PDR: per R. Emrit

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

Reference (1252)

SEP 3 0 1988

MEMORANDUM FOR: T. L. King, RES/ARGIB

FROM: C. Z. Serpan, Jr., RES/MEB

SUBJECT: REEVALUATION OF ISSUE 15, "RADIATION EFFECTS ON REACTOR VESSEL SUPPORTS"

## Introduction

The purpose of this memorandum is to request that ARGI Branch elevate the priority of Issue 15, "Radiation Effects on Reactor Vessel Supports," and reevaluate the issue considering information recently developed concerning the effects of low-temperature, low-flux irradiation. At this point, it does not appear to us that the new information suggests an immediate threat to public safety. However, the effects of low-temperature, low-flux irradiation are causing significantly increased embrittlement of the supports and the potential for risk to the public should be reevaluated to bring about prompt generic resolution of the issue.

## Background

The subject issue was reviewed in NUREG-0933, dated November 30, 1983, with the conclusion that occupational dose increases associated with remedial measures for this issue far outweigh the public risk reduction. Consequently, the issue was recommended to remain as a Low Priority issue until new data on the severity of the concern were available.

When the issue was considered originally, the deleterious effects of low fluence rate and of differences in neutron energy spectrum on the predicted level of radiation embrittlement of the supports were not evaluated properly. The irradiation effects technology has progressed to the point where we routinely account for low energy neutrons using the dpa (displacements per atom) parameter when the energy spectrum is known to have a significant number of low energy neutrons.

Assessments of neutron irradiation damage using the dpa parameter and our earlier understanding of low-temperature irradiation would still support the conclusions reached in NUREG-0933 regarding Issue 15. However, use of dpa plus our new understanding of low-temperature, low-flux irradiation would not.

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## New Results

In 1986 ORNL tested surveillance specimens removed from their High Flux Isotope Reactor (HFIR). They found significantly greater increases in the nil-ductility (NDT) temperature, as determined from Charpy impact energy data, than would have been predicted using the low-temperature irradiation trend

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data developed in materials test reactors. After a significant research effort, they concluded that the greater than expected increases in the NDT were due to a flux, or "dose rate," effect. The entire issue and a discussion of the flux effect are presented in ORNL/TM-10444, "Evaluation of HFIR Pressure-Vessel Integrity Considering Radiation Embrittlement," Ref. 1. In summary, the flux effect results in a significant increase in neutron embrittlement, as measured by increases in the NDT, for steel irradiated a low temperatures, in the range of 75 to 150 F and at low fluxes, typically below about $10^{10}$ n/cm$^2$/sec. While it had been well known that irradiation at temperatures below the 550 F normal operating temperature for LWR's resulted in higher embrittlement levels, irradiation at temperatures and fluxes typical of LWR pressure vessel supports now has been shown to result in even greater embrittlement.

## Analysis

Responding to questions posed by the ACRS, we initiated a study at ORNL to consider the possible effects of low-temperature, low-flux irradiation on reactor vessel supports. The initial questions posed by the ACRS asked if any plants were operating today with the support operating temperature below the NDT of the support material, or if there would be any plants doing so by the end of their design life. Based on a preliminary study, we could not state conclusively that no plants would be operating with the supports below their NDT by the end of their design lives. Consequently, the scope of the study was expanded to consider the effects of irradiation on the fracture behavior of the supports.

ORNL categorized the supports from each LWR in the U.S. With one exception, all of the BWR's are supported on skirt supports which are sufficiently removed from the "high" irradiation zone that neutron irradiation induced embrittlement is not a problem. The one BWR not supported on a skirt is Big Rock Point and it may warrant plant specific attention. However, it is likely that the Big Rock Point supports are operating at a relatively high temperature and may not be a concern. As with the BWR's, all but one of the B&W PWR's are supported on skirt supports. All of the C-E PWR's are supported on "long" columns that pass the core midplane and are exposed to the high cavity fluence. Similarly, all of the Westinghouse PWR's supported by shield tanks pass the core midplane. There are approximately 13 plants that use shield tanks as the reactor pressure vessel support structure and all of these structures were designed by Stone & Webster. The balance of the PWR's are supported on what has been termed "short" columns. The designs included in this category range from designs with tension members embedded in the biological shield wall near the core midplane, to designs that are fabricated box beams that are supported by the shield wall near the top of the core.

