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LOFT PRIMARY COOLANT PUMP INLET NOZZLE
THERMAL ANALYSIS CLASS I REVIEW

W. C. Kettenacker

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DEPARTMENT OF ENERGY

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RESEARCH, ENGINEERING AND CONSTRUCTION REPORT ENGINEERING ANALYSIS DIVISION

THERMAL ANALYSIS.

LOFT PRIMARY COOLANT

PUMP INLET NOZZLE

THERMAL ANALYSIS CLASS 1

REVIEW

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**IDAHO NATIONAL ENGINEERING LABORATORY
LOFT TECHNICAL REPORT
LOFT PROGRAM**

TITLE LOFT Primary Coolant Pump Inlet Nozzle		REPORT NO. 1142-18
Thermal Analysis Class 1 Review		
AUTHOR W. C. Kettenacker <i>WC Kettenacker</i>		GWA NO. 52151-243-386
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LOFT PRIMARY COOLANT PUMP INLET NOZZLE
THERMAL ANALYSIS CLASS I REVIEW

I certify that the LOFT Primary Coolant Pump inlet nozzle thermal analysis (References 1 and 2) has been reviewed and that this analysis meets the ASME Code, Section III thermal analysis requirements for Class 1 components for the thermal transients and conditions found in the primary coolant pump specification (INC-60008).

APPENDIX A

REVIEW OF LOFT PRIMARY COOLANT PUMP

INLET THERMAL ANALYSES

DISCUSSION

Two thermal analyses were performed on the inlet nozzle of one of the LOFT Primary Coolant Pumps. Both analyses were performed by the Thermal Analysis Branch. The first analysis^[1] calculated the temperature response of the inlet nozzle during LOCE, and the second analysis^[2] considered the following transients for the nozzle; (1) plant heat-up followed by nuclear start-up, (2) a combination of control rod drop, inadvertent moderator cool-down, and loads from spurious operation, and (3) a combination of excessive rod withdrawal and loss of normal feedwater. All transients are as defined in Reference [3].

In accordance with the ASME Code requirements, all analyses of Class 1 components must be independently reviewed. Since the LOFT pumps are Class 1 components, the thermal analyses were reviewed as presented in Appendix A. Appendix B contains the Thermal Analysis Branch comments to this review. It is the opinion of the Thermal Analysis Branch that these comments satisfy all of the reviewer's questions and that the analyses should stand as is, without additional considerations, in meeting the ASME Code requirements and ANC Specification 60008.

REFERENCES

1. W. C. Kettenacker, LOCE Temperature Response of the Inlet Region in a LOFT Primary Coolant Pump, TR 821, LTR 1142-12 (November 9, 1976).
2. H. F. Rhodes, LOFT Primary Coolant Pump Temperature Response of the Inlet Region to Some Normal Operating and Upset Condition Transients, TR 821, Supplement No. 1, LTR 1142-12, Supplement No. 1 (April 27, 1977).
3. W. C. Kettenacker letter to E. D. Uldrich, "LOFT Primary Coolant Pump Nozzle Thermal-Hydraulic Transients," WCK-10-76 (December 21, 1976).

INTEROFFICE CORRESPONDENCE

date June 28, 1977
 to N. E. Pace
 from R. R. Stiger *RR Stiger*
 subject REVIEW OF LOFT PRIMARY COOLANT PUMP NOZZLE THERMAL ANALYSIS - Stig-190-77

- Ref:
- (1) LOFT Technical Report, 1142-12, November 9, 1976
 - (2) Supplement 1 to LOFT Technical Report 1142-12
 - (3) ASME Boiler and Pressure Vessel Code, Section III, Division 1 - 1974 Edition, Subsection NA
 - (4) Idaho Nuclear Corporation, Specification INC-60008, LOFT Primary Coolant Pump
 - (5) Technical Report TR-471, TA-15, dtd February 28, 1974, Couple - A Two-Dimensional Steady-State & Transient Heat Correlation Code for Use on IBM 360/175 Computer

GENERAL

The thermal analyses represented in References (2) and (3) were reviewed for compliance with Specification 60008⁽⁴⁾ and ASME Code Section III⁽³⁾.

In general the analysis was found to be acceptable and the results are considered valid. Several questions concerning boundary conditions and the computer code used⁽⁵⁾ are listed below:

BOUNDARY CONDITIONS

No mention was made of the possibility of internal heat generation. Since the pump is located inside the LOFT containment, the possibility of nuclear heating should be reviewed and the assumption of zero internal heat generation justified. Those portions of the pump nozzle that are in contact with the pump body were assumed to be adiabatic. Results indicate that a ΔT of over 250°F can exist at this boundary which could invalidate the adiabatic assumption.

COUPLE COMPUTER CODE

Review of the technical report on the Couple Code⁽⁵⁾, indicates that it is indeed a proper code to use for the subject analysis. The ability of the code to produce verified answers however, has not been demonstrated. It is not apparent from the statement of checkout in the manual⁽⁵⁾ that the code has ever been checked out on the INEL computer system.

1a

APPENDIX B

COMMENTS TO THE REVIEW OF THE
LOFT PRIMARY COOLANT PUMP
INLET THERMAL ANALYSES

COMMENTS

1. The question was raised in the review that no nuclear heating was considered for the pump.

Comment: Pump gamma-neutron heating during steady state operation will be approximately $10^{-8} \frac{W}{g}$ (personal communication with R. A. Grimesey of Reactor Technology Branch, 7/13/77). This value is extremely small and may be neglected.

2. It was pointed out in the review that the adiabatic surfaces at the nozzle - pump body interface may not really be present. The reviewer indicated that results showed a ΔT of 250°F at the boundary.

Comment: After scrutinizing the data, no ΔT of 250°F could be found normal to the surface at either nozzle - pump body interface. Temperature differences as high as 433°F were found at Location 1 of Figure B-3 at 400 seconds after LOCE, but this ΔT was parallel to the nozzle - pump body interface, not normal to it. Maximum normal temperature gradients at the nozzle - pump body interface are shown in Figure B-3 (Figures B-1 through B-3 give the complete picture), with the maximums occurring during LOCE at both locations. Temperature gradients during steady state operation are also shown on Figure B-3.

The large maximum temperature gradient at Location 2 (Figure B-3) is disturbing. However, the temperature gradient is in the vicinity of the interface and not the exact value at the interface. True adiabatic surfaces would have a zero temperature gradient normal to them across the surface, but this cannot be checked here since temperatures are limited to those of the model only up to the surface. A larger computer model would have to

be developed to extend the interface beyond the current boundary to back check the actual temperature gradient at the current model boundary. But since this area is not critical from a thermal stress standpoint (personal communication with T. K. Burr of Applied Mechanics Branch, Aug. 10, 1977), no further thermal considerations appear justified. At Location 1 (Figure B-3), the maximum and steady state temperature gradients are small enough to justify the adiabatic assumption there.

3. The reviewer was concerned about COUPLE verification and check-out on the INEL computer facility.

Comment: Page 51 of the COUPLE code documentation (E. C. Lemmon, COUPLE - A Two-Dimensional Finite Element Steady-State and Transient Heat Conduction Code For Use On An IBM 360/75 Computer, TR-471, TA-15, February 28, 1974) states:

"The solutions to a large number of problems have been approximated by COUPLE. In many cases, these results have been compared with solutions by Schneider (19), Arpaci (3), and also with various heat transfer codes (which have been checked out) such as SAHARA (20), ARBASH (21), and TEMP (22). In all cases, the agreement has been quite satisfactory and it is the author's opinion that the code performs as previously described."

The references are as follows:

3. Arpaci, V. S., Conduction Heat Transfer, Addison-Wesley, Reading, Mass., 1966.
19. Schneider, P. J., Temperature Response Charts, John Wiley and Sons, Inc., New York, 1963.
20. Gabrielson, V. K., SAHARA: A Multidimensional Heat-Transfer Computer Code, SCL-DR-720024 (Sandia Laboratories Report), September 1972.
21. Biffle, J. H., and Von Riesemann, W. A., ARBAS-H - A Finite Element Computer Code for Heat Conduction and Stress Analysis of Plane Solids and Axisymmetric Solids, SC-DR-69-833 (Sandia Laboratories Report), April 1971.
22. Emery, A. R., TEMP - A Two Dimensional Finite Element Temperature Computing Program, University of Washington, Department of Mechanical Engineering Report, 1972.

WELDING INTO H.P. TEST LOOP AFTER ALL TESTS ARE COMPLETED: CUT CASE OUT OF LOOP, CUT NOZZLE TO $1\frac{1}{2}$ AND SCARE PER DETAIL F

LVR1142 18

CUT OFF NOZZLES OF THREE CASES TO THIS DIM. (15) AND SCARE PER DETAIL F

Modeled Area

Wear Ring

Axis of Rotation

Flow In

63/ POLISH

Figure B-1: LOFT Primary Coolant Pump Inlet Details

Figure B-2: LOFT Primary Coolant Pump
Inlet Finite Element Model -
Nodes Numbered (Distorted
Scaling).

Figure B-3: LOFT Primary Coolant Pump Inlet
Finite Element Model Boundary
Conditions Used in COUPLE
Computer Code.