7.7 Control Systems Not Required for Safety

The general objectives of the non-safety instrumentation and control (I&C) systems are:

- To make sure the major process variables of the nuclear steam supply system (NSSS) are kept in pre-defined and allowed ranges during normal power operation.
- To limit the variation of process parameters during normal operation in such a way that the initial conditions for operation are met at the onset of anticipated operational occurrences (AOOs) and postulated accidents (PAs) as assumed in the safety analyses.
- To minimize the need for protective actions and thus increase plant availability.
- To provide the reactor operator with monitoring instrumentation that indicates the required input and output control parameters of the systems and provide the operator with the capability of assuming manual control of the system.

7.7.1 Description

This section provides a description of the non-safety I&C system used to implement non-safety-related functions.

The non-safety functions are categorized as follows:

- Process control I&C functions.
- Process limitation I&C functions.

Process control I&C functions provide control of plant systems during normal operation. These functions are used to make sure the major process variables of the NSSS are kept in predefined and allowed ranges during normal power operation. These functions are described in Section 7.7.2.1 and Section 7.7.2.2.

Process limitation I&C functions are functions that execute one or more of the following actions:

- Prevents plant disturbances from causing normal operating limits to be exceeded.
- Alerts the operator when normal operating limits have been exceeded.
- Prevents disturbances from leading to an AOO or PA.

Process limitation I&C functions are described in Section 7.7.2.3.

Some process control I&C functions have a minor direct influence on the process of nuclear power generation. These functions are presented in Section 7.7.2.4 and are listed in Table 7.7-1—Cross Reference of Non-Safety-Related I&C Controls.

7.7.1.1 I&C Systems Related to Core Control

The I&C systems that provide core-control functions are the reactor control, surveillance and limitation (RCSL) system, the process information and control system (PICS), and the control rod drive control system (CRDCS). The architecture of RCSL, PICS, and CRDCS is described in Section 7.1.

The RCSL system receives input signals from the signal conditioning and distribution system (SCDS) and implements the automation level I&C functions related to core control. The SCDS provides the instrumentation interface to the RCSL system. PICS interfaces with the RCSL system to provide the operator with control and monitoring capability of the core control functions. The architecture of the SCDS is described in Section 7.1.

The CRDCS cabinet layout is shown in Figure 7.1-26. The CRDCS controls the actuation of the 89 rod cluster control assemblies (RCCA) in the reactor vessel. The RCSL logic transmits the direction of movement (i.e.,withdrawal or insertion), speed of movement, and drop and hold information to the rod control units of the CRDCS. Each rod control unit generates the cycling sequence input to the corresponding CRDCS coil modules in order to control the rod speed and movement for one RCCA. The coil modules control the amount of current applied to the operating coils (i.e. lift coil, movable gripper coil and stationery gripper coil) of the control rod drive mechanism (CRDM) in order to move the corresponding RCCA. A feedback signal is sent from the rod control unit to the RCSL. This feedback signal is used by the RCSL to generate a digital position indication of the RCCA and is based on the number of rod movement steps sent from the CRDCS to the operating coils of the CRDM.
Figure 7.7-2 indicates the RCCA maximum speed withdrawal rate is 75 steps/minute. Because each rod movement step equals 0.393 inches/step, the maximum withdrawal rate of the RCCA is 29.48 inches/minute which is less than the maximum allowed of 30 inches/minute. A detailed description of the CRDM and its associated operating coils is provided in Section 3.9.4.

The rod position measurement system (RPMS), described in Section 7.1.1.5.14, uses analog rod position measurement coils located within the CRDM to provide an indication of RCCA position that is separate from the position signal developed by the rod control unit of the CRDCS.

Adjustments to boron concentration levels in the reactor coolant system (RCS) provide another means of core control. Boron addition and dilution demand signals are generated by RCSL and are sent to the chemical and volume control system (CVCS). Boron concentration adjustments are addressed in Section 9.3.4.

The process control I&C functions related to core control are described in Section 7.7.2.1. The process limitation I&C functions related to core control are described in Section 7.7.2.3.1 through Section 7.7.2.3.10.

7.7.1.2 I&C Systems Related to Plant Control

The I&C systems that provide control of plant parameters are the process automation system (PAS) and the PICS. The PAS implements the automation level I&C functions related to the control of the plant parameters. The architecture of PAS is described in Section 7.1. The PICS interfaces with PAS to provide operator control and monitoring capability of plant parameters. The PAS receives input signals directly from sensors and I&C systems, as well as signals from the SCDS.

The process control I&C functions related to plant parameters are described in Section 7.7.2.2. The process limitation I&C functions related to plant parameters are described in Section 7.7.2.3.11 through Section 7.7.2.3.14.

7.7.2 Design Basis Information

The design basis for the non-safety I&C systems is based on the functions described in this section.

7.7.2.1 Operational Core Control Functions

7.7.2.1.1 Principles of RCCA Control

A description of some of the principles of RCCA control is necessary to aid in the explanation of the core control functions.

Bank Descriptions

The RCCAs are divided into control banks that are used as control elements for the average coolant temperature (ACT) control function, axial offset (AO) control function, and the neutron flux control function. Shutdown banks are only used for negative reactivity insertion during a reactor trip. The 89 RCCAs have the same characteristics.

The bank composition is as follows:

- Control Bank D 9 RCCAs.
- Control Bank C 12 RCCAs.
- Control Bank B contains 12 RCCAs.
- Control Bank A contains 8 RCCAs.
- Shutdown Bank SA contains 20 RCCAs.

- Shutdown Bank SB contains 12 RCCAs.
- Shutdown Bank SC contains 16 RCCAs.

The bank name allocation is definable on a cycle-by-cycle basis. RCCA bank composition is subject to change based on the core operating limits report (COLR) requirements. The COLR is addressed in Chapter 16, Specification 5.6.3.

Bank Sequence and Overlap

The rods move in the bank configuration for all cases except in the case of the partial trip (PT). In a PT, the sub-bank of rods that are dropped is a function of rod worth and relative position in the core.

The bank insertion and withdrawal sequence and overlap are defined by the control bank insertion limits. Control rod banks are withdrawn and inserted in a prescribed sequence and overlap. For withdrawal, the sequence is shutdown SA, shutdown SB, shutdown SC, control A, control B, control C, and control D. The insertion sequence is the reverse of the withdrawal sequence. The control bank rods move in a prescribed overlap that is specified in the COLR. This means that during bank withdrawal, control D will begin withdrawal before control C is fully withdrawn. Conversely, control C will begin insertion before control D is fully inserted.

7.7.2.1.2 Average Coolant Temperature Control

The ACT control function is designed to maintain a programmed average RCS average temperature (T_{avg}) by regulating core power. The ACT control is the predominant function of core control. The control logic is illustrated in Figure 7.7-1—Average Coolant Temperature Control Logic. Additionally, Figure 7.7-6—Signal Flow from SCDS through CU is provided to illustrate how the logic for ACT control could be assigned to the RCSL functional units and how the RCSL system architecture can support its assigned functions. Section 7.1.1.5.14 describes the Acquisition Units (AU). Control Units (CU). and Drive Units (DU). The ACT control logic consists of the following four main elements:

- The mismatch between turbine generator load and reactor power (i.e., power imbalance feed forward).
- The formation of the ACT control setpoint based on power level.
- The difference between the measured average RCS temperature and the desired average temperature (i.e., temperature error).
- The relationship between the sum of the two error signals and the resulting rod movement actuation requests.

The ACT setpoint serves as an input to determine the temperature error. The setpoint follows the ACT versus the power relationship as shown in Figure 4.4-7.

The ACT control function consists of two main error signal channels which are summed to provide a total error input signal to the rod speed control program. The rod speed program is shown in Figure 7.7-2—Rod Speed Control Program. The rods that are used to perform this function are designated as control bank rods that move into or out of the core in a prescribed manner, referred to as sequence and overlap, that is followed during insertion or withdrawal. The signal output of the rod speed program is a digital pulse that determines both rod stepping speed and direction (i.e., insertion or withdrawal). The two error channels are:

- Average temperature error - Difference between the second highest (auctioneered) measured loop T_{avg} and the ACT setpoint.
- Power imbalance feed-forward error - Mismatch between turbine generator load and reactor power.

The power imbalance feed-forward error signal and the temperature error signal are combined additively to produce a total error signal. This total error signal is the output that determines whether the control rods need to be inserted or withdrawn and the speed at which the movement needs to occur. If the total error is negative, rods are withdrawn. If the total error is positive, rods are inserted. The rod speed control program determines the rod movement as a function of total temperature error.

At or near full power operation, this function uses boron addition and dilution batches as final control elements.

