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DOCUMENT TITLE INSTRUMENT SETPOINTS AND TECHNICAL SPECIFICATION LIMITS

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1. SCOPE

1.1 Purpose: This document has been prepared to record appropriate methods for the establishment of recommended instrument nominal trip setpoints and technical specification limits in a consistent and repeatable manner.

1.2 Setpoints Covered: The setpoints considered are those associated with the Reactor Scram Instrumentation, Isolation Instrumentation, Emergency Core Cooling System and Rod Withdrawal Block Instrumentation.

2. APPLICABLE DOCUMENTS

2.1 General Electric Company Documents

2.1.1 Supporting Documents. None

3. SYSTEM DESIGN REQUIREMENTS

3.1 General: System design requirements are contained in the appropriate design documentation. They are utilized here, when necessary, to insure that the nominal trip setpoint recommendations do not result in violation of system design requirements.

3.2 Definitions: The definition of terms used in this document are those contained in IEEE Standard 100-1972, IEEE Standard Dictionary of Electrical and Electronic Terms, as further defined in this document.

3.2.1 Analytic Limit (A.L.): the value of the sensed process variable established as part of the safety analysis, prior to which a desired action is to be initiated to prevent the process variable from reaching the associated design safety limit.

3.2.2 Calibration accuracy: the quality of freedom from error to which the trip setpoint is calibrated with respect to the true desired setting, including both calibration instrumentation accuracies and calibration procedure allowances.

3.2.3 Conformity, independent: the maximum deviation of the actual characteristic (average of upscale and downscale readings) from a specified curve, so positioned as to minimize the maximum deviation.

3.2.4 Design safety limit: the design limit on a process variable that is necessary to reasonably protect the integrity of physical barriers that guard against uncontrolled release of radioactivity.

3.2.5 Extreme steady state operating value: the extreme value of the process variable anticipated during normal steady state operation. This value may be either a maximum or a minimum value depending upon the process variable.

3.2.6 Instrument accuracy: the quality of freedom from error of the complete instrument channel from the sensor input through the trip unit output including the combined conformity, hysteresis and repeatability errors.

3.2.7 Instrument drift: the change in the value of the process variable, at which the trip action will actually occur, between the time the nominal trip setpoint is calibrated and a subsequent surveillance test, due to all causes, as measured in terms of the instrumentation indicator scale. The value of the process variable at which the trip action will actually occur at the time of calibration is taken to be the intended nominal trip setpoint value.

3.2.8 Licensing Event Report (LER): a report which must be filed with the United States Nuclear Regulatory Commission by the power plant operator (Utility) when a technical specification limit is exceeded, e.g., when a trip setpoint value is found to have exceeded the corresponding technical specification limit.

3.2.9 Limiting normal operating transient: the most severe sensed process variable transient anticipated during normal operation for which initiation of the trip action associated with the instrumentation monitoring the process is not anticipated.

3.2.10 Maximum design instrumentation drift: the maximum drift permitted by the instrumentation design and procurement specifications for the complete instrument channel from the sensor through the trip unit, inclusive. The maximum drift represents two standard deviations of the probability distribution of instrument drift. The maximum drift is specified for a period of time equivalent to or greater than the surveillance test interval.

3.2.11 Operational limit: the operational value established by the limiting normal operating transient.

3.2.12 Nominal Trip Setpoint (N.T.S.): the intended calibration point at which a trip action is set to operate, commonly the center of an acceptable range of trip operation.

3.2.13 Repeatability: the closeness of agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions, approaching from the same direction, for full range traverses.

3.2.14 Technical Specification Limit (T.S.L.): the limit prescribed as a license condition on an important process variable.

3.3 Limit Relationships: The relationship between the nominal setpoint and the various limiting values discussed are shown in Figure 3.1.

