RECOMMENDED PRACTICE
ISA–RP67.04.02–2010

Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation

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Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation

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Introduction

Before utilizing this recommended practice, it is important that the user understand the relevance of instrument channel uncertainty and safety-related setpoint determination for nuclear power plants. Safety-related instrument setpoints are chosen so that potentially unsafe or damaging process excursions (transients) can be avoided and/or terminated prior to exceeding safety limits (process-design limits). The selection of a setpoint requires that consideration be given to much more than just instrumentation.

Experience has shown that an operational limit should be placed on critical process parameters to ensure that, given the most severe operating or accident transient, the plant's design safety limits will not be exceeded. Performance of transient or accident analysis establishes the analytical limits for critical process parameters. Typically, the analysis models include the thermodynamic, hydraulic, and mechanical dynamic response of the processes as well as assumptions regarding the time response of instrumentation. The analytical limits, as established by analysis, do not normally include considerations for the accuracy (uncertainty) of installed instrumentation. To ensure that the actual trip setpoint of an instrument channel is appropriate, additional analyses are generally necessary, including identification of applicable uncertainties.

Instrument channel uncertainty should be determined based on the characteristics of installed instrumentation, the environmental conditions present at the plant locations associated with the instrumentation, and on process conditions. A properly calculated setpoint will initiate a plant protective action before the process parameter exceeds its analytical limit, which, in turn, ensures that the transient will be avoided and/or terminated before the process parameter exceeds the established safety limit.

ISA-67.04 (now ANSI/ISA-67.04.01) was initially developed in the mid-1970s by the industry in response to large numbers of licensee event reports (LER). These LERs were attributed to the lack of adequate consideration of equipment drift characteristics when establishing the trip setpoints for the limiting safety system settings (LSSS) and engineered safety features actuation system (ESFAS) setpoints. These setpoints are included as part of a nuclear power plant's operating license in their technical specifications. Hence, trip setpoints were found beyond the allowable values identified in the Technical Specifications.

The scope of the standard was focused on LSSS and ESFAS setpoints. As the standard evolved, it continued to focus on those key safety-related setpoints noted previously. It should also be noted that as the Technical Specifications have evolved, the values now included in the Technical Specifications may be the trip setpoint, the allowable value, both the trip setpoint and allowable value, or the limiting safety system setting (LSSS), depending on the setpoint methodology philosophy used by the plant and/or the nuclear steam supply system (NSSS) vendor. The methodologies, assumptions, and conservatism associated with performing accident analyses and setpoint determinations, like other nuclear power plant technologies, have also evolved. This evolution has resulted in the present preference for explicit evaluation of instrument channel uncertainties and resulting setpoints rather than implicitly incorporating such uncertainties into the overall safety analyses. Both the explicit and implicit approaches can achieve the same objective of assuring that design safety limits will not be exceeded. During the process of developing the 1988 revision of ISA-67.04 (ANSI/ISA-67.04.01), it was determined that, because of the evolving expectations concerning setpoint documentation, additional guidance was needed concerning methods for implementing the requirements of the standard. In order to address this need, standards Committees ISA67.15 and ISA67.04 were formed and prepared ISA-RP67.04, Part II, 1994. It is the intent of the Committees that the scope of the recommended practice be consistent with the scope of the standard. The recommended practice is to be utilized in conjunction with the standard. The standard is ANSI/ISA-67.04.01, Setpoints for Nuclear Safety-Related Instrumentation, and the recommended practice is ISA-RP67.04.02, Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation.

Previous versions of the standard and the recommended practice focused on the calculation of an allowable value and trip setpoints. In most cases the allowable value represented a limiting surveillance as-found test value. As long as the as-found trip setpoint was conservative to or could be reset conservative to the allowable value, the channel was defined as operable. (From the Technical

Specification's perspective, this meant the channel would protect the safety limit.) These versions in some cases confused the actual operability of the channel (functioning within the confines of the setpoint calculation) with nuclear power plant licensing issues. The use of a single value to verify the channel met all requirements failed to identify any conditions where the channel was not performing within identified expectations. The previous recommended practice also identified three separate methods for the determination of allowable values and trip setpoints to support existing NRC-approved methodologies. These different methods defined variations on statistical methods, and all resulted in conservative setpoints and allowable values when the basic assumptions were evaluated and confirmed.

This revision of the recommended practice focuses on the functioning of the channel within expected limits and requires validation of the assumptions in the calculation when performing periodic surveillance testing to confirm the status of the channel. The limiting trip setpoint is defined as the least conservative value for the setpoint (including the tolerances) before returning the channel to service. The as-left tolerance value ensures that the channel, or any part being evaluated by the test, will be reset to an acceptable value. The as-found tolerance verifies that the channel is functioning within expected variations. Should the channel continually be found outside the as-found tolerance (or found to deviate only a small fraction of the as-found tolerance over multiple cycles) then the channel should be evaluated to ensure that operation is within expectations.