ACT Control using Boron Addition and Dilution

Rod movements are used to respond to rapid temperature deviations in the RCS or to a rapid generator power increase or decrease. For small, long lasting temperature deviations that occur due to fuel burn-up at or near full power, this function will use boron addition and dilution batches as the method to perform the ACT control in order to avoid rod movement. ACT control using boron or dilution batches does not consider the power imbalance feed-forward signal and will only correct an average temperature error that has existed for a predetermined period of time. Boration or dilution batches will occur within the dead bands shown in Figure 7.7-2—Rod Speed Control Program. If the total error is negative, a dilution batch will be requested. If the total error is positive, a boron addition batch will be requested. Dilution or boration batches are not permitted by this function when rods are moving and for a time after rods have moved. Dilution or boration batches are not permitted by this function when the axial power distribution is not within predetermined limits. Dilution or boration batches are subordinate to the actions of the AO control function described in Section 7.7.2.1.4.

The transition between the neutron flux control function to the ACT control function occurs at 25 percent reactor power.

7.7.2.1.3 Neutron Flux Control

The neutron flux control function is designed to control reactor power (i.e., neutron flux) during startup and shutdown operations, while the secondary pressure is controlled with the turbine bypass system (TBS). This function simplifies the constant power operation and facilitates the operator tasks during the startup of the turbine and the synchronization of the generator with the grid.

In the neutron flux control mode, the control bank movements operate in the same way as under the ACT control (i.e., in sequence and overlap). This function is used below 25 percent reactor power when the secondary steam pressure is controlled with the turbine bypass valves. At higher powers the ACT control function is used instead of the neutron flux control function.

The neutron flux control setpoint can be adjusted manually by the operator using the PICS.

When the reactor is at hot shutdown with all the banks inserted, the operator begins the first stage of the startup by withdrawing the shutdown and control banks. The withdrawal sequence requires that the shutdown banks are pulled to their all rods out (ARO) position before control banks are pulled. Control banks are then withdrawn in sequence and overlap as described in Section 7.7.2.1.1.

During startup (i.e., after exceeding a low reactor power permissive P5) and shutdown operation, the reactor power (i.e., neutron flux) can be controlled in conjunction with the main steam (MS) pressure control using the turbine bypass valves. The neutron flux control function blocks turbine synchronization at power levels less than a setpoint on increasing reactor power and blocks power reductions below a setpoint until the turbine is tripped on decreasing reactor power.

The neutron flux control acts on the rod control banks in the same way as the ACT control function. The neutron flux deviation is appropriately amplified to give an output signal corresponding to that from the ACT control.

7.7.2.1.4 Axial Offset Control

The AO control function is designed to maintain core axial power within analyzed limits. AO is a measure of the axial power distribution in the core. Extreme shifts in power distributions have an adverse impact on accident analysis results.

The AO control strategy works in conjunction with the ACT control to restore AO to within prescribed limits.

Above a predetermined power level, the AO control can be enabled. If the AO exceeds a power dependant positive value, a dilution batch will be requested. This effectively raises the core-wide power and average coolant temperature, which causes the ACT control to insert rods, thereby correcting the AO. If the AO exceeds a power dependant negative value, a boration batch will be requested. This effectively lowers the core-wide power and average coolant temperature, which causes the ACT control to withdraw rods and correct the AO.

7.7.2.2 Operational Plant Control Functions

7.7.2.2.1 RCS Pressure Control

The RCS pressure control maintains the RCS pressure within allowable limits during Mode 1 through Mode 5. When in the automatic control mode, the RCS pressure control maintains the primary pressure at a setpoint value in steady-state operation and within an allowable range around its setpoint (i.e., control band) during transients, including startup and cooldown operations. Figure 7.7-3—RCS Pressure Setpoints indicates the control band relative to other RCS pressure setpoints.

When the automatic heatup and cooldown mode is selected, the RCS pressure control has an automatically generated temperature dependent setpoint. The automatic heatup and cooldown mode is selected during plant Mode 2 and Mode 3. The primary pressure is required to stay in an allowable range around the automatically generated setpoint. If the pressure drifts from the limits of the setpoint, the Max2 sliding pressure limitation function described in Section 7.7.2.3.11 is actuated. If the pressure progresses further from the temperature dependent setpoint to the high pressure (HP) or low pressure (LP) locking setpoints, the automatic heatup and cooldown is interrupted, and an alarm is sent to PICS.

RCS pressure control is performed by actuating pressurizer (PZR) heaters or PZR normal spray.

A manual control mode allows manual setpoint control and manual control of the actuators.

7.7.2.2.2 Pressurizer Level Control

The PZR level control provides:

- Sufficient RCS water inventory for cooling and for proper control of RCS pressure.
- A sufficient steam volume in the PZR to accommodate in-surges in the PZR from the RCS without causing an excessive pressure increase for normal operating transients. There is also sufficient water mass to accommodate out-surges from the PZR to the RCS without causing an excessive pressure decrease.

The function of the PZR level control is to maintain the PZR level at a setpoint value in steady-state operation and within the allowable range around its setpoints during normal operational situations, including startup and cooldown. When in automatic control mode, PZR level control channel makes sure that the PZR level remains within given limits (i.e., control band) around the setpoint. Figure 7.7-4—Pressurizer Level Setpoints indicates the control band relative to other PZR level setpoints.

The PZR level control monitors the PZR level for deviations from its setpoint during Mode 1 through Mode 4, and based on mode changes, actuates different control valves at the pressure reducing stations located in the CVCS letdown lines.

A manual control mode allows manual setpoint control and manual control of the pressure reducing valve actuators.

7.7.2.2.3 RCS Loop Level Control

The RCS loop level control function provides an automatic and continuous control of the RCS water inventory during mid-loop operation. In case of primary system inventory changes, the control function limits the resulting mid-loop operation level deviations within the specified control band.

The loop level control function provides an automatic control of RCS water inventory by continuously monitoring the RCS loop level and controlling the coolant letdown flowrate.

RCS loop level control is maintained by a closed-loop control I&C function, which is put in service manually at cold shutdown conditions.

RCS loop level control is manually enabled at cold shutdown conditions. Control actions are only effective when an HP charging pump is in operation and the volume control tank (VCT) bypass line is not opened.

7.7.2.2.4 Steam Generator Level Control

The steam generator (SG) water level control automatically maintains SG level by matching feedwater flow to steam demand. The level can also be controlled manually.

This SG level control I&C function provide the following:

- Sufficient water level for heat removal from the primary to secondary side.
- Minimizes moisture carryover to the turbine.

The SG level control I&C function maintains the SG level at a setpoint value in steady-state operation during heatup and cooldown (Mode 1 through Mode 4), and within allowable limits (called the control band) during normal operational transients.

Figure 7.7-5—Steam Generator Level Setpoints illustrates the control band relative to other SG level setpoints.

This function acts on the following valves in the main feedwater system (MFWS) to control SG water level:

- Full load control valve (FLCV).
- Low load control valve (LLCV).
- Very low load control valve (VLLCV).

The system can be operated in the following modes:

- Automatic control mode which controls SG water level within given limits of a setpoint. Automatic control mode is the normal mode of operation.
- Manual control mode.

7.7.2.2.5 Main Steam Pressure Control

The purpose of the MS pressure control function is to provide MS overpressure control and limitation in case of load reduction due to load steps, load ramps, or load rejection. MS pressure is controlled by automatically modulating the turbine bypass valves.

During normal power operation, this function is realized by maintaining a floating MS pressure setpoint above the measured MS pressure. As the measured pressure changes, the setpoint changes accordingly. However, a limitation is placed on the rate of change of the setpoint so that if the measured pressure increases at a rate greater than the limitation of the floating setpoint, the turbine bypass valves will be opened. The turbine bypass valves close and are prevented from opening on high condenser backpressure or high hot well level.

During plant heatup and cooldown operations, the operator can adjust a target pressure setpoint which is adapted with a limited temperature gradient. Based on the target pressure setpoint, the turbine bypass valves control MS pressure and thus reactor coolant temperature. Locking logic is provided to interrupt the automatic heatup or cooldown process when RCS parameters deviate from their setpoint thresholds.

When partial cooldown is initiated, the MS pressure setpoint follows a specific partial cooldown setpoint which has priority over all other setpoints and locking signals.

Following a reactor trip, in order to avoid primary overcooling, the MS pressure setpoint is immediately set to a fixed maximum pressure setpoint.

7.7.2.2.6 Feedwater Temperature Control

Main feedwater to each steam generator is temperature controlled to ensure sufficient heat removal from the primary coolant system and to prevent thermal stress on the steam generator itself. This temperature control is performed using several stages of feedwater heating by low-pressure heaters in the condensate system and high-pressure heaters in the Main Feedwater System.

Condensate pumps are utilized to move condensate from the low-, intermediate-, and high-pressure condensers to the low-pressure (LP) feedwater heaters (FWH) and then in to the deaerator/feedwater storage tank. There are two stages of LP FWH in the condensate system. The first stage consists of three parallel strings, each having two LP FWH in series. Each string contains two FWH bypass valves that operate in tandem to bypass the heaters. The warmed feedwater is passed through the first stage of heaters, combined via a common header, and then passed through the second stage of LP FWH. The second stage consists of two parallel strings, each having two LP FWH in series.

