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BVY 03-64

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Reference:
1) VY to USNRC, "Technical Specification Proposed Change No. 257, Implementation of ARTS/MELLLA at Vermont Yankee," BVY 03-23, dated March 20, 2003.
2) VY to USNRC, "Implementation of ARTS/MELLLA at Vermont Yankee – Supplement No. 1," BVY 03-39, dated April 17, 2003.
3) USNRC to VY, "Request for Additional Information Re: ARTS/MELLLA (TAC No. MB8070)," NVY 03-40, dated May 21, 2003.
4) VY to USNRC, "Implementation of ARTS/MELLLA at Vermont Yankee, Response to Request for Additional Information," BVY 03-56, dated June 11, 2003.

Subject: **Vermont Yankee Nuclear Power Station**
License No. DPR-28 (Docket No. 50-271)
Technical Specification Proposed Change No. 257, ARTS/MELLLA
Additional Information in Response to RAI No. 9

During a telecon with your staff on July 9, 2003, NRC requested that Vermont Yankee (VY) provide a summary of the current licensing basis for our Setpoint Control Program (SCP) and applicability of the program to VY Technical Specification (TS) values. Also requested were example calculations and methodology documentation from our program.

VY's SCP was formalized in 1996 and expanded following an NRC Architect Engineering (AE) Inspection. In our response letter to the AE inspection (BVY 97-138, dated 10/27/97) VY committed to a SCP that meets the intent of the guidance provided in Instrumentation Society of America Standard ISA 67.04, "Methodologies for Determination of Setpoints for Nuclear Safety Related Instrumentation."

Vermont Yankee's licensing basis TS values are limiting values that do not reflect the calculated drift and appropriate uncertainties. Drift and appropriate uncertainties are applied to these TS values to establish the actual instrument setpoints and are controlled under our 10CFR50 Appendix B quality programs and subject to the controls of 10CFR50.59.

Included with this submittal for your information and use in evaluating our proposed change request are the following:

Attachment A, "Instrument Uncertainty and Setpoint Design Guide"
Attachment B, "Instrument Drift Analysis Design Guide"
Attachment C, VYC-0467, "Reactor System High Pressure Trip Loop Accuracy Review"

-A001

Attachments A and B represent the essential elements of VY's setpoint methodology. Attachment C is an example calculation demonstrating implementation of the setpoint methodology. An additional example calculation demonstrating application of drift methodology will be provided under separate cover, to supplement VY's TS change request (PC-260, BVY 03-49) involving surveillance frequency of Intermediate Range Monitors.

If you have any questions concerning this transmittal, please contact Ronda Daflucas at (802) 258-4232.

Sincerely,

Jay K. Thayer
Site Vice President

STATE OF VERMONT)
)ss
WINDHAM COUNTY)

Then personally appeared before me, Jay K Thayer, who, being duly sworn, did state that he is Site Vice President of the Vermont Yankee Nuclear Power Station, that he is duly authorized to execute and file the foregoing document, and that the statements therein are true to the best of his knowledge and belief.

Sally A. Sandstrum, Notary Public
My Commission Expires February 10, 2007

cc: USNRC Region 1 Administrator
USNRC Resident Inspector – VYNPS
USNRC Project Manager – VYNPS
Vermont Department of Public Service

Attachment A

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 257, ARTS/MELLLA

Additional Information in Response to RAI No. 9

Instrument Uncertainty and Setpoint Design Guide

VERMONT YANKEE

NUCLEAR POWER STATION

INSTRUMENT UNCERTAINTY AND SETPOINT

DESIGN GUIDE

APPENDIX D To Setpoint Program Manual

Revision 2

Approvals: JOSEPH GAROZZO Joseph Garozzo 7/15/03
Prepared By/Date

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Reviewed By/Date

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PREFACE

This document is intended to support the overall Setpoint Program at the Vermont Yankee Nuclear Power Station by providing guidance for the preparation of instrument uncertainty and setpoint calculations. Historical background, implementation, and responsibilities will be contained in the Setpoint Program Manual.

This design guide is written for a diverse group of potential users, which include:
(1) Preparers or reviewers of both nuclear safety-related and non-safety related setpoint calculations,
(2) Potential auditors of the Setpoint Program,
(3) Preparers of instrument calibration and testing procedures.

Since not all information in this guide will be of interest to all users, the following "road map" is provided to help the user quickly find the information he or she may require.

- Specialized terms are defined in section 5., "Definitions and Abbreviations."

- Cross-references to documents listed in section 6., "General References," are shown as [Ref. x.xx], where x.xx is the paragraph number. References to other sections of this guide are shown as [Sec. x.xx] or "see Appendix X."

- This guide employs a "graded" approach to the evaluation of uncertainty and the development of setpoints or operator decision points. The degree of rigor and the conservatism of the calculation are based upon the safety significance of the instrument function. The classification scheme is introduced in section 2., "Scope", the effect on uncertainty calculations discussed in section , "Module Uncertainty," as well as under each uncertainty element, guidance for classifying particular functions is provided in section , "Setpoint Classification," and the specifics of setpoint calculations for each classification are covered in section , "Setpoint Determination."

- Section 3., "Uncertainty Evaluation," begins with a general discussion of how uncertainty is calculated, covers evaluation of specific elements of uncertainty from vendor and testing data, then shows how these elements may be combined, first for individual modules, and then entire loops.

- Section 4., "Setpoints and Decision Points," begins with the different bases for each type of setpoint, shows how loop uncertainty is used to find the nominal setpoint and Allowable Value as appropriate, includes the evaluation of the calculated setpoint against the estimated operating limitations and concludes with a discussion of the content of a setpoint calculation and general design considerations.

- Topics which apply to only a few calculations have been placed in the appendices. Related information in an appendix will be noted in the text. Appendix A, "Graded Approach to the Determination of Instrument Channel Accuracy," defines the graded approach used for calculations and Appendix B, "Recommended Calculation Format," shows a recommended shell for a setpoint calculation.

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REVISION HISTORY

Revision	Date	Description of Change
Original	5/7/97	Original Issue
1	2/5/2000	Numerous changes have been incorporated such that this revision is viewed as a **Major Change**. As such, revision bars will not be applied. A summary of key changes follows: 1. Converted text from Word Perfect to Microsoft Word 2. Added Attachment H, I, J & K 3. Revised the discussion on Graded Approach. 4. Improve the description of statistical analysis and the applicability of Confidence Interval, Tolerance Interval, Proportion, and Probability. 5. Attachment A – Replaced 'Standard Criteria and Assumptions' with 'Graded Approach to the Determination of Instrument Channel Accuracy' 6. Attachment B – Revised the 'Recommended Calculation Format' and included a setpoint check-off list. 7. Attachment D – Updated the method of propagating flow uncertainty.
2	7/15/03	Revised the following pages as described: 1. Pages 6 and 7 – Removed references to FSAR Tables, which are no longer applicable. Removed reference to accuracy for RG 1.97. 2. Page 39 – Removed Figure which is no longer applicable. 3. Page 54 - Revised Figure to remove erroneous references. 4. Page 56 – Editorial corrections made to uncertainty terms, removed AL/PL check that are not necessary. 5. Page 57 – Editorial corrections made to uncertainty terms. 6. Page 58 – Removed AL/PL check that are not necessary. 7. Page 60 – Removed TSL check that is not necessary. 8. Page 68 – Removed unecessary wording from LSSS definition.

1. INTRODUCTION

This design guide establishes a methodology for the preparation of instrument loop uncertainty and setpoint calculations. A systematic method of identifying and combining instrument uncertainties is necessary to ensure that adequate margin has been provided to protection limits as well as normal operations. The methodology is based on the industry standard ANSI/ISA S67.04 Part I-1994, "Setpoints for Nuclear Safety-Related Instrumentation" [Ref. 6.4].

Instrument setpoints associated with nuclear safety-related (NSR) functions are generally based on established safety or analytical limits, while setpoints associated with a non-nuclear safety-related (NNS) function will frequently be based upon estimated operating limits. NSR and NNS are categories used in this design guide to denote the classification of the function that a particular channel or loop performs. This guide complies with the intent of ISA RP67.04 Part II-1994 [Ref. 6.5] with respect to NSR setpoints. Where appropriate, clarifications of the standard as it applies to Vermont Yankee will be provided; however it is not the intent of this guide to replicate the material in the recommended practice. Anyone using this guide to prepare NSR calculations should also be familiar with ISA S67.04 Part I and ISA-RP67.04 Part II .

This design guide provides an appropriate degree of rigor in the method by which a setpoint is determined. The intent is to provide a format for combining uncertainties caused by process variations with those due to the instrumentation to ensure that there is adequate margin for the given plant parameter. This provides a consistent criterion for assessing the magnitude of uncertainties associated with each component, thereby ensuring plant safety and adequate operating margin.

Instrument uncertainty is of interest for purposes other than setpoint determination. Operators use parameter indications (e.g. indicators and recorders) to monitor plant performance. This monitoring function supports surveillance activities as well as supporting the operators in the use of the emergency operating procedures (EOPs). Specific monitoring systems are relied upon post-accident and must be evaluated for uncertainty under those conditions.

This design guide will be applied to the determination of setpoints applicable to both Vermont Yankee's existing Technical Specifications and the yet to be implemented Improved Technical Specifications.

It is expected that as the Setpoint Program evolves this guide will be revised.

2. SCOPE

This design guide applies to the determination of instrument uncertainties and setpoints, as well as the evaluation of EOP decision points. These include any of the instrumentation used in NSR channels, other TS required loops, post-accident monitoring channels, and NNS/BOP setpoints and indication loops at Vermont Yankee, for example:

- Temperature, flow, conductivity, and radiation detector elements;
- Temperature, pressure, flow, level, and conductivity transmitters and switches;
- Signal conditioners, discriminators, converters, and analog isolators;
- Alarm switches, bistables, and trip units;
- Display meters, panel indicators, and recorders;
- Time delay relays, counters, rate meters, totalizers, summers, characterizers, and function modules;
- Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC) devices.

This design guide does not currently apply to setpoints for control loop controllers, motor-operated valve (MOV) torque switches, snubbers, transformer tap settings, mechanical limit switches, or mechanical relief valves. MOV requirements are addressed in the Vermont Yankee Motor Operated Valve Program Manual [Ref. 6.23]. Response times associated with setpoint initiation and actuation of nuclear safety-related devices are separately addressed in VYC-264, "Safety Class Instrument Accuracy Review: Instrumentation and Logic Circuit Time Response" [Ref. 6.31].

2.1. Setpoint Classes

The methods described in this guide are intended to apply to the entire range of protective setpoints, and to a limited extent to control setpoints, applicable to Vermont Yankee. Differences in instrument functions are recognized and accounted for by the degree of rigor required in the methodology employed to arrive at the instrument uncertainty and final setpoint. The Vermont Yankee graded methodology classifies instrument setpoints into four levels. These correspond to a "level of confidence" that the setpoint will perform its function with respect to a limit or other limiting criteria. These levels range from Class 1, which provides the highest confidence, to Class 4, which may only document engineering judgment.

The following sections identify instrument channel functions and the minimum level of confidence and proportion used when determining instrument loop accuracy. Those

individuals preparing and reviewing instrument loop accuracy calculations may choose to perform a particular instrument loop accuracy calculation using a higher level of confidence. The basis for this decision shall be fully documented in the instrument loop accuracy calculation.

It is not the intent of this standard to identify every instrument function encountered in a nuclear station. The following sections should provide sufficient guidance for selecting the appropriate confidence level for those instrument functions not explicitly identified. Care should be taken to ensure that the function of the setpoint, or use of the uncertainty is clearly identified and that the instrument loop accuracy is determined consistent with the following levels.

2.1.1. Class 1: Nuclear Safety Related

RG-1.105, ISA S67.04 Part I, and ISA-RP67.04 Part II are all concerned with setpoints for nuclear safety-related instrumentation, which are defined as follows:

"That which is essential to the following:

a) Provide emergency reactor shutdown
b) Provide containment isolation
c) Provide reactor core cooling
d) Provide for containment or reactor heat removal
e) Prevent or mitigate a significant release of radioactive material to the environment or is otherwise essential to provide reasonable assurance that a nuclear power plant can be operated without undue risk to the health and safety of the public."

The design guide is predicated on this definition which is taken from ISA-RP67.04 Part II [Ref. 6.5].

Nuclear safety related trips (e.g. Low Low Reactor Water Level) and initial process conditions assumed in the accident and transient analysis (e.g. Torus Water Temperature) are considered Class 1. Class 1 instrument functions are those that are required to fulfill the safety functions or support systems important to safety described in the Vermont Yankee Engineering Design Basis Manual [Ref. 6.26]. Those instrumentation functions and loops are generally found in the FSAR tables identified in Section 2.3 below, however the specific list of setpoints and functions for each class will be contained in the Setpoint Program Manual.

Attachment A provides the application of Rigor for Class 1 setpoints and uncertainty calculations.

2.1.2. Class 2: Parameter Monitoring Important to Safety

This level will include those setpoints that:

1) Ensure compliance with Technical Specification but are not Class 1 setpoints.
2) Provide setpoints or limits associated with RG 1.97, category 1 and 2 variables.
3) Provide essential setpoints or limits associated with station emergency operating procedure (EOP) requirements.

The RG 1.97 category 1 and 2 variables are included in Class 2 since they: 1) provide the primary information required to permit the control room operator to take specific manually controlled actions for which no automatic control is provided and that are required for safety systems to accomplish their safety functions for design basis accident events, and 2) provide the operator with information that is essential to ensuring safety related post-accident functions are occurring.

Class 2 instrument loops are typically associated with those setpoints that provide the station operator with specific action values or limits used to verify plant status. This includes instrument loops that provide an indication of acceptable performance for structures, systems and components in the Technical Specifications.

Setpoints or limits contained in station EOPs that are RG 1.97 category 1 and 2 variables, or setpoints that provide specific action values are included in Class 2. Other EOP setpoints may be either Class 2 or 3 depending on their function.

This class includes instruments qualified under the Vermont Yankee Environmental Qualification (EQ) Program [Ref. 6.21] for harsh environments, as well as NSR and NNS instruments which do not require qualification for harsh environments.

Attachment A provides the application of Rigor for Class 2 setpoints and uncertainty calculations.

2.1.3. Class 3: NNS Functions Requiring Detailed Analysis

This Class will include those setpoints that:

1) Provide setpoints or limits associated with RG 1.97, category 3 variables.

2) Provide setpoints or limits associated with other regulatory requirements or operating commitments, e.g. OSHA, EPA, etc.

3) Provide setpoints or limits that are clearly associated with personnel safety or equipment protection.

The RG 1.97, category 3 variables are associated with contingency actions and may be included in EOPs or other written procedures.

Classification of EOP setpoints as Class 3 shall be approved by the station EOP coordinator or other individual designated by the station operations department.

Attachment A provides the application of Rigor for Class 3 setpoints and uncertainty calculations.

2.1.4. Class 4: NNS Functions Not Requiring Detailed Analysis

This Class will include those setpoints that:

1) Provide setpoints or limits not identified with the requirements in Class 1, 2 or 3 above.

2) Require documentation of engineering judgment, industry or station experience, or other methods that have been used to set or identify an operating limit.

Class 4 shall provide documentation of all non-Vermont Yankee methodologies used to establish instrument loop accuracies or instrument setpoints.

2.2 Site-Specific Criteria

Safety-related calculations prepared in accordance with this guide shall satisfy the requirements of WE-103, "Engineering Calculations and Analyses" [Ref. 6.12], Project Procedure VYDEP-15, "Calculations," AP-0017, "Calculations and Analyses" [Ref. 6.13], and Vermont Yankee Procedure AP-0022, "Setpoint Change Requests" [Ref. 6.14]. Non-safety related calculations should also be prepared in accordance with WE-103 or approved Vermont Yankee plant procedures and VYDEP-15.

2.3 Regulatory and Standards Commitments

From the Vermont Yankee Final Safety Analysis Report (FSAR) Section 7.2.2, Safety Design Bases (7.c.):

> "The system shall be designed for a high probability that when any monitored variable exceeds the scram setpoint, the event shall result in an automatic scram and shall not impair the ability of the system to scram as other monitored variables exceed their scram setpoints."

From FSAR Section 7.2.4, Safety Evaluation:

> "Because the Reactor Protection System meets the precision requirements of Safety Design Bases 1, 2, and 3 using instruments with the characteristics described in Table 7.2.1, it is concluded that Safety Design Basis 5 is met."

2.3.1 Vermont Yankee Commitment Tracking System

(a) AUDITRPT9207EEC1: Develop VERMONT YANKEE position for SSCA 0878 defining setpoint methodology and setpoint design basis.

(b) INF96022_01: Revise setpoint program to specify M&TE acceptable for given surveillance calibration. Modify surveillance test and/or calibration procedures to incorporate M&TE specified by the calculations.

(c) INS941601: Reevaluation of the surveillance setpoint tracking program to ensure compliance with NRC bulletin 90-01, Supplement 1.

(d) MOOID9207MGT1: Develop setpoint philosophy document to ensure that setpoint issues are consistently addressed.

(e) OE7795: Humidity effects on setpoint drift in Barksdale B1T and B2T pressure switches at Duane Arnold.

These and parts of other commitments will be addressed by this design guide and other parts of the Improved Setpoint Program.

2.3.2 Surveillance Extension

As part of the Vermont Yankee effort to extend surveillance test intervals (i.e. from monthly to quarterly), a commitment was made to the NRC to document the plant specific drift and reliability of the affected instrumentation and submit an amendment to the Technical Specifications [Ref. 45]. This design guide will provide a methodology to evaluate and document the setpoint changes as a result of the required drift studies.

2.3.3 Regulatory Guide 1.97

The Vermont Yankee RG 1.97 commitments are summarized in "Guidance & Methodology Associated with Vermont Yankee's Regulatory Guide 1.97 Program Commitments [Ref. 6.22]. This document identifies those instruments, ranges and design features required to satisfy RG 1.97. The methodology discussed in the Instrument Uncertainty and Setpoint Design Guide addresses those requirements.

2.3.4 Custom Technical Specifications (CTS)

CTS criteria apply until Improved Technical Specifications (ITS) are implemented. CTS requirements need to be included, as well as any formal Technical Specification interpretations and clarifications provided in "VY Clarification Document".

3. UNCERTAINTY EVALUATION

All instrumentation exhibits some error from the true value of the measured parameter; however, that error may not be known exactly. The limits of that error may however be evaluated statistically. Uncertainty is the term used to describe the distribution of errors and the numerical limits of error which are "most likely" [Sec. 3]. See Attachment F: "Statistical Considerations", for further detail.

Instrument accuracy and uncertainty are terms that are often misunderstood and misused. Accuracy is the closeness of agreement between a recognized standard or ideal value and the result of a measurement [Sec. 3]. Often, this is quantitatively expressed as error or inaccuracy. Unfortunately, the value of error for any one measurement is not knowable, all that can be known is an estimate of the range of values of likely error [Ref. 6.8]. Accuracy will be used in this guide as synonymous with reference accuracy.

The principal application of uncertainty covered by this design guide applies to the evaluation of families of similar instruments to establish limits of error over an extended calibration cycle and a wide range of conditions, as is typical of the installed process instruments at Vermont Yankee. This view of uncertainty is central to the setpoint methodology described in this design guide. Rather than being dependent upon the behavior of a specific instrument or loop the resulting setpoints may be expected to be valid for any similar model of instrumentation, for similar conditions and test intervals.

An important feature of the setpoint program at Vermont Yankee is the collection and analysis of plant instrument drift data. This guide provides direction for interpreting the results of this type of analysis to develop appropriate uncertainties, testing limits, and setpoints for instrument loops likely to be found at Vermont Yankee.

3.1 Types of Uncertainties - Random and Bias

There are two basic categories of errors described by this guide-random (R) and bias (B). The total error (u) of a particular measurement (k) can be expressed as a sum of these two types of errors.

$$U_k = B_k + R_k$$

Bias errors and normally distributed random errors are illustrated in Figure 1, "Bias and Normally Distributed Random Uncertainties."

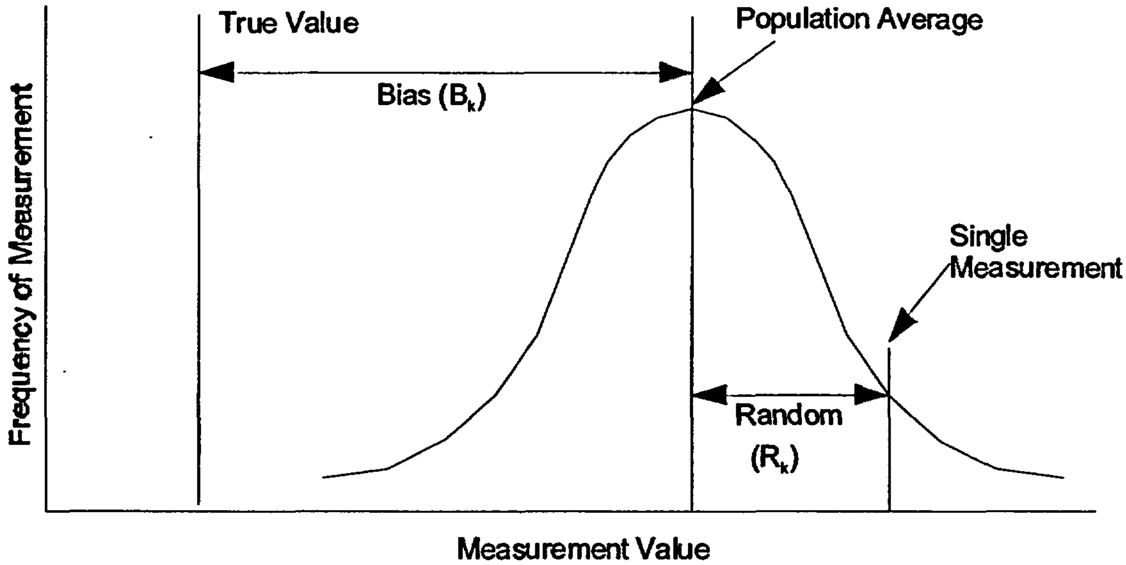

Figure 1: Bias and Normally Distributed Random Uncertainties

Bias errors (also called systematic errors) show a repeatable pattern to the errors [Sec. 3]. With only bias errors, the difference between the "true" value and the measured value is consistent and theoretically predictable. Also treated as biases are those effects that are not predictable, but are likely to assume values near known limits.

Random errors can vary both in sign and magnitude for each measurement [Sec. 3]. Random errors cannot be predicted exactly but can be estimated by a distribution function. As generally used in this design guide, random terms are those which have an equal possibility of deviating from the norm in a positive or negative direction (e.g., ±), and are approximately normally distributed; however, guidance is also provided in Attachment G: "Abnormal and Uniform Uncertainty Distributions," for those distributions which are not "covered" by the normal, bell shaped distribution.

Sign Convention: Throughout this guide a positive uncertainty implies that the "sensed" output is greater than the actual process condition, as is the case with a signal-developing instrument and associated loop. However, the signal convention for field devices (e.g. pressure switches) may be reversed where the uncertainty is a shift of setpoint rather than a shift of ideal signal output.

3.2 Evaluation of Randomness

The uncertainty behavior of an instrument for a given effect may be random or bias. If the effect is random, then the characteristics of a group of instruments will also be random. Commonly, an individual instrument may show a systematic or bias error for a given effect. Other similar instruments (e.g., same model number) may also individually exhibit bias behavior. However, as a group, the sign of the individual instrument errors is equally likely to be positive as negative and the possibility of a positive error of a given magnitude is as likely as a negative error of equal magnitude. This satisfies the concept of a symmetric random distribution. This kind of effect is considered as random independent, since the installation of any particular device is random. This allows us to use the Square-Root-Sum-of-Squares (SRSS) to evaluate overall uncertainty and to apply that uncertainty symmetrically to a particular point of interest (e.g., a process limit or setpoint). Obviously, if individual devices have random characteristics, then the characteristics of the group of instruments will also be random. However, even if individual devices have non-random characteristics, the characteristics of the group of instruments may also be random. Random in these discussions assumes a normal distribution.

