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Description:
SA S67.04 METHODS FOR DETERMINING TRIP SETPOINTS AND ALLOWABLE VALUES FOR SAFETY-RELATED INSTRUMENTATION

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December 5, 2003

Mr. Eric Leeds
Deputy Director, Division of Licensing Project Management
Office of Nuclear Reactor Regulation
Washington, DC 20555-0001

Subject: SA S67.04 Methods for Determining Trip Setpoints and Allowable Values for Safety-Related Instrumentation

The purpose of this letter is twofold. First, it addresses licensing-process issues associated with NRC review of License Amendment Requests (LARs) pertaining to trip setpoints and allowable values for safety related instrumentation. Second, it addresses technical issues pertaining to the determination of trip setpoints and allowable values using ISA-S67.04-1994, "Setpoints for Nuclear Safety-Related Instrumentation," and allowable values using Method 3 of ISA-RP67.04-1994, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation." Regulatory endorsement of ISA-S67.04-1994 is contained in Regulatory Guide 1.105, Revision 3, "Setpoints for Safety-Related Instrumentation."

With respect to license amendments, a number of licensees have been informed by their NRC project managers that the staff does not plan to review LARs based on ISA-RP67.04 Method 3, even if that method is the current licensing basis for protection system instrumentation setpoints and allowable values (which is the case for approximately 75 domestic nuclear units). This licensing approach is having a significant effect on licensee plans and schedules for implementing operational and safety improvements. We believe that changing from one setpoint methodology to another will impact plant operating and/or safety margins at an average estimated cost of $1,000,000 per site. Consistent with NRC regulations and regulatory guidance, NEI requests that the staff process setpoint-related LARs in accordance with plant-specific licensing bases pending generic resolution of NRC concerns with Method 3.

With respect to technical issues, NEI, through its Setpoint Methods Task Force (SMTF), is prepared to work with NRC to resolve generic concerns with ISA-RP67.04 Method 3. During a public meeting held on October 8th, we requested that NRC provide a "problem statement" to support the issue-resolution process. Subsequently, the SMTF has prepared the enclosed technical White Paper to provide the industry perspective on the regulatory requirements and technical bases associated with the trip setpoint and allowable value determination process for protection system instrumentation. The paper finds that the setpoint and allowable value determination requirements defined by ISA-S67.04-1994 are acceptable and that the allowable value Method 3 guidance provided by ISA-RP67.04-1994 is acceptable. The paper concludes that licensee use of setpoints and allowable values established using these requirements and guidance does not raise any safety issues. NRC comments on the technical White Paper are requested as soon as practicable.

If you have questions or require additional information, please contact Mike Schoppman at (202) 739-8011; mas@nei.org.

Sincerely,

Alex Marion

Alex Marion

Enclosure

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NEI WHITE PAPER

ISA S67.04 METHODS FOR DETERMINING TRIP SETPOINTS AND ALLOWABLE VALUES FOR SAFETY-RELATED INSTRUMENTATION

DECEMBER 2003

ACKNOWLEDGEMENTS

NEI ACKNOWLEDGES THE ASSISTANCE OF THE "SETPOINT METHODS TASK FORCE" IN PREPARING THIS TECHNICAL WHITE PAPER. THE LICENSING ASPECTS OF DETERMINING TRIP SETPOINTS AND ALLOWABLE VALUES (REGULATORY INTERPRETATIONS, LICENSING BASES, AND TECHNICAL SPECIFICATIONS) ARE NOT ADDRESSED BY THIS PAPER.

<u>NEI SETPOINT METHODS TASK FORCE</u>

Jim Andrachek – Westinghouse Owners Group
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Don Hoffman – Joint Owners Group Technical Specification Subcommittee
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TABLE OF CONTENTS

ISA S67.04 METHODS FOR DETERMINING TRIP SETPOINTS AND ALLOWABLE VALUES FOR SAFETY-RELATED INSTRUMENTATION

1.0 INTRODUCTION / PURPOSE

Each commercial nuclear power plant is equipped with instrumentation and controls to monitor and maintain system process parameter variables (e.g., temperature, pressure, flow, level) within prescribed operating ranges during normal operation. The process instrumentation also provides inputs to the reactor trip system and engineered safety feature actuation system voting logic when predefined limits (i.e., setpoints) are exceeded. The reactor trip system provides automatic protection signals to assure fuel and cooling system design / safety limits are not exceeded during normal operation and anticipated operational occurrences (AOOs). The engineered safety features actuation system provides automatic protection signals to initiate the protective components and systems that guard against the uncontrolled release of radioactive materials to the environment. The protection system instrument loops (i.e., channels) and voting logic are safety-related equipment, and the minimum design requirements are defined by 10 CFR 50 Appendix A General Design Criterion 13 and 20 – 29 [Reference 1] and 10 CFR 50.55a(h) [Reference 2]. The instrument channel setting requirements are defined by 10 CFR 50.36 [Reference 3].

