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

MAR 29 1985

MEMORANDUM FOR: Inez K. Bailey, Chief
Record Service Branch
Division of Technical Information
and Document Control

FROM: Louis M. Shotkin, Chief
Reactor Systems Research Branch
Division of Accident Evaluation

SUBJECT: UTILITY COMMENTS ON THE H. B. ROBINSON PTS STUDY FOR SUBMISSION TO THE PUBLIC DOCUMENT ROOM "see Repts" For enclosure "Nureg/CR-3935

Enclosed is a copy of Carolina Power and Light's review of the H. B. Robinson pressurized thermal shock study. We request that these documents be submitted to the Public Document Room to be incorporated with the existing file on Unresolved Safety Issue A-49 Pressurized Thermal Shock.

If you have any questions, please contact Jose' N. Reyes on 427-4422.

Louis M. Shotkin

Louis M. Shotkin, Chief
Reactor Systems Research Branch
Division of Accident Evaluation

Enclosure: Ltr fm Phillips
to Shelby dtd 10/12/84

CP&L

Carolina Power & Light Company

October 12, 1984

A2-TS-115
CNS-84-265

Mr. D. L. Selby
Oak Ridge National Laboratories
Post Office Box X
Building 6025
Oak Ridge, Tennessee 37830

Dear Mr. Selby:

The purpose of this letter is to document our review of the August, 1984 report, "Thermal-Hydraulic Analyses of Overcooling Sequences for the H. B. Robinson Unit 2 Pressurized Thermal Shock Study," NUREG/CR-3935, EGG-2335, Draft Report.

The report appears very satisfactory. We do however, have the following comments.

The basis for various analysis assumptions critical to the T&H analysis should be addressed and documented. Some of these are the reason for the selection 2.5" Hot Leg Break, and why 100 hours shutdown was assumed for hot standby. These were specified by ORNL, are reasonable, but need to be documented in this report or elsewhere in the final report.

Similarly, event definitions and how they were arrived at should be documented somewhere in the final report.

Attached also are comments from our consultant, Dr. D. M. Speyer.

Concerning the remainder of the project, our understanding is that CP&L will continue to comment on the draft chapters as they are transmitted. After review of the individual chapters when the draft report is complete. The analysis details and results will be presented separately to the NRC's Research Review Group and CP&L. After the presentation CP&L will provide comments on the final report.

Please call me if you wish to discuss these comments.

Sincerely,

Jerry H. Phillips

Jerry H. Phillips

JHP/laD1

Attachment

cc: Mr. J. G. Hammond
Dr. J. D. E. Jeffries
Mr. C. E. Johnson (NRC)
Mr. D. S. Lucas
Mr. D. M. Ogden (INEL)
Mr. R. E. Oliver

COMMENTS ON SUMMARY SECTION

p.v, 1st Paragraph. Clarify that assessments with regard to severity in the present report are somewhat qualitative - e.g., add sentence as follows*:

> ... control actions, and uncertainties. As part of this report limited assessments have been made with regard to transient severity and these are (1) qualitative and (2) based solely on thermal-hydraulic pressure and downcomer temperature. Computer simulations ...

p.v, 2nd Paragraph. Clarify that the severity of sequences refers to thermal hydraulic severity as apposed, for example, probability or consequences.- e.g.,

> ... indicate that the most severe thermal-hydraulic sequences for PTS ...

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* In this and subsequent write up changes to existing draft report are underlined.

COMMENTS ON 1. INTRODUCTION SECTION

p.1 2nd Paragraph. The present study deals with a specific plant, accounts for minimal operator corrective actions and utilizes transients that were based on a more extensive basis than may be inferred from "postulated."

