UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001

Sept. 11, 2001

Subject: 2 Abstracts for ICONE-10

ASME/ICONE-10
c/o Barbara Signorelli/MS-22S1
3 Park Ave.
New York, NY 10016-5990

Dear Ms. Signorelli:

Attached please find two Abstracts for the ICONE-10 meeting, April 14-18, 2002.
The two proposed paper titles, and indicated Session Track, are:

> ***Operational Events Noted for Power Uprated Plants & Potential Safety Implications*** Suggested Session: Plant Operations & Maintenance....(Track-1)
>
> ***Margin Impact Estimates for Re-Licensed/Uprated Plants: Hatch Case Study*** Suggested Session: License Renewal, Life Extension.....(Track-4)

These papers were also submitted electronically to your WEB site, however much of the abstract formatting appeared lost in the electronic version.

Thanking you for your consideration, I remain

Sincerely,

August W. Cronenberg
ACRS-Fellow
ACRS/TWFN 2E26
E-mail: awc@nrc.gov
Phone: 301-415-6809

ABSTRACT: ICONE-10
Suggested Session: Plant Operations & Maintenance (Track-1)

Operational Events Noted for Power Uprated Plants and Potential Safety Implications

by

A. W. Cronenberg (ACRS-Fellow), D. A. Powers (ACRS), and R. P. Savio (ACRS-Staff)
Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

During the 1980s and 1990s the U. S. Nuclear Regulatory Commission (NRC) reviewed and approved in excess of 30 licensee requests for power uprates, which were generally in the range of 4-7 % power increase. More recently NRC has received License Amendment Requests (LARs) for significantly higher uprates, examples being the 15-% power increase request for the Duane Arnold plant and the 17-% increase for the Dresden and Quad City units. Although each such uprate request is evaluated to assure that current regulatory requirements are satisfied, concerns have developed regarding the safety implications of power uprates of this magnitude for an aging population of US-LWR plants. Such concerns stem from operational events noted for plants having received power uprates, including failures to fully insert control rods in high-power/high-burnup fuel assemblies, piping failures, and reactivity transients. Of particular concern is the potential for synergistic/compounding effects, for example the effects of higher power levels when combined with system/component degradation via plant aging, or higher power levels in conjunction with fuel life extensions to higher burnup. This paper examines a number of operational events for uprated plants and their potential safety implications.

Control rod insertion problems occurred at the Wolf Creek and North Anna plants, both having received power uprate approvals of 4-5%. At Wolf Creek five control rods failed to fully insert during scram from full power. The affected control rods involved Westinghouse Vantage-5H fuel assemblies with burnups greater than 47,6000 MWD/t-U. Root cause analysis indicate Zircaloy guide tube distortion due to irradiation induced growth. Since irradiation growth in metals is influenced by neutron energy spectrum, power level, and total exposure (burnup) effects, synergistic processes are evident. Other incidents include power offset anomalies for long-cycle/high-power cores tied to crud buildup on high-burnup rods. The crud appears to getter boron causing a distortion of the axial power profile.

Aged reactor components, in combination with higher power levels, may likewise produce degradation that is greater than the sum of the individual effects. Research has shown that pipe corrosion can be exacerbated by increased fluid velocity, indicative of a synergistic corrosion /erosion process. The pipe ruptures at the Callaway and Susquehanna plants provides examples of such piping degradation/rupture. Other aging factors include vibrational fatigue, particularly for pumps and valves, where higher coolant velocities associated with power uprates would tend to aggravate vibrational fatigue for aged components.

Inadequacies are also noted in regards to the Maine Yankee and Brunswick uprate applications, indicating the need for independent agency thermal-hydraulic and neutronic analysis capabilities to verify the accuracy of licensee submittal information. NRC in-house computational efforts would go a long way in providing an independent check and verification of what is now essentially a licensee effort. In view of such observations and current licensing actions involving significant uprates (10-20%), the following recommendations are made:

- NRC should issue a Standard Review Plan (SRP) for power uprate applications, which should include acceptance criteria which consider the influence of synergistic effects, specifically high fuel burnup levels and component/system aging effects in combination with uprated power conditions.

- NRC uprate review procedures should include requirements for independent NRC staff analysis (i.e. thermal-hydraulic and neutronic code predictions) and verification of uprate plant predictions submitted by the licensee. The results of these NRC audit calculations should be included in the SER for each uprate application and include comparisons with licensee submittal analysis.

- The impact of power uprates on potential diminished margins to design limits for safety related systems and components should be evaluated and included in future uprate applications.

DISCLAIMER: The views expressed in this paper are solely those of the authors and do not necessarily represent the views of the ACRS as a body or that of the Commission.

