Setpoint Methodology for Plant Protection System

Revision 1

Non-Proprietary

February 2017

REVISION HISTORY

Revision	Date	Page	Description
0	November 2014	All	First Issue
1	February 2017	2 (2.1)	Described clearly the relationship between the periodic test error band and the draft trip setpoint and added the effect on the draft trip setpoint, allowable value, and trip setpoint when the PPS cabinet periodic test error band is zero. (RAI 301-8280, Question 07.01-41)
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		A5 (App.A)	Described clearly the purpose of a margin between the allowable value and the trip setpoint (RAI 301-8280, Question 07.01-41)
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		F4 (App.F)	Described clearly the purpose of a margin between the allowable value and the trip setpoint (RAI 301-8280, Question 07.01-41)
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Revision	Date	Page	Description
		H4 (App.H)	Described clearly the purpose of a margin between the allowable value and the trip setpoint (RAI 301-8280, Question 07.01-41)
		I3 (App.I)	Described clearly the purpose of a margin between the allowable value and the trip setpoint (RAI 301-8280, Question 07.01-41)
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		N4 (App.N)	Editorial Change : Insertion of acronym

ABSTRACT

This technical report describes the setpoint determination methodology applied to the plant protection system (PPS) and diverse protection system (DPS) for the APR1400.

The methodology described in this technical report has been established to ensure that the PPS and DPS setpoints are consistent with the assumptions made in the safety analysis and conform to current setpoint-related requirements of industry standard, ANSI/ISA-S67.04-1994, which is endorsed by US NRC Regulatory Guide 1.105 Rev. 3, NUREG- 0800 Brach Technical Position (BTP) 7-12, and US NRC Regulatory Issue Summary (RIS) 2006-17.

The detailed setpoint calculation processes for the PPS and DPS are described in Appendices of this document and may change according to the plant-specific data. The uncertainty methodology and application for instrumentation for the APR1400 are addressed in a separate technical report, APR1400-Z-J-NR-14004P, which is referenced by this technical report. The setpoint determination methodology used for the core protection calculator system (CPCS) for APR1400, which is not covered by this technical report is documented in a separate technical report, APR1400-F-C-NR-14001P, “CPC Setpoint Analysis Methodology for APR1400”.

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ACRONYMS AND ABBREVIATIONS

AC	accident condition
AFAS	auxiliary feedwater actuation signal
AL	analytical limit
ANSI	American National Standards Institute
ANTS	analysis nominal trip setpoint
APC-S	auxiliary process cabinet – safety
AV	allowable value
BTP	branch technical position
CCF	common cause failure
CFR	code of federal regulations
CIAS	containment isolation actuation signal
CPC	core protection calculator
CSAS	containment spray actuation signal
CU	cabinet uncertainty
COLSS	core operating limit supervisory system
DBE	design basis event
DCD	design control document
DNBR	departure from nucleate boiling ratio
DPS	diverse protection system
DRT	derived response time
DSP	derived setpoint
DTSP	draft trip setpoint
ESF	engineered safety features
ESFAS	engineered safety features actuation system
ESF-CCS	engineered safety feature - component control system
HE	harsh environment
ISA	Instrument Society of America
KEPCO	Korea Electric Power Corporation
KHNP	Korea Hydro & Nuclear Power Co., Ltd.
LOCA	loss of coolant accident
LPD	local power density
LRCF	low reactor coolant flow
LSSS	limiting safety system setting
MCU	measurement channel uncertainty

MSIS	main steam isolation signal
NHE	non harsh environment
PE	process equipment
PPS	plant protection system
PTE	periodic test error
RIS	regulatory issue summary
RLVS	rate-limited variable setpoint
RPS	reactor protection system
RTSG	reactor trip switch gear
SDT	signal delay time
SIAS	safety injection actuation signal
SRP	standard review plan
SRSS	square-root-sum–of-squares
SRT	sensor response time
TART	total analysis response time
TS	technical specifications
TSP	trip setpoint
VOP	variable over power
WCN	worst case normal

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1 INTRODUCTION

1.1 Purpose

This report describes the general setpoint calculation methodology for plant protection system (PPS) for the APR1400. This methodology has been established to ensure that the PPS setpoints are consistent with the assumptions made in the safety analysis and conform to current licensing requirements and industry standards.

1.2 Scope

This report describes the setpoint methodology used in calculating PPS setpoints. This method satisfies current setpoint-related requirements of industry standard ANSI/ISA-S67.04-1994 (Reference 4.1), which is endorsed by USNRC regulatory guide 1.105 Rev. 3 (Reference 4.2), and BTP 7-12 (Reference 4.5), and RIS 2006-17 (Reference 4.6).

Section 2.0 describes the present methodology of setpoint determination. A general explanation of setpoint determination is given for the design control document (DCD) Sections 7.2 and 7.3, and technical specifications (TS). This section provides more detailed discussion of determining setpoints for specific categories of PPS functions.

Section 3.0 describes the assumptions regarding equipment calibration and periodic test procedures used in the setpoint calculations.

Appendices A through N provide the detailed setpoint calculation process for the PPS and the diverse protection system (DPS). However, the setpoint calculation process may change according to the plant-specific data.

The uncertainty methodology and application for instrumentation for the APR1400 are specifically described in Reference 4.7.

Departure from nucleate boiling ratio (DNBR) and local power density (LPD) setpoint calculation for the CPCS is provided in the Reference 4.9.

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 that a periodic result exceeds the AV. The final TSP is synonymous with “nominal trip setpoint” as used in Reference 4.6.

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 that 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.

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.

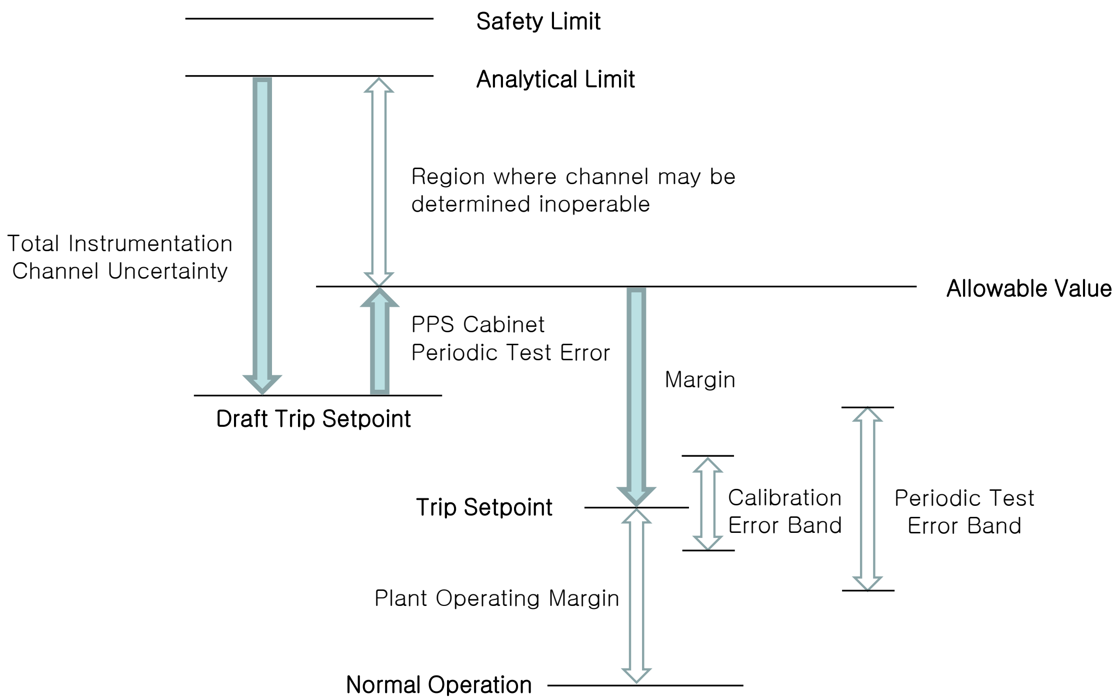

Figure 1 Nuclear safety-related setpoint relationships for raising trip

The remainder of Section 2.0 discusses in more detail the specific components of the setpoint methodology.

