Loss of Coolant Accident in a Natural Circulation Cooled Advanced Boiling Water Reactor

Phil Benavides, Jay Breitlow, Nick Lingler, Justin Thomas and Shripad T. Revankar

School of Nuclear Engineering
Purdue University
West Lafayette, IN 47907

Abstract
This research involved undergraduate students to perform safety analyses of an advanced light water reactor designs and to observe flow phenomena that occur during LOCA. Both experimental and computational methods were developed. The design and construction of a small experimental facility capable of modeling specific aspects of phenomena during LOCA and the development of a thermal-hydraulics model for the facility were implemented. This facility was completed by first performing detailed scaling methods, which allowed for design and development of a physical experimental facility to produce and gather data, followed by modeling with RELAP5 thermalhydraulics codes to compare physical data to computationally generated data.

1. Introduction

The U.S. Department of Energy (DOE) supports research in development of advanced nuclear reactors referred as Generation III and IV. It is expected that these advanced reactors have significant improvements over existing reactors in safety, economics, and proliferation resistance. The advanced light water reactor (ALWR) of focus in this study is the GE Simplified Boiling Water Reactor (SBWR), which has enhanced safety by implementing passive safety systems and simplifying the BWR design [1]. The goal of this work was to introduce Purdue’s nuclear engineering students to the field of safety analysis of ALWR designs. This is done via exposure to the newly redesigned experimental facility to model phenomena during ALWR loss-of-coolant-accidents (LOCAs). Accompanying the facility, the thermal-hydraulic computational models have been developed using RELAP5. An existing blowdown facility which was used to simulate LOCA in a BWR was used in this study. The previous facility was small and had not been scaled to a BWR prototype, and was used as an educational tool that models local phenomena. In this study this facility was modified to model LOCA in an ALWR. The project objectives were: (1) to perform scaling analysis and successfully design and develop an experiment to model a LOCA in an ALWR; (3) to developed a RELAP5 model for the transient analysis and (4) to compare experimental data to the code results. The General Electric designed simplified boiling water reactor (SBWR) of 600 MWe [1] was used as the prototype reactor in this study.
The SBWR uses passive safety systems. The reactor safety systems are the gravity driven cooling system (GDCS) and the automatic depressurization system (ADS). The ADS is designed to rapidly depressurize the reactor pressure vessel (RPV) vessel following the receipt of a low vessel water level signal. This system is made up of both Safety Relief Valves (SRV) and Depressurization Valves (DPV). The depressurization of the reactor vessel allows gravity injection from the GDCS. For long term cooling of the drywell (DW), passive containment cooling system (PCCS) is used to condense steam from the DW. This PCCS is in addition to an isolation condenser system (ICS) which is connected to RPV. The steam from the DW is condensed through the PCCS condenser and is returned to the reactor vessel. The PCCS non-condensable vent line purges non-condensable gas into the suppression pool (SP). In the later stage of the blowdown phase during an accident, temperature stratification is formed in the SP water. PCCS purges the uncondensed steam to this hot temperature stratification layer, which turn raises the SP pressure.

2. Scaling

2.1 Scaling Approach

The scaling was based on the methodology developed for the design of an integral test facility at Purdue University [2-5]. The scaling relies on one-dimensional area averaged continuity, integral momentum and energy equations for single-phase flow. For a two-phase natural circulation system, similarity groups have been developed from a perturbation analysis based on the one-dimensional drift flux model. This scaling method consists of three levels of scaling detail. These levels, which will be explained in greater detail, are: (1) Integral System Scaling which is applied to the system circulation paths, (2) Mass and Energy Inventory and Boundary Flow Scaling which is applied in order to preserve integral mass and energy inventory, and (3) Local Phenomena Scaling to preserve the similarity of local phenomena such as choking, condensation and bubble rise time.

