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# ABSTRACT

A version of MELCOR 1.8.2, modified for use in International Thermonuclear Experimental Reactor (ITER) Preliminary Safety Report analyses, was validated against recent data from the European Vacuum Impingement Test Apparatus (EVITA) facility located in Cadarache, France. EVITA Test Series 7 was used for this study to verify MELCOR's ability to predict pressures, temperatures, cryoplate ice mass, and vacuum vessel (VV) condensate mass for test conditions in EVITA that included injections of steam, nitrogen, and water in to the EVITA VV after the VV walls had been heated to 165 ºC and the cryoplate had been cooled to -193 ºC. In general, the ability of MELCOR to predict the VV pressure and wall temperatures for the steam only and water only injection tests was very good. Predicted ice layer masses were larger than reported for the EVITA cryoplate, in particular for the steam only injection tests (~40% too high), and the predicted condensate masses were less that measured in EVITA. Both of these discrepancies can be explained by ice porosity. The modified MELCOR 1.8.2 over predicts the EVITA VV pressure for the co-injection tests (e.g., steam plus nitrogen, or water plus nitrogen injections) by almost a factor of two. Based on parametric runs that were made by increasing the predicted cryoplate condensation rate, it is believed that this pressure over prediction is a result of an under predicted cryoplate condensation rate. The details of this study are documented in this report as well as conclusions about the impact this study has regarding the use of this version of MELCOR for consequence analyses for ITER safety reports.

# ACRONYMS

| | |
|---|---|
| CV | Control Volume |
| EC | Enhanced Condensation |
| EVITA | European Vacuum Impingement Test Apparatus |
| FP | Flow Path |
| FR | Flow Rate |
| HS | Heat Structure |
| ICE | Ingress of Coolant Experiment |
| IEA | International Energy Agency |
| INL | Idaho National Laboratory |
| ITER | International Thermonuclear Experimental Reactor |
| IO | International Organization |
| PSR | Preliminary Safety Report |
| VV | Vacuum Vessel |

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# Benchmarking MELCOR 1.8.2 for ITER Against Recent EVITA Results

## 1. INTRODUCTION

The International Thermonuclear Experimental Reactor (ITER) Program has adopted a modified version of the MELCOR 1.8.2 code [Moore, 2007] for assessing the consequence of selected accidents on the ITER device. The results of these accident consequence analyses will be included in the ITER Preliminary Safety Report (PSR). Because this ITER safety document is to be used in the licensing process for the ITER device, this modified version of MELCOR was validated against data from experiments that simulated accident conditions in ITER [Takase, 2001], [Tolpilski, 2001], [Sardain, 2005], [Sardain, 2006]. This report documents the results of a new validation study that benchmarks predictions from this modified MELCOR 1.8.2 code against the most recent data from the European Vacuum Impingement Test Apparatus (EVITA). This report was funded through an ITER Task Agreement for MELCOR Quality Assurance and Safety Analyses [Sauthoff, 2007].

The following section (Section 2) describes the physical layout and operation of the EVITA facility during the most recent test series in EVITA, Test Series 7. Section 3 describes the MELCOR input model developed to simulate the EVITA facility with the MELCOR code. Section 4 presents an overview of the ice formation model of the modified MELCOR 1.8.2 code, which is one of the MELCOR models being validated by this study. Section 5 gives a comparison of the results obtained from MELCOR with ten tests conducted in EVITA. The final section (Section 6) presents conclusions from this benchmarking study.

# 2. EVITA Facility Description

A significant effort has been undertaken worldwide to validate thermal hydraulic codes that are used for the safety assessment of fusion reactors [Takase, 2001], [Tolpilski, 2001], [Sardain, 2005], [Sardain, 2006]. This work is conducted under a task on thermal hydraulic code validation through an International Energy Agency Implementing Agreement on the Environmental, Safety and Economic Aspects of Fusion Power (IEA-ESE/FP). Several programs, related to transient analysis in water-cooled fusion reactors, were run in order to assess the capabilities of these thermal hydraulic codes to treat the physical phenomena governing accident sequences related to water/steam discharge into a vacuum vessel or a cryostat. The phenomena studied were pressurization of a volume at low initial pressure, critical flow, water flashing, pressure relief into an expansion volume, condensation of vapor in a pressure suppression system, formation of ice on a cryogenic structure, and heat transfer between walls and fluid in various thermodynamic conditions. One of these programs was the EVITA facility, operated at Cadarache, France.

The EVITA facility simulates the ingress of coolant into the cryostat, i.e. into a volume at low initial pressure containing surfaces at cryogenic temperatures. A view of this test facility appears in Figure 1. In this figure is a flow schematic of the facility, a photo of various components of the facility showing the EVITA vacuum vessel (VV) interior, and photos of the cryoplate inside of the VV both prior to and during a test in EVITA. During a typical test in EVITA, the VV was evacuated to a very low pressure (~0.1 mBar), the VV walls were heated to the desired test temperature (~165 °C), the cryoplate was cooled by liquid nitrogen flow down to 80 K, and either water (40 bar, 165 °C) or steam (7.5 bar, 165 °C) was injected into the VV for a set period of time. Once the injection time had been achieved, the injection of water or steam was terminated, the VV vented to atmosphere, the condensate drained from the bottom of the vessel (collect and measured), and then the VV was re-closed. After closing the VV, the cryoplate cooling was stopped, the plate allowed to return to room temperature, causing the ice layer on the cryoplate to melt, and the water from the ice layer melt collected and measured. Time-dependent measurements made during the test included:

- VV pressure
- VV atmosphere temperature at three locations
- VV wall temperature at nine locations
- Cryoplate temperatures at ten locations (including one for each plate face quadrant, both left and right surface)
- Injected water or steam flow rate and temperature
- Vaporized liquid nitrogen flow rate (from which plate heating was estimated)
- Liquid nitrogen system temperatures.

Table 1 contains a results summary supplied by [Ayrault, 2005] for some of the recent, successful EVITA tests. This table presents the test identifier, the injected water or steam flow rate, the co-injected flow rate of a non-condensable gas (nitrogen), the temperature conditions for the VV walls, the average power absorbed by the cryoplate during water or steam injection, the mass of water condensate at the bottom of the VV following water or steam injection, the duration of water or steam injection, the mass of ice that accumulates on the cryoplate, and the final pressure inside the VV at the end of injection. In addition to this information, each participant of the IEA Task Agreement received a report that documented the time-dependent measurements [Ayrault, 2005] and the same time-dependent data in Excel spread sheet format.

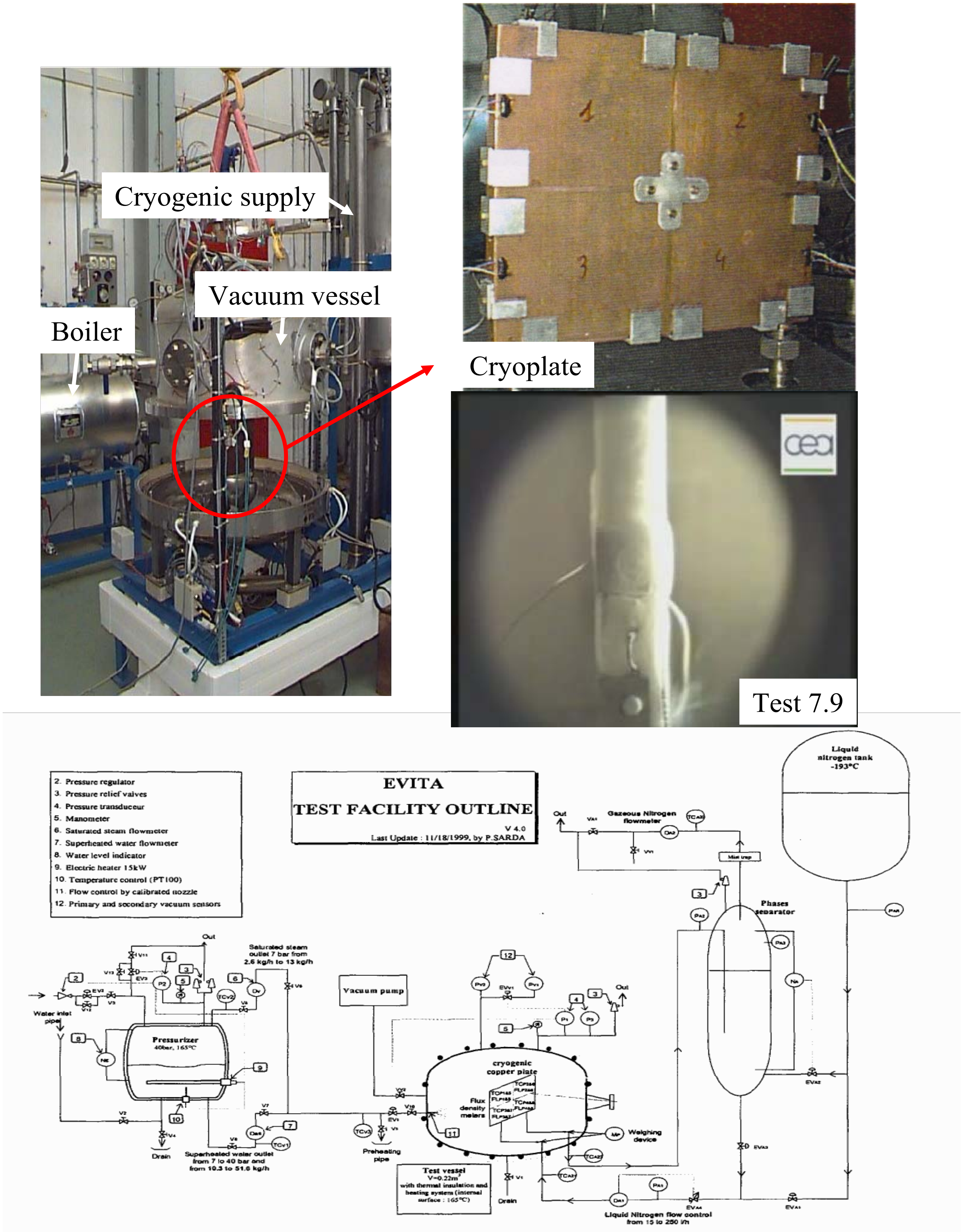



**Figure 1.** Physical layout of EVITA Test Facility.

**Table 1**. Summary results from recent EVITA tests.

| Test | Steam/water FR (g/s) | Non-condensable gas FR (g/s) | VV-walls | $\Delta P_{N2}$ (W) | Condensed water (g) | Duration of test (s) | Ice mass (g) | Final VV-pressure (abs bar) |
|---|---|---|---|---|---|---|---|---|
| **7.1** | Steam / 2.1± 0.018 | 1.540 ± 0.013 | Isothermal | 3896 | 180± 2.9 | 200± 1 | 118± 11 | 1.25± 0.039 |
| **7.2** | Steam / 1.9 ± 0.018 | 1.540 ± 0.013 | Isothermal | 3300 | 33± 2.9 | 120± 1 | 111± 11 | 1.04± 0.039 |
| **7.3** | Steam / 2.04±0.015 | 0 | Isothermal | 4861 | 30 ± 2.9 | 120± 1 | 175± 11 | 0.295± 0.039 |
| **7.4** | Steam / 1.9± 0.015 | 0 | Isothermal | 4045 | 310 ± 2.9 | 300± 1 | 126± 11 | 0.995± 0.039 |
| **7.5** | Water / 2.45 ± 0.011 | 0.340 ± 0.013 | Isothermal | 3480 | 335 ± 2.9 | 300± 1 | 338± 11 | 0.57± 0.039 |
| **7.6** | Water / 2.54 ± 0.011 | 0.340 ± 0.013 | Isothermal | 3877 | 10 ± 2.9 | 80 ± 1 | 136 ± 11 | 0.520 ± 0.039 |
| **7.7** | Water / 2.40± 0.011 | 0 | Isothermal | 3876 | 0 ± 2.9 | 80± 1 | 165 ± 11 | 0.18 ± 0.039 |
| **7.8** | Water / 2.72 ± 0.011 | 0 | Isothermal | 4150 | 440± 2.9 | 300± 1 | 293± 11 | 0.64± 0.039 |
| **7.9** | Steam 2.1± 0.011 | 0 | No VV-heaters during injection | 4493 | 1050 ± 2.9 | 660 ± 1 | 205± 11 | 1.35 ± 0.039 |
| **7.10** | Water / 2.45± 0.011 | 0 | No VV-heaters during injection | 3220 | 1210 ± 2.9 | 720 ± 1 | 420± 11 | 0.63 ± 0.039 |

From [Ayrault, 2005]

# 3. MELCOR Model of EVITA

A modified version of the MELCOR code [Moore, 2007] was benchmarked against the EVITA experimental data described in the previous section. Figure 2 contains a schematic of the MELCOR input model used to calculate EVITA VV coolant flow, pressures and temperatures and VV wall and in-vessel component temperatures for this validation study. For this study, the EVITA VV and boiler were divided into four fluid volumes, connected by six fluid flow paths. Further nodalization of these volumes was not attempted at this time to allow for a fast running simulation of EVITA. It is known from previous validation studies that detailed flow estimates improve the agreement between tests and MELCOR predictions; however, there are not enough fluid velocity and temperature measurements from the EVITA facility to warrant a more detailed fluid flow model at this time. For this study, the injected flow rate for a given test was set to the measured value and was not calculated by MELCOR fluid conservation of momentum equations or flow choking correlations.

Based on previous attempts at modeling the EVITA facility [Sardain, 2005], heat transfer between the injected coolant and the cryoplate and VV walls plays a prominent role in predicting cryoplate ice formation and VV internal pressurization. An attempt at modeling the heat transfer between the liquid nitrogen and the cryoplate was not made in this model because of the added uncertainty that this would introduce into this validation study. Instead, the measured temperatures of the copper cryoplate were used as boundary conditions for the heat structures simulating the cryoplate in this model. Consequently, the cryoplate was simulated by eight heat structures, each location representing a portion of the cryoplate for which temperature measurements were made for the EVITA tests. In addition, the cryoplate coolant supply lines were modeled by four more heat structures to simulate the condensation that may have occurred on these structures.

The VV wall was divided into 10 heat structures, simulating poloidal rings at various axial locations of the bottom head, sidewall, and top head of the vessel. A more detailed segmentation of the vessel would have improved the MELCOR prediction, but it was not warranted because of the low number of VV temperature locations being monitored for these tests. However, the hemispherical bottom head was segmented in an attempt to simulate the heat transfer between any pool that might form at the bottom of the EVITA VV and the steel wall of the VV bottom head. Axial heat conduction between poloidal rings was included through user defined control functions in this model to simulate 2D heat conduction in the bottom head. Both the applied heater power during EVITA tests and the heat transfer between the VV wall and the ambient had to be estimated because the EVITA experimentalist did not record the heater power required to maintain the vessel at temperature. A request was also made to the experimentalists to bring the VV to temperature, and subsequent to achieving initial conditions to turn the heaters off without injecting coolant into the VV. The rate of wall temperature decay would have allowed modelers the opportunity to derive accurate over all heat loss coefficients for the VV to the environment, but the experimentalists did not attempt this test either. Because the EVITA experimenters did not record the heater power or perform a VV cool down test, an estimate to this power and heat loss had to be obtained by adjusting the ambient heat loss coefficient in the model to match the wall temperature trends measured for a test during which the heat power was switched off. This approach assumes that the jet heat transfer inside the vessel is being correctly simulated by MELCOR correlations. The test used to estimate the ambient heat loss was Test 7.10. A copy of the input deck used for Test 7.10 appears in Appendix A. Thermal properties for these cryo-components extend down to cryogenic temperatures for this analysis [SAD05].

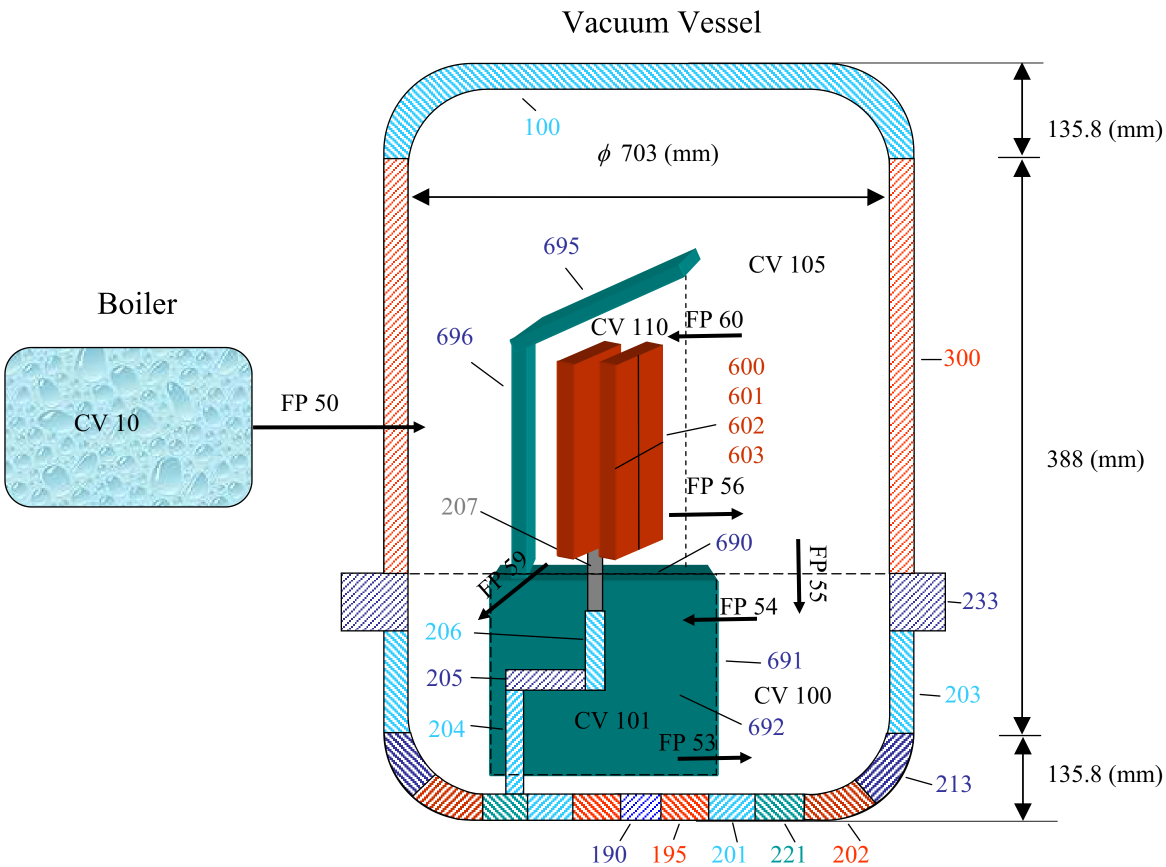



**Figure 2.** Schematic of MELCOR model of the EVITA VV and VV internals, showing control volumes (CV), flow paths (FP), and heat structures (numbers).

# 4. Modified MELCOR 1.8.2 Ice Layer Formation Model

The heat structure model in MELCOR 1.8.2 allows a film mass to develop on a heat structure whose surface remains at or below the dew point temperature (e.g. water saturation temperature associated with the steam partial pressure) given the predicted condensation rate at the surface [Gauntt, 2000]. The film is assumed to be at the same temperature as the heat structure surface. The energy associated with condensing steam and lowering the condensate temperature to that of the film mass on a given surface is conserved by passing this energy on to the heat structure beneath the film as a heat flux. The condensation rate for pure steam atmospheres is a modified Nusselt condensation correlation, which assumes that the limiting rate for condensation is the rate at which a flowing film, due to gravity, can conduct the condensation energy to the underlying surface. This rate is the film thermal conductivity divided by the film thickness as predicted by the Nusselt correlation.

When the atmosphere above the film contains a non-condensable gas, then the rate-limiting step for condensation is no longer the structure's ability to absorb the condensation heat flux but the rate at which steam can diffuse through a boundary layer of non-condensable gas that forms at the film surface. MELCOR employs the analogy between heat and mass transfer to predict this rate of diffusion or mass transfer through the boundary layer to the condensate film. This analogy is based on the fact that heat diffusion and mass diffusion through a surface boundary layer obey the same boundary layer conservation of mass, momentum, and energy equations. As a consequence, boundary layer mass transfer coefficients can be related to boundary layer heat transfer coefficients. The relationship used by MELCOR is the following Sherwood analogy:

$$Sh = Nu\, Sc^{1/3} / Pr^{1/3} \tag{1}$$

where

| | |
|---|---|
| $Nu$ | = Nusselt number (convective heat transfer) |
| Sc | = Schmidt number (diffusive mass transfer) |
| $Pr$ | = Prandtl Number (convective heat transfer) |

Once the Sherwood number has been determined by MELCOR, based on its convective heat transfer package, the mass transfer coefficient, $h_m$ (m/s), is calculated from this Sherwood number as follows:

$$h_m = Sh \frac{D}{L_c} \tag{2}$$

where

| | |
|---|---|
| $D$ | = the binary gaseous diffusion coefficient, $m^2/s$ |
| $L_c$ | = the heat structure characteristic dimension, m |

With this mass transport coefficient, the mass condensation rate, $\Gamma_c$ (kg/m$^2$-s), is evaluated from the following analytical solution for binary gaseous diffusion through the boundary:

$$\Gamma_c = h_m \rho_v \, ln\left(\frac{P - P_{srf}}{P - P_{stm}}\right) \tag{3}$$

where

$\rho_v$ = steam density, kg/m$^3$
$P$ = total pressure (e.g., steam plus non-condensable gas), Pa
$P_{srf}$ = steam saturation pressure at the surface temperature, Pa
$P_{stm}$ =steam partial pressure in the atmosphere above the surface, Pa

The modification to the film model for this version of MELCOR 1.8.2 is in the growth of the film or ice layer, $\delta_{ice}$ (m), once the heat structure surface temperature falls below the triple point temperature, $T_{TP}$ (K), of water [Merrill, 2000]. The growth of an ice layer with a surface temperature of $T_{TP}$ is calculated from the following conservation of energy equation:

$$\rho_{ice} h_{fus} \frac{\partial \delta_{ice}}{\partial t} = q_{cd} - q_{cv} - \Gamma_c \left( h_v - h_l \right) \qquad (4)$$

where

$\rho_{ice}$ = ice density, kg/m$^3$
$h_{fus}$ = heat of fusion for forming ice, J/kg
$q_{cd}$ = ice layer conductive heat flux = $k_{ice}(T_{TP}-T_{srf})/\ \delta_{ice}$, W/m$^2$
$q_{cv}$ = vapor convective heat flux = $h_{conv}(T_{stm}-T_{TP})$, W/m$^2$
$h_v$ = steam enthalpy, and $h_l$ is the liquid water enthalpy at the $T_{TP}$
$k_{ice}$ = ice thermal conductivity, W/m-K
$T_{stm}$ = steam temperature, (K)
$T_{srf}$ =ice surface temperature, (K)
$h_{conv}$ =heat transfer coefficient between the steam and the ice surface W/m$^2$

The maximum growth rate for this ice layer is evaluated from the following conservation of mass equation:

$$\rho_{ice} \left. \frac{\partial \delta_{ice}}{\partial t} \right|_{max} = \Gamma_c \qquad (5)$$

If the predicted growth rate from Equation 4 is less than this maximum growth rate (Eq. 5), the excess condensation flux is assumed to be drainage or runoff from the ice layer surface. If the predicted growth rate from Equation 4 is greater than the maximum growth rate (Eq.5 ), the growth rate is set equal to the maximum growth rate. The purpose for including this discussion in this report is not only to familiarize the reader with some of the models being validated, but to illustrate that in order for this modified version of the MELCOR 1.8.2 code to accurately simulate EVITA experiments, not only does the modeler have to develop a reasonably accurate model of the EVITA VV that accounts for vessel wall heat conduction, as discussed in the previous section, but the code needs to accurately simulate the heat transfer between steam or water and cryogenic or superheated walls, and account for any influence that a non-condensable gas has on steam condensation on cooler structures.