ORNL was asked to identify the limiting designs and perform a plant specific analysis for them to evaluate the potential for brittle fracture of the supports. Because we had an analysis from Stone & Webster on shield tanks and an informal response from C-E on long columns indicating there were no problems with these designs, ORNL chose to concentrate on the short column category. They selected the Trojan plant and the Turkey Point 3 & 4 plants (these two are identical) as limiting designs. Although the Trojan and Turkey Point designs are drastically different, they both have tension members in the vicinity of the core--at the core midplane for Trojan and at the top of the core for Turkey Point.

ORNL submitted their report on these analyses on September 29, 1988. The report indicates that (1) there probably are locations on these supports that have been embrittled to the point that the material's NDT exceeds, or is near to, the operating temperature today and certainly will exceed it by the end of the design life, and (2) there are design-specific locations that, depending on the analysis assumptions, may pose a fracture problem by the end of life. It is important to note that the ORNL analyses are indicating that design-specific features are the limiting factors rather than any general "flaw" in the design codes or procedures. Unfortunately, without a plant-by-plant evaluation it is impossible to tell what other design-specific features may be more limiting than those identified for Trojan and Turkey Point.

As indicated above, ORNL did not consider shield tanks or long columns in this study because Stone & Webster and C-E indicated that they had considered these designs and there were no problems. However, it is not clear that these designs really were considered in light of the new low-temperature, low-flux irradiation data. Consequently, detailed reevaluation of these designs by an independent organization would appear to be in order.

Recommendation

We recommend that Issue 15, "Radiation Effects on Reactor Vessel Supports," be raised to a High Priority, and be reevaluated in light of the new information on increased radiation embrittlement due to low-temperature, low-flux irradiation. Because safety margins are barely adquate in some cases, we also recommend that the first priority for follow-on work be a consequences analysis--(a) a structural analysis of vessel movement when a support breaks and leaves the vessel hanging on the piping, and (b) a study of potential fractures of piping, instrument lines and other electrical connections due to the vessel movement. Background references are provided in the enclosed list of references. The staff of the Division of Engineering Materials Engineering Branch, and that of the ORNL HSST program will be available to discuss this issue.

C. Z. Serpan, Jr., RES/MEB

Enclosure: as stated

# LIST OF REFERENCES
# FOR
# SERPAN TO KING MEMORANDUM ON ISSUE 15


1) R. D. Cheverton, J. G. Merkle, and R. K. Nanstad, Oak Ridge National Laboratory, "Evaluation of HFIR Pressure-Vessel Integrity considering Radiation Embrittlement," ORNL/TM-10444, April 1988.

2) W. Kerr, ACRS, to V. Stello, NRC,
Subject: "ACRS Comments on the Embrittlement of Structural Steel," July 15, 1987.

3) R. D. Cheverton, ORNL to C. Z. Serpan, Jr., NRC,
Subject: "LWR Vessel Supports," September 2, 1987.

4) V. Stello, NRC, to W. Kerr, ACRS,
Subject: "ACRS Comments on the Embrittlement of Structural Steel," October 7, 1987.

5) W. Kerr, ACRS, to V. Stello, NRC,
Subject: "ACRS Comments on Memorandum from Victor Stello, Jr., EDO, Dated October 7, 1987, Regarding the Embrittlement of Structural Steel," December 8, 1987.

6) V. Stello, NRC, to W. Kerr, ACRS,
Subject: "ACRS Comments on the Embrittlement of Structural Steel in Reactor Support Structures," January 28, 1988.

7) W. R. Corwin, ORNL, to M. E. Mayfield, NRC,
Subject: "Continued Investigation of the Integrity of LWR Vessel Supports," February 11, 1988.

8) F. Miraglia, NRC, to D. Crutchfield, NRC,
Subject: "Embrittlement of Reactor Vessel Supports," March 16, 1988.

9) W. Kerr, ACRS, to L. Zech, Jr., NRC,
Subject: "ACRS Comments on Embrittlement of Structural Steel," March 15, 1988.

10) W. R. Corwin, ORNL, to M. E. Mayfield, NRC,
Subject: "Choice of PWR Plants for Specific-Plant Evaluation of Vessel-Support Integrity," March 25, 1988.

11) C. Z. Serpan, Jr., NRC, to Distribution, NRC,
Subject: "Meeting to Discuss Acceptance Criteria for RPV Support Analysis," July 22, 1988.

12) W. R. Corwin, ORNL, to M. E. Mayfield, NRC,
Subject: "Draft Report on Pressure Vessel Support Integrity," September 29, 1988.