The MFW system contains the high-pressure (HP) feedwater heaters (FWH). There is one stage of HP FW heating. This consists of two parallel strings, each having two HP FWH in series. Each string contains two FWH bypass valves that operate in tandem to bypass the heaters.

The LP and HP FWH bypass valves are three-way valves that are provided such that each string can be isolated and bypassed. Relief valves are provided to protect the heat exchanger tube sides and associated piping from over pressurization due to thermal expansion of trapped fluid.

Each FWH is equipped with high- and low-level indicators to throttle open the appropriate drain valve when the condensate level in the FWH reaches either of the preset levels. Each FWH is also equipped with a high-high level indicator to send an alarm to the control room to indicate abnormal operation of the Feedwater Heater Drains System.

If the level in LP FWH A3 or LP FWH A4 of either train rises for any reason, the emergency drain control valve to the HP condenser of the respective LP FWH opens. If the level in one of the LP FWH A3 is too low, the associated LP FWH drain pump is tripped.

If the water level in the run-off loop of one of the LP FWH Al or A2 rises and reaches the specified setpoint, the corresponding FWH train will be isolated. If the water level in LP FWH A3 or A4 rises above the control range of the emergency drain valve, the FWH train will be bypassed and the flow will be diverted to the second FWH train. If the water level in LP FWH A3 or A4 rises over the maximum setpoint, the main condensate pumps will be tripped. LP FWH bypass valve operation will have no automatic controls, only manual.

If the water level in HP FWH A6 or HP FWH A7 of either train rises above the normal control range, the emergency drain control valve to the HP condenser of the respective FWH throttles open.

If the water level in HP FWH A6 or A7 rises above the emergency control range, the respective FWH train will be bypassed and the flow will be diverted to the second FWH train. If the water level in any of the HP FWHs rises above the maximum level, the feedwater pumps are tripped. HP FWH bypass valve operation will have no automatic controls, only manual.

7.7.2.3 Process Limitation I&C Functions

7.7.2.3.1 Loss of One Reactor Coolant Pump Limitation

This limitation function is designed to avoid the low reactor coolant system flow rate (i.e., one loop) reactor trip function described in Section 7.2.

This function initiates a PT and a turbine load reduction when two RCS loop flow values of the same loop drop below the setpoint value and the P3 permissive is validated.

7.7.2.3.2 Axial Offset Limitation

The objective of this limitation is to survey the axial offset and make sure that the axial power distribution is within the parameters assumed in the safety analysis to limit the consequences at high power levels of accidents or AOOs for which a top-peaked core power distribution is penalizing. The limited parameter is the AO value calculated from the self powered neutron detectors. The AO operating range is bounded by positive and negative thresholds. This function generates alarms and the blocking of the generator power increase.

This limitation function is inhibited below a low level of power.

The calculated AO is compared with thresholds derived from reactor power. When the threshold is met an action occurs to block the increase of generator power.

7.7.2.3.3 Reactor Power Limitation with Respect to Feedwater Flow Rate

This limitation function limits the reactor power with respect to the feedwater flowrate. The limitation function is designed to correct plant conditions before a protective action due to low SG level occurs. The loss of one or more main feedwater (MFW) pumps leads to a large imbalance between power generation in the reactor and heat transfer to the main heat sink. Process control I&C will detect the failure of one pump and start a standby pump, if available, within a few seconds, thus allowing normal operation to continue.

This limitation function can handle the following three events:

- Loss of one MFW pump (if standby pump not available).
- Loss of all MFW pumps.
- Imbalance of feedwater flowrate and reactor power during startup phase.

Loss of One MFW Pump (if standby pump not available)

This limitation function deals with the loss of one MFW pump (if standby pump not available) by initiating a PT and a turbine load reduction. An imbalance between MFW flowrate and a nominal MFW flowrate (according to feedwater temperature and reactor power) initiates a PT and a generator power reduction to a power level corresponding to operation with two MFW pumps.

Loss of All MFW Pumps

A low MFW flowrate combined with a high reactor power level is the criteria for the detection of the loss of all MFW pumps. In this case the limitation function will initiate a non-safety-related reactor trip, initiates turbine trip, and close all FW FLCVs. The reactor trip signal resets this actuation.

Imbalance of Feedwater Flowrate and Reactor Power During Startup Phase

Indications of a low enough feedwater flowrate and a high enough reactor power leads to blocking the withdrawal of any RCCA. This prevents an increase of the reactor power without an increase of the MFW flowrate during the startup phase.

7.7.2.3.4 Reactor Power Limitation with respect to Generator Power

This limitation function limits reactor power after loss of generator load events. The objective is to limit the energy level of the primary system in case of load rejections or turbine trip in order to avoid reaching the RT criteria. This will be done by initiating a PT. The target reactor power level is determined by:

- The maximum of generator power.
- The minimum PT target power.

In case of turbine trip or load rejection to house load, the plant is first stabilized at minimum PT target power while heat removal is performed via the turbine bypass valves. A further controlled reduction to the minimum load reactor power will then be done by ACT control.

7.7.2.3.5 Reactor Power Limitation with respect to Thermal Power

The reactor power limitation with respect to thermal power function is designed to maintain reactor power below 100 percent rated thermal power. This function provides the capability to adjust turbine power and indirectly reactor power due to cooling tower temperature changes that affect overall plant efficiencies. The reactor power signal is selected from the highest of the following:

- Continuous secondary calorimetric calculation (i.e., above 25 percent power).
- Median select RCS enthalpy indication of reactor power.

The continuous secondary side calorimetric uses the following sensors and parameters as input:

- Feedwater flow rate for each train of feedwater (refer to Section 10.4.7.5 and Figure 10.4.7-1).
- Feedwater temperature for each train of feedwater (refer to Section 10.4.7.5 and Figure 10.4.7-1).
- Feedwater pressure for each train of feedwater (refer to Figure 10.4.7-1).
- Steam generator blowdown flow rate for each steam generator (refer to Figure 10.4.8-1).
- Steam generator blowdown temperature for each steam generator (refer to Figure 10.4.8-1).
- Reactor coolant system charging flow rate (refer to Section 9.3.4.5 and Figure 9.3.4-1, Sheet 5 of 9).
- Reactor coolant system charging flow temperature (refer to Section 9.3.4.5 and Figure 9.3.4-1, Sheet 5 of 9).
- Reactor coolant system charging flow pressure (refer to Section 9.3.4.5 and Figure 9.3.4-1, Sheet 5 of 9).
- Reactor coolant system letdown flow rate from both high pressure reducing stations in the chemical and volume control system (refer to Section 9.3.4.5 and Figure 9.3.4-1, Sheet 1 of 9).
- Reactor coolant system letdown flow temperature (refer to Section 9.3.4.5 and Figure 9.3.4-1, Sheet 1 of 9).
- Reactor coolant system letdown flow pressure (a constant value is assumed).
- Main steam pressure for each steam generator (refer to Figure 10.3-1).

- The power losses from the reactor coolant system (including the control rod drive mechanisms) to the ambient air (a constant value is assumed).
- The reactor coolant pump power (a constant value is assumed).
- The pressurizer heater power (a constant value is assumed).
- The moisture content of the main steam (a constant value is assumed).

The enthalpy of the main steam flow, main feedwater flow, steam generator blowdown flow, charging flow, and letdown flow are calculated using the corresponding pressures and/or temperatures. The continuous secondary calorimetric calculation of reactor thermal power is performed according to methodology outlined in Reference 3, which has been accepted by the NRC, per Reference 4. As an analytical requirement, 0.48 percent uncertainty on core thermal power was assumed in the safety analysis. However, the measurement requirements for the U.S. EPR allow the secondary side calorimetric to calculate reactor thermal power within a ± 0.40 percent uncertainty. To achieve the required uncertainty in the secondary side calorimetric algorithm, the elemental uncertainties of the instrument strings and parameters, previously mentioned, are verified to comply with requirements provided in Table 7.7-2—Elemental Uncertainties for Secondary Side Calorimetric.

The control logic compares the mismatch between main turbine and generator load and the highest of the previously listed power signals and takes actions when reactor power exceeds 100 percent. There are two thresholds. The intent of the first is to alert the operator and take action to prevent further power increase. The intent of the second threshold is to reduce power to 100 percent.

A COL applicant that references the U.S. EPR design certification will, following selection of the actual plant operating instrumentation and calculation of the instrumentation uncertainties of the operating plant parameters, calculate the primary power calorimetric uncertainty. The calculations will be completed using an NRC acceptable method and confirm that the safety analysis primary power calorimetric uncertainty bounds the calculated values.

7.7.2.3.6 Rod Drop Limitation

The objective of this limitation function is to detect the spurious drop of RCCAs and to reduce the turbine generator power level to match the reactor power reduction due to the dropped RCCAs.

This limitation function is designed to avoid reactivity compensation by core control functions after the RCCAs drop and to avoid the low departure from nucleate boiling (DNBR) and high linear power density (HLPD) protective actuations after one or more RCCAs drop into the core.

Rod drop is detected in the RCSL system based on the RCCA position measurements. In each RCSL division, a quarter of the RCCAs are monitored and the four RCCA drop detection logic signals (i.e., one per RCSL division) are voted one out of four.

The other criterion indicating an RCCA drop is derived from the decrease of the reactor power level (i.e., neutron flux from power range detectors). The derivative of the four nuclear power signals are compared with a low threshold and voted one out of four.

The limitation will be actuated if both criteria coincide and no intended PT has been initiated by other limitation functions.

7.7.2.3.7 Intermediate Range High Neutron Flux Limitation

This limitation function is designed to avoid the high neutron flux (i.e., intermediate range) and low doubling time (i.e., intermediate range) reactor trips when an excessive reactivity increase occurs during reactor startup from a subcritical or a low power startup condition. At the limitation criteria the withdrawal of any RCCA is blocked.

Limitation signals are generated in RCSL, which combine the following criteria:

- Low doubling time IR limitation threshold.
- High neutron flux IR limitation threshold.
- Manual inhibition above a low power level (permissive P6).

If these criteria are met in two out of four RCSL divisions, the following actions are performed:

- RCCA withdrawal is blocked.
- Alarm on PICS.

7.7.2.3.8 High Linear Power Density Limitation

There are three sub-functions to the HLPD limitation function. The three sub-functions are:

- Block function.
- Reduction function.
- PT function.

The HLPD limitation sub-functions are designed to avoid a reactor trip on HLPD for each transient that leads to an uncontrolled increase of the linear power density of the reactor core. This function initiates a PT and a fast turbine load reduction.

For the block and reduction sub-functions, a calculation of the linear power density (LPD) in the lower and upper portions of the core is performed in RCSL. In each sub-function the calculated LPD values for the upper and lower portions of the core are compared to threshold levels for each portion of the core. The self-powered neutron detectors (SPND) provide input for the calculation of the LPD values in RCSL.

The threshold levels for the block sub-function are above the threshold levels for the reduction sub-function, and therefore, the block sub-function actuates before the reduction sub-function.

Violation of the block sub-function threshold levels results in the following actions:

- Block dilution signal (for lower core half threshold level violation only).
- RCCA bank withdrawal blocking signal.
- Generator power increase blocking signal.
- Block lead control bank insertion (for lower core half threshold level violation only).

Violation of the reduction sub-function threshold levels results in the following actions:

- Reduce generator power signal.
- Insert lead control bank (for upper core half threshold level violation only).

For the PT sub-function, the actuator logic signals are generated in the RCSL and are inhibited below a low power level by the P2 permissive. When these actuator logic signals are generated, the following actions are performed:

- PT.
- Turbine load reduction.

7.7.2.3.9 Low Departure from Nucleate Boiling Limitation

There are three sub-functions to the low DNBR limitation function. The three sub-functions are:

- Block function.
- Reduction function.
- PT function.

These functions are designed to correct conditions to avoid the low DNBR protective functions as described in Section 7.2. The functions provide DNBR margin with respect to the DNB criterion.

For the block and reduction sub-functions, a calculation of the minimum DNBR value is performed in RCSL. The following are the inputs for the calculation of the minimum DNBR value in RCSL:

- Power density distribution of the hot channel which is derived from SPNDs.
- Average reactor inlet temperature.
- Average PZR pressure.
- Core flowrate derived from average RCP speed.

The threshold level for the block sub-function is above the threshold level for the reduction sub-function, and therefore, the block sub-function will actuate before the reduction function.

If the DNBR value drops below the threshold for the block sub-function, the following actions are performed:

- Alarm in the main control room (MCR).
- Block RCCA withdrawal.
- Block generator power increase.

If the DNBR value drops below the threshold for the reduction sub-function, the following actions are performed:

- Reduce generator power setpoint.
- Insert RCCAs.

The actuator logic signals for the low DNBR PT limitation sub-function are generated in the RCSL and are inhibited below a low power level by the P2 permissive. When these actuator logic signals are generated, the following actions are performed:

- PT.
- Turbine load reduction.

7.7.2.3.10 RCS Dilution (Shutdown Condition) Limitation

This limitation function is designed to avoid the actuation of the antidilution in standard shutdown states protective function as described in Section 7.3. This function contains the following sub-functions:

- Limitation in case of low RCS boron concentration.
- Prevent dilution at shutdown.

In the first sub-function, the RCS boron concentration is calculated in the boron concentration measurement system (BCMS) based on boron meter measurements and on charging flowrate measurements. This value is acquired by the RCSL, via the SCDS interface, where it is compared to the permissible shutdown state boron concentration. The low concentration limitation threshold is generated in the RCSL at a higher threshold than the antidilution at a shutdown condition state protection criterion. When the limitation signals are generated in two out of four RCSL divisions, the following actions are initiated:

- Boron addition with maximum injection rate.
- Isolation of demineralized water injection lines of the reactor boron and water makeup system (RBWMS). Both demineralized water injection pumps are shut off and both control valves are closed with highest priority.

The second sub-function is enabled when shutdown conditions are detected (reactor trip or no RCPs running). In this sub-function, boron concentration injected by RBWMS is measured. If the injected concentration is below the permissible value then the demineralized water injection lines will be isolated.

7.7.2.3.11 Reactor Coolant System Pressure Limitations

When the RCS pressure goes out of the normal operating range, the following RCS pressure limitation functions are enabled. These functions are designed to correct RCS pressure transients before a RT setpoint is reached, or to protect equipment. These functions have a more stringent action than the RCS pressure control function as described in Section 7.7.2.2.1. A graphical presentation of the RCS pressure limitation setpoints in relation to protective function setpoints and the control band is presented in Figure 7.7-3.

In case of post-accident operations, the operator is able to inhibit the activation of the RCS pressure limitation functions from PICS.

Max2 Pressure Function

The Max2 pressure function improves the availability of the plant by avoiding an RT on the Max2p setpoint (i.e., high PZR pressure). When the RCS pressure measurement reaches the setpoint, this function de-energizes the PZR heaters and actuates the normal spray. If the normal spray is not functional, auxiliary spray is actuated. The normal spray availability is determined based on RCP speed or the loop flowrate.

This function is operational in Mode 1 through Mode 3.

Max2 Sliding Pressure Function

The Max2 sliding pressure function improves plant availability by preventing a lock of the automatic heatup and cooldown on Max2p and limits the temperature differences between the PZR and RCS loops. The Max2 sliding pressure function is similar to the Max2 pressure function except this function has an automatically generated temperature dependent setpoint and is operational during the automatic heatup and cooldown.

When the pressure measurement reaches the setpoint, this function de-energizes the PZR heaters and actuates the normal spray. If the normal spray is not functional, the auxiliary spray is actuated. The normal spray availability is determined based on RCP speed or the loop flowrate.

Residual Heat Removal System Function

The RHRS function protects the RHRS equipment from overpressurization and prevents challenging the PZR safety relief valves (PSRV) during low temperature operation. The setpoint for the RHRS function is below the RHRS maximum pressure. This function is similar to the Max2 pressure function except the setpoint is temperature dependent and the function is operational during Mode 4 through Mode 6 when the P14 permissive has been acknowledged. The RHRS is normally connected to the RCS for decay heat removal when the P14 permissive setpoints are met and the P14 permissive has been acknowledged by the operator.

When primary pressure reaches the RHRS function setpoint, this function de-energizes the PZR heaters and actuates normal spray. If the normal spray is not working properly, the auxiliary spray is actuated. The unavailability of the normal spray is detected by RCP speed or the loop flowrate.

Reactor Coolant Pump Function

The reactor coolant pump (RCP) function avoids a RT on Min2p (i.e., low PZR pressure) during Mode 1. It also protects RCPs from cavitation and keeps pressure from falling below the Min3p setpoint for initiation of safety injection. The RCP function setpoint is temperature dependent and below the nominal operating pressure setpoint of the RCS pressure control function. The function is operational in Mode 1 through Mode 5.

When pressure reaches the RCP function setpoint, the function secures the PZR spray and energizes PZR heaters.

Reactor Pressure Vessel Brittle Fracture Function

At low RCS temperatures, the PSRVs opening setpoint is lowered to protect the RCS from overpressurization. The lowering of the PSRV opening setpoints is performed by the PS and is described in Section 7.3. The RPV brittle fracture function is implemented in the PAS to prevent pressure from reaching the electrically controlled PSRV open setpoints when in Mode 4 and Mode 5. The RPV brittle fracture setpoint is temperature dependent.

When the pressure measurement reaches the setpoint of the function, the RPV brittle fracture function stops the CVCS charging pumps, the medium head safety injection (MHSI) pumps, and de-energizes the PZR heaters. If the MHSI pumps are running due to a safety function actuation, the MHSI pumps will continue to run.