2.2 Analytical Limit

ALs are the limits of a measured or calculated variables required to ensure that the three primary reactor safety limits are not violated. These limits are: pressurizer pressure not to exceed 2750 psia, DNBR greater than or equal to 1.29, and LPD not to exceed 21.0 kilowatts per foot at a 95/95 probability/confidence level. If protective action is initiated at or before the AL, the integrity of the physical barriers that guard against the uncontrolled release of radioactivity will be maintained.

TSPs, in turn, ensure initiation of protective action at or before reaching the analytical limit. This results in acceptable consequences for safety related DBEs. TSPs also ensure that performance related DBEs can be accommodated without protective action.

Some events analyzed in the safety analysis result in a more severe environment for protection system equipment than other events. As a result, the expected total equipment uncertainties can be event-specific and a trip parameter can have an AL for each design basis event. The final ALs used in the safety analysis are then used in the setpoint calculation to determine TSPs and AVs, which are described in subsequent sections of this report.

2.3 Equipment Errors

2.3.1 General

Good engineering practice and current setpoint requirements dictate that all factors that can affect the operation of equipment be considered in the setpoint calculation. In this setpoint methodology, uncertainty components are determined separately and combined by a statistically valid method to arrive at a total instrument channel uncertainty. Those uncertainties that are both random and independent are combined by the square-root-sum–of-squares (SRSS) technique, a standard method of combining random uncertainties. Those uncertainties that are non-random and dependent are combined by algebraic summation.

For means of setpoint calculation, the PPS is divided into two major regions. The first region is the measurement channel portion of the instrument loop and it consists of the sensor, transmitter, power supply, and signal processing equipment - all equipment up to the PPS cabinet. This region is susceptible to four individual errors. These individual elements are specific to plant and equipment.

- Measurement Channel Calibration Error
- Measurement Channel Periodic Test Error
- Measurement Channel Worst Case Normal Error
- Measurement Channel Accident Condition Error

The second region is the PPS cabinet itself, which is susceptible to three errors. These individual elements are specific to plant and equipment.

- PPS Cabinet Calibration Error
- PPS Cabinet Periodic Test Error
- PPS Cabinet Worst Case Normal Error

2.3.2 Individual Errors

2.3.2.1 Measurement Channel Calibration Error

The measurement channel calibration error accounts for the uncertainties introduced in the transmitter and/or the auxiliary process cabinet – safety (APC-S) during the calibration process that must be accommodated if the instrumentation is required for protective action immediately after calibration. As with the previous errors, the measurement channel calibration error is determined from tests and from the information supplied by the manufacturer. The measurement channel calibration error band uses the SRSS combination of the reference accuracy, power supply effect, and measurement test error. The combination method for each trip parameter is described in appendices.

2.3.2.2 Measurement Channel Periodic Test Error

The measurement channel periodic test error for the transmitter and/or the APC-S accounts for the expected, measurable process equipment drift that might accumulate in the maximum allowable calibration interval that is 25% greater than the interval required by the TS. The measurement channel periodic test error band uses the SRSS combination of the reference accuracy, drift, temperature effect, power supply effect, radiation effect, and measurement test error. In this case the measurement test error is taken, twice in the calibration of periodic test error because it must be reapplied at the end of the test interval. The specific combination method for each trip parameter is described in appendices.

2.3.2.3 Measurement Channel Worst Case Normal Error

This error accounts for the maximum expected uncertainty in the measurement channel caused by the environmental extremes, drift and background radiation expected during normal plant operation. The specific combination method for each trip parameter is described in appendices.

2.3.2.4 Measurement Channel Accident Condition Error

During certain design basis events, combinations of atmospheric changes and seismic events are considered to occur simultaneously. Event specific environmental effects on the measure channel equipment can introduce: temperature effects, pressure errors, reference leg heating errors, seismic errors, and radiation errors. The environment postulated in the DCD Sections 7.2 and 7.3 for a specific event determines which environmental errors are combined to calculate the accident environment error for that event. The specific combination method for each parameter is described in appendices. This environment is assumed to be maintained up to the time of reactor trip or ESF actuation. Consequently, the errors associated with a steam line break, feedwater line break and loss of coolant accident can be different and depend on the event temperature and radiation exposure.

2.3.2.5 PPS Cabinet Calibration Error

The PPS cabinet calibration error accounts for the uncertainties introduced in the PPS cabinet during the calibration process that must be accommodated if the instrumentation is required for protective action immediately after calibration. This error is determined for the specific equipment installed in the PPS cabinet from the information supplied by the manufacturer. The PPS cabinet calibration error for the APR1400 is not applicable since there is no calibration associated with the PPS cabinet. The specific combination method for each trip parameter is described in appendices.

2.3.2.6 PPS Cabinet Periodic Test Error

The PPS cabinet periodic test error accounts for the expected drift of the PPS cabinet equipment between the periodic channel functional test. The following factors contribute to uncertainty components: setting and checking the setpoint, the difference between PPS cabinet setting and checking environments, and anticipated drift of the PPS cabinet equipment. The maximum interval used is 25% greater than the interval required by the TS. These component errors, which are calculated from manufacturer's information and from tests, are combined to determine the PPS Cabinet Periodic Test Error. The PPS cabinet Periodic Test Error for APR1400 is not applicable since the processor module error and measurement test error are negligible. The specific combination method for each trip parameter is described in appendices.

2.3.2.7 PPS Cabinet Worst Case Normal Error

This error accounts for the PPS Cabinet uncertainty caused by the non-containment environmental extremes expected during normal plant operation. The specific combination method for the PPS cabinet worst case normal for each trip parameter error is described in appendices.

2.3.3 Total Instrument Channel Uncertainty

After the individual error components have been determined, they are combined to arrive at a total instrument channel uncertainty, which is used in calculating the TSP. Each individual uncertainty consists of both random (±) and non-random (having a known sign) components. Random uncertainties are combined by the SRSS technique. These are then added algebraically to the non-random uncertainties. The total instrument channel uncertainty is the maximum error that could occur at any time during the periodic surveillance interval for the limiting event for which the function is required to operate. Event-specific total instrument channel uncertainties are calculated for each function, and are used to determine the TSPs.

2.3.3.1 Total Channel Worst Case Normal Error

This error accounts for the total channel uncertainty caused by the environmental extremes expected during normal plant operation. The specific combination method for the total channel worst case normal error is described in appendices.

2.3.3.2 Total Channel Accident Condition Error

This error accounts for the total uncertainty caused by the limiting DBE environment. The specific combination method for the total channel accident condition error is described in appendices.

2.4 Assumptions

2.4.1 Calibration and Testing Environment

The tolerances provided are based on calibrating and testing the equipment under the following environmental conditions:

2.4.1.1 Auxiliary Building

Transmitters located inside the auxiliary building are assumed to be calibrated between the temperatures of 12.5 – 37.5℃ (54.5 – 99.5˚F). Temperature shifts from the calibration temperature are assumed not to exceed 27.8℃diff. (50˚Fdiff.).

2.4.1.2 Containment

Transmitters located inside the containment are assumed to be calibrated between the temperatures of 15.6 - 40℃ (60 to 104˚F). Temperature shifts from the calibration temperature are assumed not to exceed 33.3℃ diff. (60˚F diff.).

2.4.1.3 Electrical Equipment Room

Equipment located in electrical equipment rooms is assumed to be calibrated between the temperatures of 21.1 – 25℃ (or 70 - 77˚F). Temperature shifts from the calibration temperature are assumed not to exceed 2.9℃ diff. (7˚F diff.).

2.4.2 Calibration and Testing Equipment

The equipment used to calibrate and test the process instrumentation will have an accuracy that is five (5) times better than the accuracy of the process instrumentation being calibrated or tested.

2.4.3 Calibration and Testing Interval

The PPS cabinet will be tested on interval that does not exceed 39 days.

