

**MASTER**

LOFT TECHNICAL REPORT LTR 112-130  
RE & C REPORT NUMBER RE-A-77-138  
FEBRUARY 14, 1978

LOFT BLOWDOWN LOOP PIPING  
THERMAL ANALYSIS CLASS I REVIEW

T. L. Kinnaman



**EG&G** Idaho, Inc.



IDAHO NATIONAL ENGINEERING LABORATORY

**DEPARTMENT OF ENERGY**

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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# RESEARCH, ENGINEERING AND CONSTRUCTION REPORT ENGINEERING ANALYSIS DIVISION

## THERMAL ANALYSIS

LOFT BLOWDOWN LOOP PIPING  
THERMAL ANALYSIS CLASS I REVIEW

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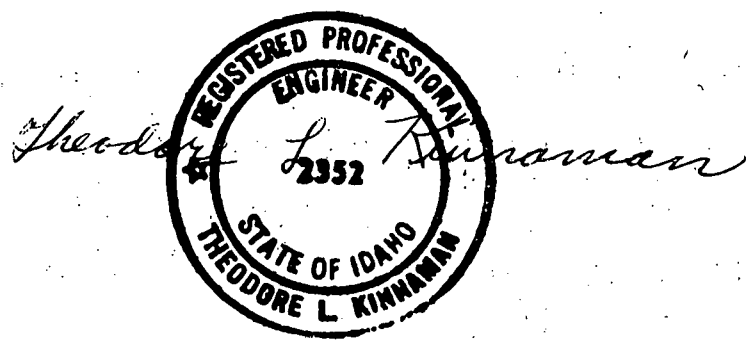
TITLE LOFT Blowdown Loop Piping Thermal Analysis Class I Review		REPORT NO. 112-130
AUTHOR T. L. Kinnaman <i>T. L. Kinnaman</i>		GWA NO. 52151-500-509
PERFORMING ORGANIZATION Thermal Analysis Branch		DATE February 14, 1978
LOFT APPROVAL <i>1-16-78</i> <i>1-17-78</i> <i>PSB mgr</i> <i>PACSB mgr</i> <i>RSB mgr</i>		

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LOFT BLOWDOWN LOOP PIPING  
THERMAL ANALYSIS CLASS I REVIEW

I certify that the LOFT blowdown loop piping thermal analyses (References 1 through 5) has been reviewed and that these analyses meets the ASME Code Section III thermal analysis requirements for Class I components for the thermal transients and conditions found in the LOFT Class I Nuclear Piping Specification, ANC-60139.



DISCUSSION

Thermal analyses were performed on the LOFT blowdown piping loop by the Thermal Analysis Branch. The results of these analyses are documented by References 1 through 5. The analyses documented by References 1 and 5 calculated the temperature response of selected components in the blowdown loop for the heatup and LOCE transients. Reference 2 calculated the axial and radial temperature response of the blowdown valve auxiliary piping during a LOCE. Reference 3 calculated the temperature response of Flange 7 in the blowdown loop for heatup and LOCE transients while Reference 4 was a re-analysis of Flange 7 using a less severe heatup rate.

In accordance with ASME Code, Section III requirements, all analyses of Class I components must be independently reviewed. Since the LOFT blowdown loop piping up through the blowdown valve is a Class I piping system, 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 reviewers questions and that the analyses should stand as is, without additional considerations in meeting the ASME Code requirements and ANC Specification 60139<sup>(6)</sup>.

REFERENCES

1. I. J. Ingvarsson, LOFT Blowdown Loop Thermal Transient Analyses, LTR No. 112-41, Aerojet Nuclear Company (August 29, 1974).
2. D. J. Varacalle, Thermal And Fluid Reaction Loads Analysis of the LOFT Quick Opening Blowdown Valve Auxiliary Piping LTR 112-40, Aerojet Nuclear Company (August 1, 1974).
3. W. C. Kettenacker, Steady State and Transient Thermal Analysis of Flange 7 in LOFT Blowdown System, LTR 112-45, Aerojet Nuclear Company (September 4, 1974).
4. R. L. Moore, Steady State and Transient Thermal Analysis of Flange 7 in LOFT Blowdown System, LTR 112-45 Supplement Aerojet Nuclear Company (August 15, 1975).
5. G. T. Rainey, Thermal Transient Analysis of 1/2 Inch Boss - 5-Inch Pipe Weld in LOFT Blowdown Piping, LTR 112-66, Aerojet Nuclear Co. (January 15, 1975).