> The purpose of the thermal-hydraulic analyses presented in this report is to quantify the behavior (downcomer pressure, temperature and to a lesser extent heat transfer coefficient versus time) for a specific plant during various kinds of postulated severe overcooling transients, with multiple failures of equipment and with only minimal operator corrective actions. The transients were specified by Oak Ridge National Laboratory (ORNL) based on probablistic and other related studies carried out as part of the program. ORNL will calculate both the reactor vessel...

p.2, 2nd Paragraph. Current status as of the time period the analysis was completed is probably more appropriate - e.g., as follows:

> The reactor is of Westinghouse three-loop design and is currently undergoing steam generator replacement. Prior to the SG replacement outage the unit was operated at reduced power, due in part to steam generator plugging. ... Other anticipated (during the SG replacement outage) changes were also incorporated into the analysis in order to more realistically model the plant.

COMMENTS ON 2. SEQUENCE DEFINITIONS SECTION

p.3, 1st Paragraph. It would be beneficial to clarify "highest probability of vessel failure" and to identify that Tables 13 and 14 provide clarification/description of the entries found earlier in Tables 1 thru 12 - e.g.,

> Oak Ridge ... those sequences expected to have the potential to rapidly cool the RCS, coincident or followed by moderate to high RCS pressure, and of event frequency greater than 10^{-7} per reactor year. The sequences ... Groups 1 through 12, respectively (Tables 13 and 14 provide additional clarification/ description for the entries in Tables 1 through 12).

p.8 (Table 5). Heading MSIV CLOSE not required and not used on other small SLB Tables. If left in, change to be consistent with Table 13 (or add entry to Table 13).

p.9 (Table 5). Under AFW SG ISO the entry "occurs on demand" is included. Either change to occurs as required or clarify with additional description in Table 13.

p.11 (Table 7). Same as Table 5, p.8 above.

p.12 (Table 8). Same as Table 5, p.9 above.

p.14 (Table 9). Potential confusion on MSIV CLOSE as per text the signal (steam flow and low T-AVG) is not generated for 5 SDVs failing to close - but per Table 14" probably not demanded unless at least 4 SDVs fail to close."

p.26 (Table 13). For MSIV closure (MSIV RPCL and RM MSIV CL) the phrase "not required for small break" is confusing - e.g., change to:

> heading not used for small break as MSIV closure signal not generated.

Also the NA is used (e.g., Table 9) for cases where signal is not generated. Add to description(s) - e.g., as follows:

> Closure not required if check valve operates properly OR signal not generated due to size of break.

AFW ACT Description states minimum AFW was used. This is not correct - e.g., change as follows:

> AFW always actuates on demand and delivers flow based on two motor driven aux. feedwater pumps, and turbine driven AFW where 2 of 3 low SG level indications were reached.

SDV CLOSE - add basis - e.g.,

> ... were not considered based on probablistic considerations.

p.27 (Table 13). THR AFW and THR HPI CH Descriptions appears superfluous, potentially confusing and incorrect - i.e., the 10^{-7} is event frequency (not failure probability) and could imply a similar criterion was not used for other sequences.

p.28 (Table 13). FW REG VLV Description - same as p.26 (Table 13) SDV CLOSE, above.

p.29 (Table 14). FW REG VLV and SDV CLOSE Description(s) - same as p.26 (Table 13) SDV CLOSE, above.

MSIV CLOSE Description - see p.14 (Table 9), above.

AFW ACT Description - see p.26 (Table 13), above.

p.30 (Table 14). AFW Heading - Tables used heading AFW AUTO.

THR AFW - see p.27 (Table 13), above.

p.31 (Table 14). THR HPI CH - see p.27. (Table 13)., above.

COMMENTS ON 3. METHODS SECTION

p.35 (Table 16). Note C is correct but potentially confusing - e.g., change as follows:

> C - Since only on feedwater isolation valve fails open, the failure of one or two feedwater regulating valves are equivalent.