2.1.1 First Level – Integral System Scaling

Since many components operate under single phase as well as two-phase flow conditions, the overall system scaling should consistently satisfy both single phase and two-phase flow scaling criteria. Because of this, single phase and two-phase flow criteria are imposed simultaneously. It can also be shown that the two-phase flow scaling criteria can satisfy the requirements of the single phase flow scaling criteria. Each component is considered to have a thermal energy source, energy sink and connecting flow path. For a natural circulation loop under single phase flow conditions, the similarity criteria are obtained from the integral effects of the local conservations of mass, momentum and energy along the entire flow path. These conservation equations used with the appropriate boundary conditions and solid structure energy equations to derive important dimensionless physical groups that characterize geometric, kinematic, dynamic and energetic similarity parameters (such as the Richardson Number, Friction Number, Modified Stanton Number, Time Ratio Number, Heat Source Number and Biot Number). Also physical similarity groups must be defined (such as the Axial Length and Flow Area Scale). These physical similarity groups basically tell us that the ratios of the SBWR components should be the same as the ratios for the corresponding model components.
2.1.2 Second Level – Mass and Energy Inventory and Boundary Flow Scaling

Nuclear reactor systems such as the SBWR consist of many inter-connected components, so it is important to simulate the thermal-hydraulic relations between these components. The conservation principles of mass, energy and momentum govern these physical processes with the mass and energy balances being the key to the proper scaling of the inter-component relations. Note that the conservation of momentum relationship is important, but not essential, for the forces acting on the structure. Since this system, which consists of several components, the scaled mass and energy inventory histories must be preserved for the integral similarity of the thermodynamic state of each component. These important scaling criteria are obtained for the boundary mass flow and energy at the interface of between two components.

Pressure Scaling

Since the facility cannot handle the large pressures of a SBWR, the scope of our experiment is to focus on transients when at lower pressures (well into the transient at ~790 kPa or 100 psig). For the pressure scaling of this facility, two effects should be evaluated separately: (1) System pressure level, which affects all the thermal hydraulic properties of the liquid, vapor and phase changes and (2) Individual component or inter-component pressure distributions. For the SBWR the safety system typically are active at lower pressure (less than 1 MPa), a prototype pressure was used with a pressure scaling ratio of one.

2.1.3 Third Level – Local Phenomena Scaling

Throat Scaling

In order to maintain scaled mass and energy inventories it is necessary to scale the throat area between the model and the prototype by the power ratio for choked flows. In order to assure correct transition to subsonic or unchoked flow it will be necessary to preserve the diffusion characteristics of the downstream section of the nozzle. This requires that geometric similarity be maintained, and to a lesser degree that Reynolds similarity be maintained. For a break flow area, \( a_b \), with break flow velocity, \( u_b \), the boundary flow scaling requirement is given by:

\[
(a_b u_b)_r = (a_{line} u_{line})_r = (a_{line})_r (u_{line})_r = Q_r
\]

Scaling for Flows Driven by Elevation Change

The GDCS drain area obtained using scaling factors could not be used due to the high friction factors in such a small cross sectional. These friction factors would cause the GDCS exit flow rate to be slower than required. So, the GDCS instead used a larger drain line in effort to compensate for this flow rate. This larger GDCS drain line was provided with flow restriction to obtain required scaled flow rate. Prototype flow rate was calculated using conditions of the GDCS (during transients conditions), resistances for the SBWR (based on reference PUMA) and the Bernoulli equation.
2.2 Scaling Ratios

Existing RPV tank height and volume were used as the base reference geometry for scaling. Based on the RPV height, volume and area ratios were determined. The velocity ratio and volume ratio gives the power ration $Q_r = \frac{V_r}{U_r}$. At the prototypes pressure, the scaling relationships obtained from the integral system scaling and boundary flow scaling results are shown in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model to Prototype Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Pr = \frac{P_m}{P_p}$ (Pressure Ratio)</td>
<td>1</td>
</tr>
<tr>
<td>$V_r = \frac{V_m}{V_p}$ (Volume Ratio)</td>
<td>$\frac{1}{42970}$</td>
</tr>
<tr>
<td>$L_r = \frac{L_m}{L_p}$ (Height Ratio)</td>
<td>$\frac{1}{12.692}$</td>
</tr>
<tr>
<td>$A_r = \frac{A_m}{A_p}$ (Area Ratio)</td>
<td>$\frac{1}{3385}$</td>
</tr>
<tr>
<td>$U_r = L_r^{\frac{1}{2}}$ (Velocity Ratio)</td>
<td>$\frac{1}{3.563}$</td>
</tr>
<tr>
<td>$Q_r = \frac{V_r}{U_r}$ (Power Ratio)</td>
<td>$\frac{1}{12060}$</td>
</tr>
<tr>
<td>$\tau_r = L_r^{\frac{1}{2}}$ (Time Ratio)</td>
<td>$\frac{1}{3.563}$</td>
</tr>
</tbody>
</table>