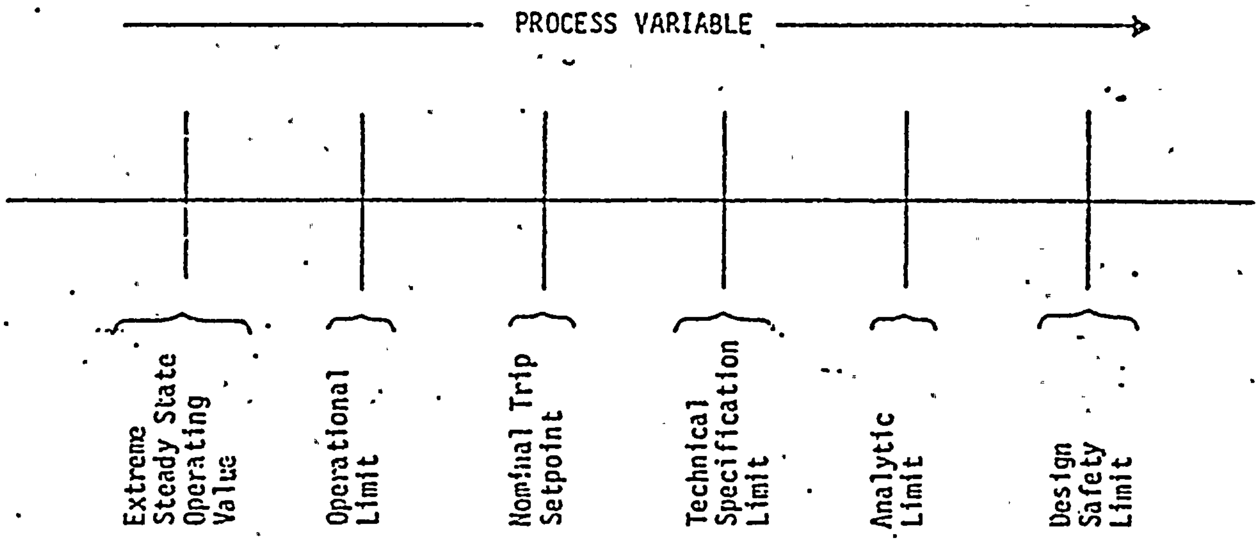

FIGURE 3.1 SETPOINT AND LIMIT RELATIONSHIPS

4. QUALITY ASSURANCE PROVISIONS

4.1 This document has been reviewed in accordance with the current GE-NED engineering design review procedures.

5. HANDLING, SHIPPING AND STORAGE - Not applicable.

6. RECOMMENDATIONS

6.1 General: In order to provide a consistent and repeatable method for establishing instrument nominal trip setpoint and technical specification limit value recommendations the procedures described in the appendices have been developed. Due to the general characteristics of the instrumentation and processes involved it has been necessary to provide three (3) different methods. These three (3) methods are based on computation, engineering judgment, and historical data. The methods are to be applied independently. However, portions of the computational method may be incorporated into the other two methods. Each of the methods is explained in a separate appendix. The methods and associated appendix are as follows:

a. Computational — Appendix 10

b. Engineering Judgment — Appendix 20

c. Historical Data — Appendix 30

6.2 Specific Setpoint Recommendations: Specific nominal trip setpoint and technical specification limit recommendations along with the analytic limits are delineated in plant unique data sheets.

APPENDIX 10

10. METHOD FOR ESTABLISHING TRIP SETPOINTS AND TECHNICAL SPECIFICATION LIMITS BY COMPUTATION

10.1 General

10.1.1 When sufficient information is available regarding a dynamic process and the associated instrumentation, it is possible to establish the nominal trip setpoint and technical specification limit values utilizing the following procedure. This procedure does not attempt to apply a rigorous statistical evaluation of the instrumentation parameters. The analytic limit is established through the use of computational models which include combined margins for related instrumentation parameters but do not necessarily include separate margins for each individual instrument characteristic. Consequently, it is not practical to remove the instrument related margins from the models used to establish the analytic limits. In order to separately account for instrumentation accuracy and calibration accuracy it is therefore necessary to introduce redundancy into the technical specification limit establishments.

10.1.2 The differential between the nominal trip setpoint value and the technical specification limit is established as the maximum drift permitted by the associated instrumentation specification. This differential allows for the maximum drift between calibrations without compromising the analytic limit since there will still be sufficient margin to account for instrumentation and calibration accuracies.

10.1.3 Once the nominal trip setpoint and technical specification limit values have been established using 10.2 below, they are checked to insure they will not result in an unacceptable level of Licensing Event Reports (LER) or trips due to normal operational transients. If the nominal trip setpoint and technical specification limit values are not acceptable there are several alternatives available. One alternative is to establish these values using a more rigorous statistical evaluation and taking credit for instrument channel redundancies. Another alternative is to replace the instrumentation design specification data with actual operational data and establish the nominal trip setpoint and technical specification limit values based on this data.

