AEOD TECHNICAL REVIEW REPORT*

UNIT: Callaway 1
DOCKET NO.: 50-483
LICENSEE: Union Electric Company
NSSS/AE: Westinghouse/Bechtel

TR REPORT NO. AEOD/T504
DATE: May 17, 1985
EVALUATOR/CONTACT: R. Freeman

SUBJECT: LOSS OF INSTRUMENT AIR AND SUBSEQUENT PRESSURE TRANSIENT

EVENT DATE: July 16, 1984

REFERENCES:

(1) Licensee Event Report 84-015, Union Electric Company Callaway Unit 1, Docket No. 50-483, dated August 10, 1984.

(2) Phillip J. Potter, "Power Plant Theory and Design," 2nd edition, Ronald Press Company, New York, (1959).

SUMMARY

On July 16, 1984, with Callaway Unit 1 in cold shutdown, a pressure transient occurred in the reactor coolant system (RCS) as a result of a loss of instrument air. The loss of instrument air caused the charging pump to fail to full speed, and isolated normal letdown. A review of the chemical and volume control system (CVCS) with respect to the loss of instrument air revealed that this is a design failure mode (i.e., maximum charging and isolated letdown) for most Westinghouse CVCS designs.

Because this is an analyzed event in Callaway's Final Safety Analysis Report and pressure mitigating systems were available and mitigated the event, it is concluded that adequate RCS pressure boundary protection was maintained during this event. Since this event involved a loss of instrument air which resulted in an adverse systems interaction during low temperature plant conditions, this event will be included as a part of the AEOD air systems study. No further action on this event is deemed necessary.

INTRODUCTION

AEOD identified an event at Callaway Unit 1 in which a pressure transient occurred in the RCS while the plant was in cold shutdown. The pressurizer overpressure protection system (POPS) mitigated the pressure transient and ensured the integrity of the reactor coolant pressure boundary. This event was caused by loss of instrument air which isolated letdown flow to the CVCS (letdown isolation valves failed closed) and which increased the makeup flow to the RCS (positive displacement pump (PDP) failed to full speed).

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

DISCUSSION

Figure 1 shows a simplified schematic of a CVCS system representative of Westinghouse-designed plants. The letdown isolation valve and letdown orifice isolation valves are air-operated globe valves. These valves are designed to fail closed and are wired so that the electrical solenoid of the air diaphragm operator is energized to open the valves. Closure of these valves will occur on low-low pressurizer level, phase A containment isolation, engineered safety feature actuation signal, loss of electrical power to valves and loss of instrument air. Designing these valves to fail closed is a desirable failure mode since it prevents a loss of the RCS inventory. Charging flow from the CVCS into the RCS can be controlled by varying the speed of the PDP or by varying the position of the charging flow control valve. The amount of required flow is determined from the pressurizer level control system which generates an error signal that is sent to the CVCS system.

The PDP uses a hydraulically coupled, variable-speed drive unit as shown in Figure 2 (Ref. 2). For the hydraulic coupling, a runner attached to the output shaft receives a vortex of oil from the impeller that is attached to the input shaft. No mechanical connection exists between the runner and impeller, and each component resembles half of a grapefruit as shown at the top of this figure. Kinetic energy is imparted to the oil by the impeller, and the oil flows radially outward and into the vanes of the runner. The oil then flows from the outer perimeter of the runner towards the center, transferring its energy to the runner. The amount of energy imparted on the runner for a given impeller speed is determined by the amount of oil flow. A scoop tube is used to regulate the oil level in the working circuit of the coupling between the impeller and runner. The position of this scoop tube determines the quantity of oil in the coupling and the resulting speed of the runner and output shaft. Instrument air and a spring are used to regulate the position of the scoop tube. Loss of instrument air causes the scoop tube to fail in a position that results in maximum oil level in the working circuit of the coupling and produces maximum pump speed.

In contrast to PDP, the centrifugal charging pump (CCP) is a constant speed pump and the flow is controlled by varying the position of the charging flow control valve. This flow control valve is also an air operated globe valve, and is designed to fail open. It is wired such that the electrical solenoid for the air diaphragm operator is energized to close the valve. The basis for having maximum charging flow as a failure mode for the CVCS is to maintain adequate seal injection flow to the reactor coolant pumps and maintain RCS water inventory.

