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# POSTTEST ANALYSIS OF LOFT LOCE L2-3 USING THE ESA RELAP4 BLOWDOWN MODEL

by

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A posttest analysis of the blowdown portion of Loss-of-Coolant Experiment (LOCE) L2-3[1], which was conducted in the Loss-of-Fluid Test (LOFT) facility[2], was performed using the experiment safety analysis (ESA) RELAP4/MOD5 computer model[3]. Measured experimental parameters were compared with the calculations in order to assess the conservatisms in the ESA RELAP4/MOD5 model.

LOFT LOCE L2-3 simulated a 200% double-ended offset shear break in the cold leg of a four-loop large pressurized water reactor (PWR). The initial conditions for the LOCE were: maximum linear heat generation rate of 39.6 kW/m, system pressure of 15.06 $\pm$ 0.2 MPa, hot leg temperature of 592.85 $\pm$ 3.0 K, and intact loop flow rate of 199.8 $\pm$ 6.3 kg/s. Scaled quantities of high-pressure, low-pressure, and accumulator emergency core coolant (ECC) were injected during the LOCE. The primary coolant pumps were operated at constant speed throughout the experiment.

The MOD5 version of the RELAP4 computer code with the following conservative model options were used for the analysis:

(1) Evaluation model (EM) heat transfer model

(2) Baker-Just metal water reactor model

(3) American Nuclear Society decay heat times 1.2

(4) EM fuel cladding swell and rupture model

(5) ECC bypass model, which calculates an end-of-bypass time and subtracts all previously injected ECC from the system inventory

(6) Adiabatic fuel heatup model, which allows the hot rod in the core to adiabatically heat up during the refill portion of the transient

(7) Ross-Stoute gap conductance model

(8) Henry-Fauske and Homogeneous Equilibrium critical flow models with multipliers applied to give the most conservative discharge flow conditions.

The overall ESA methodology includes conservatisms in initial conditions as well as in the computer code models selected. However, for this analysis, the actual measured experiment initial conditions were used allowing only the conservatisms in the code models to be determined.

Table I presents a chronology of some of the major events occurring during the blowdown portion of LOCE L2-3 compared with the calculated times for these events. Generally, most of the calculated events agreed well with measurements. However, the calculated end-of-ECC-bypass time, which is the time at which ECC flow can penetrate the downcomer and all previously injected ECC is subtracted from the system mass inventory, significantly differed from the measured time. In the experiment, the flow in the downcomer initially reversed (t = 0 s), then gradually stagnated at 3.0 s; however, in the calculation it was 29 s before flow stagnated in the downcomer. By using the end-of-ECC-bypass model, 654 kg of ECC water was subtracted from the system.

The calculation of system depressurization agreed well with the test data, even though the pressurizer emptied during the experiment 4.8 s earlier than was calculated. Since the calculated accumulator flow was initiated 1 s earlier than the data, this indicates that the calculated and actual system depressurization rates are nearly the same.

Figure 1 presents a comparison of the measured peak cladding temperature (PCT) compared with the calculation. The core thermal response during the experiment was dominated by the system hydraulics, which caused a core-wide rewet at approximately 6.0 s after rupture. This rewet, which significantly reduced the stored energy in the rods, was not calculated. The ESA RELAP4/MOD5 model calculated a 0.66 s earlier departure from nucleate boiling (DNB) than was observed in the experiment, resulting in the earlier increase in calculated PCT. The maximum measured PCT during the entire experiment was 914 K at 4.95 s after rupture. For the same time, the calculated value was 1085 K.

This posttest analysis of LOCE L2-3 covers the time span from the initiation of the transient until the start of reflood, which is defined as the time when the reactor vessel mixture level is at the bottom of the core. This was calculated to occur at 40 s after rupture or 5 s later than in the test. At the beginning of reflood, the PCT was 750 and 1160 K, respectively, for the experiment and the calculation.

In conclusion, this posttest analysis exercise using the LOFT ESA model for LOCE L2-3 with only model conservatism incorporated (that is, not including conservatisms due to initial conditions which were included in the actual ESA) serves to show that the LOFT ESA model does exhibit a conservative calculation throughout the transient.

