7.5 INSTRUMENTATION SYSTEMS

7.5.1 PROCESS INSTRUMENTATION

7.5.1.1 Design Basis

The non-nuclear process instrumentation measures temperatures, pressures, flows, and levels in the RCS, secondary system, and auxiliary systems. Process variables required for startup, operation, and shutdown of the plant are indicated, recorded, and controlled from the Control Room. Other instrumentation used less frequently or which requires a minimum of operator action is located near the equipment. Alternate indicators and controls are located in places other than the Control Room to allow reactor shutdown should the Control Room have to be evacuated.

The containment pressure transmitter sensing lines are the only instrument lines to which Safety Guide 11, "Instrument Lines Penetrating Primary Reactor Containment," was applicable, and are designed accordingly.

The containment pressure transmitters are located outside the containment structure in the electrical penetration room. They are located as close as practical to the containment and installed using short connections between the containment penetrations and the instruments. The transmitters are designed as pressure retaining devices, whereby rupture of the sensing device would not release radioactivity to the environment, but would contain the radioactivity within the housing of the instrument. Each sensing line is provided with a solenoid-operated isolation valve which is located as close as possible to the containment penetration. The isolation valves are controlled from the Control Room and are provided with position switches for remote indication in the Control Room. The isolation valves and instrument lines, up to and including the pressure retaining parts of the instruments, are Seismic Category I.

Provisions have been made for periodic visual in-service inspection of the isolation valves, pressure sensing lines, sample lines, and the pressure transmitters.

Four independent measurement channels are provided to monitor each process parameter required for the RPS. Redundant channels are provided for ESFs action to meet the single-failure criterion.

Two channels are provided to monitor parameters required for critical control functions. These channels and associated sensors are independent of the RPS.

7.5.1.2 System Description

The process instrumentation described below is associated with the RPS, reactor control, or reactor plant controls (Figure 4-1).

Temperature

The temperature measurements are made with precision RTDs, which provide a signal to the remote temperature indicating control and safety devices.

The following is a brief description of each of the temperature measurement channels:

a. Hot leg temperature: Each hot leg contains five temperature measurement channels. Four of these channels provide a hot leg temperature signal to the TM/LP trip circuits and the sub-cooled margin monitors (SCMM). The other hot leg temperature measurement channel provides a signal to the loop T_{avg} computer in the Reactor Regulating System. The five hot leg temperatures are indicated on the control panel.

b. Cold leg temperature: Each cold leg branch contains three temperature measurement channels. Two of the channels in each branch provide a cold leg temperature signal to the TM/LP trip circuits and the SCMM. These channels also provide cold leg temperature indication on the control panel. The third cold leg temperature measurement channel in one branch provides a signal to the loop T_{avg} computers. This channel also provides a high alarm and a signal to an automatic CEA withdrawal prohibit. The third channel in the other branch is recorded on the control panel.

c. Loop average temperature: Each of the two Reactor Regulating System channels receives a hot leg and cold leg temperature from each loop (as mentioned above). The T_{avg} summer receives input hot and cold leg temperatures from any combination of the loops and provides an average temperature output to the Reactor Regulating System and to a recorder. The temperature recorders are equipped with two pens. One pen records the average temperature and the other pen records the programmed reference temperature signal (T_{ref}) corresponding to turbine load (first stage pressure). Redundant hot and cold leg temperatures for each loop are displayed at the alternate shutdown panel.

Redundant hot and cold leg temperatures for each loop are displayed at the alternate shutdown panel.

<u>Pressure</u>

Pressure is measured by electromechanical pressure transmitters. The transmitter produces a DC output that is proportional to the pressure sensed by the instrument. The DC outputs are used to provide signals to the remote pressure indicating, control, and safety devices.

The following is a brief description of each of the pressure measurement channels:

a. Pressurizer pressure (protective action): Four pressurizer pressure transmitters provide independent pressure signals over a 1000 psi range. These four independent pressure channels provide the signals for the RPS high-pressure trip, the variable TM/LP trip, and the DSS high-pressure trip. The channels also provide the low-low pressure signal to initiate safety injection. All four pressure channels are indicated in the Control Room and high, low, and low-low alarms are annunciated. Figure 7-3 is a functional diagram of one of these channels.

b. Pressurizer pressure (control action): Two independent pressure channels provide narrow range signals for control of the pressurizer heaters and spray valves. The output of either controller may be manually selected to perform the control function. Outputs from the two pressure control channels are recorded in the Control Room and provide independent high and low alarms.

c. Pressurizer pressure (miscellaneous channels): Two pressure channels, electrically independent of the safety and control channels, but sharing pressure taps with the safety channels, provide inputs to the Control Room, and generate the power interlocks (blocking) for the shutdown cooling isolation valves on high pressurizer pressure.

d. Pressurizer pressure (Wide Range): Two pressure channels, electrically independent of the safety and control channels, but sharing pressure sensing lines with the safety channels, provide inputs to the SCMMs, the auxiliary shutdown panels, and the Control Room.

Pressurizer Level

Level is sensed by level transmitters which measure the pressure difference between a reference column of water and the pressurizer water level. This pressure difference is converted to a DC signal proportional to the level of water in the pressurizer. The DC output of the level transmitters provides signals to the remote level indicating and control devices.

Two independent pressurizer level transmitters provide signals to the chemical and volume control charging and letdown system. In addition, signals are provided for pressurizer heater override control. These level transmitters are calibrated for steam and water densities existing at normal pressurizer operating conditions.

The two pressurizer level control channels each provide a signal for level recorders in the Control Room. These recorders are two-pen recorders, with one pen recording actual level as sensed by the level control channel and the other pen recording the programmed level setpoint signal from the Reactor Regulating System.

The pressurizer pressure level channels provide read-out in the Control Room and on the auxiliary shutdown panel.

Flow

An indication of reactor coolant flow is obtained from measurement of pressure drop between the hot leg piping and the outlet plenum of each SG. The pressure drop is sensed by d/p transmitters which convert the pressure difference to DC output. The DC output provides a signal to the remote flow indicating and safety devices.

Four independent d/p transmitters are provided in each reactor coolant loop to measure the pressure drop across the SGs. The outputs of corresponding transmitters in each loop are summed by pairs to provide four independent signals representative of flow through the reactor core. These signals are indicated and supplied to the RPS for loss-of-flow determination. The d/p sensed by each transmitter is indicated in the Control Room.