10.1.4 It is recommended that the instrumentation parameters utilized in establishing the nominal trip setpoints and technical specification limits be monitored during operation. When sufficient operational data has been gathered, the nominal trip setpoints and technical specification limits should be recomputed to improve plant operational margins and further minimize LERs.

10.2 Procedure for Establishing Nominal Trip Setpoint and Technical Specification Limit

10.2.1 Data Required: The following data is required to establish the nominal trip setpoint and technical specification limit.

a. Analytic Limit (A.L.).
b. Instrumentation accuracy.
c. Calibration accuracy.
d. Maximum design instrumentation drift.

10.2.2 Technical Specification Limit

10.2.2.1 The technical specification limit (T.S.L.) is established so there is at least a 0.9772 probability of providing the trip action before the process variable reaches the analytic limit in the case where the maximum drift has occurred as shown on Figure 10.1. The maximum drift being the instrumentation design maximum drift (D).

10.2.2.2 The instrumentation parameters involved in establishing the technical specification limit are the instrumentation accuracy and the calibration accuracy. Instrumentation accuracy is the specified design accuracy and is assumed to represent two standard deviations ($2\sigma_a$) of the instrumentation indication at the trip level of the process variable.

10.2.2.3 It is assumed that the plant operator will calibrate the instrumentation with an accuracy equivalent to the instrumentation resolution. This assumption is necessary since specific data related to the plant operators calibration procedures, calibration equipment, and calibration equipment maintenance are not available. The instrumentation resolution is taken to represent one standard deviation (σ_c) of the instrumentation calibration at the trip level of the process variable. The instrumentation includes the sensor, signal conditioning circuitry and trip unit.

10.2.2.4 In order to obtain the desired 0.9772 probability, for a one sided normal distribution, the technical specification limit must be set two (2) standard deviations from the analytic limit. In this case the standard deviation is determined as the statistical combination of the instrumentation accuracy and the calibration accuracy, i.e., $\sqrt{\sigma_a^2 + \sigma_c^2}$. T.S.L. = A.L. $- 2\sqrt{\sigma_a^2 + \sigma_c^2}$, for process variables that increase toward the A.L., or T.S.L. = A.L. $+ 2\sqrt{\sigma_a^2 + \sigma_c^2}$, for process variables that decrease toward the A.L.

10.2.2.5 When actual calibration accuracy data becomes available the technical specification limit can be adjusted using this procedure and the new calibration accuracy standard deviation.

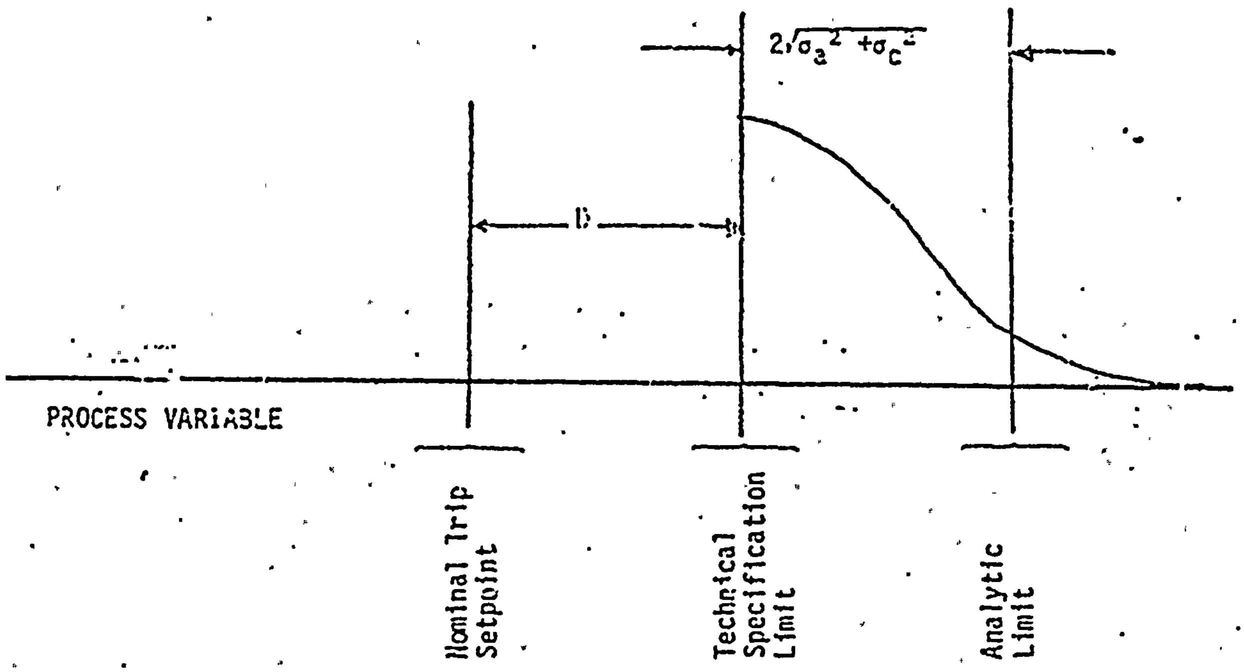
$2\sqrt{\sigma_a^2 + \sigma_c^2}$
B
PROCESS VARIABLE
Nominal Trip Setpoint
Technical Specification Limit
Analytic Limit