## REFERENCES


1. P. A. Harris et al, "Power Ascension Test Series L2," LOFT Experiment Operating Specification Volume II, NE L2 Series, Revision 2 (July 1978).

2. D. L. Reeder, LOFT System and Test Description (5.5-ft Nuclear Core 1 LOCES), NUREG/CR-0247, TREE-1208 (July 1978).

3. EG&G Idaho, Inc., RELAP4/MOD5: Computer Program for Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems Users Manual, ANCR-NUREG-1335 (September 1976).

## TABLE I

CHRONOLOGY OF EVENTS FOR NUCLEAR LOCE L2-3
WITH CALCULATED COMPARATIVE VALUES

| Event | Experiment | Calculation |
|---|---|---|
| LOCE initiated (s) | 0.0 | 0.0 |
| Blowdown valves opened (ms) | 20.6 | 20.6 |
| First indication of departure from nucleate boiling (s) | 0.96 | 0.3 |
| End of ECC bypass[a] (s) | 3.0 | 29.0 |
| Peak cladding temperature (PCT) at 4.95 s (time of measured PCT) (K) | 914 | 1085 |
| High-pressure injection system initiated (s) | 14.0 | 19.0 |
| Pressurizer emptied (s) | 14.0 | 18.8 |
| Accumulator injection initiated (s) | 16.0 | 15.0 |
| Low-pressure injection system initiated (s) | 29.0 | 30.0 |
| Lower plenum filled with liquid (s) | 35.0 | 40.0 |
| Core volume reflooded (s) | 55.0 | 0.0 |

a. End of ECC bypass is defined as the time when the mass flux resumes its normal flow direction in the reactor downcomer.

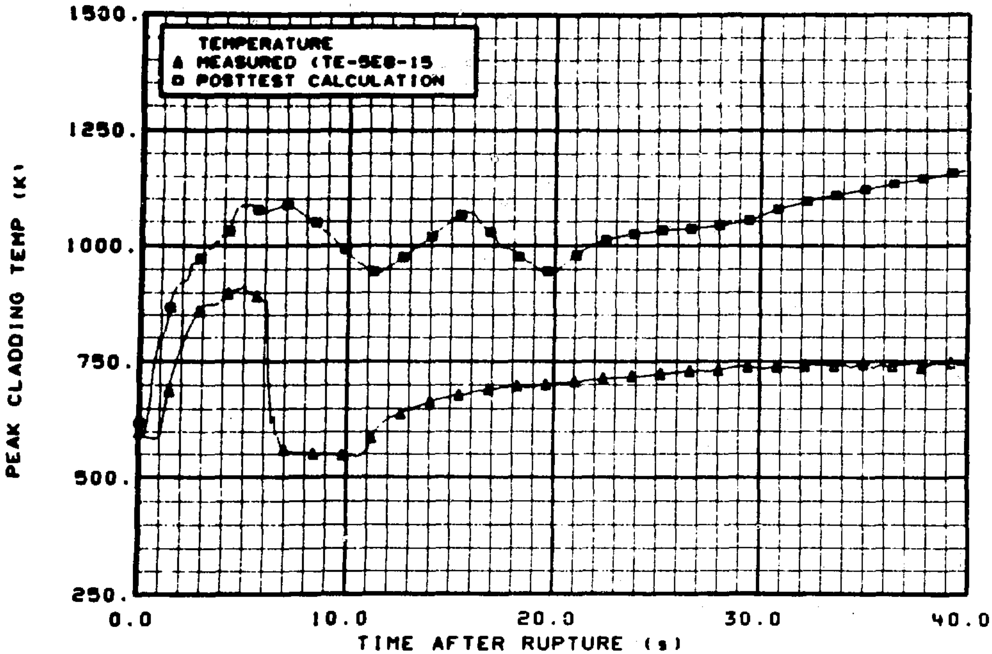


Fig. 1 Comparison of measured and posttest calculation of fuel rod peak cladding temperature for LOCE L2-3.