Also, most devices (within a family of similar devices) will exhibit little error, with a few having larger errors. This in a general way implies a normal distribution. Use of a normal distribution allows relating two standard deviations to a 95% confidence interval.

In some cases, the likelihood that one member of the group may exhibit a large error is on the same order as the likelihood of a small error, although the distribution is still random, it does not have the same coverage as the normal distribution. In those cases, this guide will apply the mathematical rules of a uniform or rectangular distribution, which are based upon the fact that in such a distribution the possibility of all errors within the range of the distribution are equally likely [Attachment G].

For this design guide, determination of whether a given type of uncertainty or effect is random or biased is based upon the characteristics of a group of similar instruments (e.g., same model), rather than of a single installed instrument (which may be replaced some time later).

Care must be exercised in relying on vendor supplied test results to determine whether an uncertainty is random or bias. Although most vendors specify nearly all of their instrument performance specifications as "±", there is often insufficient data available to support classifying the uncertainty as random. In some cases, an examination of the actual test results will reveal that the "±" specification refers to an arbitrary limit of error rather than a statistical distribution.

Summary

If available, testing data should be evaluated statistically to determine randomness.

If no data are available, then try to obtain a statement from the vendor characterizing a specification as random or biased.

If neither testing data or vendor statements are available, follow the assumptions provided in this guide for specific uncertainty elements.

3.3 Dependency

Dependent errors can exist when there is an interaction between two or more effects. Those interactions could be intra device (multiple effects acting on one instrument) or inter-device (an effect causing an interaction between devices). Where errors are truly random, normally distributed or near normally distributed, there can be no dependency. Dependency can exist between different parts of the process (i.e. an increase in temperature can result in a decrease in density for a fluid in a tank and an increase in tank pressure). Since both the changes are directional and produced by the single temperature change event these results are dependent. Any analysis performed for density errors must also include dependent pressure errors. Where there is indication of a non-normal distribution, for a given error, dependency should be evaluated. Where errors are random and normally distributed, dependency may be ignored. Using site-specific analyzed drift would account for any intra device dependencies for testing conditions. For further information see Attachment F, "Statistical Considerations."

3.4 Methods of Combining Uncertainties

The method presented in this guide for combining uncertainties, while conservative in nature, is not unnecessarily restrictive with respect to plant operations. This method does not determine the maximum loop error; rather, it determines the uncertainty that can reasonably be expected for a given set of conditions. By using a "Square-Root-Sum-of-the-Squares" (SRSS) relationship, the method recognizes that the elements of uncertainty are free to vary in both direction and magnitude. This results in smaller total uncertainty, while maintaining the desired confidence level.

Determination of maximum loop uncertainty on the basis of a "Straight Sum" or algebraic method would imply that all component errors apply at the same time, at their maximum values, and all in the same direction (+/-). In other words, the uncertainties would all be biases. While this method provides almost 100% assurance that the derived uncertainty is conservative, it is likely that the resulting setpoints would be set too deep into the normal operating ranges of a parameter.

The final form of the uncertainty expression is determined by characterizing each element of uncertainty as one of the following:

(a) Random, Independent
(b) Random, Dependent
(c) Bias

The method presented here is a combination of the algebraic and SRSS methods. The random elements of uncertainty are combined under the SRSS method, and any bias uncertainties are added algebraically (straight-sum) to the SRSS result. Any random dependent elements are added to each other algebraically and then combined with random independent terms using the SRSS method.

In equation form, the combination of uncertainty elements for a particular module, might be expressed as follows:

$$u=\sqrt{w^2+(x+y)^2}+v$$

Where,
x and y are random, dependent elements
w and (x + y) are random, independent elements
v is a bias element
u is the total uncertainty for a particular module

The overall uncertainty (U) for a loop consisting of 3 modules (n = 1, 2, 3) would be found by separately combining the random uncertainties (u_{Rn}) of each module using SRSS and adding the bias terms (u_{Bn}) as follows:

$$u=\sqrt{u_{R1}^2+u_{R2}^2+u_{R3}^2}+u_{B1}+u_{B2}+u_{B3}$$

3.5 Combining Uncertainties with Different Confidence Interval Levels

This guide generally assumes that random errors are normally distributed. See Attachment G, "Abnormal and Uniform Uncertainty Distributions," for guidance in using abnormally distributed uncertainties. For conservatism, it shall be assumed that published vendor specifications are no better than 95% confidence with 95% proportion (2σ) values unless specific information is available to indicate otherwise.

If there is very strong evidence that a particular error specification represents a higher confidence level, the individual preparing an uncertainty calculation may adjust that specification in accordance with guidance provided in Attachment F or the drift analysis calculations if available. If there is strong evidence that a particular error specification

represents a low confidence or proportion level, the individual preparing an uncertainty calculation must adjust that specification also.

3.6 Uncertainty Elements

The elements of instrument uncertainty discussed in this section are typical of effects which can alter the overall accuracy of an instrument. Other effects or uncertainties may exist for an instrument (e.g., radiation monitors) which are not covered by this general list.

The normal manner of handling environmental effects is to consider each effect separately and then combine the factors as appropriate for random and bias terms. The sections below deal with the effects of individual environmental factors.

Throughout this section, vendor performance specifications are shown in a form that applies to most cases. The reader is cautioned that this is not always a valid assumption. In actuality, the performance specification may take virtually any form (i.e., linear, exponential, or stepped functions).

Although the preparer of an uncertainty or setpoint calculation is expected to consider each category of uncertainty addressed in this section, not every uncertainty will be applicable to every instrument. The preparer shall provide a discussion sufficient to explain his/her rationale for any uncertainty category that is not included in the uncertainty calculation.

3.6.1 General Considerations

- All random, normally distributed elements of uncertainty are independent of each other. All other elements of device uncertainty should be evaluate for independence based on the error cause and effect relationship [see Attachment F section 4]

- Most instrument uncertainty elements are random. The vendor expressions are used as limits of error. An individual instrument can have an error smaller than the published value, and can vary in both sign and magnitude between instruments. The process measurement and static pressure terms are usually biases, though in some cases each could be random, abnormally distributed, and could be treated as a uniform distribution [Attachment G].

- Vendor expressions may or may not be linear. Some terms may be exponential, quadratic, constants, or step functions. Vendor expressions which are not linear may not be extrapolated up or down without additional justification. Contact the vendor when in doubt.

- For consistency between calculations, all elements of device uncertainty should be calculated in terms of percent calibrated span (% CS) of the device. If constant percent of calibrated span is not applicable, percent of input value (% IV) may be used. Once combined with other elements for a given module, the preparer may convert the resulting uncertainty to engineering units (inches level, psig, gpm). For loops containing more than one instrument it is strongly suggested that units of %CS or %IV be used.

  However, where the loop contains non-linear devices the error must be propagated through the non-linear device based on the specific input and output signal units at the point of interest. Error values associated with non-linear devices will not be converted to percent of calibrated span. In any case, the same units should be used throughout the calculation, converting to specific signal levels only when necessary (i.e., as found tolerance in mA for trip units).

- For any effect, for which vendor or plant data is not available, a value estimated by similarity with other instruments, or based upon other applicable experience should be used, rather than assuming a default of zero. This should be explained in the assumptions section. As noted in ISA-RP67.04 Part II, the absence of a rating does not necessarily mean the effect is negligible.

The guides provided below are the results of extensive experience and discussion; however, the individual performing the calculation must ensure the values used for device uncertainty and the manner in which the elements of device and loop uncertainty are combined are consistent with the instrumentation as installed.

3.6.2 Reference Accuracy (A)

Reference accuracy is a performance specification to which the instrument is tested during calibration [Sec. 3]. Instrument manufacturers often disagree on the terms used to describe an instrument's advertised accuracy. For the purpose of this method, accuracy shall include the combined effects of hysteresis, linearity, deadband, and repeatability.

Inclusion of any terms missing from the vendor's stated accuracy should be as follows:

$$A=\sqrt{(AX)^2+h^2+l^2+r^2+db^2}$$

where,

A = Reference accuracy of instrument
AX = vendor's stated basic accuracy expression
h = Hysteresis
l = linearity
r = repeatability
db = deadband

Determination of the accuracy of flow elements is discussed in Attachment D, "Flow Loop Scaling and Uncertainties."

3.6.3 Calibration Effect (CE) and Calibration Tolerance (CT)

Accuracy is not usually used alone but combined with other terms to determine the overall calibration effect (CE). Calibration effect is the overall inaccuracy introduced into the calibration process due to the procedural allowances given to the technician during instrument calibration, not including measurement and test equipment (M&TE) uncertainty. If the as-left calibration tolerance (CT) for an instrument is larger than the vendor stated accuracy of the device, then the vendor's stated accuracy cannot be verified by calibration. For this reason, the accuracy is effectively limited by the calibration tolerance since that is the limit on how well the instrument can be shown to perform. As part of calculations prepared using this guide, the appropriate calibration tolerance shall be determined. Preferably the calibration tolerance should be equal to the reference accuracy. Whether or not the existing calibration tolerance is appropriate, CT shall be stated in the calculation requirement section.

Per the ISA Recommended Practice (Ref. 6.5), various approaches may be taken to account for calibration effect, depending on the calibration techniques implemented in the field. For the purpose of this Design Guide:

A. Analog Loop Components

CE = CT + A,

Where: A is taken as a dependent term when, during calibration testing, less than a full traverse is performed.

B. Bistables/Switches

CE = CT + A,

Where: A is taken as a dependent term when, during calibration testing, actuation is only tested once.

C. Full Traverse/Multiple Actuations

CE = CT,

Where: analog loop component testing uses full traverses and bistables/switches are tested with multiple actuations.

D. Exception

CE = CT,

Where: for a single point device (i.e. bistables/switches/time delays relays) used in a single direction, where repeatability is the primary contributor to A, and where drift analysis has been performed, determine if the value for analyzed drift is within expected performance characteristics. To simplify verification within performance characteristics, combine (via SRSS) the vendors published accuracy (or the current calibration tolerance if larger), the vendors stated drift term, and the M&TE terms. This value will be compared to the plant specific drift. Plant specific drift must be less than the expected performance,

IF $DA < (A^2 + DR^2 + M\&TE^2)^{1/2}$ THEN CE = CT
IF $DA \geq (A^2 + DR^2 + M\&TE^2)^{1/2}$ THEN CE = CT + A

For Class 2 and 3 setpoints the confidence interval may be reduced based on the nature of the function being analyzed. Since the effect of reducing the confidence interval is to reduce the value of the error used, the associated acceptance band for the instrument calibration or setting tolerance can not be also reduced. Reduction of the tolerances would in effect require a more precise calibration where the calculation justifies relaxing the calibration requirements. The following multipliers are used to define the confidence interval and can be used to convert from one confidence interval value to another.

Confidence Interval Factors for One and Two Sided Uncertainties

Proportion	Single-Sided	Two-Sided
75%	0.68	1.15
90%	1.29	1.65
95%	1.65	1.96
99%	2.33	2.58

Example: Given a calibration tolerance value of 0.25% of span assumed to be three sigma (99 % confidence interval) convert to a 75% confidence interval value. Since three sigma is approximately a 99% value the following calculation is used:

0.25% * 1.15/2.58 = 0.1114% of span equivalent error.

However, using the reduced confidence interval values complicates the evaluation of analyzed drift discussed above. The confidence interval reduction factor is not used as a multiplier to determine the as left, as found or M&TE associated with the calibration. The same values used for the 99% confidence interval would be used. The reduction in confidence interval does not require smaller values for calibration tolerance or M&TE errors.

The M&TE, Calibration Tolerance, and Analyzed Drift comparisons discussed above should use the Reference Accuracy, Vendor Drift allowance (or applicable assumption) and the M&TE value determined for 95% confidence interval. The analyzed drift term for 95 % tolerance interval should be compared to these values to determine if performance is within expected limits. Since the reduction of drift and the reduction of the other terms is by a simple ratio, if the 95% confidence interval values indicate acceptable performance the 75% confidence interval values will also indicate acceptable performance.

Table 1: Standard Calibration Tolerances

Instrument Type	Input Tolerance	Output Tolerance	Calibration Units
Rosemount Pressure Transmitters (1151, 1152, 1153) 4-20 mA output	--	±0.25% CS	±0.04 mA (4-20mA span)
GEMAC Type 551, 552 Transmitters	--	±0.5% CS	±0.2 mA (10-50mA span)
GEMAC Type 555 Transmitters		±0.4% CS	±0.16 mA (10-50mA span)
Rosemount mA Master Trip Units (510, 710) RTD Master Trip Units (710)	±0.20% CS ±0.80% CS	--	±0.03 mA (4-20mA span) ±0.13 mA (4-20mA span)
Rosemount mA Slave Trip Units (510, 710) RTD Slave Trip Units (710)	±0.25% CS ±0.90% CS	--	±0.04 mA (4-20mA span) ±0.14 mA (4-20mA span)
GE/Westinghouse Type 180 Indicators	--	±2.0% CS	-
Sigma/International Type 1151 Indicators	--	±2.0% CS	-
Static-O-Ring Pressure Switches	±1.0% URL[1]	--	

[1] URL = upper range limit, which for switches refers to the maximum setting.

3.6.4 Readability Uncertainty (RD)

Readability is the ability of the user to determine the markings on a device. Readability is limited to the number of markings on a device and the operators ability to distinguish between the marks. Analog indicator or recorder readability is generally half of a minor division. Analog indicator or recorder readability uncertainty is generally one quarter of a minor division.

3.6.5 M&TE Uncertainty (MTE)

M&TE uncertainty is the inaccuracy introduced into the calibration process due to the limitations of the test instruments. M&TE uncertainty includes three principal components: (1) reference accuracy of the test equipment, (2) effect of temperature on the test equipment, and (3) accuracy of the test equipment calibration process. The first two components are included directly in M&TE uncertainty and the third is assumed to be included in the conservatism of the accuracy.

All (100%) of test equipment is certified to pass the calibration requirements, not just 95%, the common confidence interval used for uncertainty calculations. Discussions with vendors have shown that the actual accuracy of the test equipment is better than the vendor published values. Both of these provide conservatism in the accuracy of the M&TE. Further the standards used to calibrate the M&TE are generally rated 10:1 better than the equipment being calibrated [Ref. 6.15, Ref. 6.16]. The published accuracy of the M&TE should not be included with the accuracy of the test equipment calibration process since M&TE divided by 10 is negligible in relation to other uncertainties.

> Note: where the 10:1 ratio is not achievable for the calibration standards, the accuracy of the calibration standard should be included in the overall M&TE accuracy.

Since M&TE is certified before and after use at several data points (i.e. 100 % verification) M&TE error may be considered a 3 sigma value. This 3-sigma value may then be reduced to 2 sigma for the calculation. The uncertainty of the measurement and test equipment used for calibration affects the overall accuracy of an instrument loop. The uncertainty included should be representative of the way calibrations are performed by site personnel, or of an assumed method which is clearly stated as one of the requirements for the calculation to be valid.

If loop calibrations are not performed, then total loop uncertainty includes M&TE for each instrument. If loop calibrations are performed, the total loop uncertainty would include only the input and output M&TE for the loop test.

The M&TE uncertainty for a single test instrument is the SRSS combination of the accuracy, readability, and temperature effect. Usually more than one test instrument is involved in the calibration of a process transmitter or signal converter. The uncertainty of the test instrument should be applied to the process instrument to which it provides input, or from which it measures output. When multiple test instruments are used for a given process instrument, the accuracy and temperature effect of each test instrument should be combined using SRSS.

$$m = \sqrt{A^2{}_m + RD^2{}_m + TE^2{}_m}\,\frac{CS_m}{CS}$$

$$MTE_i = \sqrt{m_1^2 + m_2^2}$$

where,

A_m = accuracy of test instrument in percent of span of the test instrument (including hysteresis, linearity, repeatability and deadband).
RD_m = readability of test instrument in percent of span of the test instrument
TE_m = temperature effect on the test instrument in percent of span of the test instrument
CS_m = calibrated span of the test instrument
CS = calibrated span of process instrument being tested
m_1, m_2 = uncertainty of 1st and 2nd test instrument in percent calibrated span of the process instrument
MTE = M&TE uncertainty in percent of calibrated span of the instrument being tested

The temperature effect on the test instrument may be calculated using: (1 the difference between the test temperature and the temperature at which the test instrument was calibrated or, (2 the difference between the temperature at which the M&TE will be used and the limits of a rating band within which the basic accuracy applies. Consult the M&TE specifications to see which applies.

Generally the MTE allowance is an **output** requirement of the uncertainty or setpoint calculation, which is to be imposed upon the testing procedure to ensure that a minimum accuracy is met. To avoid imposing requirements that can not be met, the calculation preparer shall verify that the specified uncertainty can be met by available equipment. VYC-1758 (Ref. 6.46) calculates the accuracy for most common M&TE available. This calculation should be used as the primary reference for M&TE accuracy. The values in VYC-1758 should be considered as 3 sigma.

Accuracies for other parameters, such as pressure, are typically based on requiring that the SRSS of all M&TE used to calibrate a process instrument be at least as accurate as that instrument.

For example, if a pressure transmitter has a rated accuracy of ±0.25% CS. The combined uncertainty of the input pressure gauge and the output current measurement (2 sigma values) should then be no greater than the same ±0.25% CS. The accuracy of the current measurement is ±0.127% CS (±0.0203 mA over a 4-20 mA span). The minimum accuracy of the pressure measurement can be determined by solving the following equation for x:

$$\pm 0.25 = \sqrt{0.127^2 + x^2}$$

$$x^2 = 0.25^2 - 0.127^2 = 0.046371$$

$$x = 0.2153$$

Solving for x results in a minimum accuracy for the pressure gauge of ±0.215% CS. This can then be converted into engineering units, for example for a transmitter with a 0 - 300 psi span, the minimum accuracy would be 0.64 psi.

3.6.6 Analyzed Drift (DA)

Analyzed drift (DA) is the term used here to describe uncertainty values derived in accordance with the Vermont Yankee Instrument Drift Analysis Design Guide [Ref. 6.17] to statistically represent the change in instrument uncertainty from one calibration to the next. Each data point, in addition to drift (DR), includes the influence from M&TE errors (MTE, Sec. 3.6.5), personnel errors, errors caused by misapplication of the instrument or other cumulative operating effects. True drift (DR, Sec. 3.6.7) is only that uncertainty which cannot be attributed to other influences beside the passage of time. Where plant specific drift has not been determined Section 3.6.7 provides guidance on using vendor or assumed drift values.

The overall analyzed drift tends to account for Reference Accuracy (A), M&TE, and for normal environmental effects, including temperature (TE_{cal}, Sec. 3.6.8), radiation (RE, Sec.3.6.11), power supply voltage variations, assuming that the power supply is not calibrated prior to device calibration (VE, Sec. 3.6.14), humidity (HE, Sec. 3.6.10), and barometric pressure (PB, Sec. 3.6.9). The calculation preparer does need to account for any difference between normal and applicable accident conditions.

Since both the as-found and as-left measurements include any M&TE error, any random error in these measurements will be reflected in the analyzed drift term.

Since the present testing method only involves increasing signal levels, dead band is not reflected in analyzed drift, however readability is generally included for indicators and recorders, since the technician must read off the output value from the instrument under test.

The analyzed drift does not include process effects that are not within the scope of the calibration procedure. Nor does it usually include effects of conditions that are not present during the calibration process such as equipment vibration, if the source of vibration is shut down. However for instruments in radiation zones, the normal effect of radiation is cumulative and is typically reflected in the calibration data.

Analyzed drift is reported as a 95/95 confidence and proportion, along with the sample mean, sample standard deviation and the number of data samples analyzed. For Class 1 setpoints or decision points, the 95/95 confidence and proportion shall be used as the DA term. For Class 2 and 3 functions, the proportion may be reduced while maintaining the confidence. The proportion may be reduced to 90 percent for Class 2 functions (95/90). For Class 3 functions, the proportion may be reduced to 75 percent (95/75).

A detailed summary is provided in each drift calculation describing the results of the analysis. Included in the summary are discussions on time dependency, distribution (normal or not normal), etc. In addition, data is provided which specifies the statistical results of the drift analysis associated with Kurtosis, mean, standard deviation, and the TIF used. Analyzed drift values for various probabilities may be calculated based on the drift analysis.

The summary provided in the associated drift analysis should be included (all or in part) within the setpoint calculation as well as any other portion or the drift calculation which provides an input to the setpoint calculation. Guidance is provided in Attachment F. The determination of time dependence, in the drift analysis, will be used as the basis for extending the drift value for a longer time interval.

The drift analysis evaluates the change in instrument output for a given input over the normal instrument calibration cycle (based on the average time between calibrations). The drift analysis may indicate that there is no relationship between the magnitude of drift and time, some relationship between magnitude and time or a strong relationship between magnitude and time. If the desired calibration cycle does not match the analyzed drift cycle, it will be necessary to expand the analyzed drift value. The determination of this relationship between magnitude and time will indicate the method of expanding the drift value.

Where it can be proven that there is no relationship between time and drift magnitude , the calculated drift may be used for any time period. However, extension of the calibration interval may also require that the instruments be evaluated for other time based failure mechanisms:

$DA_{\text{any time interval}} = DA_{\text{analyzed}}$

Where there is indication of a relationship between magnitude and time, it is necessary to increase the drift value to ensure that the increased time interval does not result in drift values in excess of predicted. If the drift analysis determines that slight time dependence exists (bounded by a non-linear extrapolation), a non-linear extrapolation of the drift value is used to determine drift for the interval of interest.

As an example if the device is currently calibrated on a monthly bases and the drift analysis determines a value for drift, and determines a mild dependence between drift magnitude and time. The drift value will be expanded based on the equation:

$DA_{\text{Quarterly}} = (114/38 \times DA^2_{\text{Monthly}})^{0.5}$
$DA_{\text{Quarterly}}\text{(random)} = (114/38 \times 2.124^2)^{0.5} = (3 \times 4.51138)^{0.5} = 3.679\%$

If the drift analysis determines that strong time dependence exists (bounded by a linear extrapolation), a linear extrapolation of the drift value is used to determine drift for the interval of interest.

As an example if the device is currently calibrated on a monthly bases and the drift analysis determines a value for drift, and determines a strong dependence between drift magnitude and time. The drift value will be expanded based on the equation:

$DA_{\text{Quarterly}} = 114/38 \times DA_{\text{Monthly}}$
$DA_{\text{Quarterly}}\text{(random)} = 114/38 \times 2.124 = 3 \times 2.124 = 6.372\%$

Summary

(a) Drift values derived from plant testing data in accordance with the Drift Analysis Design Guide [Ref. 6.17] are assumed to include the following effects for **normal** conditions:

- Drift (DR)
- Temperature Effect (TE_{cal})(20 °F calibration temperature range)
- Readability (RD)
- M&TE Uncertainty (MTE)
- Barometric Pressure Effect (PB)
- Power Supply Voltage Effect (VE)(assuming no calibration of the power supply)
- Humidity Effect (HE)
- Radiation Effect (RE)

(b) Accident or post-accident effects do not take credit for any environmental effects already included in analyzed drift, unless the conditions are shown to be the same as normal.

c) Class 1 calculations shall use 95/95 tolerance intervals for DA. Class 2 calculations may use 95/90 tolerance intervals and Class 3 calculations may, under certain conditions, use 95/75 tolerance intervals for DA.

3.6.7 Drift (DR)

The input/output relation for an instrument may change with time. Drift is often specified by the instrument manufacturer based on testing under laboratory conditions. The period of drift applied to an instrument for the purpose of this method is dependent on the calibration period of the instrument. In many cases, the period for which drift has been specified does not agree with the calibration period of the instrument. For long test intervals, it is acceptable to assume the drift is **not** dependent upon total time, but the vendor specification represents two standard deviations of a distribution which applies to any time interval equal to the vendor's specification (t_d). Where drift is determined to have a linear relationship with time to adjust drift to match the calibration period of an instrument, the following equation is then applied:

Or where drift does not have a linear time to magnitude relationship:

$$DR = DRX * \sqrt{\frac{t_t}{t_d}}$$

Where,

DR = time dependent drift in percent of calibrated span

DRX = vendor's drift expression in percent of CS

t_t = instrument test interval (months) should include 125% of nominal test interval for technical specification devices.

t_d = drift interval specified by vendor.

Note: Calibrated span for trip units, bistables, switches, etc., refers to the input span.

If data is available to justify an alternative expression, drift may be a constant, a linear function, a step function, an exponential, or a polynomial.

Note: The following elements are associated with conditions that are generally called environmental influences or environmental effects. For more information on environmental categories and their relationship to setpoints, see Section 3.7, "Environmental Influences."

3.6.8 Temperature Effect (TE)

Temperature variation normally affects the uncertainty of an instrument. The temperature variation of concern is the difference between the temperature of the device at calibration and the temperature for the environment of interest. The environment of interest can be the peak temperature during an accident, the temperature at the next calibration, or the maximum temperature during normal operations. Because both the calibration temperature and the current temperature can vary, a bounding temperature difference for each environmental category is used to simplify the calculation while still providing the appropriate conservatism.

There are three general temperature categories that need to be considered: normal, accident and post-accident. The temperatures experienced during testing may be different from those during full power operations, however at Vermont Yankee, nearly all instruments may be calibrated at power and due to the compact plant layout and the design of the HVAC system, the temperature distribution during normal operations and testing are generally the same. For non-Class 1 setpoints, the range of normal temperatures may be assumed to be the range of testing temperatures. A possible exception would be the Turbine Building, which may be cooler during shut down periods, however in this instance, the normal range will be extended 10°F, so the value shown in the Table below applies to both conditions.

For Class 1 setpoints, outside the control room a calibration temperature range of 20°F shall be assumed, and any analyzed drift data would be assumed to account for that variation. For Class 1 setpoints inside the control room a calibration temperature range 10°F shall be assumed, and any analyzed drift data would be assumed to account for that variation. These assumptions are based on the consideration that many plant instruments may be calibrated on-line and that the plant temperature varies between calibrations. This variation in plant temperature is captured in the as-found to as-left difference between calibrations and therefore also in the analyzed drift values. The temperature effect for Class 1 setpoint calculations which then use analyzed drift (DA) data would account for the temperature difference between the calibration temperature range and the normal design temperature range. For instruments that are removed from service in the plant and shop calibrated or sent off-site for calibration, no calibration temperature variation may exist or the variation may be different from these assumed values. The calculation developer must determine the appropriate calibration temperature variation for these conditions.

Example:

To determine the error associated with an instrument installed in the VY Reactor Building occupied areas, determine the effective differential temperature. This effective differential temperature will then be combined with the vendor's error expression to determine the associated effect. Review Table 2 to determine if the location of instrument installation is defined and captured. The effective differential temperature is calculated as follows:

ΔT = (106 - 62) °F Maximum normal temperature variation
ΔT = 44 °F
ΔT_n = (44 - 20) °F reduce the maximum value based on the normal temperature error assumed included in the analyzed drift (20°F)
= 24°F

Where:
ΔT_n = Effective differential temperature for normal plant conditions.

Assuming a temperature error of 0.5 % of calibrated span per 100°F the final error for normal conditions would be determined as follows:

Error = 0.5% * 24/100 = 0.12% of calibrated span temperature error.

The temperature range for the Control Room is not specified by current plant documents, however the estimate shown in Table 2 below is reasonable based upon the type of heating and ventilation used. Other values in the following Table are taken from the Vermont Yankee Environmental Qualification Manual

[Ref. 6.21] and include normal temperature ranges for various plant areas. Plant areas not included in the Table require the calculation originator to determine the minimum and maximum normal as well as the maximum accident environmental conditions. Area values may be found in the VY Environmental Qualification Manual, the VY USAR, or other VY design documents.

Table 2: Normal Temperature Ranges

Plant Area	Minimum	Maximum
Control Room	60°F	80°F
Reactor Building -		
Occupied Areas	62°F	106°F
Torus Area	60°F	120°F
RHR Corner Room at 213' - 9"	67°F	109°F
RHR Corner Room at 232' - 6"	60°F	104°F
Drywell - Operating & Hot Standby[2]		
Below 270'	140°F	160°F
Between 270' and 315'	175°F	195°F
Above 315'	260°F	280°F
Torus (Internal, Above Water Level)	60°F	120°F
Steam Tunnel	100°F	150°F
Turbine Building[3]		
Occupied Areas	85°F	105°F
Lube Oil Hallway	86°F	104°F

For accident and post-accident conditions, the concern is for high temperatures; therefore, the bounding difference is between the peak temperature during an accident and the lowest temperature at which the instrument would have been calibrated. The delay time of instrument heat up due to thermal inertia effects the actual temperature of an instrument during accident conditions. The vapor temperature during a HELB may reach a peak temperature approaching 300°F in some compartments; however the calculated temperature falls quickly to a much lower level. In those cases and in the absence of specific data to the contrary, temperature excursions shorter than 120 seconds may be neglected.

The EQ manual has graphs for compartment temperatures during specific events that should be used to determine the applicable temperatures. If no specific curve is applicable, the user should refer to the Attachment C of the EQ manual, "Envelope Accident Environmental conditions."

The following equation is for an uncertainty that is a linear function of temperature. This is conservative for most instruments.

$$TE_x = TEX(T_{x,max} - T_{x,min})$$

[2] Minimum is lower than implied by EQ manual to reflect surveillance data for reference leg thermocouples.
[3] Minimum is 10°F lower than otherwise calculated to allow for lower temperatures during shut down conditions.

where,

$T_{x,max}$ = Maximum temperature for the conditions of concern
$T_{n,min}$ = Minimum temperature during normal operations.
$T_{calibration}$ = Temperature effect accounted for in DA (if available).
TEX = Vendor's temperature effects expression in % CS per °F
Note: The subscript "x" can be: n (normal), a (accident), or p (post-accident).

Some pressure instruments, notably environmentally qualified Static O-Ring (SOR) switches and ITT-Barton gauge pressure transmitters, are sealed at approximately atmospheric pressure. When the instrument heats up, the internal pressure does not vent but builds up opposing the process pressure. Consequently, in addition to the usual temperature effect specified by the vendor, there is a negative bias effect due to the thermal expansion of trapped air. Not all SOR switches are sealed nor are all sealed instruments affected by this problem.

Summary

(a) Temperature excursions shorter than 120 seconds may usually be neglected.

(b) The temperature effect is calculated based upon the difference between the peak temperature for the condition being considered and the minimum normal temperature, less any temperature effect accounted for in analyzed drift data.

3.6.9 Barometric Pressure Effect (PB)

Except for transmitters and switches designed to measure pressure, this effect is negligible. Design pressure values for electronic devices are not needed since the devices will work correctly at any reasonable pressure where they are installed.

There are two general ways that barometric pressure can affect the output of an instrument. For pressure measuring devices with one side of the pressure cell exposed to the atmosphere, a change in barometric pressure has a direct bias effect on the output. If the instrument is calibrated in units of absolute pressure (psia) this is an error, if the units are gauge pressure (psig) the effect may be ignored.

If the instrument were sealed, a change in atmospheric pressure would cause an apparent error when calibrated using a vented test gauge and the effect should be included when calculating normal uncertainty, unless compensated for in the calibration procedure.

For accident conditions the effect is usually significant and should only be neglected when it can be shown that the loop function does not depend upon the absolute pressure.

3.6.10 Humidity Effect (HE)

Most modern instrumentation, except devices operating at high voltage and low direct currents (e.g., nuclear detectors and preamplifiers) do not display effects due to humidity exposure less than 90% relative humidity. For those high voltage/ low current instruments specific guidance should be obtained from the vendor.

Some environmentally qualified instruments, particularly recorders and indicators have a separate humidity effect specified. This term may be neglected unless the expected humidity exceeds 90%. Generally there is no separate specification and the effect of humidity is included in the rated temperature or design basis accident response.

A change in humidity can also cause a change in the insulation resistance in a signal cable. This is discussed more in Section 3.10, "Insulation Resistance (IR) Leakage Effects."

3.6.11 Radiation Effect (RE)

Radiation can have a cumulative damaging effect on the materials and components of an instrument. This damage can affect the instrument uncertainty. At relatively high dose rates, the effect may also be rate dependent, which means the results of qualification testing may be misleading if the dose rate of the test greatly differs from those expected during a specific accident scenario.

This design guide assumes that the effects of radiation doses during normal plant operation (characterized by low dose rates) are compensated for by calibration. Therefore, the radiation dose of concern is the Total Integrated Dose (TID) received between calibrations and during an accident. The worst case for radiation effects would be if an accident occurred just before an instrument was to be calibrated. It would have received the normal dose plus the dose for the accident. Accident radiation effects need only be considered up to the time the loop performs its safety-related function.

For instruments in mild environments (TID per calibration interval less than 10^4 rads), the radiation effect can be neglected.

The following assumptions apply to the radiation effect for specific models of transmitter which are developed from specific references. The assumptions are identified by model and the corresponding references are included.

(a) The radiation effect for Rosemount 1152 transmitters is given by the step functions below. A step function is provided since the effect is not considered linear with dose. RE is the radiation effect and R is the radiation dose between calibrations.

These step functions are based on a combination of vendor information and interpretation of vendor test reports. The information for the upper step (highest radiation) comes from Ref 6.35. The information for part of the 0.5% CS step comes from Ref 6.28. The lowest radiation step is based on mild environments having no significant radiation effects. The 0.5% step is intended for use in calculating a testing uncertainty for instruments which normally receive small but significant doses between calibrations.

$$RE = \begin{cases} 0\%CS; R \le 1000 rad \\ 0.5\%CS; 1000 rad < R \le 1.0 Mrad \\ 8.0\%URL; 1.0 Mrad < R \le 5.0 Mrad \end{cases}$$

(b) The radiation effect for Rosemount 1153 Series B transmitters is given by the step functions below. A step function is provided since the effect is not considered as linear with dose. RE is the radiation effect and R is the radiation dose between calibrations.

$$RE = \begin{cases} 0\%CS; R \le 1000 rad \\ 0.5\%CS; 1000 rad < R \le 1.0 Mrad \\ 1.0\%URL; 1.0 Mrad < R \le 5.0 Mrad \\ 8.0\%URL; 5.0 Mrad < R \le 22.0 Mrad \end{cases}$$

These step functions are based on a combination of vendor information and interpretation of vendor test reports. The information for the upper step (highest radiation) comes from Ref 6.32. The information for part of the 1.0% URL step comes from Ref. 6.36 and part from Ref 6.34. The lowest radiation step is based on mild environments having no significant radiation effects. The 0.5% step is intended for use in

calculating a testing uncertainty for instruments which normally receive small but significant doses between calibrations.

(c) The radiation effect for Rosemount 1153 Series D transmitters, excluding range code 0 (for range code 0, the upper step is 8.2% URL), is given by the step functions below. A step function is provided since the effect is not considered as linear with dose. RE is the radiation effect and R is the radiation dose between calibrations.

$$RE = \begin{cases} 0\%\,CS; R \leq 1000\,rad \\ 0.5\%\,CS; 1000\,rad < R \leq 1.0\,Mrad \\ 1.0\%\,URL; 1.0\,Mrad < R \leq 5.0\,Mrad \\ 6.0\%\,URL; 5.0\,Mrad < R \leq 51.9\,Mrad \end{cases}$$

These step functions are based on a combination of vendor information and interpretation of vendor test reports. The information for the upper step (highest radiation) comes from Ref 6.36. The information for part of the 1.0% URL step comes from Ref. 6.32 and part from Ref. 6.34. The lowest radiation step is based on mild environments having no significant radiation effects. The 0.5% step is intended for use in calculating a testing uncertainty for instruments which normally receive small but significant doses between calibrations.

3.6.12 Seismic/Vibratory Effect (SE)

The shaking and physical acceleration due to a seismic event may affect the uncertainty of an instrument, particularly instruments with mechanical parts. Instruments, which are mounted in locations subject to vibration from nearby machinery, may also be adversely effected.

The seismic effect is based upon the instrument response to the acceleration at the instrument location due to a Safe Shutdown Earthquake (SSE), which corresponds to a ground acceleration of 0.14 gravity [Ref. 6.10.1]. The original testing program for instrumentation simulated an SSE by testing each component to 2-axis horizontal acceleration of 1.5 gravities and vertical acceleration of 0.5 gravity [Ref. 6.10.2]. Earthquakes less than an OBE (0.07 gravity, Ref. 6.10.1) are considered not to have a significant effect on instrument uncertainty. Conversely, if the instrument has been qualified by test to accelerations exceeding 3 gravities in three axes, then the seismic effects may be considered negligible. The maximum qualified acceleration for the original GE supplied instrumentation is shown in FSAR Table C.2.7, "Summary of Results -- Class I Equipment Seismic Test."

Seismic effects during and after an event, are usually determined based on the instrument vendor's expression for seismic effect and the seismic response spectrum at the instrument's location. It is likely that a step function or other nonlinear form should describe this effect; consequently, no recommended form is shown. For original scope equipment qualified at less than 3 gravities, an allowance equivalent to ±2% of span shall be used, which corresponds to the testing margin used in the original tests.

The Engineering Design Basis does not consider coincident SSE and safety-related HELB to be a credible event; therefore, in cases where an instrument loop is required to operate for both a SSE and a HELB, only the worst overall loop uncertainty need be used [Ref. 6.26]. Coincident LOCA and SSE are considered credible in the design basis, however not with a licensing basis radiation release. Only the worst of (LOCA + SE) or (LOCA + RE) should be considered. The Engineering Design Basis document includes the following list of safety functions required operable during and following a design basis earthquake:

a. Reactivity Control
b. RPV Level and Pressure Control
c. Decay Heat Removal
d. Post-Accident Monitoring
e. Fuel Pool Cooling and Makeup

The corresponding systems are also shown in matrix form in the EDB document. Only those systems and functions require accounting for the seismic effect.

3.6.13 Process Static Pressure (SP) Effects

Several effects, generally applied only to differential pressure instruments, are associated with exposure to a high static line pressure that interferes with the basic measurement function. If an instrument is not exposed to the process or is not a differential pressure instrument, then these effects are not applicable and may be omitted from the uncertainty or setpoint calculation without comment. For differential pressure instruments, the effects may be applicable and the appropriate uncertainty should be included, or an explanation given why the effect is not applicable. For additional information, see Attachment C: "Process Corrections and Measurement Uncertainty."

Static Pressure Span Correction (SP_C)

Exposure of a differential pressure instrument to process static pressure may affect its span. Generally, this effect is a bias, directly dependent on pressure. This effect can be accounted for by calibrating the instrument at the operating pressure or by using a correction factor to compensate the calibration.

If the static pressure is not calibrated out, or if significant operation occurs at a pressure different than that for which it was calibrated, the static pressure correction should be included. Typical, this is not calibrated out and should be included in the analysis.

At low pressure S.C. should be incorporated with an understanding of how the instrumentation is being used. For example flow indicating instruments in the low pressure systems (e.g. Low Pressure Coolant Injection) could normally be at system pressure as high as 400 psig but be at much lower pressures when most monitoring is required.

Static Pressure Span Correction Uncertainty (SP_U)

When a correction is made to an instrument's calibration by using a vendor supplied expression, there is an additional uncertainty due to the uncertainty of the vendor expression used to correct for static pressure. This is, in effect, the random variations around the bias which occur during testing to determine the vendor correction expression. If the instrument is calibrated at the pressure at which it must later operate, there is no need to include this uncertainty. In that case, the instrument has been adjusted for that particular pressure in that particular installation, and the vendor expression was not used.

Static Pressure Zero Effect (SP_Z)

Static pressure zero effect is the shift of the zero point of the calibrated scale due to operation at a process pressure different than the pressure at which the instrument was calibrated. The uncertainty may be taken as a random term equal to the limits specified by the vendor. The effect is generally not predictable between instruments, so an expression cannot be used to correct for the difference in pressures. However, for a particular instrument the effect can be eliminated by calibrating at the desired operating pressure and adjusting the zero. Typically, this is not calibrated out and should be included in the analysis. See Attachment C for detailed discussion of the application of Static Pressure effects.

Over Pressure Effect (SP_O)

Over pressure effects should be considered when an instrument is operated outside of its normal operating limit. The normal operating limit is not the same as the design limit. Example: a transmitter may have an operating limit of 1000 psi, but its design limit may be 3000 psi. The effects above 1000 psi must be considered. For differential pressure instruments, there may be two operating limits, one for high static line (common mode) pressure and another for differential pressures. For Rosemount transmitters the Over Pressure rating applies to any differential pressure above the Upper Range Limit (URL).

3.6.14 Power Supply Voltage Effect (VE)

Power supply stability refers to the variation in the loop's power supply voltage under design conditions of supply voltage, ambient environment conditions, power supply accuracy, regulation, and drift.

This effect is usually linear with voltage variation, the equation to use is:

$$VE_x = VEX \times \Delta V$$

where,

VEX = instrument vendor's power supply effect expression in percent of CS per volt

ΔV = power supply stability in volts

This effect may be negligible, particularly for components with regulated power supplies. Power Supply effect is normally considered to be included in the plant specific drift DA term. However, if the power supply is calibrated prior to calibration of the loop components, then the VE term is not included in the DA term and must be considered separately.

3.7 Environmental Influences

The following environmental conditions for uncertainties are considered for an instrument loop at Vermont Yankee: normal, accident, post-accident, and seismic event.

Uncertainties during normal operations and during performance of periodic calibration will generally be needed for any loop of Class 1, 2 or 3.

Those instrument loops, which must perform a safety-related function during an accident, must have an uncertainty calculated for the bounding conditions that are expected to prevail, during the specific limiting accident event, for the time interval for which the

safety-related function is required to be operable. This only applies to Class 1 functions. Additionally for Reactor Protection System Instruments (RPS) the calculation must verify that the RPS instrument will not fail, or spuriously operate for a High Energy Line Break (HELB) in the vicinity of the instrumentation. This is limited to instruments that are not required to function to mitigate the HELB in their vicinity. Devices which must function must consider accuracy of the trip point also.

Class 2, instruments used in the emergency operating procedures which are subject to an abnormal or harsh environment following an accident, should have post-accident uncertainties determined.

Seismic uncertainties are significant only for those Class 1 instruments which must operate during or after an earthquake. Indicators would not be useful during an earthquake (OBE or SSE), since operators would have significant difficulty reading any display type instrument (e.g., indicators, recorders, and printouts) accurately and operator action is not credited for some time after an earthquake. For those safety-related instrument functions, which are required for safe shutdown of the reactor, a seismic uncertainty should be calculated. Figure 2, illustrates the conditions considered for DBA evaluations.

3.8 Module Uncertainty (e)

The individual uncertainty elements are combined according to equations below, for devices which can be considered internally linear, to obtain the overall instrument uncertainty in terms of three groups of uncertainties: (1) random, (2) positive bias, and (3) negative bias. Bias uncertainties are combined algebraically and random uncertainties are combined using the Square-Root-Sum-of-Squares (SRSS). This insures that the total uncertainty is neither non-conservative (by using SRSS for all uncertainties) nor overly conservative (by combining all algebraically).

Note: It is possible to calculate uncertainty with excessive precision and also to introduce unnecessary round-off errors. To avoid calculations which are difficult to duplicate, module uncertainty calculated in %CS should be rounded to two decimal places (i.e. 2.87% CS). Intermediate values using SRSS should be carried to four decimal places. Final module, loop or Total Loop Uncertainty values should be rounded to the readability of the test equipment (if it is only possible to read the instrument to 1 psi increments a value of 1.02 psi has no meaning). All rounding where performed must be in the conservative direction. Rounding for values a factor of 10 smaller than the readability is not required, since these values would have no effect if considered in their error combination. For an increasing process condition to a trip setpoint the TLU values would be rounded up, the setpoint values would be rounded down, and the AV value would be rounded down.

For random uncertainties:

$$e_{xRi} = \sqrt{\sum_i u_{xRi}^2}$$

Where,
e_{xRi} = random uncertainty of the i^{th} device
u_{xRi} = an effect or uncertainty which is random as it applies to the i^{th} device

The subscript "x" represents the environmental conditions.

The bias terms of opposite signs are not usually allowed to cancel each other. This is done by having a positive bias equation and a negative bias equation.

$$e_{xBi}^{+} = \sum u_{xBi}^{+}$$

$$e_{xBi}^{-} = \sum_i u_{xBi}^{-}$$

Where,
e_{xBi} = the bias uncertainty, positive and negative, of the i^{th} device

3.8.1 Testing Conditions

For testing conditions, no instruments are exposed to the process, and there would be no earthquake. Therefore, the static pressure terms (SP) and seismic (SE) are not included. The barometric pressure effect (PB) would only be due to the variation in atmospheric pressure between calibrations, which is negligible for most cases. As explained in Section , the current leakage effect is negligible for normal (and testing) conditions. The radiation effect is the cumulative effect of normal operations since the previous calibration. Under testing conditions the total module error is typically all random. For testing a single instrument, this value is equal to the as-found tolerance (AF).

$$e_t = \sqrt{CE^2 + MTE^2 + DR^2 + TE_{cal}^2 + HE_n^2 + RE_n^2 + VE^2}$$

For indicators or recorders, the instrument readability uncertainty (RD) is also included in the equation. If analyzed drift values are available, the equation simplifies to :

$$e_t = \sqrt{CE^2 + DA^2}$$

For indicators or recorders, readability uncertainty (RD) is not required, since it is included in analyzed drift (DA).

3.8.2 Normal Conditions

For normal conditions, with the instrument connected to the process, the static pressure effects may apply and the overall uncertainty may then contain bias components. The normal uncertainty is therefore given by the equations:

$$e_{nR} = \sqrt{CE^2 + MTE^2 + DR^2 + TE_n^2 + HE_n^2 + RE_n^2 + VE^2 + SP_U^2 + SP_Z^2}$$

For indicators or recorders, the instrument readability uncertainty (RD) is also included in the equation. If analyzed drift values are available, the random equation simplifies to (as before RD is included in DA):

$$e_{nR} = \sqrt{CE^2 + DA^2 + TE_{\Delta n}^2 + SP_U^2 + SP_Z^2}$$

Where:

$TE_{\Delta n}$ = The differential temperature effect between the testing range and normal design range (reduced by the 20°F delta assumed in DA for calibration conditions).

3.8.3 Accident and Seismic Conditions

Only Class 1 instruments need to consider Design Basis Accident (DBA) conditions. Some instruments may be in an environment where they could not be affected by an accident. The Vermont Yankee design basis recognizes the combination of an earthquake with most limiting events except the High Energy Line Break (HELB) of a seismically qualified line and a Loss of Coolant Accident (LOCA) with fuel failure. For instruments associated with those specific scenarios, two accident uncertainties need to be calculated.

