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Turbine Trip Accident Analysis using TRAC-M/F77

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Abstract

The LANL (Los Alamos National Laboratory) developed the TRAC to provide advanced best-estimate simulations of transients in PWR. But, the main purpose of using TRAC-M code seems to be restricted to LBLOCA or SBLOCA accidents. In this report, we expanded the applicability of the code to non-LOCA accidents. The selected non-LOCA accident is the turbine trip accident described in the Chapter 15 of FSAR.

1. Introduction

The Los Alamos National Laboratory (LANL) has developed the modernized Transient Reactor Analysis Code (TRAC-M) to provide advanced, best-estimate simulations of real and postulated transients in pressurized water reactors (PWRs) and for many related thermal-hydraulic facilities. The code features one and three-dimensional (1D/3D), two-fluid treatment for the thermal hydraulics, together with other necessary modeling capabilities to describe a reactor system.

Despite the rigorous functions of TRAC, its use seems to be restricted to the LOCA analysis. Here, we expanded the applicability of the code to non-LOCA analysis. The selected case is a turbine trip accident described in the Chapter 15 of PSAR. Also, a best-estimate calculation of the turbine trip accident is performed and presented.

2. Model Description

The noding diagram for primary system is shown in Figure 1. It models a westinghouse 2308 MWt powered nuclear-core, three-loop pressurized water reactor with constrained steady-state and transient calculations. This model contains the following components and subsystems :

- three-dimensional (r=2,t=6,z=12) reactor vessel;
- vessel upper-plenum guide tubes;
- powered-rod and unpowered-slab heat structures in the vessel;
- three primary- and secondary-coolant loops modeled individually;
- makeup, letdown, and pressurizer-sprayer cvcs flows;
- accumulator and hpsi fills in each primary-coolant loop;
- pressurizer and pressurizer porv and srv;
- pressurizer, steam generator, and steam-dump control systems;
- main-steam and steam-dump lines;
- high-pressure feedwater system after hp heaters; and
- auxiliary-feedwater fills (motor and steam driven).