FIGURE 10.1

10.2.3 Nominal Trip Setpoint

10.2.3.1 The nominal trip setpoint (N.T.S.) value is established by the maximum design instrumentation drift (D). The nominal trip setpoint is offset from the technical specification limit by an amount equal to the maximum design instrumentation drift expected during the surveillance test interval. As noted in the establishment of the technical specification limit this will provide an assurance of required trip actions in the case where the maximum drift has occurred.

N.T.S. = T.S.L. - D, for process variables that increase toward the A.L., or

N.T.S. = T.S.L. + D, for process variables that decrease toward the A.L.

10.2.3.2 Actual observed drift will differ from plant to plant due to environmental factors, maintenance procedures and trip setpoint surveillance frequencies. Also, the actual observed drift characteristic may include a statistically significant bias. Consequently, as actual drift data is accumulated, including confirmed, statistically significant bias data, the nominal trip setpoint can be adjusted to reflect the instrumentation performance.

10.3 Operational Transient Trip Avoidance

10.3.1 In order to evaluate the impact of the nominal trip setpoint value (X_S) on plant availability one of two simple tests can be applied. These tests are based on a distribution of difference calculation and are used here to evaluate the probability of a trip occurring due to the spectrum of normal operating transients or due to the limiting normal operating transient when no safety constraints are compromised. The calculations establish the probability of avoiding a trip under safe conditions. Five (5) factors, not previously used, are utilized in these tests. They are predicted extreme steady state operating value for the variable (X_o), the limiting predicted normal operating transient, the standard deviation associated with the limiting operating transient (σ_m), the required trip avoidance probability during the limiting transient and the value of the standard deviation (σ_d) associated with the instrumentation drift. In the absence of actual observed drift data the standard deviation (σ_d) for drift is taken as one half of the maximum design instrumentation drift (D).

10.3.2 The test to evaluate the operational transient trip avoidance associated with the spectrum of normal operating transients is based on the nominal trip setpoint distribution and the operational process variable distribution as shown in Figure 10.2.

