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APPLICATION OF THE MELCOR CODE TO DESIGN BASIS SUBCOMPARTMENT ANALYSIS

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ABSTRACT

The MELCOR computer code has been developed by Sandia National Laboratories under USNRC sponsorship to provide capability for independently auditing analyses submitted by reactor manufactures and utilities. MELCOR is a fully integrated code (encompassing the reactor coolant system and the containment building) that models the progression of postulated accidents in nuclear power plants. To assess the adequacy of containment thermal-hydraulic modeling incorporated in the MELCOR code for subcompartment pressure and temperature transient analysis in reactor containment buildings, demonstration calculations were analyzed. This report documents MELCOR code demonstration calculations performed and the results are compared to CONTAIN calculations. These code-to-code comparisons reveal an "equivalency" between the calculated results, and therefore, MELCOR can be used for these types of design basis analyses.

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LIST OF ACRONYMS

BWR	Boiling Water Reactor
DBA	Design Basis Accident
FSTB	Fuel and Source Term Branch (NRC/RES)
LOCA	Loss of Coolant Accident
MSLB	Main Steam Line Break
NRC	U.S. Nuclear Regulatory Commission
PWR	Pressurized Water Reactor
RCS	Reactor Coolant System
RES	Office of Nuclear Regulatory Research (NRC)
SNL	Sandia National Laboratories
SRP	Standard Review Plan

1.0 INTRODUCTION

1.1 Background

The MELCOR computer code [1,2] was developed by Sandia National Laboratories (SNL) under U.S. Nuclear Regulatory Commission (NRC) sponsorship to provide capability for independently auditing analyses submitted by reactor manufactures and utilities. MELCOR is a fully integrated code (encompassing the reactor coolant system [RCS] and the containment building) that models the progression of postulated accidents in nuclear power plants. Characteristics of accident progression that can be treated with MELCOR include the thermal-hydraulic response in the RCS, reactor cavity, containment buildings, and a variety of severe accident related phenomena.

In order to assess the adequacy of containment thermal-hydraulic modeling incorporated in the MELCOR code for subcompartment pressure and temperature transient analysis in reactor containment buildings, demonstration calculations were analyzed. This report documents MELCOR code [version 1.8.6_YV_3272] calculations performed and the results are compared to CONTAIN calculations. The NRC provides guidance though a variety of Standard Review Plans (SRPs) to nuclear reactor licensees about what types of calculations needs to be performed, and what calculation methods can be used to demonstrate the adequacy of their containment systems designs. As such, these licensing methods were used as a guidepost for assessing MELCOR's performance in design basis containment analysis.

The CONTAIN code [3] was also developed by SNL and is a specialized computer code used to perform thermal-hydraulic calculations inside containment following a variety of postulated high energy breaks, and serves as a repository of accumulated knowledge in the area of containment analysis technology. CONTAIN incorporates the best current understanding of all relevant phenomena, and has an extensive validation base. The code is the NRC's principal containment analysis tool used to audit industry's safety analysis calculations. Accordingly, CONTAIN results are used to compare against MELCOR calculations. Appropriately, the code user guidance will be similar to the existing licensing framework, e.g., as specified in the relevant SRP section. Thus, the calculated results would tend to be bounding in nature or biased in a conservative manner.

The MELCOR code assessments documented in this report are based on the CONTAIN code qualification report/user guide for auditing design basis subcompartment calculations [4]. Moreover, this CONTAIN report should be consulted for the underlying technical foundation and insights, and those CONTAIN input files which are in the Appendices of the CONTAIN report are also included in the Appendices in this report.

1.2 Accident Phases and Key Phenomena

A key result for subcompartment analyses are the pressure differentials calculated between the subcompartment and the main containment compartment, or between adjacent subcompartments during a variety of postulated high- or moderate-energy line breaks. The results obtained are transient pressure differential profiles that are calculated within a few seconds following a pipe rupture. One of the important results required in this analysis is the maximum pressure differential reached during the pipe rupture event. In this determination, the code's ability to estimate single and two-phase critical flows for the subcompartment(s) are very important.

The accident phase of importance is the short-term phase of a pipe rupture event that allows peak pressure differentials to be established, within a reasonably short relaxation period over which time the differentials are significantly reduced. A typical time period of interest for most accidents is up to a few seconds following a postulated pipe rupture.

The types of postulated accidents analyzed in subcompartment analyses may include loss-of-coolant accidents (LOCAs) and main steam line breaks (MSLBs). These accidents may occur in all types of reactor types (PWRs and BWRs). The short-term response of the subcompartment pressure differential for these types of accidents may vary due to the characteristics of the injected fluid. In the case of the LOCAs, the injected fluid will be a two-phase steam/water mixture, and the subcompartment exit flows will be an air/steam/water mixture, where significant amounts of liquid water may be entrained in the flow. For the MSLBs, the injected fluid is dry steam, and the exit flows will typically be air/steam mixture flows, with very little amounts of entrained liquid water.

1.3 Code Comparisons

This report addresses the adequacy of the MELCOR code for subcompartment analysis principally by comparing to the CONTAIN results which were previously documented in the CONTAIN subcompartment qualification report [4]. Accordingly, user guidance is presented and intended to show how to prepare each MELCOR input deck to be consistent with the corresponding CONTAIN model. A listing of the demonstration case input files for MELCOR and CONTAIN is provided in Appendices A to D.

If the margin between a plant's design values and the peak calculated values are small, sensitivity studies of important parameters may be needed to understand the impact of inherent uncertainties. As a result, key parameters that should be considered for sensitivity analysis are the vent flow path characteristics (loss and discharge coefficients, inertial length, and flow area).

In this version of the MELCOR code used in the present analysis (1.8.6_YV_3272), the upstream density includes the suspended liquid droplets in the atmosphere for the critical flow model. This formulation is consistent with CONTAIN.

2.0 DEMONSTRATION SUBCOMPARTMENT CODE COMPARISONS

Listed in Table 2.1 are the four comparison calculations that are discussed in this section. These cases were extracted from the CONTAIN subcompartment qualification report [4] in order to perform code-to-code benchmark calculations that demonstrate the code's ability to predict subcompartment pressure differentials when key phenomena governing the pressures are 1) two-phase inertia flow, and 2) two-phase choked flow. The first two cases in Table 2.1 are more academic in nature and the last two cases were taken from actual plant audit calculations.

Also discussed in reference [4] are code parameter recommendations and suggested code sensitivities. The critical element for subcompartment analysis is the mass flow exiting the break compartment which involves the potential for choking, thus limiting the mass flow which tends to produce an increased subcompartment differential pressure. However in most actual plant applications, protracted choking conditions are usually not typical.

Also a common assumption when performing design basis subcompartment analysis is to force the break water component to be suspended in the atmosphere, i.e., a 100% liquid entrainment. Most of CONTAIN and MELCOR demonstration calculations were performed with a vena contractor (discharge coefficient) of 0.7 which is consistent with the CONTAIN qualification report recommendation.

Table 2.1 Listing of subcompartment demonstration problems

Problem #	Description	Fluid	Key Modeling
C1	Two compartment, wet steam injection	air/steam/water	two-phase inertia flow
C2	Four compartment, wet steam injection	air/steam/water	two-phase inertia flow two-phase non-isentropic choking
C3	Three compartment, wet steam injection	air/steam/water	two-phase inertia flow
C4	Six compartment, dry steam injection	air/steam	single-phase mixture inertia flow single-phase mixture non-isentropic choking

2.1 Two Compartment Wet Steam Injection

Figure 2.1 shows the configuration of compartments for a simple two compartment calculation. The smaller volume is connected to the larger volume by a connecting path with an area of 38 m^2. Low quality steam (h = 1395 kJ/kg) is injected into the smaller compartment at a rate of approximately 5900 kg/s. Shown in Figure 2.2 is the pressure differential between volumes #1 and #2 calculated using the MELCOR and CONTAIN codes. Figure 2.3 shows the vent path mass flux calculated by each code and the critical flow limit (based on MELCOR upstream compartment conditions which are comparable to CONTAIN calculated conditions) which includes the vena contractor factor and the flow densities with suspended liquid. Note that the peak differential pressure occurs just before there is a brief period of vent flow choking as predicted by both codes. These results show good agreement between MELCOR and CONTAIN results for this problem, and the input files are listed in Appendix A.

