ATTACHMENT I

TECHNICAL DESCRIPTION
REACTOR COOLANT INVENTORY TRACKING SYSTEM (RCITS)
CONCEPTUAL DESIGN
CRYSTAL RIVER - UNIT 3
FLORIDA POWER CORPORATION

SUMMARY

The Reactor Coolant Inventory Tracking System design concept is intended to provide a continuous unambiguous control room indication of reactor vessel head and hot leg coolant inventory trending with reactor coolant pumps (RCPs) either running or tripped. The concept was designed to meet the parameters specified in NUREG-0737, item II.F.2.

The design concept encompasses the use of differential pressure (DP) measurements across vertical elevations of the hot leg and the reactor vessel to infer coolant level when the RCPs are tripped, plus the use of RCP motor current measurements and pump inlet temperatures to infer coolant inventory trends when the RCPs are running. The concept also includes density compensation for DP measurements due to temperature effects on reference leg and process liquid density.

DP measurements cover a wide range measurement from the top to the bottom of the hot leg, plus a narrow range measurement from the top of the reactor vessel (RV) head to the bottom of the hot leg. A total of four DP transmitters will be used to provide redundancy. Each pair of wide and narrow range transmitters will be independently powered by Class 1E instrumentation power. They will be mounted within the containment area. Seal chambers will be located at the high point of each reference leg to keep the legs full of water.

The design concept includes removal of a control rod drive mechanism to provide a penetration in the RV head for location of the top RV pressure tap. The top hot leg pressure tap will be located off the hot leg high point vent. Florida Power Corporation has already processed and plans to install the lower pressure tap on the decay heat suction line during the 1983 refueling outage.

Class 1E Qualified electronic analog equipment racks will be used to power the DP transmitters and process their outputs, with the reference leg and process temperature outputs, to compute the equivalent water level. The racks will provide outputs to indicators in the control room, and to the computer.

RCP inlet temperature and motor current data will be processed by the computer to provide outputs for control room indication of coolant inventory trending when the RCPs are running.

A conceptual drawing of the system is shown in Figure 1. Individual parts of the system are described in the following paragraphs.

1. TOP HOT LEG PRESSURE TAP

The top hot leg pressure tap will be located off the hot leg high point vent.

2. TOP REACTOR VESSEL PRESSURE TAP

The top reactor vessel pressure tap will be made to a penetration in the reactor vessel head presently occupied by a control rod drive mechanism.

3. SEAL CHAMBERS

A seal chamber will be installed at the high point of each reference leg to ensure that the reference leg to each DP transmitter remains full of water. The seal chambers will be water reservoirs only and will not contain a bellows or diaphragm. There will be three connections in the seal chambers. One will be at the top for connection to a vent valve, one at the bottom for connection to the reference leg of the transmitter, and the third at the center line on one end for connection to the pressure tap.

4. REMOVABLE SECTION OF RV HEAD REFERENCE LEG

A removable section of stainless steel tubing will be installed between the reactor vessel top tap and the refueling cavity wall for removal during refueling. Tubing configuration will be such as to allow for thermal expansion and movement of the reactor vessel head.

5. SUPPORT FOR REMOVABLE SECTION OF RV HEAD REFERENCE LEG

A removable support for the removable section of tubing between the RV head and the refueling cavity wall will be installed on the cavity wall to provide seismic support for the tubing.

6. BOTTOM HOT LEG PRESSURE TAP

The bottom hot leg pressure tap will be located off the decay heat suction line, and is scheduled for installation during the 1983 refueling outage by FPC.

7. DIFFERENTIAL PRESSURE TRANSMITTERS

Differential pressure transmitters, qualified as Class 1E in accordance with IEEE 323-1974, will be used.

Four transmitters will be installed, two narrow range and two wide range. Each will have provisions for zero suppression and elevation. Each pair of narrow- and wide-range transmitters will be powered independently from a separate Class 1E electrical power source. One pair will be completely redundant.

The DP transmitters will be mounted inside containment.

The narrow-range transmitters will be calibrated for approximately 12 ft of water which, when compensated for system temperature variations, will be equivalent to the level of the coolant in the reactor vessel, above the bottom of the hot leg, when the RCPs are tripped.

The wide-range transmitters will be calibrated for approximately 50 ft of water which, when compensated for system temperature variations, will be equivalent to the level of coolant within the hot leg when the RCPs are tripped.

The DP measurement system will not be functional when the RCPs are running or during venting operations. It will, however, be designed to withstand the conditions that will exist at those times without damage, and be fully recoverable afterwards.

8. REFERENCE LEG TEMPERATURE MEASUREMENT

The system design will include the use of strap-on RTDs on the vertical portions of the water-filled reference legs to provide the temperature input required to convert the DP measurement to the equivalent coolant level.

9. HOT LEG TEMPERATURE MEASUREMENT

RTDs already installed in the hot legs will provide the process water temperature input required by the DP measurement system.

10. ANALOG EQUIPMENT RACKS

Class 1E Qualified electronic analog equipment racks will be used to power the differential pressure transmitters and process the outputs to compute coolant level. The racks will contain interconnected plug-in modules which perform the functions of current to voltage conversion, summation, function generation, division, and isolation.

Two independently powered racks will be used. Each rack will process one narrow-range and one wide-range channel. Outputs of the racks will be sent to analog indicators located in the control room and to the computer.

