INTERIM REPORT

Accession No.__________

Contract Program or Project Title: Development of an Advanced Code for Thermal Hydraulics of Reactors (THOR)

Subject of this Document: Informal Highlights Letter - November 1978

Type of Document: Highlight letter

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Date of Document: December 1978

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U.S. Department of Energy

Prepared for
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555
Under Interagency Agreement EY-76-C-02-0016
NRC FIN No. A-3014

INTERIM REPORT

THOR PROJECT HIGHLIGHTS

for

November 1978

PROGRAM: Development of an Advanced Code
for Thermal Hydraulics of Reactors
(THOR)

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* Work carried out under the auspices of the U.S. Nuclear Regulatory Commission.

This is the highlight letter for the Development of an Advanced Code for Thermal Hydraulics of Reactors (THØR), for the month of November 1978. This program is covered under the budget activity number 60-19-10-03.

Work has continued to investigate operational characteristics of the THØR operating system and to gain experience in multicomponent operations and interactions. Emphasis has been placed on initialization and blowdown phases of the effort where manpower conflicts existed with ECC and reflood efforts. Increased emphasis utilizing both full time staff effort as well as additional consultant assistance has been placed on the N-zone hydraulic module stability questions. A presentation was given of the THØR results at the Sixth Water Reactor Safety Information Meeting.

1.1 PROCESS MODELING

a) Quench Front Propagation Velocity (W. Wulff)

Predicted quench front velocities have been compared with experimental velocities obtained on electrically heated, hollow stainless steel tubes. The comparison covers the range of pressures from 1 to 70 bar and temperatures from the minimum stable film boiling temperature to 1100°K (1520°F). The comparison involved low-flow conditions and no subcooling.

The comparison showed reasonable agreement at intermediate pressures between 10 and 50 bar, but discrepancies of up to 100% at 1 bar. The discrepancies are found to result from the correlations for critical wall superheat $\Delta T_{CHF} = T_{CHF} - T_{sat}$ (Rohsenow), for minimum stable film boiling temperature (Henry-Berenson) and for critical heat flux augmentation due to sputtering (Ishii). These correlations are being compared separately with experimental data in the range of pressures between 1 and 70 bar.

The data comparison will be extended to include flow rate and subcooling effects and the effects of gap conductance.

1.2 COMPONENT MODELING AND DEVELOPMENTAL TESTING

a) Core Reflood (J.M. Kaufman, S. Stein)

The logic development and programming for the reflood phase has been completed. Testing and debugging has begun.

b) Core/Upper Plenum Subassembly (J.H. Jo and R. Krasny)

This subassembly for Standard Problem 8 has been converted to the new user-oriented THØR input routine.

c) Downcomer/Lower Plenum Subassembly (U.S. Rohatgi and L. Slatest)

A larger subassembly for STP-8 consisting of a lower plenum, a downcomer, an ECC injection tee and several pipes has successfully computed the blowdown phase and efforts are underway to compute in the refill stage. The smaller subassembly has computed through 40 seconds in the transient. These subassemblies are now being converted to the new THØR input system.

d) Discrete Heated Channel (J.M. Kaufman and S.V. Lekach)

An improvement was made in the mixture velocity to mass flux conversion reported last month. This change incorporated an exact technique rather than the linear expansion previously used. The result is both considerably more efficient and more accurate.

In order to have a direct comparison between calculations using the lumped parameter multi-zone heated channel module, developed for the THØR core and steam generator and those calculated by a distributed description of a heated channel, work has begun on the latter including wall conduction. This may be used as a temporary substitute for the N-zone module pending satisfactory resolution of the stability questions.

e) Lumped Pipe Modeling (S.V. Lekach)

The implicit thermohydraulic coupling, already implemented into the discrete parameter pipe model, has been added to the lumped parameter pipe wall conduction algorithm.

1.3 SYSTEM DEVELOPMENT

a) THØR Operating System (S.V. Lekach)

THØR reduces all the component modeling equations to a set of linear algebraic equations for each time step. We use a standard FORTRAN-written, canned routine GELG (for full matrix solution). However, if we use a CDC COMPASS routine set (DEC/SOL) that has been optimized to take advantage of the CDC computer structure we can reduce the typical system computation times by 40-80%. These routines were set up such that no change in THØR is required (same call statements).

We also started a minor effort to convert DEC/SOL to be able to invert matrices (as opposed to being a linear equation solver). We need a matrix inverter as part of our algorithm to express internal variables in a component in terms of the global variables.

b) THØR Input Routine (R. Krasny)

A presentation of the input routine was given to the THØR group members. Suggestions collected during the presentation are being acted upon. Work is being done to include the heat conduction and neutronics in the input routine. The first version of this routine was installed and is currently being tested under operational circumstances.

d) Developmental Testing (D.I. Garber and C. Ruger)

The effort towards attaining the "steady state" for Standard Problem 8 has continued. The transit time for an element of fluid to traverse the loop is

approximately 20 seconds. Calculations have been performed for over 100 seconds of real time using a maximum time step greater than 3 seconds in an attempt to relax to "steady state," including coupling between the pressurizer and the rest of the system. The CPU time per time step for the entire system has been found to be approximately .8 seconds/step. Although this system is not presently utilizing steam generator heat transfer, or homologous pump descriptions a number of problems have been identified and corrected during the "shake-out" phase.

[illegible] NUMERICAL INVESTIGATIONS

a) N-Zone Stability (L. Eisenhart, J. Jo, P. Saha)

A two faceted approach is now underway in order to produce a robust N-zone heated channel module. First, the current formulation is being modified to contain both a better numerical discretization as well as some modifications to the linear profile assumptions during low and reversing flows. Second, the formulation of the internal discontinuities is being investigated to see if the flow regime boundaries can be tracked in a manner which does not lead to instabilities due to the introduction of discontinuities.

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