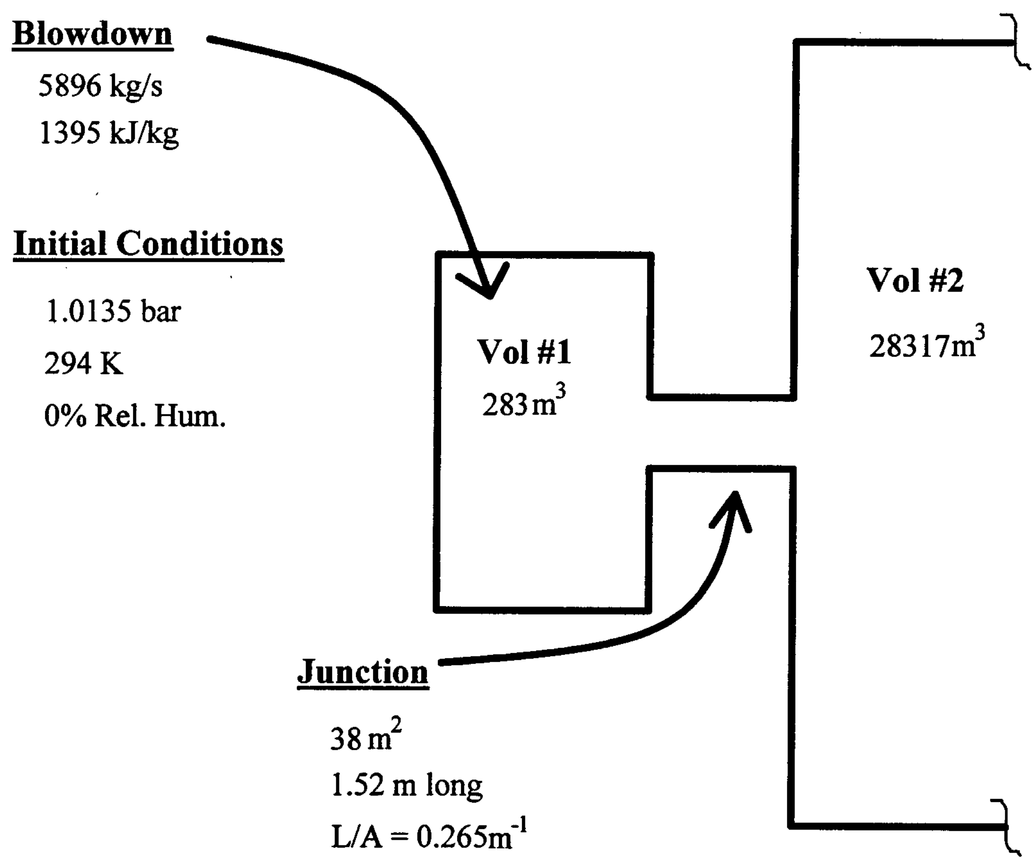

Figure 2.1 Demonstration Case 1 problem specifications

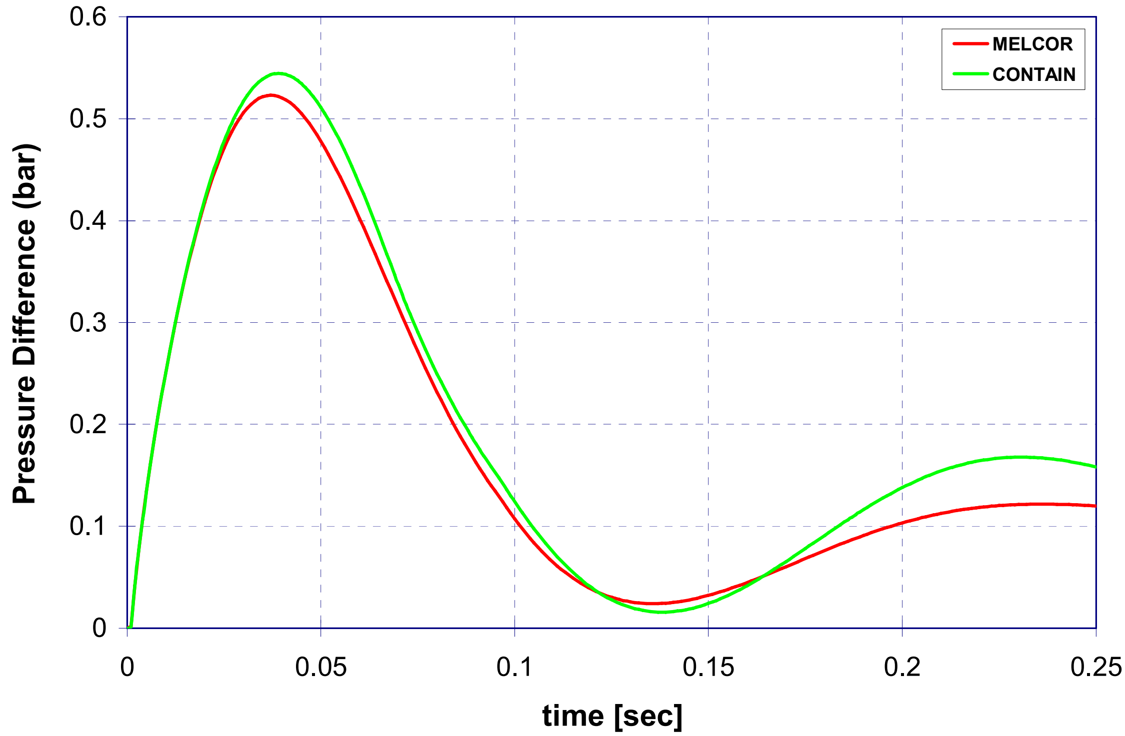

Figure 2.2 Comparison of code calculated pressure differentials for Case 1

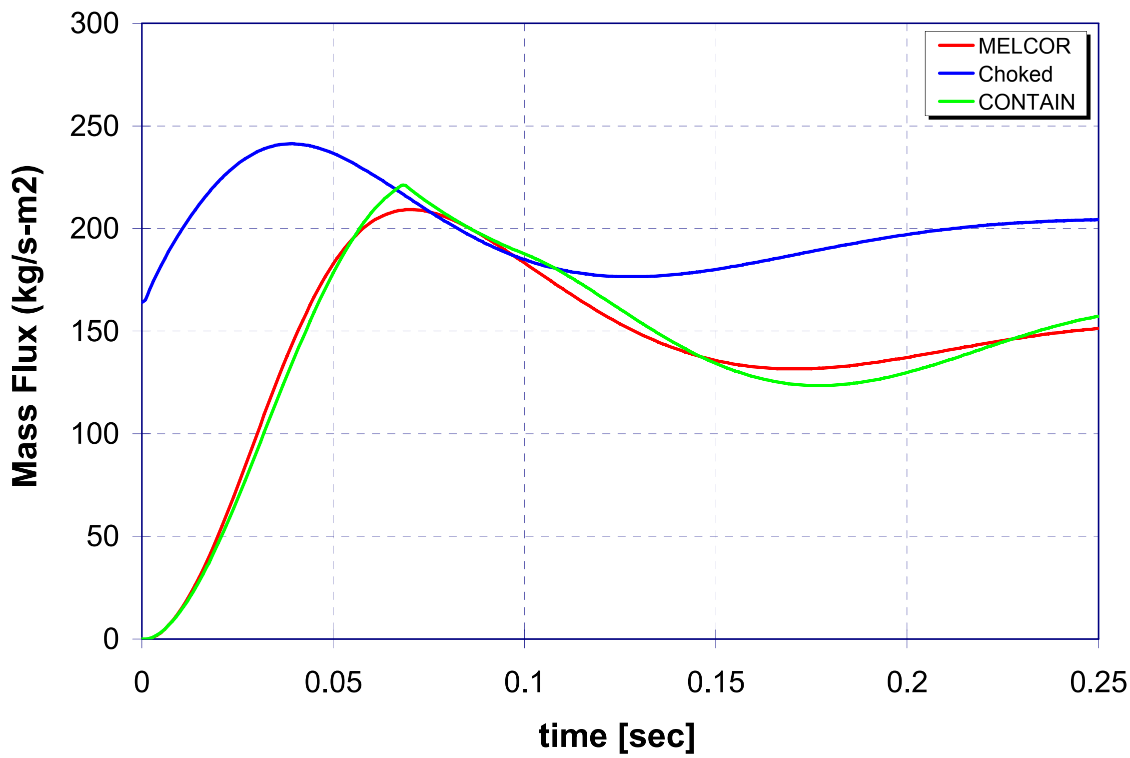

Figure 2.3 Comparisons of the flow path mass flux for Case 1

2.2 Four Compartment Wet Steam Injection

Figure 2.4 shows the configuration for a four compartment problem. In this case, low quality steam (h = 1395 kJ/kg) is injected into volume #1 at a rate of approximately 35800 kg/s. The pressure differential between volumes #1 and #2 calculated using the MELCOR and CONTAIN codes is shown in Figure 2.5. Figure 2.6 shows the comparison of the mass flow rates between the codes. The critical flow rate is also shown in the figure (calculated using the same approach as in the previous problem). In this case, the maximum differential pressure occurs when the vent flow choking begins.

Both code results are shown for a calculation where the recommended multiplier on the CONTAIN critical flux, vcontra, is set to 0.7, and in MELCOR the discharge coefficient (Cd) is also set to 0.7. These results show good agreement between MELCOR and CONTAIN results for this problem. Figure 2.7 is a MELCOR code sensitivity using the discharge coefficient of 0.9, in which this coefficient was used to match different choking models; refer to the CONTAIN subcompartment qualification report [4] for the detail discussion. The input files are listed in Appendix B.

However, what mitigates the importance of this demonstration case is that the protracted choking condition for this problem is usually not typical in most actual plant applications, i.e., extremely large two-phase release in a relatively small compartment. So when performing actual plant analysis, these conditions should be confirmed.