ABSTRACT: ICONE-10
Suggested Session: License Renewal, Life Extension.....(Track-4)

Margin Impact Estimates for Re-Licensed/Uprated Plants: Hatch Case Study

by
A. W. Cronenberg (ACRS-Fellow), M. V. Bonaca (ACRS), and G. B. Wallis (ACRS)
Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Recent electrical power shortages have lead to industry initiatives at plant life extension, power uprates, and requests for a longer fuel cycle at higher burnup levels. Of the approximately 100 nuclear units currently in operation, it is estimated that upwards of 80 may apply for plant life extensions beyond their current 40 year license. A number of plants have likewise applied for significant power increases, on the order of 15% or greater. Although each licensing action is reviewed by the NRC to assure that the current body of regulations are satisfied and that plants continue to operate safely, the Advisory Committee on Reactor Safeguards (ACRS) is concerned about potential *margin reductions* owing to the compounding effects of such multiple licensing actions, particularly in view of the age of many plants.

To examine margin reductions for power uprates and plant life extension, a case study was made for the Hatch-BWR plant, since this plant received approval for two power uprates (5-%, 8-%) and is currently under review for license renewal. An increase plant power stems from some increase in coolant enthalpy from the core, achieved by an increase in primary system pressure, temperature, net coolant through-flow, or some combination of thereof. Changes in "margins" for the primary coolant system can thus be assessed from changes to such thermal-hydraulic parameters, as compared to ASME design temperature/pressure limits for the primary pressure boundary. Table 1 presents a summary of changes in operational conditions and margins to ASME Boiler & Pressure Vessel Code design limits for the Hatch uprates.

Table 1. Hatch-1 Operational Margins

Residual Margin = [Design Limit - Value] / Design Limit		
Power Level. MWt	Parameter Value	Residual Margin. %
Main Steam-line Pressure (Design Limit = 1250 psig)		
Original = 2436	1015 psig	18.8
1st Uprate = 2558	1050 psig	16
2nd Uprate = 2763	1050 psig	16
Main Steam-line Temperature (Design Limit = 575 F)		
Original = 2436	546 F	5.04
1st Uprate = 2558	---	---
2nd Uprate = 2763	551 F	4.17

With regards to plant life extension, margin trends were estimated for several passive components for which time-limited aging analysis (TLAA) was performed as part of the Hatch license renewal application. TLAA estimates for piping largely center on estimates of the cumulative usage factor (CUF) for cyclic loadings during the period of extended operation. Such TLAA-CUF estimates essentially involve an assessment of the stress impact of various cyclic operational and off-normal transients which contribute to the total cumulative fatigue to the component considered. The ASME Pressure Vessel Code requires that all Class-1 components must have a predicted CUF value less than one at the end of the intended period of operation; thus, the margin for pipe fatigue can be estimated simply as [1.0 -CUF]. Table 2 summarizes such estimates as a function of time. As shown, CUF equals 0.56 for feedwater piping at 40 years, which increases to 0.72 at 60 years. Similar trends are indicated for other plant components. For some passive components the residual CUF margin at the end of the 60-year extension period is shown to be quite minimal.

Table 2. Residual Margin Estimates from Piping Fatigue Usage Analysis for Hatch-1 Renewal (CUF at two significant figures)

Component	Unit	CUF at 40 years	Residual Margin at 40 years, %	CUF at 60 years	Residual Margin at 60 years, %
Residual Heat Removal Suction Piping	2	0.57	43-%	0.77	23-%
Reactor Vessel Equalizer Piping	1	0.52	48-%	0.64	36-%
Core Spray Replacement Piping	1	0.16	84-%	0.19	81-%
Feedwater Piping	2	0.61	39-%	0.83	17-%
Standby Liquid Control Piping	1	0.24	76-%	0.25	75-%
Feedwater (FW), High Pressure Coolant Injection (HPCI), Reactor Core Isolation Cooling (RCIC), and Reactor Water Cleanup (RWCU) Piping	1	0.56	44-%	0.72	28-%
Steam Condensate Drainage Piping	2	0.66	34-%	0.89	11-%
Main Steam Piping (Line B)	1	0.08	92-%	0.10	90-%
Main Steam Piping (Line D)	2	0.016	>98-%	0.02	98-%

Although such estimates are crude, nevertheless they point to a general trend of component margin reductions for both power uprates and plant life extension. It is important to note that such estimates are for individual components and for separate license actions, i.e. either power increase or life extension. The more difficult problem is to translate changes in component - specific margins to the plant as a whole, i.e. a holistic measure of margin impact for the plant. An even more difficult task is the integration of component-specific margins for the compounding effects of a power increase when combined with plant license renewal, or some other combination of plant changes. Such margin integration efforts were beyond the scope of the work reported here but are recommended for future investigation.