Figure 1

CHEMICAL AND VOLUME CONTROL SYSTEM

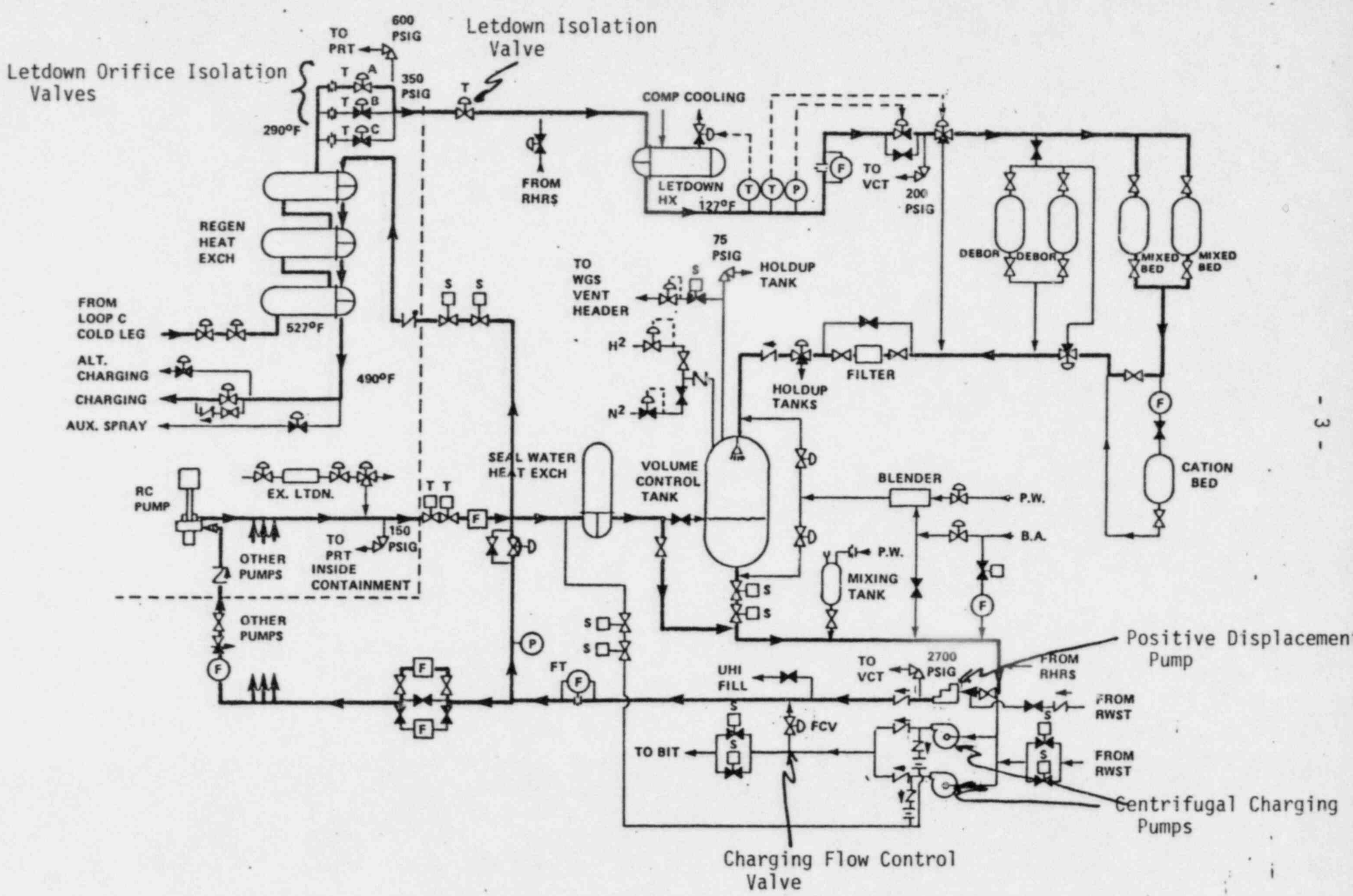

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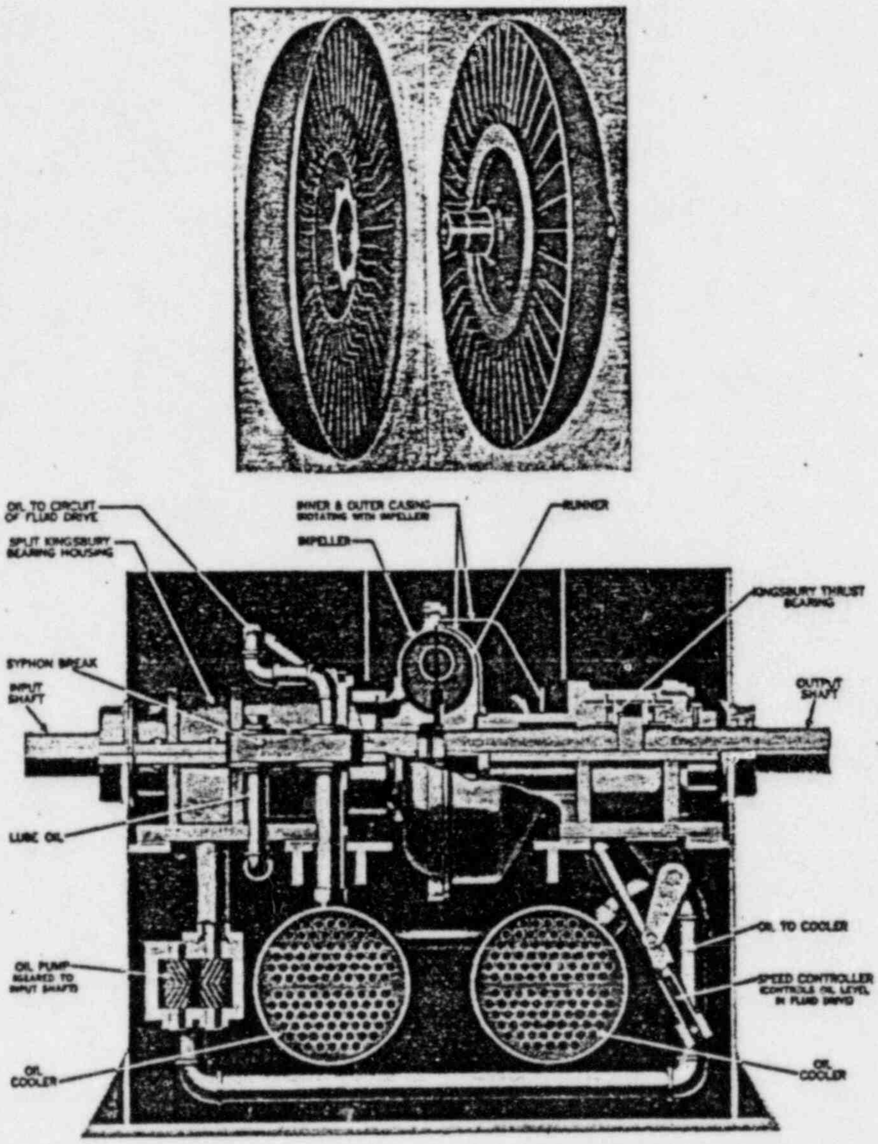
Figure 2.

PDP Variable Speed Drive Unit Internals (Ref. 2)



ANALYSIS

The failure modes for the CVCS were selected such that they would have a minimum effect on plant operation while the plant is at power and have a positive effect during upset conditions. At cold shutdown, low temperature plant conditions, the failure mode for the CVCS (i.e., maximum charging and isolated letdown) due to loss of instrument air is undesirable due to a potential for causing a low temperature overpressure transient. During such events, the rate of pressure increase due to the charging flow control valve failing open when the CCP is operating would be greater than if the PDP is operating because most CCPs have a higher pumping capacity than the PDPs.

A review of Callaway's Final Safety Analysis Report on the evaluation of low temperature overpressure transients revealed that an analysis was performed for a mass input pressure transient assuming that one CCP is operating at maximum flow rate and with letdown isolated. This analysis postulates a loss-of-air incident whereby the flow control valve in the charging line fails open and simultaneously the flow control valve in the letdown line fails closed. The analysis for this transient takes into account the single failure criteria and, therefore, only one pressurizer power-operated relief valve (PORV) was assumed to be available for pressure relief. This is a conservative analysis compared to the Callaway event because both PORVs were operable and the residual heat removal inlet lines from the RCS were open providing another potential relief path through the RHR suction line relief valves. Thus, it is concluded that adequate RCS boundary protection was maintained.

CONCLUSION

Although it was determined that adequate RCS boundary protection was maintained, this event does show that conservative system failure modes for one plant condition may not be conservative for another. Loss of instrument air results in an adverse systems interaction during low temperature plant conditions which has potential for causing a low temperature overpressurization transient. This is generic to most Westinghouse-designed plants. Since the event involved an air systems interaction, it is recommended that this event be included as a part of AEOD air systems study to evaluate the generic implications of loss of air during shutdown. No further action on this event is deemed necessary, and TAC 27090 should be considered closed.