7.5.2 NUCLEAR INSTRUMENTATION

7.5.2.1 Design Basis

The nuclear instrumentation monitors neutron flux over a range greater than ten decades with four independent and redundant channels. These channels generate a startup rate and provide the RPS with four independent signals. Neutron flux is also monitored over the power range to provide four redundant signals, proportional to reactor power, to the RPS. Furthermore, nuclear instrumentation monitors the power range with two additional channels for control of the reactor. These two channels are completely independent of those mentioned above. In addition, an independent excore wide-range neutron monitoring channel is provided to indicate neutron flux level on the auxiliary shutdown panel.

7.5.2.2 System Description

Installation

The nuclear instrumentation signal processing equipment associated with the RPS is located in the RPS cabinet in the Control Room. Four cabinets designated as A, B, C, and D each house one channel of the protective system. Each cabinet contains one power range safety channel and one wide-range logarithmic channel. Mechanical and thermal barriers between the cabinets reduce the possibility of common event failure. The detector cables are routed separately from each other. This includes separation at the containment penetration areas. The signal processing equipment for the independent wide-range channel display on the auxiliary shutdown panel is located in the switchgear room at Elevation 45'0" in the Auxiliary Building.

Functional Description

Ten channels of instrumentation are provided to monitor neutron flux. The system consists of wide-range logarithmic channels, power range safety, and power range control channels. Each channel is complete with separate detectors, power supplies, amplifiers, and bistables to provide independent operation. The operating capability of the ten monitoring channels is greater than ten decades of neutron flux and is adequate to monitor reactor power from shutdown through startup to 200% of full power.

Four wide-range logarithmic channels monitor flux from source level to above full power. The flux signals, obtained from fission chambers, are amplified and transmitted to the power and rate-of-change-of-power amplifiers located in the Control Room. Audible count rate signals are available in the Control Room. In addition to the information on reactor flux, these channels provide a rate-of-change-of-power signal to the RPS for reactor trip and to the CEDM control system for CEA withdrawal prohibit.

Four channels are designated as power range safety channels and provide signal outputs to the RPS. These channels operate from 0.1 to 200% of full power. Power level signals from these channels are supplied to the protective system. These four channels contain detectors composed of dual section ion chambers which monitor the full axial length of the reactor core at four circumferential positions equally spaced around the core. This arrangement enables detection of power tilts and imbalance.

Two separate power range control channels, similar to the power range safety channels, provide reactor power signals to the Reactor Regulating System. The channel output is a signal directly proportional to reactor power from 0.1 to 200%. The power signal is combined with the average coolant temperature, first-stage turbine pressure, and pressurizer pressure signals as the control parameters to the Reactor Regulating System. Additional power range control channel functions are discussed in Section 7.5.2.6.

The gain of each channel is adjustable to provide a means for calibrating the output against a plant heat balance. Each channel provides a power reference signal to one of the independent Reactor Regulating System channels.

The independent wide-range channel for the auxiliary shutdown panel continuously monitors neutron flux outside the reactor vessel and provides an indication of neutron flux over a range from 10^{-1} CPS to 200% power.

7.5.2.3 Design Criteria

The system associated with the RPS was designed in accordance with the criteria of IEEE 279, August 1968. In areas not covered or specifically identified by the criteria, the following criteria are used:

a. The nuclear instrumentation sensors are located so as to detect representative core flux conditions;

b. Four independent channels are used in each flux range;

c. The channel ranges overlap sufficiently to ensure that the flux is continually monitored from source range to 200% of rated power;

d. Power is supplied to the system from four separate AC busses. Loss of one bus trips one safety channel and one wide-range logarithmic channel;

e. Loss of power to channel logic results in a channel trip;

f. All channel outputs are buffered so that accidental connection to 120 Volts AC, or to channel supply voltage, or shorting individual outputs has no effect on any of the other outputs.

The independent wide-range channel for the auxiliary shutdown panel was originally designed in accordance with the requirements of 10 CFR Part 50, Appendix R. In addition, the electrical installation in the containment is seismically designed.

7.5.2.4 Wide Range Nuclear Instrumentation Channel Description

The wide-range logarithmic channels combine conventional pulse counting and mean square variation techniques to monitor power from source range to 200% of full power. The lowest decades of power indication utilize the pulse signal from the ganged fission chambers only. Power information is presented in terms of counts per second. The scale indication lights indicate the range change from source range to wide-range. The significant power information above this point is presented as a percent of full power. The two neutron flux indicating ranges overlap by approximately two decades. Pulses from the fission chambers are counted by pulse counting circuitry. After approximately five decades of counting, the counting circuitry saturates; further power level information is obtained through detection of the mean square variation of the input count rate.

Two redundant reactor cavity cooling fans (Section 9.8.2.2) cool the fission chambers. If a total loss of air flow occurred, the temperature rise in these neutron detectors would be very slow. Typically, the temperature of the closest detectors would rise from 120°F to 160°F in 30 minutes while the temperature of the farthest detectors would rise from 120°F to 138°F in 30 minutes. The fission counter assemblies have been designed to operate satisfactorily at a temperature of 300°F with no appreciable error. Therefore, ample time is available in the event of loss of air flow to take corrective action. This information is also applicable to the power range uncompensated ion chambers.

Two fission chamber detector elements within each assembly provide high sensitivity while operating in the gamma flux encountered following reactor shutdown. System reliability is enhanced through use of integral triaxial detector cables with mineral insulated insulation within the high neutron flux region and out-of-containment amplifiers. The outputs of each fission counter assembly are fed separately to an initial preamplification stage in the amplifier. The pulses are then combined, amplified, and transmitted to the signal processing drawer in the Control Room.

The high frequency pulse signal components pass through a conventional log count rate circuit utilizing a pulse shaping circuit, diode log pump circuit, and an active differentiating circuit to provide a rate-of-change signal.

A single fission chamber signal provides low frequency components which are separated by a bandpass amplifier. The AC output of the bandpass amplifier is (in accordance with Campbell's Theorem) proportional to the square root of the average pulse rate. This signal is rectified, filtered and applied to a logarithmic amplifier. As the lower portion of the output of the logarithmic amplifier is affected by gamma and alpha background, noise, imperfect rectification, and lack of pulse overlap (Campbell's Theorem applies only when pulse overlap is achieved), this portion of the response is cut off by a biased diode.

By summing the two signals, a DC signal proportional to the logarithm of neutron flux over the range of approximately 10^{-8}% full power to 200% full power is obtained. Log count rate information is presented from source level to around 10^{-7}% of full power. This signal is indicated on the main control board.