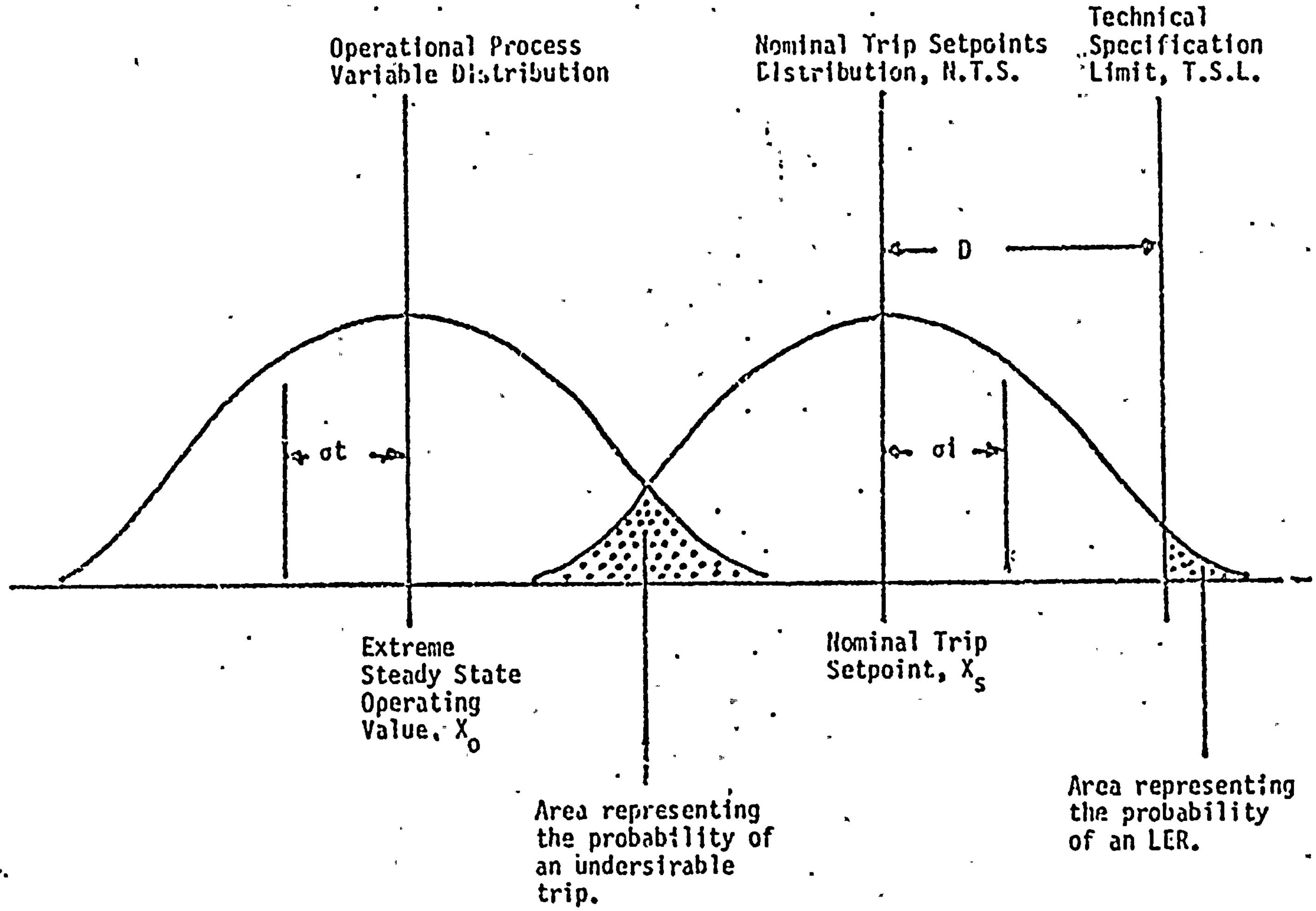
Operational Process
Variable Distribution
Nominal Trip Setpoints
Distribution, N.T.S.
Technical
Specification
Limit, T.S.L.
D
σt
σi
Extreme
Steady State
Operating
Value, X_o
Nominal Trip
Setpoint, X_s
Area representing
the probability of
an undersirable
trip.
Area representing
the probability
of an LER.

Figure 10.2

10.3.2.1 The extreme steady state operating value (X_o) is utilized as the mean of the operational variable distribution and the predicted normal process variable change of the limiting transient is taken as the standard deviation (σ_t) of the operational process variable distribution. Obviously, this is an oversimplification of the operational variable distribution. However, if this test is successful it will not be necessary to perform a more rigorous test.

10.3.2.2 The setpoint distribution utilizes the nominal trip setpoint value (X_s) as a mean. The standard deviation (σ_i) is computed as the statistical combination of the instrumentation drift standard deviation (σ_d), instrumentation accuracy (σ_a) and calibration accuracy (σ_c), i.e.,

$$\sigma_i = \sqrt{\sigma_a^2 + \sigma_c^2 + \sigma_d^2} .$$

10.3.2.3 A one sided probability of trip avoidance based on a normal distribution is obtained from a standard textbook statistical table for areas under the standard normal curve, from $-\infty$ to Z, where $Z = X/\sigma$, i.e., Probability and Statistics for Engineers, Miller and Freud, Prentice-Hall, Table III. For the delta distribution case, X_Δ is the difference between the means of the two distributions. The delta standard deviation (σ_Δ) is the statistical combination of the two distribution standard deviations, i.e.,

$$\sigma_\Delta = \sqrt{\sigma_t^2 + \sigma_i^2} .$$

Therefore,

$$Z_\Delta = \frac{X_o - X_s}{\sqrt{\sigma_t^2 + \sigma_i^2}} ,$$

when X_o is greater than X_s, and

$$Z_\Delta = \frac{X_s - X_o}{\sqrt{\sigma_t^2 + \sigma_i^2}} ,$$

when X_o is less than X_s. The probability of trip avoidance is the normal distribution statistical table value corresponding to Z_Δ.

10.3.3 The test to evaluate the operational transient trip avoidance associated with the limiting normal operating transient is based on the nominal trip setpoint distribution and the distribution of the limiting transient as shown in Figure 10.3.

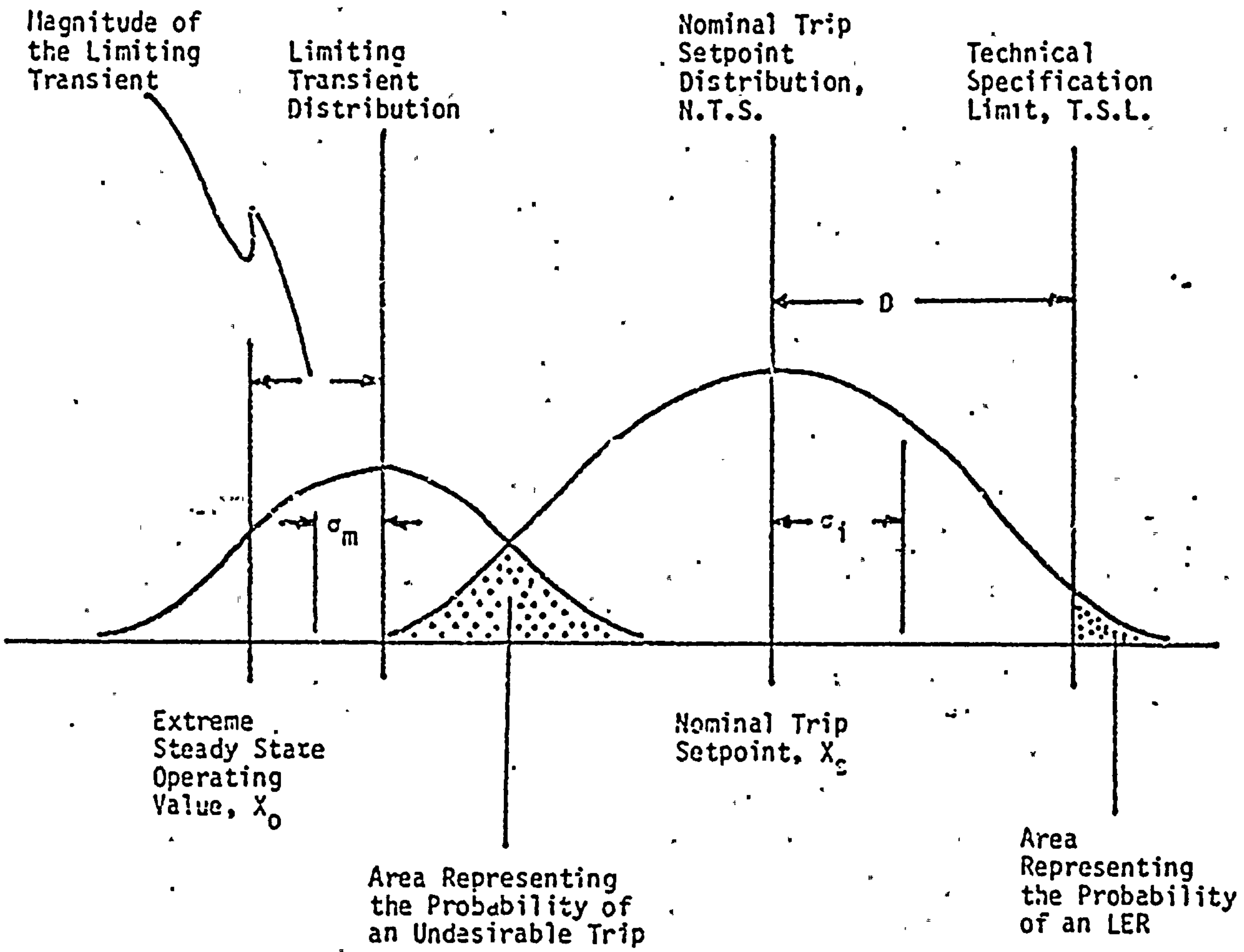
Magnitude of the Limiting Transient
Limiting Transient Distribution
Nominal Trip Setpoint Distribution, N.T.S.
Technical Specification Limit, T.S.L.
D
σm
σi
Extreme Steady State Operating Value, Xo
Nominal Trip Setpoint, Xs
Area Representing the Probability of an Undesirable Trip
Area Representing the Probability of an LER

FIGURE 10.3

10.3.3.1 The mean of the limiting operating transient distribution is taken as the extreme steady state operating value (X_0) plus, or minus as appropriate, the magnitude of the limiting transient (T), i.e., $X_T = X_0 + T$, where the process variable transient increases toward the analytic limit and $X_T = X_0 - T$, where the process variable decrease toward the analytic limit. The standard deviation associated with the limiting operating transient (σ_m) is the value used for the standard deviation to be associated with the distribution of X_T.

