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.:	**301-8280**
SRP Section:	**07.01 – Instrumentation and Controls-Introduction**
Application Section:	**7.1**
Date of RAI Issue:	**11/10/2015**

Question No. 07.01-41

The staff reviewed the response to RAI 34-7870, Question 7.1-1 and found that additional information was needed as described below.

10 CFR 50.36(c)(1)(ii)(A) states, in part, "Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded." Technical Report (TeR) APR1400-Z-J-NR-14005-P, Rev.0, "Setpoint Methodology for Plant Protection System," describes the setpoint methodology applied to the Plant Protection System (PPS) and Diverse Protection System (DPS) for the APR1400 and states conformance to BTP 7-12, Regulatory Guide 1.105 - Rev.3, and Regulatory Issue Summary (RIS) 2006-17.

For Question 7.1-1, the staff requested clarification regarding the relationships among the following items: analytical limit (AL), allowable value (AV), trip setpoint (TSP), and Draft TSP (DTSP). The applicant responded by proposing to update the TeR to correct an error in a reference to the DTSP and by stating "the AV is less conservative than the TSP by an offset which is greater than the PPS cabinet periodic test error." Since this response adequately clarified the observed inconsistency in the TeR's use of the terms AL, DTSP, TSP, AV, and PPS Cabinet Periodic Test Error, this portion of the request for clarification is resolved.

In Question 7.1-1, the staff also asked about the relationships among the DTSP, AV, and PPS Cabinet Periodic Test Error in light of the statement made in TeR APR1400-Z-J-NR-14005, Section 2.3.2.6, "PPS Cabinet Periodic Test Error for ARP1400 is not applicable since the [bistable?] processor module error and measurement test error are negligible." The applicant responded by stating that the "Periodic Test Error Band, as shown in Figure 1, is divided into individual periodic test acceptance criteria for the transmitter, APC-S, and PPS cabinet as described in Sections 2.3.2.2 and 2.3.3.5 of the TeR." Where in the TeR does the TeR describe that the periodic test error band depicted in Figure 1 consists of a transmitter periodic test error band, an APC-S periodic test error band, and a PPS cabinet periodic test error band? If this information is not explicitly provided in the TeR, then update the TeR with this new information and ensure the TeR clearly illustrates how these three error bands are combined in the DTSP calculation. The applicant also responded by stating that "When the PPS Cabinet Periodic Test Error is zero, the PPS Cabinet Periodic Test Error Band that is one of the Periodic Test Error Band[s] in Figure 1 will also be zero. Therefore, the upper limit of the PPS Cabinet Periodic Test Error Band is not equivalent to the AV since the AV has an enough margin by an offset from the TSP. However, the transmitter and APC-S Periodic Test Error Bands, which are not related to AV, are only used to ensure that the TSP does not exceed the AL." The staff does not understand this response. The staff originally requested clarification on the effect on the DTSP, AV, and TSP of having a PPS Cabinet Periodic Test Error Band with a value of zero, which is still an outstanding request.

Response

To clearly describe the periodic test error band and its relation with calculating the draft trip setpoint (DTSP) as well as the effect on the DTSP, AV, and TSP of having a PPS Cabinet Periodic Test Error Band with a value of zero, the last paragraph of Section 2.1, “Basic Description” of TeR APR1400-Z-J-NR-14005 will be revised to state the following:

> The total instrument channel uncertainty between the AL and the DTSP includes all uncertainty factors existing on the PPS channel which consists of the sensor, the APC-S, and the PPS cabinet. The total instrument channel uncertainty is generally determined by the algebraic summation of the termination and splicing effect, the static pressure effect, the reference leg error, the dynamic flow error, and the square-root-sum-of-squares (SRSS) combination of the reference accuracy, the drift, the temperature effect, the power supply effect, the radiation effect, the seismic effect, and the measurement test error. The detailed method to combine all uncertainty factors to calculate the total instrument channel uncertainty is described in Section 2.3.3 and Section III, “Measurement Channel Uncertainties” of each appendix. Only the PPS cabinet periodic test error, which is based on a monthly testing interval, is used to determine the AV since the surveillance test for the PPS cabinet is required during normal plant operation. However, the transmitter and the APC-S errors are each individually verified every refueling period to be within their respective calibration error bands and periodic test error bands.
>
> When the PPS cabinet periodic test error band has a value of zero, the DTSP is equal to the AV. When the PPS cabinet periodic test error band has a value of zero, the AV is most conservative due to the difference in value between the AL and the DTSP not being reduced by the value of the PPS cabinet periodic test error band to establish the AV. If the PPS cabinet periodic test error band is greater than zero, the AV will be less conservative than the DTSP by the value of the PPS cabinet periodic test error band, as shown in Figure 1.
>
> The final TSP is offset in a conservative direction from the calculated AV by approximately 0.5% of the channel span, which is sufficiently greater than the PPS cabinet periodic test error. This approach can reduce the possibility of a licensee event report being required when a periodic test result exceeds the AV.
>
> The calibration error band shown in Figure 1 is the as-left limit of a parameter. The

calibration error band represents the transmitter, the APC-S, or the PPS cabinet calibration error band. The transmitter, the APC-S, and the PPS cabinet errors after calibration are each individually verified to be within their respective calibration error bands. The calibration error band is determined by the SRSS combination of the reference accuracy, the power supply effect, and the measurement test error.

The periodic test error band shown in Figure 1 is the as-found limit of a parameter. The periodic test error band represents the transmitter, the APC-S, or the PPS cabinet periodic test error band. The transmitter, the APC-S, and the PPS cabinet errors before calibration are each individually verified to be within their respective periodic test error bands. The periodic test error band is determined by the SRSS combination of the reference accuracy, the drift, the temperature effect, the power supply effect, the radiation effect, and the measurement test error. The uncertainty factors to determine the band are selected from those used to determine the total instrument channel uncertainty.

