OFFICE OF THE SECRETARY
CORRESPONDENCE CONTROL TICKET

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| **AUTHOR:** | Bob Leyse |
| **AFFILIATION:** | ID |
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| **SUBJECT:** | Importance of PRM 50-76 and PRM 50-78 |
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**DATE DUE:** **DATE SIGNED:**

**From:** <Bobleyse@aol.com>
**To:** <Chairman@nrc.gov>
**Date:** Thu, May 27, 2004 10:18 AM
**Subject:** Importance of PRM-50-76 and PRM-50-78

Dear Mr. Chairman:

Please expedite action on the old petitions PRM-50-76 and PRM-50-78. In the attachment, DLSkeen, the last paragraph has two crossed out sentences as follows: Completion of the recommendations to the Commission has been delayed due to higher priority work assignments. Work is again in progress regarding these two petitions. (This attachment was included, perhaps inadvertently, in a letter that I received from Rocklein that was dated May 5, 2004, although it was not mailed until May 13, 2004.)

So, it is evident that NRC has regarded the issues of minor importance. However, when Kewaunee encountered matters addressed in PRM-50-78, NRC decided that the matter was of sufficient importance to send a special inspection team to the site. The attachment, Kewaunee, is a copy of the e-mail that I sent you on April 21, 2004.

The third attachment, West Yellowstone 2003, is a set of slides that I discussed at the
2003 RELAP5 International Users Seminar, West Yellowstone, Montana, August 27-29. This presentation, Unmet Challenges for SCDAP/RELAP5-3D: Analysis of Severe Accidents for Light Water Nuclear Reactors with Heavily Fouled Cores, covers decades of adverse experiences related to fouling in a wide range of water cooled and moderated nuclear reactors. Now, the RELAP work at INEEL is at least partially funded by the NRC. Since the NRC staff have insisted that they need their own code packages for thorough review of plant license applications, the NRC staff should be directed to include the implications of fouling in those reviews. Specifically, the Commissioners should direct their Petition Review Boards to include RELAP analyses in their reviews of PRM-50-76 and PRM-50-78.

The current regulatory rage is to strongly encourage risk informing. Certainly, the Commissioners are aware that in the absence of evaluating the impact of fouling, the risk informed analyses have been grossly misleading.

Robert H. Leyse bobleyse@aol.com
Box 2850
Sun Valley, ID 83353

**CC:** <rrudman@epri.com>, <jeb@nei.org>

Mr. Robert H. Leyse
P.O. Box 2850
Sun Valley, ID 83353

Dear Mr. Leyse:

I am writing to inform you of the status of two petitions for rulemaking that you submitted concerning the effects of crud deposition and fouling on evaluation models used to assess the performance of emergency core cooling systems (ECCSs) and on the performance of heat-transfer surfaces in nuclear power plants.

The petition for rulemaking, Docket No. PRM-50-76, dated May 1, 2002, requested changes to the regulations and guidance on evaluating ECCS performance. In the staff review process, a decision was made to request review of the petition by the NRC Office of Research (RES), relative to ongoing work on ECCS performance. The RES review is now complete and the staff has met with a Petition Review Board (PRB). A recommendation to the Commission regarding disposition of this petition is in preparation.

With respect to the petition for rulemaking, Docket No. PRM-50-78, dated September 2, 2002, requesting that fouling of heat transfer surfaces in nuclear power plants be addressed by rule changes, a staff working group was convened and analysis of the petition is complete. A PRB was convened, and a recommendation to the Commission regarding disposition of this petition is also in preparation.

~~Completion of the recommendations to the Commission has been delayed due to higher priority work assignments. Work is again in progress regarding these two petitions.~~ As you are aware, until the Commission has approved the recommended resolution of the petition, findings of the PRB are considered pre-decisional and can not be released. A letter will be sent to you regarding disposition of each of the two petitions as soon as the Commission has voted on the staff recommendations.

Sincerely,

Alan K. Roecklein
Policy and Rulemaking Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Distribution:

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| ADAMS - | SECY (Docket File for PRM-50-73, 50-73A, 50-76, 50-78) | | |
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OFFICIAL RECORD COPY

Subject: PRM-50-78 and Kewaunee
Date: 4/21/04 9:17:54 AM Mountain Daylight Time
From: Bobleyse

To: Chairman@NRC.gov
CC: jeb@nei.org

In a message dated 4/21/04 9:17:54 AM Mountain Daylight Time, Bobleyse writes:

NRC action on PRM-50-78 is long overdue. At Kewaunee, fouling of heat exchangers for the safety injection pump oil coolers led to a shutdown on January 16, 2004. I find it laughable that NRC sent a special inspection team to look into this and NRC then had the audacity to report that it Determined that there was a safety problem.