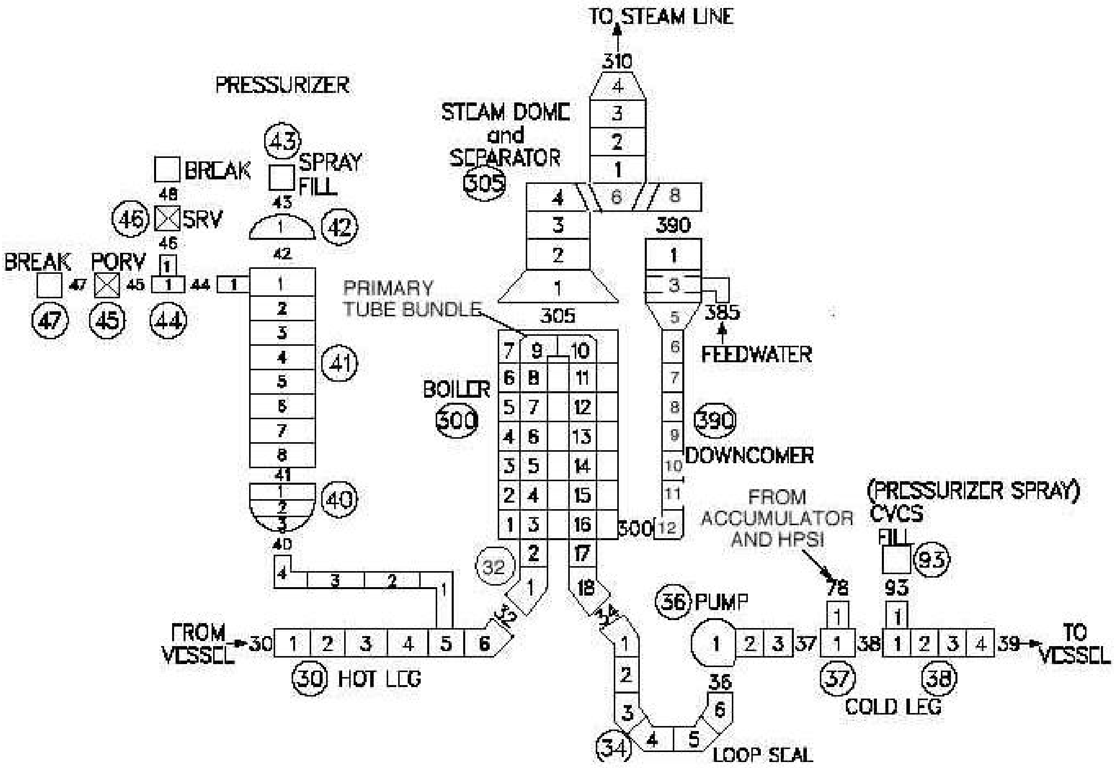

Figure 1. Noding Diagram for Primary System

3. Calculation Results

3.1 Sequence of Turbine Trip Events

A turbine trip may result from a number of conditions which cause the turbine trip generator control system to initiate a turbine trip signal. A turbine trip initiates closure of the turbine stop valves. Limit switches on the low pressure stop valves detect the turbine trip and initiate steam dump and a reactor trip. The loss of steam flow results in a rapid rise in secondary system temperature and pressure with a resultant primary system transient for the loss of external load event.

3.2 Case 1 - Chapter 15 Safety Analysis Calculation

A turbine trip initiates closure of the turbine stop valve. When the turbine trip signal generated, the reactor trip signal occurs automatically. And with the turbine trip , steam dump valves are opened to remove heat from the steam generator. But, in the safety analysis, the reactor trip signal due to turbine trip is neglected and the steam dump is not modeled.

It is assumed that the main feedwater and the main steam line are isolated with the turbine trip signal. Since the heats are not removed from the steam generator, the temperature and the pressure of the primary coolant increases. With the assumption of the failure of pressurizer PORV, the pressure of RCS increases above the PORV opening setpoint and reactor trip is generated due to the high pressurizer pressure trip signal. The increase of pressure of the primary system is stopped with the opening of the pressurizer safety valve. The opening setpoint of pressurizer safety valve is assumed conservatively high. The trip accident is terminated when the temperature and the pressure of the RCS become low and stabilized with the opening of the pressurizer safety valve. The assumptions used in the safety analysis of the turbine trip accident are summerized in Table 1. The results are shown in Figure 2 through Figure 5.

Main System related to the Turbine Trip	Assumptions
Reactor trip due to turbine trip	×
Steam dump system	×
Main feedwater isolation	On same time of turbine trip
Pressurizer PORV	×
Pressurizer sprayer	×
Opening setpoint of pressurizer safety valve	Conservatively high
Steam generator PORV	×
Opening setpoint of SG safety valve	Conservatively high

Table 1. The Major Assumptions used in the Turbine Trip Accident Analysis

3.3 Case 2 – Best Estimate Calculation

In this case, the steam dump and all control systems and protective systems are modeled. The reactor is assumed to be tripped at the same time with the turbine trip. The steam dump system removes heats generated from the steam generator. Since the heat supply from the reactor is ceased due to reactor trip and heats from the steam generator are removed through the steam dump system, the RCS pressure and the temperature decrease. The water level of the pressurizer also decrease. The results are compared with the case 1 and shown in Figures 6 through 9.

4. Conclusions

The applicability of using TRAC-M to non-LOCA analysis is examined with the selected turbine trip accident. The TRAC-M simulates well the transient phenomena of the accident.

The applicability of TRAC-M to other non-LOCA transients needs further investigation. We will examine which cases can be applicable and which cases are not in the near future.

