set to the full 14ft fuel assembly length of the US-APWR, the control rod insertion time to dashpot entry (the average time to traverse the entire rod length during the normal plant operating conditions) is expected to be about [ ] seconds. The control rod insertion time to dashpot entry is set as 3.0 seconds in the scram worth versus time curve used in the safety analysis. For this reason, the control rod insertion time delay (up to 0.1 seconds) does not influence the value used in the safety analysis.

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

This completes MHI's response to the NRC's question.