7.7.2.3.12 Pressurizer Level Limitations

The PZR level limitation functions are designed to backup the normal PZR level control function when the normal control function is outside of its normal control band. This process is achieved by performing actions that supplement the normal control function to return the RCS to the 100 percent power, level control band following a transient that caused the deviation. This improves the availability of the plant by correcting PZR level before reaching RT setpoints and other safety protective function setpoints. A graphical presentation of the PZR level limitation setpoints in relation to protective function setpoints and the control band is presented in Figure 7.7-4.

Max2 Level Function

The Max2 level function avoids overfilling the PZR and flooding the PZR spray nozzles. It improves the availability of the plant by correcting PZR level before reaching the Max1p RT setpoint (i.e., high PZR level) in Mode 1 and Mode 2. When the PZR level reaches the Max2 level setpoint, this function isolates the injection coming from the charging line and the auxiliary spray, thus limiting the increase of PZR level. When the PZR level returns below the Max2 level setpoint, the activating signal is withdrawn. Furthermore, the charging line isolation valve and the auxiliary spray line isolation valve remain closed; however, the operator can manually reopen the valves. An alarm on PICS indicates that the Max2 level function has been actuated.

This function is operational in Mode 1 through Mode 4.

In case of post-accident operations, the operator is able to inhibit the activation of this function from PICS.

Δ Max Function

The Δ Max function improves the availability of the plant by correcting PZR level before reaching the RT setpoint on Max1p (i.e., high PZR level). This function acts before reaching the Max2 level setpoint. The Δ Max level setpoint corresponds to a certain percentage above the PZR level control function setpoint. When the PZR level reaches the Δ Max level setpoint, this function adjusts the letdown flowrate at the HP reducing stations of CVCS to the maximum flowrate limit. An alarm on PICS indicates that the Δ Max level function has been actuated. When the PZR level returns below the Δ Max level setpoint, the activating signal is withdrawn and the HP reducing station returns to automatic PZR level control.

This function is operational in Mode 1 through Mode 5 when RCS temperature is greater than approximately 140°F and an HP reducing station of the CVCS is in operation.

In case of post-accident operations, the operator is able to inhibit the activation of this function from PICS.

Δ Min Function

The Δ Min function improves the availability of the plant by correcting PZR level before reaching the RT setpoint on Min2p (i.e., low PZR pressure). This function acts before reaching the Min2 level setpoint. The Δ Min level setpoint corresponds to a certain percentage below the PZR level control function setpoint. When the PZR level reaches the Δ Min level setpoint, this function increases the water injection into the RCS to the maximum possible flowrate by starting a second CVCS pump and adjusting the HP reducing station to the minimum flowrate limit. An alarm on PICS indicates that the Δ Min level function has been actuated. When the PZR level returns above the Δ Min level setpoint, the activating signal is withdrawn and the HP reducing station returns to automatic PZR level control. The CVCS charging pumps continue to run, however, the operator has the capability to manually stop a pump.

This function is operational in Mode 1 through Mode 5 when RCS temperature is greater than approximately 140°F and a HP reducing station of the CVCS is in operation.

In case of post-accident operations, the operator is able to inhibit the activation of this function from PICS.

Min2 Level Function

The Min2 level function avoids emptying the PZR, thus avoids activating the emergency core cooling criteria. When the PZR level reaches the Min2 function level, this function isolates the CVCS letdown lines and thus limits the decrease of RCS water inventory. An alarm on PICS indicates that the Min2 level function has been actuated. When the PZR level returns above the Min2 level setpoint, the activating signal is withdrawn, but the CVCS letdown lines remain isolated; however, the operator has the capability to manually reopen the letdown lines.

This function is operational in Mode 1 through Mode 5 when RCS temperature is greater than approximately 140°F and an HP reducing station of the CVCS is in operation.

In case of post-accident operations, the operator is able to inhibit the activation of this function from PICS.

Min3 Level Function

The Min3 level function protects the PZR heaters from being uncovered and is designed to prevent severe damage to the PZR heaters and also a potential breach of the RCS. When the PZR level reaches the Min3 function level setpoint, the PZR heaters are de-energized. An alarm on PICS indicates that the Min3 level function has been actuated. When the PZR level returns above the Min3 level setpoint, the PZR heaters are automatically switched back to RCS pressure control.

This function is operational during all plant modes.

The Min3 level function cannot be inhibited.

7.7.2.3.13 Reactor Coolant System Loop Level Limitation

The RCS loop level limitation function continuously monitors the loop level during mid-loop operation.

The RCS loop level limitation function makes sure that the minimum and maximum admissible water levels are in the RCS loops in case of transients. This limitation function acts when an overshoot of the control band limit occurs. This function prevents the actuation of safety functions by the PS.

The RCS loop level limitation function considers the water level required to protect the low head safety injection (LHSI) pumps from cavitation during mid loop operation.

This limitation function also prevents inadvertent filling of the loops. Filling the loops interrupts the flow area for the purge gas in the loop and the necessary free water surface for removal of noble gas. This could endanger personnel working in the SG bowls, and could potentially discharge coolant to the containment via open SG manways.

The RCS loop level limitation function fully closes the LP and HP reducing station of the CVCS letdown line when the RCS water level falls below a dedicated threshold that is below the lower control band limit of the RCS loop level control function. This limitation function fully opens the LP reducing stations to increase the coolant letdown flowrate when the water level exceeds a dedicated threshold above the upper control band limit of the RCS loop level control function. Both the upper and lower thresholds of this function are constant.

The limitation function is automatically enabled during the plant shutdown procedure when the operating range of the LHSI RHRS is reached.

The RCS loop level limitation function is disabled beyond its specified operating range in order to exclude the occurrence of inadvertent actuation signals.

7.7.2.3.14 Steam Generator Level Limitations

The SG level limitation functions are non-safety-related functions designed to correct SG level transients before a protective function setpoint is reached. A graphical presentation of the SG level limitation setpoints in relation to protective function setpoints and the control band is presented in Figure 7.7-5.

In the case of post-accident operations, the operator is able to inhibit the SG level limitation functions from PICS.

High SG Level Limitation Function

The high SG level limitation function avoids RT at Max1p and returns the SG level to its normal operating range. It has higher priority over the SG level control function described in Section 7.7.2.2.4.

This function is operable in Mode 1 through Mode 4.

The high SG level limitation function receives input from the narrow range SG level and the FLCV position. Two setpoints, Max c1 and Max c2, are set between the SG level control function setpoint and the safety setpoint Max1p, with Max c2 higher than Max c1. The LLCV and the FLCV in the MFWS are actuated depending on the SG level with respect to the Max c1 and Max c2 setpoints.

If SG level is greater than the Max c1 setpoint, a close order is sent to the FLCV first. If the FLCV position is below a certain position and the SG level is still above the Max c1 setpoint, then a close order is also sent to the LLCV. A close order to both the FLCV and the LLCV remain as long as the SG level is greater than the Max c1 setpoint.

If the SG level is greater than the Max c2 setpoint, close orders are immediately sent to both the FLCV and the LLCV regardless of their initial positions. When the water level is reduced to the intermediate region between Max c2 and Max c1, the close order is sent to the FLCV if it is not totally closed yet, while the LLCV would remain in its current position. When the FLCV is nearly closed, the LLCV will also be allowed to close.

The close orders to the FLCV and the LLCV will remain as long as the SG level is above the Max c1 setpoint.

Low SG Level Limitation Function

The low SG level limitation function avoids RT at Min1p and returns the SG level to its normal operating range. This function has higher priority over the SG level control function described in Section 7.7.2.2.4.

This function is operable in Mode 1 through Mode 4.

This function receives input from SG level (NR) and reactor power.

The low SG level limitation function defines a movable setpoint Min c1, set at a constant distance below the SG level control function setpoint and above the safety setpoint Min1p. The Min c1 setpoint is designed to be movable at a constant distance from the SG level control function setpoint to prevent undesired actuation of the low SG level safety function during SG level setpoint reduction before an RCP restart.

When the SG level is less than Min c1 and reactor power is less than 20 percent, an open order is sent to the LLCV. SG level is controlled by the LLCV at this power level. The open order to the LLCV is maintained as long as the water level is less than the Min c1 setpoint. Once the level increases above than Min c1 setpoint, the control of the LLCV returns back to the automatic control mode.

When the SG level is less than Min c1 and reactor power is greater than 20 percent, an open order is sent to the FLCV and the LLCV. The open orders are maintained to both valves as long as the water level is less than the Min c1 setpoint. Once the level increases above than Min c1 setpoint, the control of the FLCV and the LLCV return back to the automatic control mode.

Very Low Flow SG Level Limitation Function

The very low flow SG level limitation function disables the VLLCV signal stop and returns the SG level to the normal operating range. It has higher priority over the SG level control function described in Section 7.7.2.2.4.

This function is operable in Mode 2 and Mode 3.

