2.2 Control and Instrument Systems

The information in this section of the reference ABWR DCD, including all subsections, tables, and figures, is incorporated by reference with the following departures.

STD DEP T1 2.2-1 (Figure 2.2.7a, Table 2.2.7)

STD DEP T1 2.2-2 (Figure 2.2.1, Table 2.2.1)

STD DEP T1 2.2-3

STD DEP T1 2.2-4 (Table 2.2.1)

STD DEP T1 2.14-1

STD DEP T1 3.4-1 (Figure 2.2.5, Figure 2.2.7b)

2.2.1 Rod Control and Information System

STD DEP T1 2.2-2 (Figure 2.2.1—RPS, Table 2.2-1—Item 8)

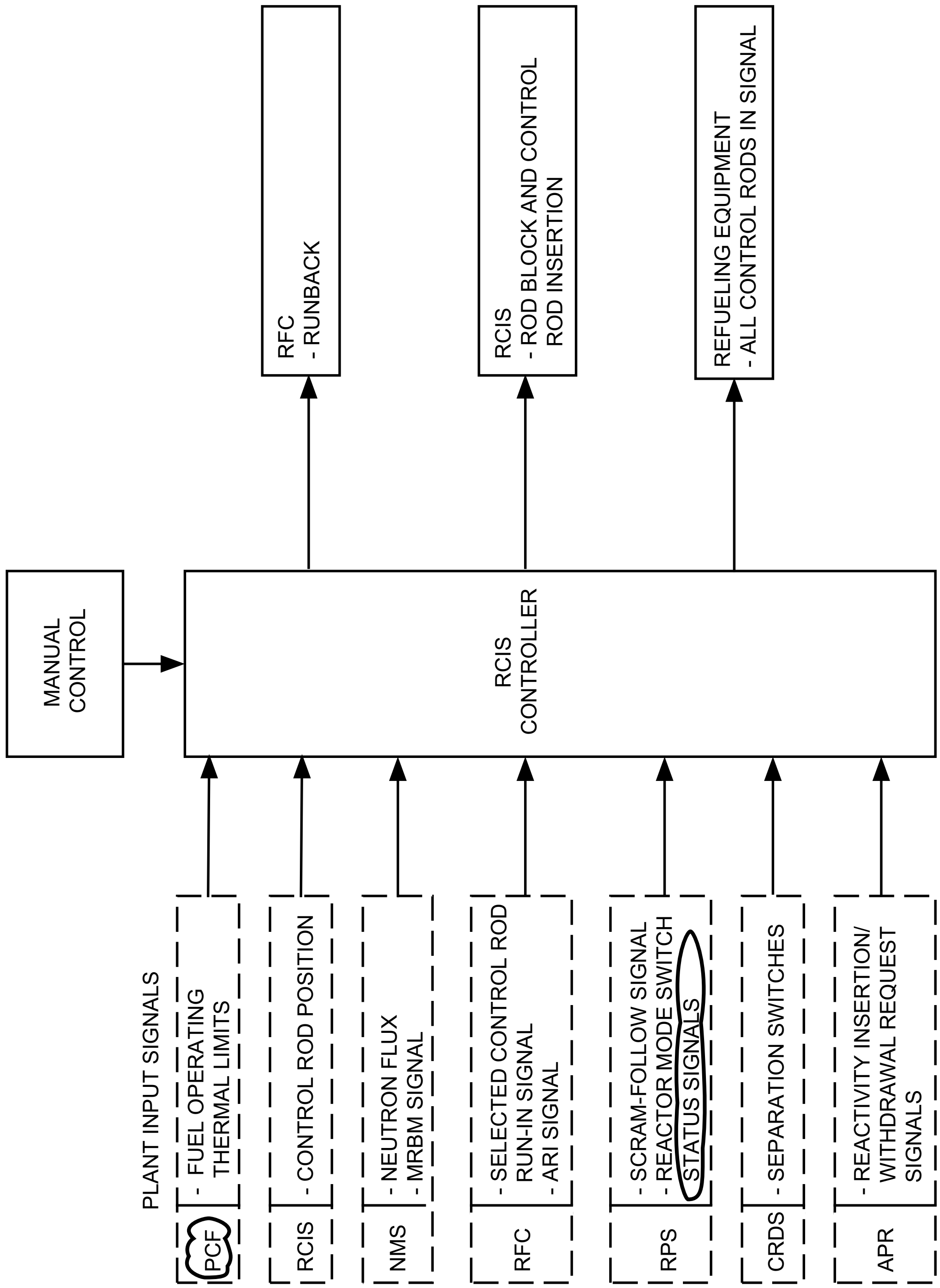
STD DEP T1 2.2-4 (Table 2.2.1—Item 11)

