System Operation

Modes of Operation

PRESSURIZER PRESSURE CONTROL

PT-444 and Master Pressure Controller

Pressure transmitter PT-444 provides the control signal for control of the PRZ heaters, spray valves, and PORV PCV-444B (1RC-114) via the PRZ master pressure controller (PK-444A1 on the MCB; PK-444A2 at ACP). PT-444 also provides a signal for indicator PI-444 on MCB panel 1A2, and PR-444 trend recorder which is located on the control room recorder panel.

To provide a signal to the various control circuits, system pressure must first be compared with desired (reference) pressure. The output of this comparison is supplied to a PI controller (Proportional + Integral) where the signal is conditioned to produce a compensated output. The proportional component of the controller produces an output that is directly proportional to the input multiplied by some amplification factor (gain). The input is the difference between actual PRZ pressure and reference pressure (Pact-Pref). The larger the input to this portion of the controller, the larger the output will be. Added to this portion of the output is an integral component that accounts for the length of time a difference between actual and reference pressure exists. Accordingly, the longer a deviation is present, the larger the output from the integral portion of the circuit. This means that there may well be an output from the integral section of the controller when Pact returns to Pref. This provides a more stable response for the PRZPCS. Included in the PRZPC circuitry is an optional derivative or rate-of-change function. To meet the requirements of NUREG-0737, Item II.K.3.9, the derivative component is removed to preclude early actuation of PORV PCV-444B due to a rapid pressure transient below the nominal PORV opening setpoint.

TIP

Placing a PI controller in MANUAL will reset the Integral portion of the controller.

The total output signal, referred to as the error signal, is developed in the PRZ master pressure controller. With the master pressure controller in AUTO, the PRZ heaters, spray valves, and PORV PCV-444B will operate to maintain system pressure at the reference setpoint for the controller. With the controller in MANUAL, the output of the controller is controlled by two manual pushbuttons. While in MANUAL, pressing the increase pushbutton will affect the system by simulating a pressure that is above reference pressure, therefore, it is sensed as a demand to decrease plant pressure. Conversely, pressing the

decrease pushbutton is sensed as a demand by the operator to increase plant pressure. The manual control portion of the circuitry continuously tracks the output of the controller when it is in AUTO, permitting a bumpless transfer to MANUAL. However, the automatic control portion of the circuitry does NOT continuously track the output of the controller when it is in MAN. Therefore, actual plant pressure and the controller setpoint must be matched prior to switching the controller from MAN to AUTO.

HEATER CONTROL

The PRZ group C heaters are the control heaters. The control heaters operate on a variable voltage signal controlled by the PRZ master pressure controller output. The PRZ master pressure controller output varies between 4 and 20 ma and linearly controls the voltage output of a 0-489V, three-phase, silicon controlled rectifier (SCR) controller. The SCR controller provides power to the variable heaters. By varying the voltage output of the SCR controller, the heat output of the control heater group is varied.

The control switch for the group C heaters controls the power supply breaker. The control heaters output is controlled by the PRZ master pressure controller output signal. They will be full on when the error signal output of the PRZ master pressure controller corresponds to a difference between actual pressure and reference pressure (2235 psig) of -15 psi (16%), or 2220 psig. Conversely, the control heaters will be full off when the error signal is +15 psi (35%), or 2250 psig. Between the high and low error from reference pressure, the heater output varies linearly. Since the PRZ Master Pressure Controller is a P + I controller, the actual pressure band in which the heaters will operate is dependent on the duration of the error signal.

Control switches for the backup heaters (groups A, B, and D) have three positions (OFF, AUTO, ON). In AUTO, the backup heaters are controlled via the PRZ master pressure controller. The heaters will be full on when the error signal output of the PRZ master pressure controller corresponds to -25 psi (9%), or 2210 psig and decreasing, and full off at -17 psi (14%), or 2218 psig and increasing. Since the PRZ master pressure controller is a P + I controller, the actual pressure band in which the heaters will operate is dependent on the duration of the error signal. Operation of the control switch to ON or OFF directly controls the heater power supply breaker. Refer to AOP-019 Attachment 1 or Figure 3 within this text to see the operator aid provided.

