AEOD ENGINEERING EVALUATION REPORT*

UNIT: Calvert Cliffs Unit 2
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EVALUATOR/CONTACT: E. V. Imbro

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SUBJECT: POWER OPERATED RELIEF VALVE (PORV) ACTUATION RESULTING IN SAFETY INJECTION ACTUATION

EVALUATION SUMMARY

On February 3, 1983 at 6:03 p.m. with the reactor in Mode 3 (Hot Standby), both power operated relief valves (PORVs) opened as a result of an operator mistakenly deenergizing reactor protective system (RPS) channel D, prior to a test of the No. 21 vital 120 V ac bus power transfer switch. As a result of the occurrence, the reactor coolant system pressure dropped from 2250 psia to 1520 psia before the operators diagnosed the event and closed the PORVs. The PORVs were open for about 30 seconds. The mass and energy release through the PORVs was sufficient to blow out the rupture disc in the quench tank. As expected, a partial safety injection actuation (channel B) occurred when the reactor coolant system (RCS) pressure decreased below the 1780 psia safety injection actuation signal (SIAS) setpoint. Since the RCS pressure never dropped below 1260 psia shutoff head of the high pressure safety injection pumps, no water was actually injected into the RCS.

A review of the PORV actuation logic and the control circuitry reveals an inconsistency in the failure positions of the PORVs on loss of electric power. If, for example, the 480 V ac power source to a PORV's solenoid was deenergized, the PORV would fail closed. If, however, 2 or more high pressure bistable trip units were deenergized, both PORVs would fail open. This inconsistency is because the output of these bistables is not only input to the RPS causing

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the reactor trip on high system pressure but is also input to the PORV actuation control logic to open the PORVs. Since the high pressure bistable trip units provide a reactor trip function, their failure mode is in the tripped position on loss of power. While the tripped position is the fail-safe position for the RPS, since it causes a reactor shutdown, it will also cause the PORVs to fail open, creating a reactor blowdown.

It is recognized that two independent failures i.e., loss of two 120 V ac vital instrument buses, are required to cause the PORVs to fail open. Also, hand switches are provided on the control board allowing plant operators to either close the PORVs, by overriding the "open signal" from the RPS, or to close the block valves. Therefore, an uncontrolled blowdown of the RCS due to the PORVs failing open is unlikely.

It is suggested that the PORV actuation logic on CE plants be reviewed and, if necessary, changed to allow the PORVs to fail closed on the deenergization of two or more RPS channels.

DISCUSSION

On February 3, 1983 at 6:03 p.m. with the reactor in Mode 3 (Hot Standby), both power operated relief valves (PORVs) opened as a result of an operator mistakenly deenergizing reactor protective system (RPS) channel D, prior to a test of the No. 21 vital 120 V ac bus power transfer switch. As a result of the occurrence, the reactor coolant system pressure dropped from 2250 psia to 1520 psia before the operators diagnosed the event and closed the PORVs. The PORVs were open for about 30 seconds. The mass and energy release through the PORVs was sufficient to blow out the rupture disc in the quench tank. As expected, a partial safety injection actuation (channel B) occurred when the reactor coolant system (RCS) pressure decreased below the 1780 psia safety injection actuation signal (SIAS) setpoint.[1] Since the RCS pressure never dropped below 1260 psia shutoff head of the high pressure safety injection pumps, no water was actually injected into the RCS.

During the transient, the pressurizer level was observed to increase from 150 inches to 190 inches due to letdown isolation and a continuation of charging pump flow. This level increase was terminated at 6:15 p.m. when the operators reset the safety injection actuation logic. The reactor coolant system pressure returned to normal at 6:50 p.m.

The PORVs opened because a Senior Control Room operator mistakenly deenergized RPS channel D instead of RPS channel A, prior to testing the power transfer switch for the No. 21 vital 120 V ac bus which powers RPS channel A.[2] The power transfer from the backup ac bus to the inverter was unsuccessful, resulting in blown input fuses on the dc side of the inverter and the loss of vital bus No. 21. Since two RPS channels were now deenergized, A due to the blown fuse and D by virtue of operator error, the 2-out-of-4 trip logic protecting against high reactor coolant pressure was satisfied, causing the PORVs to open.

The PORVs at Calvert Cliffs are pilot operated relief valves manufactured by Dresser Industries and referred to by the trademark "Electromatic." The pilot valve on these PORVs is actuated by a 480 V ac push action electrical solenoid that opens the pilot valve when it is energized. The pressure under the main disc is reduced by opening the pilot valve causing the PORV to open. On loss of the 480 V ac power source to the electrical solenoid the PORV will fail in the closed position.

(1) Engineered safety features actuation channel "A" had been disabled prior to the inverter transfer test to avoid inadvertent actuations.

(2) The A RPS channel was to have been deenergized since previous attempts at testing the power transfer switch had resulted in blown fuses.

At Calvert Cliffs, the PORVs are controlled by the RPS and open at 2400 psia coincident with a reactor trip on high RCS pressure. The input signals to the 2-out-of-4 PORV control logic originate from the same 4 high pressure bistable trip units whose output also goes to the 2-out-of-4 trip logic matrices of the RPS. The design philosphy of the RPS is such that deenergization of a protective channel causes that channel to assume a tripped condition, therefore, if 2 or more RPS channels are simultaneously deenergized the result is a reactor trip.