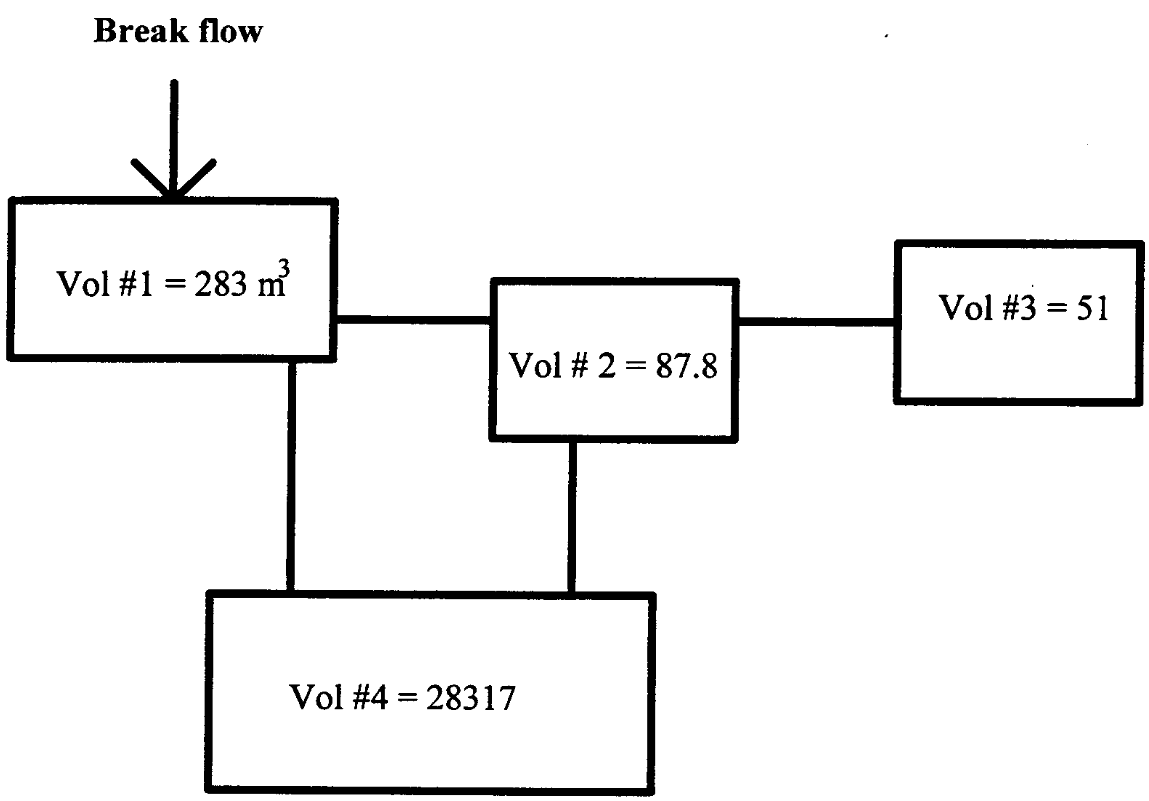

Figure 2.4 Demonstration Case 2 problem schematic

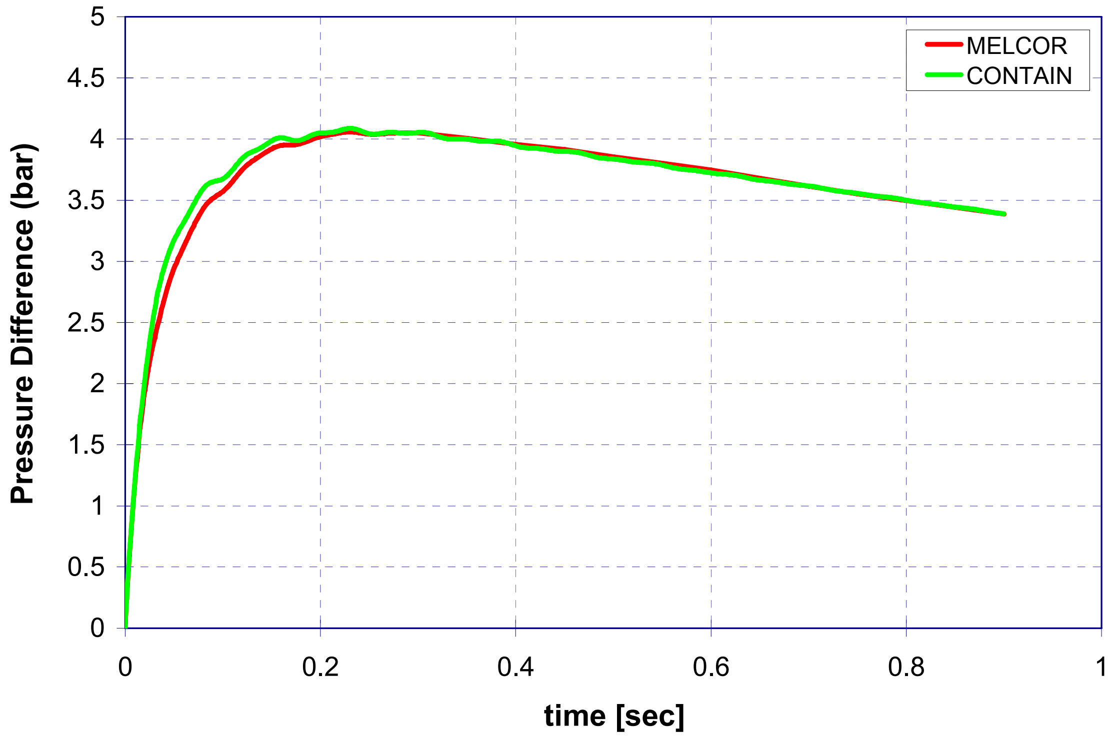

Figure 2.5 Comparisons of code calculated pressure differentials for Case 2

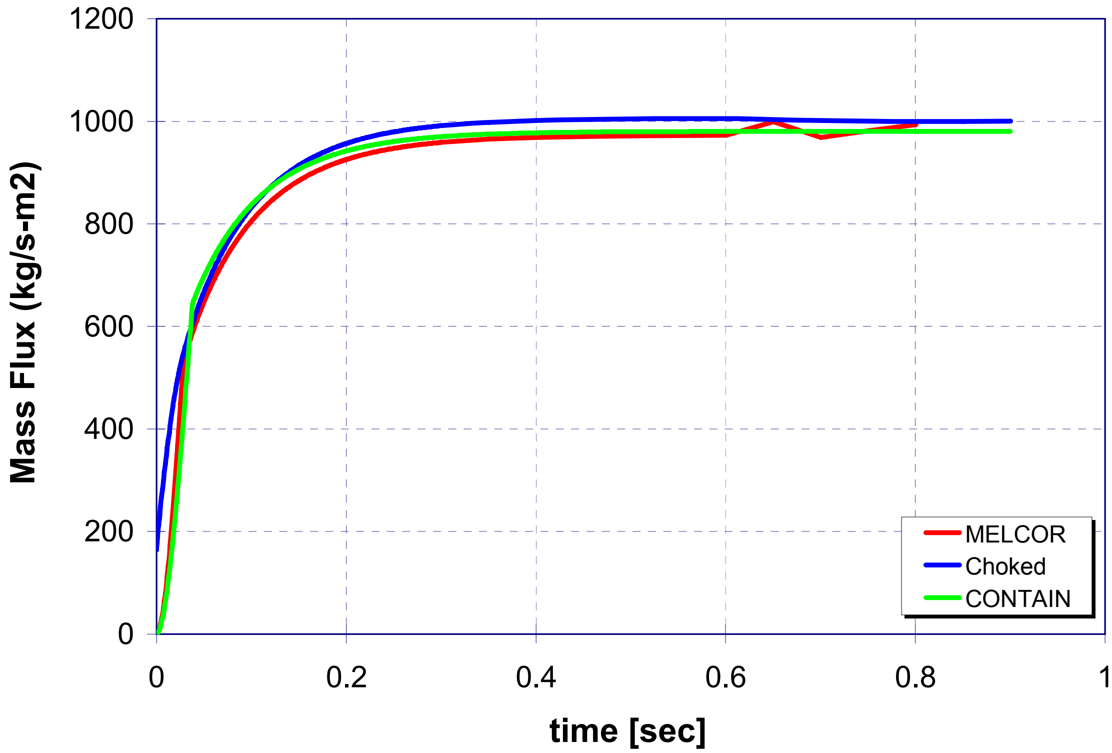

Figure 2.6 Comparisons of the flow path mass flux for Case 2

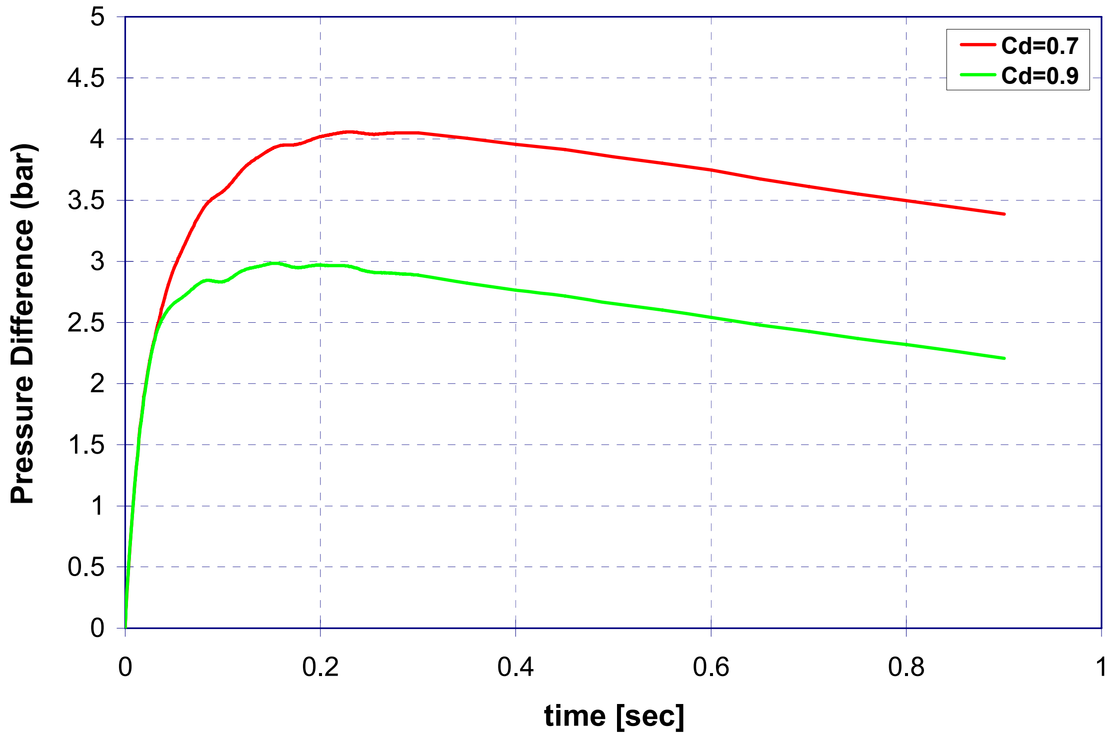

Figure 2.7 MELCOR predicted pressure differentials for Case 2

2.3 Three Compartment Wet Steam Injection

Figure 2.8 shows the configuration for a three compartment problem. In this case, low quality steam (h = 1093 kJ/kg) from a postulated break in the reactor water clean-up line is injected into a heat exchanger room (Vol. #1) at a rate of approximately 663.6 kg/s for 1.3 seconds, and then reduced to 329.5 kg/s for the remainder of the calculation. Shown in Figure 2.9 is the pressure differential between volumes #1 and #2, and volumes #1 and #3 calculated using the MELCOR and CONTAIN codes. Note there is a good comparison between volumes #1 and #2 which is confirmed by Figure 2.9 which shows the excellent comparisons of the flow path mass flux. This flow path is driven by inertial flow and the calculated flows are never choked demonstrating similar modeling of inertia flows between the codes.

Figure 2.11 shows the vent path mass flux calculated by each code between volumes #1 and #3 and the critical flow limits which includes the vena contractor factor and the flow densities with suspended liquid. Both codes predict a brief period of vent flow choking and during this period the peak pressure differential is calculated. These results show good agreement between MELCOR and CONTAIN results for this problem. The input files are listed in Appendix C.