And then, the NRC team was to issue a report of its findings. What has happened to the LER system? And are your resident inspectors so incompetent that they cannot verify the accuracy of an LER?

I note that Marion of NEI documented his organization's intense opposition to possible NRC actions that would anticipate the impact of fouling of heat transfer surfaces on nuclear plant safety.

Robert H. Leyse

# Unmet Challenges for SCDAP/RELAP5-3D

## Analysis of Severe Accidents for Light Water Nuclear Reactors with Heavily Fouled Cores

Robert H. Leyse, CEO
Inz, Inc.

*2003 RELAP5 International Users Seminar, West Yellowstone, Montana, August 27-29*

# Fouling impacts fuel pin heat transfer and fuel pin axial growth

At the 2002 RELAP5 Users Seminar, Knudson listed *Fuel pin failure timing analyses* among the *Wide Range of Analyses Completed*. However, none of the five volumes of SCDAP/RELAP5-3D instructions explicitly address the impact of fouling at the start of the events on the timing of fuel pin failure or the propagation of fuel pin failures. The Volume 4 has extensive tables of properties of fuel pin components, but there is no reference to properties of fouling.

Volume 4 does not address the change in length of fuel pins due to the thermal impact of fouling.

# Thermal impact of fouling

The heat transfer characteristics of the fouling in today's LWRs have not been reported. However, operational experience reveals that with fouling and corrosion the fuel pin heat transfer characteristics are vastly degraded in contrast to clean pins.

At the River Bend BWR, the severe fouling led to corrosion thicknesses sufficient to penetrate the cladding of many fuel pins. At more than 20 units fouling has trapped boron and this led to offsets in the power distribution. In one case, control rod binding was traced to guide tubes that deformed when fouled fuel pins lengthened beyond end space limits and bent. At Paks Units 1-3, reduced flow restricted the power level. Several units now employ ultrasonic means to remove fouling.

# Fouling is ubiquitous

River Bend
Paks-2

Experimental Boiling Water Reactor (EBWR)
Argonne Low Power Reactor (SL-1)

More than 20 LWR's have had power distribution shifts caused by boron trapped in fouling.

Two units have deployed ultrasonic fuel cleaning to remove fouling: South Texas Project and Callaway.

# River Bend Station Unit 1

A SCDAP/RELAP5-3D analysis of fuel pin failure timing for severe accidents at the River Bend Station would be revealing. Multiple fuel pin failures were attributed to "...an unusually heavy deposition of crud on the fuel bundles." It was, "Determined that an insulating layer of crud caused accelerated fuel rod corrosion. " There is no quantitative disclosure of the effective thermal conductivity of the insulating layer of crud. It is disclosed that "Measured zircaloy oxide thickness on high power unfailed HGE bundles was up to 6 mils at the 50" level where the perforations occurred." However, there has been no public disclosure of the measured zircaloy oxide thickness on the **failed** HGE bundles.

# Paks Units 1-3

A SCDAP/RELAP5-3D analysis of fuel pin failure timing for the Paks Units 1-3 would be revealing. In a May 2003 report to the Chairman, Hungarian AEC, the extensive fouling of the Paks units is candidly discussed. There is no description of the thermal resistance of the fouling or the amount of zircalloy corrosion. However, the fouling (magentite)) has been extensive. Quoting, "...magnetite deposits in the fuel assembles increased and the cooling water flow-rate decreased. Consequently the power of Units 1-3 had to be decreased." Chemical cleaning of fuel elements in batches of seven elements became routine. In 2002, Framatome ANP expanded the cleaning process to 30 element batches.

process

# Paks Units 1-3 (Continued)

On 10 April 2003, while the assemblies were being cleaned for Unit 2, severe damage occurred to an entire batch. The state of the fuel prior to the accident has not been disclosed. But as this data including the extent of fouling become available, it is likely that analysis will yield further insights on the impact of fouling on severe accidents. The cleaning process for the 30 element batch was designed by Framatom ANP. V. Asmolov, the Director of the Kurchatov Institute observed, "... it was a hand-made accident caused by those who, **mildly speaking**, clumsily thrust where they shouldn't. This is a precious experience." Clearly, this accident is a challenge for the analysts who deploy SCDAP/RELAP5-3D and related tools.

# Axial Offset Anomaly (AOA)

More than 20 LWR's have had power distribution shifts caused by boron-loaded fouling. EPRI reports, "The root cause of AOA is corrosion product deposition in the upper spans of fuel assemblies as a result of sub-cooled nucleate boiling." EPRI does not report the thermal conductivity of the deposits or the extent of zirconium oxidation. Deposits were scraped from several fuel assemblies following a cycle that experienced AOA. The thickness of the samples was in the range of 125 microns, however, that likely does not include zirconium oxides that are integral with the base cladding. Again, it is clear that the deposits constitute a significant thermal resistance that should be incorporated in SCDAP/RELAP5-3D.

# AOA (continued)

NRC Information Notice 97-85 clarifies AOA:

*Axial offset (AO) is a measure of the difference between power in the upper and lower portions of the core. This difference must remain within limits established in the technical specifications to ensure that both SDM and clad local peaking factors are not exceeded. Exceeding these limits could result in the reactor fuel exceeding 10 CFR 50.46 limits on fuel clad temperature (1204C). If the reactor approaches these limits, compensatory measures, including a power reduction, must be taken to maintain the reactor within its operational limits.*

However, the Notice does not include any discussion of the very substantial temperature increase of the limiting fuel pins

# AOA (continued)

that results from the same fouling that leads to the AOA. This temperature increase likely exceeds 250C, however the consequent increase beyond the 1204C limit of 10.46 is far greater than 250C because the fuel rods bend, distort and burst during the accident. There is a simultaneous set of physical and chemical occurrences. The fouling layers and the zirconium oxide layers become cracked, broken, shocked and loosened while zirconium-water reactions proceed at accelerating rates as additional zirconium is exposed to the water steam conditions at increasing temperatures. The AOA data reveal starting conditions that must be considered in related SCDAP/RELAP5-3D analyses of 10.46 accidents.

# South Texas Project and Callaway

**Quotes from EPRI press release:** *Ultrasonic Fuel Cleaning*

*While AOA has not been a problem for the* ***South Texas Project****, the utility purchased ultrasonic fuel cleaners for each of its two units as a proactive measure for corrosion product control after replacing steam generators and uprating both units. All reload fuel for the Unit 2 reactor was cleaned in October 2002. Reload fuel for Unit 1 will be cleaned in April 2003.*

*According to Ameren's Gail Gary, the core at the* ***Callaway*** *plant remained free of AOA throughout the fuel cycle for the first time in the eight most recent cycles after one fuel cycle in which all reload fuel was ultrasonically cleaned.*

# Experimental Boiling Water Reactor

The Experimental Boiling Water Reactor (EBWR) was designed and operated by Argonne National Laboratory during the late 1950s and early 1960s. An unfortunate selection of aluminum alloy for core filler pieces led to deposits of hydrated alumina on the zirconium clad fuel elements. 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/(cm2)(C). The peak heat flux in today's large light water reactors is in the range of 150 W/cm2 and the temperature gradient for EBWR-type fouling would be 250 C. However, the heat transfer coefficient for the combined fouling and zircaloy oxide of today's units is likely substantially less than the EBWR case.

# Argonne Low Power Reactor (SL-1)

The SL-1 was destroyed in a Reactivity Insertion Accident (RIA) on January 3, 1961. Fouling of the aluminum clad fuel plates likely intensified the severity of the accident. However, fouling was not considered by the analysts who investigated this RIA. Here is a quote from GE Report, Additional Analysis of the SL-1 Excursion, Report IDO-19313, 1962: *"The thickness of the cladding has an important effect on the magnitude of the excursion. Because of the extremely short period, this 0.89 mm cladding became an effective thermal insulator and impeded the flow of heat to the reactor water where it could initiate shutdown of the reactor."*

Now, inasmuch as the thermal conductivity of aluminum is

# SL-1 (continued)

about 200 times greater than the corrosion on the fuel plate, a corrosion layer only 0.00445 millimeters thick would have the same temperature gradient as 0.89 mm of aluminum cladding. Alternatively, the measured corrosion product thickness of 0.09 mm has 20 times the temperature gradient of the aluminum cladding. Ignoring the corrosion thus yields a grossly incomplete analysis in determining turnaround characteristics.

# Summary and Challenges

Fouling is ubiquitous

Fouling is a substantial thermal resistance

Fouling has a greater impact than burnup

Current fouling must be classified: thermal characteristics, composition, porosity, etc.

Fouling must be incorporated in SCDAP/RELAP