The log power level signal is differentiated to provide rate-of-change of power information from -1 to +7 decades/minute. The rate signal feeds a front panel meter, the RPS, and an indicator on the main control board.

Channel test and calibration is accomplished by internally-generated test signals. Pulse rates controlled by a ceramic resonator check the counting portion of the circuitry. The mean square portion of the circuitry is checked by inserting current signals of calibrated amplitude. During calibration, a full scale output signal is substituted for the rate signal feeding the RPS.

Bistable circuits are used in each wide-range log channel. These bistables perform the following functions. They initiate an alarm on decrease of detector voltage, remove the zero power mode bypass, disable the rate-of-change output to the RPS, switch the indicating lights on the control panel to indicate the appropriate indication scale (percent power or counts per second), annunciate when the start-up-rate trip is enabled, and enable the PDIL circuitry.

Each of the four wide-range nuclear instrumentation channels is capable of providing a pulse signal to an independent shutdown monitor which provides alarm capability in the Control Room to identify the approach to criticality during the postulated Boron Dilution Event (Section 14.3.2). The monitor establishes the count rate at a fixed multiple of the lowest measured count rate and alarms when the setpoint is exceeded while minimizing unwanted background counts. This provides high reliability, automatic count-rate monitoring during shutdown and refueling mode operations.

The wide-range logarithmic channels provide the signals that automatically remove the low-flow and TM/LP trip bypasses above 10^{-4}% full power.

The zero power manually-actuated bypass allows CEA drop testing, or CEA withdrawal for other tests, during shutdown. The trips bypassed are low-flow and thermal margin/low pressure. These trips are automatically reset above 10^{-4}% full power.

The high rate-of-change of power trip bypass at above 15% full power is initiated by a bistable in the power range safety channel.

The high rate-of-change of power pretrip is enabled above 10^{-4}% of full power. The pretrip also initiates CEA withdrawal prohibit.

7.5.2.5 Power Range Safety Channel Description

The four power range channels are capable of measuring flux linearly over the range of 0.1% to 200% of full power. The detector assembly consists of two uncompensated ion chambers for each channel. One detector extends axially along the lower half of the core while the other, located directly above it, monitors flux from the upper half of the core. The upper and lower sections have a total active length of 12'. The DC signal from each of the ion chambers is fed directly to the Control Room drawer without preamplification. Integral shielded cable is used in the region of high neutron and gamma flux.

The signal from each ion chamber is fed to an independent amplifier. Within each channel the outputs of the two amplifiers are indicated, compared, and summed. The range of this indication is 0.1 to 200% full subchannel power. The individual amplifier output is indicated on the amplifier drawer. This output is subtracted from the output of the other amplifier in the same channel to provide for deviation signal. The summer output of the two amplifiers feed bistables, an indicator, and the RPS.

Each power range safety channel contains 2 bistables. These bistables are responsible for initiating the ability to enable and disable Axial Power Distribution, Loss of Load, and Start-up Rate trips within a predetermined setpoint value.

Channel calibration and test is accomplished by an internal source, which checks amplifier gain and linearity.

7.5.2.6 Power Range Control Channel Description

The power range control channels are similar to the power range safety channels. They are located in the Reactor Regulating System panels in the Control Room. The two power range control channels are capable to measuring flux linearly over the range of 0.1% to 200% of full power. The detector assembly consists of two uncompensated ion chambers for each channel. One detector extends axially along the lower half of the core while the other, located directly above it, monitors flux from the upper half of the core. The upper and lower sections have a total active length of 12'. The DC signal from each of the ion chambers is fed directly to the Control Room drawer without preamplification. Integral shielded cable is used in the region of high neutron and gamma flux.

The signal from each ion chamber is fed to an independent amplifier. Within each channel, the outputs of the two amplifiers are indicated, compared, and summed. The range of this indication is 0.1% to 200% full subchannel power. The ion chamber outputs are displayed on indicators on the amplifier drawer. The compared output is derived by subtracting the output of one amplifier from the other amplifier in the same channel. The summer output is derived from either the average of the two amplifier outputs, or the value of either individual amplifier. The output for the power range control channels feed the Plant Computer, Feedwater Control System, NIS Power Range Control Recorder, Internal Vibration Monitoring System, Power Ratio Calculator, and the Reactor Control Unit Calculator.

Channel calibration and test is accomplished by an internal source that checks amplifier gain and linearity.

7.5.2.7 Independent Wide Range Channel Description

The Alternate Shutdown Panel (C43) is provided with two seismically-mounted indicators on the auxiliary shutdown panel. They have the ability to select one of two neutron flux monitoring signals from the RPSs wide-range nuclear instrumentation via optical isolation assemblies.

The associated selector switch and signal processor are seismically-mounted in the switchgear room, Elevation 45' in the Auxiliary Building. This installation is in accordance with the design requirements of the fire protection program.

7.5.3 CEA POSITION INSTRUMENTATION

7.5.3.1 Design Basis

The principal purpose of the CEA position indication system is to provide the operator with reliable, comprehensible, and timely information on CEA position.

The following bases are used in the CEA position indication system design:

a. Position readouts of all CEAs may be obtained;
b. Continuous position readouts of any selected CEA in a group are available;
c. A means of alerting the operator to deviation of CEAs within a group is provided;
d. A permanent record may be made of the position of any or all CEAs. A record is made automatically at time of CEA deviation or at predetermined intervals. The operator may obtain a record at any other desired time;
e. Separate "full-in" and "full-out" indication is provided for each CEA;
f. The position information is presented to the operator: (1) in a form easy to compare and interpret, and (2) in a compact location convenient to the CEA Controls;
g. Redundant and independent means of indicating CEA position is provided.

7.5.3.2 Pulse Counting Position Indication System Description

The pulse counting CEA position indication system infers the position of each CEA by maintaining a record of the raise and lower control pulses sent to each magnetic jack mechanism. This system provides a position indication accuracy of within 1-3/4". This system is incorporated in the plant computer which feeds control board digital displays. On these displays, there is one position indication for each CEA group. The selection of any CEA for individual movement also selects that CEA for continuous digital display. Position information is available via plant computer archive for viewing historical position information. The position of each CEA is periodically logged for permanent record purposes. A printout is available, on operator demand, of the position of all CEAs or of those CEAs within a given group. The plant computer also provides deviation information. If the deviation in position between the highest and the lowest CEA in any group exceeds setpoints of 3.75” and 7.5", the computer provides an alarm and initiates a log of the actual positions of all CEAs within the group. This group deviation alarm (DEV) setpoint was analyzed for regulating CEAs for its effects on the power distribution. The results showed the power distribution at 7.5" to be well within design limits (Section 3.4.6). The plant computer provides position information for CEA group position alarms.