References

[1] J. C. Lin, V. Martinez, and J. W. Spore, "TRAC-PF1/MOD2 Developmental Assessment Manual," Los Alamos National Laboratory (1993)

[2] 영광 1/2호기 FSAR, KEPCO

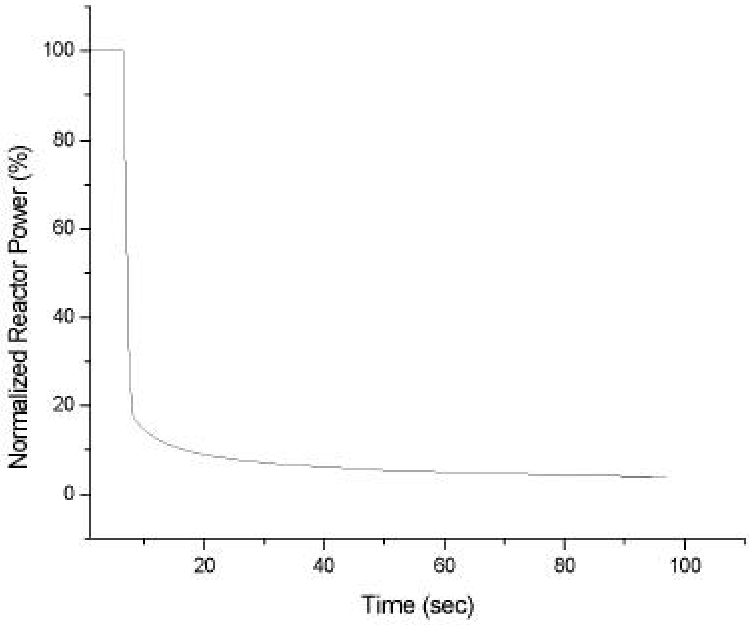

Figure 2. Reactor Power (Case 1)

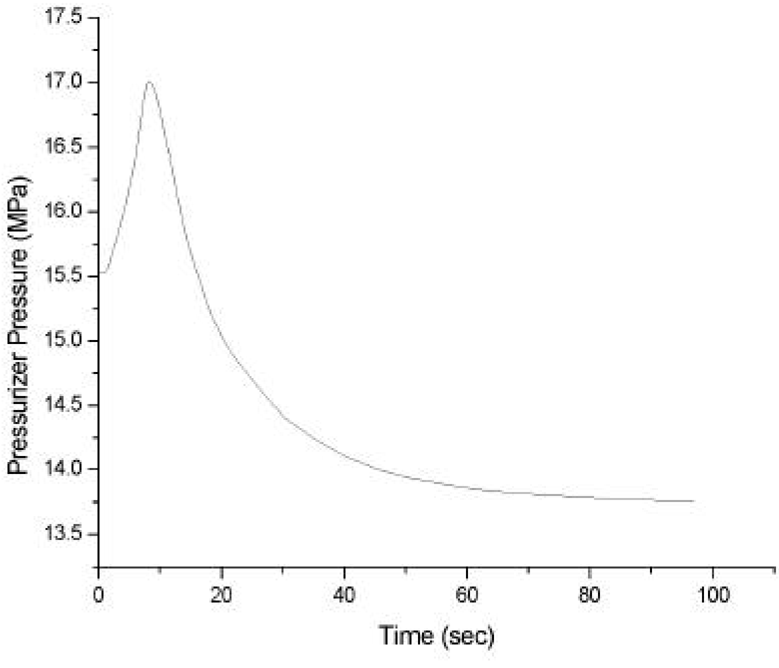

Figure 3. Pressurizer Pressure (Case 1)