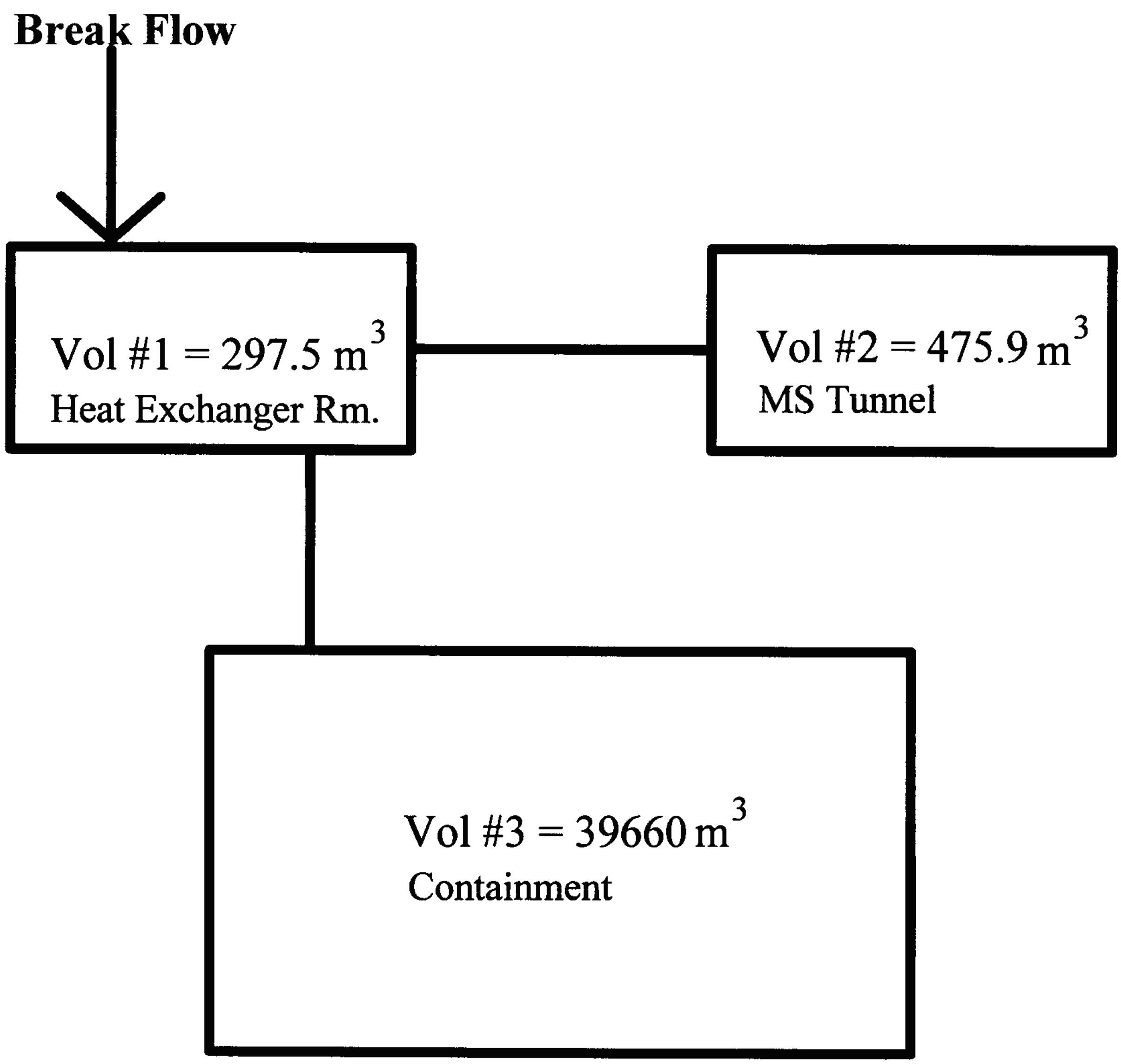

Figure 2.8 Demonstration Case 3 problem schematic

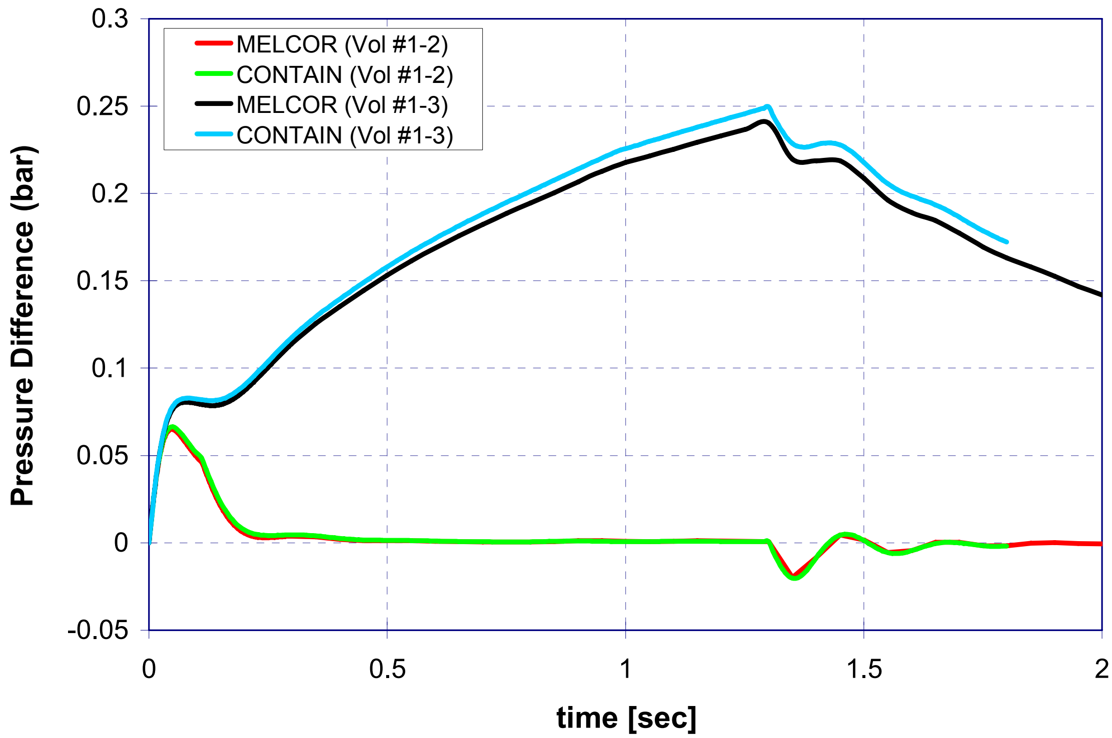

Figure 2.9 Comparison of code calculated pressure differentials for Case 3

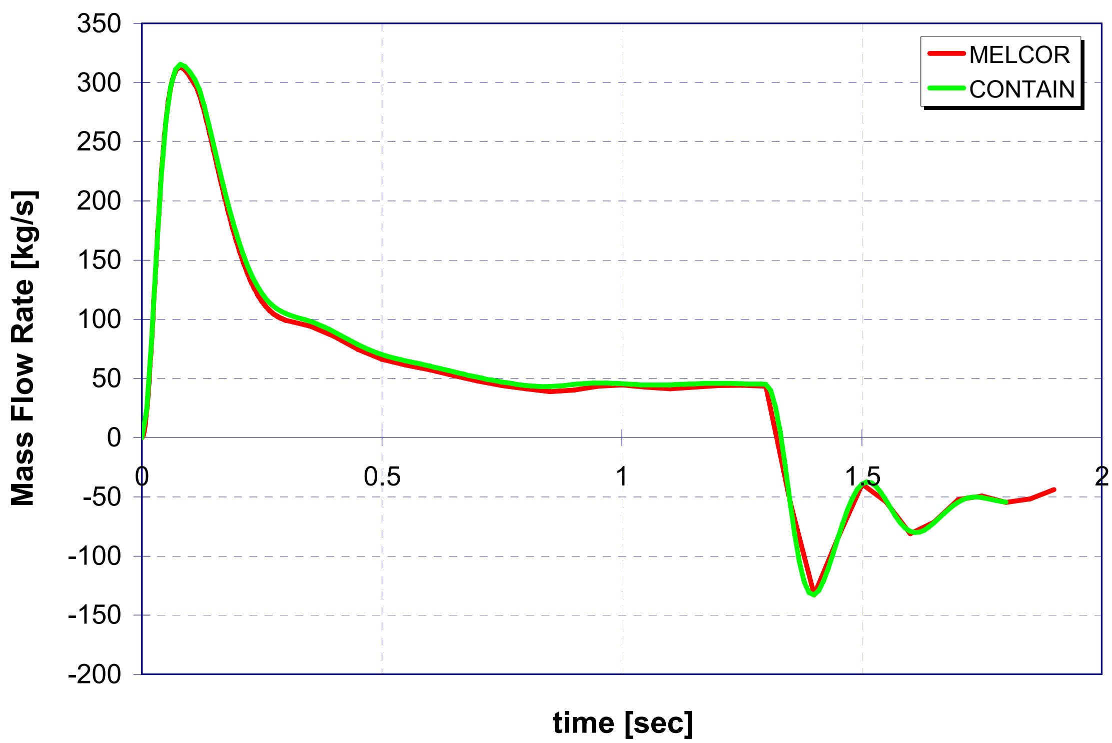

Figure 2.10 Calculated mass flux for flow path Vol #1 – Vol #2

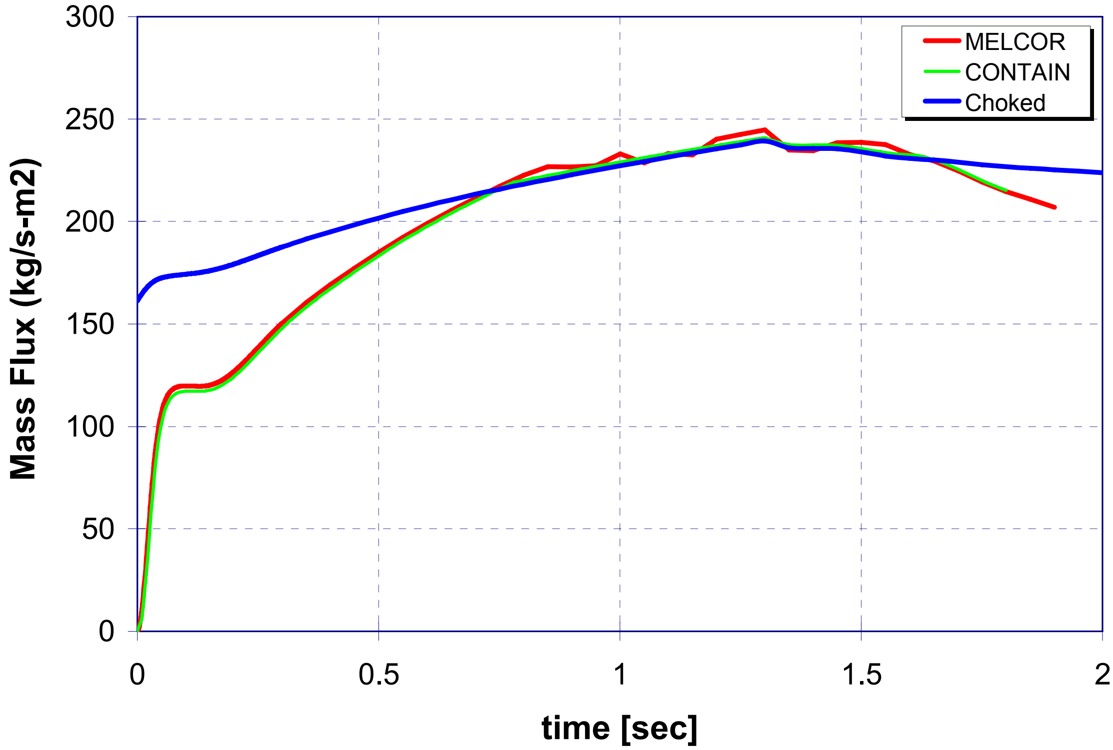

Figure 2.11 Calculated mass flux for flow path Vol #1 – Vol #3

2.4 Six Compartment, Dry Steam Injection

For this demonstration problem, a postulated main steam line break (MSLB) occurs in the upper portion of a BWR Mark III drywell, which is equally divided between volumes #1 and #2 as shown in Figure 2.12 (configuration for a six compartment simplification of the entire drywell). The sudden break flow of dry steam (h = 2767 kJ/kg) induces choked, single-phase air/steam mixture flow into the pathways surrounding the break volumes. Figure 2.13 shows the pressures calculated by MELCOR for the break volumes and largest volume. The choking begins almost immediately following the break in the main steam line, and therefore the pressure differential maximums for these volumes (Vol #1 and #2) occur during a period of choked flow. Figures 2.14 and 2.15 are plots of the pressure differentials for Vol #1 to Vol #6, and Vol #2 to Vol #6, respectively.

Figure 2.16 shows the vent path mass flux calculated by each code between volumes #2 and #4 and the critical flow limits. Note there is no suspended liquid in this problem, only steam releases. These results show good agreement between MELCOR and CONTAIN results for this problem. This problem represents an extreme test of the inertia and single-phase critical flow modeling between the codes. The fact that they agree as well as noted shows that the modeling is nearly identical. The input files are listed in Appendix D.