Note E says sequence 9-24 (and 9-19) have "NA" for SG ISO (i.e., AFW SG ISO). This is not the case - see Table 9, page 14. Correct Table 9 or Note E.

p.38, 3rd Paragraph. Previous INEL analyses investigated condensation effects - that were partially resolved in MOD2. This should be discussed to provide basis for comments on page 134.

p.40, 3rd Paragraph. Identify which ANS standard (1973 or 1979) and value of T_0 used.

p.58, 1st Paragraph. Provide additional basis for the transit time (80 sec.) used.

p. 58, 2nd Paragraph. In view of the simple model it appears additional discussion on the break fluid conditions (how obtained) may be needed.

p.62 (Figures 6 and 7). Taken out of the report the figure would imply a simplified and detailed model yield identical results for times less than 1390 sec. Include in legend,

> Simplified Model ($t \gtrsim 1390s$)

p.63 (Figures 8 and 9). As for p.62 (Figures 6 and 7) above except $t \gtrsim 75$ S.

p.65 (Figures 10 and 11). As for p.62 (Figures 6 and 7), above, except $t \gtrsim 200$ s.

p.66 (Figures 12 and 13). As for p.62 (Figures 6 and 7), above, except $t \gtrsim 390$S.

p.68 (Figures 14 and 15).and p.69 (Figure 16). As for p.62 (Figures 6 and 7), above, except $t \gtrsim 400$ s.

p.69 (Figure 17) and p.71 (Figures 18 and 19). As for p.62 (Figures 6 and 7), above, except $t \gtrsim 200$s.

p.70, 2nd Paragraph. It may be desirable to identify the reason the start of the simplified calculation and detailed calculation were not overlays as regards RCS/Downcomer temperature, since the former case is started using a state point from the latter.

COMMENTS ON 4. GROUP A RESULTS ... SECTION

p.74, 1st Paragraph, In view of the limited number of points used to generate the figures in Appendix A (as opposed to the results shown in Section 3.) and the straight line segment appearance of the figures some explanation is appropriate - e.g., add footnote as follows:

... To facilate referencing of data, plotted results * showing pressure and temperature ...

* The figures in Appendix A were computer generated using a limited number of state points, thus the discontinuties in slope are not necessarily indicative of specific events in the scenarios.

p.75, last paragraph, Some additional discussion of the hand calculations may be in order - e.g., add following paragraph at end of page 75.

It should be noted hand calculations were carried out in a simple conservative fashion. For example in the above case the heatup was based on specific heat constant. More importantly the repressurization was based on the time to reach the PORV setpoint and did not include the more detailed behavior with time (i.e., initially a slower pressure increase until the level increased significantly).

p.81, Last Paragraph. It is not clear by inspection that sequence 9-28 is more severe than 9-32 - e.g., change as follows:

Sequences 9-28 and 9-32, involving failure to throttle AFW to the USGs and failure to throttle charging, were the most severe sequences of the subgroup, ...

p.87, Last Paragraph, As above, p.81 Last Paragraph e.g., as follows:

... Sequences 9-28 (failure to throttle AFW and charging) and 9-32(9-28 plus AFW overfeed) were the most severe sequences 412 K (282°F), 16.35 MPa (2371 psia) . An important ...

p.92, 1st Paragraph. Suggest restating that no operator action to close MSIVs was credited. e.g., change as follows:

> ... Since the MSIVs are not demanded, and no credit was taken for operator action to close MSIVs, AFW is not isolated ...

p.99, Last Paragraph. Suggest adding information on operator initiated MSIV closure - e.g., change as follows:

> ... the maximum subsequent pressure was 16.35 MPa (2371 psia). In these and other steam line breaks operator action to close MSIVs would significantly reduce the severity. As an example sequence 9-22 would have experienced a minimum temperature about 130°F ~~higher,~~ if MSIV closure by 10 minutes was assumed.

p.101 and 103 (Section 6.2) and p.102 (Table 27). Previously ORNL indicated they would review cases 7-9, 10 and 11 and may discard these - for the same reason(s) sequence 3-3 was discarded. We recommend these be discarded on probablistic grounds - as was done for sequence 3-3.

p.106, Last Paragraph. It is not clear that PTS severity would be increased significantly vs. T/H severity and potential PTS be ~~severity~~. Suggest changing to T/H severity, as follows:

> ... For these sequences, thermal-hydraulic severity would be ...

p.107, 1st Paragraph. As above, p.106, Last Paragraph. Suggest change as above:

> ... the thermal-hydraulic severity of these sequences would be increased significantly.

p.117 (Table 31). Typo on detailed model calculation used. Should be 1-1 (not 11-1).

p.122, Section 10.1. It would appear appropriate to review/discuss the assumptions on MSIV closure for sequences 1-8 and 2-8. Per Table 1 and 2 it would be inferred that MSIV closure occurs which apparantly is not the case. In addition it may be that the coincident LOCA provides sufficient cooling to satisfy both high steam flow and low T_{AVG}, particularly for the M BLOCA. This should not be significant for the study since the probability of a LOCA without 5 stuck SDVs is of considerably higher frequency and is addressed by the LOCA results.

p.122, Last Paragraph. Sequence 3-2 should be 3-3.

p.129, 1st Paragraph. The use of the phase "and may not be real" is redundant. It is covered by the uncertainty statement and is also consistent with the phenominologic arguments. Suggest deleting the phrase.

p.132 (Table 35). Sequence 12-1 and 12-2 identify sequence 2-1 as the detailed model calculation used. This is presumably correct but could be interpreted as a typo. (i.e., the entry as 12-1 would also be correct as the sequences are identical to 600 seconds). Suggest clarify - such as a sentence earlier in the text.

p.134, 2nd Paragraph. The complete condensation in SBLOCAs, as not reasonable, would benefit from some discussion on the differences in the code MODs and the investigation carried out by INEL relative to same. See p. 38, 3rd paragraph, above.

p.137 (Table 36). Sequence 19-5 minimum downcomer temperature given as 406°F - should be about 370°F (see Figure A-350).

COMMENTS ON 14. HEAT TRANSFER COEF. SECTION

p.140,141 (Table 37). It appears sequences 1-5 through 1-12 and 2-5 through 2-8 are better represented by scenario no. 4. Comparing sequence 9-15 (equivalent to scenario no. 4) to sequences 1-7 and 2-7, the temperature response is similar and (as discussed in the section 10.2) is not strongly influenced by the concurrent LOCA (excepting pressure). The principal effect of interest is flow rates(s) and the steam line break at power is more representative.

COMMENTS ON 15. UNCERTAINTIES SECTION

p.145 (Table 38). Large Steam Line Break uncertainty at 200°F appears excessive - as the calculation should be reasonably accurate at the lower temperatures where essentially only a simple energy balance is involved, and ± 25°F would be more reasonable.

COMMENTS ON APPENDIX A SECTION

Figures A-192, A-326 (sequences 9-13 and 9-80). Figures are not labeled and scaling changed - see Figure A-296 (Seq. 9-65).

Figures A-357, A-358 (sequence 11-4). Figures are missing from report.

TO: DON OGDEN
Fm: JERRY PHILLIPS

Don, Here are some comments and observations from Scott Lucas. Thought it would be better to just send you these handwritten comments than to get the equations typed up.

You may want to call scott on the break flow comment.

Jerry Phillips
10/9/84

DON NEW address
CP&L
P.O. BOX 1551 WCOB 200
RALEIGH N.C. 27602

Comments on Small Model:

The results from the small model appear quite good. There are two problems that could be alleviated however.

1. Engineering judgement to a large degree has to be relied upon for assymetric transients. This could have been avoided with a larger model, say 30 ~ 40 nodes.

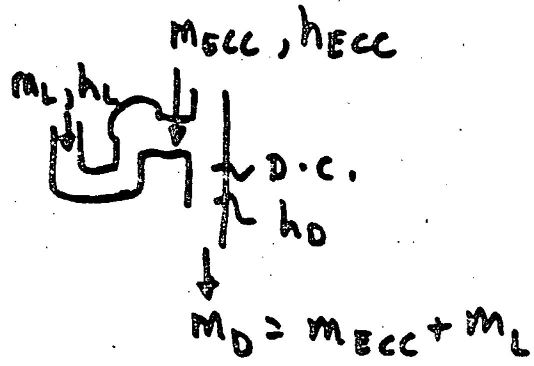
2. Nat'l circulation buoyancy effects might be questioned since the elevation heads are not correctly taken into account. Judging the results however seems to indicate that the noding is adequate for extrapolation purposes and certainly beats "eyeballing" as used previously.

