Experimental Setup for
Chemical Head Loss Experiment (CHLE) Test Equipment
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During the Chemical Effects Summit held in the Nuclear Energy Institute offices on January 26 and 27, 2012, the Chemical Head Loss Experiment (CHLE) test equipment design was presented and discussed. This document describes the status of the design of this equipment and reflects input received from the NRC during the meeting and continued progress on the equipment design by the STP team. The test apparatus for the 30-day integrated tank tests has two main sections, as follows:

1. Material corrosion tank where materials present in containment can be placed to simulate the environment inside the containment structure during a LOCA.
2. Vertical head loss assemblies to simulate the flow conditions through a debris bed that forms on a sump screen.

A general schematic of the equipment is shown in Figure 1. The following sections describe detail on scaling parameters that will be used in the design and operation of the equipment and details of the equipment.

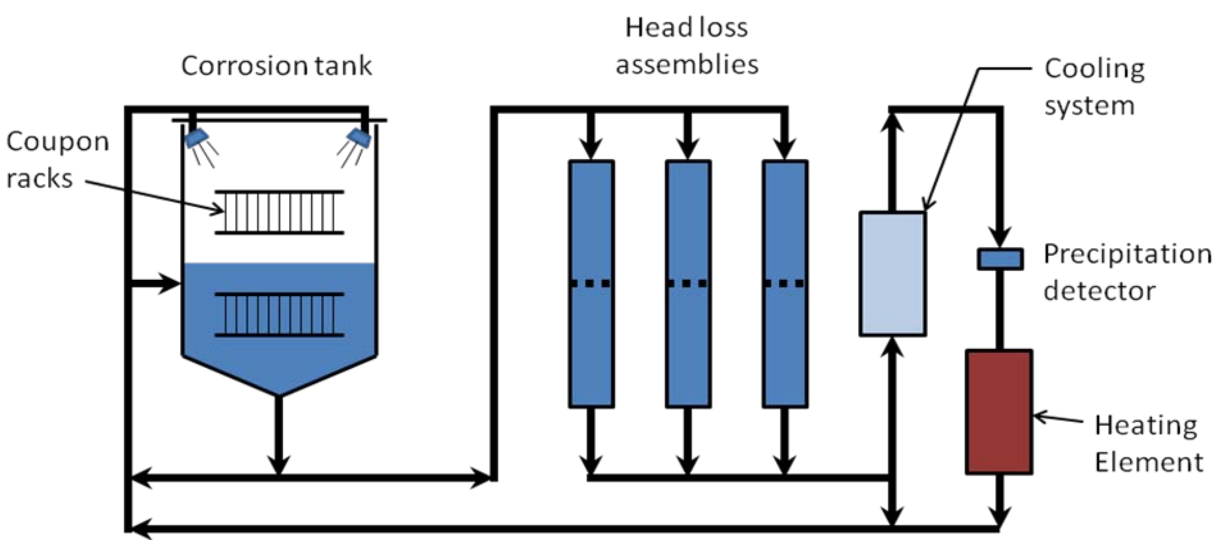

Figure 2 - Simplified Process Flow Diagram of the CHLE Test Equipment

1. CHLE Loop Design and Scaling to the STP System

Recirculation volume: The recirculation volume is the primary scaling parameter between the STP and CHLE systems. The nominal CHLE Loop volume is 250 gallons. The STP recirculation volume maximum is 668,000 gallons and minimum is 363,000 gallons. These values provide scaling parameters (STP:CHLE) of 2,670 (max) to 1,450 (min).

Sump strainer surface area: The CHLE loop has 3 parallel strainer assemblies each with a diameter of 6 inches, for a total strainer area of 0.59 ft^2. The STP strainers have area of 1,815.5 ft^2 per train. Using the scaling parameter for the maximum recirculation volume would require a total strainer area of 0.68 ft^2. Scaling to the minimum recirculation would require a total screen area of 1.25 ft^2. Thus, the CHLE system approximates the STP system at maximum pool volume with one strainer in operation. The flow in the CHLE system will pass through an area about 14 percent smaller than the area of one strainer in the STP system, which increases the mass loading per unit area over what would occur on the STP strainers. With 2 strainer trains operating at STP, the mass loading on the STP strainers will be less than half the mass loading on the CHLE system. By using a mass loading somewhat greater than the STP system, the CHLE system provides a conservative assessment of the effect of chemical precipitates on head loss.