The very low flow SG level limitation function disables the VLLCV signal stop, which provides the minimum position limitation during the startup and shutdown phases. The FLCV and LLCV are manually closed during Mode 2 and Mode 3 and therefore the FLCV and LLCV are not controlled by this limitation function.

To prevent water hammer and thermal stratification phenomena on the SG feedwater nozzle, the VLLCV signal stop guarantees a minimum continuous feedwater flowrate by preventing the VLLCV from closing below the minimum flow position. However, this could potentially cause a high water level in the SG.

When the SG level is greater than the Max c1 setpoint, the VLLCV signal stop is disabled and close orders are sent to the VLLCV. Once the SG level drops below the Max c1 setpoint, the VLLCV returns to the automatic control mode.

7.7.2.4 Non-Safety Control Systems Described in Other Sections

Table 7.7-1 provides a cross-reference to other sections of the final safety analysis report (FSAR) that contain information on I&C that support non-safety-related functions. The functions listed in Table 7.7-1 do not have direct influence on the process of nuclear power generation.

7.7.2.5 Safety Classification

With the exception of the SCDS, the I&C systems described in Section 7.7.1.1 and Section 7.7.1.2 are non-safety-related. The functions that these systems implement provide control of important parameters, but are not necessary to provide protection against AOOs and PAs. The SCDS serves only as the instrumentation interface and does not perform core control and plant control functions.

7.7.2.6 Effects of Control System Operation Upon Accidents

The effects of non-safety-related control system action and inaction on the transient response of the plant for AOOs and PAs are considered in the safety analysis addressed in Chapter 15.

The non-safety-related control functions maintain the major process variables of the NSSS in predefined and allowed ranges during normal power operation. The proper operation of the non-safety-related control functions is not necessary to provide protection against accidents.

7.7.2.7 Effects of Control System Failures

The effects of control system failures are minimized by the features described in this section.

Functions assigned to RCSL are redundant in more than one division. The failure of a function in one division is backed up by a redundant function in another division. The redundant functions and their associated equipment, including support systems are independent of each other. Independence is achieved by the following:

- Redundant functions are allocated to physically separated divisions.
- Erroneous signals or messages from one faulty division do not impair the functionality of the remaining divisions.

The RCSL is powered from the 12-hour UPS. During normal operation, the 12-hour UPS is powered from offsite power via the NPSS. In the event a LOOP occurs, the 12-hour batteries and the SBO diesel generators provide power to the severe accident portions of the RCSL.

Control functions assigned to each of the four independent PAS systems are segmented by CU pairs such that a control system failure in one CU pair of one PAS system will not propagate failure to any other CU pair or independent PAS system as whole. This segmentation reduces the probability of SWCCF such that SWCCF is not considered when analyzing PAS failures on the FSAR Chapter 15 Safety Analysis. No failure of PAS will affect all four divisions of PAS or initiate transients outside of the bounds of the Chapter 15 analysis.

Independence of each PAS division is achieved by the following:

- Segmented functions are uniquely allocated to each CU.
- Erroneous signals or messages from one faulty division do not impair the functionality of the remaining divisions or processor pairs.

PAS is powered by a battery backed source. The secondary power source is from a separate battery backed source fed from a different power bus. Upon loss of the primary source of power to PAS, the secondary power source automatically and without interruption, maintains power. In case of a total loss of power to the plant, the battery source permits continued operation of the plant controls for a two hour period.

Segregation of functions is provided by allocating functions related to core control in the RCSL and functions related to RCS parameters in the PAS. Failures of components in one non-safety-related system do not affect the functioning of the other non-safety-related system.

Control system failures are considered as event initiators in the safety analysis described in Chapter 15.

7.7.2.8 Environmental Control System

Environmental controls are provided to protect equipment from environmental extremes. Heating, ventilation, and air conditioning (HVAC) is provided to maintain ambient conditions in a range acceptable for proper operation of I&C equipment. Section 9.4 provides details on HVAC functions that maintain ambient temperature control where I&C equipment is located.

7.7.2.9 Independence

Electrical isolation and communication independence between safety and non-safety systems is provided by components of the safety I&C systems. Electrical isolation and communication independence is further described in Section 7.1.

7.7.2.10 Interactions between Safety-Related and Non-Safety-Related I&C Systems

Non-safety-related I&C systems use signal selection algorithms to select a process value on which to base process control actions. The controlling process value is selected from multiple input signals. The process controlling value is the result of a signal process algorithm which filters the values such that control of the process, feedwater flow for example, is based on intermediate values of the process variable so that extreme values (min or max) are ignored. Therefore, this control method reduces the possibility of the control system acting on an erroneous extreme value, as may result from instrument or other failures.

Feedwater flow is a controlled process variable that would cause significant plant transients if perturbed during 100% power operation. Without proper filtering, the process control system could be affected by a single process sensor malfunction or by an inadvertent perturbation of a sensor during maintenance. This type of process control input upset could result in a feedwater transient that would create challenges to safety systems.

7.7.2.11 Defense in Depth and Diversity

Non-safety-related functions that are designed to provide diverse protective functions are described in Section 7.8.

7.7.2.12 Potential for Inadvertent Actuation

The non-safety-related control systems and functions are designed to limit the potential for inadvertent actuation and challenges to the safety-related systems. Many of the process limitation I&C functions described in Section 7.7.2.3 are designed to achieve optimum plant availability. These types of limitation functions act before protection functions, and thus restore normal operating conditions without challenging the protection thresholds for the most frequent accident conditions. The limitation thresholds are set before protection thresholds (as close as possible to them), but with a margin taking into account the counter-measure response time. After exceeding a limitation threshold, rapid corrective actions are automatically initiated. The typical limitation function action is the RCCA dropping called the PT which leads to a fast power decrease.

7.7.2.13 Control of Access

Physical access to I&C cabinets is restricted to authorized personnel. Unauthorized access to system software via network connections is prevented by administrative controls. The loading of software and parameter changes via maintenance equipment is only possible in accordance with clearly defined procedures.

7.7.3 Analysis

The I&C systems described in Section 7.7.1.1 and Section 7.7.2.1 are those used for normal operation that are not relied upon to perform safety-related functions following AOOs or PAs. These systems control plant processes having an impact on plant safety.

The plant control systems are designed to prevent an undesirable condition in the operation of the plant that, if reached, is protected by the PS. The description and analysis of this protection is covered in Section 7.2 and Section 7.3.

How these I&C systems comply with the acceptance criteria and conform to guidelines set forth in NUREG-0800 (Reference 2) is described in Section 7.1.

7.7.4 References

1. Deleted.

2. NUREG-0800, Standard Review Plan, Section 7.7, "Control Systems," Revision 5, U.S. Nuclear Regulatory Commission, March 2007.

3. ER-157P, Topical Report, Revision 8, "Supplement to Topical Report ER-80P: Basis for a Power Uprate with the LEFM Check or CheckPlus System," Cameron Measurement Systems.

4. Final Safety Evaluation by the Office of Nuclear Reactor Regulation, Engineering Report ER-157P, Topical Report, Revision 8, "Supplement to Topical Report ER-80P: Basis for a Power Uprate with the LEFM Check or CheckPlus System," Cameron Measurement Systems," Project No. 1370.

Table 7.7-1—Cross Reference of Non-Safety-Related I&C Controls

System	Non-Safety-Related Control Function(s)	FSAR Section
Fuel Storage and Handling	Provides a means for handling fuel assemblies.	9.1
Essential Service Water System	Cooling of the Severe Accident Heat Removal System.	9.2.1
Component Cooling Water System	• Cooling of non-safety-related components and heat exchangers. • Cooling of the Severe Accident Heat Removal System.	9.2.2
Operational Chilled Water System	Cooling source for non-safety-related loads of HVAC.	N/A
Compressed Air System	Provides compressed air to non-safety-related components.	9.3.1
Chemical Volume and Control System	• Reactor coolant water purification and clean up. • RCP sealing water supply. • Provide auxiliary spray to PZR.	9.3.4
Air Conditioning, Heating, Cooling and Ventilation Systems	Provide ambient air cooling for non-safety-related systems and components.	9.4
Fire Protection Systems	Detects and suppresses fires.	9.5.1
Turbine Generator	Converts the thermal energy supplied by the main steam supply system into electrical energy.	10.2
Condensate and Feedwater System	Provides feedwater to the steam generators (SG) at the required temperature, pressure and flow rate	10.4.7
Liquid Waste Management Systems	Receive and process radioactive liquid wastes from various systems.	11.2
Gaseous Waste Management Systems	Receive and process radioactive gaseous wastes from various systems.	11.3
Solid Waste Management Systems	Receive and process radioactive solid wastes from various systems.	11.4