2.3 Scaling Results

*RPV*: The scaled values for the RPV are shown in Table 1. Notice that the ideal and actual are the same. This is due to the scaling is based on existing RPV tank.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prototype</th>
<th>Ideal</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>669 m$^3$</td>
<td>0.01557 m$^3$</td>
<td>0.01557 m$^3$</td>
</tr>
<tr>
<td>Height</td>
<td>24.5 m</td>
<td>1.9304 m</td>
<td>1.9304 m</td>
</tr>
<tr>
<td>Area</td>
<td>27.306 m$^2$</td>
<td>0.00807 m$^2$</td>
<td>0.00807 m$^2$</td>
</tr>
</tbody>
</table>

*GDCS*: The GDCS water height is the important parameter for this experiment. This water height will determine how close the actual water volume is to the ideal water volume.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prototype (3 tanks total)</th>
<th>Ideal</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>1044 m$^3$</td>
<td>0.024 m$^3$</td>
<td>0.124 m$^3$</td>
</tr>
<tr>
<td>Height</td>
<td>6.1 m</td>
<td>0.481 m</td>
<td>0.61m</td>
</tr>
<tr>
<td>Area</td>
<td>171.15 m$^2$</td>
<td>0.051 m$^2$</td>
<td>0.203 m$^2$</td>
</tr>
<tr>
<td>Volume of H$_2$O</td>
<td>1044 m$^3$</td>
<td>0.024 m$^3$</td>
<td>0.024 m$^3$*</td>
</tr>
<tr>
<td>Height of H$_2$O</td>
<td>6.1 m</td>
<td>0.481 m</td>
<td>0.118 m*</td>
</tr>
</tbody>
</table>

* This is Ideal, Actual Height would determine the Actual Volume of H$_2$O

*Suppression Pool*: The water volume for the suppression pool is important, but not crucial for the experiment. There has to be enough water in order to condense the steam coming out of the expansion volume.
### Table 4 – Suppression Pool Comparison

<table>
<thead>
<tr>
<th></th>
<th>Prototype</th>
<th>Ideal</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume (water)</td>
<td>3255 m³</td>
<td>0.076 m³</td>
<td>**</td>
</tr>
<tr>
<td>Volume (gas)</td>
<td>3819 m³</td>
<td>0.089 m³</td>
<td>**</td>
</tr>
<tr>
<td>Height (total)</td>
<td>11.95 m</td>
<td>0.942 m</td>
<td>1.219 m</td>
</tr>
<tr>
<td>Area</td>
<td>592 m²</td>
<td>0.175 m²</td>
<td>0.156 m²</td>
</tr>
</tbody>
</table>

** This could change for each case

*Expansion Volume:* Notice that the actual volume is about 1/3 of ideal volume for the expansion volume. The previous expansion volume (from the blowdown experiment) was used for this purpose without modification. This is a distortion in scaling and may have impact on the pressurization.

### Table 5 – Expansion Volume Comparison

<table>
<thead>
<tr>
<th>Expansion Volume</th>
<th>Prototype</th>
<th>Ideal</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>5420 m³</td>
<td>0.126 m³</td>
<td>0.038 m³</td>
</tr>
<tr>
<td>Height</td>
<td>32.3 m</td>
<td>2.545 m</td>
<td>0.076 m</td>
</tr>
<tr>
<td>Area</td>
<td>592 m²</td>
<td>0.175 m²</td>
<td>0.156 m²</td>
</tr>
</tbody>
</table>

*Miscellaneous:* These are a few important scaling findings. View Appendix B in order to find all scaling calculations.

### Table 6 – Miscellaneous Results

<table>
<thead>
<tr>
<th></th>
<th>Prototype</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decay Heat</td>
<td>40 MWt</td>
<td>3.317 kW</td>
</tr>
<tr>
<td>Core Height</td>
<td>3.83 m</td>
<td>0.302 m</td>
</tr>
<tr>
<td>GDCS Mass Flow</td>
<td>429.3 kg / s</td>
<td>0.036 kg / s</td>
</tr>
<tr>
<td>K-factor</td>
<td>13.2</td>
<td>15.1</td>
</tr>
<tr>
<td>MSL Area</td>
<td>0.397 m²</td>
<td>1.173 * 10⁻⁴ m²</td>
</tr>
</tbody>
</table>

### 3. Design and Development

#### 3.1 Hardware

The design and development stage of the project is discussed in this section. From the previous facility two structures have been carried over to the new facility, the expansion chamber and the RPV, the rest of the facility was entirely redesigned. The previous suppression pool enclosure was made with steel and two each 5 cm diameter windows for visualization. New suppression pool, spargers, main steam line break were designed and constructed. By using acrylic for the suppression pool, the condensing of steam and the saturated steam flow can be easily viewed. The other major addition to the system is a Gravity Driven Cooling System (GDCS).