STD DEP T1 3.4-1 (Figure 2.2.1—PCF)

The RCIS provides the following:

(6) *An automatic control rod withdrawal block in response to:*

(b) *A signal from the CRD System FMCRD hollow piston/ball nut separation switches (withdrawal block applies only to separated control rod* if the associated control rod is selected for movement when the RPS Mode Switch is in the Startup Mode or Run Mode)*, or*



NOTE:
1. INTERCONNECTIONS MAY BE FIBER-OPTIC OR METALLIC.

Figure 2.2.1 Rod Control and Information System Control Interface Diagram

Table 2.2.1 Rod Control and Information System

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspection, Tests, Analyses**	**Acceptance Criteria**
8. The RCIS provides an automatic control rod withdrawal block in response to: a. A signal from the NMS MRBM at above the low power setpoint. b. A signal from the CRD System FMCRD hollow piston/ball nut separation switches (withdrawal block applies only to separated control rod **if selected with the RPS mode switch in Startup Mode or Run Mode**). c. A signal from the RPS Mode Switch when in Refuel Mode that only permits the two control rods associated with the same HCU being withdrawn from the core at anytime.	8. Tests will be conducted on the RCIS using simulated signals from the NMS MRBM at above low power setpoint; and from the FMCRD separation switches **and Startup and Run Mode positions of RPS Mode Switch**; and from control rods of the same HCU and Refuel Mode position of RPS Mode Switch.	8. A control rod withdrawal block signal occurs upon receipt of simulated signals from: a. NMS MRBM at above the low power setpoint, b. FMCRD separation switches (withdrawal block is only applicable to separated control rod **if selected with the RPS mode switch in Startup Mode or Run Mode**), c. An attempt to withdraw a control rod, when the RPS mode switch is in Refuel Mode and the two control rods associated with the same HCU are withdrawn.
11. The RCIS is powered by two non-Class 1E uninterruptible supplies.	11. Tests will be performed on the as-built RCIS by providing a test signal in only one non-Class 1E uninterruptible power supply at a time.	11. The test signal exists ~~*in only one control channel at a time*~~ **in only the one power supply**.

2.2.3 Feedwater Control System

STD DEP T1 3.4-1

STD DEP T1 2.2-3

Design Description

The FDWC digital controllers determine narrow range level signal using three reactor level measurement inputs from the NBS. Sensor signals are transmitted to the FDWC digital controllers by the Non-Essential Multiplexing System (NEMS).

The steam flow in each of four main steamlines is sensed at the RPV nozzle venturis. Sensor signals are transmitted to the FDWC System digital controllers by the NEMS. These measurements are processed in the digital controllers to calculate the total steam flow out of the vessel.

Feedwater flow is sensed at a flow element in each of the two feedwater lines. Sensor signals are transmitted to the FDWC digital controllers by the NEMS. These measurements are processed in the digital controllers to calculate the total feedwater flow into the vessel.

