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GE Hitachi Nuclear Energy

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MFN 09-671
October 27, 2009

Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
ATTN: Rulemakings and Adjudications Staff (Rulemaking.Comments@nrc.gov)

Subject: Issues for Consideration, of RIN 3150–AH42, [NRC–2008–0332], Performance-Based Emergency Core Cooling System Acceptance Criteria

Section IV, Issues for Consideration, of RIN 3150–AH42, [NRC–2008–0332], Performance-Based Emergency Core Cooling System Acceptance Criteria, Advance notice of proposed rulemaking (ANPR) contains 12 requests for comment. Enclosure 1 of this letter provides the collective response of GE Hitachi Nuclear Energy Americas (GEH) and Global Nuclear Fuels-Americas (GNF) to the 12 requests. GEH and GNF have also been working with the NEI on the industry response included in NEI letter, James H. Riley to Rulemakings and Adjudications Staff, Subject: RIN 3150-AH42, Comments on Advance Notice of Proposed Rulemaking for Performance-Based Emergency Core Cooling System Acceptance Criteria. Where the GEH/GNF response is identical to the NEI industry response only a concurrence statement is provided.

GEH/GNF also offer the following summary responses:

- GEH/GNF believes that the rulemaking should be limited to the high level changes necessary to generalize the applicability to different cladding materials and the requirements for a cladding's performance based limits. Detail, such as testing configurations and key parameters, can be addressed in regulatory guidance documents, which can clarify the technical and characteristics the NRC staff would focus on in evaluating varied approaches.
- The existing 10 CFR Part 50.46 criteria for a coolable geometry is the appropriate statement of the requirement to ensure that all relevant clad integrity considerations are addressed in the ECCS-LOCA methodology. The details of demonstrating that the criteria is met should be flexible and allow for different possible approaches.

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- Quality assurance programs that comply with Appendix B to 10 CFR Part 50 and with 10 CFR Part 21 should be leveraged wherever possible as an appropriate mechanism to demonstrate the performance characteristics of the cladding.
- The performance based approach in the proposed rulemaking offers needed flexibility in the introduction of new cladding materials. GEH/GNF encourages the Staff to utilize similar flexible approaches, throughout implementation of the rule, that emphasize demonstration of what is needed to assure safety, rather than conformance to a particular method.
- The ANPR also contains a proposal that the licensees develop and justify exposure threshold for inclusion in oxidation calculation. With respect to two-sided oxidation, GEH/GNF recommends that the NRC provide clarification on the performance-based criterion that will be used to assess the justification of the threshold for including inside diameter oxidation. For example, would the presence of oxygen stabilized alpha-zirconium layer following simulated LOCA testing be a criterion?

If you have any questions, please contact Yang-Pi Lin at (910) 819-5806 or me.

Sincerely,

James F. Harrison

James F. Harrison
Vice President, Fuel Licensing
Regulatory Affairs
GE Hitachi Nuclear Energy

Enclosure
1. Issues for Consideration, RIN 3150–AH42, Performance-Based ECCS Acceptance Criteria

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ENCLOSURE 1

MFN 09-671

Issues for Consideration, RIN 3150–AH42,
Performance-Based ECCS Acceptance Criteria

Section IV, Issues for Consideration, of RIN 3150–AH42, [NRC–2008–0332], Performance-Based Emergency Core Cooling System Acceptance Criteria, Advance notice of proposed rulemaking (ANPR) contains 12 requests for comment. These requests for comment are copied from the Federal Register Notice and are followed by the GE Hitachi Nuclear Energy Americas (GEH) and Global Nuclear Fuels-Americas (GNF) response. Where the GEH/GNF response is identical to the industry position included in NEI letter, James H. Riley to Rulemakings and Adjudications Staff, Subject: RIN 3150-AH42, Comments on Advance Notice of Proposed Rulemaking for Performance-Based Emergency Core Cooling System Acceptance Criteria, only a concurrence statement is provided.

Applicability Considerations

Request for Comment 1

Objective 1 describes a conceptual approach to expanding the applicability of § 50.46 to all fuel cladding materials. Should the rule be expanded to include any cladding material, or only be expanded to include all zirconium- based cladding alloys? The NRC also requests comment on the potential advantages and disadvantages of the specific approach described that would expand the applicability beyond zirconium-based alloys. Is there a better approach that could achieve the same objective?

Response – Comment 1

GEH/GNF concurs with the NEI Industry response.

Request for Comment 2

The rulemaking objectives do not include expanding the applicability of § 50.46 to include fuel other than uranium oxide fuel (UO2). Is there any need for, or available information to justify, expanding the applicability of this rule to mixed oxide fuel rods?

Response – Comment 2

GEH/GNF concurs with the NEI Industry response.

New Embrittlement Criteria Considerations

Request for Comment 3

The NRC requests information related to the maximum time span with cladding surface temperature above 1200°F (649 °C) for the full range of piping break sizes and NSSS/ECCS design combinations. This information may be used to set a specified minimum time to breakaway in the proposed rule's applicability statement.

Response – Comment 3

GEH/GNF concurs with the NEI Industry response. However, GEH/GNF would like to provide additional discussion on basis for using a performance-based criterion to set the minimum time to breakaway oxidation.

Zircaloys are susceptible to early onset of breakaway oxidation at two temperature ranges, one near 1000°C and the other near 800°C. The tests conducted at ANL focused on temperature near 1000°C. With respect to criterion for breakaway oxidation, Figure 1 shows data reported by Leistikow and Schanz (L-S) [Nucl. Eng. Des. 103 (1987) 65] based on either accelerated weight gain or when a hydrogen pickup of 200 ppm or 400 ppm is reached. In the ANPR, a criterion of 200 ppm hydrogen is proposed. The choice of the 200 ppm hydrogen is conservative relative the hydrogen concentration when cladding embrittlement occurs. Figure 63 of NUREG/CR-6967 shows that the embrittling concentration is closer to 600 ppm, which would take longer to reach than criteria based on 200 or 400 ppm of hydrogen. For breakaway oxidation near 1000°C, the choice of criteria (weight gain, 200 ppm or 400 ppm H) has little practical consequences and the L-S data indicated a range between ~1600 – 2300 seconds. The same is not true for breakaway oxidation near 800°C. The L-S data indicate that times to breakaway oxidation are ~2000 s, ~3600 s and ~10,500 based on, respectively, weight gain, 200 ppm H and 400 ppm hydrogen. Thus while accelerated oxidation began at ~2000 seconds, embrittlement due to hydrogen (~600 ppm) would not occur until after significantly longer than 10,500 seconds (for 400 ppm H).

With respect to surface condition, the ANL results and L-S data show that the breakaway oxidation time near 1000°C increased (from ~1600 to ~3600 s) when the surface condition was changed from pickled/clean (L-S) to belt polished (HBR rough surface). There is further increase (to >5000 s) when the surface finish is further smoothened (Belt Pol). The second figure shows the ANL and the L-S data together with data reported by Baek [J. Nucl. Mat. 335 (2004) 443] and Nagase [J. Nucl. Sci. and Tech. 40-4 (2003) 213] for Zircaloy-4 cladding in the pickled/clean state and polished states, respectively. The L-S, Baek and Nagase data show that for the breakaway oxidation phenomenon near 800 °C, there is a substantial increase in time to breakaway depending on the surface condition of the test sample. The breakaway time increased from ~2000 s for pickled/clean state (L-S and Baek) to ~7000 s for belt polished finish (Nagase) as measured by the weight gain method.

In summary, the time to breakaway oxidation at near 800°C would be greater than 10,000 sec for cladding in the pickled/clean state if a 400 ppm H criterion were used; at this hydrogen level the cladding is expected to be ductile. Further increase in time to breakaway oxidation near 800°C would be expected for modern cladding in the belt polished condition. Since the time to breakaway oxidation near 1000°C is ~5000 s or less for cladding in the pickled/clean or rough polished state, the susceptibility of Zr-alloys to embrittlement due to breakaway oxidation is relevant in the temperature range near 1000°C but not near 800°C. GEH/GNF believes that the threshold temperature could be set at 1650°F (899°C) without compromising safety concern due to breakaway oxidation.