7.5.3.3 Reed Switch Position Indication System Description

The reed switch CEA position indication system utilizes a series of magnetically-actuated reed switches, spaced at 1.5" intervals along the CEA housing and arranged with-precision resistors in a voltage divider network, to provide voltage signals proportional to CEA position. This system is required to have a position indication accuracy of within ± 3.0". These signals are displayed in bar chart form by a cathode ray tube (CRT) on the main control board. A logic package associated with the CRT provides redundant alarm functions. A backup readout is provided which can be utilized to read the output of any reed switch voltage divider.

The CRT logic package generates and displays the power-dependent and pre-power dependent insertion alarm limits. The first cycle alarm limit is a straight line approximation to the curve shown in Figure 3.4-27, with the alarm occurring at an insertion less than that shown in the figure.

Additional alarms generated by this system are Group Deviation (DEV), Regulating Groups OOS, Shutdown Group Insertion Interlock (MIRG), Excessive Regulatory Group Overlap (ERGO), and Regulating Group Withdrawal Interlock (MISH).

The above provide contact openings on alarm conditions which are used to generate two different CEA motion inhibits (CMI) at the CEDS as discussed in Section 7.4.2. A CMI is generated for the shutdown CEAs should any one combination of DEV, OOS, PDIL or MIRG alarm conditions occur. A CMI is generated for the regulating CEAs should any one or combination of DEV, OOS, PDIL, ERGO, or MISH alarm conditions occur.

The reed switch system is electrically-and mechanically-isolated from the pulse counting position system.

7.5.3.4 Additional CEA Position Indication

A group of 57 light displays, arranged in a shape corresponding to the CEA distribution, is located on the main control board. Each display, which represents one CEDM, contains four colored lights providing the information listed in Table 7-6.

All lights are actuated by reed switches with the exception of the blue exercise limit lights associated with the shutdown CEAs. The blue lights are actuated by the computer.

7.5.4 INCORE INSTRUMENTATION

7.5.4.1 Design Basis

The primary function of the incore instrumentation is to provide measured data, which may be used in evaluating the gross core power distribution in the reactor core, as an aid to reactor operations. This data may be used to evaluate thermal margins and to estimate local fuel burnup. Section 7.5.9.3 describes the Core Exit Thermocouple (CET) design bases. No credit is taken for this system in the accident analysis of Chapter 14.

The bases for the design of the incore monitoring system are as follows:

a. Detector assemblies are installed in the reactor core at selected locations to measure core neutron flux and coolant temperature information during reactor operation in the power range;

b. Flux detectors of the self-powered type, with proven capabilities for incore service, are used;
c. The information obtained from the detector assemblies may be used for fuel management purposes and to assess the core performance. It will not be relied on for automatic protective or control functions;
d. The output signal of the flux detectors will be adjusted for changes in sensitivity due to emitter material burnup and for undesirable background signals;
e. Each detector assembly is comprised of four local neutron flux detectors stacked vertically for axial monitoring, and one thermocouple at the assembly outlet.

Axial spacing of the detectors in each assembly and radial spacing of the assemblies permit an evaluation of the gross core power distribution through the use of an incore analysis computer program.

7.5.4.2 System Description

The incore instrumentation system consists of 35 fixed incore detector assemblies inserted into selected fuel assemblies. Each assembly contains four 40 cm long rhodium detectors, a background wire, and one thermocouple. Rhodium detector outputs are fed via the Data Acquisition System (DAS) to the plant computer in the Control Room for processing and logging. Thermocouple outputs are fed through the CET System described in Section 7.5.9.3.

Assemblies are inserted into the core through instrumentation nozzles in the top closure head of the reactor vessel. Each assembly is guided into position in the center of the fuel assembly via a fixed guide tube and instrument thimble assembly. For both Units 1 and 2, a swagelok-type seal forms a pressure boundary for each assembly at the instrument nozzle.

The neutron detectors produce a current proportional to neutron flux by a neutron-beta reaction in the detector wire. The emitter, which is the central conductor in the coaxial detector, is made of rhodium and has a high thermal neutron capture cross section. The maximum useful life of the rhodium detectors is based on detector accuracy, after which the detector assemblies will be replaced by new units.

The incore detectors are not required to be operable during power operation. However, periodic recalibration of the excore nuclear instrumentation will require use of the incore detectors.

The data from the thermocouples and detectors are read out by the plant computer which scans all assemblies, processes, and logs the data. The computer periodically computes integrated flux at each detector to update detector sensitivity factors to compensate for detector burnout.

7.5.4.3 Incore Instrumentation Requirements for Monitoring Technical Specification Limits

On July 16, 1993, the NRC issued a Final Policy Statement on Technical Specification improvements for nuclear power reactors. The Final Policy Statement contains four criteria which can be used to determine which constraints on the design and operation of nuclear power plants are appropriate for inclusion in the plant's Technical Specifications. The ICI System does not meet any of those four criteria. Therefore, on November 3, 1993, Baltimore Gas and Electric

Company (BGE) requested the elimination of Technical Specification 3.3.3.2 and the relocation of the Technical Specification limitations on the use of the ICI System to the Calvert Cliffs UFSAR.

The NRC approved BGE's request, stating that in order to change the requirements concerning the number and location of functional detectors a successful 50.59 with a rigorous evaluation and justification is required (Reference 1). The reduction of the number of ICIs from 45 to 35 was accomplished via such a 50.59 evaluation for both Unit 1 and Unit 2. The following considerations must be included in the evaluation:

a. How an inadvertent loading of a fuel assembly into an improper location will be detected;
b. How the validity of the tilt estimates will be ensured;
c. How adequate core coverage will be maintained;
d. Why the uncertainties are adequate to guarantee that measured peak linear heat rates, peak pin powers, radial peaking factors, and azimuthal power tilts will meet Technical Specification limits; and
e. The number of operable detectors must be at least 75% of the total number of detectors prior to the start of a new cycle.

