Applicability of Figure 2 in DG-1263

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Background

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- Figure 2 in DG-1263 defined an acceptable analytical limit on integral time at temperature for the zirconium-alloy cladding materials tested in the NRC's LOCA research program, which were Zry-2, Zry-4, ZIRLO™, and M5®.

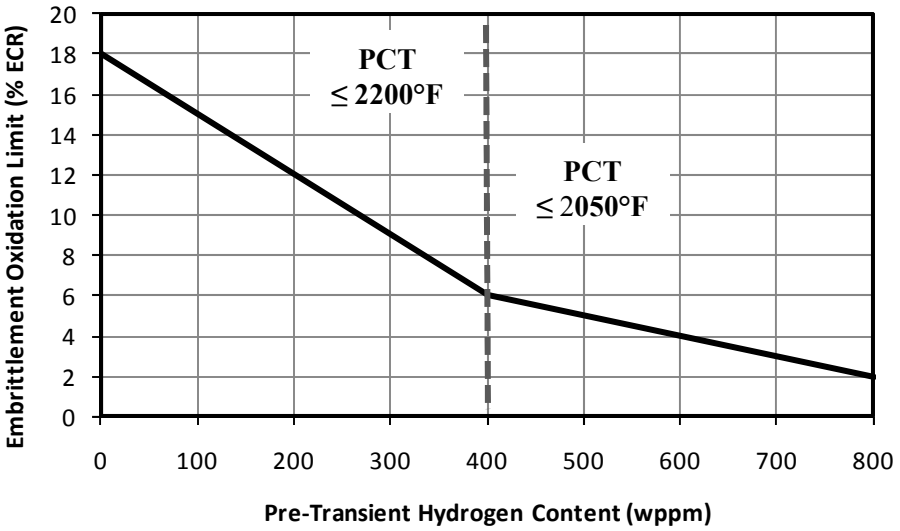

Figure 2. An acceptable analytical limit on peak cladding temperature and integral time at temperature (as calculated in local oxidation calculations using the CP correlation)

Background

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- The NRC received multiple comments regarding the applicability of this curve to new cladding alloys, particularly new cladding alloys for which alloy contents are similar to the alloy contents of the alloys tested.

- The NRC is considering the comments that proposed revisions to the draft guide to vary the extent of testing needed depending on the alloy contents of a proposed new cladding alloy.

Objective of Today's Discussion

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- Provide an outline of possible revisions to DG-1263 to address applicability of Figure 2 to new cladding alloys.
- Seek clarification on comments that included definitions of the boundaries of "similar alloy content" and any associated technical basis.
- Seek clarification on the proposed treatment and reduced test requirements for new cladding alloys that are similar to the materials tested in NRC's LOCA research program.

Review of Guidance

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- Figure 2 can be adopted without testing for cladding alloys Zry-2, Zry-4, ZIRLO™, and M5®
  - Any cladding manufactured in accordance with the topical report's alloy definitions, including: specified range of alloy contents, heat treatment, mechanical properties and corrosion models

- Guidance outlined a methodology to demonstrate consistency with the existing database for any cladding alloy outside the above definition.
  - Required testing of :
    1. As-received (AR) material
    2. Pre-hydrided material - every 100 wppm between AR & max [H] predicted at EOL
    3. Irradiated material – at least 2 [H] levels; (1) within 50 wppm of max [H] predicted at EOL and within 50 wppm of ½ max [H] predicted at EOL material

  - Required a minimum of a 3 RCT data set for each of 3 ECR levels (9 RCT test total) for each condition above. ECR levels would include oxidation and quench testing at:
    1. The appropriate transition ECR defined in Figure 2
    2. An ECR 1% above and
    3. An ECR 1% below this limit

Review of Guidance
continued

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- Guidance outlined a methodology to establish a zirconium-alloy-specific limit other than the limit in Figure 2.
    - Similar approach as that outlined for "consistency demonstration," but more repeat testing
- Guidance outlined a methodology to establish an analytical limits at PCTs $< 1204°C$ (2200°F)
    - Similar approach as that outlined for "consistency demonstration," but more repeat testing

Summary of Comments

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- A provision should be added to allow a vendor wishing to qualify an extension to an alloy family to present material and rationale supporting the extension for NRC review and approval.
- Adoption of Figure 2 should be allowed *(without testing was implied)* for alloys within the same family as those tested at Argonne. The definition of "family of alloys" could be zirconium alloys with Nb<1.5%, Fe<0.3%, Sn<2%, Cr<0.2%, Ni<0.2%, O >900ppm.
- Adoption of Figure 2 for new cladding alloys *(without testing was implied)* could be defined by the solubility of alloying elements in the beta phase.
- A discussion of what constitutes a "new alloy," for the purposes of applicability of Figure 2, should be added to the RG.
- The research found no effect of alloy composition on embrittlement and there is no reasonable expectation that a limiting curve should be found at 1200C for another zirconium alloy that would be difference from the referenced figure. *(Adoption of Figure 2 for all zirconium alloys without testing was implied.)*

Summary of Comments
continued

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- Requirements for testing irradiated material should be eliminated for alloys that meet the following conditions:

  a) The alloy uses the same zirconium reduction method as the alloys tested at ANL,
  b) The alloy uses alloying elements at concentrations that do not exceed the concentrations of the alloys tested at ANL, and
  c) The planned irradiation does not exceed the fluence of the tested alloys.