Table 7.7-2—Elemental Uncertainties for Secondary Side Calorimetric

Input	Maximum Allowable Uncertainty at 100%NP
Feedwater Flow Rate	0.28% of the Actual Value
Feedwater Temperature	± 0.6°F of the Actual Value
Feedwater Pressure	± 25 psia of the Actual Value
Steam Pressure	± 25.4 psia of the Actual Value
Blowdown Flow Rate	± 5% of the Actual Value
Blowdown Temperature	± 3.0°F of the Actual Value
Charging Flow Rate	± 4% of the Actual Value
Charging Temperature	± 3% of the Actual Value
Charging Pressure	± 3% of the Actual Value
Letdown Flow Rate	± 4% of the Actual Value
Letdown Temperature	± 3% of the Actual Value
Letdown Pressure	± 3% of the Actual Value
Reactor Coolant Pump Power	± 20% of the Actual Value
Power Losses from the Reactor Coolant System	± 20% of the Actual Value
Pressurizer Heater Power	± 20% of the Actual Value
Steam Moisture Content	± 0.25% of the Actual Value

Figure 7.7-1—Average Coolant Temperature Control Logic

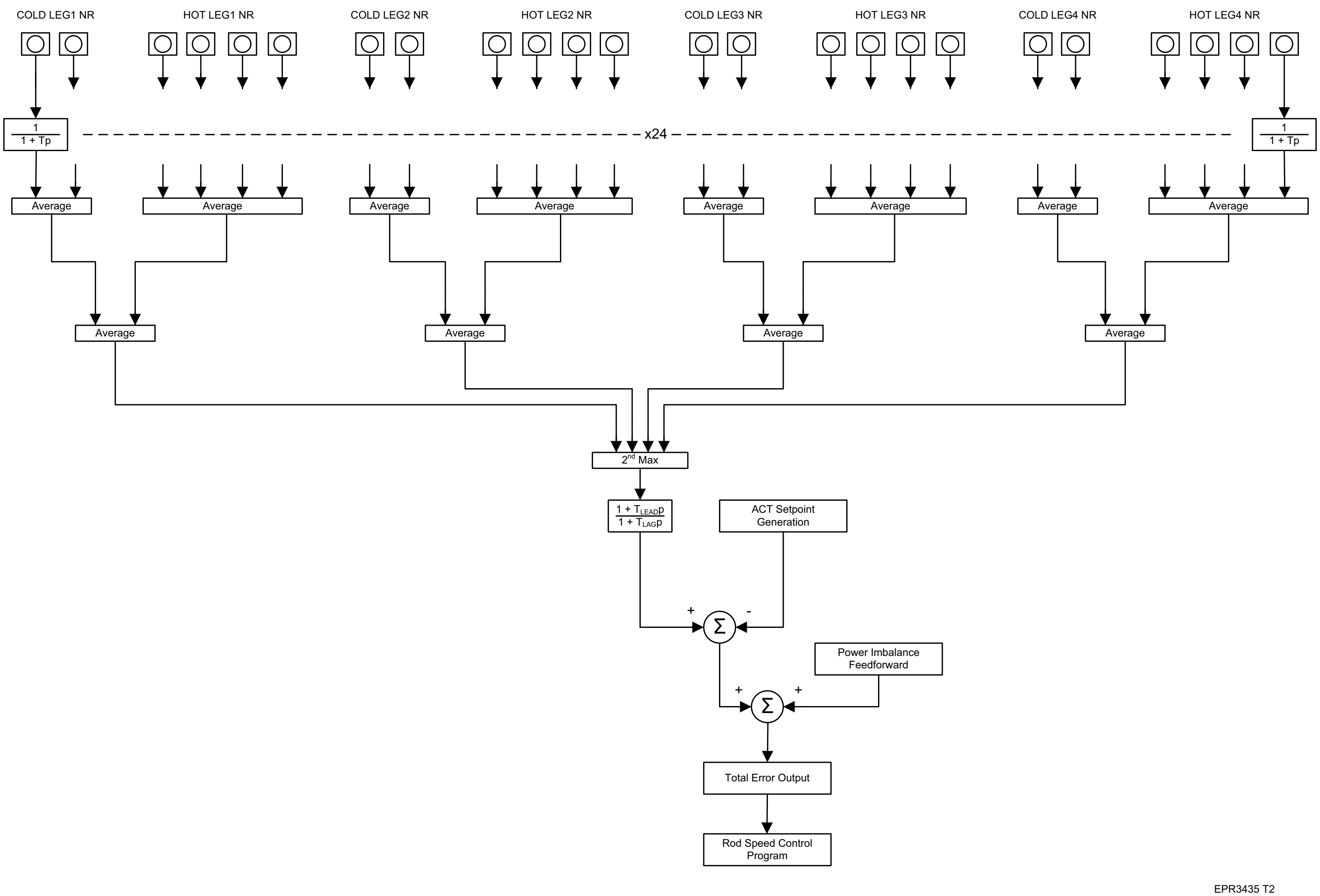


Figure 7.7-2—Rod Speed Control Program

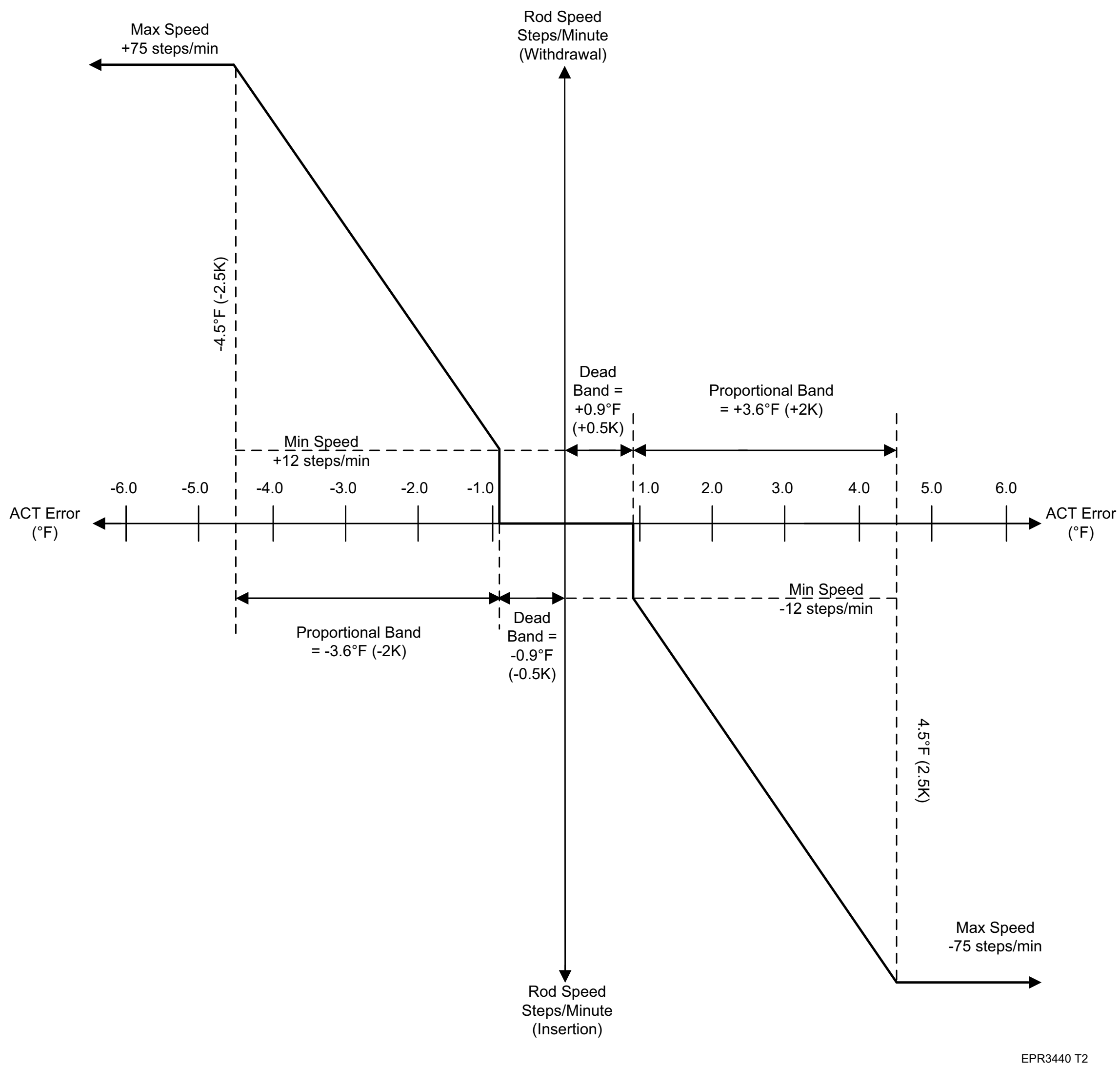


Figure 7.7-3—RCS Pressure Setpoints

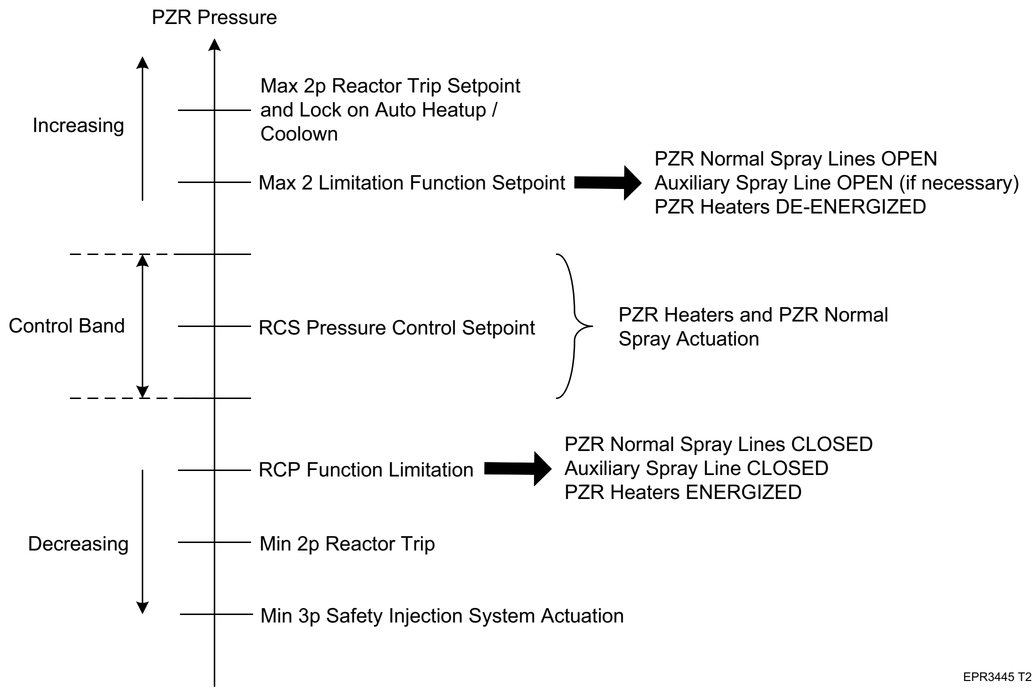


Figure 7.7-4—Pressurizer Level Setpoints

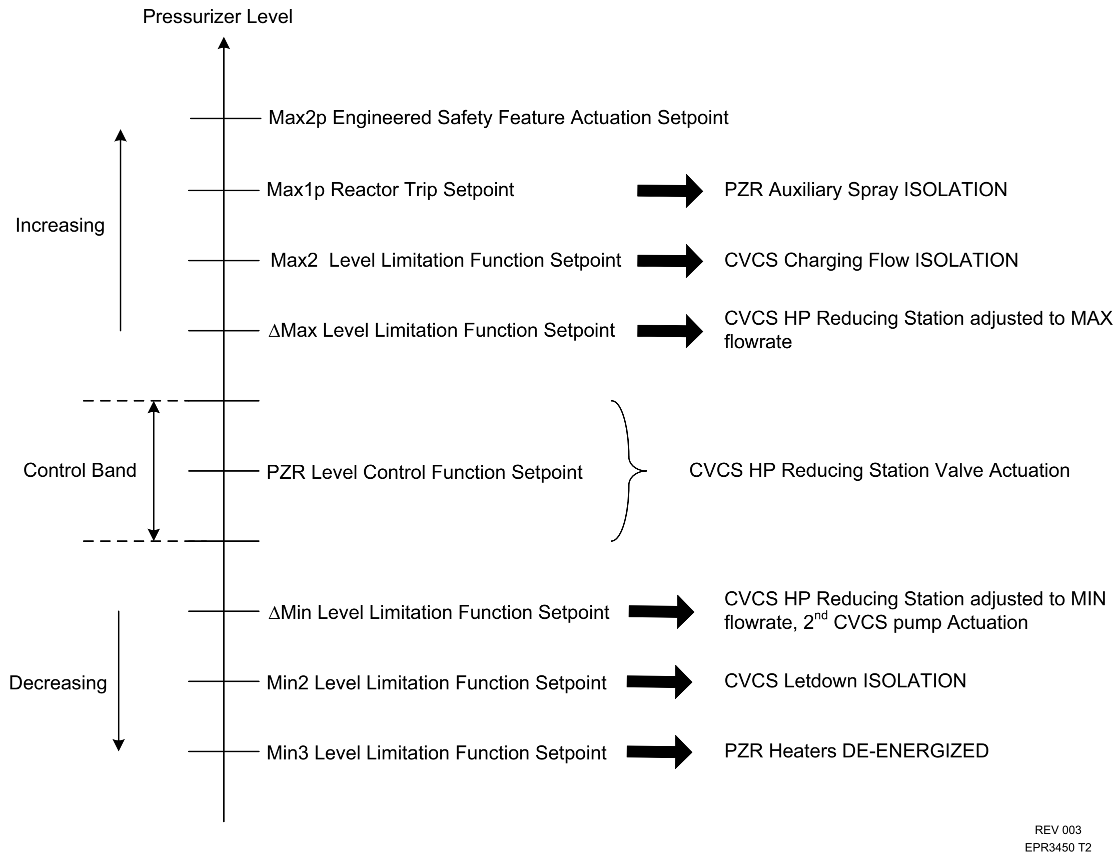
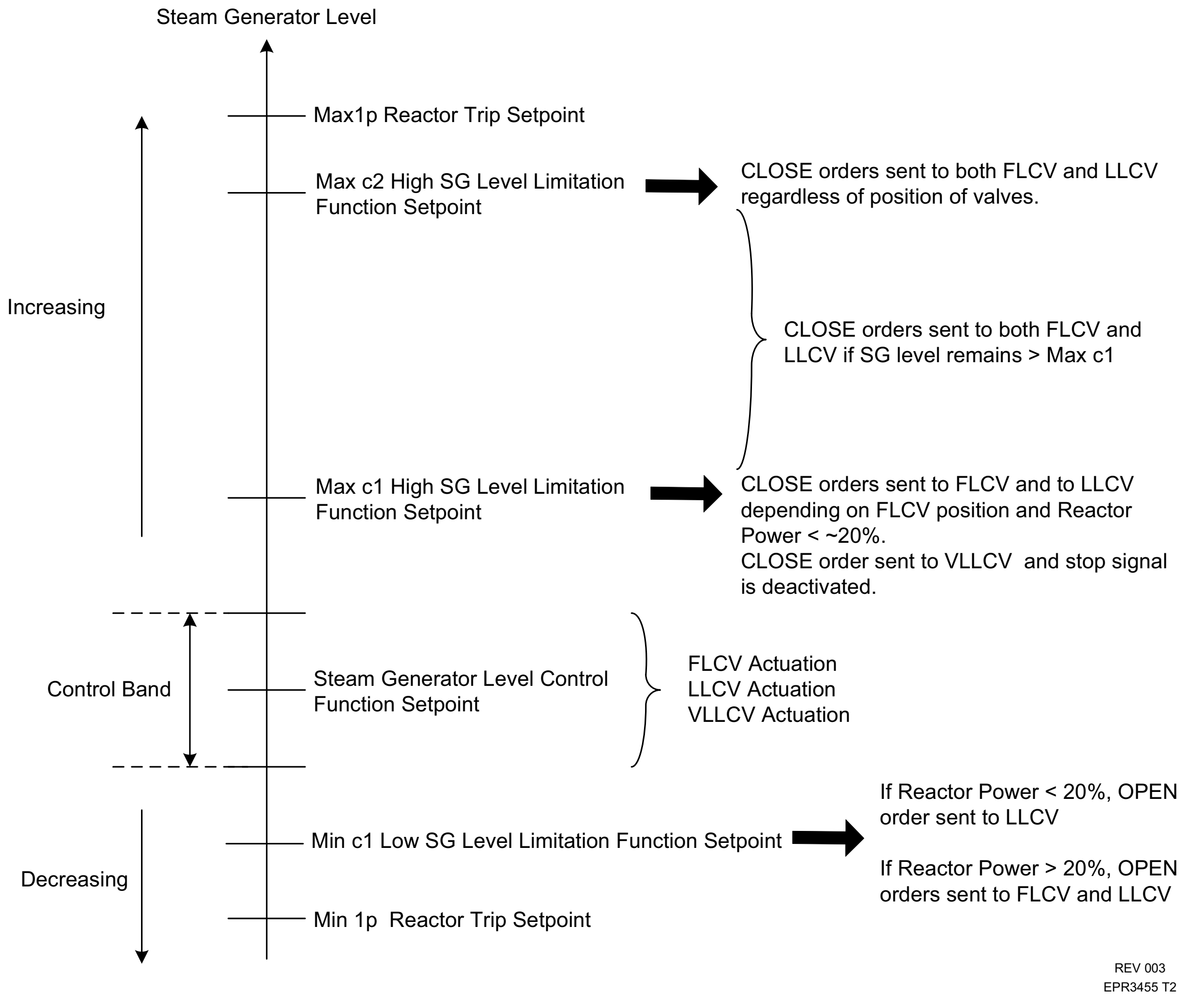


Figure 7.7-5—Steam Generator Level Setpoints



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