The engineering procedure for selecting the protection system instrument channel setpoints is a rigorous process. This paper describes the regulatory requirements and technical bases for the protection system instrumentation trip setpoint and allowable value determination process.

2.0 DEFINITIONS

2.1 SAFETY LIMIT DEFINITIONS

10 CFR 50.36(c)(1)(i)(A) [Reference 3] defines the Safety Limit (SL) as:

> Safety limits for nuclear reactors are limits upon important process variables that are found to be necessary to reasonably protect the integrity of certain of the physical barriers that guard against the uncontrolled release of radioactivity.

In concert with 10 CFR 50.36, ISA-S67.04-1994 Part I Section 3.16 [Reference 4] defines SL as:

> A limit on an important process variable that is necessary to reasonably protect the integrity of physical barriers that guard against the uncontrolled release of radioactivity.

SLs are used as acceptance criteria in the plant transient and accident (i.e., safety) analyses. Some SLs such as peak centerline fuel temperature and/or reactor coolant system pressure are also listed in the plant Technical Specifications (TS). Physical fission product barriers with assigned SLs include the fuel cladding, fuel pellet, and reactor coolant system pressure boundary.

2.2 ANALYTICAL LIMIT DEFINITION

ISA-S67.04-1994 Part I Section 3.2 [Reference 4] defines Analytical Limit (AL) as:

> [A] limit of a measured or calculated variable established by the safety analysis to ensure that a safety limit is not exceeded.

The AL is the assumed setpoint value of a given process parameter variable at which the analysis models the initiation of the instrument channel protective action. ALs are documented in the safety analyses calculations. Some ALs are listed in the Updated Final Safety Analysis Report (UFSAR). Performance of safety analyses with conservative ALs demonstrates that the established SLs and other acceptance criteria are not exceeded during normal plant transients and AOOs.

2.3 TRIP SETPOINT DEFINITIONS

10 CFR 50.36(c)(1)(ii)(A) [Reference 3] defines the Limiting Safety System Setting (LSSS) as a protection channel setting. Specifically:

> 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.

In concert with 10 CFR 50.36, ISA-S67.04-1994 Part I Section 3.20 [Reference 4] defines the instrument channel setting (i.e., the Trip SetPoint (TSP)) as:

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

The TSP provides the basis of the scaled-calibration value used to adjust (i.e., set) the final setpoint device / module of a given instrument channel during channel calibration. Thus, the TSP is the setting of the final setpoint device. TSPs are documented in instrument setpoint uncertainty calculations and instrument scaling calculations. TSPs should be listed in the plant TS and/or other controlled documents. The TSP equivalent scaled-calibration values are provided in the plant calibration procedures used to implement the TSP.

2.4 ALLOWABLE VALUE DEFINITION

ISA-S67.04-1994 Part I Section 3.1 [Reference 4] defines the Allowable Value (AV) as:

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

The AV provides the basis of the scaled-surveillance criterion used to check the TSP of a given instrument channel during a periodic surveillance (e.g., a Channel Calibration or a Channel Operational Test (COT)). The AV is not a setting but the surveillance test acceptance criterion. Such surveillance performance checks may include the entire instrument channel or a portion of the channel such as the rack signal processing modules and the final setpoint device. AVs are documented in instrument setpoint uncertainty calculations and instrument scaling calculations. AVs are normally listed in the plant TS. The AV equivalent scaled-surveillance criteria are provided in the plant surveillance test procedures.

3.0 TRIP SETPOINT DETERMINATION

3.1 TRIP SETPOINT REQUIREMENTS

Each TSP must be conservative with respect to its AL. In this context, *conservative* means that a given TSP must assure that the final setpoint device will initiate a protective action before the monitored process parameter variable exceeds the AL. Therefore, all potential instrument channel errors must be considered. Instrument channel error examples include: process parameter measurement effects; accident environmental effects; normal environmental effects; calibration accuracy; Measurement and Test Equipment (M&TE) effects; and drift. The instrument channel setpoint uncertainty evaluations / calculations demonstrate that an acceptable allowance is provided between the AL and TSP.