The process instrumentation will be calibrated on an interval that does not exceed 22.5 months.

2.4.4 Nuclear Instrumentation Calibration Interval

Nuclear instrumentation calibration interval will not exceed 3,000 hours

2.4.5 Nuclear Instrumentation Calorimetric Calibration

The uncertainty associated with calculating the secondary calorimetric power and adjusting the linear power signal to accord with the calorimetric calculation will not exceed +/- 4.0% of full power.

NOTE: Any changes to the core operating limit supervisory system (COLSS) can also change the secondary calorimetric power calculation error.

2.4.6 Containment Pressure Variations

Containment pressure variations during normal operation will not exceed +/- 35.155 cmH2O (+/- 0.5 psi).Containment pressure spikes during maneuvering transients will not exceed 84.372 cmH2O (1.2 psi) over ambient pressure.

2.4.7 Accident Condition Error

The accident condition errors for the feedwater line break event are no worse than accident condition errors for the main steam line break event.

2.4.8 PPS Cabinet Response Time

The PPS Cabinet response time for all other trip functions, except reactor trip on low steam generator water level, is less than or equal to [225]^TS milliseconds. The response times for reactor trip on low steam generator water level and low reactor coolant flow are less than or equal to[705]^TS milliseconds and [325]^TS milliseconds, respectively. The PPS response time analysis is specifically described in Reference 4.8.

2.4.9 Combination of Random Uncertainty

The combination of instrument uncertainties from various sources by the SRSS method is realistic and conservative when these uncertainties are independent of each other.

2.4.10 Combination of Non-random Uncertainty

The combination of instrument uncertainties from various sources by algebraic summation is the most conservative method whenever the errors are non-random.

NOTES

1. Random errors (errors of uncertain algebraic sign) are indicated by the upper case letters A, B, C, …, N. When encountered in the analysis, these errors are combined by the SRSS technique, denoted by SRSS (A, B, C, …, N).

2. Non-random errors (errors of known algebraic sign) are indicated by the upper case letters with prime A’, B’, C’, …, N’. When encountered in the analysis, these errors are added algebraically.

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

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 that is sufficiently greater than the PPS cabinet periodic test error. The drift allowance value is based on the total uncertainty requirement of the APR1400 PPS cabinet, which is less than 0.5% of the selected full range value for a period of 39 days across the range of environmental conditions. This approach does not affect the safety aspect since the TSP is moved to the conservative direction by reducing the plant operating margin..

2.6 Rate-Limited Variable Setpoints (RLVS)

2.6.1 Rate Limited Variable Setpoint Model and Function

The RPS uses an RLVS for the variable over power (VOP) trip and the LRCF trip. The VOP trip uses 12 ex-core linear neutron detectors in four channels to monitor the reactor thermal power level. This function is designed to trip at high power levels and to provide continuous protection against sudden power excursions at any power level. For the LRCF trip, flow is assessed as a function of initial differential pressure as measured across each steam generator. There are four differential pressure input signals from each steam generator. This function is designed to trip at low flow but not during a coastdown caused by underfrequency due to loss of offsite power to the coolant pumps.

If two or more input signals from the ex-core linear neutron detectors, when compared in a bistable, equal to the setpoint value, a VOP reactor trip will occur. If two or more of the input signals from a single steam generator, when compared in a bistable, equal to the setpoint value, an LRCF reactor trip will occur.

The LRCF trip function provides protection for a sheared shaft event and a steam line break with a concurrent loss of off-site power. In both of these events, the reduction in flow causes a reduction in the differential pressure across the primary side of the affected steam generator. The LRCF trip function uses a RLVS module to initiate a reactor trip based on the rate of change of the differential pressure input signal.

Under steady state conditions, the trip setpoint will stay below the differential pressure input signal by the trip function parameter STEP. During a transient, the trip setpoint will move away from the decreasing differential pressure input signal to try and maintain the separation defined by STEP. The rate of decrease of the trip setpoint is fixed by the trip function parameter RATE. If the rate of decrease of the differential pressure input signal is greater than RATE, a trip will occur when the differential pressure input signal eventually equals to the trip setpoint. The minimum value that the trip setpoint can have is defined by the trip function parameter FLOOR.

2.6.2 RLVS Uncertainty Components

Calculations for events resulting from feedwater line break and steam line break must use accident condition uncertainties, while non-environmental events need not. Both types of calculations use the same RPS cabinet uncertainties, but different process equipment uncertainties.

2.6.2.1 PPS Cabinet Uncertainties

Uncertainties associated with the PPS cabinet are described in Sections 2.4.2.1 through 2.4.2.3.

2.6.2.2 Measurement Channel Uncertainties

Uncertainties associated with the process equipment and their combination method measurement channel are described in Appendices G and N.

2.6.2.3 Total Instrument Channel Uncertainty

As for the other PPS trips, this total uncertainty is calculated for specific events, and accommodation in the setpoint calculation is made for the greatest event value.

2.6.3 Response Time

An expected response time is included in the derivation of the setpoints. This response time takes into account the lags and delays of the measurement channel and the bistable trip unit and is obtained from vendor data. The required response time is verified periodically according to the TS guidelines.

2.6.4 LSSS Sets for RLVS Constants

2.6.4.1 Trip Values

TSPs for adjustable constants FLOOR, RATE, and STEP, are established by considering, in the conservative direction, the event-specific total instrument channel uncertainty.

The resultant TSPs in conjunction with the fixed delay time and application of the total instrument channel uncertainty, will give good margin to the required responses.

2.6.4.2 Allowable Values

An AV is defined, broadly, as the least conservative value a setpoint (or constant) could have, when checked periodically, and still be consistent with the assumptions and requirements of the safety analysis.

3 EQUIPMENT CALIBRATION

3.1 Basic Description

The setpoint methodology determines TSPs and AVs for the PPS trip parameters. When the setpoint calculation is made, it is assumed the equipment will be maintained and will operate in accordance with TS requirements. These requirements cover measurement channel environment, PPS cabinet environment, frequency of calibration and testing, the LSSS setpoint data, and equipment response time limits. Assumptions and requirements used in the setpoint calculations in these areas form the basis for the PPS operational requirements of the plant TS.

Other assumptions, about the actual operation of the PPS equipment, are not explicitly stated in the TS. Items such as required accuracy (as a function of temperature) of the instruments to be achieved during calibration are supplied to the plant owner as an output of the setpoint calculation results. This information is then incorporated into plant calibration and testing procedures.

This system ensures the equipment is operated in a manner such that the setpoint calculation remains valid. The equipment will then perform conservatively with respect to the safety analysis.

3.2 Technical Specifications

The majority of assumptions are documented in the plant TS. RPS assumptions are entered in TS sections 3.3.1, 3.3.2, 3.3.4, B 3.3.1, B 3.3.2, and B 3.3.4, "Limiting Conditions for Operations", and "Surveillance Requirements". ESFAS assumptions are entered in the corresponding TS sections 3.3.5, 3.3.6, B 3.3.5, and B 3.3.6. Requirements that correspond to setpoint assumptions in these sections include:

1. the frequency of calibrations and the types of testing and calibration

2. the frequency of instrument response time verification and the maximum acceptable response times during testing

3.3 PPS Calibration and Testing Data Guidelines

The channel functional test should be performed on the PPS cabinet as stated in the TS in order to verify that the TSP is within the AV.

3.4 RLVS Calibration

Safety analysis assumptions specific to the RLVS calculations are part of the calibration guidelines. These include, for the VOP trip, ex-core linear neutron detector calibration equipment accuracy, calibration interval and error limits associated with secondary calorimetric evaluations. For the LRCF trip, the assumed primary differential pressure range is provided for the steam generator.