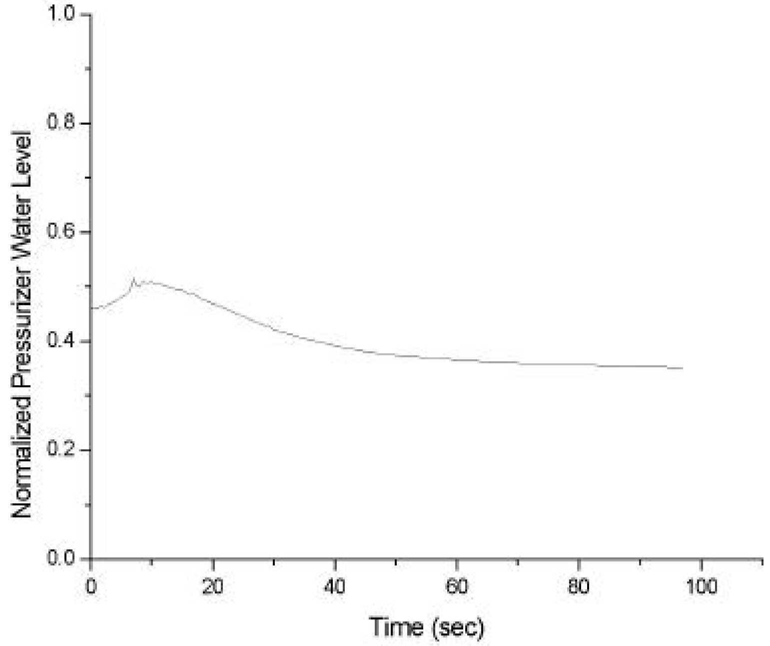

Figure 4. Pressurizer Water Level (Case 1)

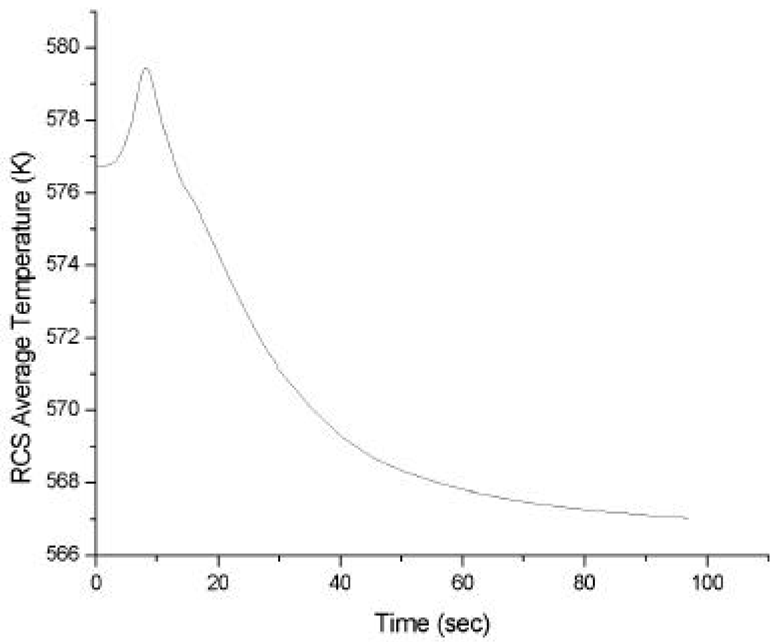

Figure 5. RCS Average Temperature (Case 1)