Control switches are provided for heater groups A and B at the ACP. The switches at the ACP have three positions (ON, AUTO, OFF). The switches must be selected to AUTO to allow automatic heater control at the ACP, after activating the transfer. Automatic operation from the ACP is provided from PT-444.

A bistable in the heater control circuit energizes all the backup heaters whenever PRZ level is +5% above reference level. This signal overrides the

master pressure controller signal. The purpose is to quickly heat subcooled water from a PRZ insurge. The heaters decrease the response time for RCS pressure control by reducing the time necessary to bring the cooler insurge water to saturation temperature. All heaters are interlocked with PRZ level, so if PRZ level falls below 17%, the backup and control heaters are deenergized (breakers open). This interlock prevents uncovering energized heaters and damaging them. This interlock is bypassed for groups A and B when they are operated from the ACP. The interlock is provided by a selectable level channel, using a switch on MCB panel 1A2.

If the pressurizer heaters are on when a PRZ low level condition occurs (17% level), then each breaker should open, de-energizing the heaters. However, they will not automatically reenergize when the low level condition clears. For the control heaters, the operator will have to place the control switch to ON to reenergize the heaters. For the backup heaters, groups A and B, an anti-pumping circuit is energized whenever the heaters receive an automatic start signal. This prevents the heaters from automatically reshutting when the trip signal clears. In order to reshut the breaker, the operator must interrupt the constant start signal being applied. This is accomplished by cycling the control switch to OFF and then back to ON (or AUTO) in order for the heater breaker to reshut. If these heater groups were deenergized when the PRZ low level occurred, they will automatically reenergize on demand (AUTO or ON) after PRZ level is restored.

During a loss of offsite power or SI actuation, the PRZ backup heaters groups A and B will be deenergized by the load sequencers. Groups A and B are supplied by emergency buses 1A1 and 1B1, which are automatically de-energized. The heaters may be reenergized from the MCB after the sequencer load block 9 permissive is received and 1A1 and 1B1 are re-energized. Additional details on sequencer operation may be found in the Sequencer text. The group C and D heaters are not affected by an SI actuation, but will be de-energized if offsite power is lost to their nonsafety-related power supplies (buses 1D1 and 1D2).

SPRAY VALVE CONTROL

The PRZ spray valves may be operated in AUTO or MANUAL. In MANUAL, increase and decrease pushbuttons allow the operator to open or shut individual spray valves to regulate spray flow. In AUTO, both spray valve controllers receive a signal from the PRZ master pressure controller. The valves begin to open when the error signal output of the PRZ master pressure controller corresponds to +25 psi (41%), or 2260 psig. They are fully open at +75 psi (75%), or nominally 2310 psig. Between +25 psi (41%) and +75 psi (75%) error signal the spray valves ramp open linearly. Since the PRZ master pressure controller is a P + I controller, the actual pressure band in which the spray valves will operate is dependent on the duration of the error signal. Refer to AOP-019 Attachment 1 to see the operator aid provided.

The individual spray valve controllers are simple proportional controllers. Their gain is such that a one psi error signal from the PRZ master pressure controller will provide a signal to change the spray valve position by 2%. These controllers provide bumpless transfer from AUTO to MANUAL but not from MANUAL to AUTO.

The PRZ spray lines are connected to RCS Loops A and B cold legs. The RCPs provide the driving head for spray flow. When one or more RCPs are idle, the effectiveness of spray flow from each spray valve varies depending upon the specific configuration of pumps in service. Spray from loop A is effective if either the loop A or loop B RCP is operating. Spray valve loop B is effective only if the loop B RCP is operating. If neither RCPs A nor B is operating, then spray flow through both valves is ineffective. As B RCP is the only RCP that provides spray flow via loop A or B spray valve, it is the preferred RCP for restart when none are running due to its unique ability to support PRZ and thus RCS pressure control.