6. LOFT Class I Nuclear Piping System ANC-60139, Aerojet Nuclear Company  
(January 15, 1973).
7. R. L. Moore, LOFT Primary System Coolant System Heatup and Cooldown Rates and Operational Transients for Blowdown Piping System, LTR-11-19 Aerojet Nuclear Company (April 30, 1975).

APPENDIX A

REVIEW OF LOFT BLOWDOWN LOOP PIPING

THERMAL ANALYSES

(RLB-9-77)



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## INTEROFFICE CORRESPONDENCE

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date: November 1, 1977

to: N. E. Pace

from: R. L. Benedetti *RLB*

subject: CLASS 1 REVIEW OF LOFT BLOWDOWN PIPING THERMAL ANALYSIS -RLB-9-77

Ref: (a) W. C. Kettenacker ltr to R. L. Benedetti, Request for Class 1 Review of LOFT Blowdown Piping Thermal Analysis, WCK-11-77; August 15, 1977

(b) LOFT Class 1 Nuclear Piping System Specification ANC-60139

In accordance with Reference (a) the following documents were reviewed:

- (1) LTR 112-40
- (2) LTR 112-41
- (3) LTR 112-45
- (4) LTR 112-45 supplement.
- (5) LTR 112-66

Comments on the analysis described in the above documents are grouped into three categories:

- (1) Transients analyzed
- (2) Thermal Properties used
- (3) Conduction models

### Transients Analyzed

Reference (b) was reviewed to determine if the transients analyzed in documents 1 through 5 complied with those specified. In document 2 through 5 a heat up and LOCE transient were analyzed. However, the heat up transient is not that specified in Reference (b). Reference (b) specifies a heat up transient of 100°F/hr from 70-540°F and 540-610°F in 10 minutes (420°F/hr). Documents 2, 3, and 5 used a heatup of 100°F/hr only. Document 4, supplement to document 3, had to back off to 60°F/hr. No justification for non-compliance with Reference 6 was given. The transient used in document 1 appears to be self generated. The correct basis for the transient analyzed must be set.

N. E. Pace  
November 1, 1977  
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### Thermal Properties

Both documents 2 and 5 use constant properties for material conductivity and volumetric heat capacity. Conservative results can be generated in this manner if the properties are selected to give the highest gradients. With respect to conductivity this appears to be the case since a low value was chosen. However, when a single property value is chosen for a temperature range its value should be justified. In addition, document 5 used only one material property for both the weld and base material. Depending on the weld material this may not be a conservative assumption.

### Conduction Models

In documents 2 and 5 a two-dimension R-Z model is used to model the intersection of two pipes. In both documents a statement is made that this does not effect accuracy. These models may be conservative but can not be considered accurate. The question of conservatism should be addressed. In essence one of the pipes must be represented as a flange. The basis for the diameter of the flange (representing the pipe) should be stated so that the conservatism in the model can be determined.

Clarification of the items identified in the above comment is required prior to total acceptance of the analysis in the documents reviewed.

td

cc: T. L. Kinnaman  
N. B. Smith  
R. L. Benedetti file  
Central File

APPENDIX B

RESOLUTION OF REVIEWER'S COMMENTS

TO THE LOFT BLOWDOWN

PIPING THERMAL ANALYSIS

RESOLUTION OF REVIEWERS' COMMENTS

Resolution of the reviewers' comments to the LOFT blowdown piping thermal analyses will be addressed on a comment by comment basis. The reviewers' comment will be given first followed by the Thermal Analysis Branch resolution to that comment.

(1) Comment:

Reference 6 was reviewed to determine if the transients analyzed in References 1 through 5 complied with those specified. In References 2 through 5 a heatup and LOCE transient were analyzed. However, the heatup transient is not that specified in Reference 6. Reference 6 specifies a heatup transient of 100°F/hr from 70-540°F and 540-610°F in 10 minutes (420°F/hr). References 1, 3, and 5 used a heatup of 100°F/hr only. Reference 4, supplement to Reference 3, had to back off to 60°F/hr. No justification for non-compliance with Reference 6 was given. The transient used in Reference 2 appears to be self generated. The correct basis for the transient analyzed must be set.