Loss-of-Coolant Accident

For the LOCA, the first scenario is LOCA no seismic event and includes accident effects for TE, HE and RE, but not SE. The second scenario for Seismic with LOCA but without fuel Failure includes accident effects for TE, HE and SE, but not RE. In equation form:

LOCA no Seismic event.

$$e_{aR1} = \sqrt{CE^2 + DB^2 + MTE^2 + DR^2 + TE_{Loca}^2 + HE_{Loca}^2 + RE_{Loca}^2 + VE^2 + SP_U^2 + SP_Z^2}$$

LOCA with Seismic event but no fuel failure

$$e_{aR2} = \sqrt{CE^2 + DB^2 + MTE^2 + DR^2 + TE_{Loca}^2 + HE_{Loca}^2 + RE_n^2 + VE^2 + SP_U^2 + SP_Z^2 + SE^2}$$

For indicators or recorders, the instrument readability (RD) is also included in the equation. If analyzed drift values are available, the random equations simplify to (as before RD is included in DA) :

LOCA no Seismic event.

$$e_{aR1} = \sqrt{CE^2 + DA^2 + TE_{Loca}^2 + HE_{Loca}^2 + RE_{Loca}^2 + SP_U^2 + SP_Z^2}$$

LOCA with Seismic event but no fuel failure

$$e_{aR2} = \sqrt{CE^2 + DA^2 + TE_{Loca}^2 + HE_{Loca}^2 + SP_U^2 + SP_Z^2 + SE^2}$$

where,
TE_{LOCA} = Temperature effect for LOCA conditions
HE_{LOCA} = Humidity effect for LOCA conditions
RE_{LOCA} = Effect for postulated source term release

High Energy Line Break (Mitigation)

For the HELB, one value includes accident effects for TE and HE, but not SE. The second includes only SE. In equation form:

$$e_{aR1} = \sqrt{CE^2 + MTE^2 + DR^2 + TE_{HELB}^2 + HE_{HELB}^2 + RE_n^2 + VE^2 + SP_U^2 + SP_Z^2}$$

$$e_{aR2} = \sqrt{CE^2 + MTE^2 + DR^2 + TE_n^2 + HE_n^2 + RE_n^2 + VE^2 + SP_U^2 + SP_Z^2 + SE^2}$$

For indicators or recorders, the instrument readability (RD) is included in the equation. If analyzed drift values are available, the random equations simplify to (as before RD is included in DA):

$$e_{aR1} = \sqrt{CE^2 + DA^2 + TE_{HELB}^2 + HE_{HELB}^2 + SP_U^2 + SP_Z^2}$$

$$e_{aR2} = \sqrt{CE^2 + DA^2 + SP_U^2 + SP_Z^2 + SE^2}$$

where,
TE_{HELB} = Temperature effect for HELB conditions
HE_{HELB} = Humidity effect for LOCA conditions

For those loops, the most restrictive case of seismic or accident should be used to determine total loop uncertainty. In performing this calculation, however, the total loop uncertainty should be determined for all instruments under seismic conditions, and then for all instruments under accident conditions, and the more restrictive case used. Combining individual worst cases is not appropriate.

High Energy Line Break (Non-Mitigation)

As discussed in Section 3.7, for RPS channels sufficient margin must exist such that spurious actuation will not occur in a HELB environment during the time necessary to effect a controlled plant shutdown. This margin check is independent of setpoint analysis for HELB mitigation loops. This check is performed by determining the effects due to the HELB event and then adding these error values to the maximum normal operating value of the process variable measured. If the result is less than the trip setpoint spurious trip for HELP is assumed not to occur.

Other Design Basis Events

For other limiting events, the seismic effect is simply included in the calculation with the environmental effects:

$$e_{aR} = \sqrt{CE^2 + MTE^2 + DR^2 + TE_a^2 + HE_a^2 + RE_a^2 + VE^2 + SP_U^2 + SP_Z^2 + SE^2}$$

For indicators or recorders, the instrument readability (RD) is included in the equation. If analyzed drift values are available, the random equation simplifies to (as before RD is included in DA) :

$$e_{aR} = \sqrt{CE^2 + DA^2 + TE_a^2 + HE_a^2 + RE_a^2 + SP^2{}_U + SP^2{}_Z + SE^2}$$

And for any event the bias component of uncertainty is found from:

$e_{aB} = SP_C + SP_O$

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Figure 2: Deleted

3.9 Process Corrections and Measurement Uncertainties (PM)

Process corrections are adjustments to the instrument calibrated range or setpoint. By themselves, they are not considered as uncertainties. The need for adjustments normally arises because of differences in location between the point of concern for a process variable and point of measurement and location of the sensor. Variations in process corrections, or in the process itself, may cause uncertainties (e.g., variations in the head correction, or fluid density of a flow system). Both the corrections and the uncertainty of the correction need to be considered. The variations discussed here are typical, but there can be others. More detailed discussion may be found in Attachment C.

3.9.1 Level Measurements

ISA-RP67.04 Part II, Attachment B, "Vessel/Reference Leg Temperature Effects on Differential Pressure Transmitters Used for Level Measurement," contains a detailed discussion and equations for evaluating the process uncertainties for a PWR steam generator level measurement. The methods described are generally applicable to any level measurement; however, at Vermont Yankee (or any BWR), the vessel level application in particular is complicated by the fact that pressure sensing lines may pass through multiple temperature gradients, consequently the user is cautioned to apply the principles described in ISA-RP67.04 Part II with care to ensure the model reflects the as-built design. The following variables are the principle determinants of level measurement error using differential pressure instruments:

- Process liquid density, determined by process temperature and pressure.
- Process vapor density, determined by process temperature and pressure.
- Reference leg density, determined by process pressure and environmental temperature.
- Tank vortexing, if applicable see mechanical design calculations.

There may be cases where the sensing lines to the transmitter are routed through different environments, then the different head effects on the two lines should also be accounted for in the overall PM allowance. The specific problem of Reactor Vessel Level measurement is addressed in Attachment C.

3.9.2 Flow Measurements

In ISA-RP67.04 Part II, Attachment C, "Effects on Flow Measurement Accuracy," contains guidance to account for fluid density effects and piping

configuration in establishing PM for flow measurements. Attachment D of this guide, "Flow Loop Scaling and Uncertainty," extends the ISA-standards treatment to include flow element uncertainty and the propagation of uncertainty through a square root converter. Generally, the problem is complicated by the fact that both the flow element and square root converter are non- linear devices and that most process influences are functions of flow rate; consequently, the overall uncertainty must be evaluated at specific flow rate points of interest, which should include the Analytical Limit (AL) or Process Limit (PL), setpoint, and normal flow rates (representative values).

3.9.3 Pressure Measurements

ISA-RP67.04 Part II, Attachment F, "Line Pressure Loss/Head Pressure Effects," contains guidance to account for head effects in process piping under conditions where significant flow exists. Attachment C, "Process Corrections and Measurement Uncertainty," addresses the more common situation of head corrections (hC) and the resulting uncertainty (hU) associated with variations in temperature of the sense line. Pressure variations of the process, which also effect density may be ignored, unless the fluid is a compressible gas, since the change in pressure is sensed directly by the instrument and any residual bias is usually negligible. The calculation should include a derivation of hC, since the correction is usually significant and any errors in calculation represent an un-analyzed bias.

3.10 Insulation Resistance (IR) Leakage Effects

Reduced insulation resistance in the signal cables allows more current to leak between cables or to the ground. The change in current affects the loop uncertainty. For all but accident conditions, the leakage current should be negligibly small. When current leakage effect is present, it is normally a positive bias. The effect of current leakage on a loop's performance is a function of the amount of current leakage in an instrument loop's current carrying components. The effects of current leakage due to a harsh environment are developed in ISA-RP67.04 Part II, Attachment D, "Insulation Resistance Effects," for the typical current loop. Two and three-wire RTD circuits are also susceptible to significant IR loss.

There are four shunt resistances that have been identified which will produce significant leakage currents in harsh environments. They are:

- Cable insulation leakage
- Cable splice leakage
- Terminal boards
- Penetrations (if any)

At Vermont Yankee, environmentally qualified instrumentation have been evaluated for IR loss in VYC-700, "Post-Accident Insulation Resistance Effects on the Accuracy of Selected Environmentally Qualified Instrumentation" [Ref. 6.27]. The effects were found to be negligible.

3.11 Total Loop Uncertainty

The total instrument uncertainty (U_{xij}) is found by (1) combining all effects for a given device to find a total device uncertainty and then (2) combining the device uncertainties to find the total instrument uncertainty. The total loop uncertainty (U_{xL}) will be determined by combining the random and bias terms for the instrument uncertainty and the process uncertainties.

Most instruments and loops encountered at Vermont Yankee are linear in the way the input signal is processed, the major exceptions being flow loops and logarithmic display systems for radiation monitoring. If there are nonlinear devices in the loop, the total loop uncertainty must be determined for specific points of interest as described in Attachment D, "Flow Loop Scaling and Uncertainty" and Attachment E, "Special Considerations for Radiation Monitors."

The equations below present the method for determining total loop uncertainty for combinations of linear devices. If some of the instrument uncertainties are expressed as a percent of input or output, the total loop uncertainty must also be determined at specific points of interest, or a bounding input or output value must be used. The total loop uncertainty is typically shown with PM as a bias. If treated as a random term, justification shall be provided in the calculation.

Note: As noted before under Module Uncertainty, certain conventions for precision are necessary. For calculations performed in %CS, intermediate results under the SRSS operations should be carried to four decimal places and the final result rounded to one decimal place (i.e. ±3.1% CS). Final module, loop or Total Loop Uncertainty values should be rounded to the readability of the test equipment (if it is only possible to read the instrument to 1 psi increments a value of 1.2 psi has no meaning). All rounding where performed must be in the conservative direction (within the limitations discussed in Section 3.8). For an increasing process condition to a trip setpoint the TLU values would be rounded up, the setpoint values would be rounded down, and the AV value would be rounded down.

RANDOM

$$U_{xRij} = \sqrt{\sum_{i}^{j} e_{xRk}^{2}} = \sqrt{e_{xR1}^{2} + e_{xR2}^{2} + e_{xR3}^{2} \cdots + e_{xRj}^{2}}$$

where,
U_{xRij} = combined random uncertainty of the i[th] through the j[th] devices
= u_{xRL} for the total loop
e_{xRk} = the random uncertainty of the k[th] device

The subscript "x" represents the environmental conditions (n = normal, a = accident, p = post-accident).

BIAS

$$U_{xBij}^{+} = \sum_{i}^{j} e_{xBk} + PM^{+} = e_{xB1}^{+} + e_{xB2}^{+} + e_{xB3}^{+} \ldots + e_{xBj}^{+} + PM^{+}$$

$$U_{xBij}^{-} = \sum_{i}^{j} e_{xBk} + PM^{-} = e_{xB1}^{-} + e_{xB2}^{-} + e_{xB3}^{-} \ldots + e_{xBj}^{-} + PM^{-}$$

where,

U_{xBij} = bias uncertainty, positive and negative, of the i[th] through the j[th] devices
= U_{xBL} for the total loop
e_{xBk} = the bias uncertainty, positive and negative, of the k[th] device
Note: The subscript "x" represents the environmental conditions (n = normal, a = accident, p = post-accident).

The bias terms of opposite signs are not usually allowed to cancel each other. This is because the bounding conditions do not generally apply simultaneously. This is accomplished using separate positive bias and negative bias equations. Specific justification is required anytime offsetting bias will be used to reduce TLU or other error components.

3.12 Difference Uncertainties for Sequential Setpoints

For sequentially operating (stacked) setpoints, the difference uncertainty associated with two different bistables actuating out of sequence needs to be considered. Of similar concern is the situation of an indicator reaching an operating limit prior to an alarm sounding (which is intended to warn the operator of the approaching limit).

In either case, the uncertainty is calculated in the same fashion. Figure 3 is an example of such stacked setpoints. The figure shows one possible loop configuration, in this case, for a pressure measurement. The uncertainty of interest is that for the difference between two outputs from the same loop. Mathematically, the solution for random variables has the same form as for the sum (the general case of loop uncertainty).

The difference random uncertainty (u_{ij}) for two devices or loop segments is equivalent to the SRSS combination of the errors associated with the components not shared in the loop:

$$u_{ij} = \sqrt{e_i^2 + e_j^2}$$

where e_i and e_j refer to the device uncertainty or combined uncertainty of all those devices which are not common to both outputs. Bias components would sum algebraically. See the discussion of stacked setpoints in section 4.6.5 and Figure 8.

Example:

The normal total loop uncertainty to the alarm switch ($u_{n1\text{-}5}$) in Figure 3 might be 2.5% CS; however, the uncertainty of the alarm switch (u_5) might be 0.7% CS and that of the indicator (u_4) might be 1.0% CS. Since the transmitter errors and the I/E converter errors would be present for either loop function, they are not included in the difference evaluation. The difference uncertainty of the indicator and alarm switch ($u_{4\text{-}5}$) is:

$$u_{4,5} = \sqrt{u_4^2 + u_5^2}$$

$$u_{4,5} = \sqrt{1.0^2 + 0.7^2}$$

$$u_{4,5} = \sqrt{1.0^2 + 0.7^2} = 1.22\%CS$$

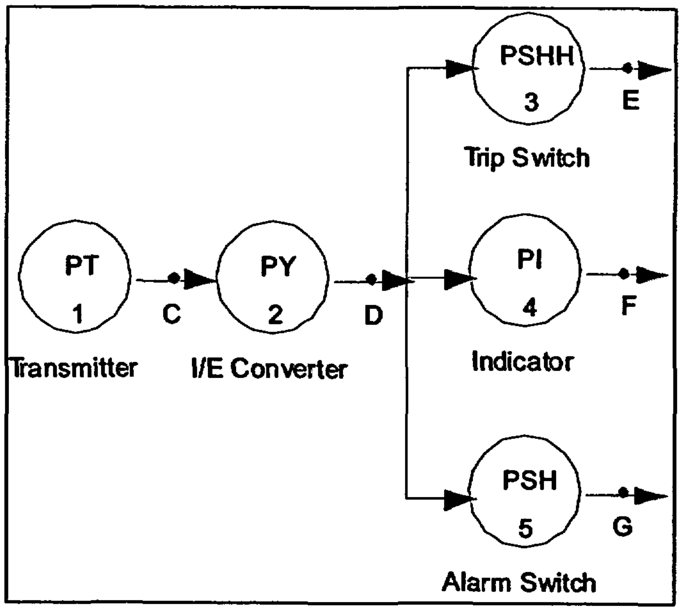


Figure 3: Stacked Setpoint Loop

4. SETPOINTS AND DECISION POINTS

This section discusses the methods that can be used to obtain a setpoint or decision point that will adequately fulfill the intended design function. A setpoint as used in this guide refers to the nominal value at which an automatic protective function or alarm is to be actuated. A decision point refers to an indicated value at which an operator action is to take place, either in accordance with the Technical Specifications or by procedure.

All setpoints are based upon a limit (or limits) which bound the range of the process variable over which an actuation is allowed to occur. Two parameters are required to adequately specify the limit: (1) the qualitative description or definition (what is to be accomplished under what conditions) and (2) the quantitative or analytical determination of the magnitude of the limit.

Once a total loop uncertainty has been calculated for the applicable conditions, the limiting setpoint (LSp) or decision point is found by adding either the positive or the negative uncertainty to the applicable limit. In principle there is no difference between calculating the setpoint for an automatic actuation and an operator decision point based upon reading an indicator or recorder. Whenever "setpoint" is used alone in the following discussion, it is understood to refer to decision points as well. In practice there are some useful distinctions between the two. Those issues, which apply specifically to only setpoints or decision points, are so identified.

The limiting setpoint is the **least conservative** value for the setpoint, which accounts for the known uncertainties. There are several reasons for using a setpoint that is different from the LSp, for example:

1. Trip functions may have more than one Analytical Limit or Process Limit. Then the most conservative LSp is chosen.

2. Equalize the setpoints among loops of similar function, but diverse design (different equipment or installation and therefore different uncertainty).

3. Account for missing or uncertain vendor specifications. Also, over time vendor specifications may change. Including margin allows an increase in the instrument uncertainty without a required change in the setpoint.

4. A margin between the existing TS value and the setpoint is preferred even though the calculation supports a less conservative setpoint.

5. Human factors. Round numbers are more easily recalled. For example, a low pressure setpoint of 804.6 psia is more difficult to recall than a setpoint of 805 psia. Also available test equipment may not be readable to 0.1 psia.

6. Accommodate historical precedence. The plant already has existing setpoints. Where they are conservative with respect to the LSp and do not interfere with operations, there is no need to change them.

Figure 4, "Typical Safety-Related Setpoint Allowances ITS" and Figure 5 Typical Safety-Related Setpoint Allowances CTS" show in general terms the types of allowances included in a NSR (Class 1) setpoint determination for an increasing process trip. Class 2 calculations involve similar considerations, however there would be no Allowable Value involved. A Class 3 calculation, since it does not involve the safety analysis, would have a Process Limit instead of the Analytical Limit and there would be no consideration of accident conditions.

Setpoints with safety functions will generally be based upon established analytical limits or from a process limit derived from other design calculations. Setpoints without a safety function may be based upon a calculated process limit, but will frequently be based upon an estimated or qualitative limit.

The Setpoint Program is intended to support both the existing Technical Specifications and the Improved Technical Specifications Project if implemented. The following considerations apply:

- For setpoints to be evaluated for the Vermont Yankee Custom Technical Specifications (CTS) the values in the CTS are typically treated as Analytical Limits. There are no Allowable Values. Only normal uncertainties are applied between the Analytical Limit and the nominal trip setpoint.

- For setpoints to be evaluated for the Vermont Yankee Improved Technical Specifications (ITS) the values in the ITS are typically Allowable Values.

- For decision points to be evaluated for the Vermont Yankee Improved Technical Specifications (ITS) the values in the ITS are typically calculated including normal uncertainties in the same way a setpoint is calculated.

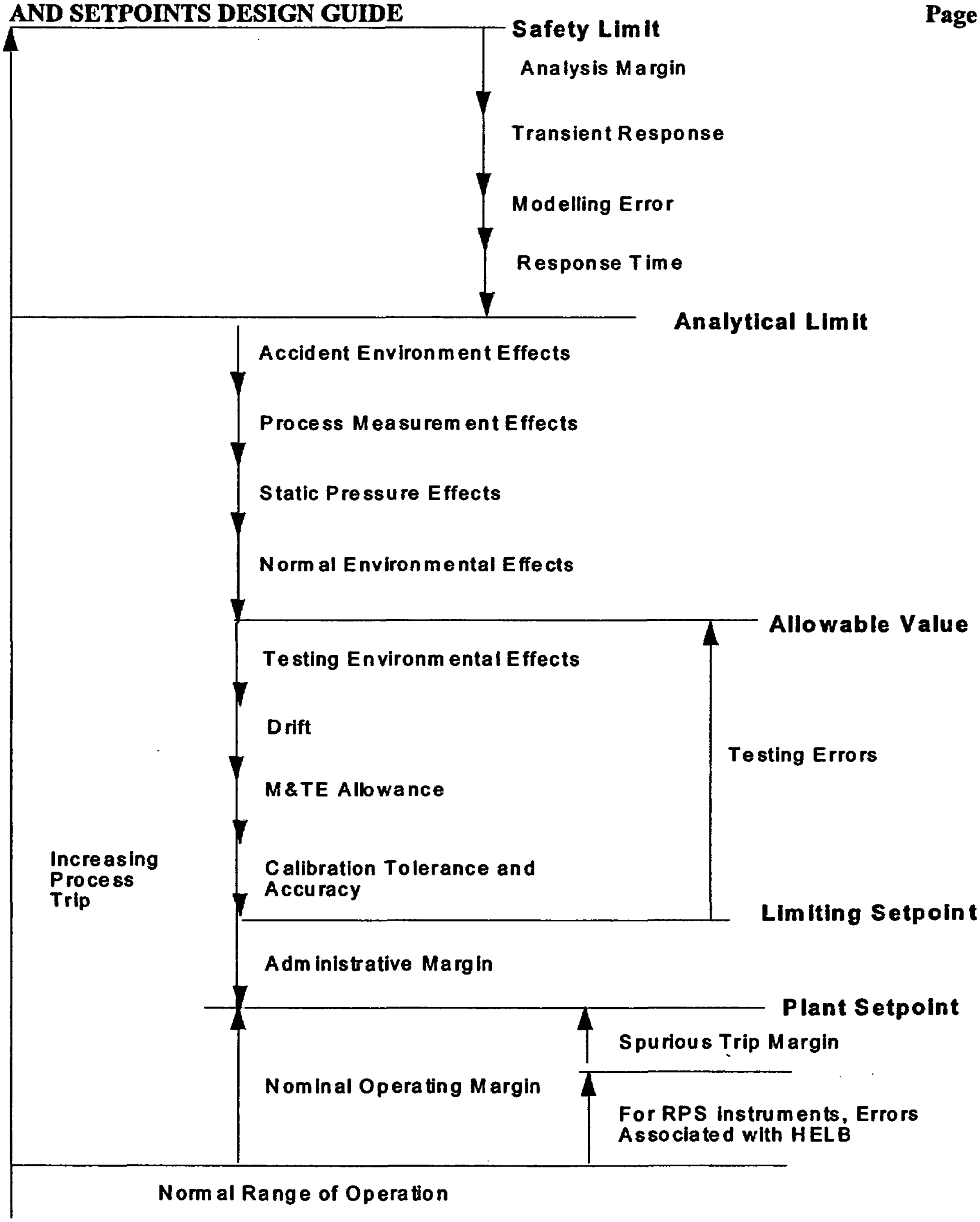


Figure 4: Typical Safety-Related Setpoint Allowances (ITS)

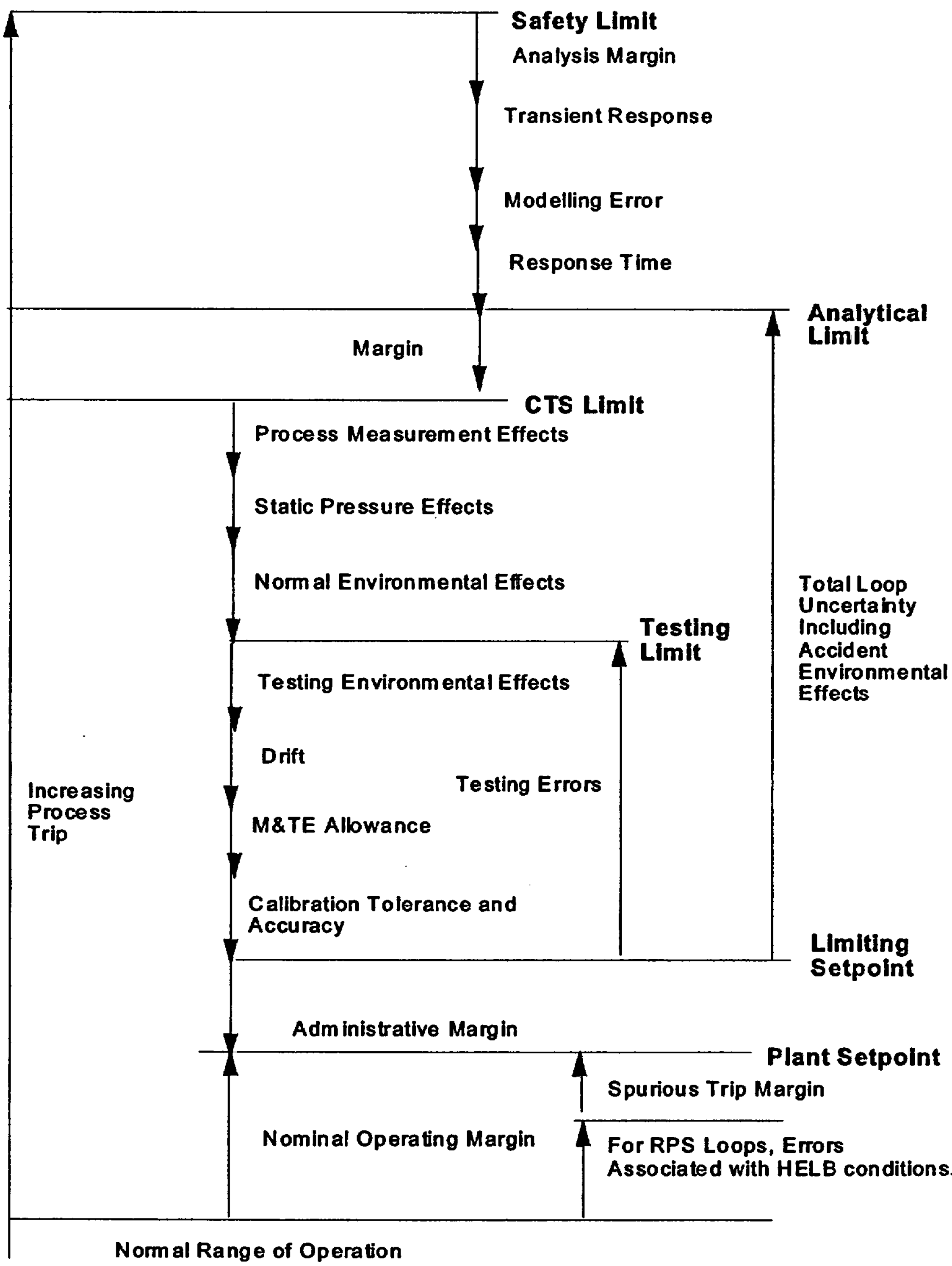


Figure 5: Typical Safety-Related Setpoint Allowances (CTS)

4.1 Setpoint Basis

The first and most important step in preparing a setpoint calculation is to clearly define the purpose and function of the trip actuation or indication being evaluated. The calculations being performed for Vermont Yankee will typically evaluate all of the outputs from a particular loop. This may involve more than one automatic actuation, alarm or indication function. For each of these functions the preparer must answer the following questions:

- What is the safety significance of the function being performed?
- Does this function correspond to an input to an accident or transient analysis. If so, what is the Analytical Limit?
- Does this function correspond to the initial conditions for an accident or transient analysis. If so, what is the value or description of that condition and when does it apply.
- Under what conditions must the function be operable (i.e. normal, accident or post-accident)?
- Under the ITS, is there an Allowable Value (AV) associated with the setpoint?
- Is the process increasing or decreasing as it approaches the setpoint [Sec. 4.6]?
- Does the function act as an anticipatory actuation or as a permissive for some other function [Sec. 4.6]?
- If there is no Analytical Limit (AL), is there a basis for a Process Limit (PL)? Is there an engineering calculation or other documented basis for a Process Limit?
- In the absence of a documented AL or PL, is there a basis for an estimated Process Limit?
- What is the **normal** range of the process? Does the existing setpoint provide adequate margin to operations?