IMPORTANT

Use of 'A' spray line by itself has proven an ineffective pressure control configuration with low temperature and pressure conditions.

The effect described above is due to the physical location of the Pressurizer surge line in loop B hot leg, and the fact that an idle reactor coolant loop operates at a higher static pressure than an operating loops. When loop B RCP is operating and loop A RCP is idle, the pressure in loop A is higher, and a positive differential pressure exists across the loop A spray valve. When the loop B RCP is idle, the loop B pressure increases, but this higher pressure is transmitted to the surge line and the Pressurizer, such that there is not a positive differential pressure across the loop B spray valve. Spray lines connect to RCS Loops 1 and 2 cold legs. Spray lines extend into Cold Legs 1 and 2 to 'scoop' flow, adding velocity head to driving force from RCP discharge pressure (reactor D/P drop). Each spray valve can pass 350 gpm flow when fully open and all RCPs are running.

POWER-OPERATED RELIEF VALVE CONTROL

Control switches for the three PRZ PORVs are provided at the MCB panel 1A2 and at the ACP. They have three positions (SHUT, AUTO, OPEN). When the PORVs are selected to operate in AUTO, they are controlled by bistables that energize solenoid valves and admit nitrogen (instrument air is the backup) to the PORV actuator to fully open the valve. The bistable for PORV PCV-444B (1RC-114) receives a signal via the PRZ master pressure controller. This PORV will open when the error signal output of the PRZ master pressure controller corresponds to +100 psi (87.5%), or 2335 psig . When the error signal output from the PRZ master pressure controller is reduced to +80 psi (75%), or 2315 psig, PORV PCV-444B will reclose. Since the PRZ master

pressure controller is a P + I controller, the actual pressure at which the PORV cycles is dependent on the duration of the error signal. PORV PCV-444B (1RC-114) receives an automatic control signal from a separate PRZ master pressure controller (PK-444A2) when control is transferred to the ACP.

PORVs PCV-445B (1RC-116) and PCV-445A (1RC-118) receive a control signal from pressure transmitter PT-445. When pressure increases to 2335 psig, a bistable actuates to open the PORVs. When pressure reduces to 2315 psig, the bistable resets and the PORVs shut.

The PORVs are blocked from automatically opening whenever plant pressure is below the P-11 bistable setpoint. When PT-455, 456 and 457 (2 of 3) detect pressure less than 2000 psig, the P-11 bistable will block the automatic open signal to all PORVs. When pressure is above P-11 (2 of 3 PTs greater than 2000 psig) automatic operation of the PORVs is allowed. Note that this interlock only affects the normal control circuit, but does not effect LTOP automatic operation. Manual operation of the PORV control switches from either the MCB or the ACP overrides the automatic control circuits and bypasses the P-11 block signal.

LOW TEMPERATURE OVERPRESSURE PROTECTION

The PRZ Low Temperature Overpressure Protection System (LTOPS) provides protection for design basis RCS overpressure transients occurring at low temperatures. LTOPS (Figure 7) is manually enabled prior to reducing RCS cold leg temperature below 325°F by actuation of manual control switches located on MCB panel 1A2. The MCB switch must be taken from BLOCK to NORMAL to allow the arming signal to be received. After the switch is in NORMAL, the T-410 and T-413 permissive bistables automatically arm/disarm LTOPS at 325°F. If temperature is below the arming setpoint (325°F) and the switch is in BLOCK, an annunciator will sound. Likewise, if temperature is above 325°F and the switch is in NORMAL, an annunciator will sound. If an arming signal is sent to an LTOPS PORV and its respective isolation valve is shut, an annunciator will sound.