A given TSP must also assure that automatic actuations do not inadvertently occur during the plant design basis normal operational transients. The Nuclear Steam Supply System (NSSS) control system analyses and operating experience demonstrate that inadvertent actuations do not occur during at-power plant maneuvering.

3.2 TRIP SETPOINT CONSIDERATIONS

To establish the allowance between the AL and TSP, applicable instrument channel errors (i.e., uncertainties) are combined by algebraic and/or statistical methods. Before combining the errors, each error must be evaluated to establish its category or grouping. Such groupings require consideration of the following.

Random / Bias	Errors can be random or non-random. Systematic or non-random errors are typically treated as biases.
Independent / Dependent	When there is no significant correlation between errors, the errors are considered independent. When errors are affected in predictable ways by a common influence and are strongly correlated, the errors are considered dependent.
Normal / Accident	The error can be of one magnitude under normal operating conditions and of a different magnitude under accident conditions.
Measurable / Non-Measurable	When the error can affect the results of periodic surveillance testing or channel calibration, it is considered as measurable. When the error is not present during periodic surveillance testing or channel calibration, it is considered as non-measurable.

3.3 TRIP SETPOINT DETERMINATION BASIS

ISA-S67.04-1994 Part I Section 3.7 [Reference 4] defines Error (e) as:

> The algebraic difference between the indication and the ideal value of the measured signal.

Thus, the magnitude of a given error is the difference between the indicated and ideal instrument channel measurement, and the total error is the summation of errors from multiple sources. Therefore,

$$Indicated = Ideal + e_1 + e_2 + e_3 + e_4 \cdots + e_{n-1} + e_n.$$

Because errors can have non-random and random terms,

$$e_i = \mu_i \pm k_i \sigma_i.$$

Where,

e = error (uncertainty) term;
μ = mean of the uncertainty term;
k = sample weighted tolerance multiplier; and
σ = standard deviation of the uncertainty term.

However the mean is considered a bias in the setpoint calculations so,

$$e_i = b_i \pm k_i \sigma_i .$$

As per Reference 5, the resultant uncertainty of the random independent variables is the sum of the means of each variable, and the variance of the resultant uncertainty is the sum of the variances of each variable. The standard deviation of the resultant uncertainty is the square root of the sum of the variances. As the variance of each variable is the square of the standard deviation of that variable, the standard deviation of the resultant uncertainty is thus the Square Root Sum of the Squares (SRSS) of the standard deviations of each of the random variables.

Therefore, assuming the same *k* for each uncertainty, the resultant standard deviation is:

$$k\,\sigma = \sqrt{k\sigma_1^2 + k\sigma_2^2 + k\sigma_3^2 + \cdots + k\sigma_n^2} = k\sqrt{\sum_{i=1}^{n} \sigma_i^2} .$$

The resultant standard deviation of the combined uncertainties is less than the straight arithmetic sum of the standard deviations of each of the included uncertainties. This statistical result is similar to using the Pythagorean Theorem square root combination of the squares of lengths of two sides of a right triangle to derive the hypotenuse length. Without providing the rigorous mathematical proof of this statistical process, the layman's explanation is that there is a low probably or expectation that all uncertainties in the combination will be at or near the maximum value at the same time. Therefore, a straight algebraic summation of the standard deviations would be extremely conservative. Thus,

$$Indicated = Ideal + \sum_{i=1}^{l} b_i \pm k\sqrt{\sum_{i=1}^{n} \sigma_i^2} .$$

A 95% probability tolerance limit is typically used to set the bounds for the number of standard deviations (*k*) used in the protection system instrument setpoint uncertainty calculations. To apply this principal to the TSP, assume that the AL is the *ideal* TSP prior to accounting for any uncertainties and that the TSP is the *indicated* TSP that considers all of the measured and unmeasured uncertainties.

Thus, for a trip designed to limit an increase in a process parameter,

$$TSP = AL - \left(\sum_{i=1}^{l} b_i + k\sqrt{\sum_{i=1}^{n} \sigma_i^2} \right).$$

And, for a trip designed to limit a decrease in a process parameter,

$$TSP = AL + \left(\sum_{i=1}^{l} b_i + k\sqrt{\sum_{i=1}^{n} \sigma_i^2}\right).$$

The resultant TSP is therefore based on a reasonable probability that the difference (or allowance) between the AL and TSP includes the combination of all applicable uncertainties.

