AEOD ENGINEERING EVALUATION REPORT*

UNIT: Waterford-3
DOCKET NO.: 50-382
LICENSEE: Louisianna Power & Light Co.
NSS/AE: Combustion Engineering, Inc./
Ebasco Corp.

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DATE: August 27, 1984
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SUBJECT: LOSS OF PRESSURIZER HEATERS DURING PRECORE HOT FUNCTIONAL TESTING

EVENT DATE: March 10, 1983 (Significant Construction Deficiency No. 76)

SUMMARY

Operational experience has shown that liquid filled reference legs of level measuring instruments are vulnerable to a variety of malfunctions. When a malfunction occurs, the liquid level indication will be nonconservative and will display a higher tank level indication than the actual level of liquid in the tank. This event occurred at a unit with a construction permit, the pressurizer heaters were inadvertently uncovered and most of heaters burned out.

The inoperability of the pressurizer heaters such that the pressurizer pressure control system is ineffective is addressed in CEN-152, "Combustion Engineering Emergency Procedure Guidelines" and does not involve any new unrecognized safety issues. However, we believe that operational problems with liquid filled reference leg instrumentation will continue to occur in the future and this event should be published in the next Power Reactor Events.

*This document supports ongoing AEOD and NRC activities and does not represent the position or requirements of the responsible NRC program office.

DISCUSSION

During precore hot functional testing at Waterford-3, a plant with a construction permit, the primary coolant level in the pressurizer unknowingly decreased, uncovering the energized pressurizer heaters. This resulted in damage to most of the heaters and all thirty heaters were subsequently replaced.

The reduction of actual pressurizer level was undetected due to leaks in the instrument tubing of the liquid filled reference leg on the level instrumentation channel that had been selected to control pressurizer level. The event occurred on March 10, 1983 while the plant was being maintained at steady state conditions of 460°F and 1100 psia at a primary system test plateau. Channel "X" had been selected for pressurizer level control while previously identified leaks in the instrument tubing connections on the redundant channel "Y" system were being repaired. Throughout the afternoon, channel "X" level instrumentation incorrectly indicated an acceptable pressurizer level of approximately 40%. In the meantime, it was determined that channel "Y" had been operating correctly and did not need repairs. The control room was not informed of this fact. Channel "Y" showed the actual level in the pressurizer ranged from 31% to 2.8%.

A low-low pressurizer level signal deenergizes all pressurizer heaters to protect the heaters before they become uncovered. Channel "X" was selected for this function and due to the incorrect channel "X" level indication the pressurizer heaters were maintained energized without being covered with primary coolant. This resulted in the failure of most of the pressurizer heaters.

It was determined that the channel "X" pressurizer level measurement and control system was falsely providing higher readings due to leaks in the instrument tubing connections in the liquid filled reference leg. This leakage reduced the height of liquid that could be sustained by the condensate chamber in the reference leg. The reduction in the level of liquid in the reference leg made the indicated pressurizer liquid level appear higher than actual. Channel "Y" was providing a valid level indication and would have protected the pressurizer heaters.

The pressurizer is a cylindrical vessel of about 15% of the reactor coolant system (RCS) volume that is connected to one of the RCS hot legs by a surge line. At full load conditions, slightly more than one-half of the pressurizer is occupied by saturated water and the remainder by saturated steam. The pressurizer pressure control system (PPCS) controls the pressure of the RCS at, or near, a fixed setpoint of 2250 psia during both steady state and design transient conditions by controlling the temperature of the saturated liquid in the pressurizer through actuation of the heaters or condensing some of the steam through the use of the pressurizer spray valves. Also, the heaters

are needed to compensate for heat losses through the pressurizer vessel and the 1/2 gpm continous subcooled pressurizer spray flow provided to minimize thermal cycling of the pressurizer nozzles and spray piping.

The pressurizer heaters are direct immersion heaters that protrude vertically into the pressurizer through sleeves welded into the lower head. Approximately one-fifth of the heaters are connected to proportional controllers that adjust the heat input when the pressurizer pressure is within 25 psi of the setpoint. The remaining four banks of backup heaters are connected to on-off controllers. They energize at a decreasing presssure of 2200 psia and deenergize on an increasing pressure of 2225 psia.

The two banks of proportional heaters have a capacity of 300 KW; the backup heaters are 1200 KW. One bank of proportional heaters with a capacity of 150 KW can be loaded manually on the emergency diesel generators to provide RCS pressure control during a loss of offsite power.

The Combustion Engineering (CE) pressurizer design (see Figure 1.) has two independent measurement channels to indicate the level of coolant in the pressurizer. The level control channel, "X" or "Y", is selected by a switch on the control board. The pressurizer level control system uses the selected pressurizer level signal to maintain a programmed liquid level in the pressurizer by modulation of the letdown control valves and starting/stopping additional charging pumps. A second three position handswitch is used to select the level channels used for pressurizer heater cutoff protection. The signal to cutoff pressurizer heaters is generated by a bistable sensing low-low pressurizer level. With this arrangement, either channel "X", "Y", or an auctioneered signal which is the lowest of "X" or "Y", can be selected as the control function. Normally, the auctioneered signal is selected. Single channel selection is used only with a known failure of one of the channels. In this situation, the switch is aligned to the presumed operational liquid level channel.

Each pressurizer level indication channel is comprised of a differential pressure transducer with the high pressure port of the transducer connected to the liquid filled reference leg. The reference leg is kept full by a condensate chamber that is connected to the saturated steam bubble in the pressurizer. The chamber, by virtue of ambient cooling, continously conderses steam to keep the liquid filled reference leg full. Excess condensate flows back to the pressurizer through the upper level tap. Thus, the liquid filled reference leg is maintained full with a constant head of liquid to provide a constant static pressure on the high side of the differential pressure transducer.

Because the height of liquid in the liquid filled reference leg is assumed constant, problems arise whenever the reference leg liquid height varies. The resulting false level indications are not obvious to the operator, are

nonconservative and common mode if shared reference legs are involved. There is no way, other than comparing the readings on both level instruments, that the operator would be aware of false level indications and improper operation of associated control functions. The level indication with a partially drained reference leg will always be higher than the actual level. Finally, in shared reference leg systems, all of these instruments will display a uniformly higher indicated level than is actually present. Operating experience has shown that the liquid filled reference legs are vulnerable to a variety of malfunctions. These have included:

- o Leaks in reference leg tubing
- o Lack of sufficient condensation to maintain the reference leg full or unexpected high evaporation rates
- o Air entrapment in the liquid filled reference leg
- o Inadvertent reference leg isolation
- o And finally, many events allude to an unknown reason for discovery of a dry reference leg.

FINDINGS

Although the pressurizer heaters are not safety related, the automatic operation of the PPCS is the method of RCS pressure control most familiar to plant operators for both steady state and off-normal operating conditions. Availabilty of this system is sufficiently important that some of the pressurizer heaters can be powered from the emergency busses. This provides the capability to maintain an adequate subcooling margin during loss of offsite power to preclude void formation which could inhibit natural circulation. A review of CEN-152, "Combustion Engineering Emergency Procedure Guidelines", specifically addresses alternative means of pressure control during the loss of forced circulation. In addition, an entire section is devoted to RCS pressure control in Chapter 10, "Functional Recovery Guidelines".

Although liquid filled reference legs are vulnerable to a variety of problems, the nonshared reference legs and auctioneered signals make the possibility of pressurizer heater burnout a low probability event since it requires a combination of equipment failures and operator error.

CONCLUSIONS

The sequence of events that originated with a decrease in the liquid filled reference leg of the pressurizer level instrumentation that led to a loss of presssurizer liquid inventory and subsequent failure of most of the pressurizer heaters does not involve any new unrecognized safety concerns.

We believe that operational problems with liquid filled reference leg instrumentation will continue to occur in the future and recommend this event be published in the next Power Reactor Events.