The following definitions apply to this section:

a. An operable incore detector segment consists of an operable rhodium detector constituting one of the segments in a fixed detector string.
b. An operable incore detector location consists of a string in which at least three of the four incore detector segments are operable.
c. An operable quadrant symmetric incore detector segment group consists of a minimum of three operable rhodium incore detector segments in 90° symmetric fuel assemblies.
d. An axial elevation refers to any axial plane of core height that contains an incore detector segment.

The following uncertainties apply to this section:

a. A F_r^T measurement uncertainty factor of 1.06;
b. A linear heat rate measurement uncertainty factor of 1.07;
c. An engineering uncertainty factor of 1.03;
d. For measured thermal power less than or equal to 50%, but greater than 20% of rated full core power, a thermal power measurement uncertainty factor of 1.035; and
e. For measured thermal power greater than 50% of rated full core power, a thermal power measurement uncertainty factor of 1.020.

The Incore Detector System use is described in Technical Requirements Manual Section 15.3.3.

The Incore Detector System may be used for monitoring the core power distribution by verifying that the incore detector local power density alarms are adjusted to satisfy the requirements of the core power distribution map, which shall be updated at least once every 31 days of accumulated operation in Mode 1 and have their alarm setpoint adjusted to less than or equal to the limits when the uncertainties are appropriately included in the setting of the alarms.

7.5.5 COMPUTER SYSTEMS

7.5.5.1 Data Acquisition System

The DAS is a two-channel system consisting of multiplexers and data concentrators. The multiplexers receive digital and analog process inputs from plant systems. The data concentrators convert this information into engineering units capable of being used by the computer systems which receive their input from the DAS. Additionally, the DAS processes plant data for sequence of events contacts and serves as the Class 1E isolation between safety-related process loops and the non-safety-related plant computers. The DAS has two channels to provide redundancy where required.

A Plant Data Network is provided for network connectivity to non-safety-related plant instruments, controls, and information systems. The Plant Data Network provides the first three layers of the Open Systems Interconnection model using network switches. Core switches provide layer 3, 2, and 1 services, while edge switches provide layer 2 and 1 services only. Uplinks are provided for connecting edge switches to the core switches. The Plant Data Network has two channels to provide redundancy. Plant applications are hosted by various input/output devices, programmable logic controllers, servers, workstations, and miscellaneous devices that are considered external to the Plant Data Network.

7.5.5.2 Plant Computer

A process computer is provided to assist the Control Room operators in the safe and efficient operation of each unit. The plant computer performs the following major functions:

a. receive and process data from the DAS and other acquisition interfaces;
b. store processed data for logging and trending purposes;
c. provide alarms on printers, displays and annunciators;
d. provide status information on monitors;
e. provide plant performance information such as calculating power distribution, burnup, and thermal margin, and various secondary plant efficiency assessment reports;
f. CEA regulating group position indication on C05, input to the CEA drive system, as described in Section 7.4.2 and 7.5.3.1; and,
g. provide input of selected data to the Technical Support Center (TSC).

7.5.5.3 Safety Parameter Display System

The Safety Parameter Display System (SPDS) software application is a subsystem of the plant computer. The function of the SPDS is to provide a display of critical plant parameters to Control Room personnel to aid in rapidly determining the safety status of the plant. The SPDS meets the requirements of NUREG-0737, Supplement 1, (TMI Action Plan Item I.D.2), taking into account the information provided in NUREG-1342.

The SPDS performs its function by presenting graphic displays of selected parameters from which an evaluation can be made to determine if critical safety functions (CSF) are being met. Critical safety functions are those safety functions that are essential to prevent a direct and immediate threat to the health and safety of the public and plant personnel. The CSFs monitored are:

a. reactivity control,
b. RCS pressure and inventory,

c. core/RCS heat removal,
d. containment environment,
e. containment isolation,
f. radiation control, and
g. vital auxiliaries.

This information is arranged into display pages which are available on monitors in the Control Room, Shift Manager's office, and the TSC.

7.5.5.4 Technical Support Center Computer

The function of the Technical Support Center Computer is implemented by the Plant Process Computer historian server. This server has been designed to satisfy the requirements of NUREG-0696. The TSC computer receives input from the plant computers on both Units. Its function is to provide selected plant status information to support the staff assigned to the TSC during designated times. This information is available on workstations. The TSC computer enables the support staff to monitor and assess the status of the plant and assist the Control Room operators in analyzing events and safely stabilizing the plant.

7.5.6 RADIOACTIVITY MONITORING

The radiation monitoring systems are designed to detect, indicate, record, and on high levels provide radiation alarms throughout the plant. The system is divided into three subsystems: area radiation monitoring for personnel protection and indication of abnormal conditions in various areas of the plant; liquid process monitoring for personnel protection and indication of abnormal conditions in the process systems; and, gaseous monitoring for personnel protection and indication of airborne radioactivity.

For detailed information of the Radiation Monitoring System see Chapter 11.

7.5.7 SEISMIC INSTRUMENTATION

A seismic acceleration monitoring system that will automatically detect and record the seismic activity acceleration response of important features of the nuclear power plant has been engineered to ensure complete fulfillment of Nuclear Regulatory Commission Safety Guide 12.

Strong motion, triaxial transducers monitor the seismic response of selected Seismic Category I structures and the vibratory ground motion of the plant site. Points to be monitored include: Unit 1 Containment basement Elevation 10'0"; Unit 1 Containment Building floor at Elevation 69'0"; and, Auxiliary Building basement slab, Intake Structure, and free field. Each instrument listed below will be operable at all times.

Instruments and Sensor Locations	Measurement Range
1. Triaxial Time-History Strong Motion Accelographs	
a. 0-YE-001 Unit 1 Containment Base	0-1g
b. 0-YE-002 Unit 1 Containment 69'	0-1g
c. 0-YE-003 Auxiliary Building Base	0-1g
d. 0-YE-004 Intake Structure	0-1g
e. 0-YE-005 Free Field	0-1g

Instruments and Sensor Locations			Measurement Range
2.	Seismic Acceleration Recorder		
	a.	0-YRC-001 Control Room	NA
	b.	0-YRC-002 Control Room	NA
	c.	0-YRC-003 Control Room	NA
3.	Seismic Computer		
	a.	0-CPU-1C26B Control Room	NA
	b.	0-CRT-1C26B Control Room	NA

A computer with multiple recorders located in the Control Room provides the time-history records necessary to evaluate the frequency response of the selected Seismic Category I structures. The recorder units indicate to the Control Room operator if predetermined values of seismic acceleration have been exceeded.

