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AP1000 Subcompartment Models

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TRANSIENT MASS DISTRIBUTION CODE FOR AP1000 SUBCOMPARTMENT MODEL

The Transient Mass Distribution (TMD) code (References 1 and 2) is a mathematical model developed by Westinghouse to simulate the pressure transients subsequent to a loss-of-coolant accident (LOCA) or a main steamline break (MSLB) inside the containment. This code is used to calculate the pressure transient for a short time period during the initial blowdown of the transient. The peak pressure differences on various structures occur within the first few seconds of these transients.

The pressure and temperature transients inside the containment are calculated for the postulated breaks using the TMD code. In order to model the various compartments of a containment, a control volume technique is used to spatially represent these regions. The conservation of mass, momentum, energy, and equation of state are solved within each control volume as a function of time and space. The model includes moisture entrainment effects in the momentum and energy equations. The peak pressures in each element, and the peak differential pressures across structures within the containment, are determined from these calculations. The pressure differentials occur because of the propagation of the pressure disturbance around the containment subsequent to the pipe break. The TMD code has been reviewed by the Nuclear Regulatory Commission (NRC) and approved for use in subcompartment differential pressure analyses.

Design Control Document (DCD) subsection 6.2.1.2 provides the maximum differential pressure results for postulated breaks in the AP1000 containment subcompartments. The break sizes and locations are defined by the leak-before-break criteria described in DCD section 3.6.

The primary TMD model of the AP1000 subcompartments is represented by [ ]^{a,c} separate control volumes with a flow path network designated by "hoop," "radial," and "axial" flow paths. The designation of hoop, radial, or axial is of no physical importance for subcompartment analyses (it simply facilitates the ability to model a maximum of three flow paths from one control volume). The specific geometric and friction factor data for the "hoop" flow paths is shown in Table 1 (sheets 1 through 4). The data for the "radial" flow paths is shown in Table 2 (sheets 1 through 4), and the data for the "axial" paths is shown Table 3 (sheets 1 through 4).

The free volume of each of the [ ]^{a,c} nodes, and the respective initial conditions, is shown in Table 4 (sheets 1 through 3).

The control volume and flow path network for the [ ]^{a,c} TMD model is shown in Figure 1 (sheets 1 through 12)

The following piping is postulated to break:

- 4-inch steam generator blowdown line
- 4-inch pressurizer spray line
- 3-inch Reactor Coolant System branch lines from the hot leg or cold leg
- 1.0-ft^2 MSLB

These breaks can be postulated to occur in the following AP1000 compartments:

- Steam generator compartment
- Pressurizer compartment
- Pressurizer valve room
- Chemical and Volume Control System (CVS) room
- CVS pipe tunnel
- Pipe penetration area

REFERENCES

1. Bordelon, F. M., Colenbrander, H. G. C., WCAP-7548, "Analysis of the Transient Flow Distribution During Blowdown in the Ice Condenser Reactor Containment (TMD Code)," July 1970 (Westinghouse Proprietary).

2. "Ice Condenser Containment Pressure Transient Analysis Methods," WCAP-8077, March 1973 (Westinghouse Proprietary).

Table 1 Hoop Flow Path Data

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

a,c

Table 1 (cont.) Hoop Flow Path Data

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

a,c

Table 1 (cont.) Hoop Flow Path Data

a,c

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

Table 2 Radial Flow Path Data

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

a,c

Table 2 (cont.) Radial Flow Path Data

a,c

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

Table 2 (cont.) Radial Flow Path Data

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

a,c

Table 3 Axial Flow Path Data

a,c

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

Table 3 (cont.) Axial Flow Path Data

a,c

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

Table 3 (cont.) Axial Flow Path Data

Element	K-Factor	F-Factor	Inertial Length (ft)	Hydr. D (ft)	Flow A (ft^2)	Equi. L (ft)	A/A

a,c

Table 4 Transient Mass Distribution Model Node Information

Element Number	Volume (ft^3)	Steam Pressure (psig)	Air Pressure (psia)	Temperature (°F)

a,c

Table 4 (cont.) Transient Mass Distribution Model Node Information

a,c

Element Number	Volume (ft^3)	Steam Pressure (psig)	Air Pressure (psia)	Temperature (°F)

Table 4 (cont.) Transient Mass Distribution Model Node Information

Element Number	Volume (ft^3)	Steam Pressure (psig)	Air Pressure (psia)	Temperature (°F)

a,c

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 1 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 2 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 3 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 4 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 5 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 6 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 7 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 8 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 9 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 10 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 11 of 12)

a,c

Figure 1 Transient Mass Distribution Model Noding Diagram (Sheet 12 of 12)