Sump strainer loading rate: The minimum and maximum strainer flow rates are 1,620 gpm and 7,020 gpm, respectively. These rates correspond to filtration rates of 0.89 to 3.86 gpm/ft^2 or approach velocities of 0.0020 to 0.0086 ft/s. The CHLE tests will be conducted at the maximum flowrate, thus, the flowrate to each CHLE strainer will be 0.76 gpm. The total to the 3 strainer assemblies will be 2.28 gpm.

Recirculation time: At the maximum pool volume in the STP system, the recirculation time is 95 minutes at maximum flow through one strainer and 410 minutes at minimum flow through one strainer. At the minimum pool volume in the STP system, the recirculation time is 52 minutes at maximum flow through one strainer and 224 minutes at minimum flow through one strainer. Recirculation times would be decreased accordingly if 2 strainer trains were operating. At 250 gallons and a flow rate of 2.28 gpm, the recirculation time through the strainers in the CHLE loop would be 110 minutes. Thus, the recirculation times in the CHLE system are within the boundaries of the recirculation times in the STP containment.

Chemicals and materials: Chemicals and materials will be added to maintain the same (quantity)/(recirculation volume) ratios as the STP plant. Chemicals will be based on concentration (mass/volume). Metals, concrete, and coatings will be based on surface area/volume. Insulation debris will be based on volume/volume.

2. Material Corrosion Tank

The material corrosion tank is shown in Figure 2. The physical attributes of this tank are as follows:

Figure 2 - Photograph of 30-Day Integrated Corrosion Head Loss Test Tank

1. The tank is nominally 4 ft × 4 ft × 6.6 ft in height, with vertical sides and a bottom that slopes to a centrally-located discharge port and 3 polycarbonate view windows.
2. The tank is divided into upper and lower sections. The lower section is designed to accommodate 250 gal. of solution and all materials that may be submerged in containment and contribute to chemical effects. The tank contains flow injection headers below the water line on the north and south walls, which are designed to provide turbulence in the tank pool and achieve a uniform flow pattern across the submerged coupons with velocities in the 0-3 cm/s range. The injection headers are 1-in.-diameter pipe with a symmetric pattern of holes to distribute the solution discharge. The necessary flow patterns are achieved when the recirculation pump operates at 25 gpm. Flow is controlled manually with a variable speed drive on the pump and a throttle valve.
3. The upper section is designed to accommodate all materials that may be in the vapor space in containment and contribute to chemical effects by being exposed to containment sprays. Spray nozzles are located in the four corners near the top of the vapor space.
4. The tank is insulated and contains two titanium-jacketed rod-type heaters in the tank pool to maintain the temperature of the solution at a maximum of 185 °F with a range of ± 5 °F. The heaters are fully redundant; either can provide the required heating capacity so that experiments can continue in the event of failure of a single heater.
5. A recirculation pump withdraws solution from the bottom discharge port, circulates it through the instrumentation pipe loop and supplies it the vertical head loss assemblies, and reintroduces it into the material corrosion tank through the upper spray nozzles or lower flow injection headers. Throttle valves and flow meters allow the flow to be apportioned to the

spray nozzles and flow injection headers at the proper rates. The instrumentation pipe loop contains a flow meter, pressure gage, temperature sensor, pH meter, and sample port. Flow, temperature, and pH are recorded continuously by a data acquisition system, temperature is reported locally.
6. The tank is constructed of type 304 stainless steel.
7. A removable cover and gantry crane allow for placing and removing samples.

3. Vertical head loss assemblies

A schematic of the piping systems for the test equipment, including the vertical head loss assemblies, is shown in Figure 3. The physical attributes of the vertical head loss assemblies and piping systems are as follows:

1. The system will contain 3 identical vertical head loss assemblies, operated in parallel. Each consists of a 6-in diameter pipe assembly. The upper and lower portions of the pipe assembly are constructed of Sch 80 chlorinated polyvinyl chloride (CPVC) pipe. The middle section is constructed of 1/8-in thick polycarbonate to allow view of the debris bed. A schematic of the head loss assembly is shown in Figure 3.
2. The polycarbonate section will be 18-in long, with a support ring located 6-in from the bottom to support a perforated plate. This section allows a view of 6 inches below the debris bed and 12 inches above the debris bed. The top and bottom sections of the polycarbonate section will be flanged so that they can be removed from the piping system to allow the debris bed to be removed from the head loss assembly intact.