3.4 TRIP SETPOINT DETERMINATION CONCLUSION

The TSP is chosen such that there is a reasonable probability that the instrument channel will produce the required protective action before the process parameter variable reaches the AL. This approach to TSP determination provides reasonable assurance that the AL is protected and the SL is not exceeded.

4.0 ALLOWABLE VALUE DETERMINATION

4.1 ALLOWABLE VALUE REQUIREMENTS

ISA-S67.04-1994 Part I Section 4.3.2 [Reference 4] states:

> The purpose of the allowable value is to identify a value that, if exceeded, may mean that the instrument has not performed within the assumptions of the setpoint calculation. A channel whose trip setpoint as-found condition exceeds the allowable value should be evaluated for operability, taking into account the setpoint calculation methodology.

The AV is the acceptance criterion used to confirm protection system instrument channel operability for the portion of the channel tested during periodic surveillance testing such as a COT. The AV does not protect the AL. The AV ensures that the performance of the tested portion of the instrument channel is consistent with the supporting setpoint uncertainty calculation assumptions. All potential instrument channel uncertainties associated with the tested portion of the channel must be considered. Examples may include, but are not limited to: rack M&TE effects; rack module calibration accuracy; normal rack environmental effects; and rack module drift. The assumptions, data, and methods used to determine the AV must be consistent with those used to determine the TSP. In addition, a given AV should: be consistent with the expected performance of a healthy channel; assure that the AV is satisfied with a 95% probability during surveillance testing; and not include excessive margin.

4.2 ALLOWABLE VALUE UNCERTAINTY CONSIDERATIONS

Each periodic surveillance provides information about the value of some of the instrument uncertainties at the time of the test. Since the test may be performed on only part of the channel, and since the test is usually performed under normal environmental conditions, not all uncertainty contributors will influence the results of a given test. Uncertainties that influence test results during surveillance testing are designated as Measurable Uncertainties (MUs). Uncertainties that do not influence the test results during surveillance testing are designated as Unmeasurable Uncertainties (UMUs). Evaluations of actual plant data, during the work used to justify twenty-four month fuel cycles, demonstrate that the MUs deduced from documented surveillance test results vary randomly between tests. This finding is not unexpected. Since the MUs are the results of a number of independent random uncertainties (including drift), the MU summation will be a random uncertainty. Therefore, a single surveillance test result does not provide sufficient basis to invalidate the TSP determination.

4.3 ALLOWABLE VALUE DETERMINATION BASIS

The following AV determination basis provisions are based on the requirements of ISA-S67.04-1994 Part I Section 4.3.2 [Reference 4].

For each periodic surveillance test used to verify an instrument channel setpoint against an AV, the portion of the channel to be surveilled must be identified as well as the uncertainties that would be expected to affect the results of the test. The selection of the uncertainty magnitudes should be appropriate for the measurement and no larger than the magnitudes used in the TSP determination.

The MUs are combined into one allowance using the same method used to determine the TSP. If a different combinational technique is used, the results may not be representative of the deviation in the setpoint assumed in the TSP calculation, which could lead to an incorrect surveillance test conclusion. The combined MUs allowance is the maximum deviation from the TSP expected during a surveillance test.

Hence, the AV for an increasing process parameter trip is defined as

$$AV = TSP + \left(\sum_{i=1}^{I} b_{MUi} + k\sqrt{\sum_{i=1}^{n} \sigma^2_{MUi}} \right).$$

And, the AV for a decreasing process parameter trip is defined as

$$AV = TSP - \left(\sum_{i=1}^{I} b_{MUi} + k\sqrt{\sum_{i=1}^{n} \sigma^2_{MUi}} \right).$$

If margin is added between the TSP and the scaled-calibration value used to adjust the final setpoint device, the margin must not be included in the MU, and the AV must be based on the actual scaled-calibration setpoint value. Inclusion of margin in the AV determination would allow equipment degradation to be masked without causing a surveillance failure due to exceeding the AV.

4.4 ALLOWABLE VALUE DETERMINATION METHODS

ISA-RP67.04-1994 Part II Section 7.3 [Reference 6] provides three methods for determining the AV from the MU and UMU values. Other methods, or variations of the three methods, may be used as long as the requirements of ISA-S67.04-1994 Part I Section 4.3.2 [Reference 3] are satisfied. A comparison assessment follows.