  - For alloys where condition (b) cannot be met, the guidance should be to perform testing of irradiated cladding to show similarity in terms of PQD behavior to the pre-hydrided cladding only at one hydrogen level which is at or above two-thirds of the maximum best estimate hydrogen level.

- Irradiated testing should occur within 100 ppm of (1) the maximum expected [H] during operation and (2) at 75% of the maximum expected [H] during operation.

Proposal

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The NRC is considering introducing two distinct methodologies to demonstrate consistency with the existing database (i.e., adoption of Figure 2) for new cladding alloys. Assuming the reduction method and maximum fluence are the same as previously tested materials,

1. if the subject new alloy introduces an alloying element not present in the materials tested or the alloying content of an element is significantly different than the materials tested, then testing would include:
   - As-received (AR) material
   - Pre-hydrided material - every 100 wppm between AR & max [H] predicted at EOL
   - Irradiated material – at least 2 [H] levels; (1) within 50 wppm of max [H] predicted at EOL and within 50 wppm of ½ max [H] predicted at EOL material

2. if the subject new alloy includes only the alloying elements present in the materials tested and the alloying content of each element is similar to the materials tested, then a reduced level of testing could be considered.
   - As-received (AR) material
   - Reduce pre-hydrided testing to only 2 [H] levels
   - Eliminate testing of irradiated material

Proposal
continued

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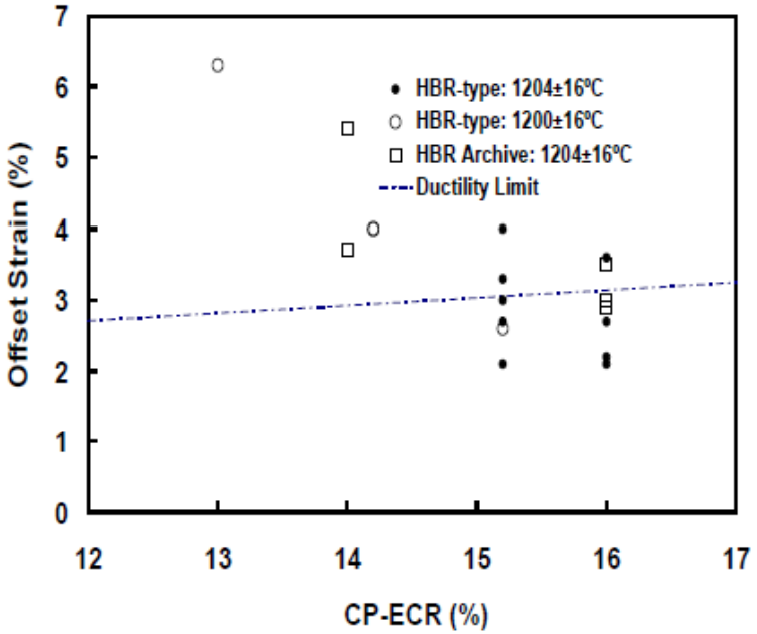
"Assuming the reduction method and maximum fluence are the same as previously tested materials, if the subject new alloy includes only the alloying elements present in the materials tested and the alloying content of each element is ***similar*** *to the materials tested, then a reduced level of testing could be considered."*

The NRC staff understands the interest and potential benefit in reducing the test requirements for new cladding alloys that are "similar" to previously tested alloys.

However, few details were provided in the comments to discern the technical basis for defining the boundaries of "similar."

Some technical basis will need to be articulated to support this proposed revision.

Proposal
continued



Putting it all together….

If the NRC moves forward with approach outlined in Day 1 presentation on RCT data assessment and the approaches outlined in this presentation, a new cladding defined as "similar" to the materials previously tested could be approved with 3 plots similar to the one on the right – one for as received, and two at selected target H levels X and Y with RCT data from samples with hydrogen levels X+/-10% and Y+/-10%

Alloys that are "different" from previously tested alloys to test AR, and pre-hydrided material every 100 wppm and irradiated material at 2 [H] levels.

Conclusion

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- The NRC received multiple comments regarding the applicability of this curve to new cladding alloys, particularly new cladding alloys for which alloy contents are similar to the alloy contents of the alloys tested.
- The NRC is considering the comments proposing revisions to the draft guide to reduce the extent of pre-hydrided testing and possibly eliminate the need for irradiated testing for new cladding alloys that are similar to previously tested materials.
- The NRC would like to seek clarification on the technical basis of specific comments related to defining the boundaries of "similar alloy content" before considering specific revisions to DG-1263.