REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**38-7878**
SRP Section:	**07.05 – Information Systems Important to Safety**
Application Section:	**7.5**
Date of RAI Issue:	**06/18/2015**

Question No. 07.05-01

APR1400 FSAR Tier 2, Section 7.5.1.1 does not provide the basis or analysis for the selection of the accident monitoring instrumentation (AMI) variables.

10 CFR Part 50, Appendix A, General Design Criteria 13, "Instrumentation and Controls," requires, in part, instrumentation to be provided to monitor variables and systems over their anticipated ranges for normal operation, anticipated operational occurrences, and accident conditions. APR1400 FSAR Tier 2, Table 7.5-1, "Accident Monitoring Instrumentation Variables," identifies a list of AMI variables and states that the design conforms to RG 1.97, Revision 4, in APR1400 FSAR Tier 2, Section 7.5.1.1. However, the applicant did not clearly demonstrate how they conform with RG 1.97, Revision 4, for each variable, including the analysis or basis for the variable. Provide the basis for the AMI variable selection in accordance with RG 1.97, Revision 4. If alternative criteria to RG 1.97, Revision 4 are used, identify that criteria and the justification for why it provides a comparable level of safety to the guidance in RG 1.97, Revision 4.

Response – (Rev. 1)

The AMI variables were selected according to the selection criteria in IEEE 497-2002, which is endorsed by RG1.97, Rev.4.

The basis and analysis for selecting each AMI variable are described as follows:

Type A

Type A variables are those variables that provide the primary information required to permit the control room operating staff to:

a) Take specific planned manually-controlled actions for which no automatic control is provided and that are required for safety systems to perform their safety-related functions as assumed in the plant Accident Analysis Licensing Basis.

b) Take specific planned manually-controlled actions for which no automatic control is provided and that are required to mitigate the consequences of an AOO.

KHNP's response to the Request for Additional Information (RAI) 294-8302, Question 07.05-6 (ref. KHNP submittal MKD/NW-16-0584L, dated June 1, 2016) provides the basis and analysis for the APR1400 Type A variables.

Type B

Type B variables are those variables that provide primary information to the control room operators to assess the plant critical safety functions.

Any plant critical safety functions addressed in the emergency operation guidelines (EOGs) that are in addition to those identified above are also included.

In order to select Type B variables for meeting the requirements in IEEE 497-2002 (endorsed by RG 1.97, Rev. 4), the EOGs are reviewed. EOGs provide the plant critical safety functions to be verified for each event and the criteria for deciding the plant critical safety functions.

The plant critical safety functions described in the EOG are as follows:

- Reactivity control
- Maintenance of vital auxiliaries
- Reactor coolant system (RCS) inventory control
- RCS pressure control
- Core heat removal
- RCS heat removal
- Containment isolation
- Containment temperature and pressure control
- Containment combustible gas control

Type C

Type C variables are those variables that provide primary information to the control room operators to indicate the potential for breach, or the actual breach of the three fission product barriers (extended range): fuel cladding, reactor coolant system pressure boundary, and containment pressure boundary.

The selection of these variables represents a minimum set of plant variables that provide the most direct indication of the integrity of the three fission product barriers and provide the capability for monitoring beyond the normal operating range.

Type D

Type D variables are those variables that are required in procedures and licensing basis documentation to:

- Indicate the performance of those safety systems and auxiliary supporting features necessary for the mitigation of design basis events (DBEs).

- Indicate the performance of other systems necessary to achieve and maintain a safe shutdown condition.

- Verify safety system status.

The Type D variables are based upon the plant accident analysis licensing basis and those necessary to implement the EOGs.

The resource tree of the EOG functional recovery guides describes the systems, including instruments and components, that are required for recovering the plant critical safety functions. Those instruments and components, as well as the variables required for verifying the system-base safety function performance, were selected as Type D variables.

Type E

Type E variables are those variables required for use in determining the magnitude of the release of radioactive materials and continually assessing such releases.

The selection of these variables include, but are not limited to the following:

- Monitor the magnitude of releases of radioactive materials through identified pathways (e.g., secondary safety valves, and condenser air ejector).

- Monitor the environmental conditions used to determine the impact of releases of radioactive materials through identified pathways (e.g., wind speed, wind direction, and air temperature).

- Monitor radiation levels and radioactivity in the plant environs.

- Monitor radiation levels and radioactivity in the control room and selected plant areas where access may be required for plant recovery.

Below is a listing of the AMI variables of the APR1400 DCD Tier 2, Table 7.5-1, along with the variables' type classifications and their justifications.

Table 2.5.3-2 of APR1400 DCD Tier 1, Section 7.5 of APR1400 DCD Tier 2 will be revised as indicated in the attachment associated with this response.

Technical Specification Table 3.3.11-1 and the associated Bases for 3.3.11 Chapter 16 of the APR1400 DCD Tier 2 will be revised as indicated in the attachment associated with this response.

The Safety I&C System Technical Report, APR1400-Z-J-NR-14001-P, and Section 3.5.2 of the Basic Human-System Interface Technical Report, APR1400-E-I-NR-14011-P, will be revised as indicated in the attachment associated with this response.

Variable	Type	Basis and analysis
Pressurizer Pressure (Wide Range)	A, B	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B)
Pressurizer Level	A, B, D	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B) It verifies the status of a safety system. (Type D)
Hot Leg Temperature (Wide Range)	A, B, D	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B) It verifies the status of a safety system. (Type D)
Cold Leg Temperature (Wide Range)	A, B, D	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B) It verifies the status of a safety system. (Type D)
Steam Generator Pressure	A, B, D	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B) It verifies the status of a safety system. (Type D)
Steam Generator Level (Wide Range)	A, B, D	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B) It verifies the status of a safety system. (Type D)
RCS Subcooling Margin	A, B	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B)
CET Subcooling Margin	A, B	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B)
RV Upper Head Subcooling Margin	B	It is a primary variable for monitoring critical safety function (Type B)
Core Exit Temperature (CET)	B, C	It is a primary variable for monitoring critical safety function (Type B) This variable also is an indicator for probable breach of cladding. (Type C)

Variable	Type	Basis and analysis
Reactor Vessel Level (RV Closure Head Level/RV plenum Level)	B	It is a primary variable for monitoring critical safety function (Type B)
RCS Pressure	C, D	It is a primary variable for monitoring RCPB integrity and breach of the RCPB (Type C) It verifies the status of a safety system. (Type D)
Holdup Volume Tank Level	B	Holdup volume tank level is a monitoring variable for RCS integrity check. RCS integrity is included in the critical safety functions for IEEE 497-2002. (Type B)
Containment Level	B	Containment level is a monitoring variable for RCS integrity check. RCS integrity is included in the critical safety functions for IEEE 497-2002. (Type B)
Containment Pressure (Wide Range)	B, D	It is a primary variable for monitoring critical safety function (Type B) It is a primary variable for monitoring the operating status for a safety system. (Type D)
Reactor Cavity Level	B	Reactor cavity level is a monitoring variable for RCS integrity check. RCS integrity is included in the critical safety functions for IEEE 497-2002. (Type B)
Containment Isolation Valve Position	B, D	It is a primary variable for monitoring critical safety function (Type B) Containment isolation valves are variables to monitor the containment integrity status. (Type D)
Logarithmic Reactor Power(Neutron Flux)	A, B	It is required for manual operator action based on the Accident Analyses (Type A) It is a primary variable for monitoring critical safety function (Type B)
CEA Position	D	These variables monitor the performance of CEDMs that affect the core reactivity. (Type D)
Containment Pressure	C	It is a primary variable for monitoring the integrity of protection barrier against fission product release. (Type C)
Containment Operating Area Radiation	C	Containment operating area radiation is a variable for monitoring fueling handling accident during refueling operation inside containment. A breach of fuel cladding is detected by this variable. (Type C)
Spent Fuel Pool Radiation	C	Spent fuel pool radiation is a variable for monitoring fueling handling accident. A breach of fuel cladding is detected by this variable. (Type C)
Containment Upper Operating Area Radiation	C	Containment upper operating area radiation is a variable to monitor loss of coolant accident (LOCA). A breach of RCPB is detected by this variable. (Type C)

Variable	Type	Basis and analysis
IRWST Level	B, D	IRWST is the borated water source of safety injection system (SIS) and containment spray system (CSS) during the accident. IRWST level is a monitoring variable for RCS integrity check. (Type B) IRWST level is a monitoring variable for indicating the performance of SIS and CSS necessary for the mitigation of DBEs. (Type D)
IRWST Temperature	B, D	IRWST is the borated water source of SIS and CSS during the accident. IRWST temperature is a monitoring variable for RCS integrity check. (Type B) IRWST temperature is a monitoring variable for indicating the performance of SIS and CSS necessary for the mitigation of DBEs. (Type D)
Main Steam Automatic Depressurization Valve (MS ADV) Position	B	MS ADV position is a monitoring variable for verifying the RCS heat removal. Therefore, this variable meets the criteria for the selection of Type B variable in IEEE 497-2002. (Type B)
Auxiliary Feedwater Flow	B	Auxiliary feedwater flow meters are designed as safety-related and seismic Category I. It is an important parameter for monitoring the cooling capability of the RCS which is a critical safety function. Therefore, this variable meets the criteria for the selection of Type B variable in IEEE 497-2002. (Type B)
POSRV Position	D	It verifies the status of a safety system. (Type D)
CS Flow	D	Containment spray flow is a variable for monitoring containment spray operation. Containment spray flow indicates the performance of CSS necessary for the mitigation of DBEs. (Type D)
Containment Atmosphere Temperature	D	Containment atmosphere temperature is a variable for monitoring accomplishment of cooling. This variable is used to monitor the performance of safety systems for the mitigation of DBEs. (Type D)
SI Hot Leg Injection Flow Rate	D	SI hot leg injection flow rate is a variable that monitors the operation status of safety injection pump (hot leg injection) in case of an accident. It is an indicator to monitor the operating status for a safety system. This variable is included in EOG functional recovery guide. (Type D)
Safety Injection Tank(SIT) Level	D	It is a primary variable for monitoring the operating status for a safety system. (Type D)
Safety Injection Tank(SIT) Pressure	D	It is a primary variable for monitoring the operating status for a safety system. (Type D)

Variable	Type	Basis and analysis
Emergency Ventilation Damper Position	D	Emergency ventilation damper position is used to monitor the performance of safety systems for the mitigation of design basis events. (Type D)
Auxiliary Feedwater Storage Tank Level	D	The auxiliary feedwater storage tanks are designed to have sufficient feedwater to allow an orderly plant cooldown to shutdown cooling initiation without additional makeup. During normal plant operation, the main purpose of this variable is to confirm sufficient inventory of auxiliary feedwater for accident conditions. If an accident occurs, it is not necessary to monitor water level for additional makeup to the auxiliary feedwater storage tanks. Therefore, this variable meets the criteria for the selection of Type D variable in IEEE 497-2002. (Type D)
DC Bus Voltage	D	DC bus voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
Instrument Power Bus Voltage	D	Instrument power bus voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
Emergency Diesel Generator Voltage	D	Emergency diesel generator voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
Emergency Diesel Generator Current	D	Emergency diesel generator current is a variable for monitoring Electrical Power supplies for safety systems and safe shutdown systems. (Type D)
4.16 kV Switchgear Voltage	D	4.16 kV switchgear voltage is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
4.16 kV Switchgear Current	D	4.16 kV switchgear current is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
480 V L/C Voltage	D	480 V L/C voltage is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
480 V L/C Current	D	480 V L/C current is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
CCW Temperature	D	Component cooling water (CCW) system removes heat from all safety-related components necessary for the safe shutdown and the mitigation of DBEs. CCW temperature is a variable for monitoring CCW operation. This variable indicates the performance of the CCW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)