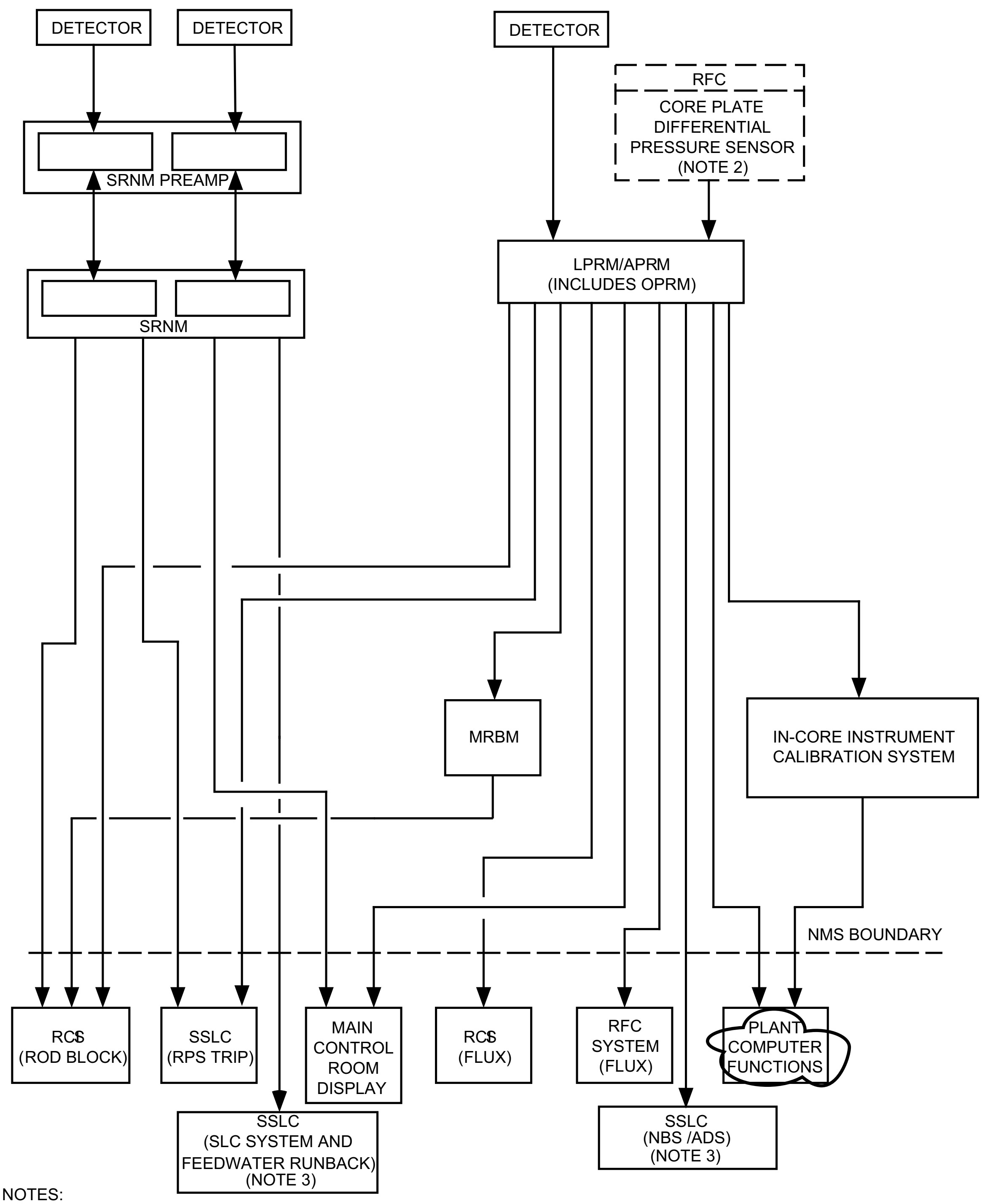
The total feedwater flow is displayed on the main control panel. The FDWC System operating mode is selectable from the main control room. The FDWC System microprocessors are located in the Control Building.

2.2.5 Neutron Monitoring System

STD DEP 3.4-1 (Figure 2.2.5)

Design Description

The automated in-core instrument calibration system provides local power information at various core locations that correspond to LPRM locations. The automated in-core instrument calibration system uses its own set of in-core detectors for local power measurement and provides local power information for three-dimension core power determination and for the calibration of the LPRMs. The measured data are sent to the ~~Process Computer System~~ Plant Computer Functions *for such calculation and LPRM calibration*.



NOTES:
1. DIAGRAM REPRESENTS ONE OF FOUR NMS DIVISIONS (MRBM IS A DUAL CHANNEL SYSTEM. THERE IS ONLY ONE IN-CORE INSTRUMENT CALIBRATION SYSTEM).
2. USED FOR RAPID CORE FLOW DECREASE TRIP.
3. SRNM AND APRM ATWS PERMISSIVE SIGNALS TO SSLC.
4. INTERCONNECTIONS MAY BE FIBER-OPTIC OR METALLIC.

Figure 2.2.5 Neutron Monitoring System

2.2.6 Remote Shutdown System

STD DEP T1 2.14-1

Licensing Topical Report NEDO-33330P, "Hydrogen Recombiner Requirements Elimination," pages B-3 and B-4 are incorporated by reference.

2.2.7 Reactor Protection System

STD DEP T1 2.2-1 (Figure 2.2.7a, Table 2.2.7)

STD DEP T1 3.4-1 (Figure 2.2.7b)

Design Description

As shown in Figure 2.2.7a, the RPS interfaces with the Neutron Monitoring System (NMS), Nuclear Boiler System (NBS), Control Rod Drive (CRD) System, Rod Control and Information System (RCIS), Recirculation Flow Control (RFC) System, and the Suppression Pool Temperature Monitoring System (SPTM).~~, and the Essential Multiplexing System (EMS)~~. Figure 2.2.7a also depicts the primary ~~implementation of~~ RPS logic ~~within the Safety System Logic and Control (SSLC)~~.

The RPS has four divisions. Figure 2.2.7b shows the RPS divisional aspects and the signal flow paths from sensors to scram pilot valve solenoids. Functions ~~Equipment~~ within an RPS division ~~consists of~~ include sensors (transducers or switches), ~~multiplexers,~~ data communication, digital trip ~~modules~~ functions (~~DTM~~ DTF), trip logic ~~unit~~ function (~~TLU~~ TLF), output logic unit (OLU), and load drivers (LD). The LDs are only in Divisions II and III. The (DTF) and (TLF) are performed in digital control processors. The data communication functions are described in Section 2.7.5.

The RPS consists of logic and circuitry for initiation of both automatic and manual scrams. The automatic scram function is ~~comprised of~~ accomplished redundantly in four independent divisions of sensor ~~instrument channels, hardware/software based logic~~ and logic processing, and two independent divisions of actuating devices. Automatic scram is initiated whenever a scram condition is detected by two or more automatic divisions of RPS logic. ~~For automatic scram, the sensor input signals to the RPS originate either from the RPS's own sensors or other systems' sensors.~~ For determination of the existence of an automatic scram condition, within each ~~automatic scram channel~~ division of the RPS, the ~~DTM~~ DTF of a given RPS ~~channel~~ division compares the monitored process variable with ~~the~~ a ~~stored~~ setpoint stored in its memory and issues a trip signal if the monitored process variable exceeds the setpoint. The ~~DTM~~ DTF ~~then~~ sends the trip signal to the ~~TLU~~ TLF of its own ~~channel~~ division and the ~~TLU~~ TLFs of the other three ~~channels~~ divisions of RPS~~, where two-out-of-four voting is performed (see Figure 2.2.7b)~~. The TLF in each division performs an independent two-out-of-four vote on each RPS DTF input.

~~In the case of high suppression pool average temperature trip and inboard/outboard MSIV closure signals, the SPTM module of SSLC and NBS provide their divisional trip signals directly to the corresponding divisional RPS DTM. However, in the case of the NMS,~~ Each of the four ~~channels~~ divisions of the NMS ~~each~~ provide their trip and Simulated Thermal Power (STP) signals to ~~each~~ the corresponding RPS divisional ~~TLU~~ TLF independent of the DTF for all other RPS automatic trip input parameters. A list of conditions that can cause automatic reactor scram is provided below. The name of the system that provides the sensor input signal or the trip signal is shown in brackets.

(3) *NMS Trips [~~Discrete trip signals to RPS TLUs~~*NMS*]*

(7) *Main Steamline Isolation [NBS ~~discrete signals to RPS DTMs~~]*

(9) *High Suppression Pool Average Temperature [SPTM ~~Module of SSLC trip signals to RPS DTMs~~]*

The ~~TLU~~ TLF*s provide their trip signals to their divisional OLUs which ~~are used to~~ control the solid-state LDs that control the Class 1E AC power to the scram solenoids~~,~~ and relays that control DC power to back-up scram valves. For automatic scram initiation, the ~~TLU~~* TLF *trip signals cause the LDs to interrupt Class 1E AC power to the scram solenoids (fail-safe logic), cause the back-up scram relays to supply DC power to back-up scram solenoids, and provide scram follow signals to the RCIS. Each division of RPS controls eight LDs. The LDs are arranged to switch AC power to the scram solenoids in a two-out-of-four ~~format~~*arrangement*. That is, reactor scram will occur only if two or more divisions of the RPS provide trip signals to their associated LDs and both scram solenoids are de-energized.*

~~M~~anual scram function, which is separate and independent from automatic scram logic, is implemented in Divisions II and III of the RPS. For manual scram initiation, two manual scram push buttons ~~of the RPS~~ must be simultaneously depressed. When manual scram is initiated, the RPS~~, through manual scram switches,~~ interrupts Class 1E AC power to the scram solenoids, connects divisional Class 1E DC power to back-up scram solenoids, and provides scram follow signals to RCIS. The RPS logic seals in the scram signals and permits reset of scram logic only *after a time delay of at least 10 seconds.*

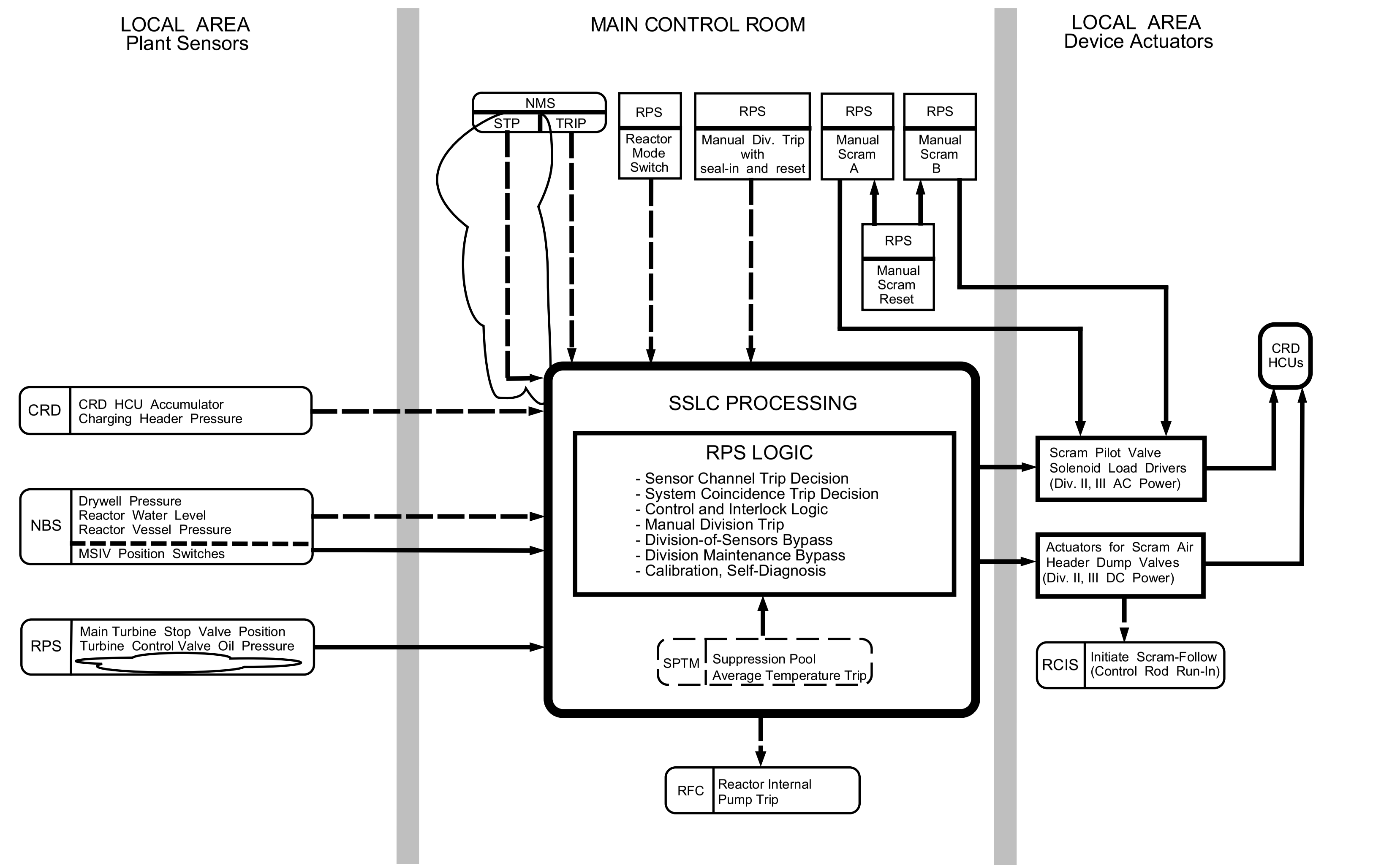
RPS initiates a reactor internal pump (RIP) trip on receipt of either a turbine stop valve closure or a low turbine control valve oil pressure signal when the reactor power is above 40% (from ~~a turbine first stage pressure~~ NMS STP signal).

The RPS design is single-failure-proof and redundant. Also, the RPS design is fail-safe in the event of loss of electrical power to one division of RPS logic.

The OLU and LDs are implemented with non-microprocessor-based equipment. The remaining RPS functions are primarily implemented with microprocessor-based equipment.

Each of the four RPS divisional logic and associated sensors are powered from their respective divisional Class 1E power supply. In the RPS, independence is provided between Class 1E divisions, and also between the Class 1E divisions and non-Class 1E equipment.

As shown on Figure 2.2.7a, the RPS has manual divisional trip switches, reactor mode switch, manual scram switches, and scram reset switches for manual controls. Divisional trip displays, and scram solenoids electrical power status lights are also provided. These RPS controls and displays are provided in the main control room. Fail safe RPS sensors are turbine control valve oil pressure ~~switches,~~ sensors and *turbine stop valve position switches~~, and turbine first-stage pressure sensors. These sensors are located in the Turbine Building~~.*



NOTES:
1. Diagram represents one of four divisions.

Figure 2.2.7a Reactor Protection System Control Interface Diagram

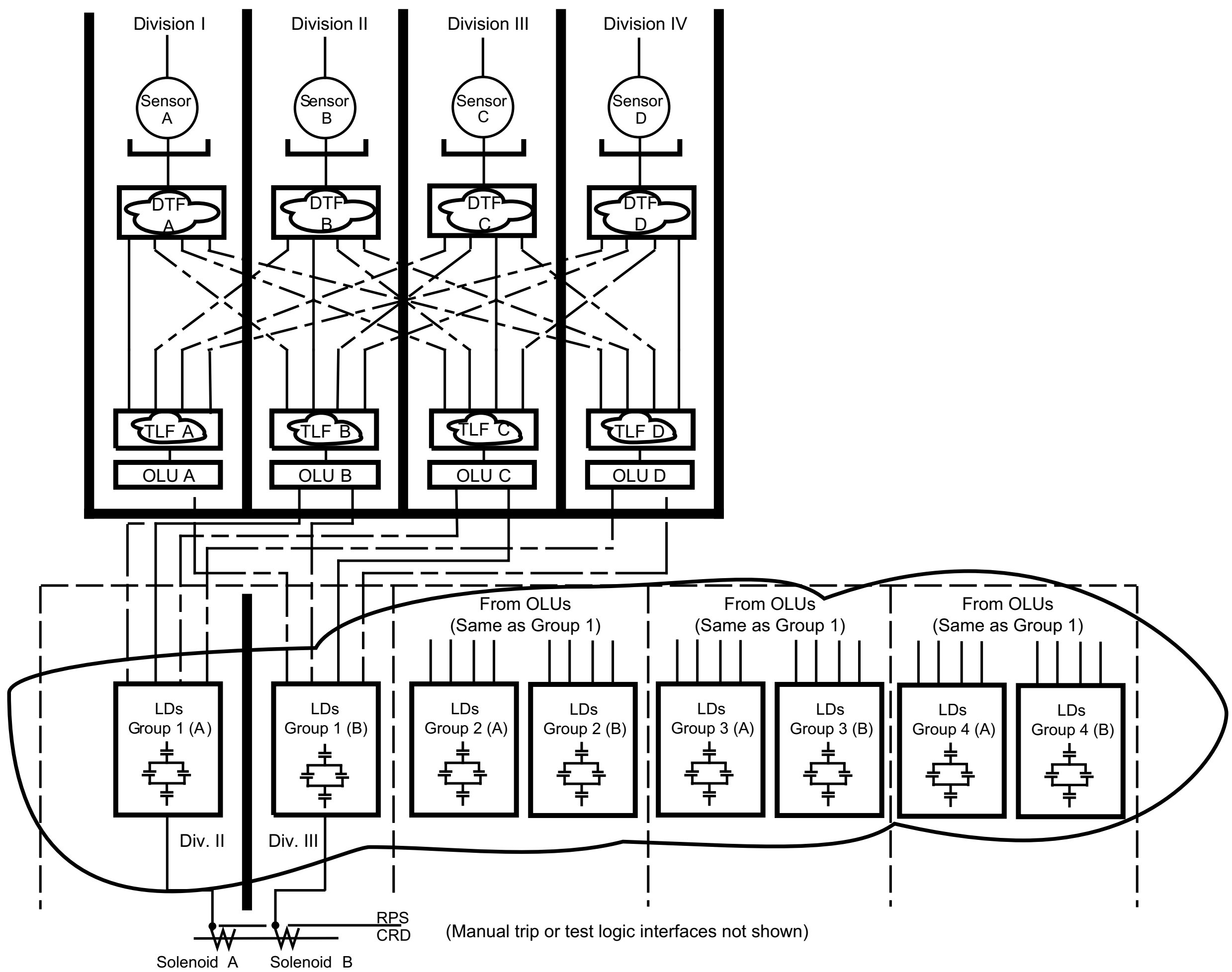


Figure 2.2.7b Reactor Protection System

Table 2.2.7 Reactor Protection System

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
5. RPS initiates an RIP trip on receipt of either a turbine stop valve closure or a low turbine control valve oil pressure signal when reactor power is above 40% (from ~~*a turbine first stage*~~ **NMS STP** signal).	5. Test will be conducted on the as-built RPS using simulated turbine stop valve position, turbine control valve oil pressure and ~~*turbine first stage pressure*~~ **NMS STP** signals.	5. The RPS initiates an RIP trip on receipt of either a simulated signals indicating turbine stop valve closure or low control valve oil pressure when reactor power is above 40%.