The RPV used for this system was chosen because it was previously used in the Boiling Water blowdown experiment. Upon inspection of the RPV, the exit holes for the top and bottom line breaks were determined to be 3/8” in diameter. It was determined that the mass flow rate
through these sized breaks would be adequate for the current tests. The top 3/8 inch penetration was used as the main steam line (MSL). This line was connected to the expansion volume as the main steam line break. No new penetrations were made to the RPV tank. The eight-kilowatt heater that was in place in the previous experiment was used without an upgrade.

Removing the old suppression pool that was essentially a large stainless steel canister and implementing a new acrylic cylinder was a major upgrade of the whole system. The suppression pool is a 0.6m diameter and 1.2 m tall acrylic cylinder. The cylinder was designed using AutoCAD. There was some small concern about the melting point of the acrylic and the temperature of the sparger, but the location of the sparger was far enough from the walls of the cylinder and there was enough water in the pool that the temperature was not a problem.

The sparger design allows steam/air injected from the expansion volume representing the drywell to pass through the bottom of the suppression pool and form a “bubbler” effect. The current sparger was made from two 2-in. stainless steel pipes with a total of one hundred and twenty 0.25-in diameter holes around the circumference of the two pipes. The sparger pipes protrude 4 inches in each direction from a tee.

A new GDCS tank was designed. The GDCS is 0.6 m tall and has an inner diameter of 25.4 cm. There are total of four ¼” half couplings and three 1” half couplings welded into the tank to provide inlet/outlet flow as well as pressure, level and temperature measurement ports. The top of the GDCS has a ball valve to serve as a manual pressure relief valve to aid the system during filling and draining. The previous ½ inch tubing on the facility was removed and replaced with ½” piping. All the piping, and the elbows, unions, couplings, tees and valves are type 304/304L Stainless Steel.

3.2 Instrumentation and Data Acquisition System (DAS)

Temperatures are measured with 1/16 inch sheathed T-type thermocouples (Omega). The thermocouple measurement error is ± 1°C. Three thermocouples were placed to measure temperature in the RPV, GDCS and the MSL break. Four pressure transducers were used to measure the GDCS level, the pressure differential at the MSL (flange) break and the absolute pressure in the RPV. The Honeywell Smart Transmitter was used to measure the RPV level during the event. The other three pressure transducers were variable reluctance Validyne pressure transducers. For water level measurement the differential pressure transducers were calibrated and calibration curves were obtained. These pressure measurement positions are shown in Figure 1. All voltage signals were received by the DAS input board (PCIM-DAS1602/16). The Data Acquisition System was based off of one PCI-DAS-TC card [6] (for temperature readings) and one PCIM-DAS1602/16 card (for voltage output for pressure/level). Labview-6 software was used to collect, store and display the data. The PCIM-DAS1602/16 [7] was a multifunction measurement and control board designed to operate in computers with PCI bus accessory slots.

More details on the design of the hardware are given in a report [8].
4. Modeling

A model of the experimental facility was developed using RELAP5/MOD3 Beta version [9]. RELAP5 is a thermal-hydraulics code that is often used to study reactor transients and to perform reactor safety analysis. The model was intended to be used in for both pre-test and post-test calculations. A pre-test calculation was used to compute proper initial conditions to use for a test, where a post-test calculation was used to compare with data and check code capability. Two models were developed for this project. The first model, called the ideal model, is a model of what the system would look like if every component were of properly scaled dimensions. The second model, called the real model, more accurately represents the actual facility. Details on the modeling of the facility with RELAP5 code are available in a report [8].

4.1 Description of the Real Model

The real model was developed to model the actual facility as closely as possible. The dimensions of components in the real model are intended to be the same as the dimensions of the components in the actual facility. A schematic of the real model is shown in Figure 2. The primary components of the system are the reactor pressure vessel (RPV), the expansion volume (EV), the suppression pool (SP), and the gravity-driven cooling system (GDCS) tank. Other components include the connecting lines between these components—such as the break lines that connect the RPV to the EV—and a system of valves.

