NRR-PMDAPEm Resource

From: Clifford, Paul
Sent: Wednesday, November 05, 2014 3:35 PM
To: Donna Gilmore
Subject: RE: Status of M5 and Cirlo fuel cladding storage issues per my question in St. Lucie 11/3/2014 meeting on Areva M5 fuel use

Ms. Gilmore:

Thanks for your interest in the FP&L telecom earlier this week. With respect to your concerns regarding drying operations and transportation of spent nuclear fuel:

All zirconium alloys have a ductile to brittle transition temperature (DBTT), which is the temperature below which the ductility is significantly reduced. For almost all zirconium cladding alloys coming out of the reactor with circumferential hydrides, the DBTT is around room temperature. The process of drying the fuel for storage or transportation puts some of these hydrides into solution which subsequently precipitate as radial hydrides due to the cladding stress imposed by the internal rod gases. These radial hydrides raise the DBTT. The degree to which it is raised depends on the stress in the rod, cladding alloy type, cladding manufacturing technique, and maximum temperature used to dry the fuel. Experimentation indicates that, depending on these parameters, the DBTT can rise to between 25 and 120°C. Guidance related to the drying process will be updated based on ongoing and planned future research programs, as appropriate. When approving Certificates of Compliance or licenses to store the fuel, the DBTT for the fuels allowed to be stored or transported is taken into consideration. For example for a transport cask there may be a condition placed in the certificate specifying the minimum temperature the cladding can be at when transported in order to maintain ductility. The condition will depend on the path that the applicant wants to use when licensing in order that the reduced ductility does not become an issue.

As a result, any future application to transport spent fuel would take into account alloy type (e.g., M5, Zircaloy-4), initial heat treatment (e.g., CWSRA, RXA), and the drying process that the fuel was exposure to.

With respect to the in-reactor performance of M5, slide 9 of the Billone presentation lists post-irradiated cladding hydrogen content for various zirconium cladding alloys. Examination of this slide reveals superior in-reactor corrosion performance of M5 (less than 100 wppm hydrogen) compared with ZIRLO and Zircaloy-4. As a result, the overall ductility of this alloy is better both during irradiation and in the spent fuel pool. Billone's paper shows that alloy-specific guidance on drying in needed to ensure that these enhanced properties are maintained for transportation.

-----Original Message-----
From: Donna Gilmore [mailto:dgilmore@cox.net]
Sent: Monday, November 03, 2014 3:47 PM
To: Saba, Farideh
Cc: Marvin Lewis; Marvin Resnikoff; Clifford, Paul; Arjun Makhijani; Arnie Gundersen; Dave Lochbaum; Gordon Thompson (gthompson@irss-usa.org); Woollen, Mary; CHAIRMAN Resource; Robert Alvarez
Subject: Status of M5 and Cirlo fuel cladding storage issues per my question in St. Lucie 11/3/2014 meeting on Areva M5 fuel use

What is the status of resolving the M5 and Zirlo cladding hydride reorientation and embrittlement dry storage issues identified in the 2013 Billone presentation and report that show the problems are worse for these new alloys compared to Zircaloy-4 (for high burnup fuel)? I'm surprise the NRC would continuing approving exceptions to use these fuel claddings when they are worse that the problems with Zircaloy-4 and you have no solutions as of yet for even the Zircaloy-4.

Paul Clifford mentioned in the meeting he was aware of the Billone Argonne study and maybe others, and said experiments haven't been completed to determine how to resolve these issues. He said drying temperature, time and pressure are the variables that may need adjusting to attempt to eliminate or reduce these problems.

Regulations in Japan limit peak cladding temperature to only 275°C, much lower than the 400 °C peak cladding temperature limit in the United States. Is there a reason the NRC allows much higher temperatures? For source, see page 27 of DOE Review Of Used Nuclear Fuel Storage and Transportation Technical Gap Analyses, July 2012.
http://energy.gov/sites/prod/files/Gap%20Comparison%20Rev%200.pdf

Here are links to the Billone presentation and Argonne report. I've also included the text of Slide 6 and 12, since this represents the key issues identified.

http://www.nwtrb.gov/meetings/2013/nov/billone.pdf
http://sanonofresafety.files.wordpress.com/2014/02/billone2013-09-30embrittlementdbtthighbrnup-pwrfuelclad-alloys.pdf

Key issues identified:
Slide 6 Cladding Mechanical Properties and Failure Limits:
- Available for HBU Zircaloy-4 (Zry-4) with circumferential hydrides
- Available for Zry-2 but data needed at high fast fluence (i.e., HBU)

Data needs
- Tensile properties of HBU M5® and ZIRLO™ cladding alloys
- Failure limits for all cladding alloys following drying and storage
- Radial hydrides can embrittle cladding in elastic deformation regime

Slide 12 Summary of Results
- Susceptibility to Radial-Hydride Precipitation
  - Low for HBU Zry-4 cladding
  - Moderate for HBU ZIRLO™
  - High for HBU M5®
- Susceptibility to Radial-Hydride-Induced Embrittlement
  - Low for HBU Zry-4
  - Moderate for HBU M5®
  - High for HBU ZIRLO™

Thank you,

Donna Gilmore
SanOnofreSafety.org
949-204-7794

Hearing Identifier: NRR_PMDA
Email Number: 1692

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Sent Date: 11/5/2014 3:34:41 PM
Received Date: 11/5/2014 3:34:00 PM
From: Clifford, Paul

Created By: Paul.Clifford@nrc.gov

Recipients:
"Donna Gilmore" <dgilmore@cox.net>
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