2.2.9 Automatic Power Regulator System

STD DEP T1 3.4-1

Design Description

The APR System operates in either manual or automatic control mode. The system control logic is performed by redundant, digital controllers. The digital ~~controller~~ controllers ~~receives~~ receive *inputs from* and send outputs *to interfacing ~~system~~* systems *via the non-essential ~~multiplexing system (NEMS)~~* data communication function (NECF). *~~It~~* The APR System *performs power control calculations and* provides *system outputs to ~~the NEMS~~* interfacing systems to allow coordinated control.

2.2.11 ~~Process Computer System~~ Plant Computer Functions (PCFs)

STD DEP T1 3.4-1

Design Description

The ~~Process~~ Plant *Computer ~~System~~* Functions *(~~PCS~~* PCFs*) ~~consists of~~* are a set of control, monitoring and data calculation functions that are implemented on *~~redundant~~ digital central processing units and associated peripheral equipment* provided by the Plant Information and Control System (PICS). Redundant processors are used for functions that are important to plant operation. The PCFs *~~and is~~* are *classified as ~~a~~ non-safety-related ~~system~~.*

The ~~PCS~~ PCFs *~~performs~~* perform *local power range monitor (LPRM) calibrations and calculations of fuel operating thermal limits data*, *which ~~it~~* is *~~provides~~* provided *to the automated thermal limit monitor (ATLM) function of the Rod Control & Information System (RCIS) for the purpose of updating rod block setpoints.*

The ~~PCS functions also as a~~ PCFs also include top-level controller functions which *~~monitors~~* monitor *the overall plant conditions, ~~issues~~* issue *control commands and ~~adjusts~~* adjust *setpoints of lower level controllers to support automation of the normal plant startup, shutdown and power range operations. In the event that abnormal conditions develop in the plant during operations in the automatic mode, ~~the PCS~~* these functions *automatically ~~reverts~~* revert *to the manual mode of operation.*

Inspections, Tests, Analyses and Acceptance Criteria

Table 2.2.11 provides a definition of the inspections, tests and/or analyses, together with associated acceptance criteria, which will be undertaken for the ~~PCS~~ PCFs.

Table 2.2.11 ~~**Process Computer System**~~ Plant Computer Functions

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
1. The PICS equipment ~~*comprising*~~ performing the ~~*PCS*~~ **PCFs** is defined in Section 2.2.11.	1. Inspections of the as-built system will be conducted.	1. The as-built ~~*PCS*~~ PICS equipment implementing the PCFs conforms with the description in Section 2.2.11.
2. The ~~*PCS*~~ **PCFs** ~~*provides*~~ **provide** LPRM calibration and fuel operating thermal limits data to the ATLM function of the RCIS.	2. Tests of the as-built ~~*PCS*~~ **PCFs** will be conducted using simulated plant input signals.	2. LPRM calibration and fuel thermal limits data are received by the ATLM function of the RCIS.
3. In the event that abnormal conditions develop in the plant during operations in the automatic mode, the ~~*PCS*~~ **PCFs** automatically ~~*reverts*~~ **revert** to the manual operating mode.	3. Tests of the as-built ~~*PCS*~~ **PCFs** will be conducted using simulated abnormal plant input signals, while the ~~*PCS*~~ **PCFs** ~~*is*~~ **are** in the automatic operating mode.	3. Upon receipt of the abnormal plant input signals, the ~~*PCS*~~ **PCFs** automatically ~~*reverts*~~ **revert** to the manual operating mode.