4 REFERENCES

1. ANSI/ISA-S67.04-1994, "Setpoints for Nuclear Safety-Related Instrumentation.", September 1994

2. US NRC Regulatory Guide 1.105, Rev.03, "Setpoints for Safety-Related Instrumentation," December 1999

3. US NRC 10 CFR 50.36, “Technical Specifications.”

4. NUREG-0737, Position 5, "Containment Isolation Dependability," October, 1980

5. NUREG-0800, SRP BTP 7-12, Rev.05, “Guideline on Establishing and Maintaining Instrument Setpoints,” March 2007.

6. USNRC Regulatory Issue Summary RIS 2006-17, “NRC Staff Position on the Requirements of 10 CFR 50.36, “Technical Specifications,” regarding Limiting Safety System Settings during Periodic Testing and Calibration of Instrument Channels,” August, 2006.

7. APR1400-Z-J-NR-14004-P, Rev.0, “Uncertainty Methodology and Application for Instrumentation,” November 2014.

8. APR1400-Z-J-NR-14013-P, Rev.0, “Response Time Analysis of Safety I&C System,” November 2014.

9. APR1400-F-C-NR-14001P, Rev.0, “CPC Setpoint Analysis Methodology for APR1400,” July 2014.

5 DEFINITIONS

Analytical Limit (AL)

Limit of a measured or calculated variable established by the safety analysis to ensure that a safety limit is not exceeded.

Allowable Value (AV)

A limiting value that the trip setpoint may have when tested periodically, beyond which appropriate action shall be taken.

Calibration Error (CE)

The as-left error of a device or loop due to the potential inaccuracy of test equipment used during calibration.

The calibration error is synonymous with “as-left limit” as used in Reference 4.1 and “setting tolerance” as used in Reference 4.6.

Ceiling

Maximum value that the rate limited trip setpoint can have within the allowed range.

Design Basis Event (DBE)

Postulated events used in the design to establish the acceptable performance requirements for the structures, systems, and components.

Diverse Protection System (DPS)

The non-safety system to mitigate the effects of an anticipated transient without scram event characterized by an anticipated operational occurrence followed by a failure of the reactor trip portion of the protection system and assist in the mitigation of the effects of a postulated software common cause failure(CCF) of the PPS and engineered safety feature- component control system (ESF-CCS).

The DPS consists of the reactor-trip function and the ESFAS function. The DPS for reactor-trip function includes all equipment from the sensor output to the reactor trip switch gear (RTSG), and the DPS for ESFAS function includes all equipment from the sensor output to the ESF-CCS component interface module.

ESFAS Signal Delay Time

The time interval from when the monitored parameter exceeds the trip setpoint at the output of the channel sensor until the output of the actuation in ESF-CCS group controller changes its state.

Floor

Minimum value that the rate limited trip setpoint can have within the allowed range.

Limiting Safety System Setting (LSSS)

Settings for automatic protective devices related to those variables having significant safety functions.

The LSSS, which is maintained in the TS, establishes the AV. The LSSS is selected such that fission product physical barriers will not be penetrated or damaged beyond acceptable limits during DBEs.

Plant Protection System (PPS)

The safety system to initiate reactor trip and system-level ESF actuation functions when a safety limit is exceeded by the plant conditions.

The PPS consists of the RPS and the ESFAS. The RPS includes all equipment from the sensor to the RTSG. The ESFAS includes all equipment from the sensor to the ESF-CCS group controller.

Periodic Test Error (PTE)

The as-found error that must be taken into account when the equipment is checked at the end of the periodic surveillance interval in the normal operating environment.

The periodic test error is synonymous with “as-found limit” as used in Reference 4.1.

Rate

Maximum ratio that the rate limited trip setpoint can increase or decrease.

RPS Signal Delay Time

The time interval from when the monitored parameter exceeds the trip setpoint at the output of the channel sensor until electrical power is interrupted to the control element drive mechanism.

Safety Limit

Limits on process variables found necessary to protect the integrity of the fission product physical barriers that guard against the uncontrolled release of radioactivity.

Sensor Response Time

The time interval from when the monitored parameter exceeds the trip setpoint value at the input to the channel sensor until the channel sensor converts the input into the output which is the same as the trip setpoint value.

Step

Difference between the process input signal and the rate limited trip setpoint.

Total Instrument Channel Uncertainty

The total instrument channel uncertainty is the combination of all errors that must be taken into account for event-specific environment such as worst case normal and accident condition.

Trip Setpoint (TSP)

A predetermined value for actuation of the final setpoint device to initiate a protective action.

The TSP is the least conservative value that may be set into the protective equipment and still be consistent with the analytical limit assumptions.

APPENDIX A

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit (AL) : AL1 Non Harsh Environment (NHE)

: AL2 Harsh Environment (HE)

B. Sensor Response Time (SRT): SRT

C. RPS Signal Delay Time (SDT): SDT

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT

II. PPS CABINET UNCERTAINTIES (CU)

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift
H. Processor Module Reference Accuracy
I. Processor Module Temperature Effect
J. Processor Module Drift

CALIBRATION ERROR

[Not Applicable] TS

APPENDIX A

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

TS

PERIODIC TEST ERROR

TS

WORST CASE NORMAL (WCN) ERROR

TS

III. MEASUREMENT CHANNEL UNCERTAINTIES (MCU)

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects :

1. Normal
2. Accident Condition

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect :

1. Background
2. Accident Condition

F. Transmitter Seismic Effect

G. Transmitter Measurement, Test Error

H. APC-S Reference Accuracy

APPENDIX A

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

I. APC-S Drift

J. APC-S Temperature Effect

K. APC-S Power Supply Effect

L. APC-S Seismic Effect

M. APC-S Measurement, Test Error

N. Termination, Splicing Effects

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

APC-S CALIBRATION ERROR

[ ]TS

APC-S PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

MEASUREMENT CHANNEL PERIODIC TEST ERROR

APPENDIX A

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

MEASUREMENT CHANNEL ACCIDENT CONDITION (AC) ERROR

[ ]TS

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine:

PPS Cabinet WCN Error : CU(WCN)

Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V. TOTAL CHANNEL ACCIDENT CONDITION (AC) ERROR

Combine:

PPS Cabinet WCN Error : CU(WCN)

Measurement Channel AC Error : MCU(AC)

[ ]TS

VI. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

APPENDIX A

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

Trip Setpoint = Analytical Limit (AL1) - Total Channel WCN Error
= TSP1

Trip Setpoint = Analytical Limit (AL2) - Total Channel AC Error
= TSP2

Allowable Value = TSP1 or TSP2 + PPS Cabinet PTE

More conservative trip setpoint should be selected to calculate allowable value.

Final Trip Setpoint = Allowable Value - Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the final trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VII. PPS CHANNEL RESPONSE TIMES

A. Transmitter
B. APC-S
C. PPS Cabinet (RPS)
D. Reactor Trip Switchgear

TOTAL CHANNEL RESPONSE TIME :

A + B + C + D (For RPS)

APPENDIX A

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

The actual RPS channel delay time is less than the total analysis response time.

APPENDIX B

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL1 (NHE)
: AL2 (HE)

B. Sensor Response Time : SRT

C. RPS Signal Delay Time: SDT(RPS)

D. ESFAS Signal Delay Time: SDT(ESFAS)

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT (For RPS)
B + D = SRT + SDT (For ESFAS)

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift Effect
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift
H. Processor Module Reference Accuracy
I. Processor Module Temperature Effect
J. Processor Module Drift

APPENDIX B

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

CALIBRATION ERROR

[ ] TS

PERIODIC TEST ERROR

[ ] TS

WORST CASE NORMAL (WCN) ERROR

[ ] TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects :

1. Normal
2. Accident Condition

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect:

1. Background
2. Accident Condition

APPENDIX B

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

F. Transmitter Seismic Effect

G. Transmitter Measurement, Test Error

H. APC-S Reference Accuracy

I. APC-S Drift

J. APC-S Temperature Effect

K. APC-S Power Supply Effect

L. APC-S Seismic Effect

M. APC-S Measurement, Test Error

N. Termination, Splicing Effects

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

APC-S CALIBRATION ERROR

[ ]TS

APC-S PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

APPENDIX B

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

MEASUREMENT CHANNEL ACCIDENT CONDITION (AC) ERROR

[ ]TS

IV.TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine :

PPS Cabinet WCN Error : CU(WCN)

Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V.TOTAL CHANNEL ACCIDENT CONDITION (AC) ERROR

Combine:

PPS Cabinet WCN Error : CU(WCN)

Measurement Channel AC Error : MCU(AC)

APPENDIX B

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

[ ]TS

VI. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit (AL1) + Total Channel WCN Error = TSP1

Trip Setpoint = Analytical Limit (AL2) + Total Channel AC Error = TSP2

Allowable Value = TSP1 or TSP2 - PPS Cabinet PTE

More conservative trip setpoint should be selected to calculate allowable value.