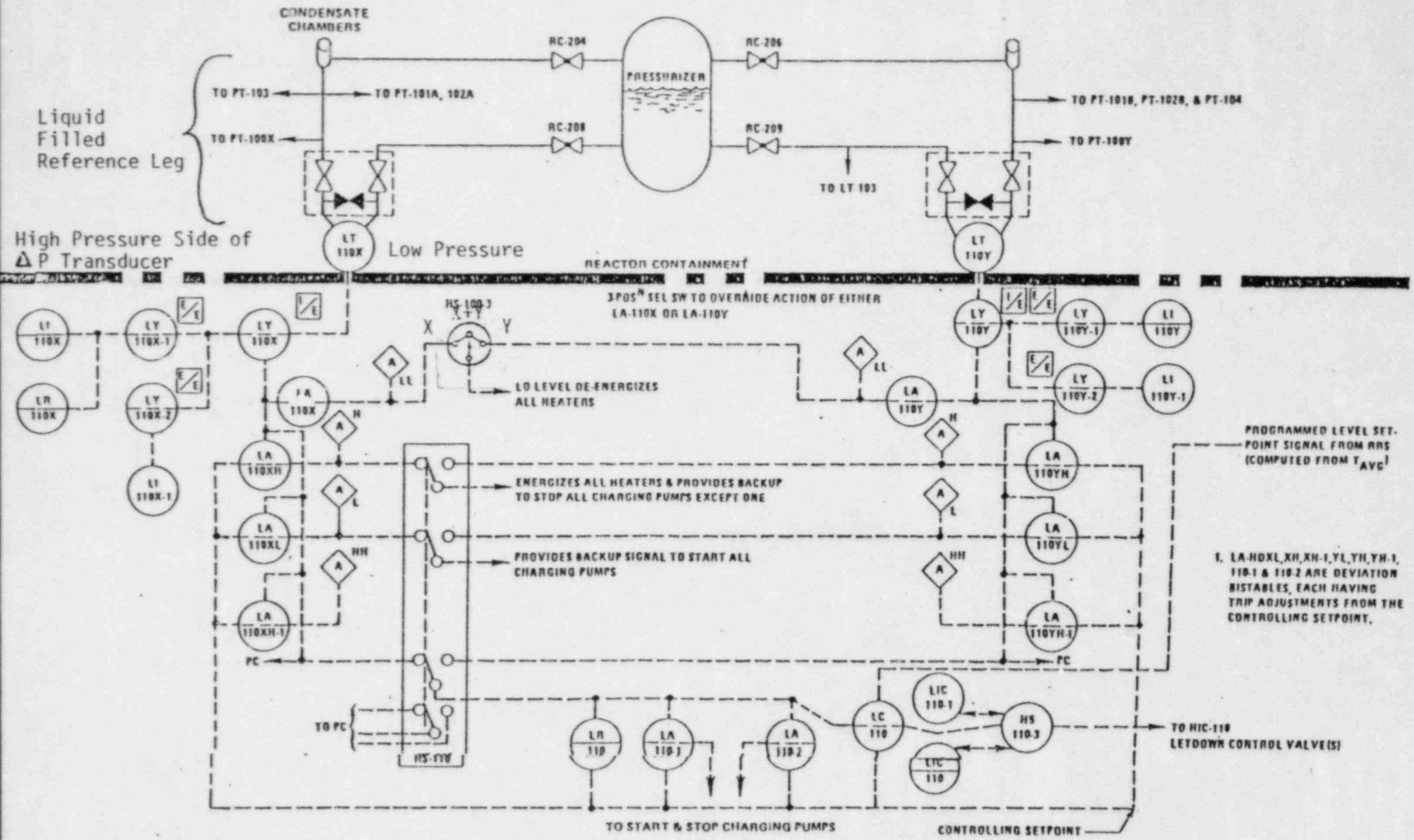

Figure 1. Pressurizer Liquid Level Instrumentation at Waterford-3