It is not quite clear whether the break flow was taken into account in the uses of the downcomer temperature extrapolation. It may have been taken into account in the term m_L, but this is not clear. The relationship for the downcomer temperature might read as:

$$T_D = \frac{(m_L - m_B)T + m_{ecc} T_{ecc}}{m_{ecc} + m_L} - \delta \frac{dT}{dt}$$

(see attachment)

Variation 7, SBLOCA Sequence, pg. 57



Jerry – Here are some comments on the INEL small model analyses
Scott

Energy equation:

$$\rho V \frac{dh_L}{dt} = m_L h_L + m_{ECC} h_{ECC} - h_D m_D \qquad \text{I}$$

$$\frac{dh_L}{dt} \sim \frac{\partial h_L}{\partial T_L} \frac{dT_L}{dt} \sim \alpha_L \dot{T}_L \qquad \text{II}$$

We can linearize the rest of the terms:

$$h_L = \tilde{h}_L + \frac{\partial h_L}{\partial T_L} (T_L - \tilde{T}_L)$$

$$h_L = \tilde{h}_L + \alpha_L (T_L - \tilde{T}_L) \qquad \text{III}$$

$$h_L \doteq \alpha_L T_L$$

Same for h_{ECC}, h_D

Using II & III in I, we get

$$M_L \alpha_L \dot{T}_L = M_L T_L \alpha_L + M_{Ecc} \alpha_{Ecc} T_{Ecc} - M_D \alpha_D T_D$$

$$M_D \alpha_D T_D = M_L T_L \alpha_L + M_{Ecc} \alpha_{Ecc} T_{Ecc} - M_L \alpha_L \dot{T}_L$$

where $M_L = \rho \cdot V$ = mass in system

$$\alpha_D T_D = \frac{M_L T_L \alpha_L + M_{Ecc} \alpha_{Ecc} T_{Ecc} - M_L \alpha_L \dot{T}_L}{M_L + M_{Ecc}}$$

let $\frac{M_L}{M_L + M_{Ecc}} = \gamma$ (time to trasport mass thru the system)

$$\alpha_D T_D = \frac{M_L T_L \alpha_L + M_{Ecc} \alpha_{Ecc} T_{Ecc}}{M_L + M_{Ecc}} - \gamma \alpha_L \dot{T}_L$$

if $\alpha_D \sim \alpha_L \sim \alpha_{Ecc}$

then

$$T_D = \frac{M_L T_L + M_{Ecc} T_{Ecc}}{M_L + M_{Ecc}} - \gamma \dot{T}_L$$

If we remove the subscript from the loop or system quantities L, we get

$$T_D = \frac{M_L T + M_{ECC} T_{ECC}}{M_L + M_{ECC}} - \gamma \frac{dT}{dt}$$

which is the same relationship used by INEL.

Discrepancies (if any)

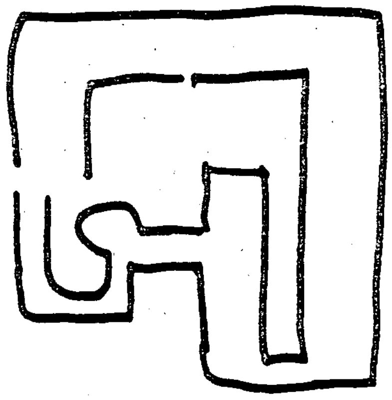
1) $\alpha_D \sim \alpha_L$ ✓

2) α_{ECC} may not be ~ to α_D or α_L

3) γ transport time is reasonable

4) heat is taken up in the small model

5) Break flow not taken into account (see next page



$$\rho V \frac{dh}{dt} = m_L h_L - m_B h_L + m_{ECC} h_{ECC} - h_D m_D$$

$$m_D = m_{ECC} + m_L$$

Thus, the relation should be modified as:

$$T_D = \frac{(m_L - m_B) T + m_{ECC} T_{ECC}}{m_{ECC} + m_L} - \gamma \frac{dT}{dt}$$

* pg. 58, not sure if 80 s is time in nat'l circ for transit time around loops or thru SG to D.C.