The answers to these questions determine the classification of the setpoint and the steps necessary to produce an adequate calculation.

4.2 Setpoint Classification

The classification of each setpoint under the Vermont Yankee Setpoint Program is maintained as part of the Setpoint Program Manual, however the correct classification of a setpoint or decision point is the responsibility of the calculation preparer, based upon the current design basis.

4.2.1 Class 1 Setpoints and Decision Points

A setpoint is considered Class 1 if any of the following statements apply:

(a) The Vermont Yankee CTS lists the setpoint as a Limiting Safety System Setting (LSSS).
(b) The Vermont Yankee ITS shows the setpoint as an Allowable Value.
(c) The setpoint represents an input or initial condition for a Vermont Yankee accident analysis or transient analysis.
(d) The Vermont Yankee licensing basis shows that the setpoint is considered to be nuclear safety-related.
(e) The setpoint is determined to be of high risk significance in the Vermont Yankee PRA or IPE analysis.

Generally all of the above characteristics will apply, however there may be exceptions and the calculation preparer should be aware of that possibility.

4.2.2 Class 2 Decision Points

The title of this section is deliberate, since the vast majority of Class 2 functions are those related to trending and operator actions in the emergency operating procedures.

A decision point (or setpoint) is considered Class 2 if **all** of the following apply:

(a) The function is safety-related or applies to Category 1 and 2 post-accident trending and monitoring.
(b) The parameter monitored is required to perform an essential evolution in the EOPs.
(c) The function is **not** identified in Guidance & Methodology Associated with Vermont Yankee's Regulatory Guide 1.97 Program Commitments [Ref. 6.22] as a Type A variable.

4.2.3 Class 3 Setpoints and Decision Points

The most convenient way to identify Class 3 setpoints is to verify that the function they perform does not fall into either of the higher categories, as follows:

(a) The associated parameter is a RG-1.97 Category 3 variable [Ref. 6.22].
(b) The function is clearly non-nuclear safety-related.
(c) The setpoint is not itself an input to the accident or transient analysis, has no CTS LSSS or ITS Allowable Value.
(d) Does not perform a function that is required to operate in order for a safety-related system to perform its required function.
(e) Is not an essential parameter in the emergency operating procedures.
(f) The variable is determined to be of very low or no risk significance in the Vermont Yankee PRA or IPE analysis.

Classification in this category is always tentative until the basis for the setpoint is clearly established.

4.2.4 Class 4 Setpoints and Decision Points

This category has all the features of a Class 3 setpoint with the addition that there is no identifiable process limit or that instrument uncertainty is an insignificant portion of the available margin, or the impact on plant risk is insignificant.

4.3 Limits for Class 1 Setpoints

There are four (4) limits associated with nuclear safety-related setpoint determination. They are:

- Safety Limit (CTS & ITS) - In most cases, the Safety Limit (SL) was established during the design of the plant.

- Analytical Limit (CTS & ITS) - The Analytical Limit (AL) is used to:

  (a) Ensure that a Safety Limit is not challenged, and
  (b) Provide the process conditions for use in Vermont Yankee's accident and transient analyses.

- Technical Specification (CTS) - The Technical Specification Limit (TSL) is used to:

(a) Ensure that a Safety Limit and the Analytical Limit are not challenged, and,
(b) Provide the process conditions for use in Vermont Yankee's accident and transient analyses.
(c) CTS applies during normal operation only.

- Allowable Value (ITS Only) - The Allowable Value (AV), as applied in the ITS, provides a limit on the setpoint during testing to ensure the Analytical Limit is not challenged.

ISA-RP67.04 Part II limits its discussion to nuclear safety-related setpoints with Analytical Limits, equivalent to Class 1 setpoints. This guide treats the AL for Class 1 setpoints in accordance with the intent of ISA-RP67.04 Part II. Figure 4, Figure 5 shows the general relationship between the SL, AL, and AV for an increasing process trip for ITS. Figure 6 shows the general relationship between the SL, AL, and AV for an increasing process trip for CTS. Figure 6 shows the specific uncertainty terms applied to a decreasing process trip.

At Vermont Yankee, the CTS trip settings are labeled Limiting Safety System Settings and have been considered generally equivalent to the Analytical Limit, taking credit for additional margin incorporated in the accident analysis for harsh environmental conditions. For CTS, the existing Technical Specification Limit shall be evaluated against the setpoint. New or revised setpoint calculations shall explicitly use a new Analytical Limit provided by the DE&S Nuclear Engineering Department, from which the Limiting Setpoint (LSp), Allowable Value, and available margins may be calculated. For ITS the Allowable value will be used as the Limiting Safety System Setting and the LSSS will be based on the Allowable value for calibration until ITS is implemented;

1. An ITS evaluation will be conducted to identify the AV, LSP and administrative setpoint. Determination of AV includes the worst case uncertainty conditions. LSP must support the arithmetic addition of the as-found values for the loop components.

2. A CTS evaluation will be conducted to identify the LSP, ensure the LSP supports the AL (for harsh environments), and administrative setpoint.

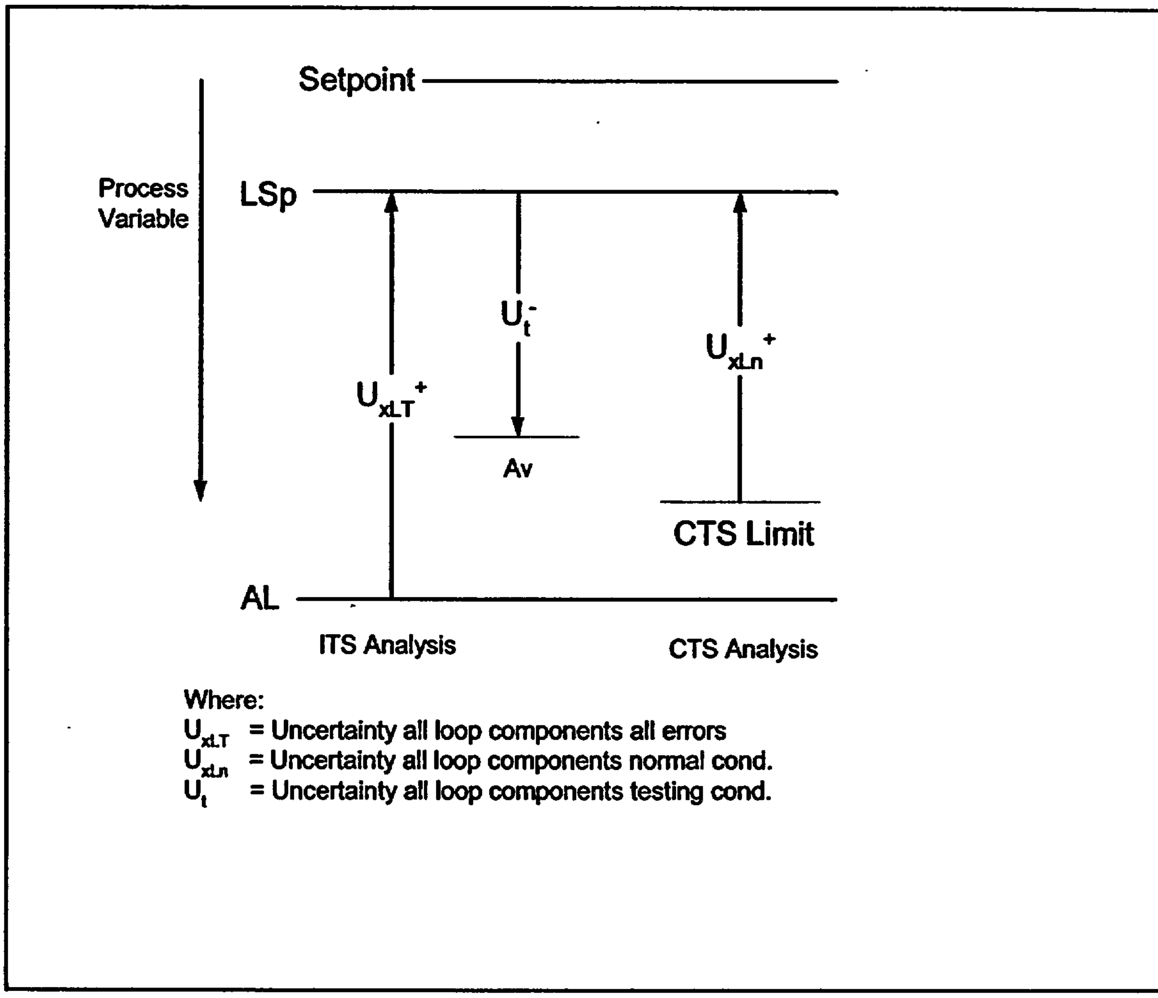


Figure 6: Uncertainty Relationships for Class 1 Setpoints

4.4 Class 2 and Class 3 Setpoints/Uncertainties

The Analytical Limit and Allowable Value are regulatory concepts and do not exist for Class 2 or Class 3 setpoints. Instead, the setpoint is based upon a Process Limit (PL) which is derived from the design function of the actuation or decision point. Generally if the setpoint has a protective function, then the PL may be found from a design specification, mechanical calculation or equipment vendor manual. The Process Limit may not be well defined or readily available, however the preparer shall ensure that for these setpoints, a reasonable estimate is provided.

For example, low pressure at the inlet of a pump can cause cavitation and eventual pump damage. Therefore, a process limit should be established which protects the pump against low pressures. In the absence of a formal calculation, the preparer may estimate the minimum pump suction pressure from the vendor's literature.

For many systems, the process limit will differ from the design limit of the physical equipment. For example, the highest pressure which a fluid process is expected to reach (transient) may be 1000 psig. The piping for that process is specified to have a design strength of 1500 psig. The pressure at which the pipe would rupture is even higher. In this case, the process limit (1000 psig) is not the same as the design limit (1500 psig).

Systems that do not figure directly in the safety analysis may have process limits imposed by various interface requirements. For many narrow range loops, the instrument input range may effectively impose upper and lower limits on the setpoint.

4.5 Class 4 Setpoints/Uncertainties

Class 4 setpoints have a low impact on plant safety. Class 4 analysis are performed to document engineering judgement or the use of non-Vermont Yankee methodologies. Class four setpoints will not normally have a process or design limit for component protection.

4.6 Setpoint Determination

The discussion which follows is complicated by (1) the need to accommodate biases, either process measurement (PM) uncertainties or static pressure (SP) effects and (2) calculation of Allowable Value testing limits applicable to safety-related Technical Specification (ITS and CTS) setpoints. Biases may be significant for any setpoint Class, however the calculation preparer may assume the worse case uncertainty applies in both directions, which would be conservative, and significantly simplify the calculation. Allowable Value calculations are applicable only to Class 1 setpoints. (See Section 4.6.2)

The parts of this section which are applicable depend upon the type of setpoint to be determined. Class 1 setpoints will use each sub-section. Class 2 and Class 3 setpoints

will omit the sub-section on Allowable Value. Class 4 setpoints may need reference to the sub-section on Administrative Limits.

The order of the steps to find the setpoint for CTS is to (1) determine the Process Limit (PL) or Analytical Limit (AL), (2) Determine the CTS Limit (CTSL) (3) add the total loop uncertainty for normal environmental conditions to the CTS Limit and sign ($U_{xLn}^{\pm}$) to obtain a Limiting Setpoint (LSp), (4) add the testing uncertainty ($U_t^{\pm}$) to obtain the Allowable Value (AV),(5) combine with margin (M) to obtain the final setpoint. Margin.The appropriate sign of the uncertainty used for each step is shown in Table 3.

The order of the steps to find the setpoint for ITS is to (1) determine the Process Limit (PL) or Analytical Limit (AL), (2) add the total loop uncertainty for the appropriate environmental condition and sign ($U_{xLT}^{\pm}$) to obtain a Limiting Setpoint (LSp), (3) add the testing uncertainty ($U_t^{\pm}$) to obtain the Allowable Value (AV), (4) combine with margin (M) to obtain the final setpoint. The appropriate sign of the uncertainty used for each step is shown in Table 3.

When margin is added to the Calculated LSp to obtain a final setpoint, the same margin should be applied to the calculated AV to ensure that any degeneration in performance is captured and evaluated.

Table 3: Uncertainty Sign for LSp and AV Evaluation

Parameter	Setpoints	
	Increasing	Decreasing
LSp	Negative	Positive
AV	Positive	Negative

It should be noted that some channels might have, functionally, two directions of interest associated with the trip setpoint-reset relationship. For example, an operational function might be a protection system BLOCK ENABLE above a certain nominal value and the safety function may be the AUTO UNBLOCK setpoint which reinstates the protection system trip. In these, and similar, cases it is necessary for the calculation to identify the safety significant direction of interest, determine if the applying of uncertainties is warranted, and document the nominal reset value in order to capture the operational functional "setpoint."

4.6.1 Limiting Setpoint (LSp)

For CTS the LSSS value in the Technical Specifications, the CTS Limit (CTSL) is assumed as the starting point for the determination of the LSp. Proper plant operation is then confirmed by verification that the Analytical Limit will not be

exceeded for any applicable plant environments. If the setpoint is based upon a Process Limit (PL) or Analytical Limit (AL), then LSp is calculated as:

$$LSp = CTSL + U^{\pm}_{xLn}$$

where,
CTSL = CTS Limit
$U^{\pm}_{xLn}$ = total loop uncertainty for normal environmental conditions Sign (+ or -) per Table 3.

For ITS if the setpoint is based upon a Process Limit (PL) or Analytical Limit (AL), then LSp is calculated as:

$$LSp = AL + U^{\pm}_{xL}$$

or

$$LSp = PL + U^{\pm}_{xL}$$

where,
AL = Analytical Limit
PL = Process Limit
$U^{\pm}_{xL}$ = total loop uncertainty for environmental condition "x" (n = normal, a = accident or p = post-accident). Sign (+ or -) per Table 3.

4.6.2 Allowable Value (AV)

For Class 1 setpoints in the ITS and CTS, the Allowable Value (AV) is found from the limiting setpoint (LSp) in accordance with the equations below. Generally, the applicable instruments are only a part of the loop (excluding PM and SP terms).

$$AV = LSp + U^{\pm}_{tjk}$$

$$AV > LSp + CT_1 + CT_2 + CT_n$$

where:
$U^{\pm}_{tjk}$ = effective uncertainty for testing conditions, including devices tested ("j" to "k"). For example, if the loop included a flow element, transmitter, and trip unit, the flow element is not tested, AV would only include the uncertainty of the transmitter (device "j") and the trip unit (device "k").

CT = the as left tolerance for each loop device. (Where the algebraic summation of the loop components as-left values would potentially allow leaving the loop outside the AV, the AV must be adjusted.)

The signs and portions of the total loop uncertainty to be used differ depending on whether LSp or AV is to be determined, because the input point of interest is different. In determining the LSp from the PL, the PL is the input value and the uncertainty is the measure of the total expected variation around that value. The LSp is the input point of interest when the allowable value is determined because allowable value is related to testing and calibration. For a rising process variable the LSp is in the negative direction from the process limit, but the allowable value is a positive direction from the LSp; hence, the sign difference.

4.6.3 Setpoints and Administrative Limits

The final setpoint will in most cases, be exactly the current setting of the plant instrumentation, and the setpoint calculation is the documented basis for that value and record of the available margin. However it is probable that the Administrative Limits (as-found and as-left tolerance) will change.

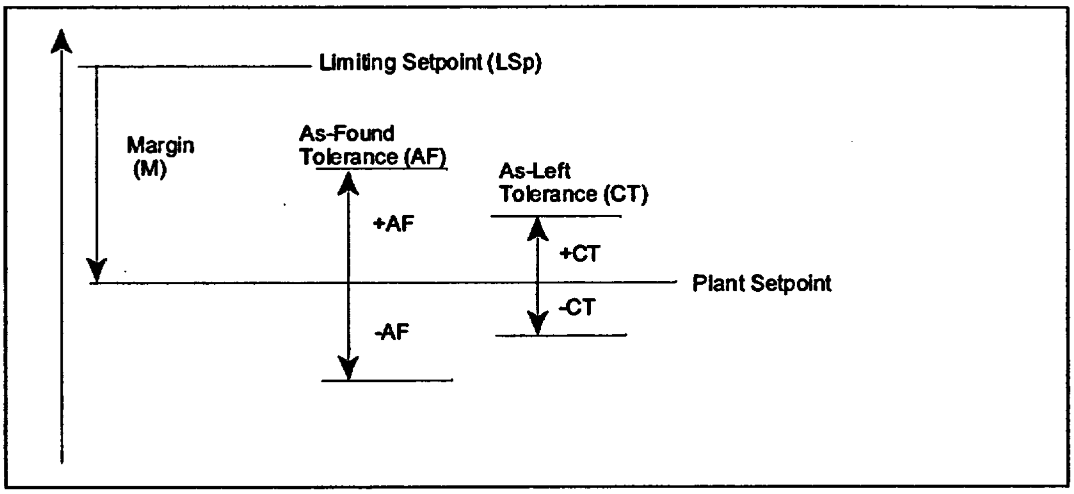


Figure 7: Setpoint and Administrative Limits

The available margin (M) is found from the LSp and Setpoint as follows:

$M = |LSp - Setpoint|$

If the existing setpoint is not acceptable, or for a new setpoint, there are several considerations which would cause the setpoint to be something other than the LSp.

(a) Additional margin is desired to ensure the AV is not challenged or to ensure the setpoint will not need to be changed if new information becomes available. Whenever possible, a margin of at least 0.5% CS should be used.

(b) a decision point should be set at a value easily remembered by the operator and easily read on the available indicators.

4.6.4 As-Found and As-Left Tolerances

Each calibration and functional test has two administrative limits determined by the setpoint calculation. The as-found tolerance (AF) for each instrument or

device is numerically equal to the calculated testing uncertainty (e_t) and is used to evaluate operability and confirm the results of the calculation. The as-left tolerance (CT) or calibration tolerance is the final acceptance criteria for the test and confirms that the device has been restored to the necessary initial conditions for the next operating interval.

Vermont Yankee uses the as-left (AL) tolerance as the as-found (AF) tolerance for calibration purposes. The calculated AF is provided for performance of Operability evaluations when the actual plant AF is outside the acceptance criteria.

4.6.5 Sequential (Stacked) Setpoint Determination

For some systems, the actions to occur for a given overall operation must occur in sequence. Instrument setpoints can be established which insure that the order is maintained. Another situation where the order is significant is for annunciators and operator actions.

For example, the pressure in a tank should not exceed some limiting value (the process limit). A switch is installed which will open a valve to relieve the pressure if the pressure rises too close to the limit. However, there are other, probably preferable, means of relieving pressure, but which method is best can only be determined by an operator who is aware of plant conditions. Therefore, an indicator is installed and an operator decision point is established below the switch setpoint, with instructions to reduce pressure by the most appropriate method. Because an operator has other duties, he probably won't be watching the indicator continuously. An alarm, which provides a warning that the pressure is approaching the decision point, is installed with a setpoint below the decision point to alert the operator. If due to instrument uncertainty, the alarm annunciates after the decision point has been reached, or if the switch to relieve the pressure trips too soon, the purpose of the switches will have been defeated. Therefore, the range of values over which the switches may be expected to operate may not overlap the region of indication that corresponds to the operator decision point.

Figure 8 shows a diagram of the relationship between stacked setpoints. The individual module uncertainties are shown for the trip switch (e_S), indicator (e_I), and alarm (e_A). Difference uncertainties shown are subscripted to show that

they apply to the combination of the alarm and indicator (U_{AI}), trip switch and indicator (U_{IS}), or whole loop (U_{xL}). These are calculated as shown in Section 3.12.

Again, a clear understanding of loop function is essential to correctly recognize stacked setpoints. Some loops have multiple functions that are only tangentially related to each other, others may have several tightly coupled functions that require that each setpoint and decision point follow one another in a specific sequence.