The RPV is modeled as a vertical pipe with 27 vertically stacked volumes, as shown in Figure 3. There are four penetrations into the RPV. Two for break lines (the top and bottom break lines) and two for the GDCS (the equalization and drain lines). There are also two volumes associated with the DP penetrations in the actual system so that information can be directly obtained from...
The model to be compared to the experimentally measured DP. For a pre-test calculation where the initial conditions match the scaled initial conditions of the SBWR at operating conditions, the initial RPV water level and pressure are 1.43 m (4.7 ft) and 7.17E+6 Pa (1040 psia). For post-test calculations, the water level and pressure are set to the initial experimental values prior to the break.

The GDCS model is depicted in Figure 4. It is another vertical pipe with penetrations for the RPV equalization line and the drain line. There are volumes associated with the DP penetrations analogous to those found in the RPV. For pre-test calculations, the initial water level is set to 0.38 m (1.25 ft). The volume above the water level is filled with gas. The initial conditions (prior to equalization with the RPV) for the GDCS are room temperature and standard pressure.

The EV model is simply a horizontal pipe with 10 equally sized volumes. Since the EV is rectangular in cross-section rather than circular, the hydraulic diameter is specified appropriately for the geometry. The EV is initially full of gas at room temperature and pressure.

The SP model is shown in Figure 5. The SP tank itself is a vertical tank mostly filled with water. Since the SP tank in the facility is open to the atmosphere, a time-dependent volume, “ambient”, is used to provide a constant pressure boundary condition. The flow area at the junction where the initial water-gas interface is located is artificially reduced to try to limit unrealistic flow velocity. In reality, the SP is a large vessel with steam bubbles entering in different radial locations through a sparger that later condense via direct-contact condensation. Such phenomena, particularly with important multi-dimensional effects, are difficult if not impossible to model accurately with a one-dimensional integral code like RELAP5. Moreover, the particular model used for this project is very simple. For these reasons, it is not recommended that the model is used to study the SP in detail. More discussion on model improvements will be given at the end of this section.

For modeling a high-break LOCA, the path from the RPV to the EV is modeled using two components. The first component models the small (½” I.D. piping) line that connect to the RPV and the second component models the larger line (1” I.D. piping) that connects the smaller line to the EV. In the model, the break area (i.e. the orifice plate in the actual facility) is one of the junctions in the second line where the area is reduced and the choking and abrupt area change models are used. For ease of input specification, two valves were moved on this flow path. The valve that is located on the smaller line was moved to the junction between the RPV and the smaller line, and the valve located on the larger line was moved to the junction between the smaller and larger lines.

There is a line intended for the bottom break line when modeling to be used when modeling a low-break LOCA. However, the model has not yet been adequately tested for low-break LOCAs and it is not recommended to be used until further testing is done.

4.2 Description of the Ideal Model

Because several of the components in the actual facility are not properly scaled, the results of the actual facility will not directly scale to the prototype. It is desirable, therefore, to develop a
model of a fictitious facility that is a scaled model of the prototype in order to estimate the errors that this lack of scaling causes. The model developed for this purpose is called the ideal model. A schematic of the ideal model is given in Figure 6. The important differences between the ideal and real models are discussed here.

The drywell model is significantly different in the ideal model. In the ideal model, there is a large drywell that is scaled to the prototype. In the real model, there is only a small horizontal expansion volume. The ideal model includes a model for the automatic depressurization system (ADS). In the prototype, the ADS are a system of valves that are opened in order to quickly depressurize the RPV to allow GDCS injection to occur. In the ideal model, there are several lines that connect the RPV to the drywell and SP. These lines are connected to the RPV via valves that are opened when RPV water level and time criteria are met. There is no such system in the actual facility, so this system was added to the ideal model. The ADS lines in the ideal model are all connected to the RPV at the same elevation that the main steam line is located. To accommodate the several connecting lines, a branch component is used.

The SP in the prototype is open to the drywell via a series of horizontal vents. Therefore, the SP pressure depends on the DW pressure. As previously mentioned the SP in the actual facility is open to atmosphere and is therefore independent of the DW pressure. In order to model the SP as it appears in the prototype, the SP model in the ideal model is not connected to a time-dependent volume constant pressure boundary as it is in the real model.

5. Results

Here the results of the RELAP5 calculations and experimental data are presented and discussed. Comparisons were made between the ideal model and the real model for a pre-test calculation—starting at 7.17E+6 Pa (1040 psia)—and between the real model and experimental results for a post-test calculation—starting at approximately 6.89E+5 Pa (100 psia). Primarily, the parameters of RPV water level and pressure will be discussed. This is done for two reasons. First, these parameters are very important in studying the transient, since the RPV level determines whether the core is being cooled. Second, these quantities are measured experimentally, and can be used for comparison. The pre-test calculations are described first, followed by the post-test calculations.