For the sensors and the APC-S, the calibration error band and periodic test error band serve as error limits during a periodic test. If the instrument reading is within the calibration error band, no recalibration is necessary. If the instrument reading is outside the calibration error band, but within the periodic test error band, the channel segment is functioning as intended although recalibration is required. If the reading is outside of the periodic test error band, the source of the anomaly is to be investigated and the operability is also to be evaluated since the instrumentation is not behaving as expected.

For the PPS cabinet, if the instrument reading is within the calibration error band, no recalibration is necessary. If the instrument reading is outside the calibration error band, but within the periodic test error band, the channel segment is functioning as intended although recalibration is required. If the reading is outside of the periodic test error band but is conservative with respect to the AV, the source of the anomaly and the possibility of exceeding the AV are to be investigated since the instrumentation is not behaving as expected. Only a violation of the AV is a reportable incident.

When the periodic test error band or the AV is exceeded, an appropriate action contains adjustment of testing frequency, setpoint revision in the conservative direction, reevaluation of the trip setpoint or acceptance criterion, evaluation of equipment installation and environment, evaluation of calibration, repair or replacement of the device, or procedure change to implement supplemental action.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-Z-J-NR-14005-P/NP, Rev.0 will be revised as indicated in the attachment associated with this response.

2 SETPOINT METHODOLOGY

2.1 Basic Description

The PPS consists of the reactor protection system (RPS) and the engineered safety features actuation system (ESFAS).

The 13 reactor trip functions of RPS are as follows: high pressurizer pressure, low pressurizer pressure, low steam generator #1 level, low steam generator #2 level, high steam generator #1 level, high steam generator #2 level, low steam generator #1 pressure, low steam generator #2 pressure, high containment pressure, high variable overpower, high logarithmic power level, low reactor coolant flow–1, and low reactor coolant flow-2.

The 6 ESFAS signals are as follows: safety injection actuation signal (SIAS), containment isolation actuation signal (CIAS), containment spray actuation signal (CSAS), main steam isolation signal (MSIS), auxiliary feedwater actuation signal-1 (AFAS-1), and auxiliary feedwater actuation signal-2 (AFAS-2).

The DPS functions consist of the reactor-trip function and the engineered safety features (ESF) actuation function. The DPS logic uses 2 reactor-trip functions (high pressurizer pressure, and high containment pressure) and 3 ESF actuation functions (AFAS-1, AFAS-2, and SIAS).

Protective action is initiated when a process value exceeds a predetermined setpoint value, which is the trip setpoint (TSP). This TSP is established such that during design basis events (DBEs) the analytical limit (AL) is not exceeded. ALs are established such that safety limits (SLs) are not reached. SLs assure that unacceptable consequences do not occur during the DBE.

The relationship between nuclear safety-related setpoints is illustrated in Figure 1.

The draft trip setpoint (DTSP) is a more conservative value than the AL by the amount of the total instrument channel uncertainty. The DTSP is synonymous with “limiting trip setpoint” as used in Reference 4.6. This uncertainty is the combination of all identified uncertainty elements. The allowable value (AV) is less conservative than the TSP by the amount of the PPS cabinet periodic test error. This uncertainty, already included conservatively in the TSP, accommodates the expected measurable equipment drift that could occur in a specified calibration interval. The final TSP is a more conservative value than the AV by the offset that is determined as a greater value than the PPS cabinet periodic test error to reduce the possibility of a licensee event report. The final TSP is synonymous with “nominal trip setpoint” as used in Reference 4.6.

The calibration error band serves as an error limit during a periodic test. If the instrument reading is within this tolerance band, no recalibration is necessary. If the instrument reading is outside the calibration error band, but within the periodic test error band, the channel segment is functioning as intended although recalibration is required. If the reading is outside of the periodic test error band, the instrumentation is not behaving as expected. The source of anomaly and the possibility of exceeding the AV should be investigated. Only the violation of the AV is a reportable incident.

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The total instrument channel uncertainty between the AL and the DTSP includes all uncertainty factors existing on the PPS channel which consists of the sensor, the APC-S, and the PPS cabinet. The total instrument channel uncertainty is generally determined by the algebraic summation of the termination and splicing effect, the static pressure effect, the reference leg error, the dynamic flow error, and the square-root-sum-of-squares (SRSS) combination of the reference accuracy, the drift, the temperature effect, the power supply effect, the radiation effect, the seismic effect, and the measurement test error. The detailed method to combine all uncertainty factors to calculate the total instrument channel uncertainty is described in Section 2.3.3 and Section III, “Measurement Channel Uncertainties” of each appendix. Only the PPS cabinet periodic test error, which is based on a monthly testing interval, is used to determine the AV since the surveillance test for the PPS cabinet is required during normal plant operation. However, the transmitter and the APC-S errors are each individually verified every refueling period to be within their respective calibration error bands and periodic test error bands.

When the PPS cabinet periodic test error band has a value of zero, the DTSP is equal to the AV. When the PPS cabinet periodic test error band has a value of zero, the AV is most conservative due to the difference in value between the AL and the DTSP not being reduced by the value of the PPS cabinet periodic test error band to establish the AV. If the PPS cabinet periodic test error band is greater than zero, the AV will be less conservative than the DTSP by the value of the PPS cabinet periodic test error band, as shown in Figure 1.

The final TSP is offset in a conservative direction from the calculated AV by approximately 0.5% of the channel span, which is sufficiently greater than the PPS cabinet periodic test error. This approach can reduce the possibility of a licensee event report being required when a periodic test result exceeds the AV.

The calibration error band shown in Figure 1 is the as-left limit of a parameter. The calibration error band represents the transmitter, the APC-S, or the PPS cabinet calibration error band. The transmitter, the APC-S, and the PPS cabinet errors after calibration are each individually verified to be within their respective calibration error bands. The calibration error band is determined by the SRSS combination of the reference accuracy, the power supply effect, and the measurement test error.

The periodic test error band shown in Figure 1 is the as-found limit of a parameter. The periodic test error band represents the transmitter, the APC-S, or the PPS cabinet periodic test error band. The transmitter, the APC-S, and the PPS cabinet errors before calibration are each individually verified to be within their respective periodic test error bands. The periodic test error band is determined by the SRSS combination of the reference accuracy, the drift, the temperature effect, the power supply effect, the radiation effect, and the measurement test error. The uncertainty factors to determine the band are selected from those used to determine the total instrument channel uncertainty.

For the sensors and the APC-S, the calibration error band and periodic test error band serve as error limits during a periodic test. If the instrument reading is within the calibration error band, no recalibration is necessary. If the instrument reading is outside the calibration error band, but within the periodic test error band, the channel segment is functioning as intended although recalibration is required. If the reading is outside of the periodic test error band, the source of the anomaly is to be investigated and the operability is also to be evaluated since the instrumentation is not behaving as expected.

For the PPS cabinet, if the instrument reading is within the calibration error band, no recalibration is necessary. If the instrument reading is outside the calibration error band, but within the periodic test error band, the channel segment is functioning as intended although recalibration is required. If the reading is outside of the periodic test error band but is conservative with respect to the AV, the source of the anomaly and the possibility of exceeding the AV are to be investigated since the instrumentation is not behaving as expected. Only a violation of the AV is a reportable incident.

When the periodic test error band or the AV is exceeded, an appropriate action contains adjustment of testing frequency, setpoint revision in the conservative direction, reevaluation of the trip setpoint or acceptance criterion, evaluation of equipment installation and environment, evaluation of calibration, repair or replacement of the device, or procedure change to implement supplemental action.

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.:	**301-8280**
SRP Section:	**07.01 - Instrumentation and Controls - Introduction**
Application Section:	**7.1, 7.2, and 7.3**
Date of RAI Issue:	**11/10/2015**

Question No. 07.01-44

Identify an ITAAC to verify the referenced Common Q platform is installed in according with the approved topical report, and to identify any modifications or changes to the Common Q platform design, processes, hardware, and software.

10 CFR Part 50, Appendix A, GDC 1, require structures, systems, and components to be designed, fabricated, erected, constructed, tested, and inspected to quality standards commensurate with the importance of the safety function to be performed. Section 8 of Technical Report APR1400-Z-J-NR- 14001-P, "Safety I&C System," Rev. 0, states "The safety I&C system is implemented on a common PLC platform using Common Q. The platform has been dedicated and qualified for nuclear power plants and accepted by NRC after reviewing Common Qualified Platform Topical Report, Revision 3. The platform is configured using various hardware building blocks and loaded with application software to develop safety I&C systems such as PPS, ESF-CCS, CPCS, and QIAS-P." The staff requests identification of an ITAAC that verifies the Common Q platform is installed in accordance with the approved Common Q topical report, and as necessary, provide corresponding updates to the APR1400 FSAR. The staff also requests details regarding any modifications to the Common Q platform design, processes, hardware, and software, since the Common Q topical report was approved by the staff.

Response

1. Installation of the Common Q platform

As described in the Technical Report APR1400-Z-J-NR-14001-P, "Safety I&C System," Rev. 0, the safety I&C systems, such as the PPS, CPCS, ESF-CCS and QIAS-P, are implemented on a common PLC platform using Common Q.

DCD Tier 1, including the ITAAC contained therein, provides top tier descriptions of safety I&C systems. To verify the installation of Common Q in accordance with the approved Common Q topical report (Rev.3, February 2013), Section 2.5 of DCD Tier 1 and Section 7.1 of DCD Tier 2 will be revised, as indicated in the attachment associated with this response.

The PLC platform is described in Section 8 of the Safety I&C System Technical Report, and the report refers to the Common Q topical report which provides the dedicated process of using the platform and the detailed description of the platform. In addition, APR1400-A-J-NR-14003-P (WCAP-17926-P), “APR1400 Disposition of Common Q Topical Report NRC Generic Open Item and Plant Specific Action Items,” Rev.0, October 2014, addresses the resolution of the Generic Open Items (GOIs) and Plant Specific Action Items (PSAIs) for the APR1400 safety I&C system design.

2. Modifications to the Common Q platform

The details regarding any modifications to the Common Q platform design, processes, hardware, and software, since the Common Q topical report was approved by the staff, are provided in the following documents;

- Table 3-2 "Common Q Record of Changes Since WCAP-16097-P-A Appendix 5 Was Issued" of WCAP-17926-P ("APR1400 Disposition of Common Q Topical Report NRC Generic Open Item and Plant Specific Action Items", Rev.0, October 2014) in APR1400-A-J-NR-14003-P

- WCAP-17922-P ("Common Q Platform Supplemental Information in Support of the APR1400 Design Certification", Rev.0, August 2014) in APR1400-A-J-NR-14004-P

Impact on DCD

Section 2.5 of DCD Tier 1, and Section 7.1 of DCD Tier 2 will be revised, as indicated in the attachment associated with this response.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

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

17. The Class 1E equipment listed in Table 2.5.1-1 is protected from accident related hazards such as missiles, pipe breaks, and flooding.

18. The RTS and ESF initiation instrumentation (referenced in Tables 2.5.1-2 and 2.5.1-3) monitors the normal operating, anticipated operational occurrence (AOO), and postulated accident (PA) events.

19. The Class 1E instrument identified in Table 2.5.1-1 as being qualified for a harsh environment can withstand the environmental conditions that would exist before, during, and following a design basis accident without loss of safety function for the time required to perform the safety function.

20 The PPS providing RTS and ESF initiation signals has the testing functions.

21 A single channel of RTS and ESF initiation is bypassed to allow testing, maintenance or repair and this capability does not prevent the RTS and ESF initiation from performing its safety function.

22. Input sensors from each channel of the RTS and ESF initiation as identified in Tables 2.5.1-2 and 2.5.1-3 are compared continuously in the information processing system (IPS) to allow detection of out-of-tolerance sensors.

23. Two sets of RTSS which consists of four RTSGs are diverse each other.

24. The PPS and CPCS are installed in accordance with the dedicated process of commercial grade hardware and software.

2.5.1.2 Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.5.1-5 specifies the inspections, tests, analyses, and associated acceptance criteria for the RTS and ESF initiation.

Table 2.5.1-5 (10 of 10)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
21. A single channel of RTS and ESF initiation is bypassed to allow testing, maintenance or repair and this capability does not prevent the RTS and ESF initiation from performing its safety function.	21. A test will be performed on the 2-out-of-4 voting logic in the as-built RTS and ESF initiation by providing simulated process signals, identified in Tables 2.5.1-2 and 2.5.1-3, to at least two of three non-bypassed channels of the as-built RTS and ESF initiation input under the manual single division bypass operation from the as-built the maintenance and test panel (MTP) in the MCR.	21. When the 2-out-of-4 voting logic in the non-bypassed divisions of each as-built RTS and ESF initiation receives at least two of three actuation signals, identified in Tables 2.5.1-2 and Table 2.5.1-3, from the respective non-bypassed channels, the 2-out-of-4 voting logic in the non-bypassed divisions of each as-built RTS and ESF initiation provides the actuation signal for the reactor trip and automatic ESF functions identified in the tables.
22. Input sensors from each channel of the RTS and ESF initiation as identified in Tables 2.5.1-2 and 2.5.1-3 are compared continuously in the information processing system (IPS) to allow detection of out-of-tolerance sensors.	22. A test of the as-built IPS will be performed by providing The simulated inputs for each monitored variable identified in Tables 2.5.1-2 and 2.5.1-3 which includes one out-of-tolerance , at the as-built RTS and ESF initiation input.	22. An alarm for the out-of-tolerance sensor detection is displayed on the as-built IPS in the MCR when the IPS receives simulated input signals for each monitored variable identified in Tables 2.5.1-2 and 2.5.1-3 which includes one out-of-tolerance signal.
23. Two sets of RTSS which consists of four RTSGs are diverse each other.	23. Inspection of the as-built RTSS equipment will be performed.	23. Two sets of the as-built RTSS which consists of four RTSGs are diverse each other.: One set of RTSGs is supplied from a different manufacturer than the other set of RTSGs.
24. The PPS and CPCS are installed in accordance with the dedicated process of commercial grade hardware and software.	24. An inspection will be performed for installation of the hardware and software.	24. A report exists and concludes that the systems are installed in accordance with the dedicated process of commercial grade hardware and software.

2.5.3.2 Inspection, Test, Analyses, and Acceptance Criteria

The inspections, tests, analyses, and associated acceptance criteria for the QIAS-P are specified in Table 2.5.3-3.

6. The QIAS-P is installed in accordance with the dedicated process of commercial grade hardware and software.

Table 2.5.3-3 (3 of 3)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
5. The QIAS-P software is implemented according to the software lifecycle process.	5.a An inspection will be performed for the requirements phase result summary report of QIAS-P software.	5.a The requirements phase result summary report exists and concludes that the plant requirements phase activities of QIAS-P software are performed.
	5.b An inspection will be performed for the design phase result summary report of QIAS-P software.	5.b The design requirements phase result summary report exists and concludes that the design phase activities of QIAS-P software are performed.
	5.c An inspection will be performed for the implementation phase result summary report of QIAS-P software.	5.c The implementation phase result summary report exists and concludes that the implementation phase activities of QIAS-P software are performed.
	5.d An inspection will be performed for the test phase result summary report of QIAS-P software.	5.d The test phase result summary report exists and concludes that the test phase activities of QIAS-P software are performed.
	5.e An inspection will be performed for the installation and checkout phase result summary report of QIAS-P software.	5.e The installation phase result summary report exists and concludes that the installation and checkout phase activities of QIAS-P software are performed.
6. The QIAS−P is installed in accordance with the dedicated process of commercial grade hardware and software.	6. An inspection will be performed for installation of the hardware and software.	6. A report exists and concludes that the system is installed in accordance with the dedicated process of commercial grade hardware and software.

18. The Class 1E equipment and components listed in Table 2.5.4-1 are protected from accident related hazards such as missiles, pipe breaks and flooding.

19. The ESF-CCS cabinets listed in Table 2.5.4-1 have key locks and door position alarms, and are located in a vital area of the facility.

20. The ESF-CCS provides ESF actuation within required response time for ESF functions identified in Table 2.5.4-2.

21. The ESF-CCS has the testing functions.

22. The ESF−CCS is installed in accordance with the dedicated process of commercial grade hardware and software.

2.5.4.2 Inspections, Tests, Analyses, and Acceptance Criteria

The inspections, tests, analyses, and associated acceptance criteria for the ESF-CCS are specified in Table 2.5.4-4.

Table 2.5.4-4 (7 of 7)

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
18. The Class 1E equipment and components listed in Table 2.5.4-1 are protected from accident related hazards such as missiles, pipe breaks and flooding.	18. An inspection and analysis will be performed on the locations of the as-built Class 1E equipment and components listed in Table 2.5.4-1.	18. A report exists and concludes that the as-built equipment and components listed in Table 2.5.4-1 are protected from accident related hazards such as missiles, pipe breaks and flooding.
19. The ESF-CCS cabinets listed in Table 2.5.4-1 have key locks and door position alarms, and are located in a vital area of the facility.	19.a A test of the as-built cabinets listed in Table 2.5.4-1 for key lock capability, and a test of door position alarms, will be performed.	19.a Each as-built cabinet listed in Table 2.5.4-1 has key lock capability, and door position alarms are received in the as-built MCR when cabinet doors are opened.
	19.b An inspection of the cabinets listed in Table 2.5.4-1 will be performed.	19.b The cabinets listed in Table 2.5.4-1 are located in a vital area of the facility.
20. The ESF-CCS provides ESF actuation within required response time for ESF functions identified in Table 2.5.4-2.	20.a A type test and analysis will be performed on the ESF-CCS to verify that the ESF-CCS actuates the ESF functions identified in Table 2.5.4-2.	20.a A report exists and concludes that the ESF-CCS actuates the ESF functions identified in Table 2.5.4-2 within response time requirements.
	20.b An inspection will be performed on the as-built ESF-CCS to determine if the response time of ESF actuation functions identified in Table 2.5.4-2.	20.b The as-built ESF actuation functions identified in Table 2.5.4-2 with response time requirements are bounded by type tests or a combination of a type test and analysis.
21. The ESF-CCS has the testing functions.	21. A type tests and analysis of the ESF-CCS will be performed using simulated failure condition.	21. A report exists and concludes that the ESF-CCS has the testing functions to detect malfunctioning components or modules and have them replaced, repaired, or adjusted.
22. The ESC–CCS is installed in accordance with the dedicated process of commercial grade hardware and software.	22. An inspection will be performed for installation of the hardware and software.	22. A report exists and concludes that the system is installed in accordance with the dedicated process of commercial grade hardware and software.

CHAPTER 7 – INSTRUMENTATION AND CONTROLS

7.1 Introduction

The APR1400 instrumentation and control (I&C) system uses advanced design features such as digital data communication, a network-based distributed digital control system, and a compact workstation-based human-system interface (HSI) in the control room.

The I&C architecture of the APR1400 is implemented by two major independent and diverse platforms: (1) safety-qualified programmable logic controller (PLC) platform for the safety systems and (2) non-qualified distributed control system (DCS) platform for the data processing system and non-safety control systems. In addition, independent systems such as the turbine/generator (T/G) control and protection system, the nuclear steam supply system (NSSS) monitoring system, and the balance of plant (BOP) monitoring system perform the required functions of a portion of the I&C systems.

Table 3.2-1 provides the safety classifications and quality groups of the APR1400 systems.

Safety Systems

described in Section 8 of the Safety I&C System Technical Report (Reference 2)

The safety systems are implemented by safety-grade hardware and previously developed software components that are dedicated or qualified for use in nuclear power plants. The PLC platform is loaded with the APR1400-specific application software to implement various safety functions.

The components of the safety system are qualified to satisfy nuclear requirements such as environmental, seismic, electromagnetic interference (EMI), and radio frequency interference (RFI) qualifications. The safety system software is designed, verified, and validated using the industry standard for software development and the verification and validation (V&V) process as described in the Software Program Manual Technical Report (Reference 1). The qualified PLC platform applies to the following safety systems:

a. Plant protection system (PPS)

b. Core protection calculator system (CPCS)

c. Engineered safety features – component control system (ESF-CCS)

d. ESF-CCS soft control module (ESCM)

e. Qualified indication and alarm system – P (QIAS-P)

The Safety I&C System Technical Report ~~(Reference 2)~~ describes the functional requirements and design features, and the Software Program Manual Technical Report describes the software design process of the safety I&C system, particularly the PPS, CPCS, ESF-CCS, and QIAS-P.

The following safety I&C systems are implemented on independent platforms that are diverse from the safety-qualified PLC platform: ex-core neutron flux monitoring system (ENFMS) (see Subsection 7.2.1.1.c), auxiliary process cabinet – safety (APC-S) (see Subsection 7.2.1), safety portion of radiation monitoring system (RMS) (refer to Section 11.5 and Subsection 12.3.4) and component interface module (CIM) (see Subsection 7.3.1.11).

Non-Safety Systems

Most of the non-safety I&C systems are implemented by a DCS-based common platform that has been proven in operating experience in the nuclear industry and other industries. The DCS conducts the functions of the operator interface, component-level control, automatic process control, high-level group control, and data processing for normal operation. The DCS is designed with a redundant and fault-tolerant architecture for high reliability and to prevent the failure of a single component from causing a spurious plant trip.

The following systems are implemented on the DCS platform:

a. Process-component control system (P-CCS), which includes the NSSS process control system (NPCS)

b. Power control system (PCS)

c. Information processing system (IPS)

The qualified indication and alarm system – non-safety (QIAS-N) is also implemented on the common PLC platform, even though it is a non-safety system, because it displays the important plant parameters and maintains diversity from the IPS.

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Docket No. 52-046

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SRP Section:	**07.01 – Instrumentation and Controls - Introduction**
Application Section:	**7.1**
Date of RAI Issue:	**11/10/2015**

Question No. 07.01-48

The staff reviewed the response to RAI 34-7870, Question 7.1-2 and found that additional information was needed as described below.

10 CFR 50.36(c)(1)(ii)(A) states, in part, "Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded." Technical Report (TeR) APR1400-Z-J-NR-14005, Rev.0, "Setpoint Methodology for Plant Protection System," describes the setpoint methodology applied to the Plant Protection System (PPS) and Diverse Protection System (DPS) for the APR1400 and states conformance to BTP 7-12, Regulatory Guide 1.105 - Rev.3, and Regulatory Issue Summary (RIS) 2006-17.

For Question 7.1-2, the staff requested clarification on the as-left limit and as-found limit of the five-point calibration of the instrument transmitter and how these limits relate to the TSP as-left limit and as-found limit. The applicant responded by stating, "The as-left limits of instrument transmitters are assigned to include the reference accuracy, power supply effect, and measurement and test error (M&TE) as described in Section 2.3.2.1 of TeR APR1400-Z-J-NR-14005-P, Rev.0. Then, the Square-Root-Sum-of-Squares (SRSS) combination will describe the tolerance to the five-point calibration for as-left limits which is implemented by the utility. Regarding the as-found limits, the drift, temperature effect, and radiation effect will be additionally included into the limits as described in Section 2.3.2.2 of the TeR. Calibration Error Band (as-left limit) illustrated in Figure 1 is composed of individual calibration acceptance criteria for the transmitter, auxiliary process cabinet – safety (APC-S), and PPS cabinet as described in Sections 2.3.2.1 and 2.3.2.4 of the TeR. Periodic Test Error Band (as found limit) in Figure 1 also includes individual periodic test acceptance criteria for the transmitter, APC-S, and PPS cabinet, as described in Sections 2.3.2.2 and 2.3.2.5 of the TeR. Calibration Error Band (as-left limit) illustrated in Figure 1 is composed of individual calibration acceptance criteria for the transmitter, auxiliary process cabinet – safety (APC-S), and PPS cabinet as described in Sections 2.3.2.1 and 2.3.2.4 of the TeR. Periodic Test Error Band (as found limit) in Figure 1 also includes individual periodic test acceptance criteria for the transmitter, APC-S, and PPS cabinet, as described in Sections 2.3.2.2 and 2.3.2.5 of the TeR. The as-left and as-found data of transmitter, APC-S, and PPS cabinet are required to be maintained appropriately within the corresponding Calibration Error Band and Periodic Test Error Band in order to ensure that the TSP does not exceed the Analytical Limit (AL) assumed in performing the safety analysis. The specific SRSS combination methods for the individual Calibration Error and Periodic Test Error Band for each trip parameter are described in appendices of the TeR. Therefore, there is no plan to revise TeR APR1400-Z-J-NR-14005-P, Rev.0, as referenced in Section 7.2.5, Item 14 of APR1400 DCD Tier 2, since the individual Calibration Error Band and Periodic Test Error Band are explained in Sections 2.3.2.1, 2.3.2.2, 2.3.2.4, and 2.3.2.5 and the detailed SRSS combination methods are described in appendices of the TeR."

The staff does not agree that the TeR adequately describes and explains the use of the individual Calibration Error Band and Periodic Test Error Band, for the transmitter, APC-S, and PPS Cabinet. Staff requests the applicant to clearly describe these error bands so staff can properly understand the relationship among DTSP, AV, TSP, as-left limit, and as-found limit.

Response

To clearly describe the calibration error band and periodic error band, the last paragraph of Section 2.1, “Basic Description” of TeR APR1400-Z-J-NR-14005 will be revised, as indicated in the attachment to the response to RAI 301-8280, Question 7.1-41.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-Z-J-NR-14005-P/NP, Rev.0 will be revised as indicated in the attachment to the response to RAI 301-8280, Question 7.1-41.

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.: **301-8280**

SRP Section: **07.01 – Instrumentation and Controls - Introduction**

Application Section: **7.1**

Date of RAI Issue: **11/10/2015**

Question No. 07.01-49

The staff reviewed the response to RAI 34-7870, Question 7.1-3 and found that additional information was needed as described below.

10 CFR 50.36(c)(1)(ii)(A) states, in part, "Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded." Technical Report (TeR) APR1400-Z-J-NR-14005, Rev.0, "Setpoint Methodology for Plant Protection System," describes the setpoint methodology applied to the Plant Protection System (PPS) and Diverse Protection System (DPS) for the APR1400 and states conformance to BTP 7-12, Regulatory Guide 1.105 - Rev.3, and Regulatory Issue Summary (RIS) 2006-17.

For Question 7.1-3, the staff requested a description on how the change in measured TSP will be verified to be within predefined limits (double-sided acceptance criteria band) and the appropriate actions to be taken if the change is outside these limits per RIS 2006-17. The applicant responded by quoting Section 2.1 of TeR, "The calibration error band serves as an error limit during a periodic test...If the reading is outside of the periodic test error band, the instrumentation is not behaving as expected. The source of anomaly and the possibility of exceeding the AV should be investigated...." In the TeR, a description was provided for the scenario where the as-found TSP is not conservative with respect to the AV and the appropriate actions taken to address guidance in RIS 2006-17. However, it is not clear to the staff what appropriate actions are to be taken in scenario where the measured TSP value is outside the predefined limits (as-found tolerance band of the trip setting value) but is conservative with respect to the AV, or is conservative with respect to the as-left value of the trip setting at the beginning of a Channel Calibration surveillance interval, as described in RIS 2006-17. The staff requests that the applicant describe what appropriate actions are to be taken in case the measured TSP value is outside the predefined limits, that is, the double-sided (as-found) acceptance criteria band as described in RIS 2006-17.

Response

To describe appropriate actions to be taken in the event that the measured trip setpoint (TSP) value is outside the periodic test error band, or that the TSP value has exceeded the allowable value (AV), the last paragraph of Section 2.1, "Basic Description" of TeR APR1400-Z-J-NR-14005 will be revised, as indicated in the response to RAI 301-8280, Question 7.1-41.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-Z-J-NR-14005-P/NP, Rev.0 will be revised as indicated in the attachment to the response to RAI 301-8280, Question 7.1-41.

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.:	**301-8280**
SRP Section:	**07.01 – Instrumentation and Controls-Introduction**
Application Section:	**7.1**
Date of RAI Issue:	**11/10/2015**

Question No. 07.01-50

The staff reviewed the response to RAI 34-7870, Question 7.1-4 and found that additional information was needed as described below.

10 CFR 50.36(c)(1)(ii)(A) states, in part, "Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded." Technical Report (TeR) APR1400-Z-J-NR-14005, Rev.0, "Setpoint Methodology for Plant Protection System," describes the setpoint methodology applied to the Plant Protection System (PPS) and Diverse Protection System (DPS) for the APR1400 and states conformance to BTP 7-12, Regulatory Guide 1.105 - Rev.3, and Regulatory Issue Summary (RIS) 2006-17.

For Question 7.1-4, the staff requested a description on how the offset between the final TSP and the AV is determined and to clarify the relationship between the terms margin and offset. The applicant responded by stating, "In order to reduce the possibility of a license event report, the final TSP would be offset from the AV by about 0.5 percent of span that is applied for the Korean nuclear power plants in service. The offset used...is based on engineering judgement...the offset is greater than the PPS cabinet periodic test error...this approach does not affect the safety aspect since the final TSP is moved in the conservative direction by reducing the plant operating margin." Although the applicant's response provided new information, the applicant did not propose to update the FSAR (DCD Tier 2) or the TeR with this information. Regarding the new information, the applicant is requested to provide a technical basis as to why a 0.5 percent of span provides adequate margin between the TSP and the AV for all specified automatic reactor trip and safety system actuation instrumentation functions. The applicant is also requested to add a description of the basis or rationale for the stated offset value to the APR1400 FSAR Tier 2 or to the TeR.

Response

To describe the basis for the stated offset, Section 2.5.4, “Drift Allowance” of TeR APR1400-Z-J-NR-14005 will be revised as follows:

> To prevent a licensee event report, the TSP is offset in a conservative direction from the calculated AV by a drift allowance of about 0.5% of the channel span, which is sufficiently greater than the PPS cabinet periodic test error. Since the PPS cabinet periodic test error is used in determining the AV from the DTSP, the drift allowance does not consider the sensor and the APC-S periodic test errors, which are individually verified to be within their respective periodic test error bands. Historically, the 0.5% of channel span value is larger than the value of the PPS cabinet periodic test error. Because the PPS cabinet periodic test error is the difference of the DTSP and the AV, the approach results in a TSP which is reasonable. This approach does not negatively affect safety since the TSP is moved in the conservative direction by reducing the plant operating margin.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-Z-J-NR-14005-P/NP, Rev.0 will be revised as indicated in the attachment associated with this response.

3. Errors may have both random and non-random components. When this occurs, the notation A+A', B+B', C+C', …, N+N' is used to indicate the combination of the two error types.

2.4.11 Measurement Test Error

Measurement test error is taken twice in the calculation of periodic test error because it must be reapplied at the end of the test interval.

2.5 Setpoint Determination

2.5.1 Limiting Safety System Setting (LSSS)

Where an LSSS is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded (Reference 4.3). LSSS for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions.

The LSSS may be TSP, AV, or both according to Reference 4.1. The TSP is described in the DCD Sections 7.2 and 7.3 and the AV is required part of the TS.

2.5.2 Trip Setpoint

The TSP is established to provide the sufficient margin from the safety limit by adding/subtracting, in the conservative direction, the event-specific total instrument channel uncertainty to the corresponding AL. The most conservative event-specific value is then used as the TSP for a PPS function.

The high containment pressure TSP is determined by two methods. Starting from 0.0 cmH_2O, the lowest possible TSP is calculated that will not interfere with normal plant operation. This conforms to the containment isolation dependability requirements of NUREG-0737 (Reference 4.4). Starting from the AL, the highest possible TSP is calculated that will guarantee reactor trip and ESF actuation when required. The more conservative of the two values is chosen as the final TSP.

2.5.3 Allowable Value

The AV is less conservative than the TSP, by the amount of the PPS cabinet periodic test error. This uncertainty accommodates the maximum anticipated drift of the PPS cabinet equipment between calibrations. The TS requires that, if upon checking a setpoint, the value set in the PPS is less conservative than the AV, the channel must be declared inoperable until the PPS setpoint is reevaluated to a conservative value.

2.5.4 Drift Allowance

In general, the PPS cabinet periodic test error is very small. To prevent a licensee event report, the TSP is offset in a conservative direction from the calculated AV by a drift allowance that is greater than the PPS cabinet periodic test error. By calculating the TSP and AV in this manner, setpoint drifts that are inconsistent with the safety analysis are virtually eliminated. The TSP is also far enough away from the process, so spurious trips during normal operation are minimized.

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To prevent a licensee event report, the TSP is offset in a conservative direction from the calculated AV by a drift allowance of about 0.5% of the channel span, which is sufficiently greater than the PPS cabinet periodic test error. Since the PPS cabinet periodic test error is used in determining the AV from the DTSP, the drift allowance does not consider the sensor and the APC-S periodic test errors, which are individually verified to be within their respective periodic test error bands. Historically, the 0.5% of channel span value is larger than the value of the PPS cabinet periodic test error. Because the PPS cabinet periodic test error is the difference of the DTSP and the AV, the approach results in a TSP which is reasonable. This approach does not negatively affect safety since the TSP is moved in the conservative direction by reducing the plant operating margin.

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.: **301-8280**

SRP Section: **07.01 – Instrumentation and Controls - Introduction**

Application Section: **7.1**

Date of RAI Issue: **11/10/2015**

Question No. 07.01-51

The staff reviewed the responses to RAI 34-7870, Questions 7.1-1 through 7.1-5, and 7.1-9, and found that additional information was needed as described below.

10 CFR 50.36(c)(1)(ii)(A) states, in part, “Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded.” Technical Report (TeR) APR1400-Z-J-NR-14005, Rev.0, “Setpoint Methodology for Plant Protection System,” describes the setpoint methodology applied to the Plant Protection System (PPS) and Diverse Protection System (DPS) for the APR1400 and states conformance to BTP 7-12, Regulatory Guide 1.105 - Rev.3, and Regulatory Issue Summary (RIS) 2006-17.

For Question 7.1-5, the staff for identification of the Limiting Safety System Settings (LSSS) for the APR1400. The applicant responded by proposing to modify TeR Section 2.5.1 to say, "The LSSS, which is maintained in the TS, establishes the AV." Per Regulatory Guide 1.105, the allowable value (AV) is the limiting value that the trip setpoint can have when tested periodically, beyond which the instrument channel is considered inoperable and correction action must be taken in accordance with the technical specifications. The TeR states that the "AV is less conservative than the TSP by an offset which is greater than the PPS cabinet periodic test error...the PPS cabinet periodic test error is not applicable since there is no calibration associated with the PPS cabinet." Based on these statements, the staff understands that the AV is less conservative than the TSP by an offset that is greater than zero. TeR Section 2.3.2.2 discusses measurement channel periodic test error (equipment drift) for the transmitter and APC-S. What is the rationale for not including these two individual periodic test errors in the AV determination/calculation? The applicant is requested to explain why the proposed offset (0.5 percent of span), as described in the applicant's response to Question 7.1-4, provides an adequate margin to ensure that automatic protective action will correct an abnormal situation before a safety limit is exceeded per Regulatory Guide 1.105.

Response

The transmitter and the APC-S periodic test error bands are not used in determining the AV since the surveillance test for the PPS cabinet is performed every month but the test frequency of the transmitter and the APC-S is every refueling period. However, the transmitter and the APC-S errors are each individually verified every refueling period to be within their respective calibration error bands and periodic test error bands. To clearly describe the reason why these two individual periodic test errors are not included in the AV determination, the last paragraph of Section 2.1, “Basic Description” of TeR APR1400-Z-J-NR-14005 will be revised, as indicated in the attachment to the response to RAI 301-8280, Question 7.1-41.

To describe the basis for the proposed offset, Section 2.5.4, “Drift Allowance” of TeR APR1400-Z-J-NR-14005 will be revised, as indicated in the attachment to the response to RAI 301-8280, Question 7.1-50.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical report APR1400-Z-J-NR-14005-P/NP, Rev.0 will be revised as indicated in the attachments to the responses to RAI 301-8280, Question 7.1-41 and Question 7.1-50.

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.:	**301-8280**
SRP Section:	**07.01 – Instrumentation and Controls – Introduction**
Application Section:	**7.1**
Date of RAI Issued:	**11/10/2015**

Question No. 07.01-52

The staff reviewed the response to RAI 34-7870, Question 7.1-9 and found that additional information was needed as described below.

10 CFR 50.36(c)(1)(ii)(A) states, in part, "Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded." Technical Report (TeR) APR1400-Z-J-NR-14005, Rev.0, "Setpoint Methodology for Plant Protection System," describes the setpoint methodology applied to the Plant Protection System (PPS) and Diverse Protection System (DPS) for the APR1400 and states conformance to BTP 7-12, Regulatory Guide 1.105 - Rev.3, and Regulatory Issue Summary (RIS) 2006-17.

For Question 7.1-9, staff requested a description on when reset setpoints would be used for reactor trip functions and the basis for manually changing the setpoint value. Also, describe how the new "fixed value" setpoint is determined and how this new setpoint is consistent with the more restrictive setpoint. The applicant responded by stating that "the low pressurizer pressure trip is provided to trip the reactor when the measured pressurizer pressure falls to a low preset value. At pressures below the normal operating range, this setpoint can be manually decreased to a fixed increment below the existing pressurizer pressure down to a minimum value. The incremental and minimum values are given in Table 7.2-4. This provides the capability to trip the reactor when required during plant cooldown." The section also states, "The low SG pressure trip is provided to trip the reactor when the measured SG pressure falls below a preset value. At SG pressure below normal, the setpoint can be manually decreased to a fixed increment below the existing system pressure. This is used during plant cooldown. The fixed increment is provided in Table 7.2-4." Regarding the "fixed value" APR1400 FSAR Tier 2, Chapter 7, Table 7.2-4 (2 of 2), Note (4), states, "Setpoint can be manually decreased to a fixed increment below existing pressure as pressure is reduced during controlled plant cooldown and is automatically increased as pressure is increased maintaining a fixed increment. This fixed increment is 28 kg/cm2 (400 psi) for pressurizer pressure and 14 kg/cm2 (200 psi) for steam generator pressure." The staff finds the response acceptable since applicant plans to use manual reduction of the setpoints for low pressurizer pressure and low SG pressure trips to shut down the plant without any unnecessary protective actions for plant cooldown. However, it is not clear to the staff if one Setpoint Reset switch on the Safety Console applies to both low pressurizer pressure and low SG pressure trips or if there are two switches, one for each manual reduction. Clarify the capability of the Setpoint Reset switch.

Response

There are two Setpoint Reset switches on the Safety Console. One switch applies to low pressurizer pressure trip and the other switch applies to low SG pressure trip. The Safety I&C System technical report (APR1400-Z-J-NR-14001-P, Rev.0) will be revised to include that there are two setpoint reset switches, one for low pressurizer pressure and the other for low steam generator pressure, on the MCR Safety Console and Remote Shutdown Console.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Sections 4.7.1.3 and 4.7.4 of the TeR APR1400-Z-J-NR-14001-P/NP, Rev.0 will be revised as indicated in the attachment.

TS

TS

4.7.4 Remote Shutdown Console HSI

TS

4.7.5 Control Panel Multiplexers

TS