FINDINGS AND CONCLUSIONS

A review of the PORV actuation logic and the control circuitry reveals an inconsistency in the failure positions of the PORVs on loss of electric power. If, for example, the 480 V ac power source to a PORV's solenoid was deenergized the PORV would fail closed. If, however, 2 or more high pressure bistable trip untis were deenergized, both PORVs would fail open. This inconsistency is because the output of these bistables not only is input to the RPS causing the reactor trip on high system pressure but is also input to the PORV actuation control logic to open the PORVs. Since the high pressure bistable trip units provide a reactor trip function, their failure mode is in the tripped position on loss of power. While the tripped position is the fail-safe position for the RPS, since it causes a reactor shutdown, it will also cause the PORVs to fail open, creating a reactor blowdown.

The PORVs do not provide a "safety function" in that they are assumed not to operate in the transient and accident analyses performed to demonstrate plant safety margins. Therefore, the fail-safe position for the PORVs should always be the closed position to prevent an inadvertent blowdown of the RCS. The overpressure protection required by the ASME Boiler and Pressure Vessel Code is provided by the RCS safety valves not the PORVs.

The primary function of the PORVs is to prevent the RCS pressure from getting high enough to lift the safety valves. This minimizes operational problems with safety valves since they tend to exhibit a small amount of leakage after having lifted.

It is recognized that two independent failures, i.e.. loss of two 120 V ac vital instrument buses, are required to cause the PORVs to fail open. Also, hand switches are provided on the control board allowing plant operators to either close the PORVs, by overriding the "open signal" from the RPS, or to close the PORV block valves. Therefore, an uncontrolled blowdown of the RCS due to the PORVs failing open is unlikely. However, since control power necessary for the operation of engineered safety features actuation channels is provided by two of the 120 V ac vital instrument buses (2Y01 and 2Y02), a loss of these two buses would result in the PORVs failing open without any engineered safety features available to mitigate the blowdown of the RCS. In this situation, only quick operator action could avert the potentially severe consequences of this scenario. In the event under consideration at Calvert Cliffs the operators were able to diagnose the event and close the PORVs within 30 seconds. Thus, this transient was terminated by operator action even befor the RCS pressure got low enough to permit injection of water by the high pressure safety injection pumps.

The deenergization of the wrong vital bus, prior to the testing of the power transfer switch, occurred as a result of an operator error due in part to the fact the Units 1 and 2 have mirror image control rooms. RPS channel D on Unit 2 is in the same relative location as RPS channel A on Unit 1, therefore the operator inadvertently deenergized channel D on Unit 2 instead of channel A. The power transfer test on the vital bus that powers RPS channel A resulted in a loss of that bus due to a blown fuse.

Since RPS channel D had been inadvertently deenergized the 2-out-of-4 PORV logic was satisfied and the PORVs opened as designed. Mirror image control rooms, it would appear, are prone to errors of this type. Some means to allow operators to better distinguish between units should be employed to reduce the possibility of operator error.

During the transient the pressurizer level increased 40 inches from 150 to 190 inches. At first glance, this appeared somewhat higher than expected but calculations show that this level increase roughly corresponds to 12 minutes of charging flow with the letdown isolated. The safety injection actuation occurred at 6:03 p.m.; as designed, it caused the charging pumps to start and isolated letdown flow to conserve RCS inventory. The safety injection signal was reset at 6:15 p.m. after approximately 12 minutes of operation. No other liquid was injected during this time since the RCS pressure did not fall below the shutoff head of the high pressure safety injection pumps. From the above, it is concluded that the pressurizer level increase during this transient was normal.

The 30 second blowdown from the PORVs resulted in the blowout of the quench tank rupture disc. At Calvert Cliffs, the quench tank is relatively small with an internal volume of 217 cubic feet. Generally, the tank is operated with 135 cubic feet of water and an 82 cubic foot nitrogen blanket kept at 3 psig. The water volume in the tank is sufficient to condense the steam discharge during a loss of load incident followed by an uncontrolled rod withdrawal. The quench tank was not designed to accept a continuous discharge. The total steam release during the design condition of loss of load followed by an uncontrolled rod withdrawal is about 1200 lbm. Therefore, considering the combined PORV capacity at Calvert Cliffs of 306,000 lbm/hr, it would take approxiamtely 14 seconds of continuous discharge from the PORVs to reach the quench tank design condition. It can be concluded that the blowout of the rupture disc following a 30 second steam discharge from the PORVs is not unusual or, by itself, indicative of an RCS blowdown in excess of that reported by the licensee.

SUGGESTIONS

It is suggested that the PORV actuation logic on CE plants be reviewed by NRR and, if necessary, changed to allow the PORVs to fail closed on the deenergization of two or more RPS channels. This would make the failure position consistent with the fail closed position of the PORVs when the solenoid operating the PORV pilot valve is deenergized. As presently installed, if two or more RPS channels are simultaneously deenergized, the PORVs will fail open, creating a controlled loss of coolant accident until terminated by operator action.

Additionally, it is suggested that a human factors review be conducted on dual unit mirror image control rooms to identify ways to reduce operator error resulting from confusion between units.