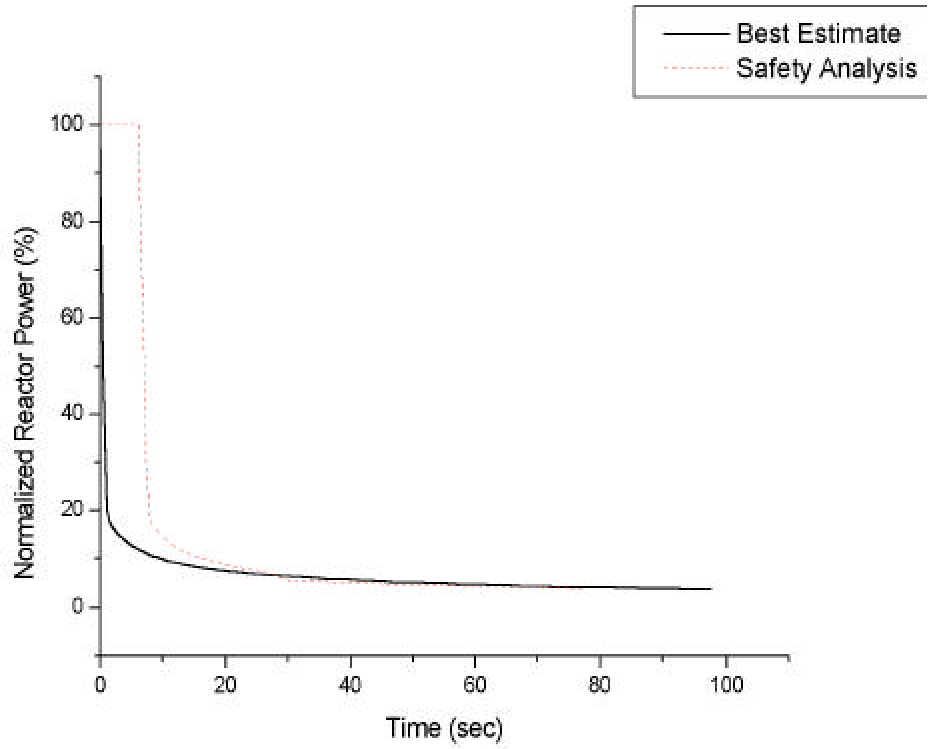

Figure 6. Reactor Power (Case 2)

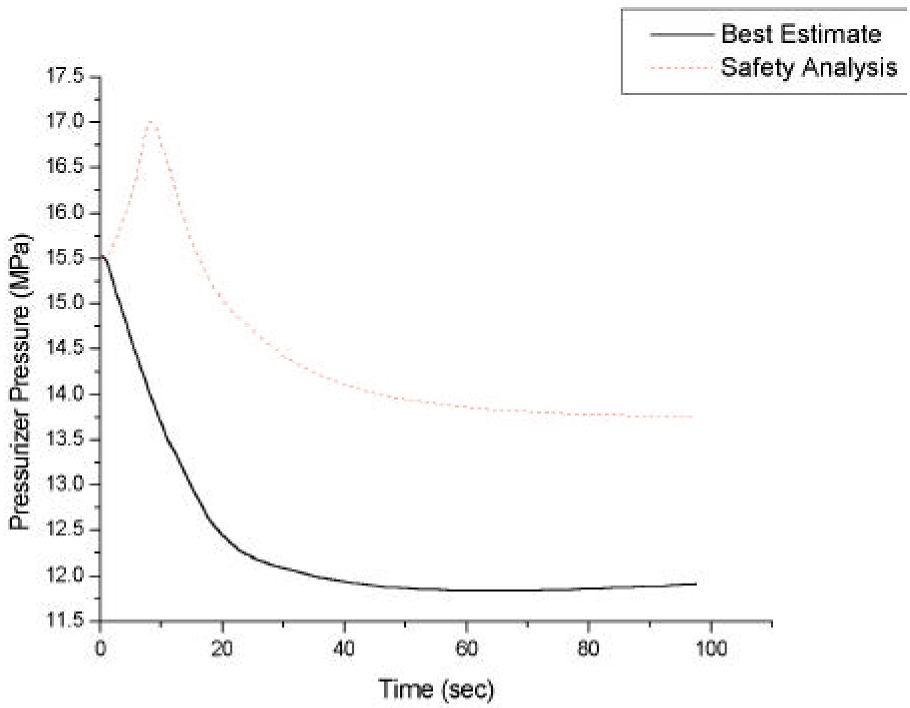

Figure 7. Pressurizer Pressure (Case 2)