4.4.1 ALLOWABLE VALUE METHOD 1

To determine the AV, Method 1 adds (subtracts) the statistical combination of the UMUs to (from) the AL. Then, the TSP is determined by adding (subtracting) the statistical combination of the MUs to (from) the AV. The probability of protecting the AL during an AOO is greater than 95%. The probability of meeting the AV during periodic surveillance is 95%.

By simply adding the MU and UMU terms, Method 1 results in a TSP that is conservative but reduces operating margin. Because this method uses the MUs to compute the TSP, it provides an effective AV for verifying compliance with the setpoint calculation assumptions.

4.4.2 ALLOWABLE VALUE METHOD 2

To determine the AV, Method 2 adds (subtracts) the total UMUs to (from) the AL. To determine the TSP, Method 2 determines the statistical combination of all uncertainties, MU and UMU. Then, the statistical total is added (subtracted) to (from) the AL to compute the TSP. The probability of protecting the AL during an AOO is 95%. The probability of meeting the AV during periodic surveillance will be less than 95%.

Method 2 results in an AV that is not separated from the TSP by the MU value. This may result in the determination that the channel is inoperable when the channel is actually operable and performing within expectations. In addition, the difference between the TSP and the AV is less than the MU; therefore, the probability of the surveillance result falling outside the AV increases. Frequent surveillance test failures force some users to add margin to the TSP, which will reduce operating margin.

4.4.3 ALLOWABLE VALUE METHOD 3

Method 3 determines the statistical combination of all uncertainties, MU and UMU. Then, the statistical total is added (subtracted) to (from) the AL to compute the TSP. Subsequently, to determine the AV, Method 3 subtracts (adds) the total MUs from (to) the TSP. The probability of protecting the AL during an AOO is 95%. The probability of meeting the AV during periodic surveillance is 95%.

Because Method 3 determines the AV from the TSP using MU values only for the portion of the loop to be surveilled, it provides an effective AV for verifying that the equipment meets the setpoint calculation assumptions.

4.5 ALLOWABLE VALUE DETERMINATION CONCLUSION

The AV is determined as a performance value to be used as the acceptance criterion for surveillance activities; therefore, the AV is not a setting.

Method 1 is an acceptable methodology for determining the AV; although it reduces operating margin. Method 2 is an acceptable methodology for determining the AV; however, it may not provide an effective acceptance criterion for periodic surveillance testing. Method 3 establishes an AV that provides a reasonable acceptance criterion for surveillance testing without challenging operating margins or safety limits.

5.0 SUMMARY / CONCLUSIONS

The requirements for determining the TSP and AV for safety-related instrument channels are well-defined by ISA-S67.04-1994 Part I [Reference 4]. Plant-specific methodologies based on these requirements provide a formal engineering process to determine TSPs and AVs and a rigorous scientific approach to satisfying 10 CFR 50.36 regulatory requirements. The following conclusions summarize the technical bases for automatic protection system TSP and AV determination.

- The protection system instrument setpoint uncertainty calculations demonstrate that the TSP, not the AV, provides reasonable assurance that protective action is initiated before the respective process parameter variable reaches the AL.
- 10 CFR 50.36 [Reference 3] defines the LSSS as a setting associated with automatic initiation of a protective action. This definition is consistent with ISA-S67.04-1994 Part I [Reference 4] TSP definition.
- The AV is a surveillance test acceptance criterion that defines the limits on the expected results of the periodic surveillance test, beyond which the instrument loop is inoperable.
- ISA-RP67.04-1994 Part II Method 3 [Reference 6] is an appropriate methodology for determining an AV and predicting instrument loop performance during a surveillance test.

6.0 REFERENCES

1. 10 Code of Federal Regulations (CFR) Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants."

2. 10 CFR Part 50.55a(h), "Protection and Safety Systems."

3. 10 CFR Part 36, "Technical Specifications."

4. Instrument Society of America (ISA) Standard ISA-S67.04-1994, Part I, "Setpoints for Nuclear Safety-Related Instrumentation."

5. Hogg and Tanis, "Probability and Statistical Inference," 2nd Edition, pages 215 through 217, 1983.

6. Instrument Society of America (ISA) Recommended Practice ISA-RP67.04-1994, Part II, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation."