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.:	**295-8263**
SRP Section:	**16 – Technical Specifications**
Application Section:	**16.3.3**
Date of RAI Issue:	**11/05/2015**

Question No. 16-123

The applicant is requested to revise generic TS 3.3.11, “Accident Monitoring Instrumentation (AMI),” and Bases to conform to RG 1.97, “Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants,” Revision 4.

1. The applicant is requested to identify all operator manual actions relied upon or otherwise assumed to occur by the DCD Tier 2 Chapter 15 safety analyses, including

   a Termination of the limiting boron dilution event in Mode 4; and

   b Termination of auxiliary feedwater flow to a faulted steam generator during secondary side events in Mode 1, 2, or 3, such as

   - A steam generator tube rupture,
   - An unisolatable main feedwater line break,
   - An unisolatable steam generator blowdown line break,
   - An unisolatable main steam line break, and
   - A stuck open main steam safety valve.

   Any control room indication of a process parameter or other variable needed by the operator, as directed by the emergency operating procedure or the emergency procedure guidlines for the APR1400, to accomplish a “planned manually-controlled action for which no automatic control is privided,” (IEEE Std 497-2002, Section 4.1; RG 1.97, Rev. 4, Section C) should be identified as a Type A post accident monitoring (PAM) system variable in DCD Tier 2 Section 7.5.1.1, Table 7.5-1, “AMI Variables,” and should be included in generic TS Table 3.3.11-1 as an AMI Function. The NRC staff is

not persuaded of the validity of the statement in DCD Section 7.5.1.1 that “There are no AMI Type A variables in APR1400 design.”

2. The applicant is requested to conform generic TS 3.3.11 and associated Bases to the list of PAM variables or functions described in DCD Tier 2 Section 7.5.1.1, and Table 7.5-1.

3. The applicant is requested to descibe the process used to determine the list of AMI variables listed in DCD Tier 2 Table 7.5-1, and what type (B, C, D, or E) each variable is.

4. Please explain what is meant by the column heading “Ambiguity” in last column of Table 7.5-1

5. The Bases for generic TS 3.3.11 often uses the word “channel” in all capital letters by itself. The applicant is requested to make this word all lower case because “CHANNEL” is not a defined term in TS Section 1.1.

Response

1. KHNP’s response to request for additional information (RAI) 294-8302, Question 07.05-6 provides the manual actions for the accident analyses and the basis for the Accident Monitoring Instrumentation (AMI) Type A selection.

2. Table 3.3.11-1 of NUREG-1432, “Standard Technical Specifications-Combustion Engineering Plants,” Rev. 4, provides the following description:

   ----------REVIEWER'S NOTE----------
   Table 3.3.11-1 shall be amended for each unit as necessary to list:
   1. All Regulatory Guide 1.97, Type A instruments and
   2. All Regulatory Guide 1.97, Category I, non-Type A instruments specified in the unit's Regulatory Guide 1.97, Safety Evaluation Report.

   Also, Bases section 3.3.11 of NUREG-1432, “Standard Technical Specifications-Combustion Engineering Plants,” Rev. 4, provides the following description:

   The PAM instrumentation ensures the OPERABILITY of Regulatory SAFETY Guide 1.97 Type A variables, so that the control room operating staff ANALYSES can:

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

   - *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.*

   The PAM instrumentation also ensures OPERABILITY of Category I, non-Type A variables. This ensures the control room operating staff can:

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

The above Bases indicates AMI Type A, B, C variables.

Therefore, Table 7.5-1 lists all AMI variables. Subsequently, Technical Specification Table 3.3.11-1 and the associated Bases will list the AMI Type A, B, C variables.

Technical Specification Table 3.3.11-1 and the associated Bases will be revised to add the Type A variables as indicated in the attachment to RAI 38-7878, Question 07.05-1.

3. KHNP's response to RAI 294-8302, Question 07.05-6 and RAI 38-7878, Question 07.05-1 provides the process used to determine the list of AMI variables listed in DCD Tier 2 Table 7.5-1 and what type (A, B, C, D or E) each variable is.
4. The column whose heading is titled as "Ambiguity" in Table 7.5-1 identifies the additional variables provided for operators to resolve information ambiguity. Refer to DCD Tier 2, Section 7.5.2.1, a.5 for additional information)
5. "CHANNEL" is revised to "channel" as indicated in the attachment associated with this response.

Impact on DCD

Same as changes described in Impact on Technical Specifications section.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

Technical Specification 3.3.11 and Bases 3.3.11 are revised as indicated in the attachment to this response.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

ACTIONS (continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
E. As required by Required Action D.1 and referenced in Table 3.3.11-1.	E.1 Be in MODE 3. AND E.2 Be in MODE 4.	6 hours 12 hours
F. As required by Required Action D.1 and referenced in Table 3.3.11-1.	F.1 Initiate action in accordance with Specification 5.6.5.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.3.11.1	Perform CHANNEL CHECK for each required measurement ~~CHANNEL~~ that is normally energized.	31 days
SR 3.3.11.2	---------- NOTE ---------- Neutron detectors are excluded from CHANNEL CALIBRATION. ---------- Perform CHANNEL CALIBRATION.	18 months

channel

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

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
20. Pressurizer Pressure (Wide Range)	2	E
21. IRWST Level	4	E
22. IRWST Temperature	4	E
23. Containment Level	2	E
24. Control Rod Position	1/rod	E
25. Containment Operating Area Radiation	2	E
26. Spent Fuel Pool Radiation	2	E

channel

(c) A measurement ~~CHANNEL~~ consists of four 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).

channels

BASES

APPLICABLE SAFETY ANALYSIS (continued)

Two measurement ~~CHANNELS~~ provide the necessary information in the MCR for adequate accident monitoring. The ~~CHANNELS~~ provide wide-range information which meets the electrical and physical separation requirements for each parameter displayed. This design is consistent with the requirements of IEEE Std. 603-1991 (Reference 4). The ~~CHANNELS~~ are provided with equipment qualified to operate in the environments specified for design basis events. These ~~CHANNELS~~ comply with the recommendations of NRC RG 1.97.

LCO

LCO 3.3.11 requires two OPERABLE ~~MEASUREMENT CHANNELS~~ for all but one Function to ensure no single failure prevents the operators from being presented with the information necessary to determine the status of the plant and to bring the plant to, and maintain it in, a safe condition following that accident.

measurement channels

Furthermore, provision of two ~~CHANNELS~~ allows a CHANNEL CHECK during the post-accident phase to confirm the validity of displayed information.

More than two channels could be required at some plants if the NRC RG 1.97 analysis determined that failure of one accident monitoring channel results in information ambiguity (that is, the redundant display disagree) that could lead operator to defeat or to fail to accomplish a required safety function.

The exception to the two ~~CHANNEL~~ requirement is the Containment Isolation Valve Position. In this case, the important information is the status of the containment penetrations. The LCO requires one position indicator for each active containment isolation valve. This is sufficient to redundantly verify the isolation status of each isolable penetration either via indicated status of the active valve and prior knowledge of passive valve or via system boundary status. If a normally active containment isolation valve is known to be closed and deactivated, position indication is not needed to determine status. Therefore, the position indication for valves in this state is not required to be OPERABLE.

channel

BASES

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~~ $\times 10^{-8}$ to 200 % power.

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

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.

channels

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 %.

channels

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)

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).

channels

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 ^{o}C [32 to 752 °F]), and Core Exit Temperatures (Minimum Sensor Range of 0 to 1,260.0 ^{o}C [32 to 2,300 °F]). The degree of subcooling indicated range is a minimum of 93.3 ^{o}C (200 °F) subcooling to 1.7 ^{o}C (35 °F) superheat.

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).

BASES

LCO (continued)

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~~.

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~~.

channels

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.

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

BASES

LCO (continued)

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.

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.

channels

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.

channel

BASES

LCO (continued)

In the case of Containment Isolation Valve Position, the important information is the status of the containment penetrations. The LCO requires one position indicator for each active containment isolation valve. This is sufficient to redundantly verify the isolation status of each isolable penetration either via indicated status of the active valve and prior knowledge of passive valve or system boundary status. If a normally active containment isolation valve is known to be closed and deactivated, position indication is not needed to determine status. Therefore, the position indication for valves in this state is not required to be OPERABLE.

APPLICABILITY

The AMI LCO is applicable in MODES 1, 2, and 3. These variables are related to the diagnosis and preplanned actions required to mitigate DBAs. The applicable DBAs are assumed to occur in MODES 1, 2, and 3. In MODES 4, 5, and 6, plant conditions are such that the likelihood of an event occurring that would require AMI is low; therefore, the AMI is not required to be OPERABLE in these MODES.

ACTIONS

Note 1 has been added in the ACTIONS to exclude the MODE change restriction of LCO 3.0.4. This exception allows entry into the applicable MODE while relying on the ACTIONS, even though the ACTIONS may eventually require plant shutdown. This exception is acceptable due to the passive function of the instruments, the operator's ability to monitor an accident using alternate instruments and methods, and the low probability of an event requiring these instruments.

Note 2 has been added in the ACTIONS to clarify the application of Completion Time rules. The Condition of this Specification may be entered independently for each Function listed in Table 3.3.11-1. The Completion Time(s) of the inoperable ~~CHANNEL~~(s) of a Function will be tracked separately for each Function starting from the time the Condition was entered for that Function.

A.1

channel

When one or more Functions have one required ~~MEASUREMENT CHANNEL~~ that is inoperable, the required inoperable ~~CHANNEL~~ must be restored to OPERABLE status within 31 days. The 31-day Completion Time is based on operating experience and takes into account the remaining OPERABLE ~~MEASUREMENT CHANNEL~~ (or in the case of a Function that has only one required

measurement channel

BASES

ACTIONS (continued)

~~MEASUREMENT CHANNEL~~, other non NRC RG 1.97 instrument ~~MEASUREMENT CHANNELS~~ to monitor the Function), the passive nature of the instrument (no critical automatic action is assumed to occur from these instruments), and the low probability of an event requiring AMI during this interval.

B.1

This Required Action specifies initiation of actions in accordance with Specification 5.6.5, which requires a written report to be submitted to the NRC. This report discusses the results of the root cause evaluation of the inoperability and identifies proposed restorative Required Actions. This Required Action is appropriate in lieu of a shutdown requirement, given the likelihood of plant conditions that would require information provided by this instrumentation. Also, alternative Required Actions are identified before a loss of functional capability condition occurs.

C.1

When one or more Functions have two required measurement ~~CHANNELS~~ inoperable (i.e., two measurement ~~CHANNELS~~ inoperable in the same Function), one measurement ~~CHANNEL~~ in the Function should be restored to OPERABLE status within 7 days. The Completion Time of 7 days is based on the relatively low probability of an event requiring AMI operation and the availability of alternate means to obtain the required information. Continuous operation with two required ~~CHANNELS~~ inoperable in a Function is not acceptable because the alternate indications may not fully meet all performance qualification requirements applied to the AMI.

Therefore, requiring restoration of one inoperable ~~CHANNEL~~ of the Function limits the risk that the AMI Function will be in a degraded condition should an accident occur.

D.1

This Required Action directs entry into the appropriate Condition referenced in Table 3.3.11-1. The applicable Condition referenced in the table is Function dependent. Each time Required Action C.1 is not met and the associated Completion Time has expired, Condition D is entered for that ~~CHANNEL~~ and provides for transfer to the appropriate subsequent Condition.

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.

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

channel

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~~.

channels

BASES

SURVEILLANCE REQUIREMENTS (continued)

It is based on the assumption that instrument ~~CHANNELS~~ monitoring the same parameter should read approximately the same value. Significant deviations between the two instrument ~~CHANNELS~~ could be an indication of excessive instrument drift in one of the ~~CHANNELS.~~ A CHANNEL CHECK will detect gross ~~CHANNEL~~ failure. Thus, it is key to verifying the instrumentation continues to operate properly between each CHANNEL CALIBRATION.

Agreement criteria are determined by the plant staff based on a combination of the ~~CHANNEL~~ instrument uncertainties, including indication and readability. If a ~~CHANNEL~~ is outside the match criteria, it could be an indication that the sensor or the signal processing equipment has drifted outside its limit.

If the ~~CHANNELS~~ are within the match criteria, it is an indication that the ~~CHANNELS~~ are OPERABLE. If the ~~CHANNELS~~ are normally off scale during time when surveillance is required, the ~~MEASUREMENT~~ CHANNEL CHECK will only verify that they are off scale in the same direction. Off scale low current loop ~~CHANNELS~~ are verified to be reading at the bottom of the range and not failed downscale.

The Frequency of 31 days is based upon plant operating experience with regard to ~~CHANNEL~~ OPERABILITY and drift, which demonstrates that failure of more than one ~~CHANNEL~~ of given Function in any 31 day interval is a rare event. The ~~MEASUREMENT~~ CHANNEL CHECK supplements less formal, but more frequent, checks of ~~CHANNEL~~ OPERABILITY during normal operational use of the displays associated with this LCO's required ~~CHANNELS~~.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.3.11.2

A CHANNEL CALIBRATION is performed every 18 months. CHANNEL ~~CALIBRATION~~ is a complete check of the instrument ~~CHANNEL~~ including the sensor. The Surveillance verifies the ~~CHANNEL~~ responds to the measured parameter with the necessary range and accuracy.

channel

For the Containment Upper Operating Area Radiation instrumentation, a CHANNEL CALIBRATION may consist of an electronic calibration of the ~~CHANNEL~~, not including the detector, for range decades above 100 mSv/hr and one point calibration check of the detector below 100 mSv/hr with a gamma source.

The Frequency is based upon operating experience and consistency with the typical industry refueling cycle and is justified by the assumption of an 18-month calibration interval for the determination of the magnitude of equipment drift.

REFERENCES

1. DCD Tier 2, Chapter 7.
2. NRC RG 1.97, Rev.4, June 2006.
3. NUREG-0737, Supplement 1, January 1983.
4. IEEE Standard 603-1991.