

October 23, 2001

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

FROM: Jay W. Collins, General Engineer */ra/*  
Materials and Chemical Engineering Branch  
Division of Engineering

SUBJECT: SUMMARY OF AUGUST 28, 2001, MEETING WITH INDUSTRY ON  
ISSUES REGARDING TECHNICAL BASIS FOR REACTOR PRESSURE  
VESSEL CLOSURE FLANGE RULEMAKING

On August 28, 2001, NRC staff held a meeting on rulemaking related to reactor vessel head closure flange requirements in Appendix G to 10CFR Part 50. A technical basis for this rulemaking is discussed in "Reactor Vessel Closure Head/Vessel Flange Requirements Evaluation for Operating PWR and BWR Plants," WCAP-15315. The purpose of the meeting was to discuss issues regarding the bases for WCAP-15315, as provided in Attachment A. An attendance list for the meeting is provided in Attachment B.

The agenda for the meeting started with an introduction by Keith R. Wichman, Chief of the Structural Integrity and Metallurgy Section of the Materials and Chemical Engineering Branch. Mr. Wichman outlined the staff's technical issues, as detailed in Attachment A.

Warren Bamford, Westinghouse Electric Company, provided a presentation to address the staff's technical issues. The briefing covered background information on the basis of the reactor pressure vessel closure flange requirement, details on the plant geometries considered, clarification on the stress and fracture analysis methods used, and the safety impact of eliminating reactor pressure vessel closure flange requirements for pressurized water reactors. The presentation slides used are shown in Attachment C.

The meeting attendees discussed the technical issues including resolution options. The industry attendees agreed to reissue WCAP-15315 with additional technical details to address the staff's issues.

Attachments: As stated

CONTACT: J. Collins, EMC/DE  
(301) 415-1038

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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   |

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

Section 2.0 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.

Section 3.0 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 Lamé'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 question (2)'s quote, "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  $\varphi$  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  $A_j$ .

## Section 4.0 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.

ATTENDANCE LIST  
MEETING WITH INDUSTRY ON ISSUES REGARDING THE TECHNICAL BASIS FOR  
REACTOR PRESSURE VESSEL CLOSURE FLANGE RULEMAKING

August 28, 2001

Name	Organization	Telephone Number
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