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November 4, 1980
GFO:148:80

Mr. Paul S. Check
Asst. Director of Plant Systems
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Ref: 1) Letter, D. F. Ross to W. S. Nechodom, dated July 15, 1976
2) Letter, G. F. Owsley to D. F. Ross, dated October 30, 1978
3) Letter, T. A. Ippolito to W. S. Nechodom, dated March 1979

Dear Mr. Check:

In Reference 1 the Staff provided Exxon Nuclear with a requested procedure for notifying the NRC of minor updates to approved evaluation models. Following the procedures requested by the Staff, Exxon Nuclear advised the Staff in Reference 2 of updates to its approved version of RELAP4. These updates were addressed and approved in the Staff's SER transmitted with Reference 3. The purpose of this letter is to advise you of further model updates to RELAP4-EM/ENC28B. The description of these changes is contained in the attachment to this letter.

The attachment describes these updates and presents the bases for concluding that these updates are not significant (i.e., less than a 20°F change) for large break calculations. Changes which affect the small break calculational results will be included in the small break model descriptions to be submitted for review and evaluation at a later date. The updates described in the attachment are to be used in future PWR and BWR ECCS analyses.

Please contact me if you have any further questions regarding this matter.

Sincerely,

G. F. Owsley, Manager
Reload Fuel Licensing

GFO:gf
Attachment
As noted

CC: [redacted] (USNRC)
Mr. T. P. Speis (USNRC)

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Attachment

GENERIC GENEOLOGY OF RELAP4-EM TO VERSION (ENC28M)

The Exxon Nuclear Company (ENC) evaluation models for LOCA ECCS analysis use versions of the RELAP4-EM program to perform the blowdown and hot channel portions of the analysis. A single version of the code is used for large break LOCA analysis of Pressurized Water Reactors (PWR's), Non-jet pump boiling water reactors (NJP-BWR's), and also for small break analysis of both reactor types. Occasionally, ENC encounters situations where changes to the RELAP4-EM program are required to model a unique system; to increase the flexibility or efficiency of the code; to upgrade editing, plotting or restarting capabilities; or to resolve a code running problem. All ENC evaluation model code changes are reported according to NRC guidelines[1]. The code changes to RELAP4-EM/ENC26A to produce RELAP4-EM/ENC28B were described in the attachment to a letter to D. F. Ross from G. F. Owsley dated October 1978. These code changes were approved by the NRC[4].

A number of changes have been made to RELAP4-EM since October 1978. These changes, which produce negligible changes in Peak Cladding Temperature, are primarily required for specific unique applications. The changes have been submitted in whole or in part as part of previous ENC LOCA analysis submittals[2,3]. ENC will reference this generic document of code changes in future applications.

The following provides a description of these RELAP4-EM changes and the effect on calculational results.

Code changes previously submitted to the NRC Staff (Reference 2) and which do not affect calculated results are as follows:

RELAP4-EM/ENC28C - Three plot variables were added to RELAP4-EM/ENC28B to permit plotting of fuel related heat slab internal temperatures, i.e. pellet surface temperature, clad inside surface temperature, etc. A time step heat slab variable was initialized to permit execution of a RELAP4 case without a core and with zero heat slabs; the time step control logic had assumed a core with heat slabs would be present in all problems. These changes do not affect calculated results.

RELAP4-EM/ENC28D - A change was made to output tape edit sub-routine to allow output tape (TAPE4) re-editing. This change does not affect calculated results.

RELAP4-EM/ENC28E - The environmental package was modified to allow input data to be entered on the data cards in column 80. This change does not affect calculated results.

RELAP4-EM/ENC28F - The maximum number of words allowed on the input data cards was increased to permit larger problems. This change does not affect calculated results.

Recent code changes made to RELAP4-EM/ENC28 which were submitted to the NRC Staff with the Dresden I ECCS analysis[3] and which do not change the calculated results are as follows:

RELAP4-EM/ENC28G - This was an experimental code version. The coding introduced was removed in ENC28I.

Code changes previously submitted to the NRC Staff (Reference 2) and which do not affect calculated results are as follows:

RELAP4-EM/ENC28C - Three plot variables were added to RELAP4-EM/ENC28B to permit plotting of fuel related heat slab internal temperatures, i.e. pellet surface temperature, clad inside surface temperature, etc. A causal heat slab variable (time step control) was initialized to permit execution of a RELAP4 case without a core and with zero heat slabs; the causal time step control logic had assumed a core with heat slabs would be present in all problems. These changes do not affect calculated results.

RELAP4-EM/ENC28D - A change was made to output tape edit sub-routine to allow output tape (TAPE4) re-editing. This change does not affect calculated results.

RELAP4-EM/ENC28E - The environmental package was modified to allow input data to be entered on the data cards in column 80. This change does not affect calculated results.

RELAP4-EM/ENC28F - The maximum number of words allowed on the input data cards was increased to permit larger problems. This change does not affect calculated results.

Recent code changes made to RELAP4-EM/ENC28 which were submitted to the NRC Staff with the Dresden I ECCS analysis[3] and which do not change the calculated results are as follows:

RELAP4-EM/ENC28G - This was an experimental code version. The coding introduced was removed in ENC28I.