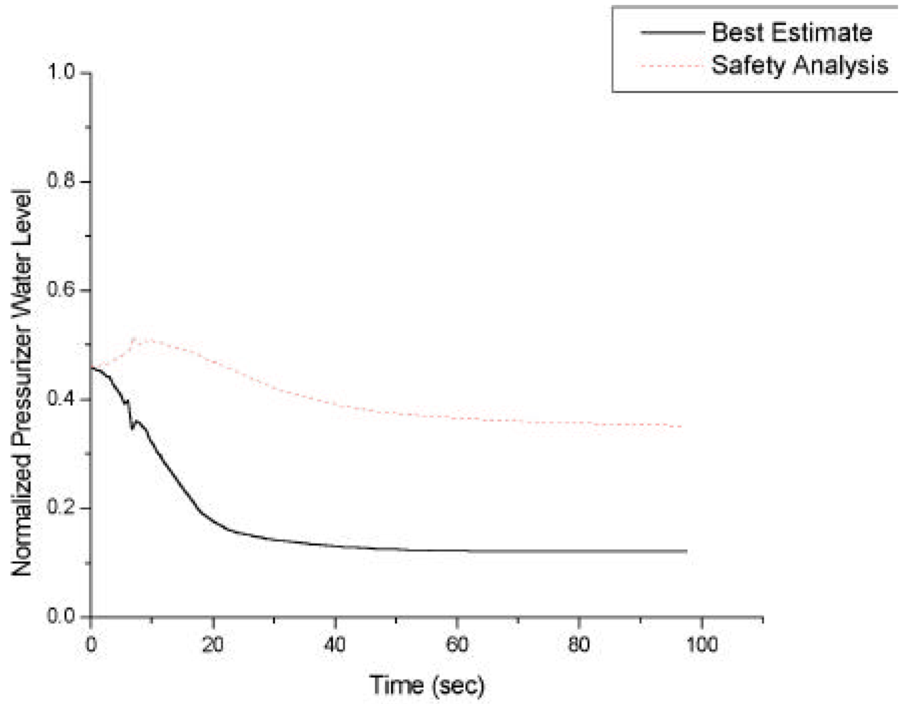

Figure 8. Pressurizer Water Level (Case 2)

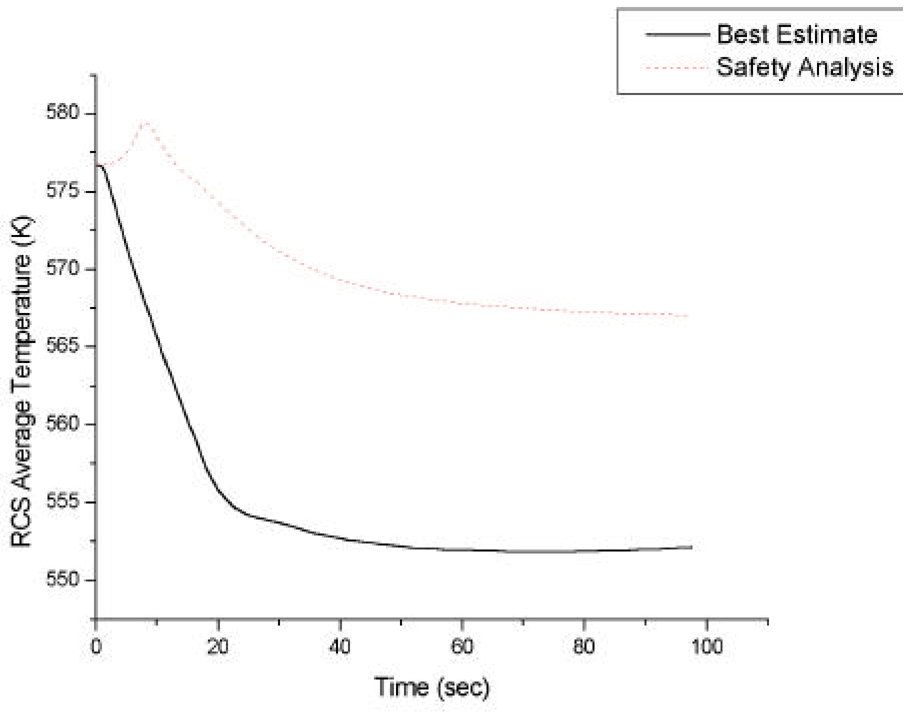

Figure 9. RCS Average Temperature (Case 2)