* for the relation, pg 57

$T_D =$

It is assumed that letdown is isolated

Yes -- Letdown isolated because of [illegible]

* pg 58

For SBLOCA sequence with stuck open PORV or primary, the T_D should also be modified as:

$$T_D = \frac{(m_L - m_B - m_{PORV})T + m_{ECC}T_{ECC}}{m_L + m_{ECC}} - \gamma \frac{dT}{dt}$$

SBLOCA is caused by a stuck open [illegible]

Energy balance [illegible] SG [illegible] dominant. No break in this region. Temperature [illegible] [illegible] [illegible]

EG&G Idaho, Inc.
P.O. BOX 1625, IDAHO FALLS, IDAHO 83415

August 13, 1984

Mr. F. L. Sims, Director
Reactor Research and Technology Division
Idaho Operations Office - DOE
Idaho Falls, ID 83401

TRANSMITTAL OF PRESSURIZED THERMAL SHOCK STUDY REPORT (A6047) - TRC-75-84

Ref.: Thermal-Hydraulic Analyses of Overcooling Sequences for the H. B. Robinson Unit 2 Pressurized Thermal Shock Study (Draft NUREG).

Dear Mr. Sims:

The referenced report (see attachment) documents RELAP5 thermal-hydraulic analyses performed in support of the U.S. Nuclear Regulatory Commission's (NRC) investigation into unresolved safety issue A-49, pressurized thermal shock (PTS) for the H. B. Robinson Unit 2 Pressurized Water Reactor. The report summarizes the analyses of 183 PTS scenarios which were developed at Oak Ridge National Laboratory (ORNL), the integrator of the PTS study for the NRC. The report also includes descriptions of the RELAP5 thermal-hydraulic and control systems models which were developed specifically for these analyses and a discussion of a unique method developed to generate reactor vessel downcomer pressure and temperature responses.

The results shown in the referenced report represent part of the information required by ORNL for the assessment of the PTS issue. These results are not to be used directly as an indication of PTS severity for the scenarios investigated. Following additional analyses of multi-dimensional and fracture mechanics effects, ORNL will integrate all results and publish a report estimating the likelihood of reactor vessel failure and identifying important event sequences, operator and control actions, and uncertainties.

The referenced report is transmitted as part of the assistance to the NRC as provided in the PWR application task of FIN No. A6047 and satisfies our committment to the Nuclear Regulatory Commission to provide a draft report documenting the results of our extrapolations for the H. B. Robinson plant (NTPD Milestone 3-06).

Recipients in the distribution list are requested to submit written comments on the Draft NUREG by October 1, 1984. Comments may be submitted to:

Don Fletcher
EG&G Idaho, Inc. (TSB)
P. O. Box 1625
Idaho Falls, ID 83415

(208) 526-9859
FTS: 583-9859

Very truly yours,

Donald O. for T.R. Charlton

T. R. Charlton, Manager
Reactor Simulation and
Analysis Branch

CDF:sb

Attachment:
As Stated

cc: C. Johnson, NRC
J. Koenig, LANL
R. Oliver, CP&L
J. Phillips, CP&L (3)
J. Reyes, NRC (3)
P. Saha, BNL
D. Selby, ORNL (3)
D. Speyer, CP&L Consultant
T. Theophanous, Purdue
E. Throm, NRC
R. L. Turner, Westinghouse (2)
J. O. Zane, EG&G Idaho (w/o Attach.)