When one of the recorders senses a seismic event, an interconnect (RS-232 Cables) network will cause all of the recorders to trigger and record data. Once recording is completed the seismic computer retrieves all of the seismic event data files from the recorders, associates the events together, and performs automatic analyses on the data. The system operates continuously for the full duration of an earthquake. The system remains in operation for a set time beyond the last detection of a seismic signal of triggering intensity.

If the system is activated during a seismic event, the instruments need to be restored to an operable status within 24 hours. Data from the activated instruments will be retrieved by computer and CAV (Cumulative Absolute Velocity) calculated automatically and analyzed to determine the magnitude of the vibratory ground motion. A report will be provided to the NRC describing the magnitude, frequency spectrum, and resultant effect upon facility features important to safety.

7.5.8 POST-ACCIDENT MONITORING INSTRUMENTATION

Generic Letter 82-33 requested a report to the NRC to describe how the post-accident monitoring system for this plant meets the guidelines of Regulatory Guide 1.97. This section summarizes the BGE response to the request.

Instrumentation meeting the applicable portions of 10 CFR Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants,” Criterion 13, “Instrumentation and Control,” Criterion 19, “Control Room,” and Criterion 64, “Monitoring Radioactive Releases” is installed in the plant. Variables and systems can be monitored under accident conditions. Included is the instrumentation required for the operators to take the plant to hot shutdown from outside the Control Room and to monitor for radiation released following a postulated accident.

Certain instrumentation in the Control Room and on the Auxiliary Safe Shutdown Panels used for normal plant operations is designated for post-accident monitoring (PAM) use. Instrumentation defined as PAM1 and PAM2, with the exception of switches and indicating lights, in the Calvert Cliffs Quality List (Q-List) is marked with colored tape to help operators recognize it as PAM instrumentation.

To determine which instrumentation is designated for PAM use, a list of instrumentation was prepared based on the guidelines of Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident," Revision 3. The guidelines establish the variables to be monitored and the design criteria for the selected equipment. Depending upon the importance of the variable (category), the design criteria ranges from fully qualified, Class 1E to highly reliable, commercial grade installation.

The list of instrumentation was then evaluated against the specific function and safety significance of the variables as defined in the UFSAR and the Emergency Operating Procedures. Where deviation from the guidelines resulted, justification was prepared to account for plant-specific needs and acceptability, or the equipment was upgraded to meet the criteria of Regulatory Guide 1.97. The evaluation performed for Regulatory Guide 1.97 resulted in a list of variables which are classified by category.

A summary of the PAM instrumentation is given here. Indicators listed may be one of several in a loop. The Q-List contains the complete list.

a. Category 1 variables. They are considered key variables that most directly indicate the accomplishment of a safety function, the operation of a safety system or radioactive materials release.

	VARIABLE	INDICATOR
1.	Pressurizer level	LI-110X, Y, X-1, Y-1
2.	Pressurizer pressure	PI-105B, AA PI-103 PI-103-1 1CRT1C06A, B (Unit 1 only) 2CRT2C06A, B (Unit 2 only)
3.	SG level	LI-1114A, B, D LI-1124A, B, D 1CRT1C04A, B (Unit 1 only) 2CRT2C04A, B (Unit 2 only)
4.	SG pressure	PI-1013A, B, C, D, AA, BB PI-1023A, B, C, D, AA, BB
5.	Condensate Storage Tank level	LI-5610, A, 5611, A LIA-5610, 5611
6.	Containment Sump level (WR)	LI-4146, 4147
7.	RCS temperature, T_{hot}	TI-112H, HA, HB, 122H, HA, HB 1CRT1C06A, B (Unit 1 only) 2CRT2C06A, B (Unit 2 only)
8.	RCS temperature, T_{cold}	TI-112C, CA, CB, 122C, CA, CB 1CRT1C06A, B (Unit 1 only) 2CRT2C06A, B (Unit 2 only)
9.	RCS Subcooled Margin (°F)	1CRT1C05A, B (Unit 1 only) 2CRT2C05A, B (Unit 2 only)
10.	Reactor Vessel level	1CRT1C05A, B (Unit 1 only) 2CRT2C05A, B (Unit 2 only)
11.	Core Exit temperature	1CRT1C05A, B (Unit 1 only) 2CRT2C05A, B (Unit 2 only)
12.	Neutron flux	JI-001, 002, 003, 004 JKI-001, 002, 003, 004
13.	Containment pressure	PI-5307, 5308, 5310
14.	Containment Isolation Valve position	ZL-505, 506, 515, 516, 2080, 2180, 2181, 3832, 3833, 4260, 5291, 5292, 6900, 6901
15.	Containment Area Radiation	RI-5317A, B

b. Category 2 variables. They provide system status information.

	VARIABLE	INDICATOR
1.	Pressurizer Heater status	II-100-1, -2
2.	Safety Relief Valve position/Flow	VI-200, A, 201, A, 402, A, 404, A
3.	RWT level	LIA-4143
4.	Auxiliary Feedwater flow	FI-4509A, B, 4510A, B, 4524A, B, 4534A, B FIC-4511A, 4512A, 4525A, 4535A
5.	HPSI flow	FI-311, 321, 331, 341, 351
6.	LPSI flow	FI-312, 322, 332, 342, FIC-306
7.	Decay Heat Removal flow (Shutdown Cooling)	same as b.6 (LPSI)
8.	Decay Heat Removal temperature (Shutdown Cooling)	TR-351
9.	Containment temperature	TI-5309
10.	Containment Heat Removal (cooling water flow to containment coolers)	FI-1581, 1584, 1589, 1592
11.	Containment Spray flow	FI-4148, 4149
12.	CCW to ESF temperature	TIA-3824, 3826
13.	CCW to ESF flow	PI-3814, 3816
14.	Main Vent radiation/flow	RIC-5415 RR-5420
15.	SG Relief Valve and Atmospheric Dump radiation	RIC-5421, 5422
16.	Boric Acid Charging flow	ZL224X, Y, Z, ZA
17.	Status of Standby Power (Class 1E distribution systems)	

4 kV Busses

1II1115A	2II2115A	1II1401A	2II2401A
1II1115B	2II2115B	1II1401B	2II2401B
1II1115C	2II2115C	1II1401C	2II2401C
1II1101AA	2II2101AA	1II1414A	2II2414A
1II1101AB	2II2101AB	1II1414B	2II2414B
		1II1414C	2II2414C
		1EI414	2EI424
1II1101AC	2II2101AC	1II1702A	
1EI411	2EI421	1II1702B	
		1II1702C	
		1EI1702	