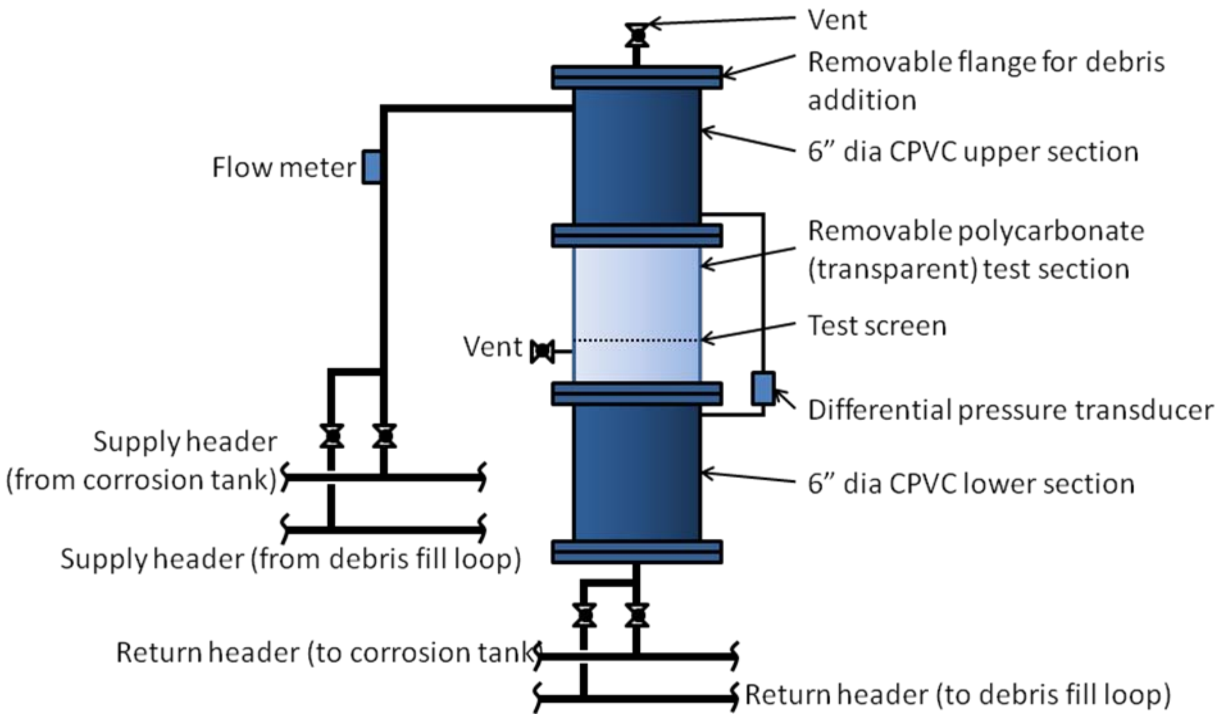

Figure 3 - Head Loss Assembly

3. Air vents will be located immediately below the support ring to allow gas to be vented from below the debris bed and at the top of the assembly.
4. The supply and discharge piping to each head loss assembly will be 1/2-in stainless steel (type 316) pipe, with either threaded or compression fittings.
5. The supply piping to each head loss assembly will have a tee to allow solution to be supplied from the material corrosion tank or from the bed formation recirculation loop (described below, see item 8). Each leg will have a ball valve for isolation.
6. The supply piping to each head loss assembly coming from the material corrosion tank will have an insertion-style magnetic flow meter.
7. The discharge piping from each head loss assembly will have a tee to allow solution to be returned to the material corrosion tank or to the bed formation recirculation loop. The leg to the material corrosion tank will have a globe valve for flow control and the leg to the bed formation recirculation loop will have a ball valve for isolation. The globe valve will also provide backpressure to prevent or minimize degassing below the debris bed due to negative pressure in the head loss assembly.
8. A separate debris bed formation recirculation loop is configured to be part of the piping system. The bed formation recirculation loop will have a pump, ball valve for throttling, and rotometer. All piping in the bed formation recirculation loop will be 3/4-in SS pipe. The bed formation recirculation loop will have a supply header and a return header so that it can provide solution to each of the three head loss assemblies independently of the others. Each head loss assemblies will have ball valves in the supply and return lines for isolation. The debris bed formation recirculation loop will have connections for filling and draining the line, equipped with ball valves and hose bibb connections.
9. The piping system will have a separate loop to do thermal cycling. This loop will have a cooling system to reduce the temperature. Following the heat exchanger will be a reservoir to provide holding time at the lower temperature. The cooled fluid will flow through a system to detect precipitates (possibly a laboratory filter with a DP cell across it). On the discharge side of the precipitation detector will be a heating system to return the fluid to the temperature of the tank.

A process flow diagram for the overall system is shown in Figure 4.

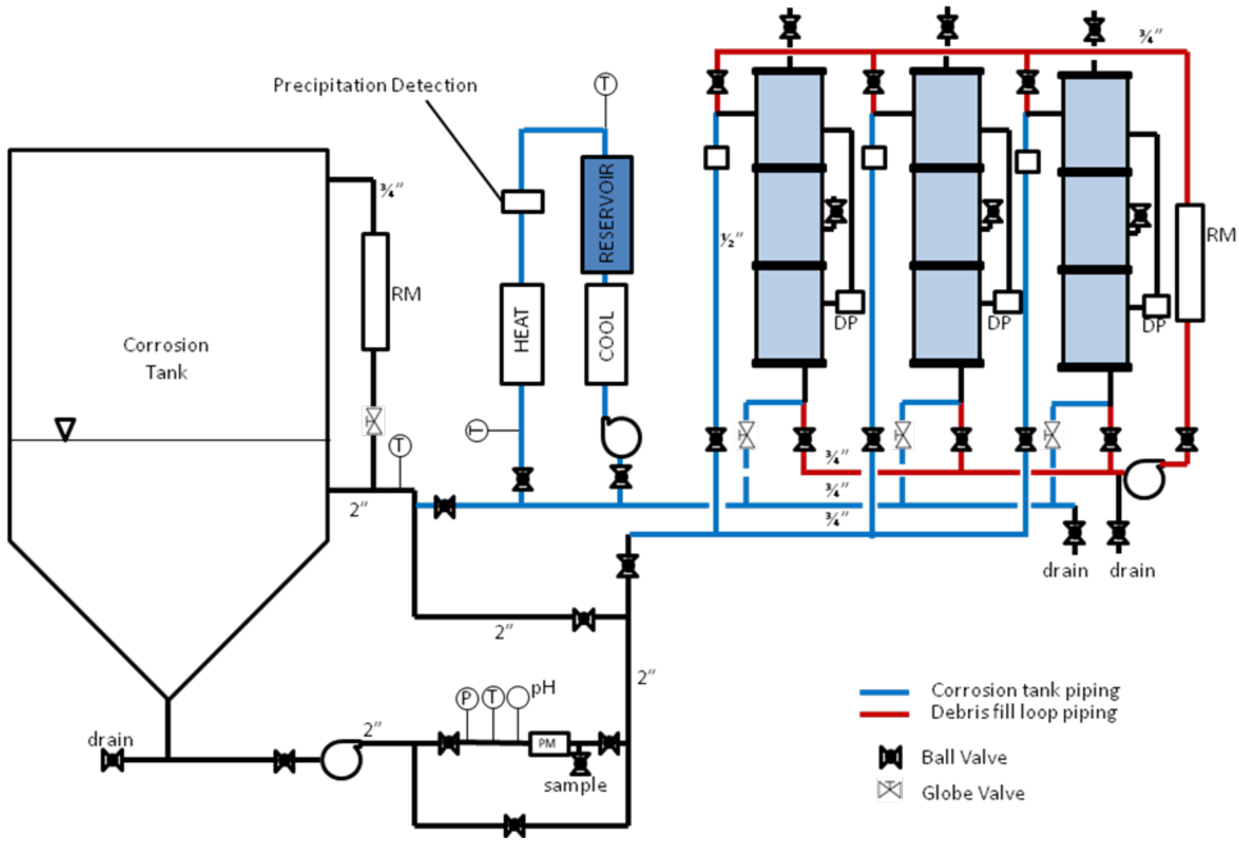

Figure 4 - Process Flow Diagram of 30-Day Integrated CHLE Test System