# 5. EVITA Test Comparison to MELCOR Predictions

Only the Series 7 tests were selected for this validation study, primarily because these tests proved to have some degree of reproducibility among the results, which was not present in previous test series. As can be seen from Table 1, Series 7 tests involved the injection of steam or water at 165 ºC into the EVITA VV, where an attempt was made to maintain the VV wall temperature at the same value (e.g., isothermal tests). However, the ability to maintain a uniform VV temperature at 165 ºC was lacking for the EVITA facility. Typically, temperatures ranged from ~125 ºC at the bottom head to ~180 ºC at the top head, with one location on the sidewall at ~165 ºC. In addition, even on the side wall there was a ~30 ºC poloidal temperature variation at the wall locations measured. Besides the isothermal steam or water tests, tests were conducted with the co injection of a non-condensable gas (nitrogen) and with heater power turned off once coolant injection started. These tests plus comparisons with predictions from the modified MELCOR 1.8.2 appear in the following subsections.

## 5.1 EVITA Steam Injection Tests 7.3, 7.4, and 7.9

Figures 3 through 6 contain EVITA data and MELCOR comparisons for EVITA Tests 7.3, 7.4 and 7.9. These EVITA Tests are grouped together for this study because the test conditions for these tests are very similar. For example, the initial temperature conditions are virtually identical for these tests and the injected steam flow rate varies by only ±5%. Aside from switching off heater power for Test 7.9, these tests should reproduce nearly the same EVITA response up to the time at which steam inject stopped. Figure 4a shows how the EVITA VV pressure changed during these tests. The steam injection rate for Test 7.3, 7.4, and 7.9 is 2.04 kg/s, 1.9 kg/s, and 2.1 kg/s, respectively; and the steam and EVITA VV temperatures were as similar as one can expect from EVITA operation. However, it is interesting to note in Figure 3a that the pressurization rate for Test 7.3 is lower than for Test 7.4, which is counter intuitive since the VV pressurization rate should be directly proportional to the magnitude of steam injection rate. The pressurization trend of Test 7.4 makes sense when compared to Test 7.9, because the steam injection and VV pressurization are less than that of Test 7.9 until about 300 s, when the heater power applied in Test 7.4 results in higher pressures in this test compared to Test 7.9.

Figure 3b compares the prediction from the modified version of MELCOR 1.8.2 to the measured pressure histories of Test 7.3, 7.4, and 7.9. The relative trends in the MELCOR predictions make sense as they track with the magnitude of the injected steam flow rate. It can be seen that initially, the pressurization rate is faster in the MELCOR prediction than for EVITA, and that the final pressures for Test 7.4 and 7.9 are lower than those measured for EVITA. The higher initial pressurization rate suggests that the initial condensation rate (on the cryoplate or elsewhere in the VV) is higher in EVITA than what MELCOR predicts. At about 200 s into the Test 7.9 simulation, MELCOR is predicting that the cryoplate ice mass has achieved a thickness that results in the ice surface temperature reaching the triple point temperature at the condensation heat flux predicted by MELCOR (note the discussion in Section 3). At this time, 0 ºC water is dripping from the cryoplate ice layer surface onto the protective lid and bottom head of EVITA. In the MELCOR prediction, either the predicted heat transfer between this ice water and the VV internals is too low or the predicted water temperature is too low. It actuality could be both. Accurately predicting the random formation of water droplets on the cryoplate ice surface and tracking the flow of these droplets as they drip from the cryoplate and find their way to the bottom of the vessel is beyond the capability of existing thermal hydraulic computer codes. In addition, as mentioned in Section 3, the heat structure film temperature in MELCOR 1.8.2 (e.g., ice layer for this analysis) is assumed to be at the surface temperature of the heat structure. Therefore, for MELCOR 1.8.2 to correctly maintain overall conservation of energy, the temperature of water dripping from the cryoplate surface is assumed to be at the same temperature as the cryoplate surface (e.g., -80ºC). The MELCOR code's ability to track condensate flow and to predict film surface temperature has been improved in MELCOR 1.8.5. However even with this problem, the agreement between EVITA data and MELCOR 1.8.2 code prediction is good up to the point of water dripping, and after that point, the resulting deviation is at most only 20% in final pressure.

Figure 4a presents measured VV temperatures during Tests 7.3, 7.4 and 7.9 for comparison. This figure contains data from thermocouples TCE 20 (top head), TCE 25 (sidewall), and TCE 18 (bottom head) reported for these tests (see Figure 7 for thermocouple placement). The effect on wall temperature of switching off the heaters can be seen in the data of TCE 20 and 25 after ~200 s. It appears from this data that the heaters for the top head and sidewall are able to make up the power loss from the EVITA VV wall to the injected steam, which steam should cool during injection due to expansion and heat transfer with the cryoplate. The response of TCE 18 illustrates the difficulty that modeling EVITA poses for any computer code. First, this thermocouple is attached to the bottom head at a location that is situated between and slightly below the elevation of the double walled nitrogen feeder pipes for the cryoplate. Because of TCE 18's proximity to the feeder pipes, this thermocouple could be reporting the lowest temperature of the bottom head. However, this thermocouple was used because it was the only thermocouple on the bottom head for which data was reported that also had the possibility of contacting any water pool forming at the bottom of the EVITA vessel. Second, TCE 18 is situated in the path that water dripping from the cryoplate would take when flowing to the bottom of the vessel by gravity for these particular tests. In this position, TCE 18 could either see an intermittent stream of cold water (plate runoff) that results in thermocouple wetting and subsequent dryout or continued thermal quench due to contact with a water pool forming at the bottom head. Interestingly enough, runoff quenching appears to have happened for Tests 7.3 and 7.9 but not for test 7.4.

Figures 4b, 5a, and 5b show comparisons of MELCOR predicted EVITA VV wall temperatures and measurements from corresponding thermocouples for Test 7.3, 7.4, and 7.9. MELCOR's ability to simulate these temperatures appears reasonable given the uncertainty in EVITA heat losses to the ambient and the sparsity of thermocouple data. MELCOR heat structure 190 is at the very bottom of the vessel and is physically several cm from the actual location of TCE 18. The quenching of this heat structure in MELCOR by runoff will continue until the condensate pool dries by heater power or axial heat conduction. This is not always the case for TCE 18.

Figures 6a and 6b contain comparisons of the reported final values of cryoplate ice layer and bottom head condensate pool masses with the transient values predicted by the modified version MELCOR 1.8.2. The MELCOR predicted ice layer mass is larger than what was measured for Tests 7.4 and 7.7, but agrees with that reported for Test 7.3. In contrast, the predicted condensate mass is less for Tests 7.4 and 7.9 than what was measured by the same amount as the excess predicted for ice layer mass. When these two factors are taken together for Tests 7.4 and 7.9, it suggests that the cryoplate ice porosity for these tests was probably much higher, ~ 40% to 60%, than in the modified MELCOR 1.8.2 prediction, which assumes an ice porosity of zero. In addition, the porosity of the ice layers formed in Test 7.4 and 7.9 was much higher than the porosity of ice layer formed in Test 7.3, which indicates that the ice layer porosity should be nearly zero based on how well this test matched MELCOR predictions, which assumes an ice porosity of zero.

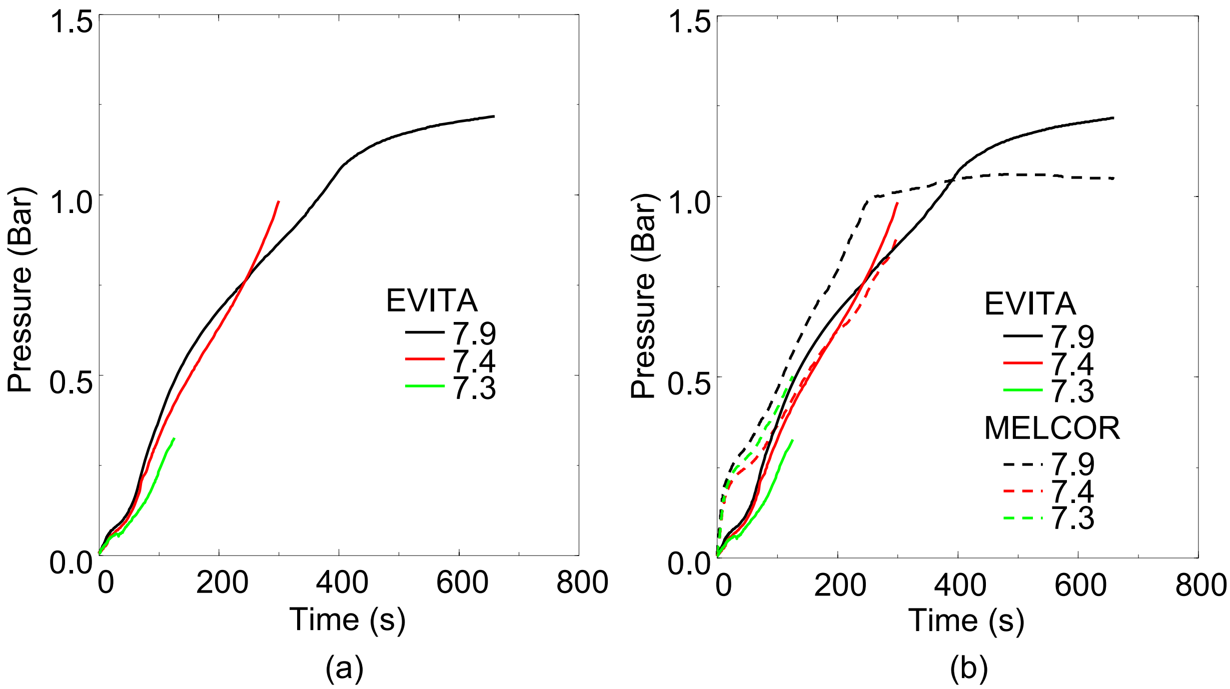



**Figure 3.** EVITA VV pressure, (a) Tests 7.3, 7.4, and 7.9, and (b) Comparison with MELCOR predictions.

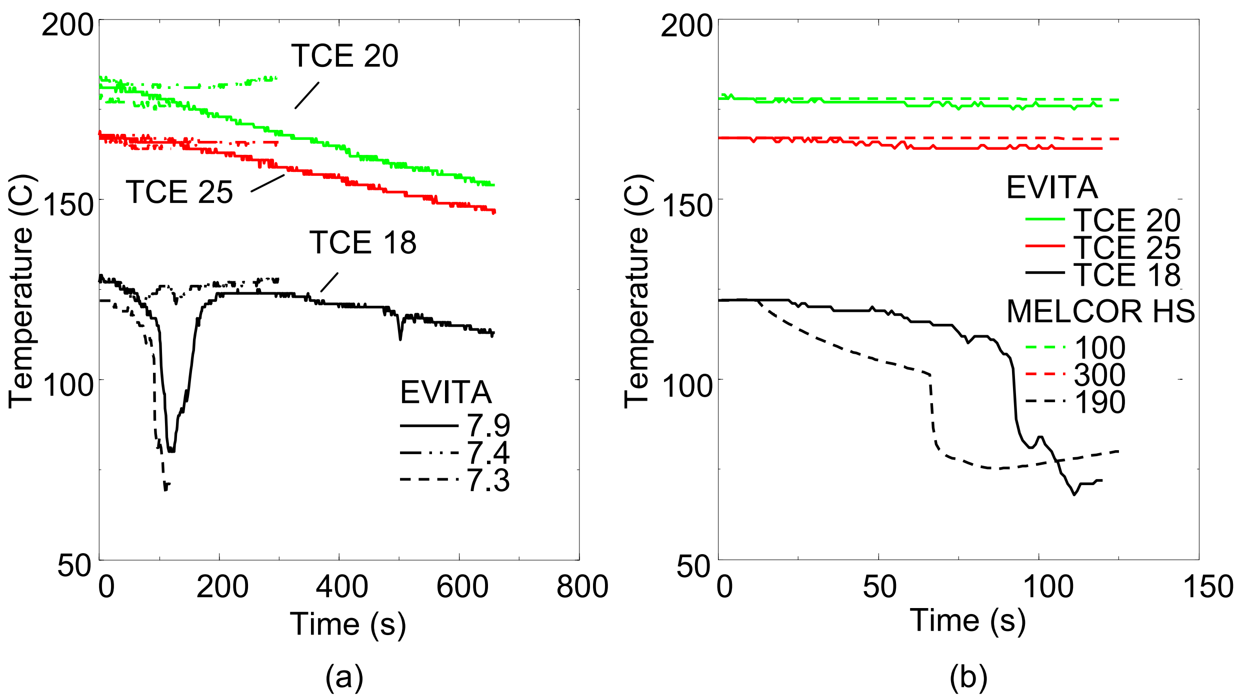



**Figure 4.** EVITA VV wall temperatures, (a) Tests 7.3, 7.4, and 7.9, and (b) Comparison with MELCOR predictions for Test 7.3.

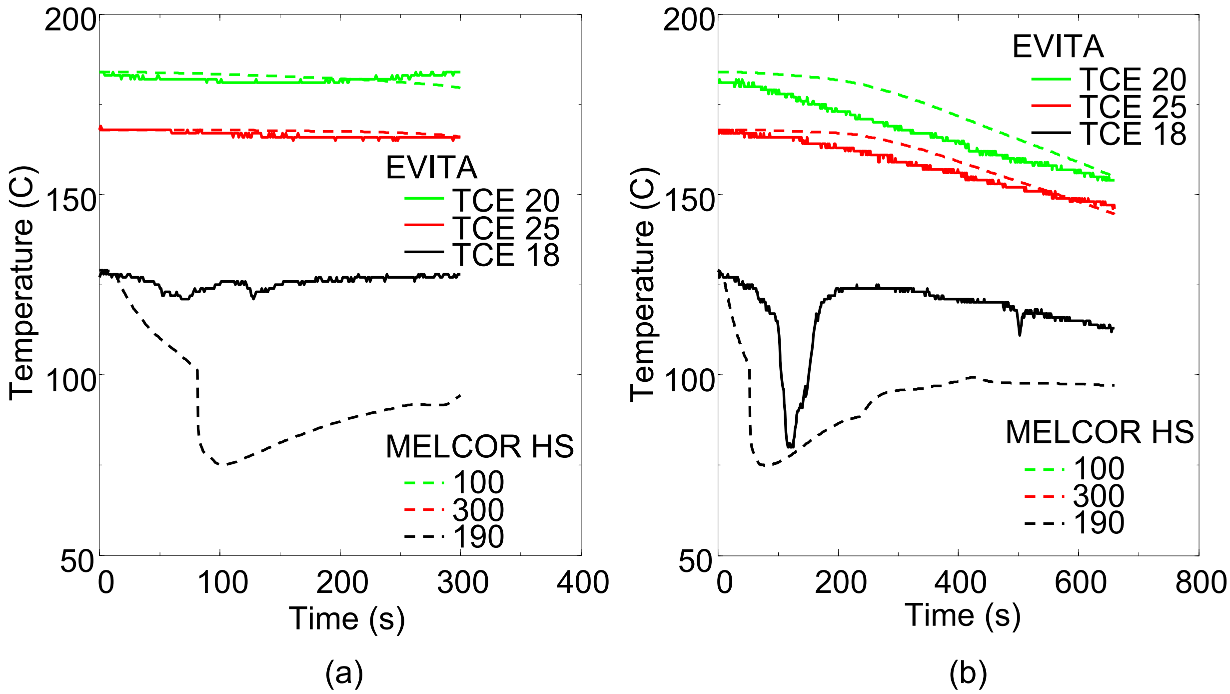



**Figure 5.** EVITA VV wall temperatures, (a) Comparison with MELCOR predictions for Test 7.4, and (b) Comparison with MELCOR predictions for Test 7.9.

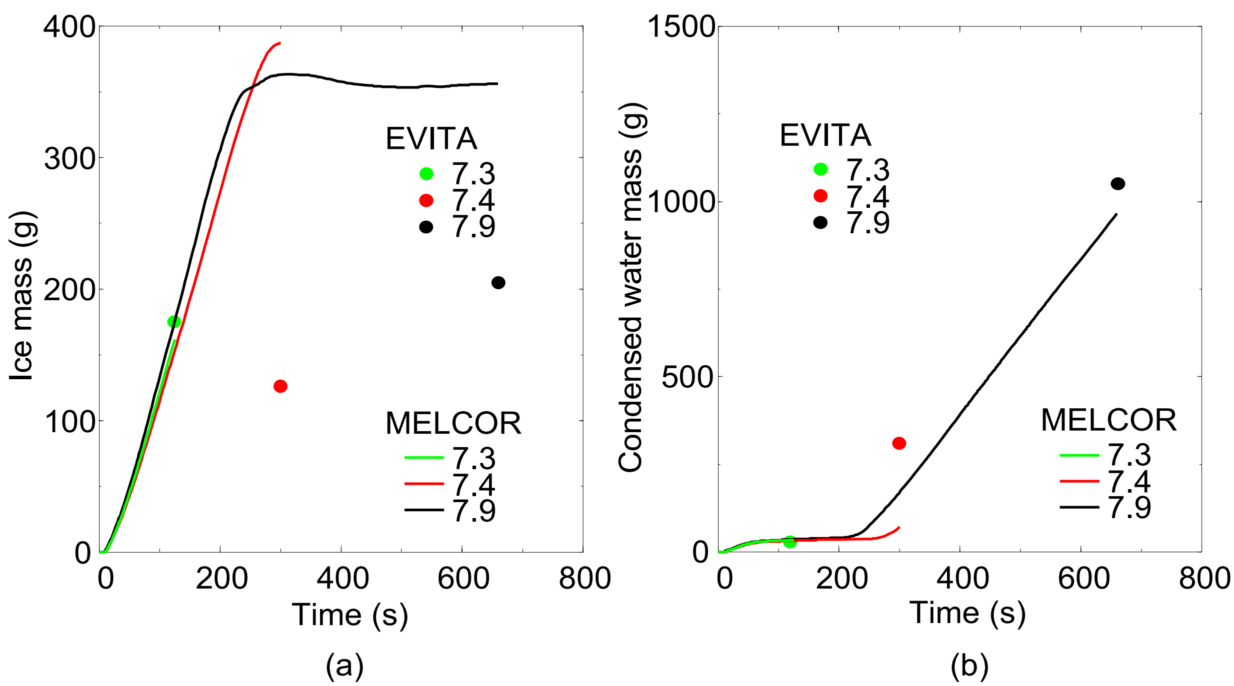
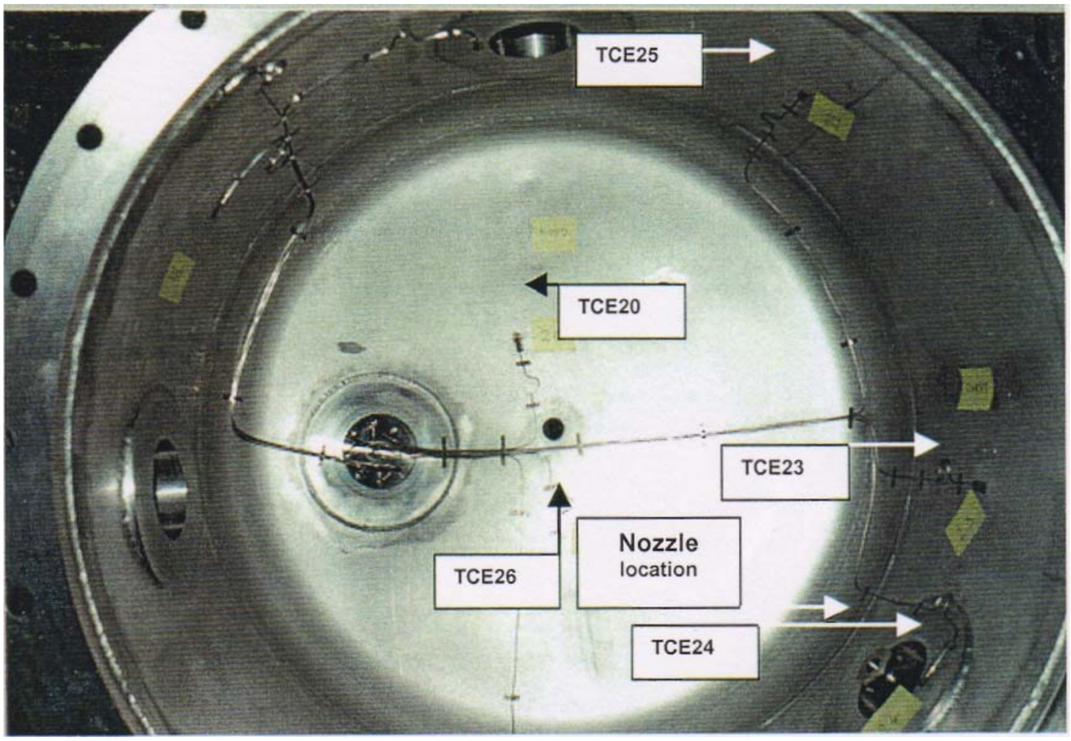
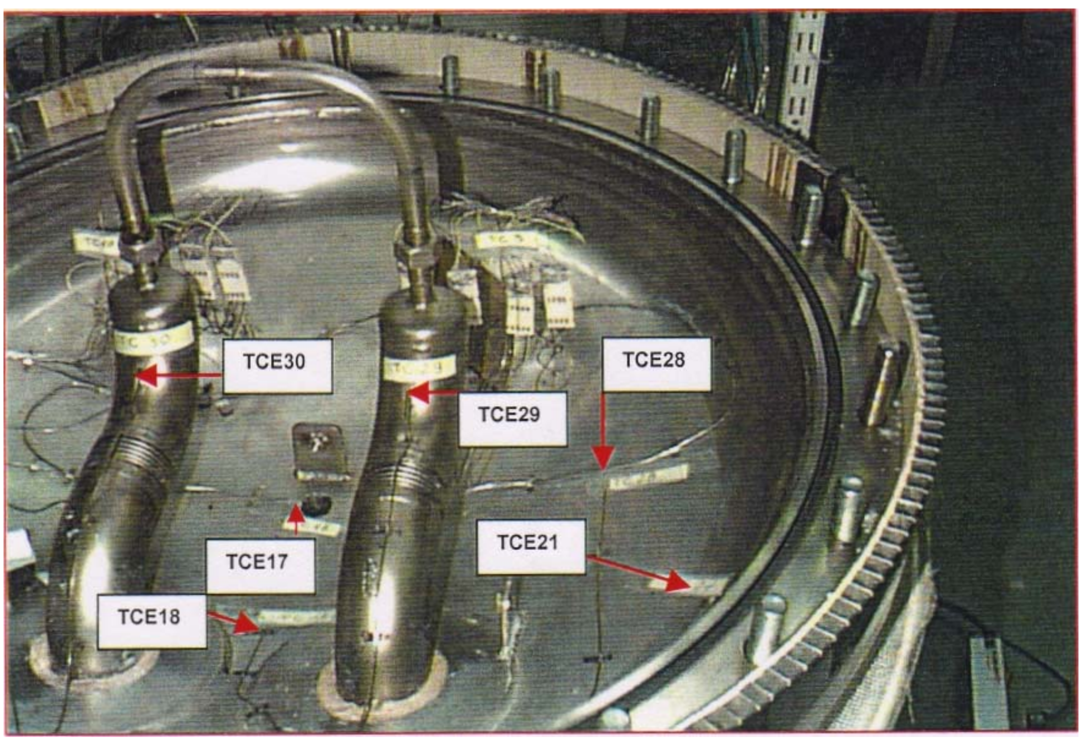



**Figure 6.** Ice and water masses for EVITA Tests 7.3, 7.4, and 7.9, (a) Cryoplate ice mass comparison with MELCOR predictions, and (b) VV condensate mass comparison with MELCOR predictions.




(a)




(b)

**Figure 7.** EVITA VV wall thermocouple placement, (a) top of vessel, and (b) bottom of vessel.

## 5.2 EVITA Water Injection Tests 7.7, 7.8, and 7.10

Figures 8 through 11 contain EVITA data and MELCOR comparisons for EVITA Tests 7.7, 7.8 and 7.10. These EVITA Water Injection Tests have also been grouped together for this study because the test conditions for these tests are also very similar. For example, the initial temperature conditions are virtually identical for these tests and the injected water flow rate for Test 7.7 and 7.10 are nearly identical with Test 7.8 being only 13% higher. Aside from switching of heater power for Test 7.10, these tests should produce nearly the same EVITA response up to the time at which water injection stops. The water injection rates for Test 7.7, 7.8, and 7.10 are 2.4 kg/s, 2.72 kg/s, and 2.45 kg/s, respectively; and the injected water and EVITA VV temperatures are as similar as one can expect based on EVITA operation history.

Figure 8a shows that the VV pressurization rate for these tests is very similar up until ~200 s. Around 200 s, the steam production from injected water flashing or water evaporation from quenching hot (165 ºC surfaces inside of EVITA appears to reach an equilibrium with the steam being lost to cryoplate ice formation and condensate runoff, which runoff drips back into the water pool forming at the bottom of the EVITA VV.

Figure 8b compares the prediction from the modified version of MELCOR 1.8.2 to the measured pressure histories of Test 7.7, 7.8, and 7.10. The relative trends in the MELCOR predictions make sense, as the pressurization rate is nearly the same for the first 100 s. This pressurization rate is not only due to water flashing as it enters the VV, but water contacting hot surfaces within the EVITA VV. Based on prior experience with the Japanese Ingress of Coolant Experiment (ICE) [Takase, 2001], where 150 ºC water was injected into a large evacuated vessel with walls heated to as high as 230 ºC, the injected water jet becomes finely atomized at low vessel pressure and impinges on the vessel walls by either direct jet flow impingement or bulk flow swirling near walls. The impinged droplets undergo rapid boiling on impact with these surfaces, which not only produces enhanced water flashing but improves the wall heat transfer over that for steam flow alone. There is a noted downturn in the predicted VV pressure for Test 7.10 after 300 s, due in part to the cryoplate ice surface runoff temperature being low in the MELCOR prediction as discussed in the previous sub-section. However, the agreement with the test pressures is good, varying by only 12% over the times these tests were conducted.

Figure 9a presents measured VV temperatures during Tests 7.7, 7.8 and 7.10 for comparison. This figure contains data from thermocouples TCE 20 (top head), TCE 25 (sidewall), and TCE 18 (bottom head) reported for these tests (see Figure 7 for thermocouple placement). As was the case for the steam injection tests, the effect on wall temperature of switching off the heaters can be seen in the data of TCE 20 and 25 after ~200 s. As mentioned in the previous sub-section and as can be clearly seen in this figure, TCE 18 experiences either an intermittent stream of cold water (cryoplate runoff) that results in thermocouple wetting and subsequent dryout or a continued thermal quench due to contact with a water pool that forms at the VV bottom head.

Figures 9b, 10a, and 10b present comparisons of MELCOR predicted wall temperatures and measurements from EVITA thermocouples corresponding to these heat structure locations for Test 7.7, 7.8, and 7.10. MELCOR's ability to simulation these temperatures appears excellent given the uncertainty in EVITA heat losses to the ambient and the sparsity of EVITA VV thermocouple data. As mentioned in Section 3, to obtain this match an estimate of the VV heat loss to ambient had to be obtained. This estimate was obtained by adjusting the ambient heat loss coefficient for Test 7.10 (for which the experimenters did switch off the heaters) until a reasonable wall temperature match was obtained, assuming that the jet heat transfer inside the vessel is being correctly simulated by MELCOR correlations (this was the heat loss used for the simulations in this report). However, because MELCOR does not have an atomized jet heat transfer correlation the approach taken to simulate this heat transfer, and to match the thermocouple data of Test

7.10, was to use the following a two-phase heat transfer coefficient, $h_{TP}$ (W/m$^2$-K), based on the MELCOR predicted steam mass fraction ($x$), or quality, in the VV atmosphere:

$$h_{TP} = x h_{stm} + (1 - x) h_{drop} \quad (6)$$

where $h_{stm}$ (W/m$^2$-K) is the steam heat transfer coefficient predicted with the standard MELCOR heat transfer package, and $h_{drop}$ (W/m$^2$-K) is the droplet impingement heat transfer coefficient. The droplet coefficient needed to match EVITA data for Test 7.10 was 1000 W/m$^2$-K. The resulting enhancement in heat transfer ($h_{TP}/h_s$) grew to ~6 by the end of the simulation, which according to the data in Figure 8 of [Hishida, 1980] is within reason for the predicted quality of ~98%.

Figures 11a and 11b contain comparisons of the reported final values of cryoplate ice layer and bottom head condensate masses with the transient values predicted by the modified version of MELCOR 1.8.2. As was the case for the steam injection tests, the predicted ice layer mass is larger than what was measured for Tests 7.8 and 7.10, but not for 7.7. In contrast, the predicted condensate mass is less in Tests 7.7 and 7.10 than measured, by the same amount as the excess predicted for ice layer mass. When these two factors are taken together for Tests 7.8 and 7.10, it suggests that the ice porosity in these tests was probably much higher, ~ 20% to 30%, for these tests than in the modified MELCOR 1.8.2 prediction, which assumes an ice porosity of zero. These porosities are lower than those inferred from the steam injection tests and may suggest that the mist droplets play a role in ice layer formation during water injection tests in EVITA. Based on the results of Test 7.7, the ice layer formed more rapidly on the EVITA cryoplate at low pressures than predicted by MELCOR, and thereby produced the lower initial pressures measured in EVITA than predicted by MELCOR.

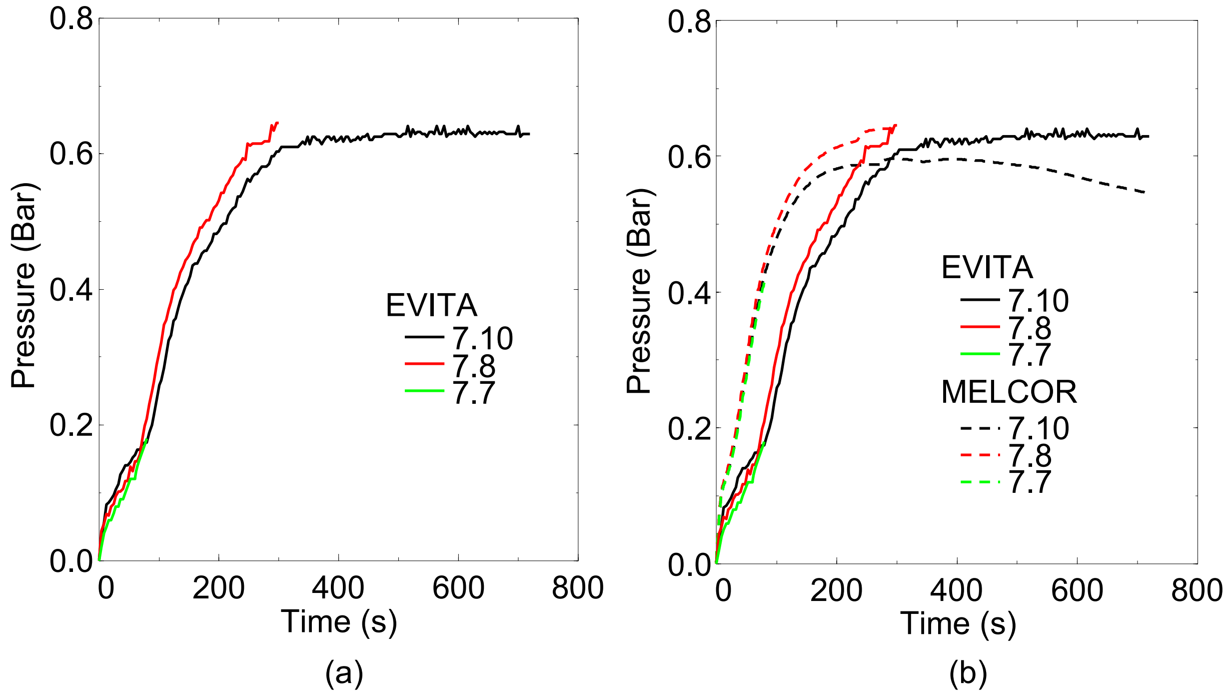



**Figure 8.** EVITA VV pressure, (a) Tests 7.3, 7.4, and 7.9, and (b) Comparison with MELCOR predictions.

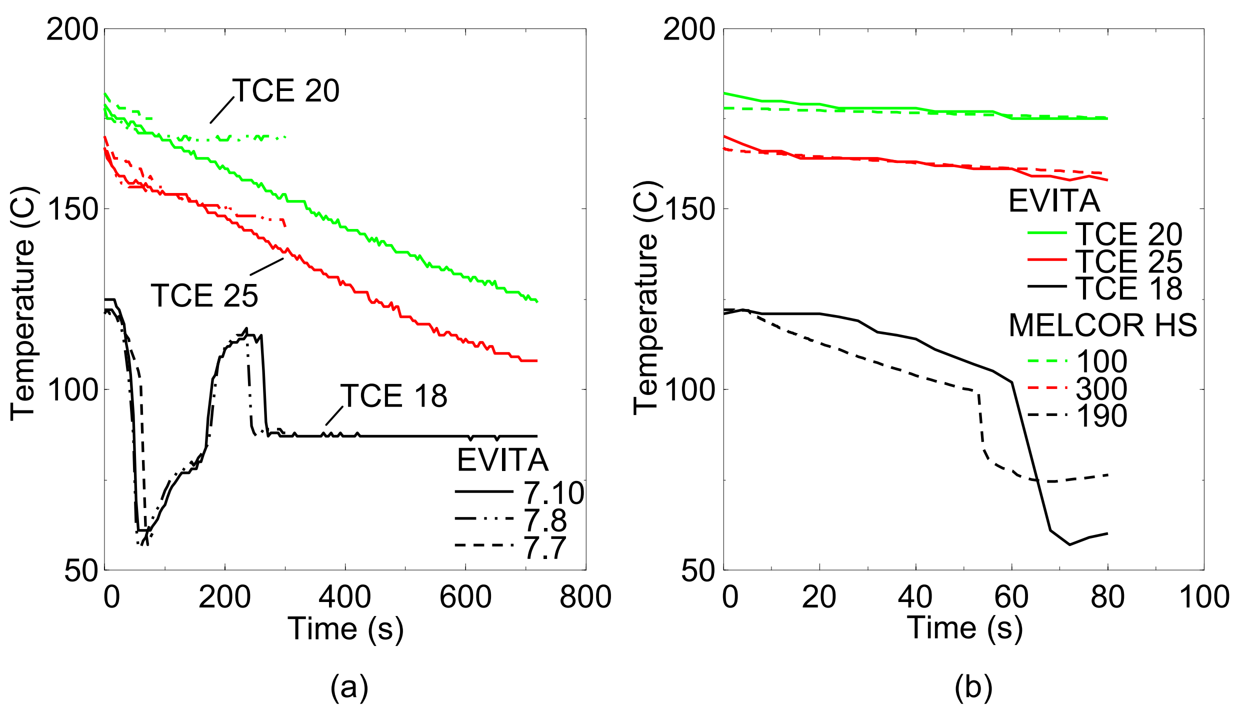



**Figure 9.** EVITA VV wall temperatures, (a) Tests 7.7, 7.8, and 7.10, and (b) Comparison with MELCOR predictions for Test 7.7.

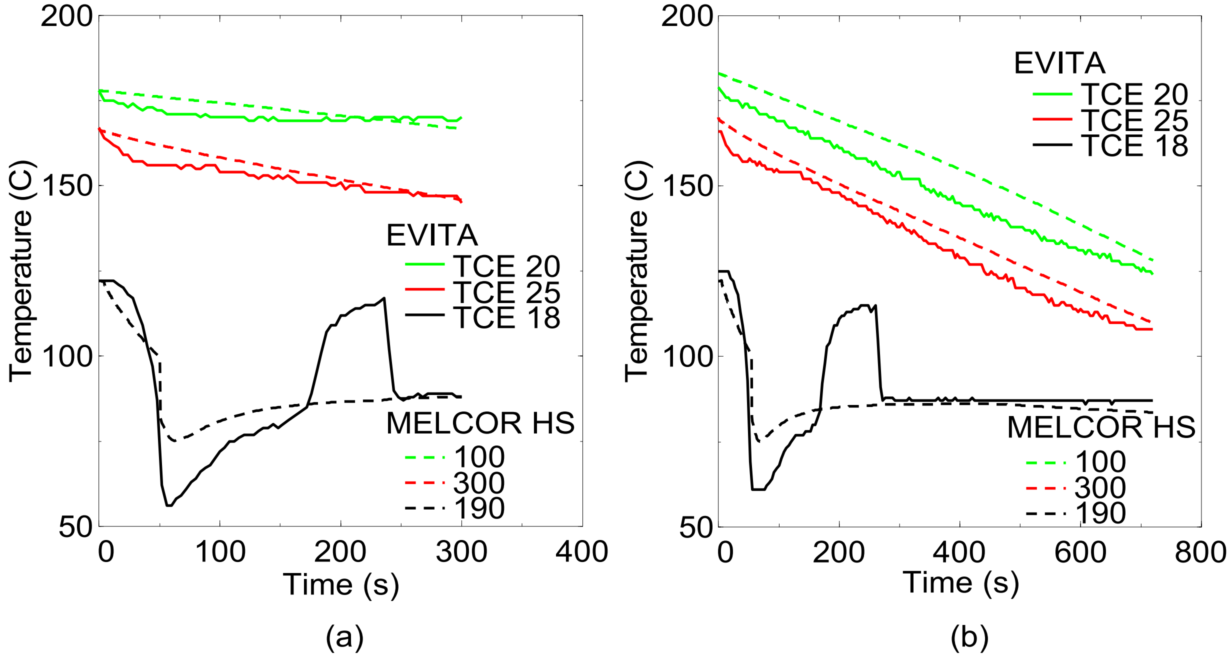



**Figure 10.** EVITA VV wall temperatures, (a) Comparison with MELCOR predictions for Test 7.8, and (b) Comparison with MELCOR predictions for Test 7.10.

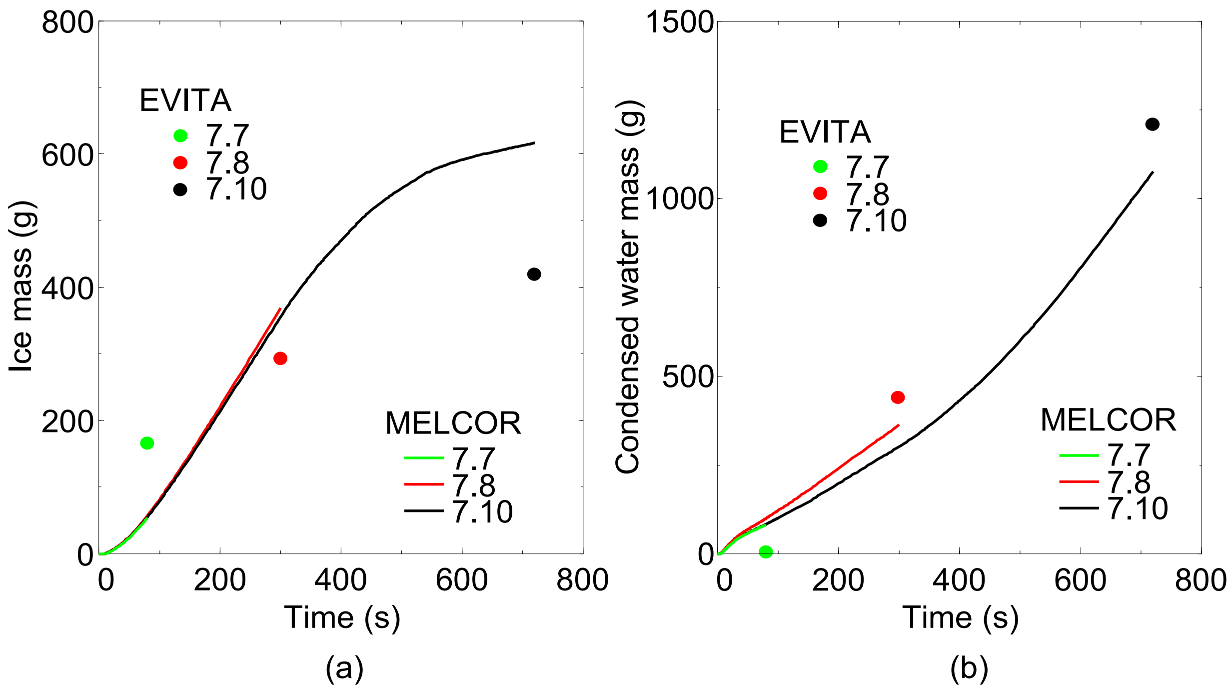



**Figure 11.** Ice and water masses for EVITA Tests 7.7, 7.8, and 7.10, (a) Cryoplate ice mass comparison with MELCOR predictions, and (b) VV condensate mass comparison with MELCOR predictions.

## 5.3 EVITA Steam and Nitrogen Co-injection Tests 7.1 and 7.2

EVITA Tests 7.1 and 7.2 are steam and nitrogen co-injection tests. The objective of these tests is to study the impact of a non-condensable gas on cryoplate ice formation and VV pressurization during steam injection tests in EVITA. In theory, the impact should yield higher VV pressure as a result of two factors: 1) an indirect impact by reducing the cryoplate steam condensation rate (note Section 4) as a consequence of a non-condensable gas layer forming adjacent to the cryoplate, and 2) a direct impact by increasing VV pressure as a consequence of the additional partial pressure produced by the non-condensable gas in the VV atmosphere. If we were to assess the impact by examining the reported data of Table 1, there appears to be an inconsistency in the impact based on reported final pressures. For example, Tests 7.2 and 7.3 have the same steam injection time (120 s) and the same steam injection rate to within 7%. The reported final pressure for the co-injection test (Test 7.2) is ~3.5 times higher than the steam only test (Test 7.3). If the partial pressure of the nitrogen (~0.24 Bar based on the ideal gas law) is subtracted from the reported final pressure of Test 7.2, then the steam partial pressure at 120s for Test 7.2 is 2.7 times higher than for Test 7.3. In contrast, the recorded pressure for Test 7.4 (steam injection test) at 200 s is 0.7 Bar, while that for the Test 7.1 (co-injection test) is 1.25 Bar. If the nitrogen partial pressure is subtracted from Test 7.1, the resulting steam partial pressure is ~1 Bar, which is only ~1.4 times higher than the pressure reported in Test 7.4, or one-half the impact seen between Tests 7.1 and 7.3. Most of the inconsistency can be attributed to the higher condensation rate inferred for the ice layer mass data of Test 7.3. In fact, the ice mass for Tests 7.1, 7.2 and 7.4 are within 15 g and at least 49 g less than the ice mass for Test 7.3. The reason for this inconsistency in EVITA tests is still not known.

Figures 12 through 13 contain EVITA data and pedigreed version of MELCOR 1.8.2 predictions for EVITA Tests 7.1 and 7.2. These tests have virtually identical initial conditions. The steam injection rate varies by only ~10%, at 2.1 g/s for 200 s during Test 7.1 and 1.9 g/s for 120 s during Test 7.2. The nitrogen injection rate was 1.54 g/s for 40 s for both tests. Figure 12a presents the measured EVITA VV pressure during these tests. As expected, the pressurization histories for these two tests are very similar. Figure 12b contains a comparison between the MELCOR predicted pressures for these tests and the reported pressures for these tests. As can be seen, this modified version of MELCOR 1.8.2 over predicts the pressure in Test 7.1 at 200 s by a factor of ~2. The reason for this over prediction will be examined later in this section.

Figure 13a presents measured VV temperatures during Tests 7.1 and 7.2 for comparison. This figure contains data from thermocouples TCE 20 (top head), TCE 25 (sidewall), and TCE 18 (bottom head). As can be seen, the VV wall temperature histories are very similar for these tests and vary over the course of the test by only a few degrees. It is interesting to note that TCE 18 did not experience any significant thermal quenching during these tests, as compared to Tests 7.3 and 7.9 (note Figure 4a). However, the result is close to that obtained for Test 7.4, and may indicate an altered drip or runoff pattern for these tests. Figure 13b shows the agreement between MELCOR predicted temperatures and EVITA data for these thermocouples is excellent.

Figures 14a and 14b compare the reported final values of cryoplate ice layer and bottom head condensate pool masses with the transient values predicted by the modified version MELCOR 1.8.2. The predicted ice layer mass is larger than that measured for Tests 7.1 and less than that measured for Test 7.2. The predicted condensate mass for both tests is nearly zero, with any runoff in the prediction being immediately vaporized on contact with internal VV structures. However, both EVITA tests measured condensate at the bottom of the vessel, with 33 g and 180 g for Tests 7.2 and 7.1, respectively.

When the predicted ice layer and condensate masses are taken together with the predicted over pressure for these tests, they suggest that the modified MELCOR 1.8.2 predicted cryoplate condensation rates for these tests that were too low. To investigate this possibility, user sensitivity coefficient C4201(1) was adjusted by trial and error to achieve a reasonable match between MELCOR predictions and measured VV pressures. This sensitivity coefficient is a multiplier on the Sherwood correlation (note Equation 1), which will directly increase the predicted mass transport coefficient of the MELCOR condensation model and can be changed by user input. At a value of 4 for C2401(1), the pressure match shown in Figure 15a was achieved for Test 7.1 (note curve labeled MELCOR 7.1 EC for enhanced condensation). It is interesting to note that the increase in condensation mass flux predicted for this EC case was a factor of ~2 larger than the case without condensation enhancement, and that the resulting cryoplate condensation mass flux was nearly the same as that predicted for a steam only injection test, such as EVITA test 7.4. This suggests that the injected non-condensable gas had very little impact on the actual cryoplate condensation rate in EVITA.

Figure 15b shows that by adjusting this sensitivity coefficient, the predicted VV wall temperature did not change significantly, except for the heat structure representing the lowest part of the EVITA lower head, which experience quenching from cryoplate runoff. Again, TCE 18 did not quench during these tests even though a significant condensate mass was measured for Test 7.1, which is likely due to the fact that TCE 18 is not located at the lowest point in the VV. Figures 16a and 16b contain predicated cryoplate ice and VV condensate masses for this EC case.

Figure 15 illustrate that a pressure match could be obtained by increasing the predicted cryoplate condensation rate. However, Figure 16 shows that the predicted condensation rate was not high enough to produce any significant ice layer melting or condensate pool formation by the ice surface runoff. As suggested in Section 5.1 of this report, the EVITA cryoplate ice layer has an inferred porosity of ~40% for steam only tests. To investigate the impact ice porosity has on the modified MELCOR 1.8.2 code's predictions, an experimental version (EV) of the pedigreed MELCOR 1.8.2 code was developed that has an ice layer porosity of 40%. Figures 17 and 18 contain the resulting prediction from this experimental version (curve labeled MELCOR 7.1 EC EV). As can be seen, the agreement is excellent.

While it can be argued that the jet like flow inside the EVITA VV does not allow a stable or effective non-condensable boundary layer to develop adjacent to the EVITA cryoplate and that the ice layers that form on cryogenic surfaces typically produce internal voids [Na, 2004], it may be too preliminary to suggest that this is what has happened in these EVITA tests. Based on video recordings of the ice layer during steam only tests, it appears that the cryoplate ice layer is opaque (note Figure 1), confirming the possibility of a porous ice layer. However, the actual 3D velocity distribution in EVITA is unknown at this time so it is not possible to confirm an unstable non-condensable boundary adjacent to the EVITA cryoplate.

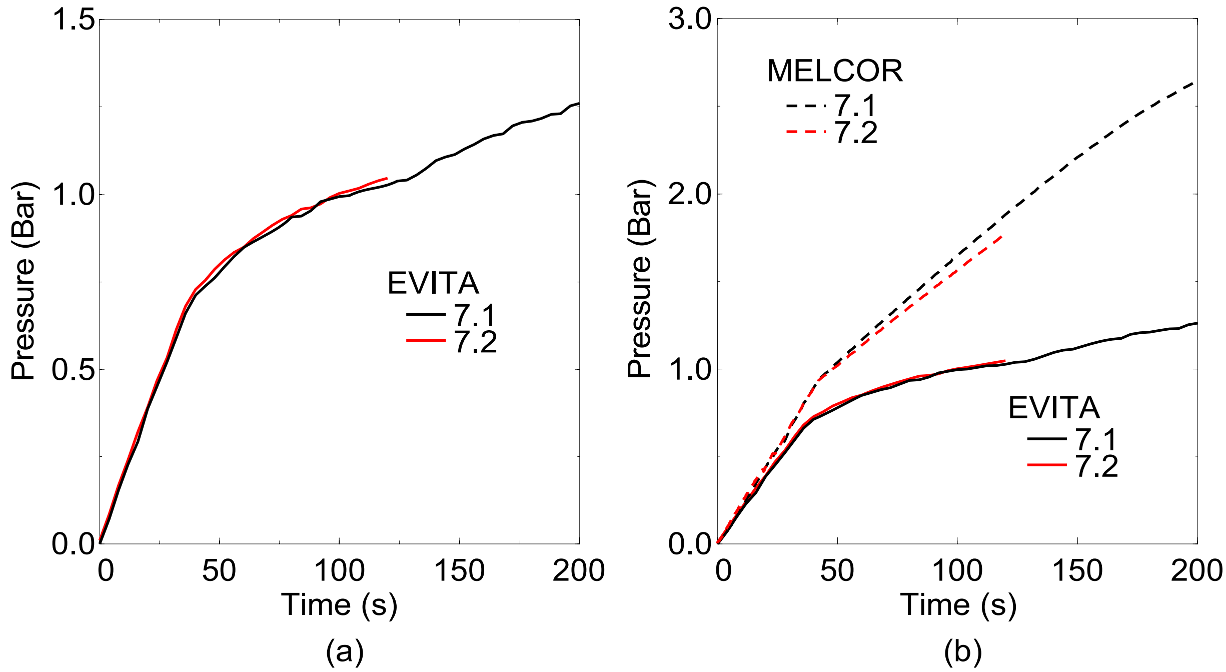



**Figure 12.** EVITA VV pressure, (a) Tests 7.1 and 7.2, and (b) Comparison with MELCOR predictions.

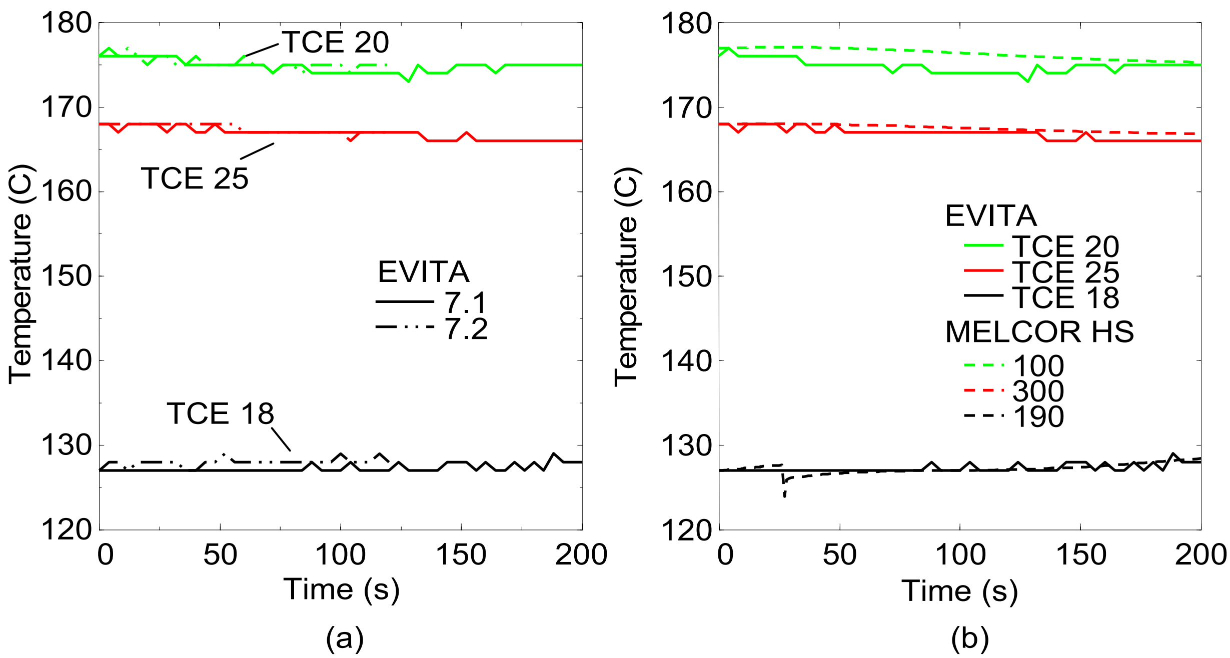



**Figure 13.** EVITA VV wall temperatures, (a) Tests 7.1 and 7.2, and (b) Comparison with MELCOR predictions for Test 7.1.

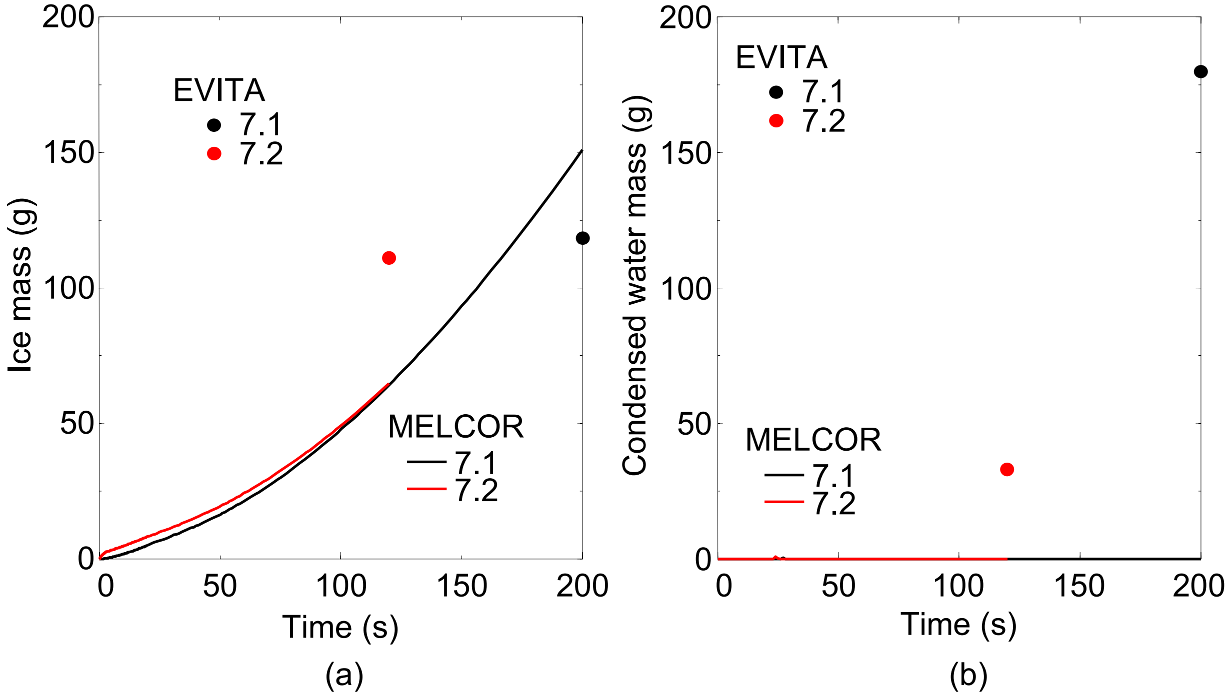



**Figure 14.** EVITA Tests 7.1 and 7.2 comparisons, (a) Cryoplate ice mass comparison with MELCOR predictions, and (b) VV condensate mass comparison with MELCOR predictions.

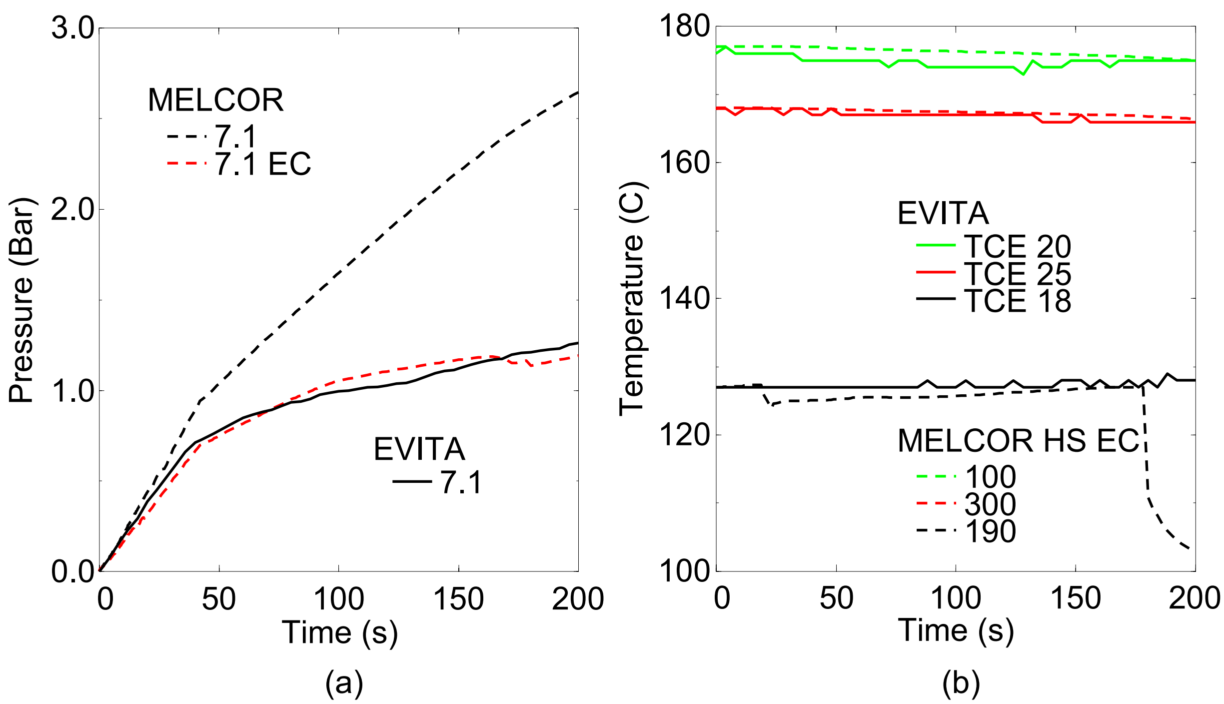



**Figure 15.** EVITA Test 7.1 comparisons, (a) VV pressure with MELCOR and MELCOR with enhanced condensation (EC) predictions, and (b) VV wall temperature with MELCOR with EC predictions.

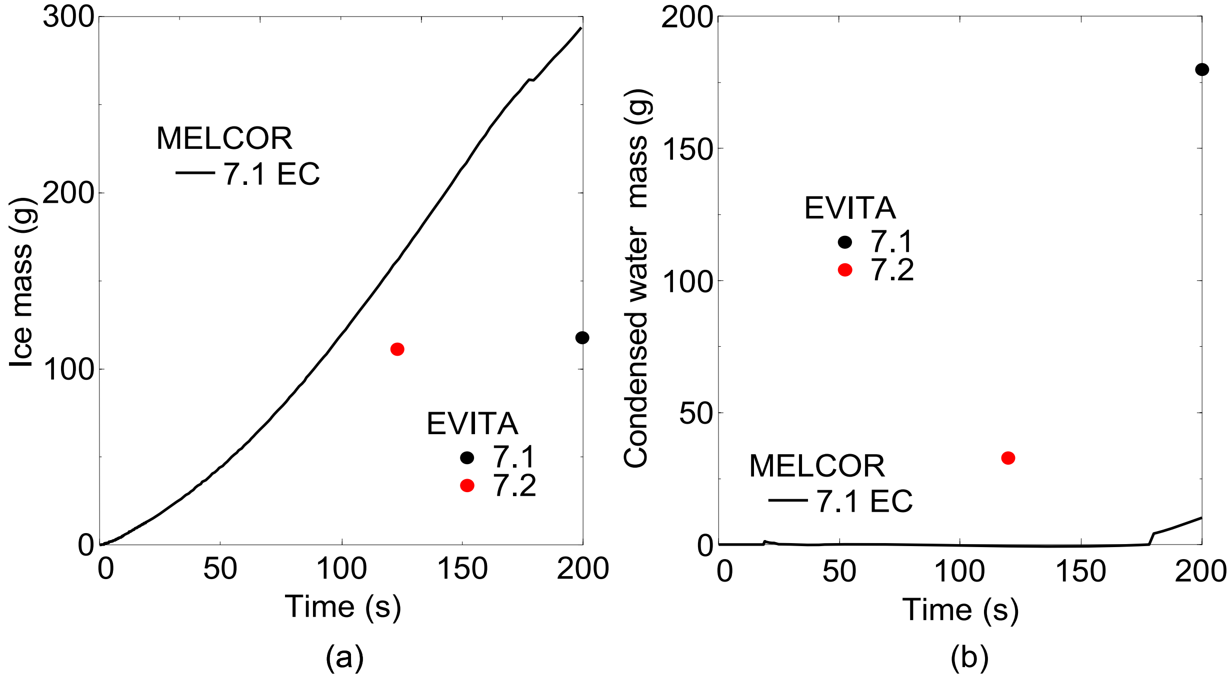



**Figure 16.** EVITA Tests 7.1 and 7.2 comparison, (a) Cryoplate ice mass comparison with MELCOR predictions with EC, and (b) VV condensate mass comparison with MELCOR predictions with EC.

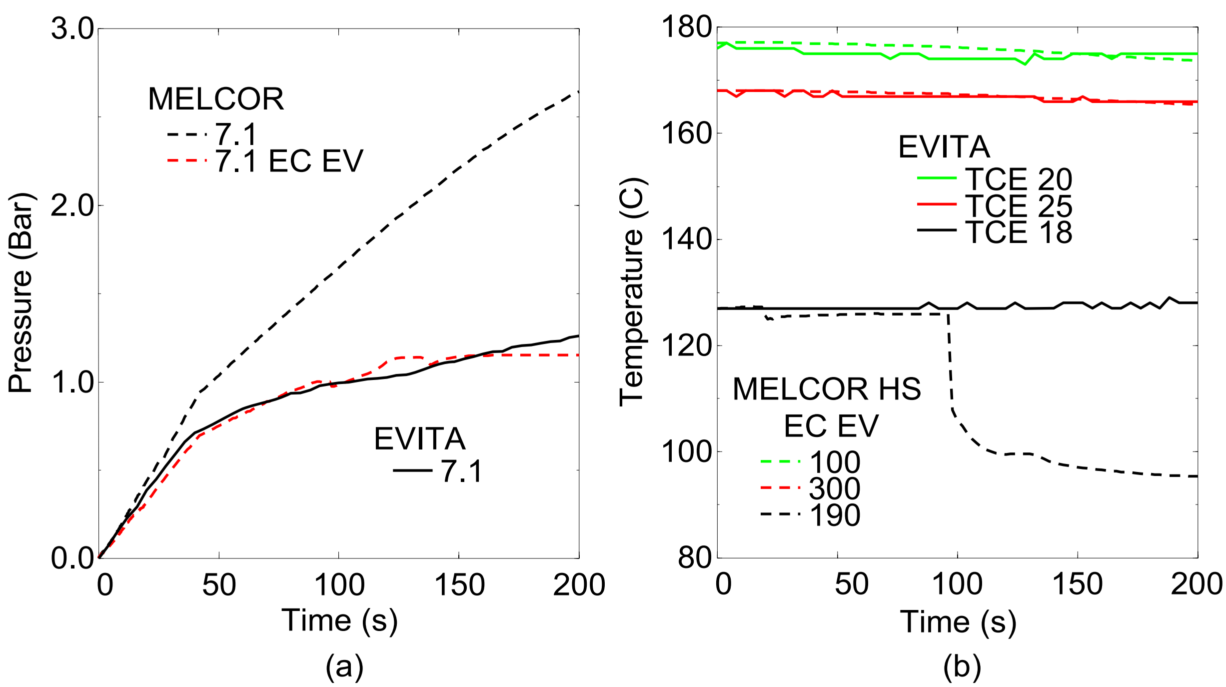



**Figure 17.** EVITA Test 7.1 comparisons, (a) VV pressure with MELCOR and experimental version (EV) of MELCOR with (EC) predictions, and (b) VV wall temperature with EV of MELCOR with EC predictions.

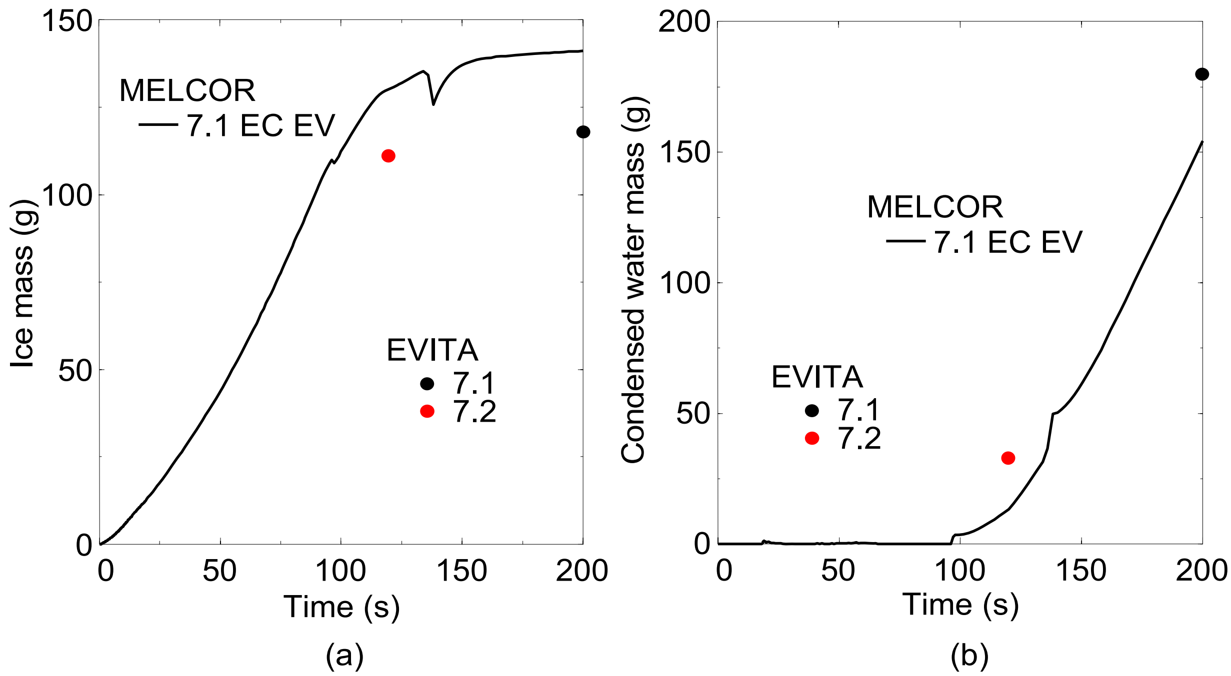



**Figure 18.** EVITA Tests 7.1 and 7.2 comparison, (a) Cryoplate ice mass comparison with EV of MELCOR predictions with EC, and (b) VV condensate mass comparison with EV of MELCOR predictions with EC.

## 5.4 EVITA Water and Nitrogen Co-injection Tests 7.5 and 7.6

EVITA Tests 7.5 and 7.6 are water and nitrogen co-injection tests. The objective of these tests is to study the impact of a non-condensable gas on cryoplate ice formation and VV pressurization during water injection tests in EVITA. In theory, the impact should yield higher VV pressure as a result of two factors: 1) an indirect impact by reducing the cryoplate steam condensation rate (note Section 4) as a consequence of a non-condensable gas layer forming adjacent to the cryoplate, and 2) a direct impact by increasing VV pressure as a consequence of the additional partial pressure produced by the non-condensable gas in the VV atmosphere.

Figures 19 and 20 contain EVITA data and predictions from the pedigreed version of MELCOR 1.8.2 for EVITA Tests 7.5 and 7.6. The initial conditions for this test are similar to the Series 7 tests already discussed in previous sections. The water injection rate is 2.45 g/s for 300 s and 2.54 g/s for 80 s for Test 7.5 and 7.6, respectively, and the nitrogen injection rate for both tests is 0.34 g/s for 40 s. Figure 19a presents the measured EVITA VV pressure during these tests, plus predictions for the modified version of MELCOR 1.8.2. As was the case for the steam and nitrogen co-injection tests in the previous section, MELCOR over predicts the VV pressure for these tests because the standard condensation model under predicts the cryoplate condensation rate. Included in Figure 19a is a MELCOR prediction for Test 7.5 with EC. Pressure agreement was achieved by adjusting SC C4201(1) to a value of 2.5. At this condensation enhancement, the predicted condensation rate for the cryoplate in Test 7.5 (a co-injection test) was very similar to that predicted for water only injection test, Test 7.8 (within 10%). The measured pressure history for Test 7.8 (a water only injection test) has been included in Figure 19a for comparison. Surprisingly, the ratio in final pressure between Test 7.8 and Test 7.5 (= 1.12) is nearly identical to the water injection rate ratio (= 1.11) for these tests, even with the added partial pressure of the non-condensable gas (=0.05 Bar) for Test 7.5. This would suggest that to within the accuracy of the tests conducted in EVITA, the 13.6 g of nitrogen injected in Test 7.5 had little to no affect. It is also notable that the pressure results, EVITA data or MELCOR predictions, for Test 7.5 (first 80 s) and Test 7.6 are the nearly the same.

Figures 20a and 20b compare the reported final values of cryoplate ice layer and bottom head condensate pool masses with the transient values predicted by the modified version MELCOR 1.8.2 with EC. The predicted ice layer mass is larger than that measured for Tests 7.5 by 35 g and the condensate mass is 43 g less than that measured for Test 7.5, which is excellent agreement. This result also suggests that the ice formed on the cryoplate in Test 7.5 had a very low porosity (~10%). It also appears from comparing MELCOR predictions for Test 7.6 that the cryoplate steam condensation and water flashing/wall evaporation rates were higher in Test 7.6 than predicted by MELCOR. However, the over predicted condensate mass is nearly equal to the under predicted ice mass for this test.

As mentioned in the previous section, the reason for the under prediction in the condensation rate for these co-injection tests is not known. It could be due to the jet like flow inside the EVITA VV preventing the formation of a stable or an effective non-condensable boundary layer adjacent to the EVITA cryoplate. However, it is too preliminary to suggest that this is what has happened in this EVITA test. It is interesting to note that the video recording of the cryoplate for Test 7.5 showed visible steam (a mist) near the plate that visually indicates a downward flow condition near the plate, which would be expected from natural convection arguments, but this flow pattern was sporadic and even appears to be upward at times.

Why an enhancement of 2.5 was needed for MELCOR to agree with measurements from these water/nitrogen co-injection tests when an enhancement of 4.0 was required for the steam/nitrogen co-injection tests is an unresolved issue at this time. However, whether the tests were water or steam injection tests the injected coolant mass flow rate was nearly the same. Because the injected steam produces the impetus for the EVITA VV gaseous flow patterns and because not all of the injected water will flash to steam during a water injection test, it is conceivable that the steam injection tests produce a more turbulent flow pattern near the cryoplate. A higher turbulence near the cryoplate would produce a less stable non-condensable gas boundary layer next to the cryoplate and consequently require a larger MELCOR condensation enhancement factor to match the data. In addition, the nitrogen mass injected in the water co-injection tests was only 1/5$^{th}$ that injected during the steam co-injection tests. If the EVITA cryoplate steam condensation rate was approximately the same for both types of co-injection tests, due to turbulence, then as the injected nitrogen mass increases the MELCOR predict condensation rate would deviate more from the actual condensation rate (note Eq. 3), also requiring a greater enhancement to match the data.

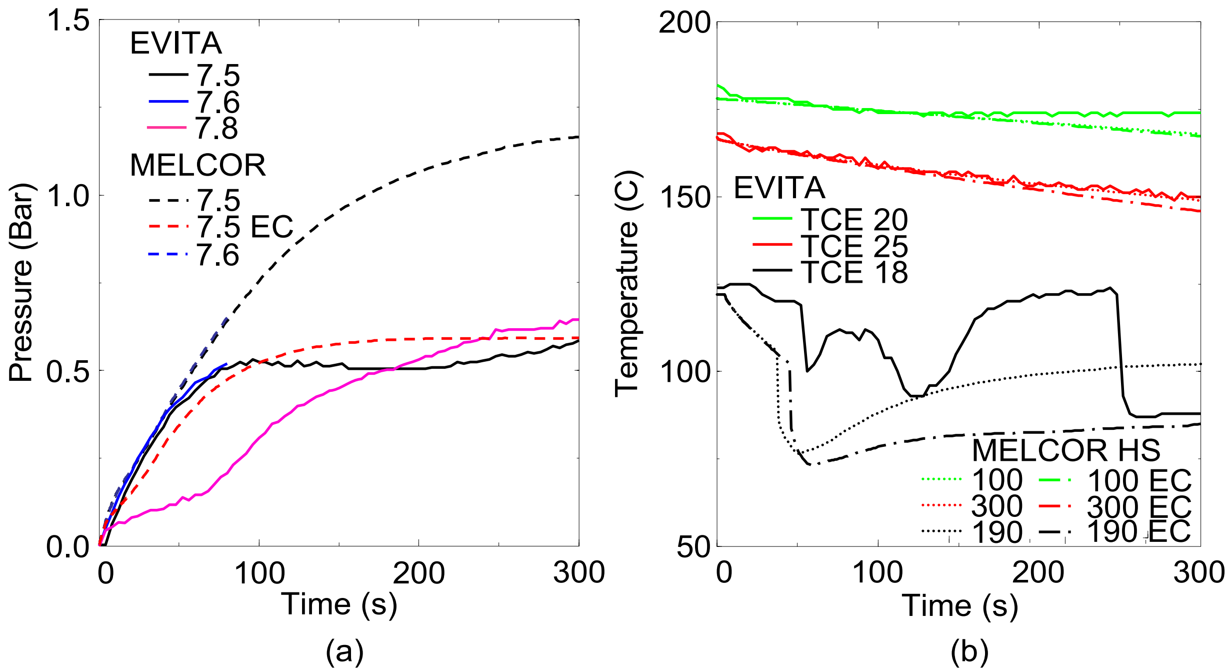



**Figure 19.** EVITA VV pressure and temperatures, (a) Tests 7.5, 7.6 and 7.8, MELCOR 7.5 and MELCOR 7.5 EC pressures, and (b) Test 7.5 VV wall and MELCOR and MELCOR EC heat structure temperatures.

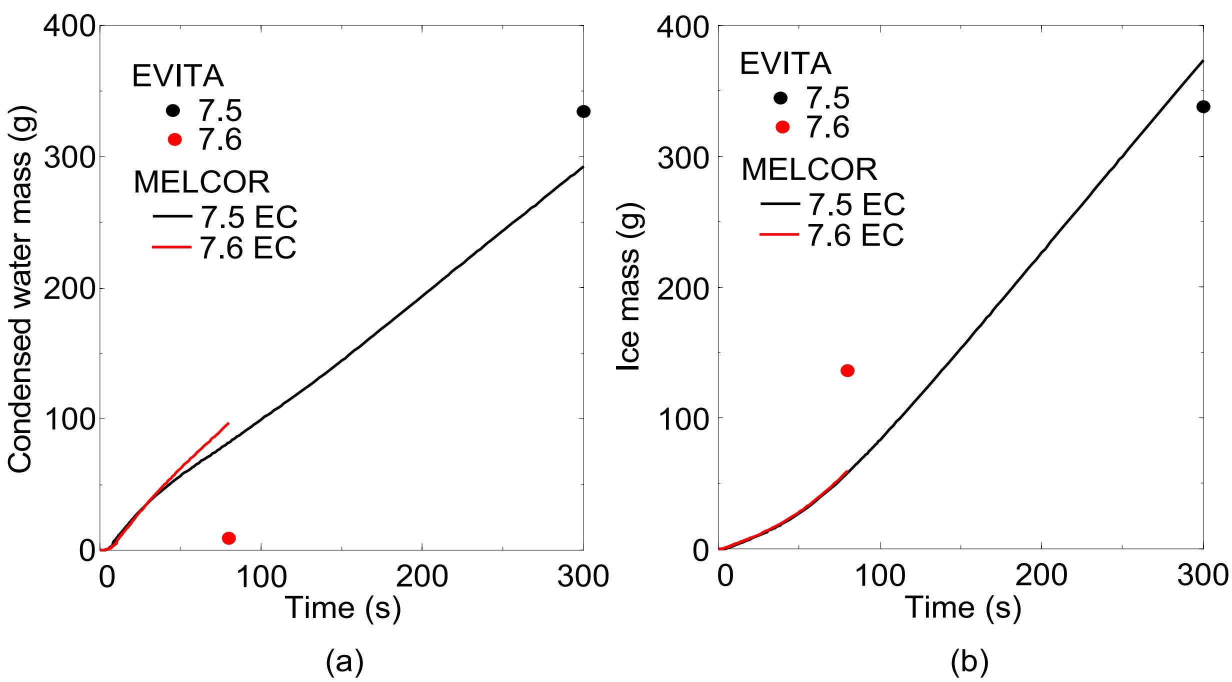



**Figure 20.** EVITA Test 7.5 and 7.6 comparisons, (a) Cryoplate ice mass comparison with MELCOR EC predictions, and (b) VV condensate mass comparison with MELCOR EC predictions.

# 6. CONCLUSIONS

A version of MELCOR 1.8.2 modified for use in ITER PSR analysis was benchmarked against recent data from the EVITA facility located in Cadarache, France. EVITA Test Series 7 was used for this study to validate MELCOR's ability to predict the pressures, temperatures, cryoplate ice mass, and VV condensate mass for test conditions in EVITA that include injections of steam, nitrogen, and water in to the EVITA VV after the walls had been heated to 165 ºC and the cryoplate had been cooled to -193 ºC. In general, MELCOR results showed the proper trends and agreed well with the EVITA data trends. This agreement should lend confidence to the modeling of water ingress events in ITER's cryostat and suggest that the MELCOR code is predicting the physical phenomena well.

The ability of MELCOR to predict the VV pressure and wall temperatures for the steam only and water only injection tests was very good. The largest deviation in pressure from EVITA was less than 20%. The predicted wall temperatures were within a few percent of the measured values, but for the most part this agreement results for the VV ambient energy loss rate found for the input model by trial and error that matched Test 7.10 data, a test for which the heater power was switched off during water injection. Predicted ice layer masses where larger than reported for the EVITA cryoplate, in particular for the steam only injection tests (~40% too high), and the predicted condensate masses were less that measured in EVITA. Both of these discrepancies can be explained by ice porosity. It is believed that the actual ice layer on the EVITA cryoplate has a porosity that varies from 20 to 40%, where as the MELCOR model assumes an ice porosity of zero. When a porosity was introduced into the modified MELCOR 1.8.2 ice formation model, the predicted ice layer mass condensate masses were in agreement with EVITA data.

The modified MELCOR 1.8.2 code over predicts the EVITA VV pressure for the co-injection tests (e.g., steam plus nitrogen, or water plus nitrogen injections) by almost a factor of two. Based on parametric runs that where made by increasing the predicted cryoplate condensation rate, it is believed that the over prediction in pressure is a result of an under prediction in cryoplate condensation rate. The reason for this under prediction could be attributed to a vapor flow distribution inside of the EVITA VV that does not allow a stable non-condensable gas (nitrogen) layer to form at the surface of the cryoplate ice layer. However, there is no way of directly verifying this hypothesis at this time and there may be other explanations for the under predicted condensation rate.

Based on the results of this study, it may be concluded that to the extent that the EVITA facility simulates coolant leaks into the cryostat of ITER that this version of MELCOR 1.8.2 modified for use in ITER could over predict the cryogenic structure ice layer mass for steam and water leaks into the cryostat, and in addition could over predict the cryostat pressure if there is a co-injection of a non-condensable gas, such as air or helium. Both of these factors will more than likely result in a conservative prediction regarding the consequence of this type of accident in ITER.

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# Appendix A

Listing of MELCOR Input Deck for Test 7.10

```
******************************************************************************
*
*   EVITA Pre-test Calculations #7_10
*   Normal condensation of vacuum vessel
*   Water flow at 2.4 gm/sec, intial pressure of vacuum vessel = 500 Pa
*   Initial temperature in vacuum vessel = 438 K = 165 C
*   For this run it is assumed that the mass flow rate will remain
*   at 2.7g/s water.  For this case we will assume a time independent volume
*   with a time independent flow rate to the vacuum vessel.
*   Temperature of vapor in boiler = 438 K
*   It is assumed that the cyoplate remains at 80 K
*   Heater turn off
*
*
*eor* melgen
******************************************************************************
title   'EVITA-model #_7_10'
crtout
outputfile   evita_7_10.out
diagfile     evita_7_10.dia
restartfile  evita_7_10.res
dttime       0.01
ncg001 h2 4
ncg002 o2 5
ncg003 n2 6
*
sc00001     4201      1.0       1   * C in Sherwood condensation
sc00002     4406      1.0       1   * Max fog density
sc00003     4200    0.999       1   * Below Psat/Ptot use Sherwood condensation
sc00004     4200    0.99999     2   * Below Psat/Ptot use Nusselt condensation
******************************************************************************
*** CONTROL VOLUMES
******************************************************************************
* Pressurizer
*****************************************************************************
cv01000   Pressurizer  1  1  1    * cvname, 1EQ-2NEQ, 1H-2V, component id
cv01001   0    -1                 * pool,fog allowed, active
cv01002   0.0  0.0                * initial velocities in control volume
cv01003   0.113                   * cross-sectional area for flow calculation
cv010a0   3                       * Separate pool and atmosphere input
cv010a1   pvol  4.e6   zpol  0.89  tpol  438.0
cv010a2   tatm 438.0   ph2o  0.61e6  mlfr.6  1.0
***       altitude   volume
cv010b1   0.7     0.0
cv010b2   1.08    0.091
*
*
******************************************************************************
* LN2
******************************************************************************
cv02000   LN2    2  1  1          * cvname, 1EQ-2NEQ, 1H-2V, component id
cv02001   0    -1                 * pool,fog allowed, active
cv02002   0.0  0.0                * initial velocities in control volume
cv020a0   3                       * Separate pool and atmosphere input
cv020a1   pvol  1.e5   vpol  0.0  tpol  405.0
cv020a2   tatm  80.0   ph2o  0.0  mlfr.6  1.0
***       altitude   volume
cv020b1   0.7     0.0
cv020b2   1.08    0.091
******************************************************************************
******************************************************************************
******************************************************************************
* *  0.21 x 0.95 for internals
******************************************************************************
* * * bottom zone
cv10000   VV100  2  2  1
cv10001   0    0
cv10002   0.0  0.0
cv10003   0.3882
cv100a0   3
cv100a1   pvol  500.0  vpol  0.0  tpol  405.0
```

```
cv100a2   tatm  405.0  ph2o  0.0  mlfr.5  0.21  mlfr.6  0.79
***       altitude   volume
cv100b1   0.7        0.0
cv100b2   0.701      1.0e-6    0.704     5.6e-5
cv100b3   0.718      9.8e-4    0.746     5.6e-3
cv100b4   0.836      3.0e-2    0.9       5.18e-2
*
cv10100   VV101  1  2  1
cv10101   0    0
cv10102   0.0  0.0
cv10103   0.003
cv101a0   3
cv101a1   pvol  500.0  vpol  0.0  tpol  405.0
cv101a2   tatm  405.0  ph2o  0.0  mlfr.5  0.21  mlfr.6  0.79
***       altitude   volume
cv101b1   0.71       0.0
cv101b2   0.9        6.28e-3
*
* * * mid zone
cv10500   MDFLOWVV105  1  2  2
cv10501   0    0
cv10502   0.0  0.0
cv10503   0.3882
cv105a0   3
cv105a1   pvol  500.0  vpol  0.0  tpol  405.0
cv105a2   tatm  405.0  ph2o  0.0  mlfr.5  0.21  mlfr.6  0.79
***       altitude   volume
cv105b1   0.9         0.0
cv105b2   1.224       0.1104
cv105b3   1.360       0.1405
*
* * * cryo zone
cv11000   MDFLOWVV110  1  2  2
cv11001   0    0
cv11002   0.0  0.0
cv11003   0.3882
cv110a0   3
cv110a1   pvol  500.0  vpol  0.0  tpol  405.0
cv110a2   tatm  405.0  ph2o  0.0  mlfr.5  0.21  mlfr.6  0.79
***       altitude   volume
cv110b1   0.9        0.0
cv110b2   1.132      0.0139
cv110b3   1.254      0.0178
*
**
********************************************************************************
********************************************************************************
*** FLOW PATHS
********************************************************************************
*** Pressurizer to Vacuum Vessel
********************************************************************************
********************************************************************************
fl05000   Flowpath50   10     105    0.7  1.0
fl05001   1.2272e-4  1.41    1.0
fl05002   3
fl05003   0.5  0.50
fl050s1   1.2272e-4  1.4      0.0125    5.0e-5
fl050s2   2.7340e-7  0.01     0.00059   5.0e-5
fl050t1   1   500
*
fl05300   Flowpath53   101    100    0.89    0.89
fl05301   0.0314  0.2  0.0
fl05302   3
fl05303   0.5  0.5
fl053s1   0.0314  0.2  0.2
fl053v1   -44  990   990
*
fl05400   Flowpath54   101    100    0.71    0.71
fl05401   0.0314  0.2  0.0
fl05402   3
fl05403   0.5  0.5
```

```
fl054s1   0.0314  0.2  0.2
fl054v1   -44  990   990
*
cf99000  vop   tab-fun   1   1.0   0.0
cf99001  0.
cf99003  709
cf99010  1.0   0.0   time
*
tf70900    q    3  1.0  0.0   * h
tf709a1     0.0  0.
tf709a2     2.0  0.
tf709a3     3.0  1.
*
fl05500   Flowpath55   105    100    0.9    0.9
fl05501   0.14  0.2    1.0
fl05502   6
fl05503   0.5  0.5
fl055s1   0.14  0.2  0.21
*
fl05600   Flowpath56   110     105    1.0  1.0
fl05601   2.4e-1   0.3     1.0   0.2  0.2
fl05602   7
fl05603   1.5  1.5
fl056s1   2.4e-1    0.3     0.4    5.0e-5
*
fl05900   Flowpath59   110    100    0.91  0.9
fl05901   0.06  0.2    1.0
fl05902   0
fl05903   0.5  0.5
fl059s1   0.06  0.2  0.21
*
fl06000   Flowpath60   110    105    1.224  1.224
fl06001   0.06  0.2    1.0
fl06002   6
fl06003   0.5  0.5
fl060s1   0.06  0.2  0.21
*******************************************************************************
*******************************************************************************
*** HEAT STRUCTURES
*******************************************************************************
*** Top of vacuum vessel
*******************************************************************************
hs00100000   5  1  -1
hs00100001   Top of VV
hs00100002   1.35  0.0
hs00100100  -1  1  0.0
hs00100101   1.e-5       2
hs00100102   1.e-4       3
hs00100103   2.70e-3     4
hs00100104   5.47e-3     5
hs00100200  -1
hs00100201   STAINLESS-STEEL   4
hs00100300   0
hs00100400   6626 105  EXT  0.0  1.0
hs00100401   0.6  gray-gas-a  0.35
hs00100500   0.485  0.703  0.703
hs00100600   -9750   -1
hs00100800  -1
hs00100801   456.0  5
*******************************************************************************
hs00105000   5  1  -1
hs00105001   Top of VV
hs00105002   1.35  0.0
hs00105100  -1  1  0.0
hs00105101   1.e-5       2
hs00105102   1.e-4       3
hs00105103   2.70e-3     4
hs00105104   5.47e-3     5
hs00105200  -1
hs00105201   STAINLESS-STEEL   4
hs00105300   0
```

```
hs00105400   1 105  EXT  0.0  1.0
hs00105401   0.6  gray-gas-a  0.35
hs00105500   0.005  0.703  0.703
hs00105600   -9750   -1
hs00105800  -1
hs00105801   456.0  5
********************************************************************************
*
cf62400  hvap   multiply   2    1.0   0.0             *
cf62401  15.                                   * initial value
cf62410  1.0     0.0      hs-htc-atms-l.00105   * hvap
cf62412  1.0     0.0      cfvalu.612            * qual
*
cf62500  hliqt   multiply   2    1.0   0.0             *
cf62501  0.                                    * initial value
cf62510  0.5     0.0      cfvalu.400            * hliq
cf62512  1.0     0.0      cfvalu.613            * 1-qual
*
cf62600  htot   add   2    1.0   0.0            *
cf62601  15.                                   * initial value
cf62610  1.0     0.0      cfvalu.624            * h1
cf62612  1.0     0.0      cfvalu.625            * h2
*
cf40000  hliq  tab-fun   1   1.0   0.0
cf40001  10.
cf40003  400
cf40010  1.0   0.0   time
*
tf40000    hliq    4   1.0  0.0
tf400a1    0.0     100.0
tf400a2   100.     200.0
tf400a3   300.     400.0
tf400a4   700.    1000.0
*
********************************************************************************
cf75000  delt   add   2    1.0   0.0            *
cf75001  0.0                                   * initial value
cf75010  1.0     0.0      cfvalu.700            * q1
cf75012  1.0     0.0      cfvalu.562            * q2
*
cf56200  qamb   add   2   5.0   0.0            * hgap
cf56201  0.0                                   * initial value
cf56210  1.0     0.0      hs-temp.0010005       * temp1
cf56211  0.0   -298.      time
********************************************************************************
*** Floor #1 of vacuum vessel
********************************************************************************
hs00190000   5  1  -1
hs00190001   Floor #1  of VV
hs00190002   0.6963  -1.e-7
hs00190100  -1  1  0.0
hs00190101   1.e-5       2
hs00190102   1.e-4       3
hs00190103   1.69e-3     4
hs00190104   3.70e-3     5
hs00190200  -1
hs00190201   fullss   4
hs00190300   0
hs00190400   1  100  EXT  0.0  1.0
hs00190401   0.6  gray-gas-a  0.35
hs00190500   0.0036  0.030  0.030
hs00190600  -9701   -1
hs00190800  -1
hs00190801   395.0  5
*
cf70000  qsurf   tab-fun   1   1.0   0.0
cf70001  10.
cf70003  700
cf70010  1.0   0.0   hs-temp.0030001
*
tf70000    q    3 -0.0  0.0   * heaters are off.........
```

```
tf700a1     0.0  2500.
tf700a2   443.0  2500.
tf700a3   448.0  0.
*
*******************************************************************************
cf70100  delt   add   3    1.0   0.0            *
cf70101  0.0                                    * initial value
cf70110  1.0     0.0      cfvalu.700            * q1
cf70111 -277.8   0.0      cfvalu.087            * q2
cf70112   1.0    0.0      cfvalu.563            * q3
*******************************************************************************
*
cf56300  qamb   add   2    0.0   0.0            * hgap
cf56301  0.0                                    * initial value
cf56310  1.0     0.0      hs-temp.0019005       * temp1
cf56311  0.0   -298.      time
************************************************************************
*  **** HTS  chiller
************************************************************************
cf70300  htsimpg     L-A-IFTE  3 1.0 0.0 *
cf70301  0.0                            *Initial value
cf70310  1.0 0.0     cfvalu.009         *trip on
cf70311  1.0 0.0     cfvalu.605         *true
cf70312  0.0 15.0   time               *false
*
cf00900  massflg     L-GT 2 1.0 0.0
cf00901  .false.                        *Initial value
cf00910  1.0 0.0      cvh-mass.1.100     *mass liquid
cf00911  0.0 3.0e-2   time               *arbitrary zero
**
cf60500  himpg  tab-fun   1   1.0   0.0
cf60501  15.
cf60503  605
cf60510  1.0   0.0   hs-pool-frac-l.190
**
**
tf60500    htcimp  4   1.0   0.0
tf605a1    0.0    15.0
tf605a2    0.05   15.0
tf605a3    0.7  5000.0
tf605a4    1.0  5000.0
*******************************************************************************
*                       Determine conductivity
*******************************************************************************
cf08500  condk   tab-fun   1   1.0   0.0
cf08501  10.
cf08503  7
cf08510  1.0   0.0   hs-temp.0019003
*******************************************************************************
*                       Heat Structure 023 to 024
*******************************************************************************
cf08600  delt   add   2    1.0   0.0            *
cf08601  0.0                                    * initial value
cf08610  1.0     0.0      hs-temp.0019001       * temp1
cf08611 -1.0     0.0      hs-temp.0019501       * temp2
*
cf08700  q1   multiply   4   -1.0   0.0           *
cf08701  0.0                                    * initial value
cf08710  1.0     0.0      cfvalu.086            * delt
cf08711  1.0     0.0      cfvalu.085            * conductivity
cf08712  0.0     2.0e-3   time                  * area
cf08713  0.0     33.3     time                  *  1./dx
*
cf08800  delt   equals   1   -1.0   0.0           *
cf08801  0.0                                    * initial value
cf08810  1.0     0.0      cfvalu.087             * opposite
*******************************************************************************
*** Floor #1 of vacuum vessel
*******************************************************************************
hs00195000   5  1  -1
hs00195001   Floor #1  of VV
```

```
hs00195002   0.6986  -1.e-7
hs00195100  -1  1  0.0
hs00195101   1.e-5       2
hs00195102   1.e-4       3
hs00195103   1.69e-3     4
hs00195104   3.70e-3     5
hs00195200  -1
hs00195201   fullss   4
hs00195300   0
hs00195400   1  100  EXT  0.0  1.0
hs00195401   0.6  gray-gas-a  0.35
hs00195500   0.0036  0.030  0.030
hs00195600  -9702  -1
hs00195800  -1
hs00195801   398.0  5
**
cf60600  himpg  tab-fun   1   1.0   0.0
cf60601  15.
cf60603  605
cf60610  1.0   0.0   hs-pool-frac-1.195
******************************************************************************
cf70200  delt   add   3    1.0   0.0            *
cf70201  0.0                                    * initial value
cf70210  1.0     0.0      cfvalu.700            * q1
cf70211 -277.8   0.0      cfvalu.198            * q2
cf70212  1.0     0.0      cfvalu.550            * q3
*
cf55000  qamb   add   2   0.0   0.0            * hgap
cf55001  0.0                                    * initial value
cf55010  1.0     0.0      hs-temp.0019505       * temp1
cf55011  0.0   -298.      time                  * temp2
*
******************************************************************************
*                       Determine conductivity
******************************************************************************
cf09500  condk   tab-fun   1   1.0   0.0
cf09501  10.
cf09503  7
cf09510  1.0   0.0   hs-temp.0019503
******************************************************************************
*                       Heat Structure 195 to 200
******************************************************************************
cf09600  delt   add   2    1.0   0.0            *
cf09601  0.0                                    * initial value
cf09610  1.0     0.0      hs-temp.0019501       * temp1
cf09611 -1.0     0.0      hs-temp.0020001       * temp2
*
cf09700  q1   multiply   4   -1.0   0.0            *
cf09701  0.0                                    * initial value
cf09710  1.0     0.0      cfvalu.096            * delt
cf09711  1.0     0.0      cfvalu.095            * conductivity
cf09712  0.0     2.0e-3   time                  * area
cf09713  0.0     33.3    time                  *  1./dx
*
cf09800  delt   equals   1   -1.0   0.0            *
cf09801  0.0                                    * initial value
cf09810  1.0     0.0      cfvalu.097             * opposite
*
cf19800  delt   add   2    1.0   0.0            *
cf19801  0.0                                    * initial value
cf19810  1.0     0.0      cfvalu.088       * q1
cf19811  1.0     0.0      cfvalu.097       * q2
******************************************************************************
*** Floor #1 of vacuum vessel
******************************************************************************
hs00200000   5  1  -1
hs00200001   Floor #1  of VV
hs00200002   0.7003  -1.e-7
hs00200100  -1  1  0.0
hs00200101   1.e-5       2
hs00200102   1.e-4       3
```

```
hs00200103   1.69e-3     4
hs00200104   3.70e-3     5
hs00200200  -1
hs00200201   fullss   4
hs00200300   0
hs00200400   1 100  EXT  0.0  1.0
hs00200401   0.6  gray-gas-a  0.35
hs00200500   0.0036  0.030  0.030
hs00200600   -9704 -1
hs00200800  -1
hs00200801   403.0  5
**
cf60700  himpg  tab-fun   1   1.0   0.0
cf60701  15.
cf60703  605
cf60710  1.0   0.0   hs-pool-frac-1.200
*
********************************************************************************
cf70400  delt   add   3    1.0   0.0             *
cf70401  0.0                                     * initial value
cf70410  1.0     0.0      cfvalu.700             * q1
cf70411 -277.8   0.0      cfvalu.208             * q2
cf70412    1.0   0.0      cfvalu.551             * q3
*
cf55100  qamb   add   2    0.0   0.0             * hgap
cf55101  0.0                                     * initial value
cf55110  1.0     0.0      hs-temp.0020005        * temp1
cf55111  0.0   -298.      time                   * temp2
*
********************************************************************************
*                        Determine conductivity
********************************************************************************
cf10500  condk   tab-fun   1   1.0   0.0
cf10501  10.
cf10503  7
cf10510  1.0   0.0   hs-temp.0020003
********************************************************************************
*                        Heat Structure 200 to 201
********************************************************************************
cf10600  delt   add   2    1.0   0.0             *
cf10601  0.0                                     * initial value
cf10610  1.0     0.0      hs-temp.0020001        * temp1
cf10611 -1.0     0.0      hs-temp.0020101        * temp2
*
cf10700  q1   multiply   4   -1.0   0.0            *
cf10701  0.0                                     * initial value
cf10710  1.0     0.0      cfvalu.106             * delt
cf10711  1.0     0.0      cfvalu.105             * conductivity
cf10712  0.0     2.0e-3   time                   * area
cf10713  0.0     33.3     time                   *  1./dx
*
cf10800  delt   equals   1   -1.0   0.0            *
cf10801  0.0                                     * initial value
cf10810  1.0     0.0      cfvalu.107             * temp1
*
cf20800  delt   add   2    1.0   0.0             *
cf20801  0.0                                     * initial value
cf20810  1.0     0.0      cfvalu.098        * q1
cf20811  1.0     0.0      cfvalu.107        * q2
********************************************************************************
*** Floor #2 of vacuum vessel
********************************************************************************
hs00201000   5  1  -1
hs00201001   Floor #2  of VV
hs00201002   0.704  -3.83e-1
hs00201100  -1  1  0.0
hs00201101   1.e-5       2
hs00201102   1.e-4       3
hs00201103   1.69e-3     4
hs00201104   3.70e-3     5
hs00201200  -1
```

```
hs00201201   fullss   4
hs00201300   0
hs00201400   1   100  EXT  0.0  1.0
hs00201401   0.6  gray-gas-a  0.35
hs00201500   0.0143  0.014  0.017
hs00201600   -9705  -1
hs00201800  -1
hs00201801   410.0  5
**
cf60800  himpg  tab-fun   1   1.0   0.0
cf60801  15.
cf60803  605
cf60810  1.0   0.0   hs-pool-frac-1.201
********************************************************************************
cf70500  delt   add   3    1.0   0.0            *
cf70501  0.0                                    * initial value
cf70510  1.0     0.0      cfvalu.700            * q1
cf70511 -69.93   0.0      cfvalu.218            * q2
cf70512  1.0     0.0      cfvalu.552            * q2
*
cf55200  qamb   add   2    0.0   0.0            * hgap
cf55201  0.0                                    * initial value
cf55210  1.0     0.0      hs-temp.0020105       * temp1
cf55211  0.0   -298.      time                  * temp2
********************************************************************************
*                        Determine conductivity
********************************************************************************
cf11500  condk   tab-fun   1   1.0   0.0
cf11501  10.
cf11503  7
cf11510  1.0   0.0   hs-temp.0020103
********************************************************************************
*                        Heat Structure 201 to 221
********************************************************************************
cf11600  delt   add   2    1.0   0.0            *
cf11601  0.0                                    * initial value
cf11610  1.0     0.0      hs-temp.0020101       * temp1
cf11611 -1.0     0.0      hs-temp.0022101       * temp2
*
cf11700  q1   multiply   4   -1.0   0.0           *
cf11701  0.0                                    * initial value
cf11710  1.0     0.0      cfvalu.116            * delt
cf11711  1.0     0.0      cfvalu.115            * conductivity
cf11712  0.0     3.0e-3   time                  * area
cf11713  0.0     58.8      time                  *  1./dx
*
cf11800  delt   equals   1   -1.0   0.0           *
cf11801  0.0                                    * initial value
cf11810  1.0     0.0      cfvalu.117            * temp1
*
cf21800  delt   add   2    1.0   0.0            *
cf21801  0.0                                    * initial value
cf21810  1.0     0.0      cfvalu.108       * q1
cf21811  1.0     0.0      cfvalu.117       * q2
********************************************************************************
*** Floor #2a of vacuum vessel
********************************************************************************
hs00221000   5  1  -1
hs00221001   Floor #2  of VV
hs00221002   0.707  -3.83e-1
hs00221100  -1  1  0.0
hs00221101   1.e-5       2
hs00221102   1.e-4       3
hs00221103   1.69e-3     4
hs00221104   3.70e-3     5
hs00221200  -1
hs00221201   STAINLESS-STEEL   4
hs00221300   0
hs00221400   6646 100  EXT  0.0  1.0
hs00221401   0.6  gray-gas-a  0.35
hs00221500   0.0072  0.014  0.017
```

```
hs00221600   -9706  -1
hs00221800  -1
hs00221801   415.0  5
*
********************************************************************************
cf70600  delt   add   3    1.0   0.0            *
cf70601  0.0                                    * initial value
cf70610  1.0     0.0      cfvalu.700            * q1
cf70612  1.0     0.0      cfvalu.553            * q2
cf70613 -138.9   0.0      cfvalu.318            * q3  = Q218/as
*
cf55300  qamb   add   2   0.0    0.0            * hgap
cf55301  0.0                                    * initial value
cf55310  1.0     0.0      hs-temp.0022105       * temp1
cf55311  0.0   -298.      time                  * temp2
********************************************************************************
*                       Determine conductivity
********************************************************************************
cf01500  condk   tab-fun   1   1.0   0.0
cf01501  10.
cf01503  7
cf01510  1.0   0.0   hs-temp.0022103
********************************************************************************
*                       Heat Structure 221 to 202
********************************************************************************
cf01600  delt   add   2    1.0   0.0            *
cf01601  0.0                                    * initial value
cf01610  1.0     0.0      hs-temp.0022101       * temp1
cf01611 -1.0     0.0      hs-temp.0023101       * temp2
*
cf01700  q1   multiply   4   -1.0   0.0            *
cf01701  0.0                                    * initial value
cf01710  1.0     0.0      cfvalu.016            * delt
cf01711  1.0     0.0      cfvalu.015            * conductivity
cf01712  0.0     3.0e-3   time                  * area
cf01713  0.0    118.5    time                 *  1./dx
*
cf01800  delt   equals   1   -1.0   0.0            *
cf01801  0.0                                    * initial value
cf01810  1.0     0.0      cfvalu.017            * temp1
*
cf31800  delt   add   2    1.0   0.0            *
cf31801  0.0                                    * initial value
cf31810  1.0     0.0      cfvalu.118       * q1
cf31811  1.0     0.0      cfvalu.017       * q2
********************************************************************************
*** Floor #2b of vacuum vessel
********************************************************************************
hs00231000   5  1  -1
hs00231001   Floor #2  of VV
hs00231002   0.713  -3.83e-1
hs00231100  -1  1  0.0
hs00231101   1.e-5       2
hs00231102   1.e-4       3
hs00231103   1.69e-3     4
hs00231104   3.70e-3     5
hs00231200  -1
hs00231201   STAINLESS-STEEL   4
hs00231300   0
hs00231400   6646 100  EXT  0.0  1.0
hs00231401   0.6  gray-gas-a  0.35
hs00231500   0.0072 0.014  0.017
hs00231600   -9707  -1
hs00231800  -1
hs00231801   420.0  5
*
********************************************************************************
cf70700  delt   add   3    1.0   0.0            *
cf70701  0.0                                    * initial value
cf70710  1.0     0.0      cfvalu.700            * q1
cf70712  1.0     0.0      cfvalu.554            * q2
```

```
cf70713 -138.9   0.0      cfvalu.418           * q3= -Q418/as
*
cf55400  qamb   add   2    0.0   0.0           * hgap
cf55401  0.0                                   * initial value
cf55410  1.0     0.0      hs-temp.0023105      * temp1
cf55411  0.0   -298.      time                 * temp2
*****************************************************************************
*                      Heat Structure 221 to 202
*****************************************************************************
cf81600  delt   add   2    1.0   0.0           *
cf81601  0.0                                   * initial value
cf81610  1.0     0.0      hs-temp.0023101      * temp1
cf81611 -1.0     0.0      hs-temp.0020201      * temp2
*
cf81700  q1   multiply   4   -1.0   0.0           *
cf81701  0.0                                   * initial value
cf81710  1.0     0.0      cfvalu.816           * delt
cf81711  1.0     0.0      cfvalu.015           * conductivity
cf81712  0.0     3.0e-3   time                 * area
cf81713  0.0   118.5      time                * 1./dx
*
cf81800  delt   equals   1   -1.0   0.0           *
cf81801  0.0                                   * initial value
cf81810  1.0     0.0      cfvalu.817           * temp1
*
cf41800  delt   add   2    1.0   0.0           *
cf41801  0.0                                   * initial value
cf41810  1.0     0.0      cfvalu.018       * q1
cf41811  1.0     0.0      cfvalu.817       * q2
*****************************************************************************
*** Floor #3 of vacuum vessel
*****************************************************************************
hs00202000   5  1  -1
hs00202001   Floor #3  of VV
hs00202002   0.714  -9.24e-1
hs00202100  -1  1  0.0
hs00202101   1.e-5       2
hs00202102   1.e-4       3
hs00202103   1.7e-3      4
hs00202104   3.7e-3      5
hs00202200  -1
hs00202201   fullss   4
hs00202300   0
hs00202400   6646 100  EXT  0.0  1.0
hs00202401   0.6  gray-gas-a  0.35
hs00202500   0.0152  0.014  0.014
hs00202600   -9708  -1
hs00202800  -1
hs00202801   420.0  5
*
*****************************************************************************
cf70800  delt   add   3    1.0   0.0           *
cf70801  0.0                                   * initial value
cf70810  1.0     0.0      cfvalu.700           * q1
cf70812  1.0     0.0      cfvalu.555           * q2
cf70813 -65.8    0.0      cfvalu.228           * q3 = -Q228/as
*
cf55500  qamb   add   2   0.0   0.0           * hgap
cf55501  0.0                                   * initial value
cf55510  1.0     0.0      hs-temp.0020205      * temp1
cf55511  0.0   -298.      time                 * temp2
*****************************************************************************
*                      Determine conductivity
*****************************************************************************
cf12500  condk   tab-fun   1   1.0   0.0
cf12501  10.
cf12503  7
cf12510  1.0   0.0   hs-temp.0020203
*****************************************************************************
*                      Heat Structure 202 to 212
*****************************************************************************
```

```
cf12600  delt   add   2    1.0   0.0            *
cf12601  0.0                                    * initial value
cf12610  1.0     0.0      hs-temp.0020201       * temp1
cf12611 -1.0     0.0      hs-temp.0021201       * temp2
*
cf12700  q1   multiply   4   -1.0   0.0            *
cf12701  0.0                                    * initial value
cf12710  1.0     0.0      cfvalu.126            * delt
cf12711  1.0     0.0      cfvalu.125            * conductivity
cf12712  0.0     6.0e-3   time                  * area
cf12713  0.0    181.8      time                  *  1./dx
*
cf12800  delt   equals   1   -1.0   0.0            *
cf12801  0.0                                    * initial value
cf12810  1.0     0.0      cfvalu.127            * opposit
*
cf22800  qtot   add   2    1.0   0.0            *
cf22801  0.0                                    * initial value
cf22810  1.0     0.0      cfvalu.818       * q1
cf22811  1.0     0.0      cfvalu.127       * q2
******************************************************************************
*** Floor #3a of vacuum vessel
******************************************************************************
hs00212000   5  1  -1
hs00212001   Floor #3  of VV
hs00212002   0.721  -9.24e-1
hs00212100  -1  1  0.0
hs00212101   1.e-5       2
hs00212102   1.e-4       3
hs00212103   1.7e-3      4
hs00212104   3.7e-3      5
hs00212200  -1
hs00212201   STAINLESS-STEEL   4
hs00212300   0
hs00212400   6646 100  EXT  0.0  1.0
hs00212401   0.6  gray-gas-a  0.35
hs00212500   0.0152  0.014  0.014
hs00212600   -9709  -1
hs00212800  -1
hs00212801   422.0  5
*
******************************************************************************
cf70900  delt   add   3    1.0   0.0            *
cf70901  0.0                                    * initial value
cf70910  1.0     0.0      cfvalu.700            * q1
cf70912  1.0     0.0      cfvalu.556            * q2
cf70913 -65.8    0.0      cfvalu.238            * q3 = -Q238/as
*
cf55600  qamb   add   2   0.0   0.0            * hgap
cf55601  0.0                                    * initial value
cf55610  1.0     0.0      hs-temp.0021205       * temp1
cf55611  0.0   -298.      time                  * temp2
*
******************************************************************************
*                       Determine conductivity
******************************************************************************
cf13500  condk   tab-fun   1   1.0   0.0
cf13501  10.
cf13503  7
cf13510  1.0   0.0   hs-temp.0021203
******************************************************************************
*                       Heat Structure 212 to 203
******************************************************************************
cf13600  delt   add   2    1.0   0.0            *
cf13601  0.0                                    * initial value
cf13610  1.0     0.0      hs-temp.0021201       * temp1
cf13611 -1.0     0.0      hs-temp.0022201       * temp2
*
cf13700  q1   multiply   4   -1.0   0.0            *
cf13701  0.0                                    * initial value
cf13710  1.0     0.0      cfvalu.136            * delt
```

```
cf13711  1.0     0.0      cfvalu.135            * conductivity
cf13712  0.0     6.0e-3   time                  * area
cf13713  0.0    103.8      time                  *  1./dx
*
cf13800  delt   equals   1   -1.0   0.0            *
cf13801  0.0                                    * initial value
cf13810  1.0     0.0      cfvalu.137            * opposite
*
cf23800  qtot   add   3    1.0   0.0            *
cf23801  0.0                                    * initial value
cf23810  1.0     0.0      cfvalu.128       * q1
cf23811  1.0     0.0      cfvalu.137       * q2
cf23812  1.0     0.0      cfvalu.148       * q3
*****************************************************************************
*** bottom flanges
*****************************************************************************
hs00213000   7  1  -1
hs00213001   Floor #3  of VV
hs00213002   0.773  -9.24e-1
hs00213100  -1  1  0.0
hs00213101   1.e-5       2
hs00213102   1.e-4       3
hs00213103    1.0e-3     4
hs00213104    3.7e-3     5
hs00213105    1.3e-2     6
hs00213106    2.6e-2     7
hs00213200  -1
hs00213201   STAINLESS-STEEL   6
hs00213300   0
hs00213400   6646 100  EXT  0.0  1.0
hs00213401   0.6  gray-gas-a  0.35
hs00213500   0.0706  0.009  0.0202
hs00213600   -9710    -1
hs00213800  -1
hs00213801   410.0  7
*
*****************************************************************************
cf71000  delt   add   3    1.0   0.0            *
cf71001  0.0                                    * initial value
cf71010  1.0     0.0      cfvalu.700            * q1
cf71012  1.0     0.0      cfvalu.557            * q2
cf71013 -14.2    0.0      cfvalu.147            * q3 = -Q147/as
*
cf55700  qamb   add   2   0.0   0.0            * hgap
cf55701  0.0                                    * initial value
cf55710  1.0     0.0      hs-temp.0021305       * temp1
cf55711  0.0   -298.      time                  * temp2
*
*****************************************************************************
*                        Determine conductivity
*****************************************************************************
cf14500  condk   tab-fun   1   1.0   0.0
cf14501  10.
cf14503  7
cf14510  1.0   0.0   hs-temp.0021303
*****************************************************************************
*                        Heat Structure 0213 to 0212
*****************************************************************************
cf14600  delt   add   2    1.0   0.0            *
cf14601  0.0                                    * initial value
cf14610  1.0     0.0      hs-temp.0021301       * temp1
cf14611 -1.0     0.0      hs-temp.0021201       * temp2
*
cf14700  q1   multiply   4   -1.0   0.0            *
cf14701  0.0                                    * initial value
cf14710  1.0     0.0      cfvalu.146            * delt
cf14711  1.0     0.0      cfvalu.145            * conductivity
cf14712  0.0     4.7e-3   time                  * area
cf14713  0.0     5.0      time                  *  1./dx
*
cf14800  delt   equals   1   -1.0   0.0            *
```

```
cf14801  0.0                                    * initial value
cf14810  1.0     0.0      cfvalu.147            * opposite
*******************************************************************************
*** Floor #3b of vacuum vessel
*******************************************************************************
hs00222000   5  1  -1
hs00222001   Floor #3  of VV
hs00222002   0.740  -9.24e-1
hs00222100  -1  1  0.0
hs00222101   1.e-5       2
hs00222102   1.e-4       3
hs00222103   1.7e-3      4
hs00222104   3.7e-3      5
hs00222200  -1
hs00222201   STAINLESS-STEEL   4
hs00222300   0
hs00222400   7839 100  EXT  0.0  1.0
hs00222401   0.6  gray-gas-a  0.35
hs00222500   0.0152  0.014  0.014
hs00222600   -9711  -1
hs00222800  -1
hs00222801   424.0  5
*
*******************************************************************************
cf71100  delt   add   3    1.0   0.0            *
cf71101  0.0                                    * initial value
cf71110  1.0     0.0      cfvalu.700            * q1
cf71112  1.0     0.0      cfvalu.558            * q2
cf71113 -67.8    0.0      cfvalu.839            * q3= -Q839/as
*
cf55800  qamb   add   2   0.0   0.0            * hgap
cf55801  0.0                                    * initial value
cf55810  1.0     0.0      hs-temp.0022205       * temp1
cf55811  0.0   -298.      time                  * temp2
*******************************************************************************
*                       Heat Structure 212 to 203
*******************************************************************************
cf83600  delt   add   2    1.0   0.0            *
cf83601  0.0                                    * initial value
cf83610  1.0     0.0      hs-temp.0022201       * temp1
cf83611 -1.0     0.0      hs-temp.0020301       * temp2
*
cf83700  q1   multiply   4   -1.0   0.0            *
cf83701  0.0                                    * initial value
cf83710  1.0     0.0      cfvalu.836            * delt
cf83711  1.0     0.0      cfvalu.135            * conductivity
cf83712  0.0     6.0e-3   time                  * area
cf83713  0.0   103.8      time                  *  1./dx
*
cf83800  delt   equals   1   -1.0   0.0            *
cf83801  0.0                                    * initial value
cf83810  1.0     0.0      cfvalu.837            * opposite
*
cf83900  qtot   add   2    1.0   0.0            *
cf83901  0.0                                    * initial value
cf83910  1.0     0.0      cfvalu.138       * q1
cf83911  1.0     0.0      cfvalu.837       * q2
*******************************************************************************
*** Floor #4 of vacuum vessel
*******************************************************************************
hs00203000   5  1  -1
hs00203001   Floor #4  of VV
hs00203002   0.752     -1.0
hs00203100  -1  1  0.0
hs00203101   1.e-5       2
hs00203102   1.e-4       3
hs00203103   1.69e-3     4
hs00203104   3.70e-3     5
hs00203200  -1
hs00203201   STAINLESS-STEEL   4
hs00203300   0
```

```
hs00203400   6646 100  EXT  0.0  1.0
hs00203401   0.6  gray-gas-a  0.35
hs00203500   0.254  0.047  0.047
hs00203600   -9712  -1
hs00203800  -1
hs00203801   426.0  5
*
********************************************************************************
cf71200  delt   add   3    1.0   0.0            *
cf71201  0.0                                    * initial value
cf71210  1.0     0.0      cfvalu.700            * q1
cf71212  1.0     0.0      cfvalu.559            * q2
cf71213 -8.96    0.0      cfvalu.248            * q3 = -Q248/as
*
cf55900  qamb   add   2   0.0   0.0            * hgap
cf55901  0.0                                    * initial value
cf55910  1.0     0.0      hs-temp.0020305       * temp1
cf55911  0.0   -298.      time
********************************************************************************
*                       Determine conductivity
********************************************************************************
cf15500  condk   tab-fun   1   1.0   0.0
cf15501  10.
cf15503  7
cf15510  1.0   0.0   hs-temp.0020303
********************************************************************************
*                       Heat Structure 0203 to 0233
********************************************************************************
cf15600  delt   add   2    1.0   0.0            *
cf15601  0.0                                    * initial value
cf15610  1.0     0.0      hs-temp.0020301       * temp1
cf15611 -1.0     0.0      hs-temp.0023301       * temp2
*
cf15700  q1   multiply   4   -1.0   0.0            *
cf15701  0.0                                    * initial value
cf15710  1.0     0.0      cfvalu.156            * delt
cf15711  1.0     0.0      cfvalu.155            * conductivity
cf15712  0.0     8.1e-3   time                  * area
cf15713  0.0     14.3     time                  *  1./dx
*
cf15800  delt   equals   1   -1.0   0.0            *
cf15801  0.0                                    * initial value
cf15810  1.0     0.0      cfvalu.157            * opposite
*
cf24800  qtot   add   2    1.0   0.0            *
cf24801  0.0                                    * initial value
cf24810  1.0     0.0      cfvalu.838       * q1
cf24811  1.0     0.0      cfvalu.157       * q2
********************************************************************************
*** vacuum vessel collar
********************************************************************************
hs00233000   7  1  -1
hs00233001   collar  of VV
hs00233002   0.792     -1.0
hs00233100  -1  1  0.0
hs00233101   1.e-5       2
hs00233102   1.e-4       3
hs00233103   5.0e-3      4
hs00233104   5.0e-2      7
hs00233200  -1
hs00233201   STAINLESS-STEEL   6
hs00233300   0
hs00233400   6646 100  EXT  0.0  1.0
hs00233401   0.6  gray-gas-a  0.35
hs00233500   0.204  0.0925  0.0925
hs00233600   -9713  -1
hs00233800  -1
hs00233801   443.0  7
*
********************************************************************************
cf71300  delt   add   3    1.0   0.0            *
```

```
cf71301  0.0                                    * initial value
cf71310  1.0     0.0      cfvalu.700            * q1
cf71312  1.0     0.0      cfvalu.560            * q2
cf71313 -4.9     0.0      cfvalu.158            * q3 = -Q158/as
*
cf56000  qamb   add   2   0.0   0.0            * hgap
cf56001  0.0                                    * initial value
cf56010  1.0     0.0      hs-temp.0023305       * temp1
cf56011  0.0   -298.      time
*
******************************************************************************
cf64000  mtot   add   5    1.0   0.0            *
cf64001  0.001                                  * initial value
cf64010  1.0     0.0      cvh-mass.1.100        * m1
cf64011  1.0     0.0      cvh-mass.2.100        * m2
cf64012  1.0     0.0      cvh-mass.3.100        * m3
cf64013  1.0     0.0      cvh-mass.5.100        * m4
cf64014  1.0     0.0      cvh-mass.6.100        * m5
*
cf64100  mtot   add   3    1.0   0.0            *
cf64101  0.001                                  * initial value
cf64110  1.0     0.0      cvh-mass.3.100        * m3
cf64111  1.0     0.0      cvh-mass.5.100        * m4
cf64112  1.0     0.0      cvh-mass.6.100        * m5
*
cf64200  qual   divide   2    1.0   0.0            *
cf64201  1.0                                    * initial value
cf64210  1.0     0.0      cfvalu.640            * m1
cf64211  1.0     0.0      cfvalu.641            * m2
*
cf64300  1mq   add   2    1.0   0.0            *
cf64301  0.0                                    * initial value
cf64310  0.0     1.0      time                  * m1
cf64312 -1.0     0.0      cfvalu.642            * m2
*
cf64400  hvap   multiply   2    1.0   0.0            *
cf64401  15.                                    * initial value
cf64410  1.0     0.0      hs-htc-atms-l.00305   * hvap
cf64412  1.0     0.0      cfvalu.642            * qual
*
cf64500  hliq   multiply   2    1.0   0.0            *
cf64501  0.                                     * initial value
cf64510  1.0     0.0      cfvalu.400            * hliq
cf64512  1.0     0.0      cfvalu.613            * 1-qual
*
cf64600  htot   add   2    1.0   0.0            *
cf64601  15.                                    * initial value
cf64610  1.0     0.0      cfvalu.614            * h1
cf64612  1.0     0.0      cfvalu.645            * h2
******************************************************************************
*** floor under Double Wall LN2 PIPE
******************************************************************************
hs00208000   5  1  -1
hs00208001   Floor #5  of VV
hs00208002   0.706  -1.0e-7
hs00208100  -1  2  0.0
hs00208101   0.008    4
hs00208200  -1
hs00208201   fullss   4
hs00208300   0
hs00208400   1 101  EXT  0.0  1.0
hs00208401   0.6  gray-gas-a  0.35
hs00208500   0.0314  0.2  0.2
hs00208600   0
hs00208800  -1
hs00208801   393.0  5
******************************************************************************
*** #5 Double Wall LN2 PIPE
******************************************************************************
hs00204000   5  1  -1
hs00204001   Floor #5  of VV
```

```
hs00204002   0.71   1.0
hs00204100  -1  2  0.0
hs00204101   0.000925    4
hs00204200  -1
hs00204201   fullss   4
hs00204300   0  -1   1.0
hs00204400   1 101  EXT  0.0  1.0
hs00204401   0.6  gray-gas-a  0.35
hs00204500   0.025  0.1  0.1
hs00204600   -9726 101  EXT  0.0  1.0
hs00204700   0.025  0.1  0.1
hs00204800  -1
hs00204801   263.0  5
*******************************************************************************
*** Radiation Exchange
*******************************************************************************
cf72600  FW1toVV1      fun1    5 -1.0    * radiation+conduction function
cf72601  0.0                            * initial value
cf72610  1.0  0.0     hs-temp.0020401   * temp1
cf72611  0.0 80.0     time              * temp2
cf72612  0.0  0.0     time              * solid%*conductivity/deltax
cf72613  0.0  0.31    time              * effective emissivity*(1-solid%)
cf72614  0.0  0.03    time              * area
*
hs00205000   5  1  -1
hs00205001   Floor #5  of VV
hs00205002   0.8   0.0
hs00205100  -1  2  0.0
hs00205101   0.000925    4
hs00205200  -1
hs00205201   fullss   4
hs00205300   0  -1   1.0
hs00205400   1 101  EXT  0.0  1.0
hs00205401   0.6  gray-gas-a  0.35
hs00205500   0.025  0.03  0.03
hs00205600  -9727 101  EXT  0.0  1.0
hs00205700   0.025  0.03  0.03
hs00205800  -1
hs00205801   263.0  5
*
cf72700  FW1toVV1      fun1    5 -1.0    * radiation+conduction function
cf72701  0.0                            * initial value
cf72710  1.0  0.0     hs-temp.0020501   * temp1
cf72711  0.0 80.0     time              * temp2
cf72712  0.0  0.0     time              * solid%*conductivity/deltax
cf72713  0.0  0.31    time              * effective emissivity*(1-solid%)
cf72714  0.0  0.03  time              * area
*
hs00206000   5  1  -1
hs00206001   Vert 2
hs00206002   0.8   1.0
hs00206100  -1  2  0.0
hs00206101   0.000925    4
hs00206200  -1
hs00206201   fullss   4
hs00206300   0  -1   1.0
hs00206400   1 101  EXT  0.0  1.0
hs00206401   0.6  gray-gas-a  0.35
hs00206500   0.025  0.1  0.1
hs00206600  -9728 101  EXT  0.0  1.0
hs00206700   0.025  0.1  0.1
hs00206800  -1
hs00206801   263.0  5
*
cf72800  FW1toVV1      fun1    5 -1.0    * radiation+conduction function
cf72801  0.0                            * initial value
cf72810  1.0  0.0     hs-temp.0020601   * temp1
cf72811  0.0 80.0     time              * temp2
cf72812  0.0  0.0     time              * solid%*conductivity/deltax
cf72813  0.0  0.31    time              * effective emissivity*(1-solid%)
cf72814  0.0  0.03    time              * area
```

```
*
hs00207000   5  1  -1
hs00207001   Pipe
hs00207002   0.9   1.0
hs00207100  -1  2  0.0
hs00207101   0.01    4
hs00207200  -1
hs00207201   fullss   4
hs00207300   0  -1   1.0
hs00207400   1 105  EXT  0.0  1.0
hs00207401   0.6  gray-gas-a  0.35
hs00207500   0.0016  0.027  0.027
hs00207600   -9729 105  EXT  0.0  1.0
hs00207700   0.0016  0.027  0.027
hs00207800  -1
hs00207801   80.0  5
*
cf72900  FW1toVV1      fun1    5 -1.0    * radiation+conduction function
cf72901  0.0                            * initial value
cf72910  1.0  0.0     hs-temp.0020705   * temp1
cf72911  0.0 80.0     time              * temp2
cf72912  0.0 500.     time              * H
cf72913  0.0  0.31    time              * effective emissivity*(1-solid%)
cf72914  0.0  0.0016  time              * area
*
********************************************************************************
*** Side of vacuum vessel
********************************************************************************
hs00300000   7  1  -1
hs00300001   Side of VV
hs00300002   0.928   1.0
hs00300100  -1  1  0.0
hs00300101   1.e-5       2
hs00300102   1.e-4       3
hs00300103   1.05e-3     4
hs00300104   2.11e-3     5
hs00300105   4.22e-3     6
hs00300106   8.44e-3     7    * account for flange mass
hs00300200  -1
hs00300201   STAINLESS-STEEL   6
hs00300300   0
hs00300400   6616 105  EXT  0.0  1.0
hs00300401   0.6  gray-gas-a  0.35
hs00300500   0.758  0.296  0.296
hs00300600   -9714  -1
hs00300800  -1
hs00300801   443.0  7
*
********************************************************************************
cf61000  mtot   add   5    1.0   0.0           *
cf61001  0.001                                 * initial value
cf61010  1.0     0.0      cvh-mass.1.105       * m1
cf61011  1.0     0.0      cvh-mass.2.105       * m2
cf61012  1.0     0.0      cvh-mass.3.105       * m3
cf61013  1.0     0.0      cvh-mass.5.105       * m4
cf61014  1.0     0.0      cvh-mass.6.105       * m5
*
cf61100  mtot   add   3    1.0   0.0           *
cf61101  0.001                                 * initial value
cf61110  1.0     0.0      cvh-mass.3.105       * m3
cf61111  1.0     0.0      cvh-mass.5.105       * m4
cf61112  1.0     0.0      cvh-mass.6.105       * m5
*
cf61200  qual   divide   2    1.0   0.0           *
cf61201  1.0                                   * initial value
cf61210  1.0     0.0      cfvalu.610           * m1
cf61211  1.0     0.0      cfvalu.611           * m2
*
cf61300  1mq   add   2    1.0   0.0           *
cf61301  0.0                                   * initial value
cf61310  0.0     1.0      time                 * m1
```

```
cf61312 -1.0     0.0      cfvalu.612            * m2
*
cf61400  hvap   multiply   2    1.0   0.0            *
cf61401  15.                                    * initial value
cf61410  1.0     0.0      hs-htc-atms-1.00305   * hvap
cf61412  1.0     0.0      cfvalu.612            * qual
*
cf61500  hliq   multiply   2    1.0   0.0            *
cf61501  0.                                     * initial value
*cf61510  0.0   300.0      time                * hliq
cf61510  1.0     0.0      cfvalu.400            * hliq
cf61512  1.0     0.0      cfvalu.613            * 1-qual
*
cf61600  htot   add   3    1.0   0.0            *
cf61601  15.                                    * initial value
cf61610  1.0     0.0      cfvalu.614            * h1
cf61612  1.0     0.0      cfvalu.615            * h2
cf61613  0.0    20.0      cfvalu.655            * h3
**
cf65500  himpg  tab-fun   1   1.0   0.0
cf65501  15.
cf65503  615
cf65510  1.0   0.0   time
**
**
tf61500    htcimp  4   1.0   0.0
tf615a1    0.0    5.0
tf615a2    10.    5.0
tf615a3    80.    5.0
tf615a4    81.    5.0
*
********************************************************************************
cf71400  delt   add   2    1.0   0.0            *
cf71401  0.0                                    * initial value
cf71410  1.0     0.0      cfvalu.700            * q1
cf71412  1.0     0.0      cfvalu.561            * q2
*
cf56100  qamb   add   2   5.0   0.0            * hgap
cf56101  0.0                                    * initial value
cf56110  1.0     0.0      hs-temp.0030005       * temp1
cf56111  0.0   -298.      time
*
hs00305000   7  1  -1
hs00305001   Side of VV
hs00305002   0.928   1.0
hs00305100  -1  1  0.0
hs00305101   1.e-5       2
hs00305102   1.e-4       3
hs00305103   1.05e-3     4
hs00305104   2.11e-3     5
hs00305105   4.22e-3     6
hs00305106   8.44e-3     7    * account for flange mass
hs00305200  -1
hs00305201   STAINLESS-STEEL   6
hs00305300   0
hs00305400   1 105  EXT  0.0  1.0
hs00305401   0.6  gray-gas-a  0.35
hs00305500   0.008  0.296  0.296
hs00305600   -9714  -1
hs00305800  -1
hs00305801   443.0  7
********************************************************************************
*** Cryogenic volume
********************************************************************************
*
cf45000  tln2  equals   1    1.0   0.0            *
cf45001  0.0                                    * initial value
cf45010  0.0    80.0      time                * opposite
*
cf46500  delt   equals   1    1.0   0.0            *
cf46501  0.0                                    * initial value
```

```
cf46510  1.0     0.0      cfvalu.490            * opposite
*
cf47000  qln2   add   2    0.05   0.0             * asurf
cf47001  0.0                                      * initial value
cf47010  1.0     0.0    hs-qflux-atms-l.00500     * q1
cf47011  1.0     0.0    hs-qflux-atms-r.00600     * q2
*
cf47500  dfdt   add   2     6.690      0.0         * 1./rho/vtot
cf47501  0.0                                      * initial value
cf47510  0.0       71.1e-3   time                 * mdot ln2 (kg/s)
cf47511 -5.155e-6    0.0     cfvalu.470           * Q/hfg
*
cf48000  dfrac   multiply   2    1.0     0.0        *
cf48001  1.0                                  * initial value
cf48010  1.0   0.0     dt                     * dtime
cf48011  1.0   0.0     cfvalu.475             * dfdt
*
cf48500  frac   add   2    1.0     0.0        *
cf48501  1.0                                  * initial value
cf48510  1.0   0.0     cfvalu.480              * dfrac
cf48511  1.0   0.0     cfvalu.465              * fraco
*
cf48600  fminchk    max   2    1.0     0.0        *
cf48601  0.1                                  * initial value
cf48610  0.0   0.1     time                   * fmin
cf48611  1.0   0.0     cfvalu.485             * frac
*
cf48700  fmaxchk    min   2    1.0     0.0        *
cf48701  1.0                                  * initial value
cf48710  0.0   1.0     time                   * fmax
cf48711  1.0   0.0     cfvalu.486             * frac
*
cf49000  frac   equals   1    1.0   0.0            *
cf49001  0.0                                    * initial value
cf49010  1.0     0.0      cfvalu.487            * opposite
*** Cryogenic plate Area = 0.1 m^2  T = 80 K
hs00500000     5  1  -1
hs00500001     CryogenicPlate1
hs00500002     0.9  1.0
hs00500100  -1  2  0.0
hs00500101     0.0025    4
hs00500200  -1
hs00500201     copper   4
hs00500300     0
hs00500400     8500  20  ext 0.0 1.0
hs00500600     1  110  ext   0.0 1.0  100.  100.  1.  1.0
hs00500601     0.6  gray-gas-a  0.35
hs00500700     0.01258  0.190  0.190
hs00500800  -1
hs00500801     80.0  5
*
cf35000  kcop   tab-fun   1   1.0   0.0
cf35001  10.
cf35003  13
cf35010  1.0   0.0   hs-temp.0050001
*
cf35100  dtdxt   add   2    100.   0.0          * 1/dx
cf35101  0.0                                    * initial value
cf35110  1.0     0.0      hs-temp.0050005       * temp1
cf35111 -1.0     0.0      hs-temp.0050001       * temp2
*
cf35200  q500   multiply   2    0.01258  0.0   * As
cf35201  1.0                                  * initial value
cf35210  1.0   0.0     cfvalu.350             * dtime
cf35211  1.0   0.0     cfvalu.351             * dfdt
*
hs00501000     5  1  -1
hs00501001     CryogenicPlate1
hs00501002     0.9  1.0
hs00501100  -1  2  0.0
hs00501101     0.002    4
```

```
hs00501200  -1
hs00501201     copper   4
hs00501300     0
hs00501400     8501  20  ext 0.0 1.0
hs00501600     1  110  ext   0.0 1.0  100.  100.  1.  1.0
hs00501601     0.6  gray-gas-a  0.35
hs00501700     0.0125  0.190  0.190
hs00501800  -1
hs00501801     80.0  5
*
cf35500  kcop   tab-fun   1   1.0   0.0
cf35501  10.
cf35503  13
cf35510  1.0   0.0   hs-temp.0050101
*
cf35600  dtdxt   add   2    100.   0.0          * 1/dx
cf35601  0.0                                    * initial value
cf35610  1.0     0.0      hs-temp.0050105       * temp1
cf35611 -1.0     0.0      hs-temp.0050101       * temp2
*
cf35700  q501   multiply   2    0.01258  0.0   * As
cf35701  1.0                                  * initial value
cf35710  1.0   0.0     cfvalu.355             * dtime
cf35711  1.0   0.0     cfvalu.356             * dfdt
*
hs00502000     5  1  -1
hs00502001     CryogenicPlate1
hs00502002     0.9  1.0
hs00502100  -1  2  0.0
hs00502101     0.0025    4
hs00502200  -1
hs00502201     copper   4
hs00502300     0
hs00502400     8502  20  ext 0.0 1.0
hs00502600     1  110  ext   0.0 1.0  100.  100.  1.  1.0
hs00502601     0.6  gray-gas-a  0.35
hs00502700     0.0125  0.190  0.190
hs00502800  -1
hs00502801     80.0  5
*
cf36000  kcop   tab-fun   1   1.0   0.0
cf36001  10.
cf36003  13
cf36010  1.0   0.0   hs-temp.0050201
*
cf36100  dtdxt   add   2    100.   0.0          * 1/dx
cf36101  0.0                                    * initial value
cf36110  1.0     0.0      hs-temp.0050205       * temp1
cf36111 -1.0     0.0      hs-temp.0050201       * temp2
*
cf36200  q502   multiply   2    0.01258  0.0   * As
cf36201  1.0                                  * initial value
cf36210  1.0   0.0     cfvalu.360             * dtime
cf36211  1.0   0.0     cfvalu.361             * dfdt
*
hs00503000     5  1  -1
hs00503001     CryogenicPlate1
hs00503002     0.9  1.0
hs00503100  -1  2  0.0
hs00503101     0.0025    4
hs00503200  -1
hs00503201     copper   4
hs00503300     0
hs00503400     8503  20  ext 0.0 1.0
hs00503600     1  110  ext   0.0 1.0  100.  100.  1.  1.0
hs00503601     0.6  gray-gas-a  0.35
hs00503700     0.0125  0.190  0.190
hs00503800  -1
hs00503801     80.0  5
*
cf36500  kcop   tab-fun   1   1.0   0.0
```

```
cf36501  10.
cf36503  13
cf36510  1.0   0.0   hs-temp.0050301
*
cf36600  dtdxt   add   2    100.   0.0          * 1/dx
cf36601  0.0                                    * initial value
cf36610  1.0     0.0      hs-temp.0050305       * temp1
cf36611 -1.0     0.0      hs-temp.0050301       * temp2
*
cf36700  q503   multiply   2    0.01258  0.0   * As
cf36701  0.0                                  * initial value
cf36710  1.0   0.0     cfvalu.365             *
cf36711  1.0   0.0     cfvalu.366             *
*
* * * total
cf36800  qplate   add   4    2.   0.0           *
cf36801  0.0                                    * initial value
cf36810  1.0     0.0     cfvalu.367            * q1
cf36811  1.0     0.0     cfvalu.362            * q2
cf36812  1.0     0.0     cfvalu.357             * q3
cf36813  1.0     0.0     cfvalu.352             * q4
*
cf36900  qplate   max   2    1.   0.0           *
cf36901  0.0                                    * initial value
cf36910  0.0     0.0     time                  * q1
cf36911  1.0     0.0     cfvalu.368            * q2
**
*
cf50000  tc1   tab-fun   1   1.0       0.0   *
cf50001  80.0                                * initial value
cf50003  770                                   * table
cf50010  1.0   0.0      time                 * tnew
*
tf77000    tc1    4   1.0    273.
tf770a1     0.0  -174.
tf770a2    40.0   -80.
tf770a3   540.0  -119.
tf770a4   720.0  -120.
*
cf50100  tc2   tab-fun   1   1.0       0.0   *
cf50101  80.0                                * initial value
cf50103  771                                   * table
cf50110  1.0   0.0      time                 * tnew
*
tf77100    tc2    4   1.0    273.
tf771a1     0.0  -174.
tf771a2    40.0  -108.
tf771a3   240.0  -120.
tf771a4   720.0  -133.
*
cf50200  tc3   tab-fun   1   1.0       0.0   *
cf50201  80.0                                * initial value
cf50203  772                                   * table
cf50210  1.0   0.0      time                 * tnew
*
tf77200    tc3    4   1.0    273.
tf772a1     0.0  -174.
tf772a2    40.0  -110.
tf772a3   140.0  -128.
tf772a4   720.0  -134.
*
cf50300  tc4   tab-fun   1   1.0       0.0   *
cf50301  80.0                                * initial value
cf50303  773                                   * table
cf50310  1.0   0.0      time                 * tnew
*
tf77300    tc4    4   1.0    273.
tf773a1     0.0  -174.
tf773a2    40.0   -90.
tf773a3   140.0   -87.
tf773a4   720.0  -110.
```

```
********************************************************************************
hs00600000      5  1  -1
hs00600001      CryogenicPlate2
hs00600002      0.9  1.0
hs00600100  -1  2  0.0
hs00600101     0.0025    4
hs00600200  -1
hs00600201     copper   4
hs00600300     0
hs00600400     1  110  ext 0.0 1.0  100.  100.  1.  1.0
hs00600401     0.6  gray-gas-a  0.35
hs00600500     0.01258  0.190  0.190
hs00600600     8600  20  ext 0.0 1.0
hs00600800  -1
hs00600801     80.0  5
*
hs00601000     5  1  -1
hs00601001     CryogenicPlate2
hs00601002     0.9  1.0
hs00601100  -1  2  0.0
hs00601101     0.0025    4
hs00601200  -1
hs00601201     copper   4
hs00601300     0
hs00601400     1  110  ext 0.0 1.0  100.  100.  1.  1.0
hs00601401     0.6  gray-gas-a  0.35
hs00601500     0.01258  0.190  0.190
hs00601600     8601  20  ext 0.0 1.0
hs00601800  -1
hs00601801     80.0  5
*
hs00602000     5  1  -1
hs00602001     CryogenicPlate2
hs00602002     0.9  1.0
hs00602100  -1  2  0.0
hs00602101     0.0025    4
hs00602200  -1
hs00602201     copper   4
hs00602300     0
hs00602400     1  110  ext 0.0 1.0  100.  100.  1.  1.0
hs00602401     0.6  gray-gas-a  0.35
hs00602500     0.0125  0.190  0.190
hs00602600     8602  20  ext 0.0 1.0
hs00602800  -1
hs00602801     80.0  5
*
hs00603000     5  1  -1
hs00603001     CryogenicPlate2
hs00603002     0.9  1.0
hs00603100  -1  2  0.0
hs00603101     0.0025    4
hs00603200  -1
hs00603201     copper   4
hs00603300     0
hs00603400     1  110  ext 0.0 1.0  100.  100.  1.  1.0
hs00603401     0.6  gray-gas-a  0.35
hs00603500     0.0125  0.190  0.190
hs00603600     8603  20  ext 0.0 1.0
hs00603800  -1
hs00603801     80.0  5
*
*
cf60000  tc5   tab-fun   1   1.0       0.0   *
cf60001  80.0                                * initial value
cf60003  780                                   * table
cf60010  1.0   0.0     time                  * tnew
*
tf78000    tc5    4   1.0    273.
tf780a1     0.0  -174.
tf780a2    40.0  -80.0
tf780a3   540.0  -100.
```

```
tf780a4   720.0  -87.3
*
cf60100  tc6   tab-fun   1   1.0       0.0   *
cf60101  80.0                                * initial value
cf60103  781                                   * table
cf60110  1.0   0.0      time                 * tnew
*
tf78100    tc6    4   1.0    273.
tf781a1     0.0  -174.
tf781a2    40.0  -104.
tf781a3   200.0  -120.
tf781a4   720.0  -128.
*
cf60200  tc7   tab-fun   1   1.0       0.0   *
cf60201  80.0                                * initial value
cf60203  782                                   * table
cf60210  1.0   0.0      time                 * tnew
*
tf78200    tc7    4   1.0    273.
tf782a1     0.0  -174.
tf782a2    40.0  -140.
tf782a3   140.0  -145.
tf782a4   720.0  -150.
*
cf60300  tc8   tab-fun   1   1.0       0.0   *
cf60301  80.0                                * initial value
cf60303  783                                   * table
cf60310  1.0   0.0      time                 * tnew
*
tf78300    tc8    4   1.0    273.
tf783a1     0.0  -174.
tf783a2    40.0  -134.
tf783a3   140.0  -145.
tf783a4   720.0  -150.
* *
cf84200  vapmas   add   2  1.0   0.0            *
cf84201  0.0                                    * initial value
cf84210  1.0     0.0      cvh-mass.3.100    *
cf84211  1.0     0.0      cvh-mass.3.110    *
*
cf84300  liqmas   add   2  1.0   0.0            *
cf84301  0.0                                    * initial value
cf84310  1.0     0.0      cvh-mass.1.100    *
cf84311  1.0     0.0      cvh-mass.1.110    *
*
cf84400  liqmas   add   2  1.0   0.0            *
cf84401  0.0                                    * initial value
cf84410  1.0     0.0      cvh-mass.2.100    *
cf84411  1.0     0.0      cvh-mass.2.110    *
*
******************************************************************************
*** protective lid
******************************************************************************
******************************************************************************
*** protective lid
******************************************************************************
hs00690000   5  1  -1
hs00690001   Floor #1  of VV
hs00690002   0.8985   -1.e-7
hs00690100  -1  1  0.0
hs00690101   1.e-5       2
hs00690102   1.e-4       3
hs00690103   0.75e-3     4
hs00690104   1.50e-3     5
hs00690200  -1
hs00690201   fullss   4
hs00690300   0
hs00690400   6636 110  EXT  0.0  1.0
hs00690401   0.6  gray-gas-a  0.35
hs00690500   0.1  0.30  0.30
hs00690600   7900 100  EXT  0.0  1.0
```

```
hs00690700   0.1  0.3  0.3
hs00690800  -1
hs00690801   423.0  5
*
hs01690000   5  1  -1
hs01690001   Floor #1  of VV
hs01690002   0.8985   -1.e-7
hs01690100  -1  1  0.0
hs01690101   1.e-5       2
hs01690102   1.e-4       3
hs01690103   0.75e-3     4
hs01690104   1.50e-3     5
hs01690200  -1
hs01690201   STAINLESS-STEEL   4
hs01690300   0
hs01690400   1 110  EXT  0.0  1.0
hs01690401   0.6  gray-gas-a  0.35
hs01690500   0.005  0.30  0.30
hs01690600   7900 100  EXT  0.0  1.0
hs01690700   0.005  0.3  0.3
hs01690800  -1
hs01690801   423.0  5
*
hs00692000   5  1  -1
hs00692001   Floor #1  of VV
hs00692002   0.70  1.0
hs00692100  -1  1  0.0
hs00692101   1.e-5       2
hs00692102   1.e-4       3
hs00692103   0.75e-3     4
hs00692104   1.50e-3     5
hs00692200  -1
hs00692201   STAINLESS-STEEL   4
hs00692300   0
hs00692400   1  100  EXT  1.0  1.0
hs00692401   0.6  gray-gas-a  0.35
hs00692500   0.19  0.2  0.2
hs00692600   7900 100  EXT  1.0  1.0
hs00692700   0.19  0.2  0.2
hs00692800  -1
hs00692801   423.0  5
*
hs00691000   5  1  -1
hs00691001   Floor #1  of VV
hs00691002   0.70  1.0
hs00691100  -1  1  0.0
hs00691101   1.e-5       2
hs00691102   1.e-4       3
hs00691103   0.75e-3     4
hs00691104   1.50e-3     5
hs00691200  -1
hs00691201   STAINLESS-STEEL   4
hs00691300   0
hs00691400   1  100  EXT  1.0  1.0
hs00691401   0.6  gray-gas-a  0.35
hs00691500   0.07  0.2 0.2
hs00691600   7900 100  EXT  1.0  1.0
hs00691700   0.07  0.2 0.2
hs00691800  -1
hs00691801   423.0  5
*
cf90000  qsurf   tab-fun   1   1.0   0.0
cf90001  10.
cf90003  901
cf90010  1.0   0.0   hs-temp.0069001
*
tf90100    q    3  0.0  0.0   * heaters are off ..........
tf901a1     0.0  850.
tf901a2   436.0  850.
tf901a3   438.0  0.
*
```

```
*****************************************************************************
cf63000  mtot   add   5    1.0   0.0            *
cf63001  0.001                                  * initial value
cf63010  1.0     0.0      cvh-mass.1.110        * m1
cf63011  1.0     0.0      cvh-mass.2.110        * m2
cf63012  1.0     0.0      cvh-mass.3.110        * m3
cf63013  1.0     0.0      cvh-mass.5.110        * m4
cf63014  1.0     0.0      cvh-mass.6.110        * m5
*
cf63100  mtot   add   3    1.0   0.0            *
cf63101  0.001                                  * initial value
cf63110  1.0     0.0      cvh-mass.3.110        * m3
cf63111  1.0     0.0      cvh-mass.5.110        * m4
cf63112  1.0     0.0      cvh-mass.6.110        * m5
*
cf63200  qual   divide   2    1.0   0.0            *
cf63201  1.0                                    * initial value
cf63210  1.0     0.0      cfvalu.630            * m1
cf63211  1.0     0.0      cfvalu.631            * m2
*
cf63300  1mq   add   2    1.0   0.0            *
cf63301  0.0                                    * initial value
cf63310  0.0     1.0      time                  * m1
cf63312 -1.0     0.0      cfvalu.632            * m2
*
cf63400  hvap   multiply   2    1.0   0.0            *
cf63401  15.                                    * initial value
cf63410  1.0     0.0      hs-htc-atms-l.01690   * hvap
cf63412  1.0     0.0      cfvalu.632            * qual
*
cf63500  hliq   multiply   2    1.0   0.0            *
cf63501  0.                                     * initial value
cf63510  1.0     0.0      cfvalu.400            * hliq
cf63512  1.0     0.0      cfvalu.633            * 1-qual
*
cf63600  htot   add   2    1.0   0.0            *
cf63601  15.                                    * initial value
cf63610  1.0     0.0      cfvalu.634            * h1
cf63612  1.0     0.0      cfvalu.635            * h2
*
*****************************************************************************
*** protective shield (no conduction or radiation incuded)
*****************************************************************************
hs00695000   5  1  -1
hs00695001   shield #1
hs00695002   0.9   1.0
hs00695100  -1  1  0.0
hs00695101   1.0e-4     2
hs00695102   1.0e-3     3
hs00695103   1.9e-3     4
hs00695104   2.0e-3     5
hs00695200  -1
hs00695201   fullss   4
hs00695300   0
hs00695400   1  105  EXT  0.0  1.0
hs00695401   0.6  gray-gas-a  0.35
hs00695500   0.069  0.23  0.23
hs00695600    1   110  EXT  0.0  1.0
hs00695601   0.6  gray-gas-a  0.35
hs00695700   0.069  0.23  0.23
hs00695800  -1
hs00695801   423.0  5
*
hs00696000   5  1  -1
hs00696001   shield #2
hs00696002   1.132  -0.5
hs00696100  -1  1  0.0
hs00696101   1.0e-4       2
hs00696102   1.0e-3     3
hs00696103   1.9e-3     4
hs00696104   2.0e-3     5
```

```
hs00696200  -1
hs00696201   fullss   4
hs00696300   0
hs00696400   1  105  EXT  0.0  1.0
hs00696401   0.6  gray-gas-a  0.35
hs00696500   0.069  0.15  0.15
hs00696600   1   110  EXT  0.0  1.0
hs00696601   0.6  gray-gas-a  0.35
hs00696700   0.069  0.15  0.15
hs00696800  -1
hs00696801   423.0  5
*
hs00697000   5  1  -1
hs00697001   shield #2
hs00697002   1.132  -0.5
hs00697100  -1  1  0.0
hs00697101   1.0e-4      2
hs00697102   1.0e-3     3
hs00697103   1.9e-3     4
hs00697104   2.0e-3     5
hs00697200  -1
hs00697201   fullss   4
hs00697300   0
hs00697400   1  105  EXT  0.0  1.0
hs00697401   0.6  gray-gas-a  0.35
hs00697500   0.005  0.15  0.15
hs00697600   1 110  EXT  0.0  1.0
hs00697601   0.6  gray-gas-a  0.35
hs00697700   0.005  0.15  0.15
hs00697800  -1
hs00697801   423.0  5
*
cf63700  hvap   multiply   2    1.0   0.0            *
cf63701  15.                                      * initial value
cf63710  1.0     0.0      hs-htc-atms-r.00697   * hvap
cf63712  1.0     0.0      cfvalu.632            * qual
*
cf63800  hliq   multiply   2    1.0   0.0            *
cf63801  0.                                       * initial value
cf63810  1.0     0.0      cfvalu.400            * hliq
cf63812  1.0     0.0      cfvalu.633            * 1-qual
*
cf63900  htot   add   2    1.0   0.0              *
cf63901  15.                                      * initial value
cf63910  1.0     0.0      cfvalu.637            * h1
cf63912  1.0     0.0      cfvalu.638            * h2
**
cf85300  sum1   add   2   1.0   0.0             *
cf85301  1.0                                      * initial value
cf85310  1.0     0.0      cvh-volvap.110    *
cf85311  1.0     0.0      cvh-volfog.110    *
*
cf85400  sum2   add   3   1.0   0.0             *
cf85401  1.0                                      * initial value
cf85410  1.0     0.0      cvh-volvap.110    *
cf85411  1.0     0.0      cvh-volfog.110    *
cf85412  1.0     0.0      cvh-volliq.110    *
*
cf85500  void110   divide   2   1.0   0.0            *
cf85501  1.0                                      * initial value
cf85510  1.0     0.0      cfvalu.854        *
cf85511  1.0     0.0      cfvalu.853        *
*
* * * total
cf91000  msteam   add   4    1.   0.0            *
cf91001  0.0                                      * initial value
cf91010  1.0     0.0     cvh-mass.3.100         * m1
cf91011  1.0     0.0     cvh-mass.3.101         * m2
cf91012  1.0     0.0     cvh-mass.3.105      * m3
cf91013  1.0     0.0     cvh-mass.3.110         * m4
*
```

```
cf91500  mliq    add   4    1.   0.0            *
cf91501  0.0                                     * initial value
cf91510  1.0     0.0     cvh-mass.1.100          * m1
cf91511  1.0     0.0     cvh-mass.1.101          * m2
cf91512  1.0     0.0     cvh-mass.1.105      * m3
cf91513  1.0     0.0     cvh-mass.1.110          * m4
*
********************************************************************************
**** MATERIAL PROPERTIES
********************************************************************************
**** STEEL & COPPER
********************************************************************************
************************************************
*
mpmat00200       fullss    *SADL
mpmat00201       cps       4
mpmat00202       rho       6
mpmat00203       thc       7
*
tf00400  cps   44     1.0      0.0
tf00401  0     0
tf004a2  10.0 7.164
tf004a3  20.0 9.766
tf004a4  30.0 28.839
tf004a5  40.0 58.473
tf004a6  50.0 94.094
tf004a7  60.0 132.260
tf004a8  70.0 170.470
tf004a9  80.0 207.008
tf004b1  90.0 240.787
tf004b2  100.0 271.218
tf004b3  110.0 298.094
tf004b4  120.0 321.486
tf004b5  130.0 341.657
tf004b6  140.0 358.990
tf004b7  150.0 373.921
tf004b8  160.0 386.894
tf004b9  170.0 398.326
tf004c1  180.0 408.574
tf004c2  190.0 417.925
tf004c3  200.0 426.584
tf004c4  210.0 434.679
tf004c5  220.0 442.270
tf004c6  230.0 449.364
tf004c7  240.0 455.942
tf004c8  250.0 461.986
tf004c9  260.0 467.515
tf004d1  270.0 472.625
tf004d2  280.0 477.529
tf004d3  290.0 482.608
tf004d4  300.0 488.457
tf004d5  400.0 492.231
tf004d6  500.0 513.306
tf004d7  600.0 534.399
tf004d8  700.0 555.510
tf004d9  800.0 576.637
tf004e1  900.0 597.782
tf004e2  1000.0 618.945
tf004e3  1100.0 640.124
tf004e4  1200.0 661.321
tf004e5  1300.0 682.535
tf004e6  1400.0 703.767
tf004e7  1500.0 725.016
tf004e8  1600.0 746.282
tf004e9  1700.0 761.818
*
tf00600  rho   2       1.0     0.0
tf00601  0     0
tf006a3  300.0 7957.986
tf006b8 1700.0 7957.986
*
```

```
tf00700  thc   44     1.0      0.0
tf00701  0     0
tf007a2  10.0 .5184
tf007a3  20.0 2.025
tf007a4  30.0 3.363
tf007a5  40.0 4.549
tf007a6  50.0 5.597
tf007a7  60.0 6.523
tf007a8  70.0 7.342
tf007a9  80.0 8.065
tf007b1  90.0 8.705
tf007b2  100.0 9.274
tf007b3  110.0 9.782
tf007b4  120.0 10.239
tf007b5  130.0 10.652
tf007b6  140.0 11.031
tf007b7  150.0 11.381
tf007b8  160.0 11.708
tf007b9  170.0 12.019
tf007c1  180.0 12.316
tf007c2  190.0 12.604
tf007c3  200.0 12.884
tf007c4  210.0 13.158
tf007c5  220.0 13.427
tf007c6  230.0 13.690
tf007c7  240.0 13.947
tf007c8  250.0 14.195
tf007c9  260.0 14.431
tf007d1  270.0 14.652
tf007d2  280.0 14.852
tf007d3  290.0 15.027
tf007d4  300.0 15.170
tf007d5  400.0 15.472
tf007d6  500.0 16.906
tf007d7  600.0 18.340
tf007d8  700.0 19.774
tf007d9  800.0 21.208
tf007e1  900.0 22.642
tf007e2  1000.0 24.076
tf007e3  1100.0 25.510
tf007e4  1200.0 26.944
tf007e5  1300.0 28.378
tf007e6  1400.0 29.812
tf007e7  1500.0 31.246
tf007e8  1600.0 32.680
tf007e9  1700.0 33.727
*

mpmat00400  copper
mpmat00401  rho  11
mpmat00402  cps  12
mpmat00403  thc  13
********************************************************************************
tf01100     rho  1  1.0  0.0
tf011a1    60.0  8861.
********************************************************************************
tf01200     cps  4  1.0  0.0
tf012a1    60.0  385.
tf012a2   180.0  399.
tf012a3   280.0  411.
tf012a4   380.0  420.
********************************************************************************
tf01300     thc  4  1.23  0.0    * keff include shape factor
tf013a1    60.0  348.
tf013a2   180.0  335.
tf013a3   280.0  323.
tf013a4   380.0  310.
*********************************************************************************
**** flux meters
*********************************************************************************
mpmat00500  flxmtr
```

```
mpmat00501  rho  14
mpmat00502  cps  15
mpmat00503  thc  16
********************************************************************************
tf01400     rho  1  1.0  0.0
tf014a1    60.0  8861.
********************************************************************************
tf01500     cps  4  1.0  0.0
tf015a1    60.0  385.
tf015a2   180.0  399.
tf015a3   280.0  411.
tf015a4   380.0  420.
********************************************************************************
tf01600     thc  2  1.   0.0    * keff gap cond 125 w/m2
tf016a1    60.0  0.625
tf016a2   380.0  0.625
********************************************************************************
*** Temperature Tables
********************************************************************************
tf10000    TopVV     2   1.0   0.0
tf100a1    0.0    438.0
tf100a2 100000.0  438.0
********************************************************************************
tf20000    External  2   1.0   0.0
tf200a1    0.0    438.0
tf200a2 100000.0  438.0
********************************************************************************
*** Velocity for time independent flow
********************************************************************************
tf50000    volume10-100   3   1.0  0.0
tf500a1    0.0     0.0221
tf500a4   720.0    0.0221
tf500a5   721.0    0.0
********************************************************************************
*** Cyro Plates
********************************************************************************
tf60000    cyrotemp  2   1.0   0.0
tf600a1    0.0    80.0
tf600a2 100000.0  80.0
********************************************************************************
*
* * * hsurf vs tsurf
tf90000  hcvst   54     1.0      0.0
tf900a2   80.0373      179.047
tf900a3   81.8420      179.044
tf900a4   82.1317      590.149
tf900a5   82.4193      960.235
tf900a6   82.7038      1343.99
tf900a7   82.9845      1727.29
tf900a8   84.3147      3621.27
tf900a9   85.4895      5416.11
tf900b1   86.6618      7339.03
tf900b2   88.2774      10062.2
tf900b3   90.9171      15408.9
tf900b4   92.9825      19705.6
tf900b5   95.7970      25938.4
tf900b6   97.9000      30826.7
tf900b7   99.7520      35257.4
tf900b8   101.948      40633.9
tf900b9   103.850      45355.6
tf900c1   105.125      48540.6
tf900c2   105.468      45941.1
tf900c3   105.820      40744.5
tf900c4   106.176      36136.8
tf900c5   106.538      32035.9
tf900c6   106.913      28337.9
tf900c7   107.317      24894.2
tf900c8   107.787      21483.4
tf900c9   108.403      17812.0
tf900d1   109.329      13643.3
tf900d2   110.836      9165.31
```

```
tf900d3   113.052      5499.71
tf900d4   115.374      3585.23
tf900d5   117.761      2456.24
tf900d6   120.186      1764.35
tf900d7   122.629      1316.68
tf900d8   125.075      1016.35
tf900d9   127.507      824.924
tf900e1   129.907      693.364
tf900e2   132.273      587.331
tf900e3   134.605      502.485
tf900e4   142.786      303.824
tf900e5   151.686      231.846
tf900e6   154.212      175.716
tf900e7   169.075      172.955
tf900e8   178.746      171.489
tf900e9   202.060      172.967
tf900f2   249.134      176.674
tf900f3   276.239      179.800
tf900f4   301.293      182.962
tf900f5   324.446      185.511
tf900f6   351.597      189.161
tf900f7   376.037      191.741
tf900f8   400.438      194.260
tf900f9   424.235      197.287
tf900g1   450.312      200.831
tf900g2   469.705      203.595
.
*eor* melcor
*
title   'EVITA-model #_7_10'
crtout
outputfile   evita_7_10.out
diagfile     evita_7_10.dia
restartfile  evita_7_10.res
messagefile  evita_7_10.mes
plotfile     evita_7_10.ptf
*
jobid   'EVITA'
nocopy
cymesf       20  100
cpuleft      20.0
cpulim       1.e10
tend        720.0
warninglevel 1,2,1
*cvhtrace
forceplot    1.0e-6,0
*sc00001     4201      0.01       1   * C in Sherwood condensation
*restart      41077
*restart      0
*
*           TIME    DTMAX     DTMIN     DTEDT   DTPLT  DTRST
time1        0.0    0.00005    1.e-15      2.0   0.1    10.0
time2        0.01   0.0002     1.e-15      2.0   0.1    10.0
time3        0.1    0.0005     1.e-15      2.0   0.1    10.0
time4        0.2    0.005     1.e-15      2.0   0.1    10.0
time5        0.5    0.01      1.e-15      2.0   0.1    10.0
time6        2.0    0.02      1.e-15      2.0   0.1    10.0
time7       12.0    0.05      1.e-15     10.0   0.2    10.0
time8       20.0    0.050     1.e-15     50.0   1.0    10.0
time9      100.0    0.050     1.e-15     50.0   2.0    20.0
time10     270.0    0.05      1.e-15     50.0   2.0    20.0
time11     310.0    0.05      1.e-15     50.0   2.0    20.0
*  end of input
.
```