The choking cross section area used was slightly larger than that of the scaled main steam break size. The consequences of the large break size caused the transient to occur must faster than it otherwise would. The RPV pressure and water level decreased rapidly. These differences had to be modeled in order to make reasonable comparisons to the real model. A modified version of the ideal model was made where the actual break size was used. In subsequent figures, the results with the scaled break will be labeled “scaled break” and those with the actual break size will be labeled “actual break.” If no such label is used, it is assumed that the break size is the actual break size used in the facility.

The results for the pre-test estimation of RPV level and pressure are shown in Figures 7 and 8 respectively. As can be seen from these two figures, the scaled and actual break sizes differ quite significantly for the ideal model. The transient is significantly longer for the case of the
scaled break and the water level and pressure do not decrease as much. The time that GDCS injection occurs can be inferred from Figure 7 as the sharp increase in water level. The GDCS injection occurs about 140 seconds sooner for the case of the actual break size. The two cases do yield approximately the same steady state conditions.

The real model can only be justifiably compared to the break-size-increased version of the ideal model. The results match very well for the first 40 seconds after the break. (Note that the break occurs at \( t=20s \), characterized by the sharp decrease in RPV pressure.) At \( t=60s \), GDCS injection occurs in the ideal model. From this point on, the model results differ. The GDCS injection rate is different in the two models. One reason for this is that the GDCS pressure is equalized to the drywell pressure in the ideal model, whereas it is equalized to the RPV pressure just before injection in the real model.

The results for the post-test calculations are compared to experimental data. The RPV level, RPV pressure, GDCS level, and break differential pressure are shown in Figures 9-12 respectively. The model results match quite well for the first 70 seconds after the break occurs. (Note that the break occurs at \( t=50 \) seconds in the figures.) At \( t=135s \), the RPV begins to actually suck in water from the expansion volume and the suppression pool. This occurs as a result of rapid condensation of steam in the expansion volume, which causes an extremely low pressure inside the expansion volume. The expansion volume then acts as a vacuum to bring water from the suppression pool to the RPV. The RELAP5 model is unable to predict this rapid condensation and pressure decrease in the expansion volume. Therefore, this phenomenon is not predicted in the model. Thus the RPV level continues decreasing in the absence of SP water entry.

Figure 2 Schematic of Real Model. In this schematic, three-digit integers written in an italics font are component numbers, labels in a bold font are component names, dark arrows describe the orientation of volumes, and dimensions are written near thin arrows and are in feet.
Figure 3: RELAP5 model of the RPV (Component 100), showing the elevation of penetrations above the bottom of the RPV in feet. There are a total of 27 volumes vertically stacked giving a total height of 76 inches.

Figure 4: The RELAP5 model for the GDCS (Component 400), showing the penetrations for the DP cell, drain line to the RPV, and the steam inlet from the RPV. The locations of the volumes that contain these penetrations are shown in detail. This model preserves the full GDCS height from end cap to end cap of 2.83’. There are a total of 11 vertically stacked volumes.
Figure 5: The RELAP5 model for the suppression pool (SP), which consists of its tank (Component 500) and the surrounding environment (Component 999) to which the SP tank is open. The environment is modeled as a constant pressure volume. The area at the air-water interface was artificially reduced to avoid unrealistic results.

Figure 6 Schematic of the Ideal Model.
Figure 7  RPV Level for Pre-Test Calculation.

Figure 8. RPV Pressure for Pre-Test Calculation
Figure 9. RPV Level for Post-Test Calculation

Figure 10. RPV Pressure for Post-Test Calculation
6. Conclusions

This completion of the facility met the objectives that were intended. ALWR safety concepts can be introduced to the undergraduate students using this facility. The experiment allows the flow visualization following a LOCA in the SBWR. The facility also introduces scaling of thermalhydraulics experiments and application of data to prototype system. The data collected...
can be compared to a RELAP5 model in order to give students some added experience with this code. The RELAP5 model has been shown to obtain good results during the early part of a large break LOCA simulation. However, it is unable to predict the increase of RPV water level because of the rapid condensation in the expansion volume. To better model the transient, the expansion volume model needs improvement.

7. Bibliography