Diesel Generators

1II1403A	2II2104A	1II1701A	2II2403A
1II1403B	2II2104B	1II1701B	2II2403B
1II1403C	2II2104C	1II1701C	2II2403C
1JI1403A	2JI2104A	1JI1701A	2JI2403A
1JI1403B	2JI2104B	1JI1701B	2JI2403B
1EI1422	2EI2122	1EI1701	2EI2422
1SI1401	2SI2101	1SI1701	2SI2401

480 Volt Busses

1II1112A	2II2112A	1II1413A	2II2413A
1II1112B	2II2112B	1II1413B	2II2413B
1II1112C	2II2112C	1II1413C	2II2413C
1EI511A	2EI521A	1EI514B	2EI524B
1II1113A	2II2113A	1II1703A	
1II1113B	2II2113B	1II1703B	
1II1113C	2II2113C	1II1703C	
1EI511B	2EI521B	1EI710	
1II1412A	2II2412A		
1II1412B	2II2412B		
1II1412C	2II2412C		
1EI514A	2EI524A		

120 Volt AC Vital Busses

1EI1911	2EI1921	1EI1913	2EI1923
1EI1912	2EI1922	1EI1914	2EI1924

125 Volt DC Vital Busses

1II201	2II205	1EI1401
1EI211	2EI221	1II1401
1II211	2II213	
1II223	2II221	
1II202	2II204	
1EI212	2EI222	
1II212	2II214	
1II224	2II222	

Individual 4 kW Load Ammeters

1II1570	2II1570	1II302X	2II302X
1II1571	2II1571	1II302Y	2II302Y
1II1572A	2II1572A	1II4146	2II4146
1II1572B	2II1572B	1II4147	2II4147
1II301X	2II301X	1II4540	2II4540
1II301Y	2II301Y	1II5199	2II5199
1II301Z1	2II301Z1	1II5200	2II5200
1II301Z2	2II301Z2	1II5201A	2II5201A
		1II5201B	2II5201B

Individual 480 Volt Load Ammeters

1II224X	2II224X	1II5300	2II5300
1II224Y	2II224Y	1II5301	2II5301
1II224Z1	2II224Z1	1II5302	2II5302
1II224Z2	2II224Z2		
1II3813	2II3813		
1II3815	2II3815		
1II3817A	2II3817A		
1II3817B	2II3817B		
1II5299	2II5299		

c. Category 3 variables. They provide backup and diagnostic information.

	VARIABLE	INDICATOR
1.	Pressurizer temperature	TI-101, 105
2.	Pressurizer Spray temperature	TI-229

	VARIABLE	INDICATOR
3.	SG Steam flow	FR-1011/1111, FR-1021/1121
4.	Safety Injection Tank level	LI-311, 321, 331, 341
5.	Safety Injection Tank pressure	PI-311, 321, 331, 341
6.	Safety Injection Tank Isolation Valve position	ZL-3614, 3624, 3634, 3644
7.	Quench Tank level	LI-116
8.	Quench Tank pressure	PI-116
9.	Quench Tank temperature	TI-116
10.	Volume Control Tank level	LI-226
11.	CVCS Make-up Water flow	FIC-210X
12.	CVCS Make-up Boric Acid flow	FIC-210Y
13.	CVCS Letdown flow	FIA-202
14.	Containment Sump level (NR)	LI-4144, 4145
15.	High Radiation Liquid Tank level (waste receiver, monitor tanks)	LI-4279, 4280, 4281, 4282
16.	Radioactive Gas Tank pressure (waste gas system)	PI-2188, 2189, 2190
17.	RCS Boron concentration	Grab Sample Equipment
18.	RCP status	II-151, 161, 171, 181
19.	MFW flow	FI-1111, 1121
20.	Boric Acid Charging flow	FIA-212
21.	CEA position	HS-5500, 5501 XL-5510 through 5531 ZL-5500, 5501, 5501A, 5511, 5513, 5515, 5517, 5519, 5521, 5523, 5525, 5527, 5529, 5531
22.	RCS radiation	RE-202 RI-202
23.	RCS radiation - gamma	Grab sample equipment
24.	Area radiation	RR-11, 21 R-7004, 7005, 7006, 7010 through 7027
25.	Plant Release Points radiation	R-5321, 5415, 1-RR-11, 2-RR-21

7.5.9 INADEQUATE CORE COOLING INSTRUMENTATION

The SCMM, Reactor Vessel Level Monitoring System (RVLMS), and CET comprise the Inadequate Core Cooling Instrumentation (ICCI) as required by Item II.F.2 of NUREG-0737, the post TMI-2 Action Plan. The ICCI supplements existing instrumentation in order to provide an unambiguous, easy to interpret indication of inadequate core cooling (ICC). The function of the ICCI is to enhance the ability of the plant operator to diagnose the approach to and recovery from ICC.

The bases for the design of the ICCI are as follows:

a. Provides an unambiguous indication of ICC.
   - Indicates the existence of ICC caused by various phenomena.
   - Does not erroneously indicate ICC because of the presence of an unrelated phenomena.

b. Gives advance warning of the approach to ICC.

c. Covers the full range from normal operation to complete core uncovery.

d. Core exit thermocouples meet requirements of Attachment 1, "Design and Qualification Criteria for PWR Incore Thermocouples," of NUREG-0737, II.F.2.

e. Types and locations of displays and alarms used, determined by human-factors analysis.

f. Provides 99% availability with respect to functional capability for liquid-level display.

g. Designed in accordance with guidance given in Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident."

The ICCI is integrated into a safety-related, Class 1E, seismically-qualified, redundant, data acquisition, processing, and display system referred to as the PAM System. Each channel has two RCS cold leg temperature inputs, two hot leg temperature inputs, a single wide-range pressurizer pressure input, eight reactor vessel level inputs, two SG level inputs, and channel-specific CET data. All PAM System data (on a channel basis) is available on any similar channel touchscreen flat panel display in the event of a display failure. Facility group ZA and ZB displays are provided on each control room panel. Specific default displays provide digital and pictorial representation of the data and trend chart data. The PAM System is connected to the Plant Data Network and provides data via Ethernet to a data storage system. Maintenance and testing of the PAM System may be performed at the maintenance and test panels. There are two panels per channel.