The allowable value (calculated using the methods discussed in previous versions of this document) may still be calculated, or the least conservative as-found value may be used as the allowable value for plants that wish to maintain current plant licensing basis.

During the development of this recommended practice, a level of expectation for setpoint calculations was identified, which, in the absence of any information on application to less critical setpoints, may lead some users to come to expect that all setpoint calculations should contain the same level of rigor and detail. The lack of specific treatment of less critical setpoints has resulted in some potential users expecting the same detailed explicit consideration of all the uncertainty factors described in the recommended practice for all setpoints. It is not the intent of the recommended practice to suggest that the methodology described is applicable to all setpoints. Although it may be used for most setpoint calculations, it is by no means necessary that the recommended practice guidance be used for all setpoints. In fact, in some cases, it may not be appropriate.

Setpoints associated with the analytical limits determined from transient or accident analyses are considered part of the plant's safety-related design since they are critical to protecting the safety limit analytical limits that assure the integrity of the multiple barriers to the release of fission products. This class of setpoints and their determination have historically been the focus of ANSI/ISA-67.04.01 as discussed above.

Also treated as part of many plants' safety-related designs are setpoints that are not determined from the accident analyses and are not required to maintain the integrity of the fission product barriers. These setpoints may provide anticipatory inputs to, or reside in, the reactor protection and/or engineered safeguards initiation functions but are not credited in any accident analysis. Alternatively, there are setpoints that support operation of, not initiation of, the engineered safety features.

In applying the standard and recommended practice to the determination of setpoints, a graduated or "graded" approach may be appropriate for setpoints that are not credited in the accident analyses to initiate automatic reactor shutdown or the engineered safety features.

While it is the intent that the recommended practice provides a basis for consistency in approach and terminology to the determination of setpoint uncertainty, it is acknowledged that the recommended practice is not an all-inclusive document. Other standards exist that contain principles and terminology, which, under certain circumstances, may be useful in estimating instrument uncertainty. It is acknowledged therefore that concerns exist as to whether the recommended practice is complete in its

presentation of acceptable methods. The user is encouraged to review several of the references in the recommended practice that contain other principles and terminology.

The uncertainty and setpoint calculations discussed in this recommended practice may be prepared either manually or with a computer software program. The documentation associated with these calculations is discussed in Section 10; however, the design control and documentation requirements of manual calculations or computer software are outside the scope of the recommended practice.

This recommended practice is intended for use primarily by the owners/operating companies of nuclear power plant facilities or their agents (NSSS suppliers, architects, engineers, etc.) in establishing setpoint methodology programs and preparing safety-related instrument setpoint calculations.

This recommended practice utilizes statistical nomenclature that is customary and familiar to personnel responsible for nuclear power plant setpoint calculations and instrument channel uncertainty evaluations. It should be noted that this nomenclature may have different definitions in other statistical applications and is not universal, nor is it intended to be. Furthermore, in keeping with the conservative philosophy employed in power plant calculations, the combination of uncertainty methodology for both dependent and independent uncertainty components is intended to be bounding. That is, the resultant uncertainty should be correct or overly conservative to ensure safe operation. In cases where precise estimation of measurement uncertainty is required, more sophisticated techniques should be employed.

ISA Standard Committee ISA67.04 operates as a Subcommittee under ISA67, the ISA Nuclear Power Plant Standards Committee, with Robert Queenan as Chairman.

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1 Scope

This recommended practice provides guidance for the implementation of ANSI/ISA-67.04.01-2006 in the following areas:

a) Methodologies, including sample equations to calculate total channel uncertainty;

b) Common assumptions and practices in instrument uncertainty calculations;

c) Equations for estimating uncertainties for commonly used analog and digital modules;

d) Methods to determine the impact of commonly encountered effects on instrument uncertainty;

e) Application of instrument channel uncertainty in setpoint determination;

f) Sources and interpretation of data for uncertainty calculations;

g) Discussion of the interface between setpoint determination and plant operating procedures, calibration procedures, and accident analysis;

h) Documentation requirements.

2 Purpose

The purpose of this recommended practice is to present guidelines and examples of methods for the implementation of ANSI/ISA-67.04.01-2006 in order to facilitate the performance of instrument uncertainty calculations and setpoint determination for safety-related instrument setpoints in nuclear power plants.

3 Definitions

3.1 analytical limit (AL):

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

3.2 abnormally distributed uncertainty:

a term used in this recommended practice to denote uncertainties that do not have a normal distribution. See 6.2.1.2.2 for further information.

3.3 as-found value:

the condition in which a channel, or portion of a channel, is found after a period of operation and before recalibration (if necessary).

3.4 as-left value:

the condition in which a channel, or portion of a channel, is left after calibration or final setpoint device setpoint verification.

3.5 bias:

an uncertainty component that consistently has the same arithmetic sign and is expressed as an estimated limit of error.