Resolution:

The LOCE transient will be less severe in the blowdown loop than in the active loop because no ECC water is to be injected directly into it. Therefore, the LOCE transient used in References 1 through 5 was developed and used. The blowdown loop is brought up to operating temperature by circulating a small portion of the primary system flow (<1%) through the blowdown loop. Due to this low steady state flowrate and the large mass of water and steel in the blowdown piping, fluid temperature changes in that loop will occur much slower. This results in significantly less severe transients in the blowdown loop. The 540°F to 610°F load change transient was not analyzed<sup>[1,3,5]</sup> because  $\Delta T$ 's across the walls are not large at the full  $\Delta T/\Delta time$  rate of 7°F/min., and the  $\Delta T/\Delta time$  for the blowdown loop should be between 0.7 and 0.07°F/min. Other operational

transients were not analyzed for the same reasons. The design specification<sup>(6)</sup> should be revised to include these transients for the blowdown loop.

The less severe heatup transient used in the reanalysis of Flange 7 of the blowdown loop<sup>(4)</sup> is 32°F/hr rather than the 60°F/hr stated in comment (1). This transient is the result of recommendations given in Reference 7. Flange 7 was initially analyzed<sup>(3)</sup> using the 100°F/hr heatup and cooldown rates<sup>(6)</sup>. When the results of these transients were combined with the LOCE transient, the usage factor (obtained from a stress analysis of the flange) was calculated to be greater than 1.0 for the number of expected heatup and cooldown cycles (1500) during the lifetime of the reactor. As a result less severe but more realistic heatup and cooldown rates were recommended<sup>(7)</sup> and used in the re-analysis of the flange<sup>(4)</sup>.

The transient used in the thermal analysis of quick opening blowdown valve auxiliary piping<sup>(2)</sup> is unique to this piping system due to the inherent functions it performs in the operation of the blowdown valves. The transients used in this analysis were obtained from expected operating conditions in the blowdown valve auxiliary piping, i.e., pressure, temperature, and flow, which resulted in conservative fluid temperature transients and film convection coefficients.

(2) Comment:

Both References 1 and 5 use constant properties for material conductivity and volumetric heat capacity. Conservative results can be generated in this manner if the properties are selected to give the highest gradients. With respect to conductivity this appears to be the case since a low value was chosen. However, when a single property value is chosen for a temperature range its value should be justified. In addition, Reference 5 used only one material property for both the weld and base material. Depending on the weld material this may not be a conservative assumption.

Resolution:

It is the opinion of the Thermal Analysis Branch that the use of constant, rather than temperature varying, thermal conductivity and volumetric heat capacity did not significantly affect the computed thermal gradients in References 1 and 5. The use of the same material properties ( $k$  and  $\rho C_p$ ) for the base and weld material is justified since the weld material and base material are 300 series stainless steel and have nearly identical material properties. The welds are all radiographed so major defects and voids would have been detected and repaired; this further means that the thermal properties should be very close.

(3) Comment:

In References 1 and 5 a two-dimensional R-Z model is used to model the intersection of two pipes. In both reports a statement is made that this does not effect accuracy. These models may be conservative but cannot be considered accurate. The question of conservatism should be addressed. In essence one of the pipes must be represented as a flange. The basis for the diameter of the flange (representing the pipe) should be stated so that the conservatism in the model can be determined.

Resolution:

The use of R-Z geometry to represent the intersection of two pipes does affect accuracy. Representing a tee in an R-Z model (two dimensional) reduces the one pipe to a flat plate. If the wall thickness,  $t$ , to diameter,  $d$ , ratio  $t/d$  is small, this representation is very good as the radial effects on conduction are small. This representation depicts, quite well, the plane that passes through both centerlines of the "tee". This section has the sharpest transition from one pipe to the other, hence it should be the section that has the highest stresses or stress concentration factors. Therefore, the Thermal Analysis Branch judges that the R-Z models used in the LOFT blowdown loop piping thermal analyses are adequate for the intended thermal-stress analyses.

The basis for the diameter of the "flange" is dictated by the direction and magnitude of the heat transfer. In the cases analyzed in References 1 and 5, most of the heat transfer is radial across the pipe wall rather than along the wall. The ASME Code allows using  $\sqrt{D_i t}$  where  $D_i$  is the inside pipe diameter and  $t$  the wall thickness. In References 1 and 5, "flange" geometries were selected so more than  $2\sqrt{D_i t}$  was allowed in the models so that the edge of the model, i.e., the outside edge of the flange, could effectively be considered as adiabatic.