August 17, 2001

MEMORANDUM TO: William H. Bateman, Chief
Materials and Chemical Engineering Branch
Division of Engineering

FROM: A. L. Hiser, Jr., Materials Engineer ***/ra/***
Structural Integrity and Metallurgy Section
Materials and Chemical Engineering Branch
Division of Engineering

SUBJECT: MEETING WITH INDUSTRY ON ISSUES REGARDING TECHNICAL BASIS FOR REACTOR PRESSURE VESSEL CLOSURE FLANGE RULEMAKING

DATE & TIME: Tuesday, August 28, 2001
12:30 p.m. - 4:30 p.m.

LOCATION: U.S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Room 4 B6
Rockville, Maryland 20852

PURPOSE: To discuss issues regarding technical basis document WCAP-15315, "Reactor Vessel Closure Head/Vessel Flange Requirements Evaluation for Operating PWR and BWR Plants" (see attached list of issues)

PARTICIPANTS:*	NRC	INDUSTRY
	K. R. Wichman, NRR	W. Bamford, et. al.
	A. L. Hiser, NRR	
	J. Collins,.NRR	
	S. M. Malik, RES	

CONTACT: A. L. Hiser, Jr.
(301) 415-1034 ALH1@NRC.GOV

* A portion of the meeting will involve discussions pertaining to proprietary information and, therefore, will be closed to the public. The nonproprietary portions of the meeting between NRC technical staff and applicants or licensees are open for interested members of the public, petitioners, interveners, or other parties to attend as observers pursuant to "Commission Policy Statement on Staff Meetings Open to the Public" 65 Federal Register 56964, 9/20/2000.

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AGENDA

12:30 p.m. - 12:45 p.m.	Introduction and Purpose of Meeting
12:45 p.m. - 4:00 p.m.	Discussion of Issues Regarding Technical Basis Document WCAP-15315, “Reactor Vessel Closure Head/Vessel Flange Requirements Evaluation for Operating PWR and BWR Plants” - see attached list of issues
4:00 p.m. - 4:30 p.m.	Summarize Discussion and Adjourn

Meeting Notice for Meeting dated: August 17, 2001

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ISSUES REGARDING TECHNICAL BASIS DOCUMENT
WCAP-15315, "REACTOR VESSEL CLOSURE HEAD/VESSEL FLANGE
REQUIREMENTS EVALUATION FOR OPERATING PWR AND BWR PLANTS"

Technical Approach

(1) The staff would like to discuss the methods and results of the stress analyses that were performed on all of the RPV designs, since these results were used to perform fracture mechanics evaluations.

(2) The staff would like to discuss the results of bounding analyses (in terms of higher crack driving forces) for the Westinghouse 2, 3 and 4 loop, B&W, Combustion Engineering, and GE designs.

Fracture Analysis Methods and Material Properties

(1) The report uses Ref. 1 which is a finite element analysis for stress intensity factors, K-solutions, for internal semi-elliptical surface cracks in a cylindrical pressure vessel that is subjected to internal pressure. The same authors (Raju and Newman) have published more general K-solutions (Ref. 2) that are applicable to any general cubic polynomial loading of internal and external semi-elliptical surface cracks in a cylindrical vessel. From Ref. 2, it can be observed that the stress intensity factors for the external surface cracks are, in general, about 5 to 10 % greater than those for the internal surface cracks subjected to the same polynomial applied stress. The staff questions the justification for use of internal crack's non-conservative K-solutions for the assumed external cracks provided in Ref. 1 in lieu of the solutions presented in Ref. 2.

(2) According to the report, "The magnification factors $G_1(\varphi)$, $G_2(\varphi)$, $G_3(\varphi)$ and $G_4(\varphi)$ are obtained by the procedure outlined in reference" of the report. The cited reference provides the following: "The expression for F, in terms of G_j, was obtained from the first four terms of a power series expansion of Lame's solution ... for the hoop stress in an internally pressurized cylinder plus the internal pressure applied to the crack surface." The staff questions the justification for the use of this method for an external surface crack which sees no pressure.

(3) WCAP-15315 further states, in a continuation of the quote from the prior question, "The result is [equation] where each G_j was obtained from the appropriate finite element solution." The staff would like to discuss the assumptions, method and results of the finite element analysis.

(4) The staff would like to discuss the G_j values, for comparison with Table A-3320-1 of Article A-3000 of ASME Section XI for the desired φ of maximum stress concentration.

(5) The method of determining A_j, stress intensity shaping factors, is not clearly defined by the report. NRC Staff requests the Stress Distribution Profiles at boltup and steady state operations, and their corresponding values of A_j.

Attachment

Flange Integrity

(1) The staff would like to discuss the need to consider thermal stresses for high heatup and cooldown rates, along with any justification for not including thermal stresses. Although tables 4-1, 4-2 and 4-3 provide stress analysis at the steady state and boltup conditions, no thermal stress conditions were discussed for heatup and cooldown states.

(2) The staff would like to discuss Figure 4-1, to determine the maximum stress intensity factors for each plant analyzed and the corresponding crack-depths.

References

1. Newman, J. C., Jr., and Raju, I. S., "Stress Intensity Factors for Internal Surface Cracks in Cylindrical Pressure Vessels," Trans. ASME, Journal of Pressure Vessel Technology, Vol. 102, 1980, p. 343.

2. Raju, I. S., and Newman, J. C., "Stress-Intensity Factors for Internal and External Surface Cracks in Cylindrical Vessels," Trans. ASME Journal of Pressure Vessel Technology, Vol. 104, 1982, p. 293-298.