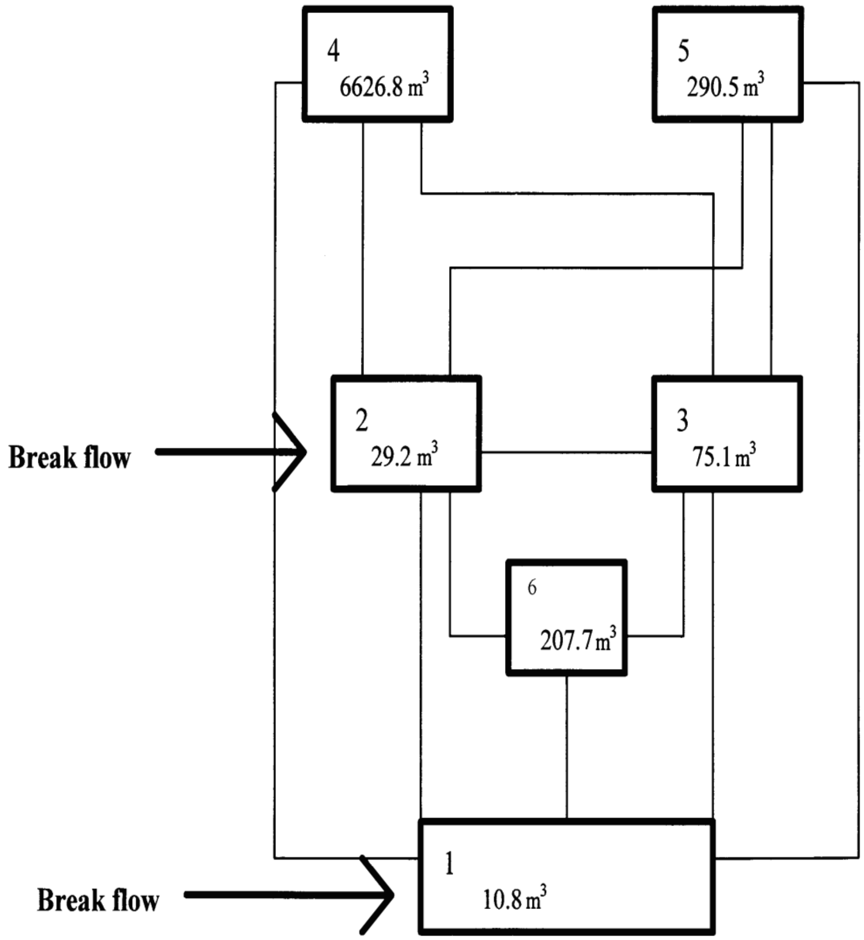

Figure 2.12 Demonstration Case 4 problem schematic

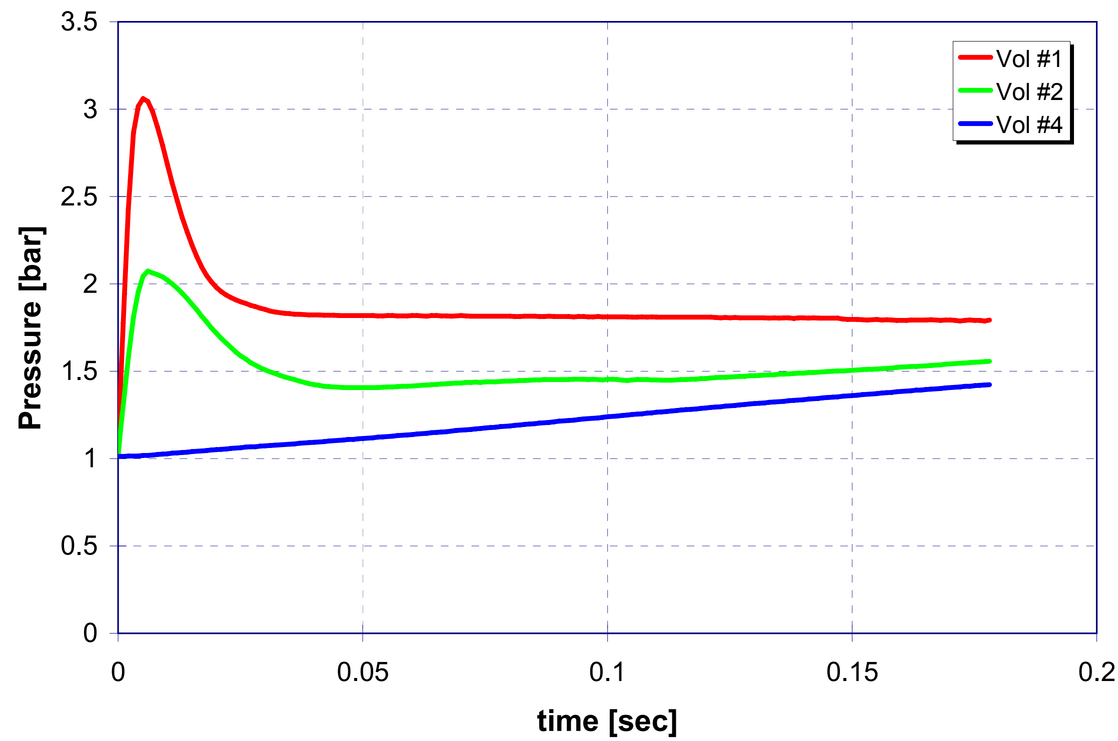

Figure 2.13 MELCOR calculated compartment pressures for Case 4

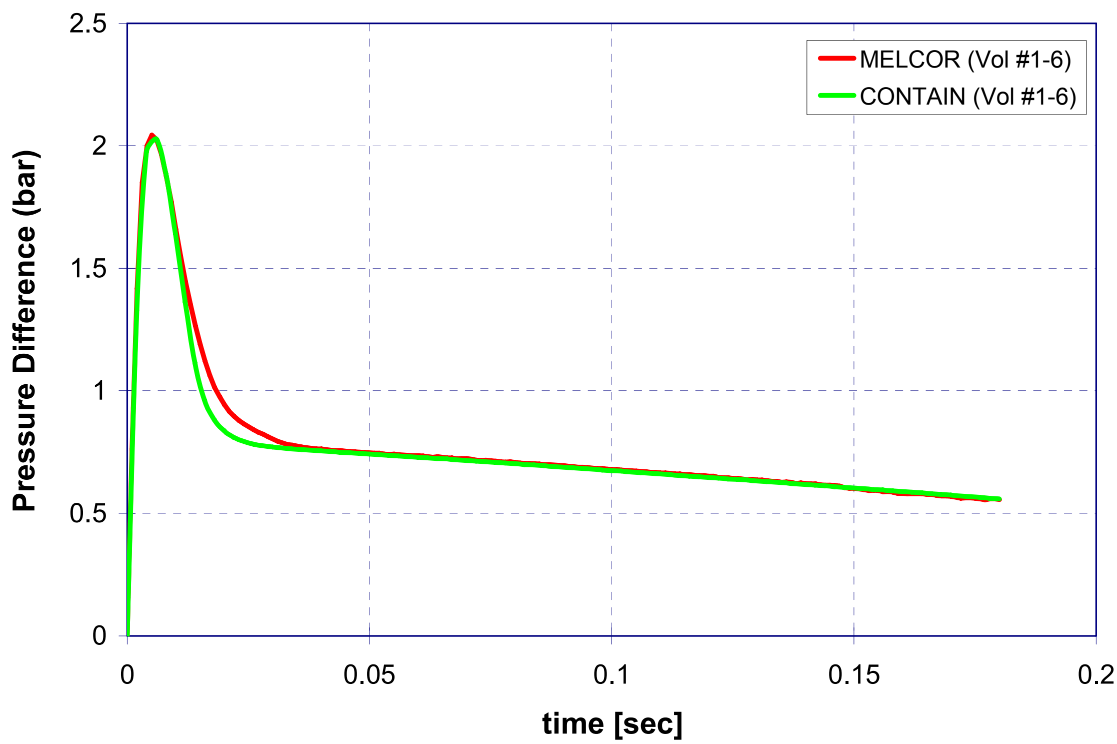

Figure 2.14 Comparison of code calculated pressure differentials for Case 4

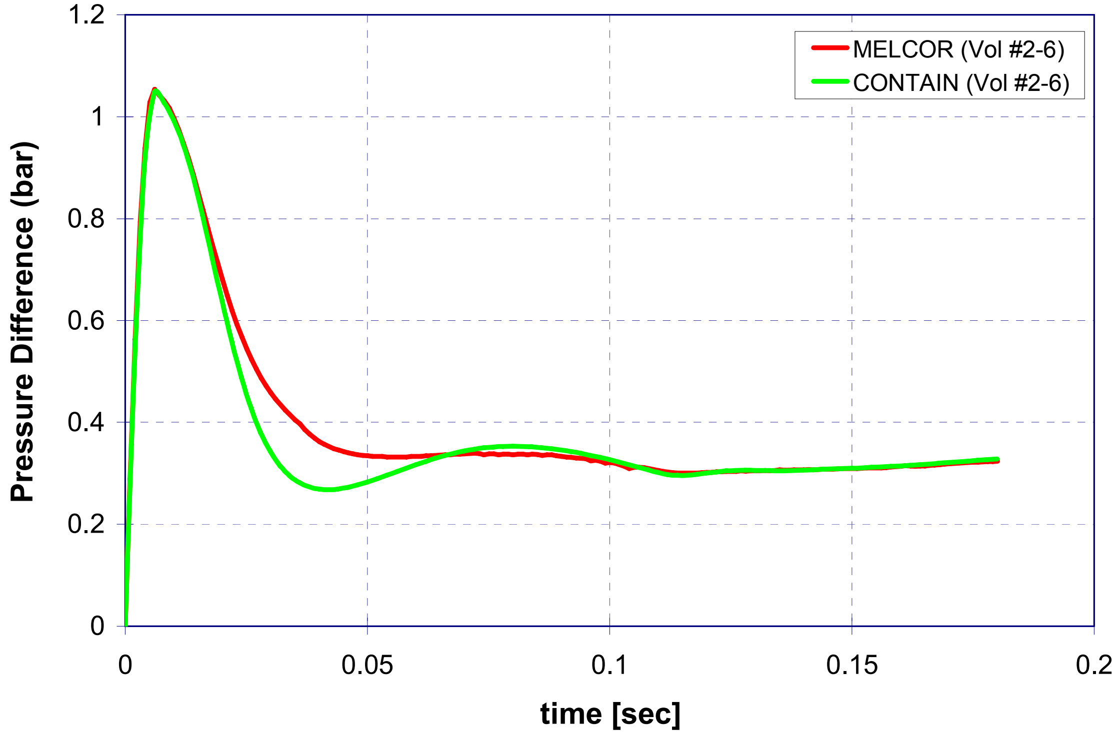

Figure 2.15 Comparison of code calculated pressure differentials for Case 4

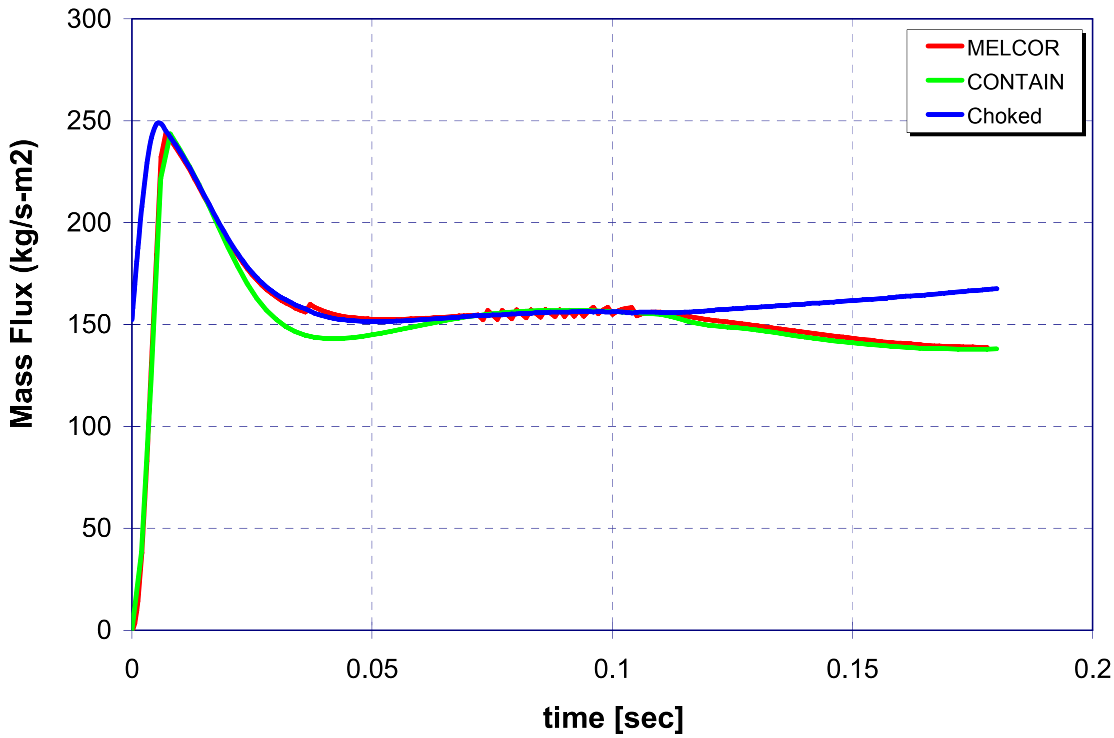

Figure 2.16 Calculated mass flux for flow path Vol #2 – Vol #4

3.0 CONCLUSIONS

To assess the adequacy of containment thermal-hydraulic modeling incorporated in the MELCOR code for subcompartment pressure and temperature transient analysis in reactor containment buildings, demonstration calculations were analyzed. This report documents MELCOR code demonstration calculations performed and the results are compared to CONTAIN predictions. These code-to-code comparisons reveal an "equivalency" between the calculated results, and therefore, MELCOR is suitable for these types of design basis analyses.

4.0 REFERENCES

1. Gauntt, R.O., et al., "MELCOR Computer Code Manuals – Vol.2: Reference Manuals, Version 1.8.6 September 2005," NUREG/CR-6119, Vol. 2 Rev 3, SAND 2005-5713, Sandia National Laboratories, Albuquerque, New Mexico, September 2005.

2. Gauntt, R.O., et al., "MELCOR Computer Code Manuals – Vol.1: Primer and User's Guide, Version 1.8.6 September 2005," NUREG/CR-6119, Vol. 1 Rev 3, SAND 2005-5713, Sandia National Laboratories, Albuquerque, New Mexico, September 2005.

3. Murata, K. K., et al., "Code Manual for CONTAIN 2.0: A Computer Code for Nuclear Reactor Containment Analysis," NUREG/CR-6533, SAND-1735, Sandia National Laboratories, Albuquerque, NM, December 1997.

4. Tills, J., et al., "CONTAIN Code Qualification Report/User Guide for Auditing Subcompartment Analysis Calculations," SMSAB-02-04, USNRC ADAMS Accession Number ML023220288, September 2002.

APPENDIX A INPUT FILES FOR CASE 1

A.1 CONTAIN Input File

```
&& Comparison problem C1
&& ********************** CONTROL BLOCK
******************************* &&
control           && to begin specification of global storage
allocation
  ncells=2
  ntitl=2         && # of lines in the title
  ntzone=1        && # of time zones
  nengv=1         && # of engineered vents
eoi
&& ********************** MATERIAL BLOCK
******************************
material       && to initiate material block
compound h2ol h2ov n2 o2
&& ********************** TITLE BLOCK********************************
title 2
 COMPARE Sample Problem (LA NUREG 6488 MS) Standard Problem No.4

&& ********************** TIME ZONES
*************************************
times 5.  0.0
  0.001   .001   0.25
&& ********************** PRINT OPTIONS
*******************************
longedt=1         && # of timesteps between longedit
shortedt=20      && # of timesteps between shortedit
prflow
prenacct
flows implicit
&& *****************ENGINEERED VENTS
**********************************
engvent
    from 1 to 2
    varea=38.08992 vavl=3.77 type=gas  vcfc=.75 vcontra=0.7 eoi
&& ****************** CELL #1  Blowdown Comp.
*************************
cell=1                  && begining of input in cell 1
control  nsoatm=1  nspatm=2
eoi
geometry
 gasvol=283.1738
 cellhist=1 0.0 28.31738 10.0
eoi
atmos=2
  pgas=1.0135e5 tgas=294.0
  molefrac o2=.21 n2=.79
eoi
condense
source=1
h2ov=2   iflag=1
```

```
t=0.0    1.0
mass= 5896.761   5896.761
enth= 1.3953e6  1.3953e6
eoi
eoi
&& ****************** CELL #2  Receiver *****************************
cell=2
control
  eoi
geometry
  gasvol= 28317.38
  cellhist=1  0.0 283.1738  100
eoi
atmos=2
  pgas=1.0135e5 tgas=294.0
  molefrac o2=.21 n2=.79
eoi
eoi
eof
```

A.2 MELCOR Input File

```
**************************************************
*                                                *
*    Subcompartment Problem C1                   *
*                                                *
*                                                *
**************************************************
*
*eor*      melgen
*********************
*********************
***                ***
***  MELGEN INPUT  ***
***                ***
*********************
TITLE     'BASE'
***JOBID      BASE
CRTOUT
OUTPUTF   'BASE.out'
RESTARTF  'BASE.rst'
DIAGF     'BASE.gdia'
TSTART         0.
DTTIME    .1
***
***
* External data file with ME
* file has time, dmdt & dedt
edf00100  s1cv  2  read      * Source
edf00101  s1cv.txt
edf00102  3e12.4
r*i*f .\cont.txt
r*i*f .\mp.txt
r*i*f .\fl.txt
*
SC00000 4406 10.0 1      * max fog density
.   * terminate
*eor* melcor
***********************
***  MELCOR INPUT    ***
***********************
TITLE     'BASE'
***JOBID      ref
*
OUTPUTF   'BASE.out'
PLOTF     'BASE.ptf'
RESTARTF  'BASE.rst'
MESSAGEF  'BASE.mes'
DIAGF     'BASE.dia'
*
CRTOUT
***CYMESF    10 10
*
RESTART             -1
tend  0.25
```

```
***EXACTTIME1         100.
CPULIM              400000.
CPULEFT             400.0
*
*
*       time    dtmax   dtmin   dtedit  dtplot  dtrest
time1     0.0   0.0005  0.0001   10.0     0.001     50.0
time2     0.3   0.0005  0.0001   10.0     0.05     50.0
time3     2.0   0.001   0.0001   10.0     0.02     50.0
time4    200.   0.02    0.0001   10.0     0.1      50.0
*
*
.  * terminate

*********************************
* CVH INPUT                     *
*********************************
* Two Compartment- Wet Steam Injection
*
*
cv00100  Vol1        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv001a0  3
cv001a1  pvol       101350.0     *
cv001a2  tatm       294.0        *
cv001a3  mlfr.4     0.21         *
cv001a4  mlfr.5     0.79         *
cv001a5  rhum       0.0          *
cv001b1  0.0       0.0
cv001b2  10.0      283.1738      *
cv001c1  mass.3   rate  edf.1.1  * The source
cv001c2  energy.a rate  edf.1.2  *
*
cv00200  Vol2        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv002a0  3
cv002a1  pvol       101350.0     *
cv002a2  tatm       294.0        *
cv002a3  mlfr.4     0.21         *
cv002a4  mlfr.5     0.79         *
cv002a5  rhum       0.0         *
cv002b1  0.0      0.0        *
cv002b2  100.0     28317.38
*
*
.                                     * terminator

****************************************************
* FL input                                         *
****************************************************
***
***       Volume 1 to Volume 2
***
fl00100  VENT   1    2     5.0  5.0           * Mid-point of Vol 1
fl00101  38.08992   10.1     1.0    .01  .01  *
fl00102  3  0  0  0                           * Horiz, Active, No SPARC
fl00103  1.5  1.5  0.7   0.7                  * Form Losses (2xCONTAIN)
fl001S1  38.08992   0.001   10.0              * Vent FArea, L, Dh
```

```
***
****************************************************
********END OF INPUT
**********************************************************
.
***   Non-Condensible gases
*****************************************************
***
***   Gas     Material Number
***
NCG000  O2       4
NCG001  N2       5
***
.

s1cv

0.0000E+00,5.8968E+03,8.2277E+09
1.0000E+00,5.8968E+03,8.2277E+09
```

APPENDIX B INPUT FILES FOR CASE 2

B.1 CONTAIN Input File

```
&& Comparison problem C2
&& ********************** CONTROL BLOCK *****************************
control           && to begin specification of global storage
allocation
  ncells=4        && # of cells
  ntitl=2         && # of lines in the title
  ntzone=2        && # of time zones
  nengv=4         && # of engineered vents
eoi
&& ********************** MATERIAL BLOCK ***************************
material       && to initiate material block
compound h2ol h2ov n2 o2
&&
&& ********************** TITLE BLOCK ********************************
title 2
COMPARE Sample Problem (LA NUREG 6488 MS) Standard Problem No. 8

&& ********************** TIME ZONES ********************************
times 100.  0.0
  0.0001   .001  0.08
  0.0001  0.001   0.9
&& ********************** PRINT OPTIONS ****************************
longedt=10         && # of timesteps between longedit
shortedt=20       && # of timesteps between shortedit
&&
prflow
prenacct
flows implicit
&& *****************ENGINEERED VENTS ********************************
engvent
    from 1 to 2
    varea=0.557414 vavl=.365753 type=gas  vcfc=.75 vcontra=0.7 eoi
   from 2 to 3
    varea=9.568933 vavl=6.278751 type=gas  vcfc=.75 vcontra=0.7 eoi
   from 2 to 4
    varea=18.58045 vavl=12.19175 type=gas  vcfc=.75 vcontra=0.7 eoi
   from 1 to 4
    varea=35.95318 vavl=3.735 type=gas  vcfc=.75 vcontra=0.7
eoi
&& ****************** CELL #1  Blowdown Comp. ***********************
cell=1                  && begining of input in cell 1
control  nsoatm=1  nspatm=2
eoi
geometry
 gasvol=283.1738
 cellhist=1 0.0 28.31738 10.0
eoi
atmos=2
  pgas=1.0135e5 tgas=294.0
  molefrac o2=.21 n2=.79
  eoi
```

```
condense
source=1
h2ov=2   iflag=1
t=0.0    1.0
mass= 35788.81 35788.81
enth= 1.3953e6  1.3953e6
eoi
eoi
&& ******************* CELL #2 ***************************************
&&
cell=2
control
eoi
geometry
  gasvol= 87.78388
  cellhist=1  0.0 8.778388  10.
eoi
atmos=2
  pgas=1.0135e5 tgas=294.0
  molefrac o2=.21 n2=.79
eoi
&& ******************* CELL #3  ***************************************
cell=3
control
 eoi
geometry
  gasvol= 50.97129
  cellhist=1  0.0 5.097129  10
eoi
atmos=2
  pgas=1.0135e5 tgas=294.0
  molefrac o2=.21 n2=.79 eoi
&& ******************* CELL #4 ****************************************
cell=4
control
eoi
geometry
  gasvol= 28317.0
  cellhist=1  0.0 283.17  100
eoi
atmos=2
  pgas=1.0135e5 tgas=294.0
  molefrac o2=.21 n2=.79
  eoi
eoi
eof
```

B.2 MELCOR Input File

```
**************************************************
*                                                *
*    Subcompartment Problem C2                   *
*                                                *
**************************************************
*
*eor*      melgen
**********************
***                ***
***  MELGEN INPUT  ***
***                ***
**********************
TITLE     'BASE'
***JOBID      BASE
CRTOUT
OUTPUTF   'BASE.out'
RESTARTF  'BASE.rst'
DIAGF     'BASE.gdia'
TSTART         0.
DTTIME    .1
***
***
* External data file with ME
* file has time, dmdt & dedt
edf00100  s1cv  2  read      * Source
edf00101  s1cv.txt
edf00102  3e12.4
*
r*i*f .\cont.txt
r*i*f .\mp.txt
r*i*f .\fl.txt
*
SC00000 4406 10.0 1      * max fog density
.   * terminate
*eor* melcor
************************
***  MELCOR INPUT    ***
************************
TITLE     'BASE'
***JOBID      ref
*
OUTPUTF   'BASE.out'
PLOTF     'BASE.ptf'
RESTARTF  'BASE.rst'
MESSAGEF  'BASE.mes'
DIAGF     'BASE.dia'
*
CRTOUT
***CYMESF    10 10
*
RESTART            -1
tend  0.9
***EXACTTIME1         100.
```

```
CPULIM             400000.
CPULEFT            400.0
*
*       time    dtmax   dtmin   dtedit  dtplot  dtrest
time1     0.0   0.0005  0.0001   10.0     0.001     50.0
time2     0.3   0.0005  0.0001   10.0     0.05     50.0
time3     2.0   0.001   0.0001   10.0     0.02     50.0
time4    200.   0.02    0.0001   10.0     0.1      50.0
*
*
.  * terminate
*********************************
* CVH INPUT                     *
*********************************
*********************************************************
* Four Compartment- Wet Steam Injection                 *
*********************************************************
*
cv00100  Vol1        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv001a0  3
cv001a1  pvol       101350.0     *
cv001a2  tatm       294.0        *
cv001a3  mlfr.4     0.21         *
cv001a4  mlfr.5     0.79         *
cv001a5  rhum       0.0          *
cv001b1  0.0       0.0
cv001b2  10.0      283.1738      *
cv001c1  mass.3   rate  edf.1.1  * The source
cv001c2  energy.a rate  edf.1.2  *
*
cv00200  Vol2        2  2  1       * Non-Equ Thermo, Vert flow, ctmt
cv002a0  3
cv002a1  pvol       101350.0     *
cv002a2  tatm       294.0        *
cv002a3  mlfr.4     0.21         *
cv002a4  mlfr.5     0.79         *
cv002a5  rhum       0.0          *
cv002b1  0.0      0.0            *
cv002b2  10.0     87.78388
*
cv00300  Vol3        2  2  1       * Non-Equ Thermo, Vert flow, ctmt
cv003a0  3
cv003a1  pvol       101350.0     *
cv003a2  tatm       294.0        *
cv003a3  mlfr.4     0.21         *
cv003a4  mlfr.5     0.79         *
cv003a5  rhum       0.0          *
cv003b1  0.0      0.0            *
cv003b2  10.0     50.97129
*
cv00400  Vol4        2  2  1       * Non-Equ Thermo, Vert flow, ctmt
cv004a0  3
cv004a1  pvol       101350.0     *
cv004a2  tatm       294.0        *
cv004a3  mlfr.4     0.21         *
cv004a4  mlfr.5     0.79         *
```

```
cv004a5  rhum       0.0          *
cv004b1  0.0      0.0            *
cv004b2  10.0     28317.38
.                                      * terminator
*****************************************************
* FL input                                          *
*****************************************************
***
***       Volume 1 to Volume 2
***
fl00100  VENT1   1    2     5.0  5.0          * Mid-point of Vol 1
fl00101  0.557414   1.524    1.0    .01  .01  *
fl00102  3  0  0  0                           * Horiz, Active, No SPARC
fl00103  1.5  1.5  0.7   0.7                  * Form Losses (2xCONTAIN)
fl001S1  0.557414   0.001   10.0              ** Vent FArea, L, Dh
***
***       Volume 2 to Volume 3
***
fl00200  VENT2   2    3     5.0  5.0          * Mid-point of Vol 2
fl00201  9.568933   1.524     1.0    .01  .01 *
fl00202  3  0  0  0                           * Horiz, Active, No SPARC
fl00203  1.5  1.5  0.7   0.7                  * Form Losses (2xCONTAIN)
fl002S1  9.568933   0.001   10.0              ** Vent FArea, L, Dh
***
***       Volume 2 to Volume 4
***
fl00300  VENT3   2    4     5.0  5.0          * Mid-point of Vol 3
fl00301  18.58045   1.524     1.0    .01  .01 *
fl00302  3  0  0  0                           * Horiz, Active, No SPARC
fl00303  1.5  1.5  0.7   0.7                  * Form Losses (2xCONTAIN)
fl003S1  18.58045   0.001   10.0              ** Vent FArea, L, Dh
***       Volume 1 to Volume 4
***
fl00400  VENT4   1    4     5.0  5.0          * Mid-point of Vol 1
fl00401  35.95318  9.626     1.0    .01  .01  *
fl00402  3  0  0  0                           * Horiz, Active, No SPARC
fl00403  1.5  1.5  0.7   0.7                  * Form Losses (2xCONTAIN)
fl004S1  35.95318   0.001   10.0              ** Vent FArea, L, Dh
 .
*****************************************************
********END OF INPUT
******************************************************
******************************************************
***   Non-Condensible gases
******************************************************
***
***   Gas     Material Number
***
NCG000  O2       4
NCG001  N2       5
***
*
.
```

s1cv

```
0.0000E+00,3.5789E+04,4.9935E+10
1.0000E+00,3.5789E+04,4.9935E+10
```

APPENDIX C INPUT FILES FOR CASE 3

C.1 CONTAIN Input File

```
&& Comparison problem C3
&& ********************** CONTROL BLOCK ****************************
&&
control           && to begin specification of global storage
allocation
  ncells=3        && # of cells
  ntitl=1         && # of lines in the title
  ntzone=1        && # of time zones
  nengv=2        && # of engineered vents
eoi
&& ********************** MATERIAL BLOCK
****************************** &&
material       && to initiate material block
compound h2ol h2ov n2 o2
&&
&& ********************** TITLE BLOCK ********************************
&&
title 2
 Ht Exchanger Rm, RWCU LB  Run on CONTAIN 2.0; Break Rm. hum=100%
&&
&& ********************** TIME ZONES *********************************
    times 100.  0.0
  0.001   .01   1.8
&& 0.01   .01   2.0
&& 0.02   .02   5.0
&&
&& ********************** PRINT OPTIONS
*******************************
&&
longedt=1         && # of timesteps between longedit
shortedt=20      && # of timesteps between shortedit
&&
prflow
prenacct
flows implicit
&&
&& *****************ENGINEERED VENTS ********************************
&&
engvent
    from 1 to 2
    varea=3.14 vavl=1.61 type=gas  vcfc=.71 vcontra=0.7 eoi
    from 1 to 3
    varea=1.95 vavl=1.56 type=gas  vcfc=.70 vcontra=0.7 eoi
&&

&& ****************** CELL #1  Blowdown Comp.
************************
cell=1                  && begining of input in cell 1
control  nsoatm=1  nspatm=3
  eoi
geometry
```

```
 gasvol=297.5
 cellhist=1 0.0 29.75 10.0
eoi
atmos=2
  pgas=1.0135e5 tgas=300.0  && Vol 1 COMPARE input
  molefrac o2=.21 n2=.79  satrat=1.0  && hum=100%
eoi
condense
source=1
h2ov=3   iflag=1
t=0.0    1.3   5.0
mass= 663.6   329.5  329.5
enth= 1.093e6  1.093e6  1.093e6
eoi
eoi
&&
&& ****************** CELL #2  MS Tunnel *****************************
&&
cell=2
control
  eoi
geometry
  gasvol= 475.9
  cellhist=1  0.0 47.59  10.
eoi
atmos=2
  pgas=1.0135e5 tgas=300.0
  molefrac o2=.21 n2=.79 satrat=0.5  && hum=50%
eoi
&& ****************** CELL #3  Containment
****************************
&&
cell=3
control
  eoi
geometry
  gasvol= 39660.0
  cellhist=1  0.0 396.6  100.
eoi
atmos=2

  pgas=1.0135e5 tgas=300.0
  molefrac o2=.21 n2=.79 satrat=0.5  && hum=50%
eoi
eoi
eof
```

C.2 MELCOR Input File

```
**************************************************
*                                                *
*    Subcompartment Problem C3                   *
*                                                *
*                                                *
**************************************************
*
*eor*      melgen
**********************
**********************
***                ***
***  MELGEN INPUT  ***
***                ***
**********************
TITLE     'BASE'
***JOBID      BASE
CRTOUT
OUTPUTF   'BASE.out'
RESTARTF  'BASE.rst'
DIAGF     'BASE.gdia'
TSTART        0.
DTTIME    .1
***
***
* External data file with ME
* file has time, dmdt & dedt
edf00100  s1cv  2  read      * Source
edf00101  s1cv.txt
edf00102  3e12.4
*
r*i*f .\cont.txt
r*i*f .\mp.txt
r*i*f .\fl.txt
*
SC00000 4406 10.0 1      * max fog density
.   * terminate
*eor* melcor
************************
***  MELCOR INPUT    ***
************************
TITLE     'BASE'
***JOBID      ref
*
OUTPUTF   'BASE.out'
PLOTF     'BASE.ptf'
RESTARTF  'BASE.rst'
MESSAGEF  'BASE.mes'
DIAGF     'BASE.dia'
*
CRTOUT
***CYMESF    10 10
*
RESTART            -1
```

```
tend  2.0
***EXACTTIME1          100.
CPULIM              400000.
CPULEFT             400.0
*
*       time    dtmax   dtmin   dtedit  dtplot  dtrest
time1     0.0   0.0005  0.0001   10.0     0.001     50.0
time2     0.3   0.0005  0.0001   10.0     0.05     50.0
time3     2.0   0.001   0.0001   10.0     0.02     50.0
time4    200.   0.02    0.0001   10.0     0.1      50.0
*
*
.  * terminate
*********************************
* CVH INPUT                     *
*********************************
********************************************************
* Three Compartment- Wet Steam Injection               *
********************************************************
*
cv00100  Vol1        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv001a0  3
cv001a1  pvol       101350.0     *
cv001a2  tatm       300.0        *
cv001a3  mlfr.4     0.21         *
cv001a4  mlfr.5     0.79         *
cv001a5  rhum       1.0          *
cv001b1  0.0       0.0
cv001b2  10.0      297.5         *
cv001c1  mass.3   rate  edf.1.1  * The source
cv001c2  energy.a rate  edf.1.2  *
*
cv00200  Vol2        2  2  1       * Non-Equ Thermo, Vert flow, ctmt
cv002a0  3
cv002a1  pvol       101350.0     *
cv002a2  tatm       300.0        *
cv002a3  mlfr.4     0.21         *
cv002a4  mlfr.5     0.79         *
cv002a5  rhum       0.5          *
cv002b1  0.0      0.0            *
cv002b2  10.0     475.9
*
cv00300  Vol3        2  2  1       * Non-Equ Thermo, Vert flow, ctmt
cv003a0  3
cv003a1  pvol       101350.0     *
cv003a2  tatm       300.0        *
cv003a3  mlfr.4     0.21         *
cv003a4  mlfr.5     0.79         *
cv003a5  rhum       0.5          *
cv003b1  0.0      0.0            *
cv003b2  100.0    39660.0
*
.                                      * terminator
****************************************************
* FL input                                         *
****************************************************
```

```
***
***       Volume 1 to Volume 2
***
fl00100  VENT1   1    2     5.0  5.0        * Mid-point of Vol 1
fl00101  3.14   1.95    1.0    .01    .01   *
fl00102  3  0  0  0                         * Horiz, Active, No SPARC
fl00103  1.42  1.42  0.7   0.7              * Form Losses (2xCONTAIN)
fl001S1  3.14   0.001   10.0                ** Vent FArea, L, Dh
***
***       Volume 1 to Volume 3
***
fl00200  VENT2   1    3     5.0  5.0        * Mid-point of Vol 2
fl00201  1.95   1.25     1.0    .01    .01  *
fl00202  3  0  0  0                         * Horiz, Active, No SPARC
fl00203  1.4  1.4  0.7   0.7                * Form Losses (2xCONTAIN)
fl002S1  1.95   0.001   10.0                ** Vent FArea, L, Dh
***
***
****************************************************
********END OF INPUT
******************************************************
.
*****************************************************
***   Non-Condensible gases
*****************************************************
***
***   Gas     Material Number
***
NCG000  O2       4
NCG001  N2       5
***
.

s1cv

0.0000E+00,6.6360E+02,7.2531E+08
1.3000E+00,6.6360E+02,7.2531E+08
1.3010E+00,3.2950E+02,3.6014E+08
5.0000E+00,3.2950E+02,3.6014E+08
```

APPENDIX D INPUT FILES FOR CASE 4

D.1 CONTAIN Input File

```
&& Comparison problem C4
&& ********************** CONTROL BLOCK *****************************
&&
control           && to begin specification of global storage
allocation
  ncells=6        && # of cells
  ntitl=1         && # of lines in the title
  ntzone=1        && # of time zones
  nengv=12        && # of engineered vents
eoi
&& ********************** MATERIAL BLOCK ***************************
&&
material       && to initiate material block
compound h2ol h2ov n2 o2
&&
&& ********************** TITLE BLOCK ******************************
&&
title 2
 CONTAIN 6 Volume Sample Problem: Drywell Head Comp. Vena Con. all 0.7
&&
&& ********************** TIME ZONES *******************************
times 100.  0.0
  0.0005   .002   0.18
&& 0.01   .01   2.0
&& 0.02   .02   5.0
&&
&& ********************** PRINT OPTIONS *****************************
&&
longedt=1         && # of timesteps between longedit
shortedt=20      && # of timesteps between shortedit
&&
prflow
prenacct
flows implicit
&&
&& *****************ENGINEERED VENTS *******************************
&&
engvent
    from 1 to 2
    varea=3.49 vavl=1.004 type=gas  vcfc=.61 vcontra=0.7 eoi
     from 1 to 3
    varea=3.49 vavl=0.4688 type=gas  vcfc=.670 vcontra=0.7 eoi
     from 1 to 4
    varea=6.23 vavl=3.718 type=gas  vcfc=.61 vcontra=0.7 eoi
   from 1 to 5
     varea=2.33 vavl=.2645 type=gas  vcfc=.61 vcontra=0.7 eoi
    from 1 to 6
    varea=.203 vavl=.2671 type=gas  vcfc=1.43 vcontra=0.7 eoi
   from 2 to 3
    varea=4.62 vavl=.3907 type=gas  vcfc=.64 vcontra=0.7 eoi
   from 2 to 4
```

```
    varea=16.18 vavl=9.2387 type=gas  vcfc=.58 vcontra=0.7 eoi
    from 2 to 5
    varea=5.81 vavl=.6165 type=gas  vcfc=.59 vcontra=0.7 eoi
   from 3 to 4
    varea=41.54 vavl=24.006 type=gas  vcfc=.58 vcontra=0.7 eoi
    from 3 to 5
    varea=15.12 vavl=1.6029 type=gas  vcfc=.6 vcontra=0.7 eoi
     from 2 to 6
    varea=.203 vavl=.3452 type=gas  vcfc=1.43 vcontra=0.7 eoi
     from 3 to 6
    varea=.405 vavl=.723 type=gas  vcfc=1.43 vcontra=0.7 eoi
&&
&& ****************** CELL #1  Blowdown Comp. 1
**********************
cell=1
control  nsoatm=1  nspatm=2
  eoi
geometry
 gasvol=10.8
 cellhist=1 0.0 10.8 1.0
eoi
atmos=2
  pgas=1.0135e5 tgas=330.0
  molefrac o2=.21 n2=.79  satrat=.50  && hum=50%
eoi
condense
source=1
h2ov=2   iflag=2
t=0.0    0.182
mass= 3073. 3027.
enth= 2.7674e6  2.7688e6
eoi
eoi
&& ****************** CELL #2  Blowdown Comp. 2
**********************
cell=2
control  nsoatm=1  nspatm=2
  eoi
geometry
 gasvol=29.2
 cellhist=1 0.0 29.2 1.0
eoi
atmos=2
  pgas=1.0135e5 tgas=330.0
  molefrac o2=.21 n2=.79  satrat=.50  && hum=50%

eoi
condense
source=1
h2ov=2   iflag=2
t=0.0   0.182
mass= 3073. 3027.
enth= 2.7674e6  2.7688e6
eoi
eoi
&&
```

```
&& ****************** CELL #3
***************************************
&&
cell=3
control
  eoi
geometry
  gasvol= 75.1
  cellhist=1  0.0 75.1  1.
eoi
atmos=2
  pgas=1.0135e5 tgas=330.0
  molefrac o2=.21 n2=.79 satrat=0.5  && hum=50%
eoi
&& ****************** CELL #4  ***************************************
&&
cell=4
control
  eoi
geometry
  gasvol= 6626.8
  cellhist=1  0.0 662.68  10.0
eoi
atmos=2
  pgas=1.0135e5 tgas=330.0
  molefrac o2=.21 n2=.79 satrat=0.5  && hum=50%
eoi
&& ****************** CELL #5  ***************************************
&&
cell=5
control
  eoi
geometry
  gasvol= 290.5
  cellhist=1  0.0 29.05  10.0
eoi
atmos=2
  pgas=1.0135e5 tgas=330.0
  molefrac o2=.21 n2=.79 satrat=0.5  && hum=50%
eoi
&& ****************** CELL #6
***************************************
&&
cell=6
control
  eoi
geometry
  gasvol= 207.6
  cellhist=1  0.0 20.76  10.0
eoi
atmos=2
  pgas=1.0135e5 tgas=330.0
  molefrac o2=.21 n2=.79 satrat=0.5  && hum=50%
eoi
eoi
eof
```