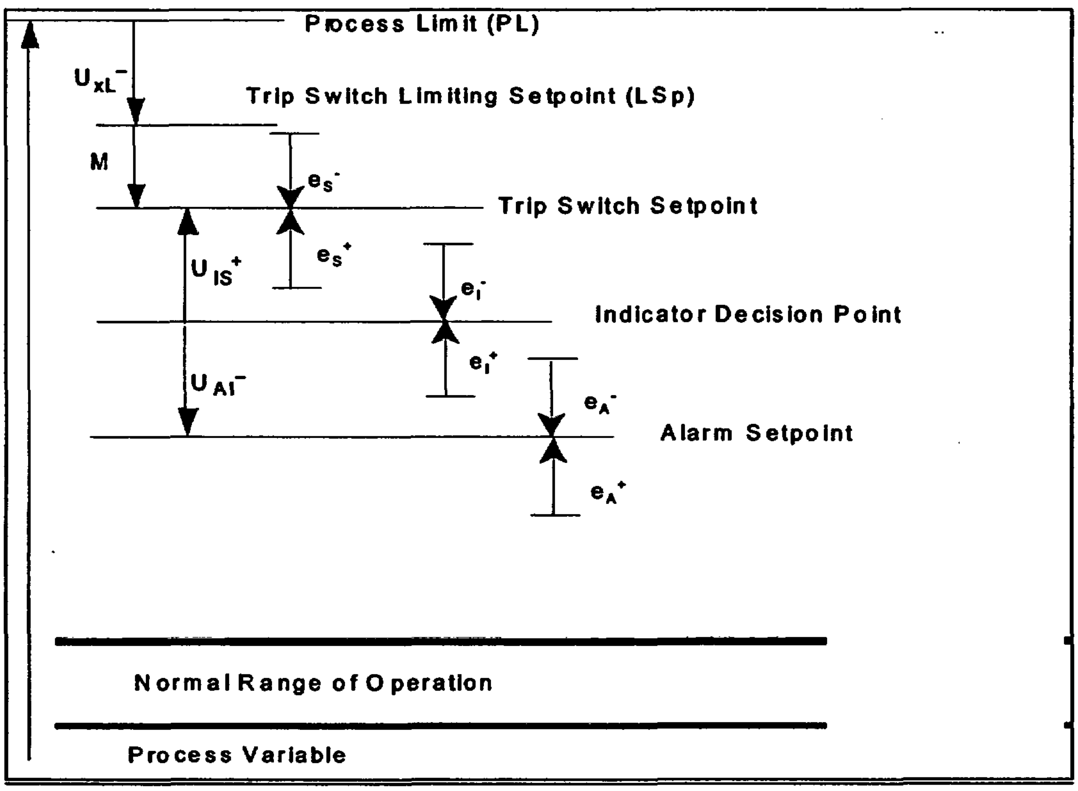


Figure 8: Sequential (Stacked) Setpoints

4.7 Design Considerations

Many design considerations have an influence on channel uncertainty and setpoint determination. The discussion here is not intended to be exhaustive, merely indicative of the type of factors the user should be looking for when preparing a calculation.

4.7.1 Scaling

Particularly in the cases of liquid level and flow measurements, the specific zero and full scale values chosen for a channel may have a profound effect on uncertainties at the process limit or setpoint.

- If the setpoint is near one end of the channel range, the uncertainties may be large enough that the expected trip action may not occur at all.
- Operator decision points in the lower 20% of a flow channel span may not be possible because the error is so large as to render the indication unreliable.
- Errors in elevations, tank dimensions, and flow orifice discharge coefficients may introduce systematic offset errors that are much more severe than the random uncertainty effects considered in this guide.
- If the process and environmental conditions assumed by the setpoint calculation are not the same as those used in the scaling calculation, then the calculated error may not include all significant error contributors.

4.7.2 Installation

All instruments have certain recommended installation requirements. If not followed, the installed loop may perform significantly worse than otherwise expected. Particularly sensitive are the placement requirements of flow orifices and elbow type flow elements (see Attachment D). The following is a list of some of the more common installation problems that need to be evaluated for an uncertainty calculation:

- Flow element piping not straight far enough upstream or downstream;
- Pressure at flow element not stable (pulsation);
- Condensate pots for level or pressure overfill, drain, or move relative to vessel;

- Narrow range level transmitters over ranged routinely, due to siphoning of reference leg;
- Slope of sense lines not constant, either draining or creating vapor traps.

5. DEFINITIONS AND ABBREVIATIONS

5.1 Definitions

- *accuracy* - In process instrumentation, degree of conformity of an indicated value to a recognized accepted standard value, or ideal value [Ref. 6.6].

- *accuracy, measured* - The maximum positive and negative deviation observed in testing a device under specified conditions and specified procedure [Ref. 6.6]. Determination of accuracy is illustrated in Figure 9.

- *accuracy rating (reference accuracy)* - In process instrumentation a number or quantity that defines a limit that errors will not exceed when a device is used under specified operating conditions. Reference accuracy is composed of repeatability (Figure 10), hysteresis (Figure 11), linearity and deadband. If all four components of accuracy are not measured, accuracy cannot be verified.

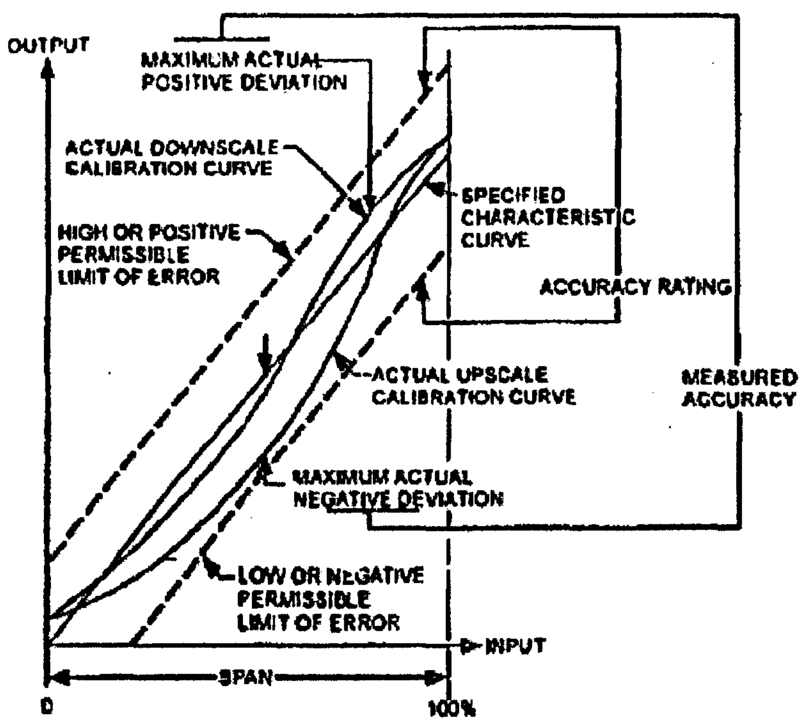


Figure 9: Accuracy

NOTE 1: When operating conditions are not specified, reference operating conditions shall be assumed.

NOTE 2: As a performance specification, accuracy (or reference accuracy) shall be assumed to mean accuracy rating of the device, when used at reference operating conditions.

NOTE 3: Accuracy rating includes the combined effects of conformity, hysteresis, dead band and repeatability errors. The units being used are to be stated explicitly. It is preferred that a ± sign precede the number or quantity. The absence of a sign indicates a + and a - sign. [Ref. 6.6]

- *Allowable Value (AV)* - A limiting value that the trip setpoint may have when tested periodically, beyond which appropriate action shall be taken [Ref. 6.5]. For Vermont Yankee the periodic testing is defined as the calibration. The limiting value for that the trip setpoint may have for other periodic testing is administratively controlled.

- *Analytical Limit (AL)* - Limit of a measured or calculated variable established by the safety analysis to ensure that a safety limit is not exceeded [Ref. 6.5].

NOTE: The analytical limit is the process limit as it applies to Class 1 setpoints.

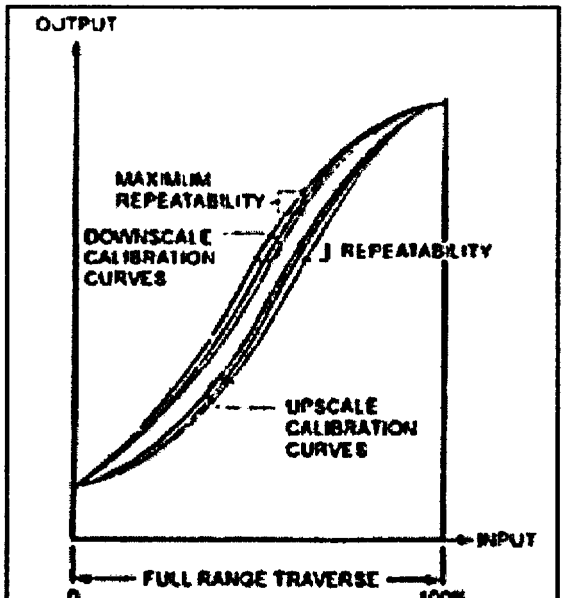


Figure 1: Repeatability

Figure 10: Repeatability

- *as-found* - The condition in which a channel, or portion of a channel, is found after a period of operations and before recalibration (if necessary) [Ref. 6.5].

- *as-found tolerance (AF)* - The calculated limits of testing uncertainty which apply to a given instrument or group of instruments, beyond which additional evaluation is required to determine operability [Sect. 3.8.1].

- *as-left* - The condition in which a channel, or portion of a channel, is left after calibration or final setpoint device setpoint verification [Ref. 6.5].

- *as-left tolerance* - See *calibration tolerance*

- *bias* - An uncertainty component that consistently has the same algebraic sign, and is expressed as an estimated limit of error [Ref. 6.5].

- *barometric pressure effect (PB)* - The change in the output of a gauge pressure instrument due to changes in the ambient pressure [Sect. 3.6.0(b)].

- *bistable* - A device that changes state when a preselected signal value is reached [Ref. 6.5].

  NOTE: As noted in the ISA-RP, as an example of the intended use of this term, electronic trip units at Vermont Yankee are considered "bistables".

- *calibration effect (CE)* - The total uncertainty associated with the calibration process, including MTE, CT, and possibly additional allowances [Sect. 3.6].

- *calibrated span (CS)* - The algebraic difference between the upper and lower values of an instrument's calibrated range, which may or may not be equivalent to the process span.

- *calibration tolerance (CT)* - The specific "leave as-is zone" or as left acceptance criteria which apply to the calibration of a given instrument [Sect. 3.6].

- *correction* - In process instrumentation, the algebraic difference between the ideal value and the indication of the measured signal. It is the quantity that added algebraically to the indication gives the ideal value [Ref. 6.6].

- *correction, head (HC)* - A correction applied to pressure instruments to account for differences in pressure between the point of measurement and the sensing device [Sect. 3.9].

  NOTE: If the head correction is incorporated into the instrument calibration, it is

not a part of the total loop uncertainty. However, variations in the head correction, usually due to temperature changes, between calibration conditions and required operating conditions (normal or accident) are included as process measurement uncertainty. If the correction is not accounted for, then it represents a bias.

- *dead band (DB)* - In process instrumentation, the range through which an input signal may be varied, upon reversal of direction, without initiating an observable change in the output signal [Ref. 6.6]. See Figure 11 normally considered as a component of Reference Accuracy.

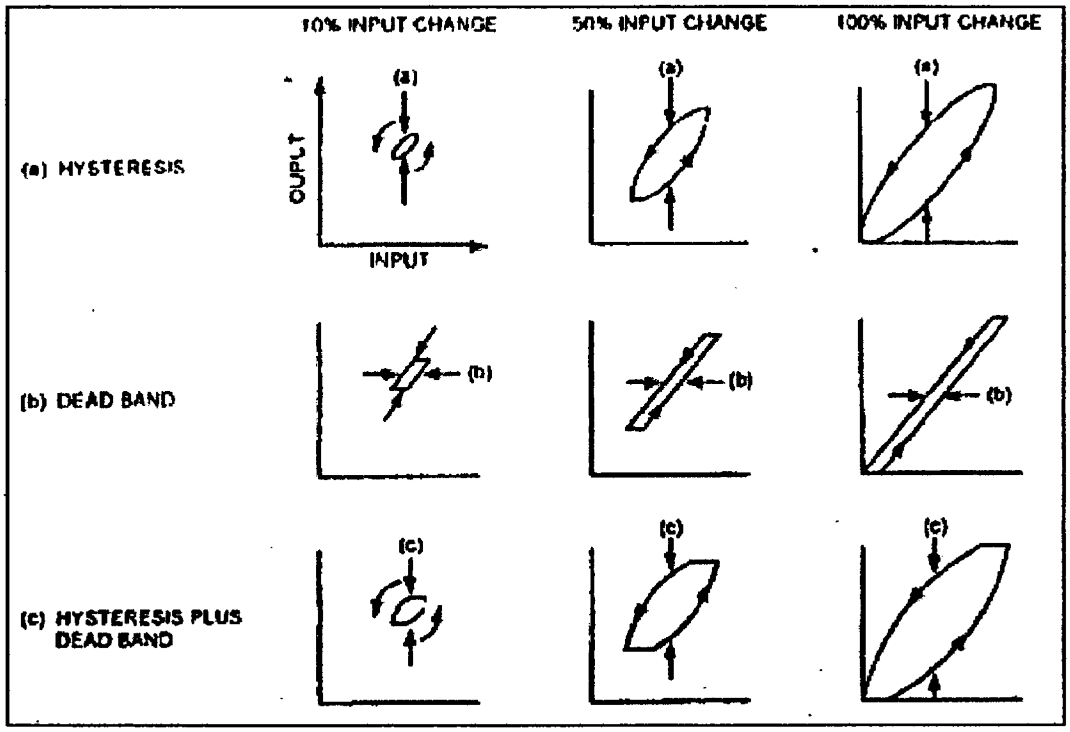


Figure 11: Hysteresis and Dead Band

NOTE: Some instruments, such as transmitters have a specification called variously sensitivity, backlash, or inertial error, which represents the minimum input change from the steady state, for a detectable change in output. For the purposes of this guide, these terms will be considered a constituent part of deadband, and thus part of Reference Accuracy.

- *drift (DR)* - An undesired change in output over a period of time where change is unrelated to the input, environment, or load [Ref. 6.5].

- *drift, analyzed (DA)* - A composite effect derived from statistical analysis of the measured change in output over the test interval for a group of instruments,

expressed as a tolerance interval of specified confidence and proportion [Sect. 3.6 and Ref. 6.17].

NOTE: For the purposes of this guide, analyzed drift is considered to include all of testing uncertainties. [Sect. 3.6].

- *effect* - A change in output produced by some outside phenomenon, such as elevated temperature, pressure, humidity, or radiation [Ref. 6.5].

- *error* - The algebraic difference between the indication and the ideal value of the measured signal [Ref. 6.5].

- *final setpoint device* - A component or assembly of components, that provides input to the process voting logic for actuated equipment [Ref. 6.5].

- *humidity effect (HE)* - The change in an instrument's input-output relationship due to variations of ambient humidity in the instrument's environment [Sect. 3.6.0(b)].

- *hysteresis* - The maximum difference for the same input between the upscale and downscale output values during a full range traverse in each direction.

- *instrument channel* - An arrangement of components and modules as required to generate a single protective action signal when required by a plant condition. A channel loses its identity where single protective action signals are combined [Ref. 6.7].

- *instrument loop* - A combination of one or more interconnected instruments arranged to measure or control a process variable or both [Ref. 6.7].

  NOTE: The term "instrument loop" is not defined in the ISA-RP or in ISA S51.1-1979 [Ref. 6.6], in this guide, loop will be used to describe the entire chain of instruments which effect the uncertainty of a particular process measurement or derived variable.

- *Limiting Safety System Setting (LSSS)* - Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions [Ref. 6.5].

- *Limiting Setpoint (LSp)* - The least conservative setpoint which, allowing for uncertainty, provides actuation before the measured variable reaches the analytical or process limit.

- *margin (M)* - In setpoint determination, an allowance added to the instrument channel uncertainty. Margin moves the setpoint farther away from the analytical limit [Ref. 6.5].

- *measurement & test equipment effect (MTE)* - The inaccuracy introduced into the calibration process due to the accuracy of the measurement instruments used to calibrate the channel or device [Sect. 3.6.5].

- *module* - Any assembly of interconnected components that constitutes an identifiable device, instrument, or piece of equipment. A module can be removed as a unit and replaced with a spare. It has definable performance characteristics that permit it to be tested as a unit. A module can be a card, a draw out circuit breaker, or other subassembly of a larger device, provided it meets the requirements of this definition [Ref. 6.5].

- *module uncertainty (e)* - The aggregate uncertainty associated with a specific module, including random and bias effects [Sect. 3.8].

- *nuclear safety related instrumentation* - That which is essential to the following:

  - Provide emergency reactor shutdown
  - Provide containment isolation
  - Provide reactor core cooling
  - Provide for containment or reactor heat removal, or
  - Prevent or mitigate a significant release of radioactive material to the environment; or is otherwise essential to provide reasonable assurance that a nuclear power plant can be operated without undo risk to the health and safety of the public. [Ref. 6.5]

- *overpressure effect (PO)* - The change in the output of a pressure instrument due to exposure to pressure outside its calibrated span. This can occur when an instrument is calibrated to detect pressure variations in a range less than the pressure to which the instrument is normally exposed [Sect. 3.6.0(c)].

- *power supply voltage effect (VE)* - The changes in an instrument's output due to power supply output variations [Sect. 3.6.0(c)].

- *primary element accuracy (PE)* - .. the accuracy of a component, piece of equipment, or installation used as a primary element to obtain a given process measurement. This would include the accuracy of a flow nozzle and/or the accuracy achievable in a specific flow metering run [Ref. 6.5].

- *process measurement uncertainty (PM)* - ... the basis ability to accurately measure the parameter of concern. This term is not governed by the accuracy of the instrumentation but by variation in actual process conditions that influence the measurement. Process influences such as temperature stratification, density variation, pressure variations, etc., which cause the basic measurement to be inaccurate, would all be considered in the PM term [Ref. 6.5].

- *process limit (PL)* - A limit on a plant process variable for equipment or site personnel protection and reliable operation.

- *process span (PS)* - The variation of the process variable which is detectable or meaningful to the instrument loop. For example, a flow process might vary from 0 to 100 gpm; however, the range 20-80 gpm is meaningful to the instrument (that is, it corresponds to the calibrated span of the instrument). In this case the process span is 20-80 gpm. [Sect. 3.6.0(c)].

- *radiation effect (RE)* - The change in an instrument's output due to the effects of ionizing radiation [Sect. 3.6.11].

- *random* - Describing a variable whose value at a particular future instant cannot be predicted exactly but can only be estimated by a distribution function [Ref. 6.5].

- *range* - The region between the limits within which a quantity is measured, received, or transmitted, expressed by stating the lower and upper range-values [Ref. 6.6].

- *readability uncertainty (RD)* - Uncertainty introduced into the calibration process by the resolution of the M&TE used or the uncertainty inherent in reading the output scale of panel indicators or recorders used in process measurement [Sect. 3.6.4].

- *safety limit (SL)* - 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 [Ref. 6.4].

- *seismic/vibratory effect (SE)* - The change in an instrument's output due to seismic activity or local vibration [Sect.]. The seismic/vibratory term could be used to account for any uncertainties associated with a safe shutdown or operating basis earthquake, physical equipment vibration-induced inaccuracies, etc. [Ref. 6.5]

- *sensor* - The portion of an instrument channel which responds to changes in a primary element or plant condition and converts the measured process variable into an electric or pneumatic signal [Ref. 6.5].

- *sensitivity* - The ratio of the change in output magnitude to the change of the input which causes it after the steady-state has been reached [Ref. 6.6].

  NOTE: This term has often been used to represent the smallest variation in signal which can be detected by the instrument. In this sense is equivalent to readability or deadband.

- *setpoint tolerance* - See calibration tolerance.

- *sigma (σ)* - Symbol for one standard deviation of a random distribution.

- *signal conditioning* - One or more modules that perform signal conversion, buffering, isolation, or mathematical operations on the signal as needed [Ref. 6.5].

- *static pressure effect (SP_x)* - The change in the output of a differential pressure instrument due to calibration at static pressure conditions different from the operating static pressure [Sect. 3.6.0(c)].

  NOTE: The subscript "x" = C - span Correction, U-correction Uncertainty, or Z-Zero effect.

- *temperature effect (TE)* - The change in an instrument's output due to variations of ambient temperature in the instrument's environment [Sect. 3.6].

- *test interval* - The elapsed time between the initiation (or successful completion) of tests on the same sensor, channel, load group, safety group, safety system, or other specified system or device [Ref. 6.4].

- *tolerance interval* - The usual notation is Y/P where Y, the confidence level is the first number to appear and P the proportion, the second number. The notation 95/99 then means a 95 percent confidence that the value will occur within the determined boundaries 99 percent of the time.

- *trip setpoint* - A predetermined value for actuation of the final setpoint device to initiate a protective action [Ref. 6.4].

- *uncertainty, dependent* - Uncertainty components are dependent on each other if they possess a significant correlation, for whatever cause, known or unknown. Typically, dependencies form when effects share a common cause [Ref. 6.5 and Sect. 3.3].

- *uncertainty, independent* - Uncertainty components are independent of each other if their magnitudes or algebraic signs are not significantly correlated [Ref. 6.5 and Sect. 3.3].

5.2 Abbreviations

Listed below are the symbols used to represent commonly used quantities throughout this design guide. Common formatting guides provide for consistent use of symbols. The general pattern is to follow the single character symbols for physical phenomena standardized by ASME, IEEE, and ICRU. Some uncertainties which are dependent only upon an intrinsic characteristic of an instrument are also single characters. The symbols for the effects or uncertainties associated with physical phenomena are two characters, with the symbol of the physical cause followed by a descriptive character which uniquely identifies the uncertainty. Some of the uncertainties are not related to physical causes, but to procedural allowances or tolerances. These will generally have the second character as an "A" or a "T". The last character of the symbol can indicate the type of value it represents: A - Allowance, E - Effect, L - limit, R - reading, S-span, T - tolerance, U - uncertainty, V - value.

Process and Environment Variables

The symbols below are used to represent physical quantities which are more commonly used in determining instrument uncertainties. The commonly used units are shown in parentheses. In some cases, two symbols are given for the same quantity. This is because both symbols are used in common engineering practice and any difference in meaning is obtained from the context in which they are used.

a	-	acceleration (multiple of gravitational acceleration, g)
ρ	-	density
d, D	-	diameter (feet, inches)
h	-	height (feet, inches)
H	-	Humidity (% relative humidity)
v	-	Specific volume
β	-	ratio of d/D (as for a flow measuring device)
I	-	Electrical current (Amp, mA)
p	-	pressure (psig, psia, psid)
q, Q	-	volume flow rate (gpm)
R	-	Radiation dose rate (mrad/hr, rad/hr)
T	-	Temperature (°F)
t	-	time
TID	-	Total Integrated Dose (rads)
V	-	Power supply stability (volts) (emf)
w	-	mass flow rate (lbm/hr, lbm/sec)
Z, z	-	elevation or height (feet, inches)

Uncertainties, Corrections, Effects, and Tolerances

Represented below are the various types of uncertainties or effects. There are three general categories of uncertainties: (1) intrinsic to an instrument, (2) effect as a result of external factors, and (3) administrative tolerances. There may also be combinations of uncertainties.

A	-	Accuracy
CE	-	Calibration Effect on accuracy
CT	-	as left Calibration Tolerance
DA	-	Drift, Analyzed
DR	-	DRift
ρE	-	density (ρ) Effect (i.e., as for gas measurements)
e	-	module uncertainty
EAP	-	Earliest Actuation Point
AF	-	As Found tolerance
hC	-	head Correction
hU	-	head correction Uncertainty error (e.g., due to density variations)
HE	-	Humidity Effect
IR	-	Insulation Resistance current leakage effect
LAP	-	Latest Actuation Point
LSp	-	Limiting Setpoint (calculated)
M	-	Margin allowance
MTE	-	Measurement & Test equipment Effect
OP	-	Over-Pressure effect
PB	-	Pressure effect, Barometric
PM	-	Process Measurement uncertainty (combined effect of process variations)
RD	-	Readability, or, resolution
RE	-	Radiation Effect
RST	-	Reset
SE	-	Seismic/vibratory Effect
S.C.	-	Static Pressure span Correction
SP_U	-	Static Pressure correction Uncertainty
SP_Z	-	Static Pressure Zero effect
TE	-	Temperature Effect
U	-	general uncertainty for a group of instruments
VE	-	power supply Voltage Effect

Miscellaneous

Provided below are some other abbreviations used in this design guide.