RELAP4-EM/ENC28H - The maximum number of data entries for time dependent volumes was increased from 20 to 50. The option of reading normalized power vs. time data in an Evaluation Model calculation was added. These changes do not affect calculated results.

RELAP4-EM/ENC28I - The coding added in ENC28G was taken out. A variable in subroutine ENQAD that previously could be undefined was initialized to allow restarts. These changes do not affect calculated results.

MODEL CHANGES FOR THE DRESDEN-1 ANALYSIS

Model changes made to RELAP4-EM/ENC28 in the performance of the Dresden I ECCS analysis[3] are discussed below:

RELAP4-EM/ENC28J - A more realistic method of calculating local heat flux in the vicinity of the core mixture level for small break analysis has been developed. The small break evaluation model previously used calculated heat flux from an adjacent core heat conductor for local heat flux on the covered region of the adjacent higher elevation conductor. A detailed description of this model is on page 13 of Reference 5.

For long duration small break transients, covered regions of the core achieve a pseudo equilibrium condition such that the decay energy is transferred to the coolant at the decay heat generation rate. For this condition, the covered region axial heat flux distribution will be directly related to the axial power distribution. Thus, the small break model was modified so that the covered region heat flux is the adjacent conductor heat flux weighted by the ratio of the powers for the two conductors. This change is not applicable to large breaks. The small break model is currently being modified in response to new NRC requirements. This feature will be

included in the small break model to be submitted to the NRC for review and evaluation.

RELAP4-EM/ENC28K - This version improved the numerical iteration scheme for heat slab temperature initialization. Stored energy in the fuel is still determined from the approved GAPEX[6] model. This change merely aids the user in obtaining the GAPEX stored energy. The modifications do not alter either the fuel/clad thermal expansion models or the gap conductance model. A sample calculation for Dresden I confirmed a negligible impact of this change on PCT (<2F°).

RELAP4-EM/ENC28L - In order to calculate the effect of the emergency condenser, this version incorporated a turbulent condensation correlation. When the surface temperature of a heat slab is below T_{sat}, $T_{bulk} \geq T_{sat}$, and the quality in the adjoining volume is greater than zero, then condensation is allowed as predicted by:

$$h_c = 0.023 \left(\frac{K_f}{D_h}\right) Re_f^{.8} Pr_f^{.4} \left[1 + X \left(\frac{\rho_f}{\rho_g} - 1\right)\right]^{.5}$$

where:

h_c = condensation coefficient $\frac{Btu}{hr\ ft^2\ F°}$

K_f = liquid thermal conductivity $\frac{Btu}{hr\ ft\ F°}$

D_h = hydraulic diameter (ft)

Re_f = liquid Reynolds Number

Pr_f = liquid Prandtl Number

X = volume average quality

ρ_f = liquid density (lb_m/ft^3)

ρ_g = vapor density (lb_m/ft^3)

This correlation was developed by Z. L. Miropolskiy, et al[7] for condensation of steam inside tubes. The correlation is valid for all anticipated blowdown pressures (60-3000 psia) and for mass fluxes of 37.9-379. (lb_m/ft^2 sec). At lower mass fluxes, the correlation conservatively underpredicts data as the effect of gravity in condensation films flows is not considered.

Sensitivity studies[3] showed that the impact of including the emergency condenser (including condensation above correlation) in the Dresden I large break analyses was minor (less than a 15F° impact on PCT). The small break model is currently being modified in response to new NRC requirements. This change will be included in the small break model to be submitted to the NRC for review and evaluation.

RELAP4-EM/ENC28M - Included in this version are added convergence criteria in the heat slab initialization subroutine. These modifications are used only in the initialization. A sample calculation for Dresden Unit 1 confirmed a negligible impact of RELAP4-EM/ENC28K and RELAP4-EM/ENC28M modifications on PCT (<2F°).

REFERENCES

1. Letter, Denwood J. Ross (NRC) to Warren S. Nechodom (ENC) dated July 15, 1976.

2. Exxon Nuclear Company, Fort Calhoun LOCA Analysis at 1500 MWt Using ENC WREM-IIA PWR ECCS Evaluation Model Large Break Example Problem, XN-NF-79-45, May 1979.

3. Exxon Nuclear Company, ECCS Evaluation of Dresden-1 Using the Exxon Nuclear Company WREM-Based Non-Jet Pump Evaluation Model, XN-NF-79-95(NP), Revision 1, April 1980.

4. U.S.N.R.C. letter, T.A. Ippolito (NRC) to W.S. Nechodom (ENC), SER for ENC RELAP4-EM-UPDATE, March 1979.

5. Exxon Nuclear Company, WREM-Based Generic PWR ECCS Evaluation Model XN-75-41, Volume III, Revision 2, August 20, 1975.

6. Exxon Nuclear Company, GAPEX: A Computer Program for Predicting Pellet-to-Cladding Heat Transfer Coefficients, XN-73-25, August 13, 1973.

7. Moropolskiy, Z.L., Shneerova, R.I., and Ternakova, L.M.: Volume III, Int. Heat Transfer Conf., Japan, Cs. 1.7 (1974).