Variable	Type	Basis and analysis
CCW Flow	D	CCW system removes heat from all safety-related components necessary for the safe shutdown and the mitigation of DBEs. CCW flow is a variable for monitoring CCW operation. This variable indicates the performance of the CCW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
ESW Temperature	D	Essential service water (ESW) system removes heat from the CCW heat exchangers and transfers to the UHS. ESW temperature is a variable for monitoring ESW operation. This variable indicates the performance of the ESW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
ESW Flow	D	ESW system removes heat from the CCW heat exchangers and transfers to the UHS. ESW Flow is a variable for monitoring ESW operation. This variable indicates the performance of the ESW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
Charging Line Flow	D	It is a primary variable for monitoring the status of boric acid flow to the RCS. (Type D)
Charging Line Pressure	D	It is a primary variable for monitoring the operating status for a safety system. (Type D)
Shutdown Cooling Heat Exchange Outlet Temperature	D	It is a primary variable for monitoring the operating status for a safety system. (Type D)
Shutdown Cooling Pump Flow Rate	D	It is a primary variable for monitoring the operating status for a safety system. (Type D)
SIT Discharge Isolation	D	It provides information of operating status for a safety system. (Type D)
SIP DVI Flow Rate	B, D	It is a primary variable for monitoring critical safety function. (Type B) It is a primary variable for monitoring the operating status for a safety system. (Type D)
Containment Purge Effluent	E	Containment purge effluent is used to monitor gaseous effluent in containment building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
Auxiliary Building Controlled Area HVAC Effluent	E	Auxiliary building controlled area HVAC effluent is used to monitor gaseous effluent of controlled area in auxiliary building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)

Variable	Type	Basis and analysis
Compound Building HVAC Effluent	E	Compound building HVAC effluent is used to monitor gaseous effluent in compound building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
Condenser Vacuum Vent Effluent Radiation	E	Condenser vacuum vent effluent radiation is used to monitor SG tube leakage. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
MCR and TSC Area Radiation	E	MCR and TSC area radiation is used to monitor radiation level and radioactivity in the control room. (Type E)
Primary Sampling Room Area Radiation	E	Primary sampling room area radiation is used to monitor selected plant areas where access is required for plant recovery. (Type E)
Chemistry Lab. Area Radiation	E	Chemistry laboratory area radiation is used to monitor selected plant areas where access is required for plant recovery. (Type E)
Wind Direction	E	Wind direction is required to monitor environmental conditions used to determine the impact of releases of radioactive materials through identified pathways. (Type E)
Wind Speed	E	Wind speed is required to monitor environmental conditions used to determine the impact of releases of radioactive materials through identified pathways. (Type E)
Atmosphere Stability Temperature Difference	E	Atmosphere stability temperature difference is required to monitor environmental conditions used to determine the impact of releases of radioactive materials. (Type E)
Main Steam Line Radiation	E	Main steam line radiation is used to monitor the magnitude of releases of radioactive materials through identified pathways. (Type E)

Impact on DCD

Table 2.5.3-2 of the APR1400 DCD Tier 1 and Section 7.5 of the APR1400 DCD Tier 2 will be revised as indicated in Attachment 1.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

Table 3.3.11-1 and the Bases for TS 3.3.11 of the APR1400 DCD Tier 2 will be revised as indicated in Attachment 2.

Impact on Technical /Topical/Environmental Reports.

The Safety I&C System Technical Report, APR1400-Z-J-NR-14001-NP, and Section 3.5.2 of Basic Human-System Interface Technical Report, APR1400-E-I-NR-14011-NP, will be revised as indicated in Attachment 3.

Table 2.5.3-2

Accident Monitoring Instrumentation Variables

Variable
Pressurizer pressure (wide range)
Pressurizer level
Cold ~~Reactor coolant cold~~ leg temperature (wide range)
Hot ~~Reactor coolant hot~~ leg temperature (wide range)
Steam generator pressure
Steam generator level (wide range)
Core exit temperature
~~Degree of subcooling~~
RCS subcooling margin CET subcooling margin Reactor vessel upper head subcooling margin Safety injection pump DVI flow rate
Reactor vessel ~~coolant~~ level (RV closure head level/RV plenum level)
Reactor coolant system pressure ~~(wide range)~~
IRWST level
IRWST temperature
Holdup volume tank level
Containment level
Containment pressure (wide range)
Reactor cavity level
Containment isolation valve position
Logarithmic reactor power (neutron flux)
~~Control rod position~~
Containment upper operating area radiation
Containment pressure (extended wide range)
Containment operating area radiation
Spent fuel pool radiation
~~Containment area radiation~~
MS ADV Position Auxiliary feedwater flow

Figure 7.3-17 CLD for a Non-reversing Motor Starter Operated Component 7.3-84
Figure 7.3-18 CLD for a Circuit Breaker Operated Component 7.3-85
Figure 7.3-19 CLD for a Modulating Component 7.3-86
Figure 7.3-20 CLD for a Electro-Hydraulic Motor Damper..................................... 7.3-87
Figure 7.3-21 EDG Loading Sequencer – Control Logic Diagram 7.3-88
Figure 7.3-22 ESF-CCS Simplified Test Logic Diagram 7.3-92
Figure 7.3-23 Radiation Monitoring System Measurement Channel Functional Diagram.. 7.3-93
Figure 7.4-1 Interface Diagram for Division A MCR/RSR master transfer switches 7.4-19
Figure 7.4-2 Interface Diagram for Division AB MCR/RSR master transfer switches 7.4-20
Figure 7.4-3 MCR/RSR Master Transfer Logic (Division A) 7.4-21
Figure 7.4-4 Layout of Remote Shutdown Room... 7.4-22
Figure 7.5-1 Diverse Display of Accident Monitoring Type A, B and C Variables 7.5-22
Figure 7.5-2 QIAS-N Block Diagram.. 7.5-23
Figure 7.6-1A Interlocks for Shutdown Cooling System Suction Line Isolation Valve 7.6-20
Figure 7.6-1B Interlocks for Shutdown Cooling System Suction Line Isolation Valve 7.6-21
Figure 7.6-1C Interlocks for Shutdown Cooling System Suction Line Isolation Valve 7.6-22
Figure 7.6-2 Interlocks for Safety Injection Tank Isolation Valve 7.6-23
Figure 7.6-3 Interlocks for CCW Supply and Return Header Isolation Valve 7.6-24
Figure 7.7-1 Reactor Regulating System Block Diagram 7.7-42
Figure 7.7-2 Digital Rod Control System - Reactor Protection System Interface Block Diagram 7.7-43
Figure 7.7-3 Pressurizer Pressure Control System Block Diagram.......................... 7.7-44
Figure 7.7-4 Pressurizer Level Control System Block Diagram 7.7-45
Figure 7.7-5 Feedwater Control System Block Diagram... 7.7-46

A, A,

The QIAS-P processors and display processors are dedicated to continuously monitor and display AMI Type B and C variables.

The QIAS-N displays AMI Type B and C variables. The QIAS-N also displays selected Type D and E variables.

The IPS displays all AMI variables.

b. Inadequate core cooling (ICC) monitoring instrumentation

The ICC monitoring instrumentation provides an unambiguous, easy-to-interpret indication of ICC. The design follows the guidance of II.F.2 of NUREG-0737 (Reference 4). The safety parameter display system (SPDS) displays ICC variables as a primary display. The QIAS-P displays the ICC monitoring signals as a backup.

c. Bypassed and inoperable status indication (BISI)

The BISI is monitored on the large display panel (LDP) and information flat panel display (FPD). The BISI provides an indication of bypassed or deliberately introduced inoperability of the protection system at the system level, which is required for safe operation of the plant.

d. Alarm system

The alarm systems are redundantly implemented by the IPS and QIAS-N. The IPS and QIAS-N are independent and diverse from each other. Therefore, any single alarm system failure will not cause a total loss of the plant's alarm system.

e. Safety parameter display system

SPDS functions are implemented in the safety parameter display and evaluation system+ (SPADES+), which is designed to meet the criteria for SPDS in NUREG-0696 (Reference 6) and NUREG-0737, Supplement No. 1 (Reference 78).

f. Information systems associated with the emergency response facilities (ERF) and emergency response data system (ERDS)

7.5.1.1 Accident Monitoring Instrumentation

The AMI listed in Table 7.5-1 is provided to allow the operator to assess the state of the plant following design basis events by monitoring instruments, equipment, or systems that provide automatic action.

The AMI is designed to meet the guidance of NRC Regulatory Guide (RG) 1.97 (Reference 1), as depicted in Figure 7.5-1 and as follows:

a. The qualified indication and alarm system - P (QIAS-P) is dedicated to continuously monitor and display AMI Type A, B and C variables. ~~There are no AMI Type A variables in APR1400 design.~~ The QIAS-P in each division (A or B) has one flat panel display, which is mounted on a safety console in the MCR.

b. The qualified indication and alarm system - non-safety (QIAS-N) is designed to support continuous plant operation if the information processing system (IPS) becomes unavailable. The function of the QIAS-N also includes displaying AMI Type A, B, C, and selected sets of Type D and E variables.

c. The IPS provides displays for all AMI variables. The IPS also has a historical data storage, retrieval, and trending capability.

The combined license (COL) applicant is to provide a description of the site-specific AMI variables such as wind speed, and atmosphere stability temperature difference (COL 7.5(1)).

Qualified Indication and Alarm System – P

The QIAS-P provides the continuous display of AMI Type A, B and C variables. The QIAS-P fulfills the requirements in NUREG-0737, Item II.F.2 (Reference 2), and NRC RG 1.97. To address these requirements, the ICC monitoring and display of the QIAS-P performs the following functions:

a. Core exit thermocouple (CET) temperature signal processing and display

b. Primary coolant ~~saturation margin~~ subcooling margin calculation and display

~~The basis and analysis for the selection of the AMI variables are described in the Selection of Accident Monitoring Variables Technical Report (Reference 19).~~

c. Heated junction thermocouple (HJTC) signal processing, display and HJTC heater power control

The QIAS-P provides an unambiguous indication of ICC and advanced warning of the approach of ICC.

The QIAS-P calculates a representative CET temperature from the CETs.

The QIAS-P calculates reactor coolant ~~saturation margins~~ subcooling margins based on the CET temperatures, the hot and cold leg temperatures, ~~and~~ the HJTC temperature measurements from the reactor vessel head region, and pressurizer pressure. The QIAS-P controls the power for the HJTC heaters. The heater power control devices are located in the QIAS-P cabinet. Heater control for the HJTC is manually switched from the QIAS-P channel A only to the diverse indication system (DIS) via DIS switch on safety console. The QIAS-P also calculates the reactor vessel ~~water~~ level based on the HJTC signals.

The QIAS-P provides backup displays for the ICC variables. The primary displays for ICC variables are implemented in the safety parameter display and evaluation system + (SPADES+) within the IPS.

The QIAS-P receives Type A, B and C variables from the plant protection system (PPS), engineered safety features - component control system (ESF-CCS)~~, core protection calculator system (CPCS)~~ via a safety system data network (SDN) and auxiliary process cabinet - safety (APC-S) and process instrumentation via a hardwired connection.

The QIAS-P has divisionalized cabinets for divisions A and B. The QIAS-P cabinets for each division are physically located in divisionalized I&C equipment rooms to meet the requirements of IEEE Std. 603 (Reference 3).

The QIAS-P generates alarms and sends them to the QIAS-N and IPS.

Qualified Indication and Alarm System – Non-Safety

The QIAS-N displays the safety parameters and key operating parameters to be used by the operators during both normal operation and accidents. The QIAS-N displays parameter values and alarms using signal validation, alarm filtering, alarm suppression, and alarm prioritization.

RV

RV

The summary page includes the following information:

1) RCS/upper head ~~saturation margin~~ – the lower value of either the RCS ~~saturation margin~~ or upper head ~~saturation margin~~

subcooling margin

2) Reactor vessel level above the core

3) Representative core exit temperature

b. Backup ICC displays

The QIAS-P provides Class 1E backup displays for ICC variables, and is seismically and environmentally qualified. The displays of ICC variables are dedicated and integrated following the guidance of the Style Guide (Reference 6).

The QIAS-P displays are designed as follows:

1) To provide display of ICC variables

2) To provide indications in the event that the primary display becomes inoperable

3) To provide confirmatory indication to the primary display

RV upper

The following information is available on the QIAS-P display pages:

1) RCS/~~Upper~~ head ~~saturation margin~~

2) Reactor vessel level above the core

3) Representative core exit temperature

7.5.1.3 Bypassed and Inoperable Status Indication

System-level automatic bypass indication is provided based on the guidance of NRC RG 1.47 (Reference 7). Compliance with NRC RG 1.47 is described as follows:

a. Flags are provided to indicate, at the system level, the bypass or deliberate inoperability of a protection system. The system-level alarms are actuated when a

To resolve the information ambiguity, additional variables are provided as listed in Table 7.5-1.

6) Power supply

The QIAS-P is powered from Class 1E, battery and emergency diesel generator (EDG) backed, vital instrument power bus A and B. The QIAS-N is classified as non-safety system but is powered from Class 1E, battery and EDG backed, vital instrument power bus D. The IPS is powered from non-Class 1E, battery backed, vital instrument power.

7) Calibration, testability, and access control

IEEE Std. 497 and NRC RG 1.97

Calibration and testing are performed after the related systems are offline.

Redundant design features provide reasonable assurance of the continuous display of AMI variables during calibration or test. Periodic tests are performed following the guidance of ~~NRC RG 1.118 (Reference 10)~~. Access to any sensor or module for calibration or testing is administratively controlled.

The display systems are designed to allow control of access to constants, alarm setpoints, calibration, and test points. Isolation devices are located outside the containment so the devices can be accessed for maintenance during accident conditions.

8) Direct measurement

The QIAS-P provides direct measurement of desired variables.

b. Qualification criteria

The QIAS-P and QIAS-N are seismically and environmentally qualified.

A,

c. Display and recording

AMI Type B and C variables are continuously displayed on the dedicated QIAS-P. AMI Type B, C, and selected Type D and E variables are also displayed on the QIAS-N. AMI Type B, C, D, and E variables are displayed on the IPS.

A, A,

A,
RAI 38-7878 - Question 07.05-01

Recording is provided for at least one division of AMI Type B and C variables. Recording on the IPS is also provided for AMI Type E variables. Recording on the IPS is provided for at least 30 minutes pre-event and 12 hours post-event.

d. Display identification

A,

Type B and C variables are identified as AMI variables with a characteristic designation to discern information intended for use under accident conditions.

e. Performance criteria

1) Range

The range of AMI described in Table 7.5-1 is established to provide reasonable assurance that it covers AOOs and PAs. Separate, narrow-range instrumentation is provided where the required range of monitoring instrumentation results in a loss of sensitivity during normal operating conditions.

The QIAS-P, QIAS-N, and IPS also allow access to individual divisions for each range.

The IPS and the QIAS-N attempt to validate data using narrow range sensors. If successful, narrow range scale and demarcation are displayed. If the parameter is out of the narrow range, wide-range sensors are used for the display with wide range scale and demarcation.

2) Accuracy

The required accuracy of AMI is established based on the assigned function.

3) Response Time

AMI is designed to provide real-time and timely information. AMI signals are transmitted from sensors to the QIAS-P, QIAS-N, and IPS. The response time between detection and indication is approximately 1 to 3 seconds. The update frequency is less than 1 second.

7. Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems," Rev. 1, U.S. Nuclear Regulatory Commission, February 2010.

8. IEEE Std. 497-2002, "IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2002.

9. IEEE Std. 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," Institute of Electrical and Electronics Engineers, 1992.

10. Regulatory Guide 1.118, "Periodic Testing of Electric Power and Protection Systems," Rev. 3, U.S. Nuclear Regulatory Commission, April 1995.

11. 10 CFR 50.34(f)(2)(xviii), "Instrumentation for Detection of Inadequate Core Cooling," [II.F.2], U.S. Nuclear Regulatory Commission.

12. 10 CFR 50.34(f)(2)(v), "Bypass and Inoperable Status Indication," [I.D.3], U.S. Nuclear Regulatory Commission.

13. SRM to SECY-93-087, Item II.T, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advance Light-Water Reactor (ALWR) Designs," U.S. Nuclear Regulatory Commission, April 2, 1993.

14. 10 CFR 50.34(f)(2)(iv), "Safety Parameter Display Console" [I.D.2] U.S. Nuclear Regulatory Commission.

15. 10 CFR 50.34 (f)(2)(xxv), "Additional TMI-related Requirements," [III.A.1.2], U.S. Nuclear Regulatory Commission.

16. IEEE Std. 7-4.3.2-2003, "IEEE Standard Design for Digital Computers in Safety Systems of Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2003.

17. APR1400-Z-J-NR-14001-P, "Safety I&C System," KHNP, November 2014.

18. 10 CFR 50.34(f)(2)(xi), "Direct Indication of Relief and Safety Valve Position (Open or Closed) in the Control Room," [II.D.3], U.S. Nuclear Regulatory Commission.

~~19. APR1400-E-J-NR-16001-P, "Selection of Accident Monitoring Variables," KHNP, June 2016.~~

Table 7.5-1 (1 of 5)

Accident Monitoring Instrumentation Variables

Variable	Range	Monitored Function or System	Channel Number	Type	Ambiguity (Division)
Pressurizer Pressure (Wide Range)	0 to 210.9 kg/cm^{2}A (0 to 3,000 psia)	Pressurizer	2	B	C,D (PPS OM)
Pressurizer Level	0 to 100 % (0 to 562.15 in)	Pressurizer	2	~~B~~	~~C,D (PPS OM)~~
~~Reactor Coolant~~ Hot Leg Temperature (Wide Range)	0 to 400°C (32 to 752 °F)	RCS	4	~~B~~	~~2 Hot Leg signals per division (QIAS-P)~~
~~Reactor Coolant~~ Cold Leg Temperature (Wide Range)	0 to 400°C (32 to 752 °F)	RCS	4	~~B~~	~~2 Cold Leg signals per division (QIAS-P)~~
Steam Generator Pressure	0 to 105 kg/cm^{2}A (0 to 1,494 psia)	Steam Generator	2/SG	~~B~~	C,D (PPS OM)
Steam Generator Level (Wide Range)	0 to 100 % (0 to 1117.6cm (0 to 440 in tap span)	Steam Generator	2/SG	~~B~~	C,D (PPS OM)
Core Exit Temperature	0 to 1260 °C (32 to 2,300 °F)	Inadequate Core Cooling	2	B, C	Validation (QIAS-P)
Degrees of Subcooling	RCS Temp Saturation Margin: -399 to 358.3 °C Upper Head (or CET) Temp Saturation Margin: -1,260 to 368.3 °C RCS (or Upper Head or CET) Press Saturation Margin: -225.5 to 210.9 kg/cm^2	Inadequate Core Cooling	2	B	C,D (PPS OM)
Reactor Vessel ~~Coolant~~ Level	0 to 100 %	RCS	2	B	Validation (QIAS-P)
RCS Pressure ~~(Wide Range)~~	0 to 281.23 kg/cm^{2}G (0 to 4,000 psig)	RCS	2	~~B, C~~	~~C,D (PPS OM)~~
IRWST Level	0 to 100 %	IRWST	4	B	C,D (ESCM)

A,

C (IPS)

A, B, D

C, D (PPS OM)

C, D (PPS OM)

Pressurizer Pressure A, B, C, D (PPS OM)

(RV closure head level/RV plenum level)

C, D

, D

To be revised as shown on the next page.

Variable	Range	Monitored Function or System	Channel Number	Type	Ambiguity (Division)
RCS Subcooling Margin	Temp. Margin : -399 to 358.3°C Press. Margin : -225.5 to 210.9 kg/cm^2	Inadequate Core Cooling	2	A, B	Validation (QIAS-P)
CET Subcooling Margin	Temp. Margin : -1,260 to 368.3°C Press. Margin : -225.5 to 210.9 kg/cm^2	Inadequate Core Cooling	2	A, B	Validation (QIAS-P)
RV Upper Head Subcooling Margin	Temp. Margin : -1,260 to 368.3°C Press. Margin : -225.5 to 210.9 kg/cm^2	Inadequate Core Cooling	2	B	Validation (QIAS-P)

Table 7.5-1 (2 of 5)

Variable	Range	Monitored Function or System	Channel Number	Type	Ambiguity (Division)
IRWST Temperature	10 to 177 °C (50 to 350 °F)	IRWST	4	B , D	C,D (ESCM)
Holdup Volume Tank Level	0 to 100 %	IRWST	4	B	C,D (ESCM)
Containment Level	0 to 100 %	Containment monitoring system	2	B	C,D (ESCM)
Containment Pressure (Wide Range)	-400 to 5,600 cmH_2O (-5.7 to 79.5 psig)	Maintaining containment integrity	2	B , D	C,D (PPS OM)
Reactor Cavity Level	0 to 100%	Maintaining containment integrity	4	B	C,D (ESCM)
Containment Isolation Valve Position	N/A	Maintaining containment integrity	1 pair/ valve	B, D	Validation (QIAS-P)
Logarithmic Reactor Power (neutron flux)	2×10^{-8} to 200 % power	Reactor power	2	A, B	C,D (PPS OM)
~~Control Rod Position~~ CEA Position	0 to 381 cm (0 to 150 in)	Reactivity control	1/rod	~~B~~ D	~~C,D (CPCS OM)~~ N/A
Containment Pressure (Extended Wide Range)	-500 to 14,500 cmH_2O (-7.1 to 206.2 psig)	Fission product release	2	C	PPS Containment pressure A,B,C,D (PPS OM)
Containment Operating Area Radiation	10^{-3} to 10^{2} mSv/hr	Monitoring fueling handling accident	2	C	C,D (ESCM)
Spent Fuel Pool radiation	10^{-3} to 10^{2} mSv/h	Monitoring fueling handling accident	2	C	C,D (ESCM)
Containment Upper Operating Area Radiation	10 to 10^{8} mSv/hr	Monitoring LOCA	2	C	C,D (ESCM)
MS ADV Position	N/A	Monitoring Position of MS ADV Actuation	4	B	A, B, C, D
Auxiliary Feedwater Flow	0 to 3,600 lpm (0 to 950 gpm)	Monitoring Auxiliary Feedwater Flow	4	B	A, B, C, D