7.5.9.1 Subcooled Margin Monitor

Subcooled margin calculations are performed by the PAM System and displayed in the Control Room. The PAM System calculates the temperature saturation margin using RCS and CET temperatures with the wide-range pressurizer pressure and displays the calculated digital value in degrees F on the PAM System flat panel displays. Pressure saturation margin is also calculated by the PAM System and that data is available via operator selectable displays. Subcooled margin data is provided by the PAM System flat panel displays. The PAM System provides a low subcooling alarm that is annunciated in the Control Room.

7.5.9.2 Reactor Vessel Level Monitoring System

The RVLMS is based on the CE Heated Junction Thermocouple (HJTC) system. The HJTC system measures reactor coolant liquid inventory with discrete HJTC sensors located at different levels within a separator tube ranging from the fuel alignment plate to the reactor vessel head. The basic principle of system operation is detection of a temperature difference between heated and unheated thermocouples. The probe assemblies are of the "Full Length Probe" design, housed within a separator tube outside a CEA shroud. Of the eight HJTC sensor assemblies in each probe assembly, two are located above the CEA shroud in the upper area of the reactor vessel closure head, and one more is located near the top of the CEA shroud. Three other HJTC sensors are located near the top, centerline, and bottom of the hot leg nozzle elevations, respectively. A seventh sensor is located approximately equidistant between the bottom hot leg area sensor and the lowest sensor, which is located less than 1' from the top of the fuel alignment plate. With at least four operable sensors in a probe, the RVLMS is capable of providing the plant operator with the information needed to assess void formation in the reactor vessel head region and the trend of liquid level in the reactor vessel plenum. The four sensors in a probe that are required for an operable RVLMS channel are: One of the upper three (vessel head region) and three of the lower five (plenum region) sensors.

The PAM System processes HJTC probe input data, provides probe heater output data, and displays reactor vessel level information in the Control Room. The

SPDS provides the primary HJTC display. The PAM System flat panel displays are backup displays and they are seismically-qualified, Class 1E. The default reactor vessel level displays in the Control Room also display subcooling margin and CET data. Coolant low level and system malfunctions alarms are provided on the control board.

7.5.9.3 Core Exit Thermocouple

The reactor incore instrumentation system consists of 35 fixed incore detectors inserted into selected instrumentation assemblies. Each assembly contains four rhodium self-powered neutron detectors, a background wire, and one CET. The CET system is composed of two channels. Each of the two channels is powered from a separate reliable Class 1E power source. The cabling and connections for the CET system are channelized, Class 1E safety grade.

The PAM System processes CET data. The PAM System consists of redundant data acquisition, processing, and display instrumentation channel. Each channel is powered from a separate reliable Class 1E power source. The primary display for the CET data is the SPDS. The PAM System is the back-up system that displays the CET data on flat panel displays mounted in the Control Room. The operator may select specific thermocouple data via the touchscreen flat panel displays.

The operability requirements for the CETs are contained in Technical Specification 3.3.10.

7.5.9.4 Reduced Reactor Coolant System Inventory and Mid-loop Operations Instrumentation

To meet the requirements of Generic Letter 88-17, reactor vessel temperature and level monitoring capabilities are provided for reduced RCS inventory and mid-loop operations. A reduced RCS inventory condition exists when the reactor coolant level is lower than 3' below the flange. A mid-loop condition exists when the reactor coolant level in the reactor vessel is below the top of the flow area of the hot leg piping at the junction with the reactor vessel.

Temperature of the reactor coolant in the reactor vessel is required to be monitored following the removal of the control rod drive mechanism platform and prior to the removal of the reactor vessel head during reduced RCS inventory and mid-loop operations. The temperature is measured through the select jumpering of a minimum of 2 of the 35 existing CETs. One CET is jumpered on electrical facility ZA and one on electrical facility ZB.

The CETs are displayed on the PAM System flat panel displays mounted on control room panel 1(2)C05. Core exit thermocouple inputs not being used at this time have to be disabled via a maintenance and test panel. High temperature and system malfunction alarms are provided in the Control Room via the main annunciators. The high temperature alarm setpoint is adjustable via a maintenance test panel. Core exit thermocouple real time and trend data is provided by the PAM System flat panel displays.

Removal of the reactor vessel head terminates the requirement to monitor the reactor coolant temperature via the CETs.

The reactor coolant level in the reactor vessel during reduced RCS inventory and mid-loop operations is monitored using narrow- and wide-range instrumentation, and the Mansell Level Monitoring System. The narrow-range instrumentation is a

Westinghouse ultrasonic level transmitter installed on the bottom of the shutdown cooling suction side of Hot Leg #12 and Hot Leg #22 for Unit 1 and Unit 2, respectively. The wide-range instrumentation comprises a 3" diameter level stillwell with a continuous level probe and a separate sight gauge. This wide-range instrumentation is tied into the refueling level pressure transmitter tubing and pressure referenced to the reactor head vent via the reactor head vent tubing. The Mansell Level Monitoring System consists of two independent channels. It uses inputs from absolute pressure transducers installed at the pressurizer vents and the RCS hot leg instrument nozzles to calculate RCS levels. The computer based system provides operator indication, alarm (audible and visual), and trending capabilities on 0C184 for the narrow- and wide-range instrument loops, as well as the Mansell Level Monitoring System.

Also, for the reduced RCS inventory and mid-loop operations, suction pressure instrument loops are provided for each LPSI pump. Each instrument loop consists of a transmitter, bistable located in panel 1(2)C10, an indicator and a trend recorder (pen) mounted on the refueling cart 0C184. The bistable provides a signal to actuate an alarm window on panel 1(2)C09 on a low suction pressure condition. The transmitter/bistable/alarm portion of each instrument is continuously in operation. Each loop's indicator and recorder (pen) is placed into operation by installing cable between panels 1(2)C10 and 0C184 when the refueling cart is placed into service.

7.5.10 REFERENCES

1. Letter from D. G. McDonald, Jr. (NRC) to R. E. Denton (BGE), dated August 24, 1994, Issuance of Amendments for Calvert Cliffs Nuclear Power Plant (License Amendment Nos. 191 and 168)

TABLE 7-6

CEA POSITION LIGHT MATRIX

LIGHT COLOR	REGULATING	SHUTDOWN CEAs
Red	Upper electrical limit	Upper electrical limit
Green	Lower electrical limit	Lower electrical limit
Amber	Dropped CEA	Dropped CEA
White	Between upper and lower limits	
Blue		Below exercise limit