10.3.3.2 The setpoint distribution and standard deviation are to be established as stated in Paragraph 10.3.2.2.

10.3.3.3 Using the method of Paragraph 10.3.2.3 but substituting X_T for X_0 and σ_m for σ_t provides the probability of trip avoidance, i.e.,

$$Z_a = \frac{X_T - X_s}{\sqrt{\sigma_m{}^2 + \sigma_i{}^2}},$$

when X_0 is greater than X_s, and

$$Z_a = \frac{X_s - X_T}{\sqrt{\sigma_m{}^2 + \sigma_i{}^2}},$$

when X_0 is less than X_s. Note, the selection of which equation is applied depends on the relationship between X_0 and X_s not on the relationship between X_T and X_s.

10.3.4 In the event an unsatisfactory trip avoidance probability has been obtained a more rigorous definition of the operational process variable distribution must be established or the nominal trip setpoint value can be adjusted based on engineering judgment to reduce the interval between it and the technical specification limit. The alternative chose will depend on the value of the trip avoidance probability, the function of the trip signal, and an evaluation of the unique plant operating requirements. A rigorous definition of the operational process variable distribution should be based on the normal steady state operating value of the process variable as the mean rather than the maximum steady state operating value. The standard deviation should be computed in a statistical manner using the normal operating transient frequency data rather than relying only on the limiting normal operating transient, and instrumentation redundancy and trip logic should be included in determining the nominal trip setpoint statistical distribution. When considering the trip logic the following expressions should be used to compute the probabilities of trip and trip avoidance.

10.3.4.1 Probability of trip avoidance = 1 - probability of trip.

10.3.4.2 Probability of trip, single channel = P.

10.3.4.3 Probability of trip for one out of two taken twice logic = $P^2 (2 - P)^2$.

10.3.4.4 Probability of trip for two out of three logic = $3P^2$.

10.3.4.5 Probability of trip for two out of four logic = $P^2 (3P^2 - 8P + 6)$.

10.3.4.6 Probability of trip for one out of four logic = $1 - (1 - P)^4$.

10.4 Licensing Event Report Avoidance

10.4.1 The probability of avoiding a LER due to instrumentation drift is determined by the associated standard deviation (σ_i) of the indication of the process variable. An LER avoidance probability of at least 0.9000 is recommended. This probability is obtained using a statistical table for areas under the standard normal curve, from $-\infty$ to Z, where $Z = X/\sigma$, i.e., text referenced in Paragraph 10.3.2.3. In this case, the value used for X is the positive difference between the nominal setpoint value and the technical specification limit, i.e., the maximum design instrumentation drift (D) as shown in Figure 10.2. The standard deviation value used is the statistical combination of the instrumentation drift standard deviation (σ_d), instrumentation accuracy (σ_a), and calibration accuracy (σ_c), i.e., $\sigma_i = \sqrt{\sigma_a^2 + \sigma_c^2 + \sigma_d^2}$. The probability of avoiding LER is the normal distribution statistical table value corresponding to Z.

10.4.2 In the event an avoidance probability of less than 0.9000 has been obtained one alternative is to increase the differential between the nominal setpoint value and the technical specification limit. Such an adjustment must be based on engineering judgment or actual operational drift data.

APPENDIX 20

20. METHOD FOR ESTABLISHING TRIP SETPOINTS AND TECHNICAL SPECIFICATION LIMITS BY ENGINEERING JUDGMENT

20.1 General

20.1.1 When it is not practical to apply the technique outlined in Appendix 10 or when the available data is so conservative as to result in unacceptable operating restrictions, or when the Lead System Engineer considers it appropriate, engineering judgment should be used to establish the nominal trip setpoint and technical specification limit values. In order to establish a consistent pattern for the application of engineering judgment suggested guidelines are delineated below.

20.1.2 The guidelines suggested are those of the zone setting concept. A two zone concept is suggested here as adequate to establish the nominal trip setpoint and technical specification limit values. The zones are a range within which the trip value is adequate for its intended function but must be reported as having compromised the applicable technical specification value.

20.1.3. Zone concepts employing more than two zones have previously been associated with the establishment of instrumentation setpoints. In particular, zones related to establishing when recalibration is, or is not, necessary, are common, i.e., leave alone zone. Since specification of the recalibration limit is not included in this document these additional zones are not addressed. However, the recalibration limiter (leave alone zone) is an important operational consideration and should be established, within the acceptable trip value zones, based on the unique plant operating requirements.

20.2 Acceptable Trip Value Zone: The acceptable trip value zone is a portion of the instrumentation trip range which will have as it's midpoint the nominal trip setpoint, and as it's extreme the technical specification limit. Figure 20.1 is a representation of the trip value and zone relationship. The acceptable trip value zone should be wide enough to allow for normal instrumentation drift during surveillance intervals.

20.3 Licensing Event Report

20.3.1 The LER zone is the portion of the instrumentation trip range beyond the technical specification limit. An LER will be required when the trip value is found within this zone.

20.3.2 The LER zone should be established so that when the maximum expected drift has occurred sufficient margin remains between the technical specification limit and analytic limits to compensate for instrumentation and calibration accuracies.

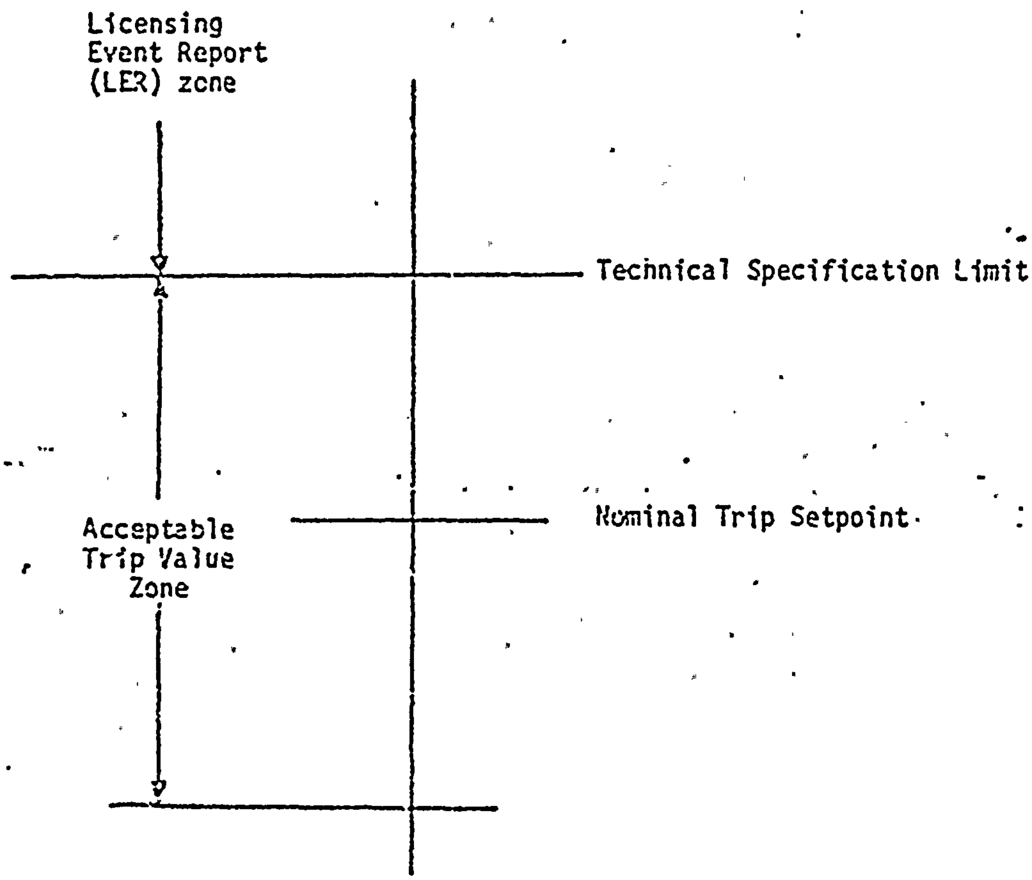
Licensing
Event Report
(LER) zone
Technical Specification Limit
Nominal Trip Setpoint
Acceptable
Trip Value
Zone

FIGURE 20.1