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June 29, 2015

(18)

Subject: Submittal of Comment for Docket ID NRC-2012-0043 on Draft Regulatory Guide DG-1263 "Establishing Analytical Limits for Zirconium Based Alloy Cladding"

In support of the rulemaking for Title 10, Section 50.46c of the Code of Federal Regulations (10 CFR 50.46c), the NRC has prepared a draft Regulatory Guidance that, once finalized, will allow fuel vendors to demonstrate compliance with the forthcoming regulation. Draft Guide (DG)-1263 provides the recommended approach for developing analytical limits for peak clad temperature and time at temperature for zirconium-alloy cladding materials corresponding to the measured ductile-to-brittle transition to demonstrate compliance with 10 CFR 50.46c for the cladding material.

During the development of the draft guidance, there was a comment period open to the industry and public which has since been closed. Westinghouse Electric Company LLC (Westinghouse) is submitting an additional comment for consideration prior to finalization of the draft guidance. Westinghouse has obtained additional data related to the Post Quench Ductility (PQD) performance of the **Optimized ZIRLO™** high performance fuel cladding material that was not available during the original commenting period. The additional data demonstrates that the PQD performance of the **Optimized ZIRLO** cladding material is comparable to that of the ZIRLO® cladding material and as such, is requesting that the **Optimized ZIRLO** material be included in DG-1263 as one of the materials for which Figure 2 is applicable. The attachment to this letter provides the comment and supporting information.

Correspondence with respect to comments for NRC Docket NRC-2012-0043 should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

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Attachment

SUNSI Review Complete
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E-RIDS= ADM-03
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Anthony Mendiola (NRR)
Jeremy Dean (NRR)

Comment for Docket ID NRC-2012-0043 on Draft Regulatory Guide DG-1263, “Establishing Analytical Limits for Zirconium Based Alloy Cladding” (Non-Proprietary)

June 2015

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INTRODUCTION

An additional comment is being provided by Westinghouse Electric Company LLC (Westinghouse) for consideration in draft regulatory guide DG-1263 (Reference 1). DG-1263 was released in support of the proposed 50.46c Loss of Coolant Accident (LOCA) rule in Reference 2. This comment requests that the **Optimized ZIRLO™** high performance fuel cladding as defined in Reference 3 be included with ZIRLO® and other fuel cladding materials as an accepted alloy to apply Figure 2 of DG-1263. This conclusion is based on additional data that were unavailable prior to the closure deadline for comments on the proposed 50.46c rule and is specific to DG-1263.

This comment supplements those submitted in Reference 4, and are based on new test data and on comments from the public meeting at Oak Ridge National Laboratory on April 29-30, 2015 (Reference 5). This additional comment supplements the comments presented at that meeting in Reference 5.

BASIS FOR CONSIDERATION

Optimized ZIRLO high performance cladding should be included in the list of zirconium alloys for which the proposed allowable Equivalent Cladding Reacted (ECR) vs hydrogen curve, Figure 2 in DG-1263 is applicable. In support of this comment, high temperature LOCA simulation test data are provided. These data, from post quench ductility (PQD) testing, demonstrate the effective equivalence between ZIRLO cladding, which is included in the current draft guidance, and **Optimized ZIRLO** cladding. This data were produced using methods described in the 2014 Top Fuel paper presented in Sendai, Japan (Reference 6). The applied test protocols followed the guidance in DG-1262 (Reference 7) with a few minor exceptions. All exceptions from DG-1262 were carefully evaluated for potential impact on the validity of the results. Where needed over checks were used to insure accurate and consistent test conditions. A summary of the resulting data which compares the PQD performance of **Optimized ZIRLO** cladding with ZIRLO cladding is provided in this letter. The comparison utilizes ZIRLO cladding which was also tested in the Argonne National Laboratory (ANL) program described in Reference 8. Examination of the summary data demonstrates that the PQD performance of both ZIRLO and **Optimized ZIRLO** cladding are nearly identical and that the same ECR limits as a function of hydrogen should be applicable to both alloys.

Figure 1 is a plot of Cathcart-Pawel (CP) ECR vs Hydrogen with PQD test results. Plotted are Ring Compression Test (RCT) results for ZIRLO and **Optimized ZIRLO** cladding in as-fabricated and pre-loaded with hydrogen to 100, 200, 300, 400 and 600 wppm target levels. Testing was conducted at 1200°C and 1125°C peak clad temperature. Solid symbols denote brittle results and open symbols denote ductile results. Each data point is the average of three ring compression tests with each ring cut from a common specimen of cladding following oxidation and quench. ZIRLO and **Optimized ZIRLO** cladding specimens were oxidized side by side. The average offset strain was compared to the ductile to brittle transition (DBT) offset strain correlation developed by ANL. If the average offset strain was

greater than the DBT strain, then the data point was considered ductile. If the average was equal to or less than the DBT transition developed by ANL, it was considered brittle. In a subset of RCTs, the specimen remained intact enough to allow the plastic strain to be measured. All tests for which the offset strain was greater than the ANL DBT correlation also had plastic strains greater than 1%.

Also plotted in Figure 1 is the ECR vs hydrogen DBT curve from Figure 2 in DG-1263. It can be observed that the transition from ductile to brittle generally follows that line and that the transition from ductile to brittle is nearly the same for both alloys.

Figure 2 is a plot of measured vs predicted weight gain based on CP over the temperature range from 1050 to 1200°C for the tested ZIRLO, **Optimized ZIRLO** and Zircaloy-4 cladding. It can be observed that the weight gain is similar for the three alloys.

Figure 3 is a comparison of post quench macrostructure. ZIRLO, **Optimized ZIRLO** and Zircaloy-4 cladding at approximately the same ECR and hydrogen combinations have been sectioned, polished and photographed as shown in Figure 3. Two levels are shown in terms of ECR and hydrogen: 7.1% ECR and 300 wppm and 15.9% ECR and 100 wppm. It can be observed that the macrostructure in terms of oxide thickness, alpha layer thickness and remaining prior beta layer thickness at each set of conditions is very similar for the three alloys tested.

CONCLUSION

The data presented herein demonstrates the equivalence of high temperature behavior between **Optimized ZIRLO** and ZIRLO cladding in terms of weight gain, post quench macrostructure and post quench ductility. Furthermore, the alloying elements used in **Optimized ZIRLO** cladding are within the range of alloying elements tested in the ANL LOCA program.

These results demonstrate that the generic ECR v Hydrogen PQD curve in Figure 2 of DG-1263 is also applicable to **Optimized ZIRLO** cladding as well as ZIRLO® cladding. Based on these results, Westinghouse is requesting that subsequent versions of DG-1263 and other similar documentation include **Optimized ZIRLO** cladding as an approved material with respect to the ECR vs hydrogen curve. The NRC is invited to audit the detailed test prospectuses, test reports, and other documentation supporting this conclusion.

Figure 1: ECR vs Hydrogen, PQD RCT Results for ZIRLO and Optimized ZIRLO Cladding

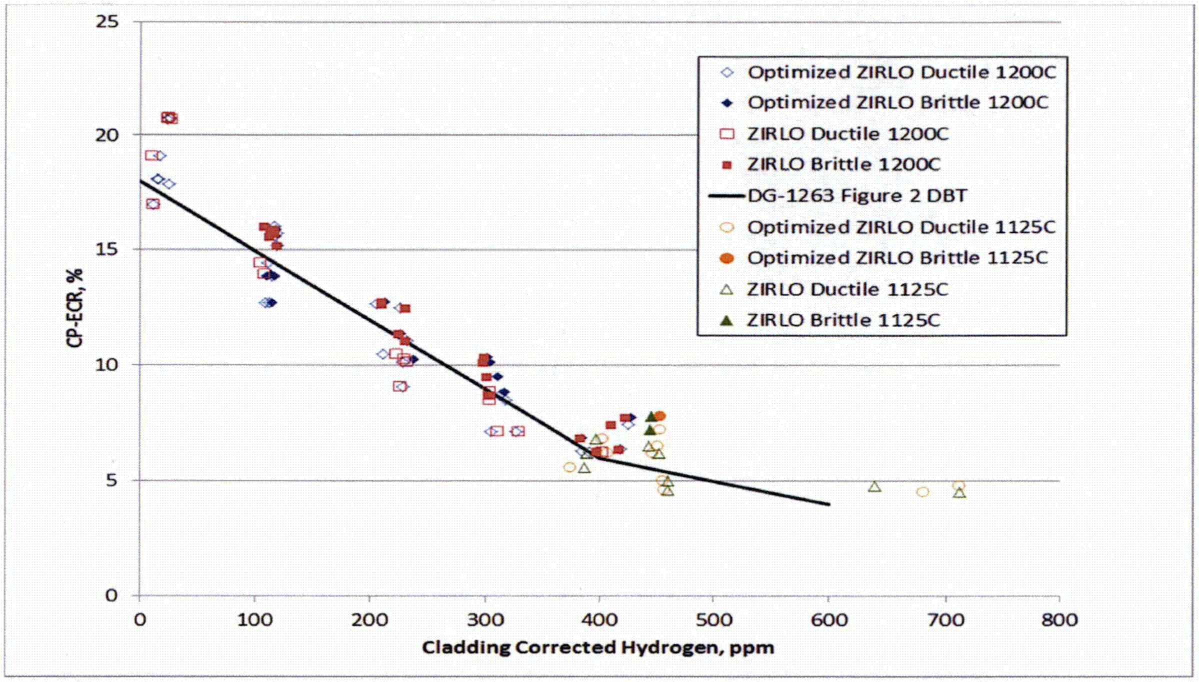


Figure 2: Measured vs Predicted weight gain by Cathcart-Pawel for temperature range from 1050 to 1200°C for ZIRLO, Optimized ZIRLO and Zircaloy-4 cladding.

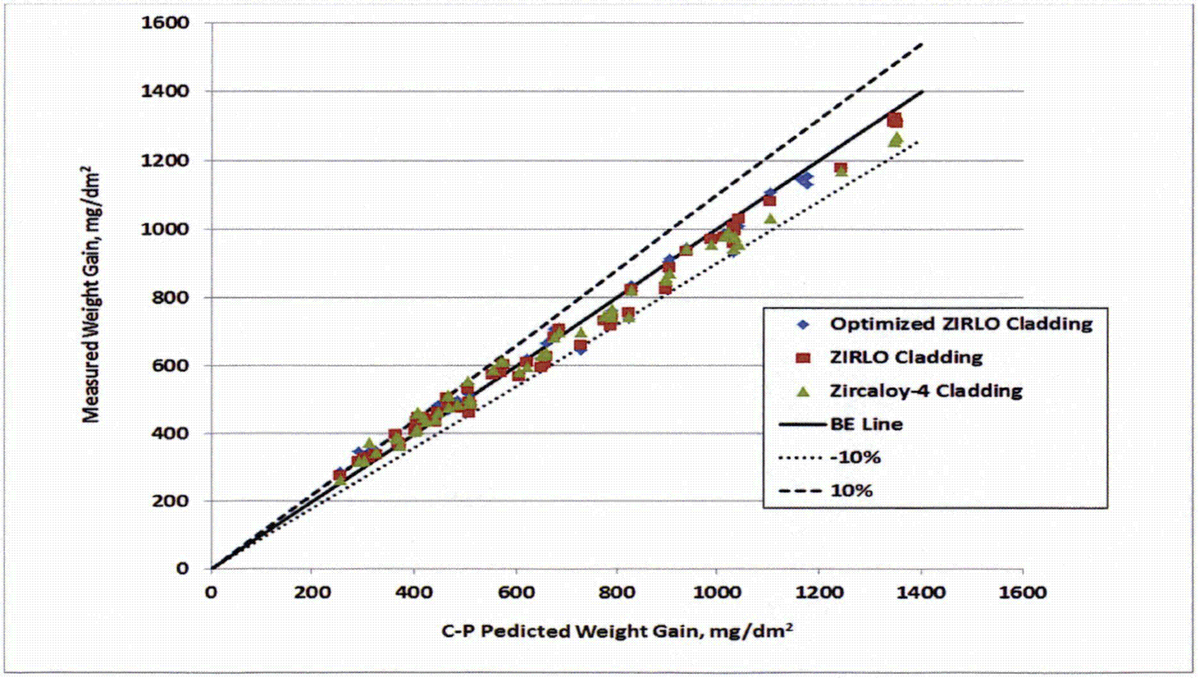
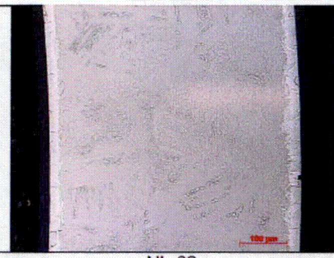
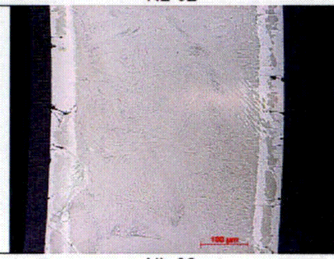
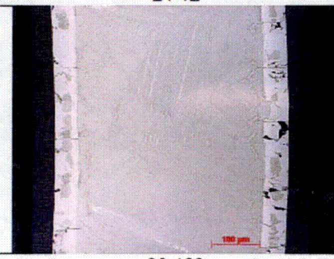


Figure 3: Comparison of Post Quench Cross Sections

ECR	Optimized ZIRLO	ZIRLO	Zircaloy-4
7.1% 300ppm H LOCA580			
	QL-32	NL-62	24-12
15.9% 100ppm H LOCA577			
	R4-32	NL-82	26-102

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2. Federal Register FRN 2014-05562, Volume 79 Number 56, "Performance-Based Emergency Core Cooling Systems Cladding Acceptance Criteria," March 24, 2014.
3. WCAP-12610-P-A and CENPD-404-P-A, Addendum 1-A, "Optimized ZIRLO™", July 2006.
4. LTR-NRC-14-52, James A. Gresham to Cindy Bladey, Subject: Submittal of Comments for Docket ID NRC-2008-0332 on the Proposed Performance-Based Emergency Core Cooling System Cladding Acceptance Criteria, August 19, 2014. (ADAMS Accession No. ML14233A400)
5. Public Meeting on Draft Regulatory Guides for 50.46c – ORNL, Draft Reg Guides and determining acceptable LOCA performance, April 29 – 30, 2015. (ADAMS Accession No. ML15124A830)
6. R. J. Comstock, A.J. Mueller, G. Pan, D. B. Mitchell, Assessment of the Determination of Post Quench Ductile to Brittle Transition of ZIRLO® and Optimized ZIRLO™ High Performance Claddings, Paper No. 100149, Proceedings of WRFPM 2014, Sendai, Japan, Sep. 14-17, 2014.
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