Final Trip Setpoint = Allowable Value + Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VII. PPS CHANNEL RESPONSE TIMES

A. Transmitter
B. APC-S
C. PPS Cabinet (RPS)
D. PPS Cabinet (ESFAS)
E. Reactor Trip Switchgear
F. ESFAS Cabinet Delay Time

TOTAL CHANNEL RESPONSE TIME

APPENDIX B

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

A + B + C + E (For RPS)
A + B + D + F (For ESFAS)

The actual RPS channel delay time is less than the total RPS safety analysis response time.

The actual ESFAS channel delay time is less than the total ESFAS safety analysis response time.

APPENDIX C

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL1 (NHE for RPS)
: AL2 (HE for RPS)
: AL3 (NHE for ESFAS)
: AL4 (HE for ESFAS)

B. Sensor Response Time: SRT

C. RPS Signal Delay Time: SDT (For RPS)

D. ESFAS Signal Delay Time: SDT (For ESFAS)

E. Analysis Nominal Trip Setpoint: ANTS

TOTAL ANALYSIS RESPONSE TIME

B + C = (For RPS)
B + D = (For ESFAS)

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift Effect
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift

APPENDIX C

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

H. Processor Module Reference Accuracy

I. Processor Module Temperature Effect

J. Processor Module Drift

CALIBRATION ERROR

[ ]TS

PERIODIC TEST ERROR

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects :

1. Normal

2. Accident Condition

APPENDIX C

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect :

 1. Background

 2. Accident Condition

F. Transmitter Seismic Effect

G. Transmitter Measurement Test Error

H. APC-S Reference Accuracy

I. APC-S Drift

J. APC-S Temperature Effect

K. APC-S Power Supply Effect

L. APC-S Seismic Effect

M. APC-S Measurement, Test Error

N. Termination, Splicing Effects

O. Transmitter Static Pressure Effect

P. Transmitter Reference Leg Errors

Q. Transmitter Dynamic Flow Error

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

APC-S CALIBRATION ERROR

[ ]TS

APPENDIX C

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

APC-S PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

MEASUREMENT CHANNEL ACCIDENT CONDITION (AC) ERROR (FOR NON-Loss of Coolant Accident (LOCA) EVENTS)

[ ]TS

MEASUREMENT CHANNEL ACCIDENT CONDITION (AC) ERROR (FOR LOCA EVENTS)

[ ]TS

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

APPENDIX C

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

Combine:

A. PPS Cabinet WCN Error : CU(WCN)

B. Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V. TOTAL CHANNEL ACCIDENT CONDITION (AC) ERROR (FOR NON-LOCA EVENTS)

Combine:

A. PPS Cabinet WCN Error : CU(WCN)

B. Measurement Channel AC Error : MCU(AC_NON LOCA)

[ ]TS

VI. TOTAL CHANNEL ACCIDENT CONDITION (AC) ERROR (FOR LOCA EVENTS)

Combine:

A. PPS Cabinet WCN Error : CU(WCN)

B. Measurement Channel AC Error : MCU(AC_LOCA)

[ ]TS

VII. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

A. For RPS

APPENDIX C

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

Trip Setpoint = Analytical Limit (AL1) + Total Channel WCN Error = TSP1

Trip Setpoint = Analytical Limit (AL2) + Total Channel AC Error = TSP2

Allowable Value = TSP1 or TSP2 - PPS Cabinet PTE

More conservative trip setpoint should be selected to calculate allowable value.

Final Trip Setpoint = Allowable Value - Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the final trip setpoint is offset from the calculated allowable value.

The more conservative value between the final trip setpoint and the analysis nominal trip setpoint should be determined as the new trip setpoint.

In case the analysis nominal trip setpoint is determined as the new trip setpoint, the new allowable value is determined by subtracting offset from the new trip setpoint.

B. For AFAS

Trip Setpoint = Analytical Limit (AL3) + Total Channel WCN Error

Trip Setpoint = Analytical Limit (AL4) + Total Channel AC Error

Allowable Value = AL3 or AL4 - PPS Cabinet PTE

More conservative trip setpoint should be selected to calculate allowable value.

APPENDIX C

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

Final Trip Setpoint = Allowable Value - Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the final trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VIII. PPS RESPONSE TIMES

A. Transmitter
B. APC-S
C. PPS Cabinet (RPS)
D. PPS Cabinet (ESFAS)
E. Reactor Trip Switchgear
F. ESFAS Cabinet Delay Time

TOTAL CHANNEL RESPONSE TIME

A + B + C + E (For RPS)
A + B + D + F (For ESFAS)

The actual RPS channel delay time is less than the total Analysis Response Time.

The actual ESFAS channel delay time is less than the total Analysis Response Time.

APPENDIX D

STEAM GENERATOR LEVEL - HIGH

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL (NHE)

B. Sensor Response Time: SRT

C. RPS Signal Delay Time: SDT(RPS)

D. ESFAS Signal Delay Time: SDT(ESFAS)

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT(RPS)

B + D = SRT + SDT(ESFAS)

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift Effect
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift
H. Processor Module Reference Accuracy
I. Processor Module Temperature Effect
J. Processor Module Drift

CALIBRATION ERROR

APPENDIX D

STEAM GENERATOR LEVEL - HIGH

TRIP SETPOINT CALCULATION

[ ]TS

PERIODIC TEST ERROR

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects:

1. Normal
2. Accident Condition

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect:

1. Background
2. Accident Condition

F. Transmitter Seismic Effect

APPENDIX D

STEAM GENERATOR LEVEL - HIGH

TRIP SETPOINT CALCULATION

G. Transmitter Measurement Test Error

H. Static Pressure Effect

I. Termination, Splicing Effects

J. Reference Leg Effect

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine:

APPENDIX D

STEAM GENERATOR LEVEL - HIGH

TRIP SETPOINT CALCULATION

PPS Cabinet WCN Error : CU(WCN)

Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V.TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit (AL) - Total Channel WCN Error = TSP

Allowable Value = TSP + PPS Cabinet PTE

Final Trip Setpoint = Allowable Value - Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VI. PPS CHANNEL RESPONSE TIMES

A. Transmitter
B. PPS Cabinet (RPS)
C. PPS Cabinet (ESFAS)
D. Reactor Trip Switchgear
E. ESFAS Cabinet Delay Time

TOTAL CHANNEL RESPONSE TIME

A + B + E (For RPS)

APPENDIX D

STEAM GENERATOR LEVEL - HIGH

TRIP SETPOINT CALCULATION

A + C + E (For ESFAS)

The actual RPS channel delay time is less than the total analysis response time.

The actual ESFAS channel delay time is less than the total analysis response time.

