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Date: Tue, Jul 15, 2003 8:03 PM
Subject: Request for Paks-2 Severe Fouling Data

Hello again from Sun Valley, Idaho:

I have read the May 23, 2003, report of Event 1120 at Paks-2.

It is interesting that the fuel cleaning process lacked sufficient instrumentation to monitor conditions within. I have a few questions:

How thick are (were) the fouling deposits? And, are (were) they predominantly magnetite?

How much of the zirconium alloy becomes oxidized in service? And how much dissolved oxygen (oxygen that is in addition to the oxygen combined with zirconium as oxide) is in the zirconium alloy cladding after partial service of the fuel (when the fuel is placed in the cleaning chamber)?

Apparently, zirconium-water and zirconium-steam reactions led to hydrogen production that displaced water from the cleaning vessel. Have you any data for the amount of water level decrease in the cleaning vessel? The incident report, event 1120, refers to a water level decrease of 7 cm in the pool when the cover was opened and water rushed into the cleaning tank. From that I'm guessing that the top of the tank was gas-bound to a depth of several meters. Certainly, someone has determined the precise uncovering of the fuel.

Comment: It is interesting that fuel cleaning was an almost regular procedure at Paks-2. It is also interesting that the cleaning process was basically an unlicensed process.

Slowly, I have been finding out that in the USA cleaning of fuel elements for removal of fouling is also commonplace. I have not been able (permitted) to collect any data on the heat transfer characteristics of the fouling in USA reactors. As far as I can determine the USA processes use ultrasonic equipment and elements are cleaned one at a time. I also believe that the USA process are basically unlicensed by the USNRC. That is, I have not found any licensing documents in limited search.

Are you members of the Relap 5 International Users' Group? Here is their web page for a forthcoming late August 2003 meeting:
http://www.inel.gov/relap5/call2003.pdf

I have submitted a revised abstract. It is attached (file relap11). Of course, it would be a great challenge for the experts to run Paks-2. However, even fouled USA reactors have not been thus evaluated.

Good luck!

Bob Leyse bobleyse@aol.com

CC: <chairman@nrc.gov>

An Unmet Challenge: Application of SCDAP/RELAP5-3D to Analysis of Severe Accidents for Light Water Nuclear Reactors with Heavily Fouled Cores

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The SCDAP/RELAP5-3D series of codes have not been employed to evaluate the impact of heavy fouling of fuel elements on the path of severe accidents such as Reactivity Insertion Accidents and Loss of Coolant Accidents. This is the case even though operation of nuclear power reactors with significant fouling deposits is commonplace. [1,2,3,4]

Fouling deposits have substantial thermal resistance. This has led to fuel element failures in several instances as the zirconium alloy cladding has failed due to high temperature corrosion.[3,6] Although the details of current fouling have not been disclosed, in one case[3] the deposits have been described as, "...unusually heavy...which induced the corrosion by thermally insulating the fuel rods..." and "...rods that failed had heavy crud with clumpy formations." Such heavy clumpy fouling is complex with substantial thermal resistance.

Relatively straightforward fouling at the Experimental Boiling Water Reactor was classified in terms of the thickness and the thermal conductivity.[6] Thickness of the fouling was 0.013 cm, the thermal conductivity was 0.008 W/cm-C; thus the heat transfer coefficient was 0.6 W/(cm^2)(C). The peak heat flux in today's large light water reactors is in the range of 150 W/cm^2 and the temperature gradient for EBWR-type fouling would be 250 C. However, the effective heat transfer coefficient of the heavy, clumpy fouling in today's reactors is likely substantially less than the EBWR case. Clearly, the heat transfer characteristics are vastly degraded in contrast to clean as-built cores. The challenge for the U. S. Nuclear Regulatory Commission is to fund the SCDAP/RELAP5-3D experts in a thorough scope of work to determine the impact of a range of heavy fouling characteristics on severe accidents. The findings are needed for the accurate licensing of water-cooled nuclear reactors (homeland security).

Currently the Nuclear Regulatory Commission is evaluating several related Petitions for Rulemaking[7,8,9] that have been initiated by the author regarding these matters. The results of those deliberations should be available at the 2003 RELAP5 International Users Seminar, West Yellowstone Meeting.

References

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6. Breden and Leyse, 1960, Water chemistry and fuel element scale in the EBWR, ANL-6136.
7. Leyse, Petition for Rulemaking to USNRC, PRM 50-73, September 3, 2001.
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9. Leyse, Petition for Rulemaking to USNRC, PRM 50-76, May 1, 2001.