D.2 MELCOR Input File

```
**************************************************
*                                                *
*    Subcompartment Problem C4                   *
*                                                *
*                                                *
**************************************************
*
*eor*      melgen
**********************
**********************
***                ***
***  MELGEN INPUT  ***
***                ***
**********************
TITLE     'BASE'
***JOBID      BASE
CRTOUT
OUTPUTF   'BASE.out'
RESTARTF  'BASE.rst'
DIAGF     'BASE.gdia'
TSTART        0.
DTTIME    .1
***
***
* External data file with ME
* file has time, dmdt & dedt
edf00100  s1cv  2  read      * Source
edf00101  s1cv.txt
edf00102  3e12.4
*
*
************************************
* Active                           *
************************************
*
r*i*f .\cont.txt
r*i*f .\mp.txt
r*i*f .\fl.txt
*
SC00000 4406 10.0 1      * max fog density
.   * terminate
*eor* melcor
************************
***  MELCOR INPUT    ***
************************
TITLE     'BASE'
***JOBID      ref
*
OUTPUTF   'BASE.out'
PLOTF     'BASE.ptf'
RESTARTF  'BASE.rst'
MESSAGEF  'BASE.mes'
DIAGF     'BASE.dia'
```

```
*
CRTOUT
***CYMESF    10 10
*
RESTART            -1
tend  0.18
***EXACTTIME1         100.
CPULIM             400000.
CPULEFT            400.0
*
*
*       time    dtmax   dtmin   dtedit  dtplot  dtrest
time1     0.0   0.0005  0.0001   10.0     0.001     50.0
time2     0.3   0.0005  0.0001   10.0     0.05     50.0
time3     2.0   0.001   0.0001   10.0     0.02     50.0
time4    200.   0.02    0.0001   10.0     0.1      50.0
*
*
.  * terminate
*********************************
* CVH INPUT                     *
*********************************
*
********************************************************
* Six Compartments- Dry Steam Injection               *
********************************************************
*
*
cv00100  Vol1        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv001a0  3
cv001a1  pvol       101350.0     *
cv001a2  tatm       330.0        *
cv001a3  mlfr.4     0.21         *
cv001a4  mlfr.5     0.79         *
cv001a5  rhum       0.5          *
cv001b1  0.0       0.0
cv001b2  1.0      10.8           *
cv001c1  mass.3   rate  edf.1.1  * The source
cv001c2  energy.a rate  edf.1.2  *
*
cv00200  Vol2        2  2  1       * Non-Equ Thermo, Vert flow, ctmt
cv002a0  3
cv002a1  pvol       101350.0     *
cv002a2  tatm       330.0        *
cv002a3  mlfr.4     0.21         *
cv002a4  mlfr.5     0.79         *
cv002a5  rhum       0.5          *
cv002b1  0.0      0.0            *
cv002b2  1.0     29.2
cv002c1  mass.3   rate  edf.1.1  * The 2nd source
cv002c2  energy.a rate  edf.1.2  *
*
cv00300  Vol3        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv003a0  3
cv003a1  pvol       101350.0     *
cv003a2  tatm       330.0        *
```

```
cv003a3  mlfr.4     0.21         *
cv003a4  mlfr.5     0.79         *
cv003a5  rhum       0.5          *
cv003b1  0.0      0.0            *
cv003b2  1.0     75.1
*
cv00400  Vol4        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv004a0  3
cv004a1  pvol       101350.0     *
cv004a2  tatm       330.0        *
cv004a3  mlfr.4     0.21         *
cv004a4  mlfr.5     0.79         *
cv004a5  rhum       0.5          *
cv004b1  0.0      0.0            *
cv004b2  10.0     6626.8
*
cv00500  Vol5        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv005a0  3
cv005a1  pvol       101350.0     *
cv005a2  tatm       330.0        *
cv005a3  mlfr.4     0.21         *
cv005a4  mlfr.5     0.79         *
cv005a5  rhum       0.5          *
cv005b1  0.0      0.0            *
cv005b2  10.0     290.5
*
cv00600  Vol6        2  2  1     * Non-Equ Thermo, Vert flow, ctmt
cv006a0  3
cv006a1  pvol       101350.0     *
cv006a2  tatm       330.0        *
cv006a3  mlfr.4     0.21         *
cv006a4  mlfr.5     0.79         *
cv006a5  rhum       0.5          *
cv006b1  0.0      0.0            *
cv006b2  10.0     207.7
.                                      * terminator
****************************************************
* FL input                                         *
****************************************************
***
***
***      Volume 1 to Volume 2
***
fl00100  VENT1   1    2    0.5  0.5        * Mid-point of Vol 1
fl00101  3.49   3.476    1.0    .01  .01   *
fl00102  3  0  0  0                        * Horiz, Active, No SPARC
fl00103  1.22  1.22  0.7   0.7             * Form Losses (2xCONTAIN)
fl001S1  3.49  0.001   10.0                ** Vent FArea, L, Dh
***
***      Volume 1 to Volume 3
***
fl00200  VENT2   1    3     0.5   0.5      * Mid-point of Vol 2
fl00201  3.49   7.445     1.0    .01  .01  *
fl00202  3  0  0  0                        * Horiz, Active, No SPARC
fl00203  1.34  1.34  0.7   0.7             * Form Losses (2xCONTAIN)
fl002S1  3.49   0.001   10.0               ** Vent FArea, L, Dh
```

```
***
***       Volume 1 to Volume 4
***
fl00300  VENT3   1    4     0.5   0.5      * Mid-point of Vol 3
fl00301  6.23   1.676     1.0    .01   01  *
fl00302  3  0  0  0                        * Horiz, Active, No SPARC
fl00303  1.22  1.22  0.7   0.7             * Form Losses (2xCONTAIN)
fl003S1  6.23   0.001   10.0               * Vent FArea, L, Dh
***
***       Volume 1 to Volume 5
***
fl00400  VENT4   1    5     0.5  0.5       * Mid-point of Vol 1
fl00401  2.33  8.809     1.0    .01  .01   *
fl00402  3  0  0  0                        * Horiz, Active, No SPARC
fl00403  1.22  1.22  0.7   0.7             * Form Losses (2xCONTAIN)
fl004S1  2.33  0.001   10.0                ** Vent FArea, L, Dh
***
***       Volume 1 to Volume 6
***
fl00500  VENT5   1    6    0.5  0.5        * Mid-point of Vol 1
fl00501  0.203   0.76    1.0    .01    .01 *
fl00502  3  0  0  0                        * Horiz, Active, No SPARC
fl00503  2.86   2.86  0.7   0.7            * Form Losses (2xCONTAIN)
fl005S1  0.203   0.001  10.0               * Vent FArea, L, Dh
***
***       Volume 2 to Volume 3
***
fl00600  VENT6   2    3     0.5   0.5      * Mid-point of Vol 2
fl00601  4.62   11.825     1.0    .01  .01 *
fl00602  3  0  0  0                        * Horiz, Active, No SPARC
fl00603  1.28  1.28  0.7   0.7             * Form Losses (2xCONTAIN)
fl006S1  4.62   0.001    10.0              * Vent FArea, L, Dh
***
***       Volume 2 to Volume 4
***
fl00700  VENT7   2    4     0.5   0.5      * Mid-point of Vol 2
fl00701  16.18   1.751     1.0    .01  .01 *
fl00702  3  0  0  0                        * Horiz, Active, No SPARC
fl00703  1.16  1.16  0.7   0.7             * Form Losses (2xCONTAIN)
fl007S1  16.18   0.001   10.0              * Vent FArea, L, Dh
***
***       Volume 2 to Volume 5
***
fl00800  VENT8   2    5     0.5  0.5       * Mid-point of Vol 2
fl00801  5.81  9.424     1.0    .01   .01  *
fl00802  3  0  0  0                        * Horiz, Active, No SPARC
fl00803  1.18  1.18  0.7   0.7             * Form Losses (2xCONTAIN)
fl008S1  5.81  0.001   10.0                ** Vent FArea, L, Dh
***
***       Volume 3 to Volume 4
***
fl00900  VENT9   3    4    0.5  0.5        * Mid-point of Vol 3
fl00901  41.54    1.73    1.0    .01  .01  *
fl00902  3  0  0  0                        * Horiz, Active, No SPARC
fl00903  1.16  1.16  0.7   0.7             * Form Losses (2xCONTAIN)
fl009S1  41.54    0.001  10.0              ** Vent FArea, L, Dh
```

```
***
***       Volume 3 to Volume 5
***
fl01000  VENT10   3    5     0.5   0.5     * Mid-point of Vol 3
fl01001  15.12     9.433   1.0    .01  .01 *
fl01002  3  0  0  0                        * Horiz, Active, No SPARC
fl01003  1.2  1.2  0.7   0.7               * Form Losses (2xCONTAIN)
fl010S1  15.12     0.001   10.0            * Vent FArea, L, Dh
***
***       Volume 2 to Volume 6
***
fl01400  VENT14   2    6    0.5  0.5       * Mid-point of Vol 2
fl01401  0.203   0.588    1.0    .01  .01  *
fl01402  3  0  0  0                        * Horiz, Active, No SPARC
fl01403  2.86   2.86  0.7   0.7            * Form Losses (2xCONTAIN)
fl014S1  0.203   0.001  10.0               * Vent FArea, L, Dh
***
***       Volume 3 to Volume 6
***
fl01500  VENT15   3    6    0.5  0.5       * Mid-point of Vol 3
fl01501  0.405   0.56    1.0    .01    .01 *
fl01502  3  0  0  0                        * Horiz, Active, No SPARC
fl01503  2.86   2.86  0.7   0.7            * Form Losses (2xCONTAIN)
fl015S1  0.405   0.001  10.0               ** Vent FArea, L, Dh
***
*****************************************************
********END OF INPUT
******************************************************
******************************************************
***
***   Non-Condensible gases
******************************************************
***
***   Gas     Material Number
***
NCG000  O2       4
NCG001  N2       5
***
*
.
s1cv

0.0000E+00,3.0730E+03,8.5042E+09
0.1820E+00,3.0270E+03,8.3812E+09
```