APPENDIX E

STEAM GENERATOR PRESSURE - LOW

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL1 (NHE)
: AL2 (HE)

B. Sensor Response Time: SRT

C. RPS Signal Delay Time: SDT(RPS)

D. ESFAS Signal Delay Time: SDT(ESFAS)

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT(RPS)
B + D = SRT + SDT(ESFAS)

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift Effect
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift
H. Processor Module Reference Accuracy
I. Processor Module Temperature Effect
J. Processor Module Drift

APPENDIX E

STEAM GENERATOR PRESSURE - LOW

TRIP SETPOINT CALCULATION

CALIBRATION ERROR

[ ] TS

PERIODIC TEST ERROR

[ ] TS

WORST CASE NORMAL (WCN) ERROR

[ ] TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects :

1. Normal
2. Accident Condition

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect :

1. Background
2. Accident Condition

APPENDIX E

STEAM GENERATOR PRESSURE - LOW

TRIP SETPOINT CALCULATION

F. Transmitter Seismic Effect
G. Transmitter Measurement, Test Error
H. APC-S Reference Accuracy
I. APC-S Drift
J. APC-S Temperature Effect
K. APC-S Power Supply Effect
L. APC-S Seismic Effect
M. APC-S Measurement, Test Effect
N. Termination, Splicing Effects

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

APC-S CALIBRATION ERROR

[ ]TS

APC-S PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

APPENDIX E

STEAM GENERATOR PRESSURE - LOW

TRIP SETPOINT CALCULATION

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

MEASUREMENT CHANNEL ACCIDENT CONDITION (AC) ERROR

[ ]TS

IV.TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine :

PPS Cabinet WCN Error : CU(WCN)
Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V.TOTAL CHANNEL ACCIDENT CONDITION (AC) ERROR

Combine:

PPS Cabinet WCN Error : CU(WCN)
Measurement Channel AC Error : MCU(AC)

APPENDIX E

STEAM GENERATOR PRESSURE - LOW

TRIP SETPOINT CALCULATION

[ ]TS

VI. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit (AL1) + Total Channel WCN Error = TSP1

Trip Setpoint = Analytical Limit (AL2) + Total Channel AC Error = TSP2

Allowable Value = TSP1 or TSP2 - PPS Cabinet PTE

More conservative trip setpoint should be selected to calculate allowable value.

Final Trip Setpoint = Allowable Value + Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may set by engineering judgment.

VII. PPS CHANNEL RESPONSE TIMES

A. Transmitter
B. APC-S
C. PPS Cabinet (RPS)
D. PPS Cabinet (ESFAS)
E. Reactor Trip Switchgear
F. ESFAS Cabinet Delay Time

TOTAL CHANNEL RESPONSE TIME

APPENDIX E

STEAM GENERATOR PRESSURE - LOW

TRIP SETPOINT CALCULATION

A + B + C + E (For RPS)

A + B + D + F (For ESFAS)

The actual RPS channel delay time is less than the total Analysis Response Time.

The actual ESFAS channel delay time is less than the total Analysis Response Time.

APPENDIX F

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL (HE)

B. Sensor Response Time: SRT

C. RPS Signal Delay Time: SDT(RPS)

D. ESFAS Signal Delay Time: SDT(ESFAS)

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT(RPS)
B + D = SRT + SDT(ESFAS)

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift Effect
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift
H. Processor Module Reference Accuracy
I. Processor Module Temperature Effect
J. Processor Module Drift

CALIBRATION ERROR

APPENDIX F

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

[ ]TS

PERIODIC TEST ERROR

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect

F. Transmitter Seismic Effect

G. Transmitter Measurement Test Error

TRANSMITTER CALIBRATION ERROR

APPENDIX F

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine:

PPS Cabinet WCN Error : CU(WCN)
Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

APPENDIX F

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

A. Starting from 0.0 cm H_20, the lowest possible value that would not interfere with operation unnecessarily is calculated.

a. Analytical Limit: 0.0 cm H_20
b. Positive Containment Pressure Limit
c. Containment Pressure Spike:
d. Total Channel Error:

Low Trip Setpoint Limit = a + b + c + d = TSP1

The above method is used additionally to satisfy the early actuation requirements of NUREG-0737.

B. Starting from AL, the highest possible value that will guarantee a reactor trip when required is calculated.

a. Analytical Limit
b. Negative Containment Pressure Limit
c. Total Channel Error

High Trip Setpoint Limit = a + b + c = TSP2

Allowable Value = TSP1 or TSP2 + PPS Cabinet PTE

More conservative trip setpoint should be selected to calculate allowable value.

Final Trip Setpoint = Allowable Value + Offset

APPENDIX F

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VI. PPS CHANNEL RESPONSE TIMES

A. Transmitter
B. PPS Cabinet (RPS)
C. PPS Cabinet (ESFAS)
D. Reactor Trip Switchgear
E. ESFAS Cabinet Delay Time

TOTAL CHANNEL RESPONSE TIME

A + B + D (For RPS)
A + C + E (For ESFAS)

The actual RPS channel delay time is less than the total analysis response time.

The actual ESFAS channel delay time is less than the total analysis response time.

APPENDIX G

VARIABLE OVERPOWER - HIGH

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limits

Ceiling : AL1 (HE)
Rate : AL2 (HE)
Step : AL3 (HE)

B. Sensor Response Time: SRT

C. RPS Signal Delay Time: SDT

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT (For RPS)

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift Effect
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift
H. Processor Module Reference Accuracy
I. Processor Module Temperature Effect
J. Processor Module Drift

APPENDIX G

VARIABLE OVERPOWER - HIGH

TRIP SETPOINT CALCULATION

CALIBRATION ERROR

[ ] TS

PERIODIC TEST ERROR

[ ] TS

WORST CASE NORMAL (WCN) ERROR

[ ] TS

III. PROCESS EQUIPMENT UNCERTAINTIES

A. Calibration Equipment Uncertainty

B. CPC Calibration Error

C. CPC Long Term Drift

D. CPC Temperature Effects

1. Ambient

2. Worst Case Normal

E. Gain Error

F. Power Supply Effect

G. Detector Non-linearity

APPENDIX G

VARIABLE OVERPOWER - HIGH

TRIP SETPOINT CALCULATION

H. Power Signal Accuracy

1. Ambient
2. Worst Case Normal

CALIBRATION ERROR

[ ]TS

PERIODIC TEST ERROR

[ ]TS

WORST CASE NORMAL / ACCIDENT CONDITION ERROR

[ ]TS

The factors which are considered in process equipment uncertainties may change according to the process equipment applied.

IV. TOTAL CHANNEL ERROR

Combine :

A. PPS Cabinet WCN Error : CU(WCN)
B. Process Equipment WCN Error : MCU(WCN/AC)
C. Calorimetric Uncertainty : CAL

[ ]TS

APPENDIX G

VARIABLE OVERPOWER - HIGH

TRIP SETPOINT CALCULATION

V.SETPOINT, ALLOWABLE VALUE, PRETRIP OFFSET

1. CEILING :

   Setpoint = Analytical Limit (AL1) - Total Channel Error
   = SP1

   Allowable Value = SP1 + PPS Cabinet PTE

   To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value.

   The pretrip offset may be determined by engineering judgment.

2. RATE :

   Setpoint = Analytical Limit (AL2)
   = SP2

   Allowable Value = SP2

3. STEP :

   Setpoint = Analytical Limit (AL3) - PPS Cabinet PTE
   = SP3

   Allowable Value = SP3 + PPS Cabinet PTE

VI. PPS CHANNEL RESPONSE TIMES

APPENDIX G

VARIABLE OVERPOWER - HIGH

TRIP SETPOINT CALCULATION

A. Process Equipment

B. PPS Cabinet (RPS)

C. Reactor Trip Switchgear

TOTAL CHANNEL RESPONSE TIME

A + B + C (For RPS)

The actual RPS channel delay time is less than the total analysis response time.

APPENDIX H

LOGARITHMIC POWER LEVEL - HIGH

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL (NHE)

B. Sensor Response Time : SRT

C. RPS Signal Delay Time : SDT

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT (For RPS)

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift Effect
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift
H. Processor Module Reference Accuracy
I. Processor Module Temperature Effect
J. Processor Module Drift

CALIBRATION ERROR

[ ]TS

APPENDIX H

LOGARITHMIC POWER LEVEL - HIGH

TRIP SETPOINT CALCULATION

[ ]TS

PERIODIC TEST ERROR

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

III. PROCESS EQUIPMENT UNCERTAINTIES

A. Calibration Equipment Uncertainty

B. Detector Non-linearity

C. Static/Calibration Error

D. Long Term Drift

E. Temperature Effects :

1. Ambient

2. Worst Case Normal

CALIBRATION ERROR

[ ]TS

PERIODIC TEST ERROR

APPENDIX H

LOGARITHMIC POWER LEVEL - HIGH

TRIP SETPOINT CALCULATION

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

The factors which are considered in process equipment uncertainties may change according to the process equipment applied.

IV. TOTAL CHANNEL ERROR

Combine:

A. PPS Cabinet WCN Error : CU(WCN)
B. Process Equipment WCN Error : MCU(WCN)

[ ]TS

V. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit(AL) - Total Channel Error
= TSP

Allowable Value = TSP + PPS Cabinet PTE

Final Trip Setpoint = Allowable Value - Offset

APPENDIX H

LOGARITHMIC POWER LEVEL - HIGH

TRIP SETPOINT CALCULATION

To reduce the possibility that a periodic test result exceeds the allowable value, the final trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VI. PPS CHANNEL RESPONSE TIMES

A. Process Equipment
B. PPS Cabinet (RPS)
C. Reactor Trip Switchgear

TOTAL CHANNEL RESPONSE TIME

A + B + C (For RPS)

The actual RPS channel delay time is less than the total analysis response time.

APPENDIX I

CONTAINMENT PRESSURE HIGH - HIGH

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL (HE)

B. Total Analysis Response Time (TART) : TART

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Termination Unit Reference Accuracy
C. Termination Unit Temperature Effect
D. Termination Unit Drift Effect
E. Analog Input (A/I) Reference Accuracy
F. Analog Input (A/I) Temperature Effect
G. Analog Input (A/I) Drift
H. Processor Module Reference Accuracy
I. Processor Module Temperature Effect
J. Processor Module Drift

CALIBRATION ERROR

[ ]TS

PERIODIC TEST ERROR

[ ]TS

APPENDIX I

CONTAINMENT PRESSURE HIGH - HIGH

TRIP SETPOINT CALCULATION

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy
B. Transmitter Drift
C. Transmitter Temperature Effects
D. Transmitter Power Supply Effect
E. Transmitter Radiation Effect
F. Transmitter Seismic Effect
G. Transmitter Measurement Test Error

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

APPENDIX I

CONTAINMENT PRESSURE HIGH - HIGH

TRIP SETPOINT CALCULATION

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine:

PPS Cabinet WCN Error : CU(WCN)
Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit (AL) - Total Channel Error
= TSP

Allowable Value = TSP + PPS Cabinet PTE

Final Trip Setpoint = Allowable Value - Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value by about 0.5 percent of span.

APPENDIX I

CONTAINMENT PRESSURE HIGH - HIGH

TRIP SETPOINT CALCULATION

The pretrip setpoint may be determined by engineering judgment.

VI. PPS CHANNEL RESPONSE TIMES

A. Transmitter

B. PPS Cabinet (ESFAS)

C. ESFAS Cabinet Delay Time

TOTAL CHANNEL RESPONSE TIME

A + B + C (For ESFAS)

The actual ESFAS channel delay time is less than the total Analysis Response Time.

APPENDIX J

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL (NHE)

B. Sensor Response Time: SRT

C. DPS Signal Delay Time: SDT

D. Analysis Nominal Trip Setpoint: ANTS

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT (For DPS Reactor Trip)

II. DPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Analog Input (A/I) Reference Accuracy
C. Analog Input (A/I) Temperature Effect
D. Analog Input (A/I) Drift
E. Processor Module Reference Accuracy
F. Processor Module Temperature Effect
G. Processor Module Drift

CALIBRATION ERROR

[ ]TS

APPENDIX J

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

[ ] TS

PERIODIC TEST ERROR

[ ] TS

WORST CASE NORMAL (WCN) ERROR

[ ] TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect

F. Transmitter Measurement Test Error

G. Isolator Reference Accuracy

H. Isolator Drift

I. Isolator Temperature Effect

J. Isolator Power Supply Effect

K. Isolator Seismic Effect

L. Isolator Measurement, Test Error

APPENDIX J

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

ISOLATOR CALIBRATION ERROR

[ ]TS

ISOLATOR PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

APPENDIX J

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine:

DPS Cabinet WCN Error : CU(WCN)

Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit (AL) - Total Channel WCN Error

= TSP

Allowable Value = TSP + DPS Cabinet PTE

Final Trip Setpoint = Allowable Value - Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

The analysis nominal trip setpoint used conservatively in the safety analysis report is determined as the new trip setpoint to reduce the possibility that the DPS trip setpoint is lower than that of the PPS. The new allowable value is determined by adding offset from the new trip setpoint.

APPENDIX J

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - HIGH

TRIP SETPOINT CALCULATION

VI. DPS CHANNEL RESPONSE TIMES

A. Transmitter

B. DPS Cabinet

C. Reactor Trip Switch Gear

TOTAL CHANNEL RESPONSE TIME

A + B + C (For DPS)

This DPS channel delay time satisfies the total Analysis Response Time.

APPENDIX K

DIVERSE PROTECTION SYSTEM

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL (NHE)

B. Sensor Response Time: SRT

C. DPS Signal Delay Time: SDT

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT (For DPS Auxiliary Feedwater)

II. DPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Analog Input (A/I) Reference Accuracy
C. Analog Input (A/I) Temperature Effect
D. Analog Input (A/I) Drift
E. Processor Module Reference Accuracy
F. Processor Module Temperature Effect
G. Processor Module Drift

CALIBRATION ERROR

[ ]TS

[ ]TS

APPENDIX K

DIVERSE PROTECTION SYSTEM

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

PERIODIC TEST ERROR

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy
B. Transmitter Drift
C. Transmitter Temperature Effects
D. Transmitter Power Supply Effect
E. Transmitter Radiation Effect
F. Transmitter Measurement Test Error
G. Transmitter Static Pressure Effect
H. Isolator Reference Accuracy
I. Isolator Drift
J. Isolator Temperature Effect
K. Isolator Power Supply Effect
L. Isolator Seismic Effect
M. Isolator Measurement, Test Error

APPENDIX K

DIVERSE PROTECTION SYSTEM

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

ISOLATOR CALIBRATION ERROR

[ ]TS

ISOLATOR PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

APPENDIX K

DIVERSE PROTECTION SYSTEM

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine:

DPS Cabinet WCN Error : CU(WCN)

Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit (AL) + Total Channel WCN Error

= TSP

Allowable Value = TSP - DPS Cabinet PTE

Final Trip Setpoint = Allowable Value + Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VI. DPS CHANNEL RESPONSE TIMES

A. Transmitter

B. DPS Cabinet

TOTAL CHANNEL RESPONSE TIME

APPENDIX K

DIVERSE PROTECTION SYSTEM

STEAM GENERATOR LEVEL - LOW

TRIP SETPOINT CALCULATION

A + B (For DPS)

The actual DPS channel delay time is less than the total analysis response time.

APPENDIX L

DIVERSE PROTECTION SYSTEM

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL (NHE)

B. Sensor Response Time : SRT

C. DPS Signal Delay Time : SDT

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT (For DPS Reactor Trip)

II. DPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Analog Input (A/I) Reference Accuracy
C. Analog Input (A/I) Temperature Effect
D. Analog Input (A/I) Drift
E. Processor Module Reference Accuracy
F. Processor Module Temperature Effect
G. Processor Module Drift

CALIBRATION ERROR

[ ]TS

[ ]TS

APPENDIX L

DIVERSE PROTECTION SYSTEM

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

PERIODIC TEST ERROR

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects

D. Transmitter Power Supply Effect

E. Transmitter Measurement, Test Error

F. Isolator Reference Accuracy

G. Isolator Drift

H. Isolator Temperature Effects

I. Isolator Power Supply Effect

J. Isolator Seismic Effect

K. Isolator Measurement, Test Error

TRANSMITTER CALIBRATION ERROR

APPENDIX L

DIVERSE PROTECTION SYSTEM

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

ISOLATOR CALIBRATION ERROR

[ ]TS

ISOLATOR PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

APPENDIX L

DIVERSE PROTECTION SYSTEM

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

Combine:

DPS Cabinet WCN Error : CU(WCN)
Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit (AL) - Total Channel WCN Error
= TSP

Allowable Value = TSP + DPS Cabinet PTE

Final Trip Setpoint = Allowable Value – Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the final trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VI. DPS CHANNEL RESPONSE TIMES

A. Transmitter
B. DPS Cabinet
C. Reactor Trip Switch Gear

TOTAL CHANNEL RESPONSE TIME

APPENDIX L

DIVERSE PROTECTION SYSTEM

CONTAINMENT PRESSURE - HIGH

TRIP SETPOINT CALCULATION

A + B + C (For DPS)

This DPS channel delay time satisfies the total analysis response time.

APPENDIX M

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limit : AL (NHE)

: AL (HE)

B. Sensor Response Time : SRT

C. DPS Signal Delay Time : SDT

TOTAL ANALYSIS RESPONSE TIME

B + C = SRT + SDT (For DPS SIAS)

II. DPS CABINET UNCERTAINTIES

A. Measurement Test Error
B. Analog Input (A/I) Reference Accuracy
C. Analog Input (A/I) Temperature Effect
D. Analog Input (A/I) Drift
E. Processor Module Reference Accuracy
F. Processor Module Temperature Effect
G. Processor Module Drift

CALIBRATION ERROR

[ ]TS

APPENDIX M

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

[ ]TS

PERIODIC TEST ERROR

[ ]TS

WORST CASE NORMAL (WCN) ERROR

[ ]TS

III. MEASUREMENT CHANNEL UNCERTAINTIES

A. Transmitter Reference Accuracy

B. Transmitter Drift

C. Transmitter Temperature Effects

1. Normal
2. Accident Condition

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect

1. Background
2. Accident Condition

F. Transmitter Measurement Test Error

G. Transmitter Static Pressure Effect

APPENDIX M

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

H. Isolator Reference Accuracy

I. Isolator Drift

J. Isolator Temperature Effect

K. Isolator Power Supply Effect

L. Isolator Seismic Effect

M. Isolator Measurement Test Error

N. Termination, Splicing Effects

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

ISOLATOR CALIBRATION ERROR

[ ]TS

ISOLATOR PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL CALIBRATION ERROR

[ ]TS

APPENDIX M

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

MEASUREMENT CHANNEL PERIODIC TEST ERROR

[ ]TS

MEASUREMENT CHANNEL WORST CASE NORMAL (WCN) ERROR

[ ]TS

MEASUREMENT CHANNEL ACCIDENT CONDITION (AC) ERROR

[ ]TS

IV. TOTAL CHANNEL WORST CASE NORMAL (WCN) ERROR WITH SEISMIC

Combine:

DPS Cabinet WCN Error : CU(WCN)

Measurement Channel WCN Error : MCU(WCN)

[ ]TS

V. TOTAL CHANNEL ACCIDENT CONDITION (AC) ERROR

Combine:

DPS Cabinet WCN Error : CU(WCN)

Measurement Channel AC Error : MCU(AC)

APPENDIX M

DIVERSE PROTECTION SYSTEM

PRESSURIZER PRESSURE - LOW

TRIP SETPOINT CALCULATION

[ ]TS

VI. TRIP SETPOINT, ALLOWABLE VALUE, PRETRIP SETPOINT

Trip Setpoint = Analytical Limit (AL1) + Total Channel WCN Error
= TSP

Trip Setpoint = Analytical Limit (AL2) + Total Channel AC Error
= TSP2

Allowable Value = TSP1 or TSP2 - DPS Cabinet PTE

Final Trip Setpoint = Allowable Value + Offset

To reduce the possibility that a periodic test result exceeds the allowable value, the trip setpoint is offset from the calculated allowable value.

The pretrip setpoint may be determined by engineering judgment.

VII. DPS CHANNEL RESPONSE TIMES

A. Transmitter

B. DPS Cabinet

TOTAL CHANNEL RESPONSE TIME

A + B (For DPS)

The actual DPS channel delay time is less than the total Analysis Response Time.

APPENDIX N

REACTOR COOLANT FLOW - LOW

TRIP SETPOINT CALCULATION

I. ANALYSIS VALUES

A. Analytical Limits : AL1 (NHE)

: AL2 (HE)

B. Signal Delay Time : SDT1

: SDT2

The trip function parameters STEP, RATE and FLOOR are derived from the analytical limits. The total response time is also derived from the analysis signal delay time. These parameters serve as the safety analysis basis for the installed setpoint values. Units are full power differential pressure across the primary side of the steam generator.

Parameter Derived value setpoint (DSP)

1. FLOOR DSP1
2. STEP DSP2
3. RATE DSP3

TOTAL DERIVED RESPONSE TIME (DRT)

DRT1

DRT2

II. PPS CABINET UNCERTAINTIES

A. Measurement Test Error

B. Termination Unit Reference Accuracy

C. Termination Unit Temperature Effect

APPENDIX N

REACTOR COOLANT FLOW - LOW

TRIP SETPOINT CALCULATION

D. Termination Unit Drift Effect

E. Analog Input (A/I) Reference Accuracy

F. Analog Input (A/I) Temperature Effect

G. Analog Input (A/I) Drift

H. Processor Module Reference Accuracy

I. Processor Module Temperature Effect

J. Processor Module Drift

CALIBRATION ERROR

[ ] TS

PERIODIC TEST ERROR

[ ] TS

WORST CASE NORMAL (WCN) ERROR

[ ] TS

III. PROCESS EQUIPMENT UNCERTAINTIES

A. Transmitter Reference Accuracy

APPENDIX N

REACTOR COOLANT FLOW - LOW

TRIP SETPOINT CALCULATION

B. Transmitter Drift

C. Transmitter Temperature Effect

D. Transmitter Power Supply Effect

E. Transmitter Radiation Effect

F. Transmitter Measurement, Test Error

TRANSMITTER CALIBRATION ERROR

[ ]TS

TRANSMITTER PERIODIC TEST ERROR

[ ]TS

PROCESS EQUIPMENT CALIBRATION ERROR

[ ]TS

PROCESS EQUIPMENT PERIODIC TEST ERROR

[ ]TS

PROCESS EQUIPMENT WORST CASE NORMAL ERROR

[ ]TS

Long term errors such as drift, temperature effects, radiation effects and seismic effects are not used to calculate the process equipment signal errors because of the ability of the trip setpoint to follow the process. Only the accuracy of the process equipment and its calibration equipment is used. Under worst case nonlinear conditions, the process equipment error component could be

APPENDIX N

REACTOR COOLANT FLOW - LOW

TRIP SETPOINT CALCULATION

increased by a factor of two. Consequently, the error used is twice the process equipment (PE) accuracy.

IV. TOTAL CHANNEL ERROR FOR FLOOR AND STEP

Combine:

A. PPS Cabinet Worst Case Normal Error: CU(WCN)

B. PE Worst Case Normal Error : MCU(WCN)

[ ]TS

V. SETPOINT, ALLOWABLE VALUE, PRETRIP BAND

1. FLOOR :

Setpoint = Derived Setpoint (DSP1) + Total Channel Error

= SP1

Allowable Value = SP1 - PPS Cabinet PTE

Final Setpoint = Allowable Value + Offset

2. RATE :

Setpoint = Derived Setpoint (DSP2)

= SP2

Allowable Value = SP2

APPENDIX N

REACTOR COOLANT FLOW - LOW

TRIP SETPOINT CALCULATION

3. STEP :

Setpoint = Derived Setpoint (DSP3) - Total Channel Error

= SP3

Allowable Value = SP3 + PPS Cabinet PTE

Final Setpoint = Allowable Value - Offset

The pretrip setpoint may be determined by engineering judgment

VI. PPS CHANNEL RESPONSE TIMES

A. Transmitter
B. PPS Cabinet (RPS)
C. Reactor Trip Switch Gear

TOTAL CHANNEL RESPONSE TIME

A + B + C (For RPS)

This is less than the derived response time.