RAI 38-7878 - Question 07.05-01

RAI 38-7878 - Question 07.05-01_Rev.1

0 to 53 kg/cm2g

Monitoring a Boron Injection Potential

Table 7.5-1 (3 of 5)

Variable	Range	Monitored Function or System	Channel Number	Type	Ambiguity (Division)
POSRV Position	N/A	Verifying status of a safety system	1/valve	D	N/A
CS Flow	0 to 28,400 lpm (0 to 7,500 gpm)	Monitoring CS operation	2	D	N/A
Containment Atmosphere Temperature	4.44 to 204.44 °C (40 to 400 °F)	Monitoring accomplishment of cooling	13	D	N/A
SI Hot Leg Injection Flow Rate	0 to 5,678.12 lpm (0 to 1,500 gpm)	Monitoring the operating status for a safety system	2	D	N/A
~~Wide Range~~ Safety Injection Tank Level	0 to 100 % (402 inch full scale)	~~Monitoring the operating status for a safety system~~	4	D	N/A
~~Wide Range~~ Safety Injection Tank Pressure	~~0 to 53kg/cm²G~~ (0 to 750 psig)	~~Monitoring the operating status for a safety system~~	4	D	N/A
Emergency Ventilation Damper Position	N/A	Prevention of radiation effluent release	1 pair/ damper	D	N/A
DC Bus Voltage	0 to 150 Vdc	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
Emergency Diesel Generator Voltage	0 to 5,250 Vac	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
Emergency Diesel Generator Current	0 to 2,000 Amps	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
4.16 kV Switchgear Voltage	0 to 5,250 Vac	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
4.16 kV Switchgear Current	0 to 2,000 Amps	Electrical power supplies for safety system and safe shutdown system	4	D	N/A

To be added as shown on the next page.

Instrument Power Bus Voltage	0 to 150 Vdc	Electrical power supplies for safety system and safe shutdown system	4	D	N/A

Auxiliary Feedwater Storage Tank Level	0 to 100%	Monitoring Level of Auxiliary Feedwater Storage Tank	2	D	N/A

Table 7.5-1 (4 of 5)

Variable	Range	Monitored Function or System	Channel Number	Type	Ambiguity (Division)
480 V L/C Voltage	0 to 600 Vac	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
480 V L/C Current	0 to 3,000 Amps	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
CCW Temperature	0 to 100 °C (32 to 212 °F)	Monitoring CCWS operation	1/division	D	N/A
CCW Flow	0 to 110% design flow	Monitoring CCWS operation	1/pump	D	N/A
ESW Temperature	0 to 50 °C (32 to 122 °F)	Monitoring ESW operation	1/division	D	N/A
ESW Flow	0 to 120% design flow	Monitoring ESW operation	1/pump	D	N/A
Charging Line Flow	0 to 749.43 lpm (0 to 198 gpm)	Monitoring the status of boric acid flow to RCS	1	D	N/A
Charging Line Pressure	0 to 220 kg/cm^{2}G (0 to 3,129 psig)	Monitoring the status of boric acid flow to RCS	1	D	N/A
Shutdown Cooling Heat Exchange Outlet Temperature	0 to 200°C (40 to 392°F)	Monitor the operating status for a safety system	2	D	N/A
Shutdown Cooling Pump Flow Rate	0 to 25,000 lpm (0 to 6,604 gpm)	Monitor the operating status for a safety system	2	D	N/A
Discharge SIT Isolation ~~Valve~~	N/A	Monitor the operating status for a safety system	4	D	N/A
SIP DVI Flow Rate	0 to 5,678 lpm (0 to 1,500 gpm)	Monitor the operating status for a safety system	4	B, D	~~N/A~~ Validation (QIAS-P)
~~Backup Heater Status~~	~~N/A~~	~~Monitor the operating status for a safety system~~	~~N/A~~	~~D~~	~~N/A~~
~~RCP Motor Current~~	~~0 to 700 A~~	~~Verifying status of RCS flow and core cooling~~	~~4~~	~~D~~	~~N/A~~

RAI 38-7878 - Question 07.05-01_Rev.1

Table 7.5-1 (5 of 5)

Variable	Range	Monitored Function or System	Channel Number	Type	Ambiguity (Division)
Containment Purge Effluent	3.7×10^{-2} to 3.7×10^{9} Bq/cc	Monitoring gaseous effluent in containment building	1	E	N/A
Auxiliary Building Controlled Area HVAC Effluent	3.7×10^{-2} to 3.7×10^{7}Bq/cc	Monitoring gaseous effluent of controlled area in AUX. building	2	E	N/A
Compound Building HVAC Effluent	3.7×10^{-2} to 3.7×10^{3} Bq/cc	Monitoring gaseous effluent in compound building	1	E	N/A
~~Liquid Radwaste System Radiation~~	~~3.7×10^{-2} to 3.7×10^{3} Bq/cc~~	~~Monitoring liquid radwaste system radiation~~	~~2~~	~~E~~	~~N/A~~
Condenser Vacuum Vent Effluent Radiation	3.7×10^{-2} to 3.7×10^{3} Bq/cc	Monitoring SG tube leakage	1	E	N/A
MCR and TSC Area Radiation	10^{-3} to 10^{2} mSv/hr	Monitoring area radiation level	1	E	N/A
Primary Sampling Room Area Radiation	10^{-3} to 10^{2} mSv/hr	Monitoring area radiation level	1	E	N/A
Chemistry Lab. Area Radiation	10^{-3} to 10^{2} mSv/hr	Monitoring area radiation level	1	E	N/A
Wind Direction	0 to 360°	Release assessment	1	E	N/A
Wind Speed	0 to 50 mph	Release assessment	1	E	N/A
Atmosphere Stability Temperature Difference	-22.78 to -7.78°C (-9 to +18°F) Delta-T	Release assessment	2	E	N/A
Main Steam Line Radiation	10^{-3} to 10^{2} mSv/hr	Monitoring leakage of steam generator	4	E	N/A

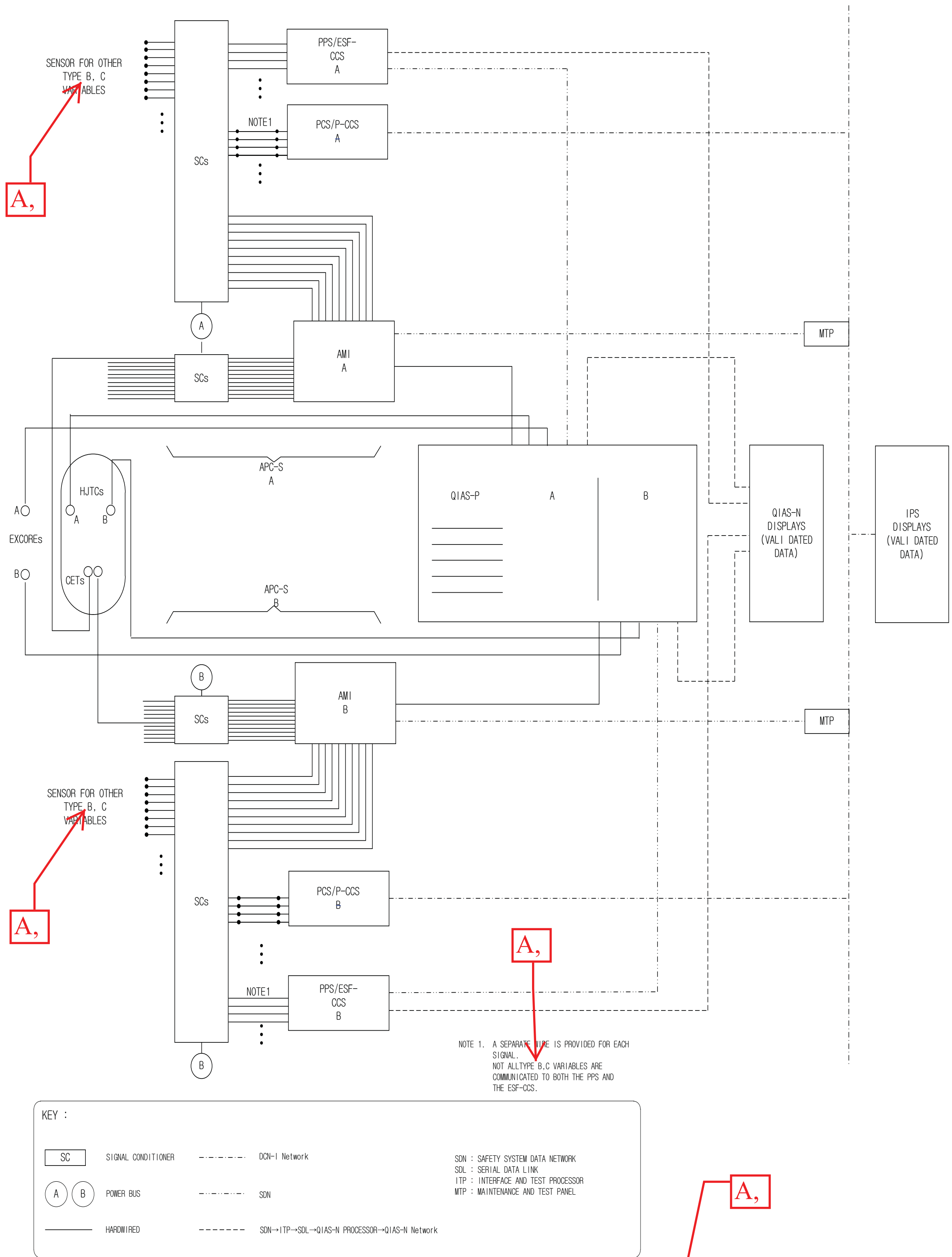
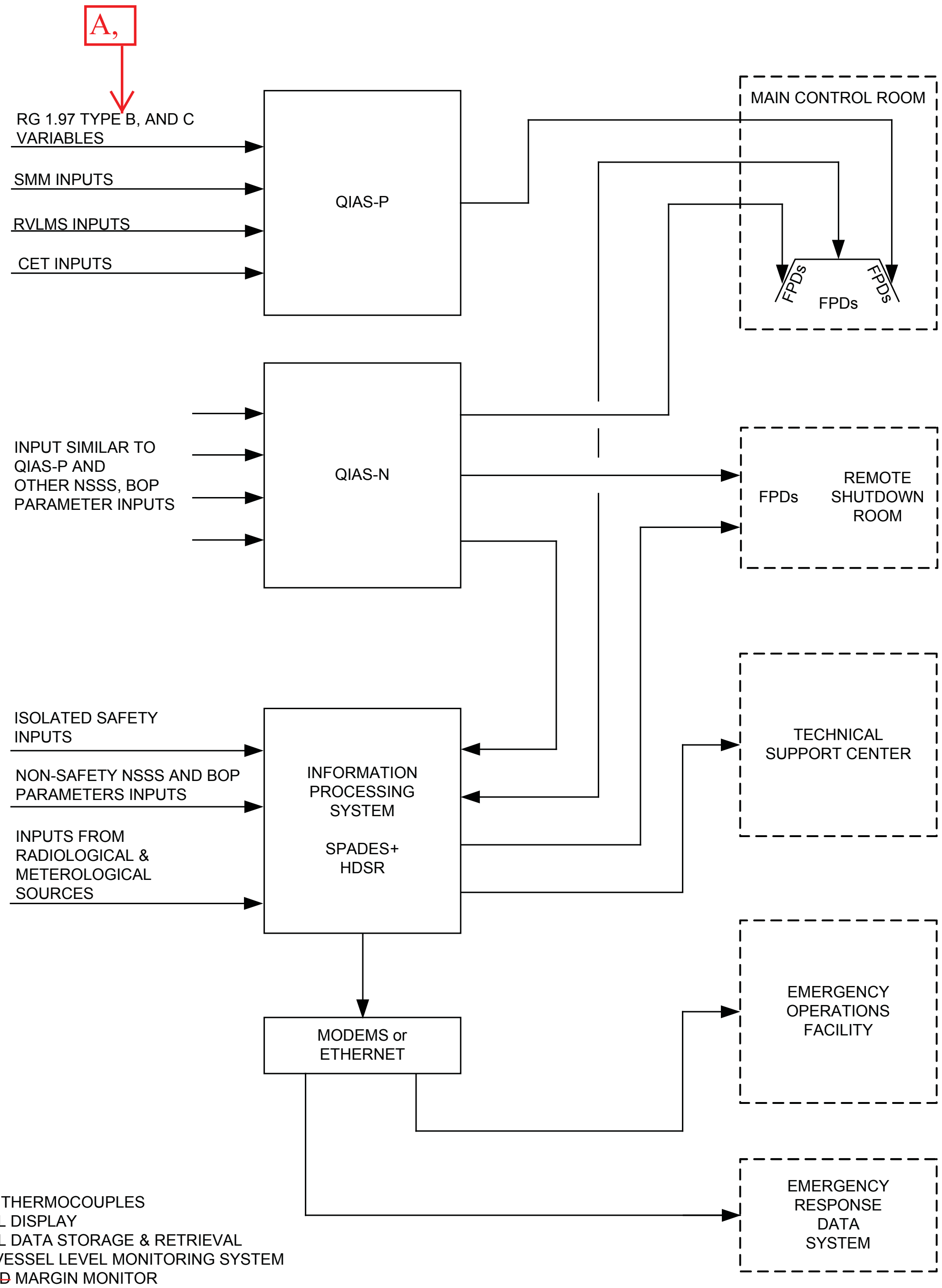


Figure 7.5-1 Diverse Display of Accident Monitoring Type B and C Variables



SUBCOOLING

LEGEND

CET	-CORE EXIT THERMOCOUPLES
FPD	-FLAT PANEL DISPLAY
HDSR	-HISTORICAL DATA STORAGE & RETRIEVAL
RVLMS	-REACTOR VESSEL LEVEL MONITORING SYSTEM
SMM	-~~SUBCOOLED~~ MARGIN MONITOR
SPD	-SAFETY PARAMETER DISPLAY
SPADES+	-SAFETY PARAMETER DISPLAY AND EVALUATION SYSTEM+

NOTE : FPDs INTERFACE WITH TRACKBALL UNITS FOR HSI

Figure 7.7-12 HSI Information Processing Block Diagram

RAI 38-7878 - Question 07.05-01

RAI 38-7878 - Question 07.05-01_Rev.1

Table 3.3.11-1 (Page 1 of 2)
Accident Monitoring Instrumentation

FUNCTION	REQUIRED MEASUREMENT CHANNELS	CONDITIONS REFERENCED from REQUIRED ACTION D.1
1. Logarithmic Reactor Power (neutron flux)	2	E
2. ~~Reactor Coolant~~ Hot Leg Temperature (Wide Range)	2 per loop	E
3. ~~Reactor Coolant~~ Cold Leg Temperature (Wide Range)	2 per loop	E
4. Reactor Coolant System Pressure (Wide Range)	2	E
5. Reactor Vessel ~~Coolant~~ Level	2	F
6. Reactor Cavity Level	4	E
7. Containment Pressure (Wide Range)	2	E
8. Containment Pressure (Extended Wide Range)	2	E
9. Containment Isolation Valve Position	1 per valve [(a),(b)]	E
10. Containment Upper Operating Area Radiation	2	F
11. Pressurizer Level	2	E
12. Steam Generator Level (Wide Range)	2 per Steam Generator	E
13. Holdup Volume Tank Level	4	E

(a) Not required for isolation valves whose associated penetration is isolated by at least one closed and deactivated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

(b) Only one position indication channel is required for penetration flow paths with only one installed main control room indication channel.

19. RCS Subcooling Margin	2(d)	E
20. Core Exit Temperature (CET) Subcooling Margin	2(e)	E
21. Reactor Vessel (RV) Upper Head Subcooling Margin	2(f)	E

Table 3.3.11-1 (Page 2 of 2)
Accident Monitoring Instrumentation

RAI 38-7878 - Question 07.05-01

RAI 38-7878 - Question 07.05-01_Rev.1

FUNCTION	REQUIRED MEASUREMENT CHANNELS	CONDITIONS REFERENCED from REQUIRED ACTION D.1
14. Core Exit Temperature – Quadrant 1	2(c)	E
15. Core Exit Temperature – Quadrant 2	2(c)	E
16. Core Exit Temperature – Quadrant 3	2(c)	E
17. Core Exit Temperature – Quadrant 4	2(c)	E
18. Steam Generator Pressure	2 per Steam Generator	E
~~19. Degree of Subcooling~~	~~2(d)~~	~~E~~
22. 20. Pressurizer Pressure (Wide Range)	2	E
23. ~~21.~~ IRWST Level	4	E
24. ~~22.~~ IRWST Temperature	4	E
25. ~~23.~~ Containment Level	2	E
~~24. Control Rod Position~~	~~1/rod~~	~~E~~
26. ~~25.~~ Containment Operating Area Radiation	2	E
27. ~~26.~~ Spent Fuel Pool Radiation	2	E
28. Safety Injection Pump (SIP) Direct Vessel Injection (DVI) Flow Rate	2	E

(c) A measurement CHANNEL consists of ~~four~~ two or more core exit thermocouples.

~~(d) A measurement CHANNEL consists of one or more Core Exit Temperature, Reactor Vessel Upper Head Temperature, Reactor Coolant Inlet Temperature (T-Cold) Wide Range, Reactor Coolant Outlet Temperature (T-Hot) Wide Range, and Pressurizer Pressure (Wide Range).~~

Insert "A" on the next page.

To be revised as shown on the next page.

RAI 38-7878 - Question 07.05-01

RAI 38-7878 - Question 07.05-01_Rev.1

29. MS ADV Position	4	E
30. Auxiliary Feedwater Flow	4	E

"A"

(d) A measurement channel consists of Reactor Coolant Cold Leg Temperature (T-Cold) Wide Range, Reactor Coolant Hot Leg Temperature (T-Hot) Wide Range, and Pressurizer Pressure (Wide Range).

(e) A measurement channel consists of one or more Core Exit Temperature and Pressurizer Pressure (Wide Range).

(f) A measurement channel consists of Reactor Vessel Upper Head Temperature and Pressurizer Pressure (Wide Range).

BASES

BACKGROUND (continued)

- Provide information to indicate the magnitude of the release of radioactive materials and to assess such releases. The AMI is displayed through the qualified indication and alarm system (QIAS).

APPLICABLE SAFETY ANALYSIS

The AMI ensures the OPERABILITY of NRC RG 1.97 variables, so that the MCR operating staff can:

- Perform the diagnosis specified in the emergency operating procedures. These variables are restricted to preplanned actions for the primary success path of DBAs.

- Take the specified, preplanned, manually controlled actions, for which no automatic control is provided, that are required for safety systems to accomplish their safety functions.

- Determine whether systems important to safety are performing their intended functions.

- Determine the potential for causing a gross breach of the barriers to radioactivity release.

- Determine if a gross breach of a barrier has occurred.

- Initiate action necessary to protect the public as well as to obtain an estimate of the magnitude of any impending threat.

AMI that performs certain functions related to verification of key safety functions and monitoring key barriers for breach must be retained in the Specification because they are intended to assist operators in minimizing the consequences of accidents. Therefore, these variables are important in reducing public risk.

A,

The seismically qualified indication and alarm system - P (QIAS-P) is dedicated to continuously monitor and display the Type B, and C variables. The qualified indication and alarm system - non-safety (QIAS-N) and information processing system (IPS) also monitor all Type B, C, D, and E variables. A,

RAI 38-7878 - Question 07.05-01

RAI 38-7878 - Question 07.05-01_Rev.1

LCO (continued)

Listed below are discussions of the specified instrument functions listed in Table 3.3.11-1. The following instruments are displayed on QIAS-P, QIAS-N, and IPS.

1. Logarithmic Reactor Power

Logarithmic Reactor Power indication is provided to verify reactor shutdown.

Inputs are provided by two safety CHANNELS with a minimum sensor and indicated range of 2×10^{-8} to 200 % power.

2, 3. ~~Reactor Coolant~~ Hot Leg Temperature (wide range) and Cold Leg Temperature (wide range)

Hot

~~Reactor coolant hot~~ leg and cold leg temperatures are variables provided for verification of core cooling and long term surveillance. They are also inputs to the reactor coolant system ~~subcooled~~ margin monitor.

subcooling

Reactor coolant outlet and inlet temperature inputs to the AMI are provided by two fast response resistance elements and associated transmitters in each loop. The CHANNELS provide indication over a minimum sensor and indicated range of 0 to 400°C (32 to 752 °F).

4. Reactor Coolant System Pressure ~~(wide range)~~

RCS pressure (wide range) is a variable, provided for verification of core cooling and RCS integrity long term surveillance. Wide range RCS loop pressure is measured by pressure transmitters with a minimum sensor and indicated range of 0 to 281.2 kg/cm^2G (4,000 psig). The pressure transmitters are located inside the containment. Redundant monitoring capability is provided by two trains of instrumentation.

BASES

LCO (continued)

5. Reactor Vessel ~~Coolant~~ Level

Reactor vessel ~~coolant~~ level is provided for verification and long term surveillance of core cooling.

The reactor vessel ~~coolant~~ level monitors provide a direct measurement of the collapsed liquid level above the fuel alignment plate surface. The collapsed liquid represents the amount of liquid mass that is in the reactor vessel above the core. Measurement of the collapsed coolant level is selected because it is a direct indication of the coolant inventory. The collapsed level is obtained over the same temperature and pressure range as the saturation measurements, thereby encompassing all operating and accident conditions where it must function. Also, it functions during the recovery interval. Therefore, it is designed to survive the high steam temperature that can occur during the preceding core recovery interval.

The level range extends from the top of the vessel down to the top of the fuel alignment plate surface. The response time is short enough to track the level during small break LOCA events. The resolution is sufficient to show the initial level drop, the key locations near the hot leg elevation, and the lowest levels just above the fuel alignment plate surface. This provides the operator with adequate indication to track the progression of the accident and to detect the consequences of its mitigating actions or the functionality of automatic equipment.

Two CHANNELS with minimum sensor range of 0 ~ 673.5 cm (0 ~ 265.16 in) above the fuel alignment plate surface is provided. The minimum indicated range for these two CHANNELS is 0 to 100 %.

6. Reactor Cavity Level

Reactor cavity level is provided for verification and long term surveillance of the RCS integrity and vessel integrity.

Reactor cavity level is measured by four instruments with a minimum sensor and indicated range of 0 to 100 %.

BASES

LCO (continued)

10. Containment Upper operating Area Radiation

The Containment Upper operating Area Radiation monitor is provided to monitor for the potential of significant radiation releases and to provide release assessment for use by operators in determining the need to invoke site emergency plans. Two sensors with a minimum sensor and indicated range of 10^1 to 10^8 mSv/hr provide input to the monitor.

11. Pressurizer Level

The Pressurizer Level is used to determine whether to terminate safety injection (SI), if still in progress, or to reinitiate SI if it has been stopped. Knowledge of pressurizer level is also used to verify the plant conditions necessary to establish natural circulation in the RCS and to verify that the plant is maintained in a safe shutdown condition.

Two pressurizer level sensors are provided. They have a minimum indicated and sensor range of 0 to 100 %.

12. Steam Generator Level (wide range)

The Steam Generator Level (wide range) monitor is provided to monitor operation of decay heat removal via the steam generators. The measured differential pressure is displayed as 0 to 100 % at the reference leg temperature of 20 °C (68 °F). Temperature compensation of this indication is performed automatically ~~manually by the operator~~. Redundant monitoring capability is provided by two trains of instrumentation.

BASES

LCO (continued)

18. Steam Generator Pressure

The Steam Generator Pressure monitor is provided to monitor operation of the Steam Generators and verification of RCS heat removal. There are two sensed CHANNELS of the Steam Generator Pressure per Steam Generator. The minimum sensor range of these CHANNELS is 1.1 to 105.5 kg/cm^2 A (15 to 1500 psia). The minimum indicated range of these CHANNELS is 0 to 105 kg/cm^{2}A (0 to 1494 psia).

To be revised as shown on the next page.

~~19. Degree of Subcooling~~

~~Degree of subcooling is provided for verification and analysis of plant conditions.~~

~~There are two sensed CHANNELS of degree of subcooling. Degree of subcooling is calculated from the following instruments: Wide Range Pressurizer Pressure (minimum sensor range of 0 to 210.9 kg/cm^2 [0 to 3,000 psi]), Reactor Coolant Hot Leg and Cold Leg Temperatures (Minimum Sensor Range of 0 to 400 °C [32 to 752 °F]), and Core Exit Temperatures (Minimum Sensor Range of 0 to 1,260.0 °C [32 to 2,300 °F]). The degree of subcooling indicated range is a minimum of 93.3 °C (200 °F) subcooling to 1.7 °C (35 °F) superheat.~~

22. ~~20.~~ Pressurizer Pressure (wide range)

Pressurizer Pressure (wide range) is measured by pressure transmitters with a minimum sensor and indicated range of 0 to 210.9 kg/cm^{2}A (0 to 3,000 psia).

19. RCS Subcooling Margin

RCS Subcooling Margin is provided for verification and analysis of plant conditions.

There are two sensed channels of RCS Subcooling Margin. RCS Subcooling Margin is calculated from Wide Range Pressurizer Pressure (minimum sensor range of 0 to 210.9 kg/cm2 [0 to 3,000 psi]), Reactor Coolant Hot Leg and Cold Leg Temperatures (Minimum Sensor Range of 0 to 400 °C [32 to 752 °F]). RCS Temperature Subcooling Margin indicated range is from 358.3 °C (677 °F) subcooling to 399 °C (750 °F) ~~superheat~~ superheated. RCS Pressure Subcooling Margin indicated range is from 210.9 kg/cm2 subcooling to 225.5 kg/cm2 ~~superheat~~ superheated.

20. CET Subcooling Margin

CET Subcooling Margin is provided for verification and analysis of plant conditions.

There are two sensed channels of CET Subcooling Margin. CET Subcooling Margin is calculated from Wide Range Pressurizer Pressure (minimum sensor range of 0 to 210.9 kg/cm2 [0 to 3,000 psi]) and Core Exit Temperatures (Minimum Sensor Range of 0 to 1,260.0 °C [32 to 2,300 °F]). CET Temperature Subcooling Margin indicated range is from ~~from~~ 368.3 °C (695 °F) subcooling to 1,260.0 °C (2,300 °F) ~~superheat~~ superheated. CET Pressure Subcooling Margin indicated range is from 210.9 kg/cm2 subcooling to 225.5 kg/cm2 ~~superheat~~ superheated.

21. RV Upper Head Subcooling Margin

RV Upper Head Subcooling Margin is provided for verification and analysis of plant conditions.

There are two sensed channels of RV Upper Head Subcooling Margin. RV Upper Head Subcooling Margin is calculated from Wide Range Pressurizer Pressure (minimum sensor range of 0 to 210.9 kg/cm2 [0 to 3,000 psi]) and Reactor Vessel Upper Head Temperature (Minimum Sensor Range of 0 to 1,260.0 °C [32 to 2,300 °F]). RV Upper Head Temperature Subcooling Margin indicated range is from ~~from~~ 368.3 °C (695 °F) subcooling to 1,260.0 °C (2,300 °F) ~~superheat~~ superheated. RV Upper Head Pressure Subcooling Margin indicated range is from 210.9 kg/cm2 subcooling to 225.5 kg/cm2 ~~superheat~~ superheated.

BASES

LCO (continued)

23. ~~21.~~ IRWST Level

The IRWST Level monitor is provided to sure water supply for Emergency Core Cooling and Containment Spray. The IRWST consists of one torus-type tank inside containment. There are four 0 to 100 % sensors and indicated range level CHANNELS.

24. ~~22.~~ IRWST Temperature

IRWST temperature is provided for verification of long term decay heat removal operation. There are four 50 to 350 °F sensors with an indicated range temperature CHANNELS.

25. ~~23.~~ Containment Level

The containment level monitor is provided for verification and long term surveillance of Emergency Core Cooling and the Containment Level is measured by two instruments with a minimum sensor and indicated range of 0 to 100 %.

~~24. Control Rod Position~~

~~To verify whether the Control Rods are full in or not full in, Control Rod Positions are calculated in CPCS with a range of 0 to 381 cm.~~

26. ~~25.~~ Containment Operating Area Radiation

A containment operating area radiation monitor is provided to monitor the potential of significant radiation releases from an event occurring in the containment (e.g., fuel handling accident) and to provide a release assessment for use by operators in determining the need to invoke the site emergency plans. In addition, this area monitoring initiates containment purge isolation actuation signal (CPIAS) to prevent radioactive release through containment purge system.
Two containment operating radiation monitors are available and two sensors with a minimum sensor indicated range of 10^{-3} mSv/hr to 10^{2} mSv/hr provide input

RAI 38-7878 - Question 07.05-01

RAI 38-7878 - Question 07.05-01_Rev.1

LCO (continued)

27. ~~26.~~ Spent Fuel Pool Radiation

The spent fuel pool radiation monitor is provided to monitor the potential of significant radiation releases from the event occurring in the fuel handling area (e.g., fuel handling accident) and to provide release assessment for use by operators in determining the need to invoke site emergency plans. In addition, this area monitor initiates fuel handling area emergency ventilation actuation signal (FHEVAS) to stop the fuel handling area normal ventilation system and to activate the fuel handling area emergency ventilation system. Two spent fuel pool radiation monitors are available and two sensors with a minimum sensor indicated range of 10^{-3} mSv/hr to 10^{2} mSv/hr provide input.

Items 28, 29, and 30 to be added as shown on the next page.

Two CHANNELS are required to be OPERABLE for all but one Function. Two OPERABLE CHANNELS ensure that no single failure within the AMI or its auxiliary supporting features or power sources, concurrent with failures that are a condition of or result from a specific accident, prevents the operators from obtaining from being presented the information necessary for them to determine the safety status of the plant and to bring the plant to and maintain it in a safe condition following that accident.

In Table 3.3.11-1 delineates that the exception to the two CHANNEL requirements is the Containment Isolation Valve Position.

Two OPERABLE CHANNELS of core exit thermocouples are required for each CHANNEL in each quadrant to provide indication of radial distribution of the coolant temperature rise across representative regions of the core. Power distribution symmetry is considered in determining the specific number and locations provided for diagnosis of local core problems. Therefore, two randomly selected thermocouples may not be sufficient to meet the two thermocouples per CHANNEL requirement in any quadrant. The two thermocouples in each CHANNEL must meet the additional requirement that one be located near the center of the core and the other near the core perimeter, such that the pair of core exit thermocouples indicates the radial temperature gradient across their core quadrant. Two sets of two thermocouples in each quadrant ensure a single failure will not disable the ability to determine the radial temperature gradient.

For loop and steam generator related variables, the required information is individual loop temperature and individual steam generator level. In these cases two CHANNELS are required to be OPERABLE for each loop of steam generator to redundantly provide the necessary information.

RAI 38-7878 - Question 07.05-01

RAI 38-7878 - Question 07.05-01_Rev.1

28. SIP DVI Flow Rate

The SIP DVI Flow Rate monitor is provided to verify that safety systems are performing their safety functions for control of RCS inventory during an accident and the SIP DVI Flow Rate is measured with a minimum sensor and indicated range of 0 to 5,678 lpm (0 to 1,500 gpm).

29. MS ADV Position

MSADV position is provided to monitor the actuation of MSADV for each main steam line. MSADV is to allow cooldown of the reactor coolant system (RC) through a controlled discharge of steam to the atmosphere when the MSIVs are closed or when the main condenser is not available as a heat sink.

30. Auxiliary Feedwater Flow

The Auxiliary Feedwater Flow is provided to verify the flow of Auxiliary Feedwater supplied to corresponding steam generator. The AF System delivers the minimum required flow of 650 gpm to the affected steam generator within 60 seconds following an AFAS. The maximum rate of auxiliary feedwater flow delivered to the steam generator at 1,240 psia or less is equal to or less than 950 gpm. The flowrate is indicated range of 0 to 3,600 lpm (0 to 950 gpm).

BASES

ACTIONS (continued)

E.1 and E.2

If the Required Action and associated Completion Time of Condition D is not met and Table 3.3.11-1 directs entry into Condition E, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 6 hours and to MODE 4 within 12 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

Upper Operating

F.1

Alternate means of monitoring Reactor Vessel ~~Coolant~~ Level and Containment Area Radiation have been developed and tested. These alternate means may be temporarily installed if the normal accident monitoring channel cannot be restored to OPERABLE status within the allotted time. If these alternate means are used, the Required Action is not to shut down the plant, but rather to follow the directions of Specification 5.6.5. The report provided to the NRC should discuss the alternate means used, describe the degree to which the alternate means are equivalent to the installed accident monitoring channels, justify the areas in which they are not equivalent, and provide a schedule for restoring the normal accident monitoring channels.

SURVEILLANCE REQUIREMENTS

A Note in the beginning of the SR table specifies that the following SRs apply to each AMI Function found in Table 3.3.11-1.

SR 3.3.11.1

Performance of the CHANNEL CHECK for each required instrument CHANNEL that is normally energized once every 31 days ensures that a gross failure of instrumentation has not occurred. A CHANNEL CHECK is a comparison of the parameter indicated on one CHANNEL to a similar parameter on other CHANNELS.

RAI 38-7878 - Question 07.05-01

3 APPLICABLE CODES AND REGULATIONS

This section describes the compliance of the safety I&C system with the applicable codes and regulations. The system's compliance with IEEE Std. 603-1991, IEEE Std. 7-4.3.2-2003, NRC Interim Staff Guidance (ISG) DI&C-ISG-04, "Highly-Integrated Control Rooms – Communications Issues" (Reference 4), and alternative to independence requirements of IEEE Std. 603-1991 are addressed in Appendices A, B, C, and D of this report, respectively.

3.1 10 CFR Part 50 and 52

a. 10 CFR 50.34(f)(2)(v), "Bypass and Inoperable Status Indication"

The indications of bypasses and inoperable status of the safety I&C system are available on the operator module (OM), maintenance and test panel (MTP), qualified indication and alarm system - non-safety (QIAS-N) and information processing system (IPS) displays.

See compliance with Regulatory Guide (RG) 1.47 in Section 3.4.3.

b. 10 CFR 50.34(f)(2)(xii), "Auxiliary Feedwater System Automatic Initiation and Flow Indication"

The low steam generator (SG) water level trip signal initiates a reactor trip when the measured water level in a SG's downcomer region falls to a low preset value. Separate initiations are provided for the reactor protection system (RPS) and auxiliary feedwater actuation system (AFAS) to allow different setpoints for reactor trips and auxiliary feedwater actuations.

The AFAS continues to deliver auxiliary feedwater to the SG until a preset water level has been reestablished. Manual actuation is provided to permit the operator to actuate the AFAS.

Auxiliary feedwater flow rate is displayed on the QIAS-N, IPS, and diverse indication system (DIS).

c. 10 CFR 50.34(f)(2)(xiv), "Containment Isolation Systems"

The containment isolation actuation system (CIAS) is provided to mitigate the release of radioactive material during an accident by actuating the containment isolation valves (CIVs) which close the process lines penetrating the containment.

d. 10 CFR 50.34(f)(2)(xi), "Direct Indication of Relief and Safety Valve Position"
10 CFR 50.34(f)(2)(xvii), "Instrumentation to Measure, Record and Readout in the Control Room"
10 CFR 50.34(f)(2)(xviii), "Unambiguous Indication of Inadequate Core Cooling"
10 CFR 50.34(f)(2)(xix), "Instrumentation for Monitoring Plant Conditions Following an Accident"
A, 10 CFR 50.34(f)(2)(xx), "Power Supplies for Pressurizer Relief Valves, Block Valves, and Level Indicators"

Types B and C accident monitoring instrumentation are displayed on the QIAS-P, QIAS-N, and IPS. The QIAS-N displays selected variables of Types D and E to support plant safe shutdown and Emergency Operating Procedure (EOP). All variables of Types D and E are displayed on the IPS.

e. 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants"

The safety I&C system is installed in a mild environment and therefore this criterion is not applicable. This criterion is applicable to instrumentation that interfaces to this system.

f. 10 CFR 50.55a(a)(1), "Quality Standards"

RAI 38-7878 - Question 07.05-01

b. GDC 2, “Design Bases for Protection Against Natural Phenomena”

The safety I&C system is designated as seismic Category I. The safety I&C system is installed in the I&C equipment rooms or main control room (MCR) that provide protection against other natural phenomena, such as wind, tornado, and flood.

c. GDC 4, “Environmental and Dynamic Effects Design Bases”

The safety I&C system is located in mild environments (MCR, I&C equipment rooms or mux rooms). The MCR, I&C equipment rooms, and mux rooms are designed to withstand the dynamic effects of missiles, pipe whipping or discharging fluids.

d. GDC 10, “Reactor Design”

The safety I&C system contributes to reactor design margin by providing conservatism in setpoint calculations and fault-tolerant features. Uncertainty methodology is described in the Uncertainty Methodology and Application for Instrumentation TeR (Reference 7) and setpoint methodology is described in the Setpoint Methodology for Plant Protection System TeR (Reference 8) and the CPC Setpoint Analysis Methodology for APR1400 (Reference 9).

e. GDC 13, “Instrumentation and Control”

The PPS consists of the RPS and the engineered safety features actuation system (ESFAS). The RPS is designed to monitor nuclear steam supply system (NSSS) operating conditions and to initiate reliable and rapid reactor shutdown if monitored variables or combinations of monitored variables deviate from the permissible operating range to a degree where a safety limit may be reached. The ESFAS is designed to monitor plant variables and to actuate engineered safety features (ESF) systems during a DBE.

The ESF-CCS performs the ESF actuation functions and executes component control through interfacing ESFAS portion of the PPS. It performs 2-out-of-4 voting logic for four division ESFAS initiation signals derived from the PPS and component control logic of ESF components.

The CPCS generates low departure from nucleate boiling ratio (DNBR) and high local power density (LPD) trip signals and sends them to the PPS.

A,

The QIAS-P provides a continuous display of Type B and C accident monitoring variables.

f. GDC 15, “Reactor Coolant System Design”

The PPS functions to mitigate the consequences in the event of an accident. Safety analyses show that the design limits for the reactor coolant pressure boundary are not exceeded in the event of any conditions stated in ANSI/ANS 51.1-1983, “Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants”.

g. GDC 16, “Containment Design”

The PPS functions to mitigate the release of radioactive materials during an accident by actuating the CIVs which close the process lines penetrating the containment.

The PPS functions to actuate the containment spray actuation system (CSAS) which removes heat from the containment atmosphere. The heat removal process results in reduction of containment temperature and pressure below the design values during and following an accident.

h. GDC 19, “Control Room”

The MCR safety console (SC) is equipped with hardwired minimum inventory (MI) switches including manual reactor trip switches and manual ESF system-level actuation switches, and OMs shared by the PPS, CPCS, and ESF-CCS. The MCR also has operator consoles and large display panel (LDP).

RAI 38-7878 - Question 07.05-01

The safety I&C system is designed to assure both the reactor safety and prevention of a spurious reactor trip. Safety is assured by design meeting the requirements of IEEE Std. 603-1991. The prevention of a spurious trip due to a single failure is assured by 2-out-of-3 voting logic in conjunction with a channel bypass function designed complying with the guidance of IEEE Std. 379-2000.

3.4.5 Regulatory Guide 1.62, "Manual Initiation of Protection Action", Rev. 1

Compliance with RG 1.62 is as follows:

a. Each of the RPS and ESFAS functions can be manually actuated.

b. Manual initiation of a protective action is provided at the system-level.

c. Manual switches are located on the MCR SC and RTSS. The reactor trip signal and main steam isolation signal (MSIS) are manually actuated at the remote shutdown console (RSC).

d. The amount of equipment common to the manual and automatic initiation paths is kept to a minimum, that is usually limited to the actuation devices. No single credible failure in the manual, automatic, or common portions of the protective system prevents initiation of a protective action by manual or automatic means.

e. Manual initiation requires a minimum of equipment consistent with the needs of a, b, c, and d above.

3.4.6 Regulatory Guide 1.75, "Criteria for Independence of Electrical Safety Systems", Rev. 3 - endorses IEEE Std. 384-1992

The instrumentation for the safety-related electrical systems complies with the guidance of IEEE Std. 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits", as endorsed by RG 1.75.

The PPS and ESF-CCS is divided into four divisions which are physically located in different geographic fire zones in order to provide the physical separation and electrical independence.

The independence and separation of redundant Class 1E circuits within and between the PPS divisions or ESF-CCS divisions are accomplished primarily through the use of fiber optic technology and barriers or conduits. The optical technology ensures that no single credible electrical fault in the PPS or ESF-CCS division can prevent the circuitry in any other redundant division from performing its safety function.

The ESF-CCS cabinets provide separation and independence for the 2-out-of-4 actuation and component control logic of the redundant ESF system divisions. The component control logic of each division is contained in a separate cabinet. The redundant cabinets are physically separated from each other by locating them in separated zones.

The analog and digital signals of the protection system sent to non-Class 1E systems for status monitoring, alarm and display (e.g., IPS, QIAS-N) are isolated. Fiber optic isolation and other techniques are used to ensure no credible failures on the non-Class 1E side of the isolation device will affect the Class 1E side and that independence of the protection system is not jeopardized.

3.4.7 Regulatory Guide 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants," Rev. 4 - endorses IEEE Std. 497-2002

A,

The QIAS-P processes and displays Types B and C variables. ~~There are no Type A variables.~~ Selection of these variables complies with the guidance identified in Clause 4.0 of IEEE Std. 497-2002, "IEEE

To be revised as shown on the next page.

Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations", as endorsed by RG 1.97 Rev.4. The QIAS-N also processes and displays variables for Types B and C. The QIAS-N displays selected variables of Types D and E to support plant safe shutdown and EOPs.

A deviation is taken to Clause 9, Quality Assurance, of IEEE Std. 497-2002 which requires all Types B and C variables to meet the requirements of IEEE Std. 7-4.3.2. IEEE Std. 7-4.3.2 requires software V&V for the systems developed to comply with IEEE Std. 7-4.3.2 to meet IEEE Std. 1012 V&V requirements for the highest integrity level (level 4). So the software for Types B and C variables should be qualified as safety-critical class which is defined as the highest software class in the Software Program Manual (SPM) TeR (Reference 10) and meet the IEEE Std. 1012 V&V requirements for the highest integrity level. However, the software for those variables is classified as important-to-safety (ITS) class. The deviation is justified in the SPM TeR.

3.4.8 Regulatory Guide 1.100, "Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants," Rev. 3 – endorses IEEE Std. 344-2004 (Reaffirmed 2009)

The safety I&C system is designated as seismic Category I to withstand the cumulative effects of five 1/2 safe shutdown earthquakes (SSEs) followed by one SSE without loss of safety functions or physical integrity.

3.4.9 Regulatory Guide 1.105, "Setpoints for Safety-Related Instrumentation", Rev. 3 - endorses Part 1 of ISA-S67.04-1994

The generation of safety system setpoints complies with ISA-S67.04-1994, "Setpoints for Nuclear Safety Related Instrumentation Used in Nuclear Power Plants".

The environment considered when determining errors is the most detrimental realistic environment calculated or postulated to exist until the worst case time of the required reactor trip or ESF system actuation. This environment may be different for different events analyzed. For the setpoint calculation, the accident environment error calculation for process equipment uses the environmental conditions up to the longest required time of trip or actuation that results in the largest errors, thus providing additional conservatism to the resulting setpoints.

For all temperature and pressure setpoints, the trip is initiated at a point that is not at saturation for the equipment. For level setpoints, no analysis setpoint is within 5% of the ends of the level span.

The uncertainty and setpoint methodologies are described in the Uncertainty Methodology and Application for Instrumentation TeR and Setpoint Methodology for Plant Protection System TeR, respectively.

3.4.10 Regulatory Guide 1.118, "Periodic Testing of Electric Power and Protection Systems", Rev. 3 - endorses IEEE Std. 338-1987

The safety I&C system is designed so that they can be periodically tested as prescribed by the criteria of IEEE Std. 338-1987, "IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems", as endorsed by RG 1.118.

The system is periodically and routinely tested to verify its operability. A complete division is tested without causing a reactor trip or ESF system actuation, and without affecting system operability or availability. Overlap in the RPS and ESFAS division tests is provided to assure that the entire division is functional. The testing scheme is described in Section 4.2.2.

RAI 38-7878 - Question 07.05-01

RAI 38-7878 - Question 07.05-01_Rev.1

QIAS-P software for Types A, B, and C variables is assigned to important-to-safety (ITS) class defined in the Software Program Manual (SPM) TeR (Reference 10), and meets the requirements of IEEE Std. 7-4.3.2-~~1993~~ 2003 and ASME NQA-1-~~2001~~ 2008 with 2009 addenda which are specified in Clause 9, Quality Assurance, of IEEE Std. 497-2002.

system via SDN, APC-S via hardwired interface, and process instrumentation directly. The safety FPDs for the QIAS-P are installed on the MCR SC.

A,

The QIAS-P transmits data to the QIAS-P safety FPD via the SDN for RG 1.97, Rev. 4, Types B and C variables.

The QIAS-P also transmits the sensor signals and their calculated variables to the IPS and QIAS-N through the MTP and ITP, respectively. In the case of the IPS, this data communication is a unidirectional protocol from the MTP. In the case of the ITP, the SDL data communication is used to transmit data to the QIAS-N.

4.1.1.5 Auxiliary Process Cabinet - Safety

The APC-S consists of four redundant channels designated as Class 1E. It receives safety-related sensor signals and distributes them to the PPS, CPCS, ESF-CCS, QIAS-P, and DIS via hardwired interfaces.

It includes signal conditioning/splitting equipment and the associated power supplies for sensor input. Qualified isolation devices are provided within the APC-S to interface safety signals to the non-safety systems.

There are no programmable digital devices in the APC-S.

4.1.1.6 Ex-core Neutron Flux Monitoring System

The ENFMS provides a means to measure reactor power level by monitoring the neutron flux leakage from the reactor vessel for reactor control, protection and information display.

The ENFMS consists of four redundant safety channels.

4.1.1.7 Component Interface Module

The CIM is a hardware based safety module for ESF component control (i.e., there is no software). The CIM is implemented using simple hardware-based non-digital technology, so that there is no potential for a software design defect that could result in a CCF of the CIM. The CIM receives component control signals from the ESF-CCS, DPS, DMA switches, and front panel control switch. The CIM prioritizes between input signals according to prioritization and transmits an output signal to the plant component according to the priority mode.

4.1.1.8 Reactor Trip Switchgear System

The RTSS consists of four divisions. The RTSS is designed as Class 1E. The RTSS receives the reactor trip signals from the PPS, manual reactor trip switches, and the DPS through hardwired cables. The PPS interfaces with the undervoltage trip device of RTSS breakers. The DPS interfaces with the shunt trip device of the RTSS breakers. The RTSS disconnects the power to the DRCS for dropping CEAs into the reactor core by RPS signals from the PPS or manual reactor trip signals from the MCR or RSR.

4.1.2 Non-safety Control and Monitoring System

4.1.2.1 Power Control System

The PCS integrates control systems that are designed to control the reactor power level, which includes the RRS, RPCS and DRCS.

The RRS/RPCS logic and DRCS cabinets include the redundant DCS controllers with associated input and output (I/O).

The PCS is distributed to separate controller groups to ensure that a single failure does not cause plant conditions more severe than those considered in the safety analysis.

4.1.2.2 NSSS Process Control System

The NPCS consists of the pressurizer pressure control system (PPCS), pressurizer level control system (PLCS), feedwater control system (FWCS), steam bypass control system (SBCS), boron dilution alarm system, and single control loops of the chemical and volume control system (CVCS).

The NPCS is implemented as a part of the P-CCS.

The NPCS is distributed to separate controller groups to ensure that a single failure does not cause plant conditions more severe than those considered in the safety analysis.

4.1.2.3 Process - Component Control System

The P-CCS is designed to control non-safety components such as pumps, valves, heaters, and fans. The P-CCS performs data acquisition from field instruments and discrete/continuous controls, and provides process variables and their status information to the IPS and QIAS-N for plant monitoring.

Standardized component control logic and I/O interfaces are provided for the various types of components to be controlled. Manual operator controls for the P-CCS are performed through the soft control display on the IFPD driven by the IPS.

The P-CCS is distributed to separate controller groups to ensure that a single failure does not cause plant conditions more severe than those considered in the safety analysis.

4.1.2.4 Fixed In-core Detector Amplifier System

The fixed in-core detector amplifier system (FIDAS) monitors the fixed in-core neutron detector current signals, performs the necessary signal conversion to engineering unit values and transmits them to the IPS. The IPS uses these signals for the core operating limit supervisory system (COLSS) to estimate the gross power distribution and thermal margin in the core, and fuel burn-up in each fuel assembly.

Neutron flux in the reactor core is measured by the fixed in-core neutron detectors. Detectors are spaced radially and axially to permit representative flux mapping of the entire core.

4.1.2.5 Qualified Indication and Alarm System - Non-safety

A,

The QIAS-N is a single division indication and alarm system that supports alternative plant operation if the IPS is unavailable. It provides the information required for EOP execution, safe shutdown, and important human actions under unavailable conditions of the operator consoles. The QIAS-N also provides a display of all RG 1.97, Rev.4, Types B and C variables. The QIAS-N displays selected variables of RG 1.97, Rev. 4, Types D and E variables to support the performing plant safe shutdown and EOPs.

The QIAS-N receives divisionalized information from the four safety divisions via their ITPs for safety variables and from the QIAS-N MTP for non-safety variables.

The QIAS-N is implemented on the common PLC platform for as the safety system. The QIAS-N HSI is provided by the FPDs on the SC.

4.5 Qualified Indication and Alarm System – P

4.5.1 Functions

A, A,

The QIAS-P provides a continuous display of RG1.97, Rev. 4 AMI variables (Types B and C) and an unambiguous indication of the approach to and the recovery from ICC as a backup to the safety parameter display system (SPDS). The recording function for Type B and C variables is performed in the IPS.

The QIAS-P calculates representative core exit temperature, primary coolant ~~saturation margins~~ subcooling margins, and reactor vessel ~~coolant~~ water level.

The QIAS-P provides output signals to the QIAS-P display via the SDN, to the MTP for the IPS (via unidirectional Ethernet datalink), and to the ITP for the QIAS-N (via the SDL). In all cases, these output signals are for display of sensor signals, ICC variables, and AMI variables.

The QIAS-P provides a backup for the SPDS for ICC variables. The SPDS is implemented in the SPADES+ application in the IPS.

Upon receipt of the analog and digital signals, the QIAS-P performs signal checking. The QIAS-P displays are a major part of the overall MCR information system used for accident monitoring. The QIAS-P configuration is presented in Figure 4-17.

4.5.2 Design Features

The QIAS-P has two divisionalized cabinets. The QIAS-P cabinet for each division is located in the divisionalized I&C equipment room. The QIAS-P receives AMI variables from the PPS and ESF-CCS via the SDN; and APC-S and process instrumentation via hard-wired connection. The QIAS-P also displays the status of CIVs from both QIAS-P divisions. The status of the other QIAS-P division CIVs are obtained from the ITP through the interdivisional SDL.

4.5.2.1 Calculation

A,

The QIAS-P processes the AMI variables (Types B and C) as determined from RG 1.97, Rev.4, for accident monitoring guidelines.

The QIAS-P calculates representative core exit temperature from the core exit thermocouples (CETs). The QIAS-P calculates primary coolant ~~saturation margins~~ subcooling margins based on CET temperatures, hot and cold leg temperatures, heated junction thermocouple (HJTC) temperatures from the reactor vessel head region, and pressurizer pressure. The QIAS-P calculates reactor vessel ~~coolant water~~ level from the top of the core to the top of the reactor vessel (based on the signals from the HJTCs). The HJTCs are discrete level measurements throughout the height of the reactor vessel. Liquid uncovery of an HJTC is determined by the temperature difference between the heated and unheated thermocouple pair at a specific height location in the reactor vessel.

subcooling margin

RAI 38-7878 - Question 07.05-01_Rev.1

- Low upper head pressure ~~saturation margin~~ (IPS only)
- Low RCS temperature ~~saturation margin~~ (IPS only)
- Low RCS pressure ~~saturation margin~~ (IPS only)
- Low CET temperature ~~saturation margin~~
- Low CET pressure ~~saturation margin~~ (IPS only)
- Low RCS /upper head temperature ~~saturation margin~~
- Low RCS /upper head pressure ~~saturation margin~~ (IPS only)
- High representative CET temperature

RV

4.5.2.6 Redundancy

A, A,

The QIAS-P consists of the redundant safety divisions A and B for signal processing and displays. Redundancy is provided for both the instrument divisions supplying the signal and the displays in the MCR. Instrument channels are electrically independent and physically separated from non-safety equipment by qualified isolation devices. The QIAS-P cabinets are located in separated I&C equipment rooms. Credited redundancy for the display of RG 1.97, Rev. 4, Type B and C variables is provided by the QIAS-P divisions. Type B and C variables are also displayed on the QIAS-N and IPS.

To prevent ambiguity of the information presented to the operator, additional sensors or diverse variables are used to ensure that the information presented to the operator is correct as described in Table 7.5-1 of the DCD.

A,

The QIAS-P monitors two redundant AMI instrument channels (A and B) for each RG1.97, Rev. 4 Type B and C process parameters. For CIVs, the QIAS-P displays all divisions on each QIAS-P display.

4.5.3 System Interfaces

The QIAS-P cabinet interfaces with the following systems and equipment:

- Process instrumentation
- Auxiliary process cabinet - safety
- HJTC (HJTC temperatures)
- In-core instrumentation system (CET temperatures)
- DIS
- ESF-CCS
- PPS
- ~~CPCS~~
- MTP (then to IPS),

TS

Table 4-2 Summary of QIAS-P I/O Signals

The response time is verified by measurement during plant startup testing. Sensor responses are measured during factory or laboratory testing and provided to the site operator for use in the test program.

A.5.8 Information Display

Clause 5.8.1 Displays for Manually Controlled Actions

"The display instrumentation provided for manually controlled actions for which no automatic control is provided and that are required for the safety systems to accomplish their safety functions shall be part of the safety systems and shall meet the requirements of IEEE Std. 497-1981. The design shall minimize the possibility of ambiguous indications that could be confusing to the operator."

A,

Analysis:

The QIAS-P provides a continuous and dedicated display of RG 1.97, Rev.4, Types B and C variables including the ICC monitoring variables.

A,

The QIAS-N processes and displays variables for Type B and C. The QIAS-N also displays selected variables of Type D and E to support performing plant safe shutdown and EOPs.

A,

The IFPD presents the displays for all variables for Type B, C, D and E, and provides recording function for Type B and C variables.

A,

Clause 5.8.2: System Status Indication

"Display instrumentation shall provide accurate, complete, and timely information pertinent to safety system status. This information shall include indication and identification of protective actions of the sense and command features and execute features. The design shall minimize the possibility of ambiguous indications that could be confusing to the operator. The display instrumentation provided for safety system status indication need not be part of the safety systems."

Analysis:

System status indication is provided for all protective actions at the OM, IPS and MTP, including identification of division trips.

Clause 5.8.3: Indication of Bypasses

"If the protective actions of some part of a safety system have been bypassed or deliberately rendered inoperative for any purpose other than an operating bypass, continued indication of this fact for each affected safety group shall be provided in the control room."

Analysis:

The operating bypass and trip channel bypass status is available for display at the IPS display and OM in the MCR, and MTP in the I&C equipment room.

"5.8.3.1 This display instrumentation need not be part of the safety systems."

Analysis:

Although the requirement does not mandate the displays be safety-related in the MCR, the OMs, which are part of the safety system, do display this information in the MCR. In addition, the status information is provided to the non-safety IPS for display in the MCR.

TS

3.5.2 Situation Awareness

TS