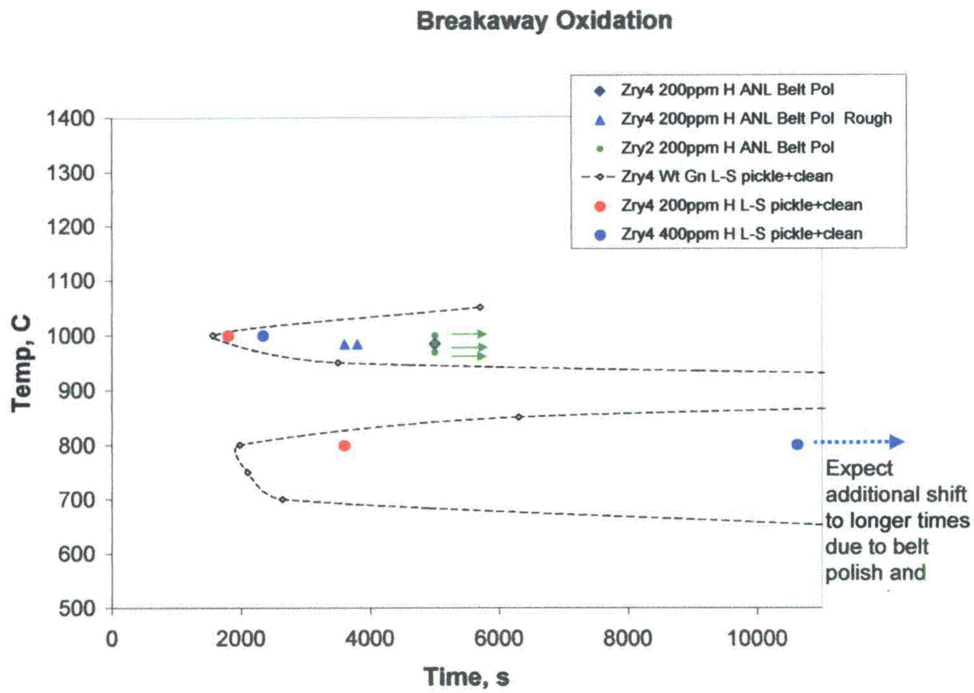

Figure 1

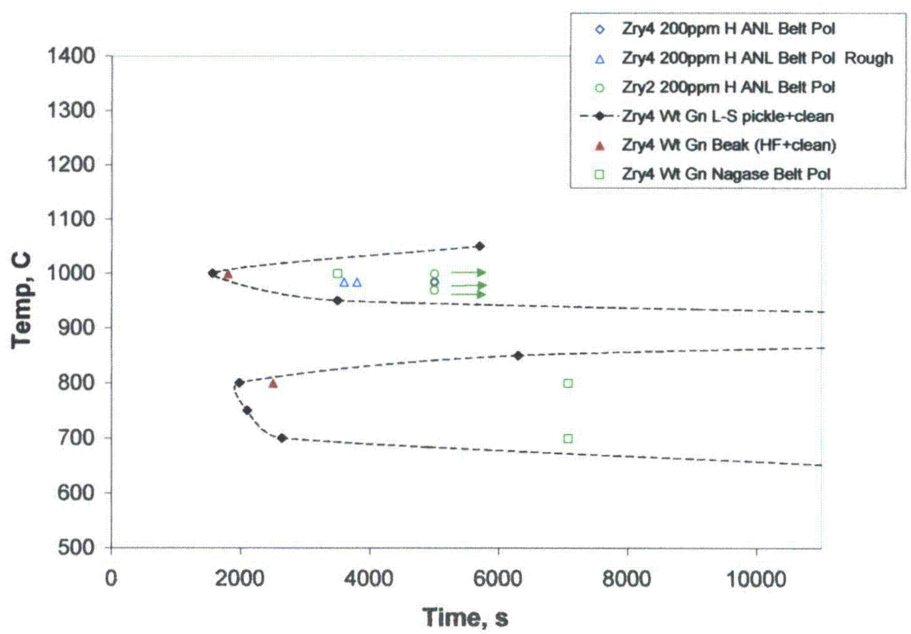

Figure 2

Request for Comment 4

The NRC requests comment on the two approaches to establishing analytical limits for cladding alloys, as described in Section III.2 of this document and expanded upon in the Appendices, where limits on peak cladding temperature and local oxidation would be replaced with specific cladding performance requirements that define an adequate level of ductility which must be maintained throughout a postulated LOCA. In addition to general comments on these approaches, the NRC also seeks specific comment on the following related items:

a. The NRC requests any further PQD ring-compression test data that may be available to expand the empirical database as shown in Appendix A of this document.

b. Because no cladding segments tested in the NRC's LOCA research program exhibited an acceptable level of ductility beyond a hydrogen concentration of 550 wppm (metal), analytical limits may be restricted to terminate at this point. Are any further PQD ring-compression test data available at hydrogen concentrations beyond 550 wppm which exhibited an acceptable level of ductility?

c. Ring-compression tests conducted on cladding segments with identical hydrogen concentrations oxidized to the same CP–ECR often exhibited a range of measured offset displacement. The variability, repeatability, and statistical treatment of these test results must be evaluated for defining generic PQD analytical limits. The NRC requests comments on the variability, repeatability, and statistical treatment of ductility measurements from samples exposed to high-temperature steam oxidation.

Response – Comment 4, 4a, 4b and 4c

GEH/GNF concurs with the NEI Industry response.

Request for Comment 5

Implementation of a hydrogen-dependent PQD criterion requires an NRC-approved hydrogen uptake model. The sensitivity of hydrogen pickup fraction to external factors (e.g., manufacturing process, proximity to dissimilar metals, plant coolant chemistry, oxide thickness, crud, burnup, etc.) must be properly calibrated in the development and validation of this model.

a. The NRC requests information on the size and depth of the current hot- cell hydrogen database(s) and the industry's ability to segregate the sensitivity of each cladding alloy to each external factor and to quantify the level of uncertainty.

b. Pre-test characterization of some irradiated cladding segments revealed significant variability in axial, radial, and circumferential hydrogen concentrations.

i. What information exists that could quantify this asymmetric distribution in the development of a hydrogen uptake model?

ii. What information exists that could inform the treatment of this asymmetric hydrogen distribution as a function of fuel rod burnup?

iii. This asymmetric hydrogen distribution could be addressed in future PQD ring compression tests on irradiated material by such requirements as orienting ring samples such that the maximum asymmetric hydrogen concentration is aligned with the maximum stress point or in pre-hydrided material by introducing asymmetric distribution during hydriding. The NRC requests comment on these or other methods to treat asymmetric hydrogen distribution.

Response – Comment 5, 5a and 5bi-iii

GEH/GNF concurs with the NEI Industry response with the additional comment that GEH/GNF does not have experience with hydride rim nor with significant circumferential variation in measured hydrogen concentrations similar to, for example, Figures 168, 169 or 180 of NUREG-CR-6967. Metallographic examinations of high burnup Zircaloy-2 cladding also do not support significant circumferential variation in visible hydride. The hydrogen content of high burnup Zircaloy-2 cladding had appreciably lower hydrogen content compared with Figures 168, 169 or 180 of NUREG-CR-6967. There is therefore no basis for GEH/GNF to include circumferential variation or hydride rim in hydrogen model. In the absence of data showing generic presence asymmetric hydride distribution, such as hydride rim, GNF recommends that PQD tests to address non-uniformities in hydrogen distribution should not be part of this rulemaking.

Testing Considerations

Request for Comment 6

A draft proposed cladding oxidation and PQD testing methodology is provided at ADAMS Accession number ML090900841.

Request for Comment 6a

a. The NRC requests comment on the details of the draft experimental methodology, including sample preparation and characterization, experimental protocols, laboratory techniques, sample size, statistical treatment, and data reporting.

Response – Comment 6a

GEH/GNF concurs with the NEI Industry response.

In addition, GEH/GNF notes that for both oxidation/PQD and breakaway oxidation testing, the draft procedures discuss details that can be readily handled by vendor QA programs that comply with 10 CFR Part 50 Appendix B and 10 CFR Part 21. Specifically, the requirements for ensuring proper calibration of furnaces, thermal couples, and devices for mechanical testing and hydrogen content determination would be addressed. The draft procedures rely on equipment vendors to provide certification with, in some cases, additional verification to ensure compliance with ISO and ANSI/NCSL quality assurance standards. GEH/GNF has a qualified certification lab/process that can perform some of the calibration/certification functions with the added assurance of Appendix B and Part 21 compliance. It is recommended that the draft procedures be revised to include, for equipment calibration, the provision of using qualified certification lab or process that comply with 10 CFR Appendix B and 10 CFR Part 21.

Specific to oxidation/PQD testing, section 11.1 of ML090900841 states that MTS used for PQD testing needs to be subjected to annual verification; yet Appendix A appears to describe a test method to justify using a test instrument that was overdue for annual verification without performing the annual verification. It is recommended that the procedure be revised to remove the ambiguity. In section 11.3, the purpose of the second paragraph is not clear, in part since reference is made to IPS-495-00-00, which does not appear to be a publically available document.

For both oxidation/PQD and breakaway oxidation testing, GEH/GNF support the use of test procedures to be developed through ASTM as alternative to the draft procedures. GEH/GNF recommends that a flexible approach be taken to allow other test procedure to be used after demonstrating equivalency of test results.

Request for Comment 6b

b. The NRC requests information on any ongoing or planned testing programs that could exercise the draft experimental methodology to independently confirm its adequacy.

Request for Comment 6c

c. Unirradiated cladding specimens pre-charged with hydrogen appear to be viable surrogates for testing on irradiated cladding segments. However, the NRC's position remains that future testing to support cladding approval reviews include irradiated material without further confirmatory work to directly compare the embrittlement behavior of irradiated material to hydrogen pre-charged material at the same hydrogen level. The NRC's LOCA research program reports PQD test results on twenty irradiated fuel cladding segments of varying zirconium alloys and hydrogen concentrations that underwent quench cooling. The NRC requests information on any ongoing or planned testing aimed at replicating these twenty PQD tests for the purpose of validating a pre-hydrided surrogate.

Request for Comment 6d

d. The NRC is considering defining an acceptable measure of cladding ductility as the accumulation of 1.00 percent permanent strain prior to failure during ring-compression loading at a temperature of 135 °C and a displacement rate of 0.033 mm/sec. Recognizing the difficulty of measuring permanent strain, the NRC requests comment on alternative regulatory criteria defining an acceptable measure of cladding ductility.

Response – Comment 6b, 6c and 6d

GEH/GNF concurs with the NEI Industry response.

Request for Comment 7

The proposed revisions to § 50.46 include a new testing requirement related to breakaway oxidation. Due to the observed effects of manufacturing controlled parameters (e.g., surface roughness, minor alloying, etc.) on the breakaway phenomena, the proposed approach would include periodic testing requirements to ensure that both planned and unplanned changes in manufacturing processes do not adversely affect the performance of the cladding under LOCA conditions.

a. The NRC requests comment on the testing frequency and sample size provided in the breakaway oxidation testing methodology (ADAMS Accession number ML090840258) and technical basis for the proposed breakaway oxidation testing requirement.

b. Is there any ongoing or planned testing to further understand the sensitivity of breakaway oxidation to parameters controlled during the manufacturing process?

Response – Comment 7, 7a and 7b

GEH/GNF concurs with the NEI Industry response that existing regulations and vendor quality assurance programs are adequate to assure maintenance of acceptable breakaway oxidation performance.

Revised Reporting Requirements Considerations

Request for Comment 8

The NRC requests comment on the proposed concept that the reporting obligation in § 50.46 depend upon the margin to the relevant acceptance criteria. Please also comment on the specific approach to implement this objective as described under Objective 3 in Section III of this document.

Response – Comment 8

GEH/GNF concurs with the NEI Industry response.

Request for Comment 9

The NRC requests comment on the proposed concept of adding the results of breakaway oxidation susceptibility testing to the annual reporting requirement. Are there other implementation approaches that could help ensure that a zirconium-based alloy does not become more susceptible to breakaway during its manufacturing and production life-cycle?

Response – Comment 9

GEH/GNF concurs with the NEI Industry response.

Crud Analysis Considerations

Request for Comment 10

The NRC requests comment on the proposed regulatory approach in which crud is required to be considered in ECCS evaluation models. If actual crud levels should exceed the levels considered in the evaluation model, the situation would be considered equivalent to discovering an error in the ECCS model. The licensee would then be subject to the reporting and corrective action process specified in § 50.46(a)(3) to resolve the discrepancy. The NRC also requests comment on the imposition of a requirement that one or more fuel assemblies be inspected at the end of each fuel cycle to demonstrate the validity of crud levels analyzed in the ECCS model.

Response – Comment 10

GEH/GNF concurs with the NEI Industry response that a regulatory requirement for periodic inspections for crud is not necessary. For the referenced crud events from one BWR plant, inspection of fuel discharged at the end of the cycles preceding the crud events did not reveal abnormal crud build up and provided no advanced information on crud buildup during the following cycle.

Request for Comment 11

What information exists to facilitate developing an acceptable crud deposition model that could correlate crud deposition with measured primary water coolant chemistry (e.g., iron-oxide concentration)? For boiling water reactors, it is difficult to perform visual inspections or poolside measurements of fuel rod crud thickness without first removing the channel box. A crud deposition model would facilitate the confirmation of design crud layers assumed in the ECCS evaluations and provide an indicator to reactor operators when crud levels approach unanalyzed conditions. Are there ongoing or planned industry efforts to monitor water coolant chemistry for comparison to observed crud deposition? If so, what amount of success has been obtained? Could a properly correlated crud model be sufficiently accurate to preclude the need for crud measurements at the end of each fuel cycle?

Response – Comment 11

GEH/GNF concurs with the NEI Industry response.

Cost Considerations

Request for Comment 12

The U.S. commercial nuclear power industry claims that implementation of the proposed rule would be a significant burden in both money and resources. The industry has discussed an implementation cost of approximately $250 million (NRC-2008-0332-0008.1 at http:// www.regulations.gov).

a. What options are available to reduce this implementation cost?

b. Are there changes in core operating limits, fuel management, or cladding material that would reduce the cost and burden of implementing the proposed hydrogen based PQD criterion without negatively impacting operations?

c. A staged implementation would be more manageable for both the NRC and industry. One potential approach involves characterizing the plants based upon safety margin and deferring implementation for the licensees with the largest safety margin (e.g., lowest calculated CP—ECR). The NRC requests comment on this implementation approach.

Response – Comment 12a - c

GEH/GNF concurs with the NEI Industry response.

In addition, GEH/GNF notes that a high implementation cost for GNF/GEH is driven predominately by the need to conduct hot cell examinations in order to develop detailed models for hydrogen pickup and crud buildup. The cost involved is highly dependent on the complexity of the hydrogen or crud model. In the case of a hydrogen model, the ANPR and issue #5 above refers to the need to address manufacturing process, proximity to dissimilar metals, plant coolant chemistry, oxide thickness, crud, burnup etc. as well as account for axial, circumferential and radial variations in hydrogen distribution. Such a hydrogen model would require considerable amount of data to develop and verify. A similar case exists for modeling crud build up. A large cost saving will therefore come from a reduction in the complexity of the models.

Rulemaking Comments

From: Harrison, James F. (GE Infra, Energy) [james.harrison@ge.com]
Sent: Tuesday, October 27, 2009 9:37 PM
To: Rulemaking Comments
Cc: Lin, Yang-Pi (GNF); Lingenfelter, Andy (GNF); Crawford, Douglas C (GNF); Philpott, Stephen; Head, Jerald G (GE Infra, Energy); Campbell, Patricia L (GE Infra, Energy)
Subject: Issues for Consideration, of RIN 3150-AH42, [NRC-2008-0332], Performance-Based Emergency Core Cooling System Acceptance Criteria
Attachments: MFN 09-671.pdf

<<MFN 09-671.pdf>> Comments attached for the subject ANPR.

Regards, Jim H

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<james.harrison@ge.com>
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