Input and output terminals on the modules will be availble for monitoring from the front of the racks. In addition, each of the input modules will have provision for insertion of a test jack, which will disconnect the normal transmitter input and connect a test input. This will be used for calibration and troubleshooting.

11. COOLANT INVENTORY TRENDING WITH RCPs RUNNING

The system concept provides a design to track reactor coolant inventory with the RCPs running. It uses measurements of RCP motor current to infer the density of the pumped fluid. It also uses pump inlet temperature in an algorithm with the pump current measurements to derive an estimate of the pumped fluid void fraction.

Existing (non-Class 1E) current transformers and RTDs (one each per pump) are used to provide pump current and pump inlet temperature signals for input to a computer. The computer will use those two inputs to:

a. Calculate the corresponding saturated liquid and vapor densities for each temperature input.

b. Combine the densities with the pump current inputs in accordance with the void fraction algorithm.

c. Provide outputs for control room indication of the void fraction for any single pump, or the average void fraction for all pumps running, over a range of 15 to 40 percent void fraction.

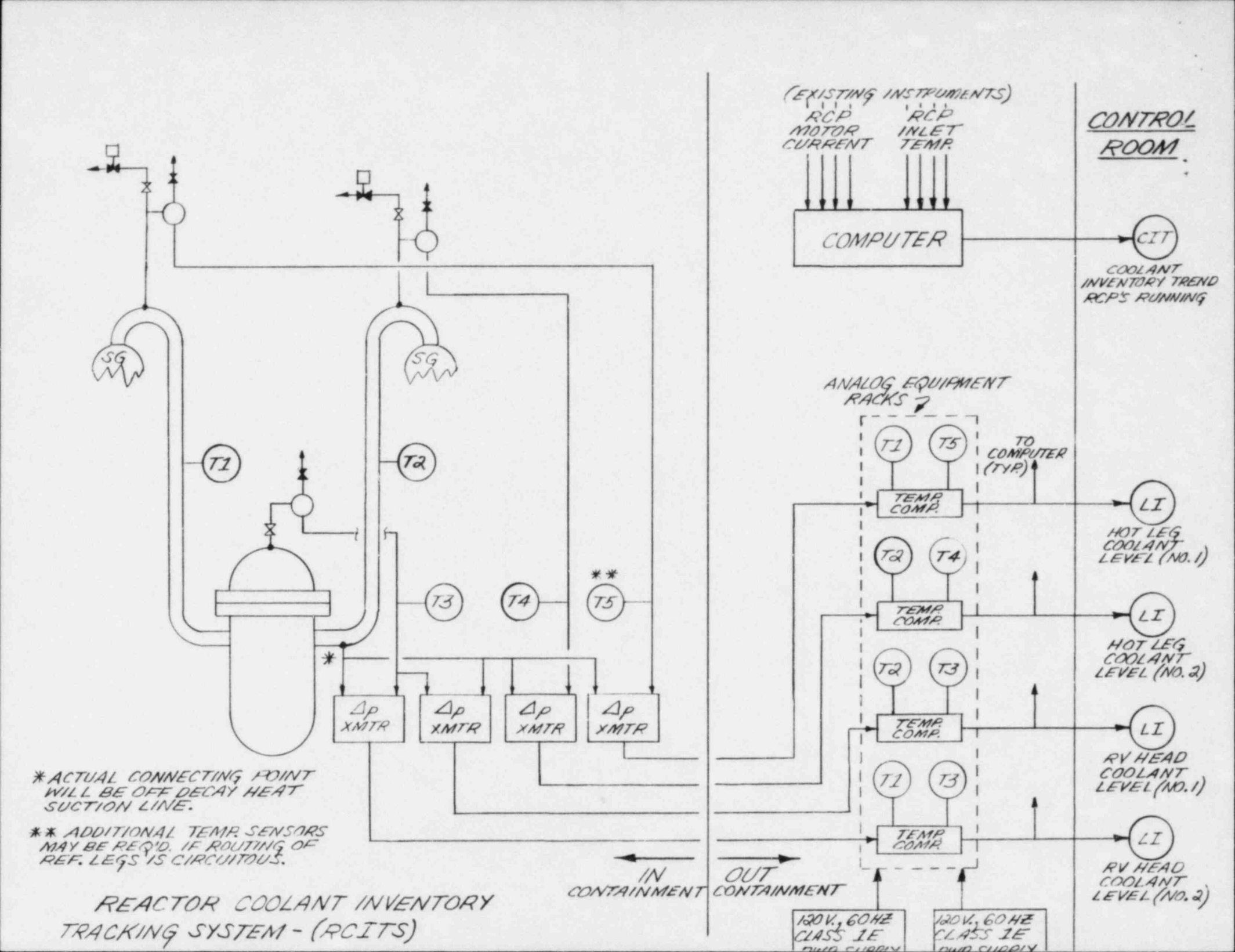
Please refer to Attachment II, entitled "Feasibility Study of Inventory Trending Methods with RC Pumps Operating."

12. CONTROL ROOM INDICATION

Analog coolant level indicators will be mounted on a panel in the control room in close proximity with the void fraction indicators.

During normal operation with the RCPs running, or during the venting operation, the data provided by the void fraction indicators will permit the operator to track the reactor coolant inventory. The coolant level indicators will read off scale high. Operational procedures will provide instructions to the operator that level indications are invalid under these conditions.

If the reactor coolant pumps are turned off and the system is not being vented, the coolant level indicators will provide a true indication of reactor coolant inventory in both the reactor and the hot legs.



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