BOP - Balance of Plant
DBA - Design Basis Accident
HELB - High Energy Line Break
LOCA - Loss of Coolant Accident
MSLB - Main Steam Line Break
M&TE - Measurement & Test Equipment
NSSS - Nuclear Steam Supplier Systems
OBE - Operating Basis Earthquake
SRSS - Square Root Sum of the Squares
SSE - Safe Shutdown Earthquake
VYNPS- Vermont Yankee Nuclear Power Station

Effect Expressions

Vendor supplied expressions are used to describe the uncertainties and effects given in Section 4.2.4. The symbols are formed by adding the character "X" to the effect. For example, TEX - Temperature Effect expression, SP_ZX - static pressure Zero effect expression.

Subscripts

There are three groups of subscripts: (1) applicable environmental and boundary conditions, (2) uncertainty distribution (random or bias), and (3) applicable instrument or group of instruments.

Environmental

a - accident (defined by specific accident scenario)
p - post-accident, EOP use
n - normal
s - seismic event
t - testing

Uncertainty Distribution

B - Bias
D - Dependent (random)
R - Random (independent)
U - Uniform, random, independent

Instrument or Group of Instruments

i	-	represents ith instrument of the loop
j	-	used with "i", represent the group of instruments from "i" to "j"
L	-	entire loop through to end device. Having no instrument subscripts can imply the entire loop, using L explicitly states the entire loop.

The process measurement effect is considered the zeroth device.

Superscripts

Only two superscripts are used. They are used to indicate direction of the uncertainty when needed. The sign convention used by this design guide is the direction of the output for a given input. For example, an indicator which has an input of 100 psi, but reads 105 psi has a positive uncertainty, or error, of +5 psi. A shift in the setpoint of a bistable device has the opposite sign.

"+"	-	positive direction
"-"	-	negative direction

Symbol Format

For clarity, the order of subscripts is standardized. The order of the subscripts, when present, is (1) environmental conditions, (2) uncertainty distribution, (3) instrument or group of instruments. The first two categories of subscripts are letters and the third is generally numbers. In some cases a multi-character subscript to designate a particular device is beneficial. In this case, a comma separates the first two categories of subscript from the instrument subscript. Examples are shown below.

e_{nRi}	-	Normal random uncertainty of the ith device
$TE_{a,Xmtr}$	-	Accident temperature effect on the transmitter
$S.C._{,R1}$	-	Random static pressure correction error for the first device
A_0	-	Accuracy of the zeroth device (primary element)
U_{nL}	-	Normal uncertainty of the entire loop.
$U_{n1,3}$	-	Total normal uncertainty for devices 1 through 3.
U_{nL4}	-	Total loop uncertainty for normal conditions for the channel ending with device 4 (for cases where there are multiple end devices within an overall loop).

6. GENERAL REFERENCES

6.1 Title 10, Chapter 1, Code of Federal Regulations – Energy

6.1.1. 10CFR50.36, "Technical Specifications"

6.1.2. 10CFR50.49, "Environmental Qualification of Electrical Equipment Important to Safety for Nuclear Power Plants"

6.1.3. 10CFR50.73, "Licensee Event Report System"

6.2 USNRC Regulatory Guide 1.105, Revision 2, February 1986, "Instrument Setpoints"

6.3 INPO Good Practice TS-405, INPO 84-026, Revision 1, "Setpoint Change Control Program"

6.4 ANSI/ISA Standard S67.04 Part I-1994, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants"

6.5 ISA RP67.04-1994, Part II-1994, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation" Second printing May, 1995

6.6 ISA-S51.1-1979 ® 1993, "Process Instrumentation Terminology"

6.7 ANSI/ISA-S5.1-1981, "Instrumentation Symbols and Identification"

6.8 ISO/TAG-4/WG-3-1992, "Guide to the Expression of Uncertainty in Measurement"

6.9 "Technical Specifications for Vermont Yankee Nuclear Power Station," U.S. Nuclear Regulatory Commission

6.10 "Vermont Yankee Final Safety Analysis Report," U.S. Nuclear Regulatory Commission

6.10.1. Attachment A: "Seismic Analyses"
6.10.2. Attachment C: "Structural Loading Criteria"

6.11 YNSD WE-002, "Design Document Control," Revision 11, IR WE-002-1

6.12 YNSD WE-103, "Engineering Calculations and Analyses," Revision 17, IR WE-103-2

6.13 AP-0017, "Calculations and Analyses," Revision 4

6.14 AP-0022, "Setpoint Change Requests," Revision 10

6.15 DP-0301, "Calibration and Control of Measuring and Test Equipment (M/TE)," Revision 15

6.16 YOQAP-I-A, "Yankee Atomic Electric Company Operational Quality Assurance Program," Revision 26 (December 21, 1995)

6.17 "Vermont Yankee Instrument Drift Analysis Design Guide," Revision 0

6.18 YAEC-1562, "Accuracy Report of Selected Class 1E Equipment Installed at Vermont Yankee Nuclear Power Station," Revision 2

6.19 YAEC-1700, "Accuracy Report of Selected Instrumentation Loops Associated with Functions Important to Safety Installed at Vermont Yankee Nuclear Power Station Phase II," Revision 0

6.20 "CRC Standard Mathematical Tables," CRC Press Inc., 25th Edition, Page 3

6.21 "Vermont Yankee Environmental Qualification Program Manual," Revision 36

6.22 'Guidance and Methodology Associated with Vermont Yankee's Regulatory Guide 1.97 Program Commitments," Vermont Yankee Design Engineering, Revision 0, December 12, 1996.

6.23 Vermont Yankee Motor Operated Valve Program Manual

6.23.1 Motor Operated Valve Program Plan, Revision 1

6.23.2 Guideline for the System and Functional Design Basis Review of Vermont Yankee MOVs, Revision 1

6.23.3 Guideline for the Component Review of Vermont Yankee MOVs, Revision 4

6.23.4 MOV Electrical Standard Guideline, Revision 0

6.23.5 Vermont Yankee In-Situ Differential Pressure Testing Valve Review and Testing Requirements, Revision 0

6.23.6 Vermont Yankee Engineering Guideline for Evaluation of MOV Design Basis Capability, Revision 1

6.23.7 Validation of MOV Design Assumptions Based on Vermont Yankee DP Tests and Industry Information

6.24 R. P. Benedict, Fundamentals of Temperature, Pressure and Flow Measurements, J. Wiley, 1984

6.25 Flow of Fluids through Pipes, Valves and Fittings, Crane Co., Technical Publication 410

6.26 Vermont Yankee Project, "Engineering Design Bases," Revision 4

6.27 Calculation VYC-700, "Post-Accident Insulation Resistance Effects on the Accuracy of Selected Environmentally Qualified Instrumentation," Revision 0

6.28 "Low Level Radiation Test Report for Rosemount Model 1152 Pressure Transmitter," Rosemount Report 8805A.

6.29 "30 Month Stability Specification for Rosemount Model 1152, 1153 and 1154 Pressure Transmitters," Rosemount Report D8900126, Revision A

6.30 Calculation VYC-193, "Vermont Yankee Design Basis Radiation Dose Specification,"

6.31 Calculation VYC-264, "Safety Class Instrument Accuracy Review: Instrumentation and Logic Circuit Time Response," Revision 2

6.32 "Model 1153 Series B Alphaline Pressure Transmitters for Nuclear Service, Instruction Manual," Rosemount Publication MAN 4302, May 1993

6.33 "Rosemount Model 1151 DP Alphaline Differential and High Differential Pressure Transmitters," Rosemount Publication 4256/4257, November 1990

6.34 "Type Test Report Results of Low Radiation Dose Rate and Low Level LOCA Evaluation for Model 1153 Series B," Rosemount, Rosemount Report D8600063, Revision A

6.35 "Rosemount Model 1152 Alphaline Nuclear Pressure Transmitters," Rosemount Publication 4235, February 1994

6.36 "Rosemount Model 1153 Series D Alphaline Nuclear Pressure Transmitters," Rosemount Publication 4288, 1984

6.37 "Model 710DU Trip/Calibration System," Rosemount PDS 4471A00, June 1994

6.38 "Type 555 Differential Pressure Transmitters," GE Publication 4532K16-300C, February 1970

6.39 "Type 551 and 552 Pressure Transmitters," GE Publication

6.40 "Type 180 Indicators," GE Publication

6.41 Letter from Bob Davidson (SOR) to G. J. Hengerle (YAEC), "Repeatability of SOR Pressure Switches," May 13, 1986

6.42 "Operating and Service Manual Digital Multimeter 3466A," Hewlett-Packard

6.43 "Instruction Manual Models 1040/1040SP," Transmation I.S. No. 100724-905, March 1982

6.44 "Mil-Qual Modular Power Supplies," Technipower Catalog No. 8220-0003.

6.45 Letter from G. J. Hengerle & R. T. Vibert to S. R. Miller, "Setpoint Support Basis for Implementing Quarterly Function RPS/ECCS Surveillance Testing," June 20, 1996

6.46 VYC-1758, Revision 0, "Measuring and Test Equipment Uncertainty Calculation"

Attachment A: Graded Approach to the Determination of Instrument Channel Accuracy

1.0 INTRODUCTION

The Vermont Yankee setpoint methodology was developed and is defined by this standard to provide the basis, consistent with ANSI/ISA-S67.04-Part I, for the determination of instrument setpoints, allowable values and instrument loop accuracy. This ISA standard defines the requirements for establishing and maintaining setpoints for nuclear safety-related instrumentation. In addition, ISA-RP67.04-Part II provides guidance for implementing ANSI/ISA-S67.04 and imposes rigorous requirements for instrument uncertainty calculations and setpoint determination for safety-related instrument setpoints in nuclear power plants.

ISA-RP67.04-Part II recognizes that the historical focus of ANSI/ISA-S67.04 was the class of setpoints associated with the analytical limits as determined in the accident analysis. The accident analyses were required to be performed with a high confidence interval. These Analytical Limits have a traceability to this same high confidence interval and should maintain this same confidence interval. These setpoints have typically been interpreted as the reactor protection (RPS) and emergency core cooling systems (ECCS) setpoints. The RPS and ECCS setpoints are those critical to ensuring that the integrity of the multiple barriers to the release of fission products are maintained. The Recommended Practice also states that setpoints that are not part of the safety analysis and are not required to maintain the integrity of the fission product barriers may not require the same level of rigor or detail as described by the Recommended Practice. For these non-RPS and non-ECCS setpoints, a graduated or "graded" approach is appropriate for setpoints that:

- provide anticipatory inputs to the RPS or ECCS functions, but are not credited in the accident analysis or,
- Support operation of, but not the initiation of, the ECCS setpoints,
- Do not have traceability to a limit bases on a high confidence interval analysis,
- Do not support risk significant components.

ISA draft Technical Report, ISA-dTR67.04.09, "Graded Approaches to Setpoint Determination", is being prepared to provide further guidance in establishing classification schemes for setpoints and recommending an approach to translate these classification schemes into a methodology for determination of instrument loop accuracies and setpoints. The technical report requires that a "graded methodology" provide a consistent hierarchy of both rigor and conservatism for classifying, determining and subsequently maintaining setpoints.

This Attachment provides the associated graded methodology for the determination of instrument loop accuracy at Vermont Yankee nuclear stations. The instrument loop accuracy may then be used to determine the associated instrument setpoints The Vermont Yankee "graded methodology" is summarized in Table A1.

2.0 DETERMINATION OF INSTRUMENT LOOP ACCURACY

2.1 CLASSES OF CONFIDENCE INTERVAL

The confidence interval associated with the calculation enforces a gradation in rigor and conservatism to the instrument loop accuracy evaluation. Class 1, the highest level of conservatism, is typically associated with a 95% confidence interval that the setpoint will provide its intended function prior to limit or limiting condition. Class 2, 3 and 4 provide decreasing levels of confidence interval by allowing various additions to the methodology used to calculate and combine errors and uncertainties. At Class 4, the instrument loop accuracy may not be associated with any clearly identified confidence interval other than experience.

The methodology associated with each level is shown in Table D1.

3.2 CLASS 1

Calculation of instrument loop accuracy, instrument setpoints and allowable values in Class1 shall use the equations in the design guide . These equations use a 2σ confidence interval and require that determination of instrument loop accuracy <u>always</u> err on the side of conservatism.

Class1 setpoints are consistent with ISA S67.04, Part I and ISA RP67.04, Part II. In order to ensure that protective actions occur 95% of the time with a high degree of confidence before the analytical limits are reached.

3.3 CLASS 2

Class 2 instrument loop accuracy is calculated using the equations in the design guide with the following exceptions:

1) Random errors are evaluated at a 90 % confidence interval.
2) Bias errors may be combined using SRSS.
3) Where it can be determined that a setpoint function is only evaluated in a single direction, either increasing or decreasing, single side of interest confidence levels may be utilized .

3.4 CLASS 3

Class 3 instrument loop accuracy is calculated using the equations in the design guide, the exceptions in Class2 and the following additional exceptions:

1) Random errors are evaluated at a 75% confidence interval.

2) Uncertainties applicable to the entire instrument channel are used wherever available, e.g. channel drift and channel temperature uncertainty vs. module/component drift and module/component temperature uncertainty.

3) All terms are expected to be approximately normally distributed. Therefore, all terms can be combined using SRSS.

4) For bistables, the RA term does not require inclusion of the hysteresis/linearity components. Only the RA uncertainty OR the ST uncertainty, whichever is larger shall be used

3.5 CLASS 4

Class 4 instrument loop accuracy may be calculated using the equations in the design guide and include the exceptions in Class2 and 3. For calculations associated with Class 4 instrument loops, the basis for determining the instrument loop accuracy shall be documented.

7. Table A1, Graded Methodology

CLASS	TYPICAL APPLICATION	METHO-DOLOGY	APPLICABLE UNCERTAINTY METHODS
1	• Protection setpoints • ECCS/RPS/	$2\sigma + \Sigma e_i$	• Consistent with ISA S67.04, Part I and ISA RP67.04, Part II. • Ensures protective actions occur 95% of the time with a high degree of confidence before the analytical limits are reached. • Random and bias error combination: $Z = \pm[A^2 + B^2 + C^2 + (E + F)^2]^{1/2} \pm (\|F\|) + (L) - (M)$ Z = resultant uncertainty, combination of random and bias uncertainties A,B,C = random, independent terms D,E = random dependent terms (independent of A,B and C) F = abnormally distributed uncertainties and/or bias (unknown sign) L,M = biases with known sign
2	• EOP operator action setpoints • RG 1.97 category 1 and 2 variables	$\sigma + \Sigma e_i$	• Bias errors combined using SRSS in accordance with ASME PTC 19.1: $e_i = \pm[F^2 + L^2 + M^2]^{1/2}$ where F, L and M are bias errors as shown above • Single side of interest confidence interval evaluation where the evaluated setpoint is in a single direction: $Z = 0.468\sigma + \Sigma e_i$
3	• RG 1.97 category 3 variables	$\sigma + \Sigma e_i$	• Uncertainties applicable to the entire instrument channel are used wherever available, e.g. channel drift and channel temperature uncertainty vs. module/component drift and module/component temperature uncertainty. • Single side of interest confidence interval evaluation where the evaluated setpoint is in a single direction: $Z = 0.468\sigma + \Sigma e_i$ • Where all terms are expected to be approximately normally distributed, the sum is assumed to be approximately distributed for $n \geq 4$: $Z = [\sigma_n^2 + e_n^2]^{1/2}$ • For bistables, the RA term does not require inclusion of the hysteresis/linearity components, therefore use the RA uncertainty OR the ST uncertainty, whichever is larger.
4	• Documentation of setpoint accuracy (e.g. non-safety, non-tech spec	as appropriate	• Engineering Judgment shall be documented • Engineering evaluation/conclusions shall be documented

	compliance) • Other regulatory related setpoints (consequences of non-compliance are deemed acceptable)		• Vendor, Vermont Yankee, or other methodologies may be utilized where appropriate

NOTE: The reduction of confidence interval is taken at the total loop uncertainty level. Errors or allowances for calibration tolerance or M&TE are not reduced for the determination of actual field settings or for the selection of the M&TE used for the calibration. In the rare case where the algebraic summation of Setting Tolerances or as-left tolerances is greater than total loop uncertainty, the summation shall be used to determine the plant setpoint or channel accuracy.

Original: PAGE 1 of __PAGES
Revision 1: PAGE 1 of __PAGES
Revision 2: PAGE 1 of __PAGES
Revision 3: PAGE 1 of __PAGES

QA RECORD?

_X_ YES

__ NO

RECORD TYPE NO. 09C16004

Safety Class/P.O. NO. (if applicable) NNS

YANKEE ATOMIC ELECTRIC COMPANY
CALCULATION/ANALYSIS FOR

TITLE ____________

PLANT: VERMONT YANKEE CYCLE 20

CALCULATION NUMBER VYC- XXXX

	PREPARED BY /DATE	REVIEWED BY /DATE	APPROVED BY /DATE	SUPERSEDES CALC./REV. NO.
ORIGINAL				N/A
Revision 1				Original
Revision 2				Revision 1
Revision 3				Revision 2

KEYWORDS Logic Response Time

COMPUTER CODES: None

EQUIP/TAG NOs.: N/A

SYSTEMS: Reactor Protection System, Emergency Core Cooling System

REFERENCES:

FORM WE-103-1
Revision 5

Table of Contents

TABLES

FIGURES

ATTACHMENTS

Rev. No.	Approval Date	Reason & Description of Change
Original	3/13/91	Initial Issue.
1		**Major rewrite**. Revise method and format to comply with VY Uncertainty and Setpoint Design Guide & incorporate the calculation of limits for Improved Technical Specifcations. Due to the extent of input/output and format changes, this revision is a major re-write and revision bars are not used. ***Add a statement for any other change that may have been performed***
2		
3		
4		

1. PURPOSE

1.1. Calculation Objectives

1.1.1. This calculation has been developed in support of the Vermont Yankee Instrument Uncertainty and Setpoints program and covers ***some set of instrumentation*** (Set point Class XX: Nuclear Safety Related). This calculation is a **Major Rewrite of Revision XX** and has the following major objectives:[Ref.]

1.1.2. Document the instrument loop functions and the basis for the setpoints associated with those functions.

1.1.3. Establish the total loop uncertainty for each output function and verify consistency with the design basis.

1.1.4. Calculate the limiting setpoints.

1.1.5. Evaluate the adequacy of existing Setpoint Administrative Limits.

1.1.6. Provide as-found and as-left tolerances for use in instrument calibration and functional test procedures. Verify and document process corrections, instrument scaling, and calibration methods.

1.2. Systems & Components

1.2.1. This calculation applies to the Main Steam Line High Flow/Bypass Flow Trip of the Nuclear Boiler System. The specific components addressed are listed below in the equipment summary table.

Table 1 - Equipment Summary

Tag No.	Location	SYS	SC	Description	MFG.	Model	CWD
				Engineering Function not MPAC			

1.3. Instrument Loop Function (Abbreviated)

Provided a discussion of the general function of the loop components. This should define the setpoint functions of indication or alarm function.

Table 2 - Channel Identification

Isolation Channel	A-1	B-1	A-2	B-2
Primary Element				
Power Supply				
Transmitter				
Trip Unit				
Relays				
Slave Relay				
ERFIS Computer Point				
Annunciator				
Associated Relays				

1.3.1. Normal Operations

Provide discussion and references

1.3.2. Accident Conditions

Discussion and references

1.3.3. Post-Accident or EOP Functions

Discussion and references

Table 3 - EQ Matrix Data

Services	Location	Accident	Cat	TBN1	F1	Duration
Function 1	Volume	LOCA				
		MS				
		HPCI				
		RCIC				
		RWCU				
		HHS				
Function 2	Volume	LOCA				
		MS				
		HPCI				
		RCIC				
		RWCU				
		HHS				

2. METHODS AND ASSUMPTIONS

This calculation has been prepared in accordance with the Governing Procedures and Programs listed in step 0. Standard methods employed in this calculation are explained in the "Vermont Yankee Instrument Uncertainty and Setpoints Design Guide". [Ref.]

2.1. Governing Procedures And Programs

2.1.1. Vermont Yankee Instrument Uncertainty and Setpoints Design Guide, Rev. 0. [Ref.]

2.1.2. Yankee Nuclear Services Engineering Instruction, WE-103, Rev. 15, Analyses and Calculations. [Ref.]

2.1.3. Vermont Yankee Engineering Procedure, AP-0017, Rev. 4, Calculations and Analyses. [Ref.]

2.1.4 Yankee Nuclear Services Engineering Instruction, WE-108, Rev. 5, Computer Codes. [Ref.]

2.1.5 VYDEP-15, "Calculations,"
AP-0022, Rev. 10 "Setpoint Change Requests"[Ref.]

2.2. Criteria

2.2.1. Numerical combination for the calculations of M&TE, Total Loop Uncertainty, Setpoint determination and other associated values have been calculated using Microsoft Excel Spreadsheets (Math Soft Mathcad documents). Representative calculations in Attachment(s) XXXX and YYYY(Microsoft Excel Spreadsheets/Math Soft Mathcad 6/7Documents) were manually verified using a hand calculator, in accordance with WE-108, Computer Codes. ***(Calculations for M&TE errors from attached spreadsheets must also be verified if different from M&TE calculation)*** [Ref.]

2.2.2. No errors were found in the manual verification of the calculations performed with the Software in Attachment(s). Physical evidence of the check (by the Preparer and to the extent necessary Reviewer) is provided by check marks next to each verified calculation. Where multiple calculations are generated by coping cells or formulas selected samples have been verified.

2.2.3. Microsoft Excel (Math soft Mathcad) stores numbers with 15 digits of accuracy, all calculation outputs displayed within this calculation are rounded from the values stored by Microsoft Excel. Rounding errors induced by Microsoft Excel are assumed to be negligible within this calculation. [Ref.]

2.2.4. Computer specifications

PC used for this calculation - Serial No. XXXXXXXX

IBM Pentium 133MHz.
16MB of Ram.
Math co-processor installed.
Running in 386 Enhanced Mode.
Software
Dos Version 6.22.
Windows Version 95.
Microsoft Excel Version 5.0c.

(Be specific enough with hardware and software so that if a problem is found it can be traced)

2.3. Process Corrections and Measurement Uncertainties (PM)/ Primary Element Accuracy (PE)

2.4. Assumptions

2.4.1. Calibration of instruments is assumed to be at a temperature within the ranges shown in the following table:

Table 4 - Normal Area Temperatures

Ref.	Plant Area	Min.	Max.

2.4.2. The temperature variation within a cabinet is assumed to be the same as the variation of the room in which it is located. The temperature difference between the room and the cabinet is therefore constant. Calibration data is collected with the equipment at the operating temperature of the cabinet. [Ref.]

2.4.3. At Vermont Yankee, environmentally qualified instrumentation have been evaluated for IR loss in VYC-700, Post-Accident Insulation Resistance Effects on the Accuracy of Selected Environmentally Qualified Instrumentation, where the IR effects were found to be negligible. For the purposes of this calculation, the IR effects on channel accuracy will be assumed to be negligible. [Ref.]

2.4.4. For Custom Technical Specifications, the Technical Specification value is assumed based upon the normal/seismic conditions. There are no harsh environment conditions for this service. [Step 0]

2.4.5. Current calibration practice is to perform a nine point calibration of the Transmitter. Previously calibrations were performed in a single direction using only three cardinal points. This method of calibration did not verify that the linearity, repeatability and hysteresis of the transmitter were within the performance specifications. Therefore, in accordance with section 3.6.2.A of "Vermont Yankee Instrument Uncertainty and Setpoint Design Guide", calibration effect is determined by the relation CE=CT+A. Once the current calibration method has verified transmitter performance the calibration effect may be revised to CE = CT. [Ref.]

2.4.6. The overall Analyzed Drift (DA) term tends to account for Reference Accuracy, M&TE errors, and for normal environmental effects, including temperature (a 20°F variation is assumed in the calibration process), radiation, power supply voltage variations, humidity and barometric pressure. The drift information for XXXX is based on drift calculation VYC-XXXX where DA terms are provided for the instruments. [Ref.]

2.4.7. The effects of radiation are taken for normal conditions only since there is no consideration of radiation effects during HELB and for LOCA, the RPS trip

occurs prior to the harsh environment. For normal conditions, it is assumed that the DA term includes the normal radiation effects. [Assumption]

2.4.8. It is assumed that the M&TE components will be limited to those devices, which support the QA requirement that M&TE accuracy is better than or equal to the accuracy of the device being calibrated. Errors associated with M&TE are assumed to be accounted for in the DA term for those devices which are contained in the drift analysis calculations. [Ref.]

2.4.9. The analyzed drift value for the calibration points for these instruments. The following considerations apply in the assumption of this value. [Ref.]
The analyzed drift shows an increasing (decreasing, no) trend. The significance at the 95% level of the slope is greater than 0.05 (***State specific values for point or points of interest***), thus there are no strong time dependent characteristics. The ADR values at XXX% have been used. The current plant setpoint is set at XXXX (XXX% of Calibrated Span) [Ref.]
From review of the drift analysis and the scatter plots, the data is bounded by a normal distribution with no evidence of time dependency. The value provided for 512 days is assumed for the 684 day operating cycle. Since the absolute value of the mean (***State specific value***) does not exceed the maximum value of non-biased mean at a standard deviation of greater than 0.1 (***State specific value)*** and 0.5 (***State specific value***), the presence of bias is assumed to be negligible and the DA term can be used without bias correction. [Ref.]

With a calibration frequency of once per cycle, the following equation is used for the DA:[Assumption 2.

$DA_{Operating\ Cycle} = DA_{512\ Days} = DA_{548\ Days} = DA_{684\ Days}$ ***(No indication of time dependence)***

[Ref.]

$DA_{Operating\ Cycle} = DA_{684\ Days} - ((DA_{512\ Days}{}^2 * (684/512))^{1/2}$ ***(slight indication of time dependence)***

$DA_{Operating\ Cycle} = DA_{684\ Days} - DA_{512\ Days} * 684/512$ ***(indication of time dependence)***

2.4.10 The calibration interval is assumed to occur once during each operating cycle (18 months + 25% or 22.5 months).

2.4.11 For gauge pressure instruments, static pressure zero (SPZ) and span (SPC) effects do not apply. Overpressure effect (PO) may be neglected if the transmitter is not subjected to more than its maximum calibration design pressure. Any uncertainty due to high pressure is part of the specified accuracy since the purpose of the transmitter is to measure that pressure. No device downstream of the transmitter or primary element is exposed to the process [Ref. "Instrument Uncertainty and Setpoints Design Guide," Vermont Yankee,].

2.4.12 Barometric pressure variation (PB) does not affect electronic components. Only gauge pressure devices are effected by barometric pressure variations [Ref.

"Instrument Uncertainty and Setpoints Design Guide," Vermont Yankee,]]. NOTE: However, absolute pressure devices may have an additional M&TE error if the calibration method is affected by changes in barometric pressure.

2.4.13 Accuracy is not considered for digital signals. The only way to change the accuracy of a digital signal is to lose a bit. If the signal is a simple "on-off", then the error is either 0% or 100%, with no intermediate values. If the signal is a computer input coming from an analog-to-digital converter, and given that the A/D converter is operating properly, any computer hardware malfunction will cause the program to halt, leading to a loss of output. This means that the uncertainty of computer displays is the same as the uncertainty of the output from the corresponding analog-to-digital converter combined with any uncertainty introduced by the software [Ref. 4.1]. Note: signal sampling rate, word size (8 bit, 16 bit etc) can affect the precision of the digital signal at the time of interest. These errors (generally small) must be considered when establishing computer point error.

2.4.14 Radiation effects are not applicable to devices receiving less than 104 rads TID over 40 years and vendor information is not needed for such devices. A TID of 104 rads over 40 years corresponds to 470 rads over a 18-month (+25% = 22.5 mo.) calibration interval. Therefore, any dose less than or equal to 1000 rads for a calibration interval less than 45 mo. will also have negligible effect. The dose rate is not significant at these levels [Ref. "Instrument Uncertainty and Setpoints Design Guide," Vermont Yankee,]].

2.4.15 Operator decision points have been rounded conservatively to the next division marking for operators convince. [Ref. 4.1] When choosing an operator decision point, readability (RD) of indicators and recorders may be accounted for by choosing some point which is on a division (mark) more conservative than the limiting operator decision point (LSp). This way an operator can readily determine whether he meets the operator decision point. For general information about what is the uncertainty of a reading, readability is to be included as is done for other effects [Ref. "Instrument Uncertainty and Setpoints Design Guide," Vermont Yankee,].

2.4.16 Drift values derived from plant testing data in accordance with the Drift Analysis Design Guide are assumed to include the following effects for normal conditions:

- Drift (DR)
- Temperature Effect (TE) (Note: Calibration Delta T only)
- Readability (RD)
- M&TE Uncertainty (MTE)
- Barometric Pressure Effect (PB)
- Power Supply Voltage Effect (VE)
- Humidity Effect (HE)

- Radiation Effect (RE)

2.4.17 Values of uncertainty to be applied when evaluating EOP decision points are calculated in accordance with a best estimate combination of temperature, pressure, and radiation dose. This approach is based on the realization that excessive conservatism may lead to faulty decisions with consequences just as severe as those resulting from overly optimistic margin assumptions. The EOP harsh environment assumed for this calculation corresponds to 90% of the pressure, temperature and radiation at 30 minutes into the appropriate limiting Design Basis Accident shown in Attachment B of the VY Environmental Qualification Manual [Ref. "Vermont Yankee Environmental Qualification Program Manual," Rev. 36.].

(NOTE: any unverified assumption (i.e. drift is equal to Reference accuracy) must be independently supported and justified or have reference to a program which will verify the assumption and revise the calculation should the assumption proved incorrect.)

3. INPUT data

Data used to calculate loop uncertainties, process corrections, setpoints, and decision points are tabulated below with the applicable reference or basis and assumptions

3.1 Process and Loop Data

Presented below are the input values required to calculate the process measurement uncertainty and those parameters such as calibration frequency which are common to all loop components.

Table 5 - Process/Loop Inputs

Basis	Description	Data
Ref.	***Design Information***	
Ref.	Technical Specification Limits	
Ref.	Analytical Limit ITS	
Ref.	Reference Elevation Process Tap Elevation Primary Containment Penetration Elevation	
Ref.	Calibration Interval- CTS	
Ref.	Calibration Interval- ITS	
Ref.	Functional Test Interval-CTS	
Ref.	Functional Test Interval-ITS	

3.2 Environmental Conditions

The following information provides the limiting environmental conditions expected for each loop instrument and the plant spaces traversed by the instrument sensing lines. The loop instruments, excluding the flow elements, are located outside the drywell in Volume 43. The flow elements are located upstream of the inboard MSIV's within the drywell.

Table 6 - Environmental Input Data

Basis	Description	Data

3.3 Primary Element (e_1) Data

Table 7 - Primary Element Input Data

Basis	Description	Data
	Make	
	Part Number	
	Discharge Coefficient	
	Reference Temperature	
	Reference Pressure (P1)	
	Fluid Density at Ref. Temp. & Pressure	
	Rated Accuracy (RA)	
	Throat Diameter ID (d)	
	Pipe Diameter ID (D)	
	Maximum Flow Maximum Pressure	
	Full Meter Flow Full Meter Pressure	
	Rated Flow Rated Pressure	

Example primary element tables for flow elements revise or delete as necessary for specific primary elements.

3.4 Power Supplies Data (e_2)

Table 8 - Power Supply Input Data

Reference	Description	Data
	Make/Model	
	Output supply voltage	
	Combined Source and Load Effect (RA)	
	Temperature Effect (TE)	
	Seismic Effect (Evaluated)4 (SE)	
	Calibration Tolerance (CT)	

Revise or remove as necessary.

3.5 Transmitter (Switch) Data (e_3)

Table 9 - Transmitter (Switch) Input Data

Basis	Description	Data
	Make/Model	
	Calibration span (CS)	
	Upper Range Limit (URL)	
	Calibrated output span	
	Accuracy rating (RA)	
	Power Supply Effect (VE)	
	Deadband (DB)	
	Rated drift (DR)	
	Rated temperature effect	
	Rated seismic effect (SE)	
	Rated static pressure zero effect (SPZ)	
	Rated static pressure span correction (SPC)	
	Rated static pressure span correction uncertainty (SPU)	
	Radiation effect (RE)	
	Calibration tolerance (CT)	
	Analyzed drift (DA) @ 0% Analyzed drift (DA) @ 50% Analyzed drift (DA) @ 100%	

3.6 Trip Unit Data (e_4)

Table 10 - Trip Unit Input Data

Basis	Description	Data
	Make/Model	
	Calibration span (CS)	
	Repeatability Normal Temperature (60-90°F) (RA_t)	
	Repeatability High Temperature (40-104°F) (RA_n)	
	Analog Out Normal Temperature (60-90°F) (RA_t)	
	Analog Out High Temperature (40-104°F) (RA_n)	
	Seismic Effect (SE)	
	Temperature Effect (TE)	
	High Gross Failure Setpoint (For Information Only)	
	Low Gross Failure Setpoint (For Information Only)	
	Current Trip Setpoint	
	Current Calibration Tolerance	
	Calibration Tolerance Recommended (CT)	
	Analyzed Drift (DA)	

Expand sections as necessary for total number of loop devices each loop component should have a table describing attributes.

3.7 Calibration M&TE input data

Table 11 - Calibration M&TE Input Data

Reference	Description	Required Scale/Range	Calculated Accuracy

4. CALCULATION DETAIL

The detailed calculation of the primary element, process measurement uncertainties, module uncertainties and loop uncertainties has been done using Microsoft Excel Version 5.0c (See section 2.2 for verification) and is documented as Attachments xx, xx & xx. For detail of the values presented in the body of this calculation, refer to the attachments listed. [Attachments]

5. RESULTS AND CONCLUSIONS

5.1. Process Measurement Uncertainties (PM - e_0)

5.2. Primary Element Uncertainties (PE - e_1)

5.3. Loop Module Uncertainties

The module uncertainties were calculated in Attachment 4 using Microsoft Excel, the results are listed below. For full details refer to Attachment XX.
[Att., Ref.]

Table 12 - Loop Module Uncertainties

Module Uncertainties	e_{Test} (As Founds)	Normal Random	Nml (+) Bias	Nml (-) Bias	Seismic Random	Seismic (+) Bias	Seismic (-) Bias
(PM) - e_0							
(PE) - e_1							
Power Supply - e_2							
Transmitter/Switch - e_3							
Trip Unit - e_4 Monthly							
Trip Unit- e_4 Quarterly							

5.4. Loop Channel Uncertainties

5.4.1. The channel uncertainties were calculated in Attachment XX using Microsoft Excel, the results are listed below.
For details, refer to Attachment XX. [Att. X, Ref.]

Table 13 - Loop Channel Uncertainties

Channel Uncertainties	Nml (+) Bias %	Nml (+) Bias psid	Nml (-) Bias %	Nml (-) Bias psid	Seismic (+) Bias %	Seismic (+) Bias psid	Seismic (-) Bias %	Seismic (-) Bias psid
Setpoint								

5.5. Setpoint Determinations

Results are presented below for the Limiting Setpoint (LSp), Allowable Value (AV), and the Technical Specifications Limit. Also calculated is the Acceptance Value (ACV) by algebraically adding the as-found tolerances for the loop devices to the existing setpoints. The calculation of this value and the margin from Allowable Value (AV) ensures that the Allowable Value (AV) will not be exceeded during surveillance. All the available margins are shown below. The current setpoint of XXXX will (will not) support the CTS and ITS limits. [Att. 5]

Table 14 - Setpoint Results

Hi Flow Setpoint Values	CTS		ITS	
	PROCESS	OUTPUT	PROCESS	OUTPUT
Analytical Limit (AL)	-	-		
Allowable Value (AV)	-	-		
TLU Testing $(e_{3Test}^2 + e_{4Test}^2)^{1/2}$	-	-		
ACV $(e_{3Test} + e_{4Test})$	-	-		
TLU Seismic				
Technical Specification Limit (TS)				
Limiting Setpoint (LSp)				
Additional Margin LSp to Stpt (M1)				
Current Setpoint			-	-
Proposed ITS Setpoint	-	-		
Margin Setpoint to Normal (M2)				
Normal Operating Value				

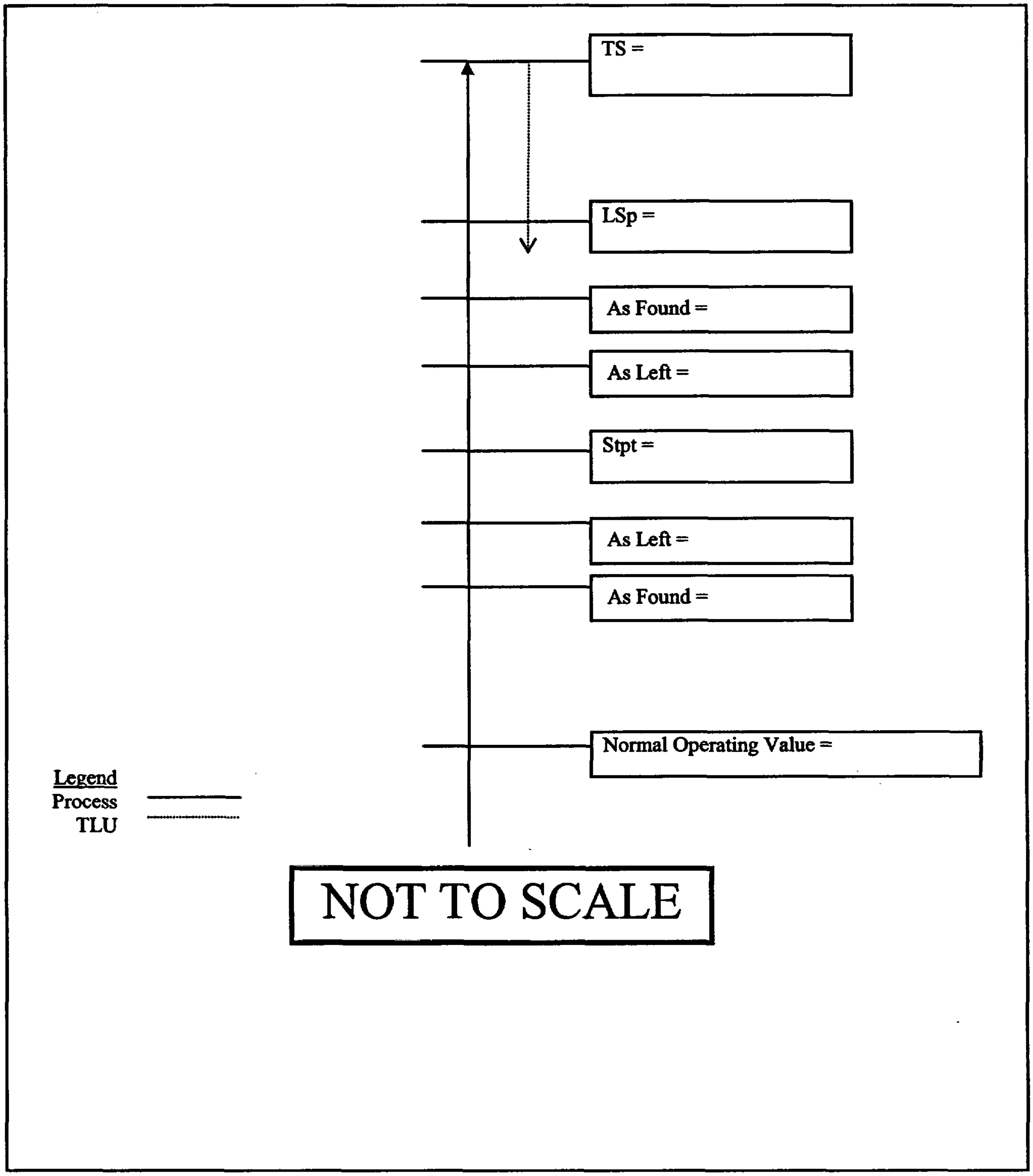
The results of Table 19 are presented graphically in Figures 1 & 2.

(M1) is the margin from the current or ITS proposed setpoint to the Limiting Setpoint (LSp - Stpt).

(M2) is the margin from the current or ITS proposed setpoint to the Normal Operating Value including the TLU Seismic (Stpt - (Norm Op Value + Abs Value TLU Seismic).

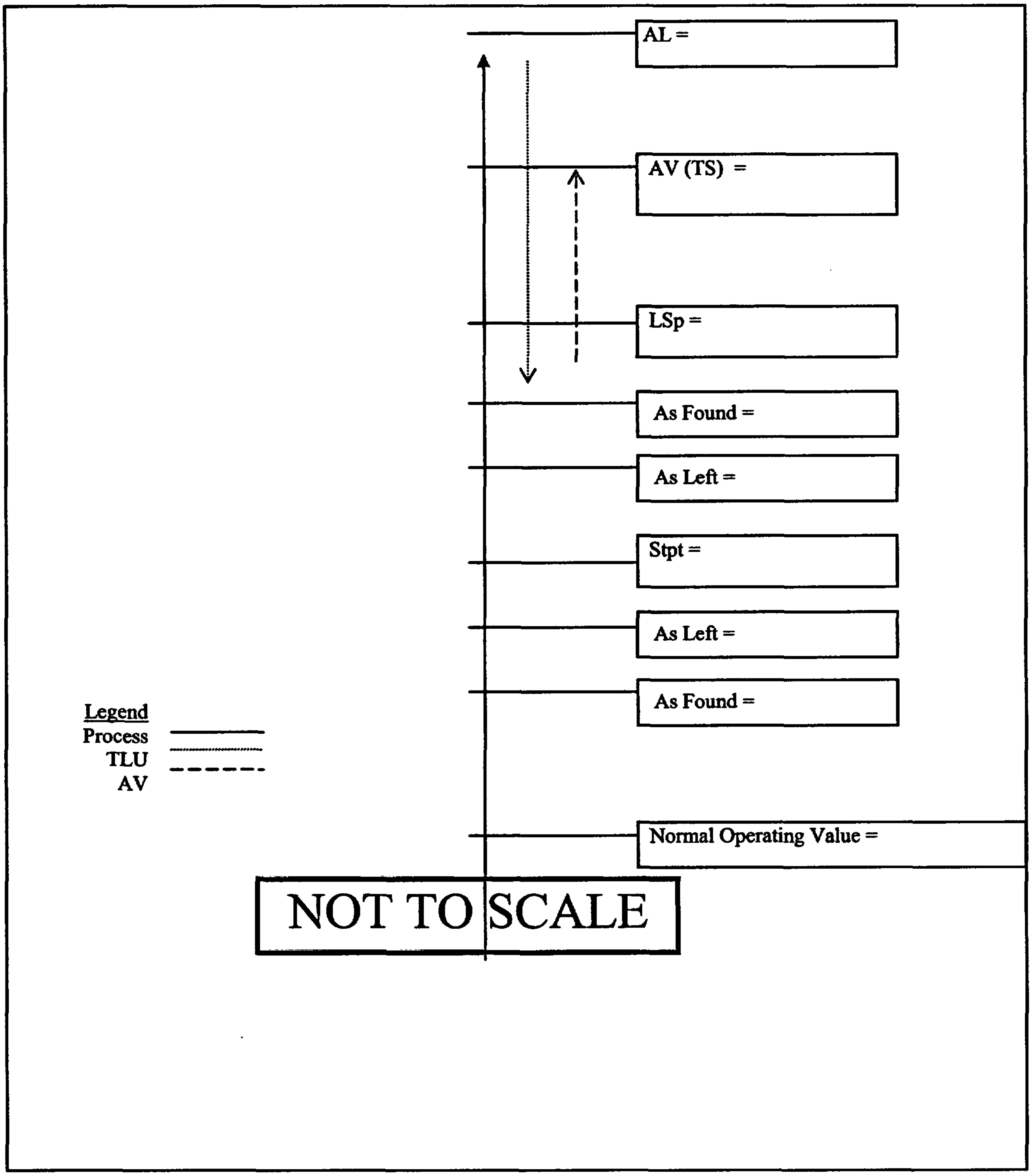
5.6 Graphical Representation of the CTS Setpoint

Figure 1 - Setpoint (Current Technical Specifications)



5.7 Graphical Representation of the ITS Setpoint

Figure 2 - Setpoint (Improved Technical Specifications)



5.8 Calibration and Test Results

5.8.1 In order to support and implement the results of this calculation, the loop instruments are to be calibrated according to the following tables:

Table 15 - Calibration Setpoint and Ranges

Description	Value (Process Units)	Value (calibration Units)
Transmitter Input Range		
Transmitter Output Range		
Trip Unit Setpoint (CTS)		
Trip Unit Setpoint (ITS)		

5.8.2 Test As Found (AF) and As Left (AL) Tolerances (CT) are shown below:

Table 16 - Calibration Tolerances

Module AF & AL Tolerances	Tags	As Found	As Left
(Power Supply) - e_2			
Transmitter Process			
Transmitter Electronic			
Trip Unit - Monthly			
Trip Unit - Quarterly			
Slave Trip Unit - Monthly			
Slave Trip Unit - Quarterly			

5.9 Conclusions and Summary of Recommendations

5.10 VYPP-15 Impact Considerations

VYPP-15 Section 2.1 [Ref. XXX] requires that applicable alarm responses, standard and off normal operating procedures, and EOPs be included in the evaluation. This calculation will evaluate the accuracy of loop components, including indicators and recorders where applicable. The accuracy determined by this calculation will be used as an input for generic evaluations for alarm response, operating procedure, off normal operating procedure, and EOP impact. The interdepartmental review will also ensure associated procedures or operator interfaces are considered as an output of this calculation. Therefore, this calculation adequately addresses the impact to the License and Design bases of the plant as well as the impact to plant procedure and operations.

The following has been considered and is either addressed in this analysis or via the Interdepartmental review process:

FSAR changes
Technical Specifications (Custom & Improved Technical Specifications)
Procedures
Technical Programs
Prints
Related Design Basis Calculations (input/output)
Design Basis Documents

Based on the above, all impact considerations of VYPP-15 are addressed.

6. REFERENCES

NOTE: It is necessary to provide selected pages of various references as attachments. References which are included in their entirety as attachments are not listed in the reference section.

6.47 General References

6.48 Procedures

6.49 Calculations and Bases

6.3.1 VYC-1758 Rev. 0 "Measuring and Test Equipment Uncertainty Calculation"

6.4 Drawings

6.5 Vendor Data

VY Independent Review Check List.
CALCULATION BODY REVIEWS

Cover Sheet

Cover sheet is most current WE-103 form.

Revision Level is appropriate and reflected in the calculation signature block and page numbering at top.

Title is appropriate for the calculation.

Data for RMS is populated with as few pointers like "See Section 6" as possible.

Keywords are reasonable for calculation and match keyword thesaurus.

Table of Contents

Page numbers coincide with paragraph numbering
Tables and figures are listed
Attachments are listed with appropriate descriptive titles

Revision Sheet

Revision description is adequate for changes made to existing calculation

Calculation Text

Calculation paragraph numbering is sequential

Spelling errors are minimized (Spell Check Performed ?)

Margins are at least ½" wide, left margin must be ½" to rev. bars

Font size is at least 10 point

Shading is not acceptable

Links to references are made within the body of the calculation (preferably shown near right margin)

Footer shows "Vermont Yankee Design Engineering" and "Page x of xx"

Header shows calculation title (abbreviated if necessary), calculation number and revision level

Tables contain appropriate information with links to references

Footnotes are clear and font size is at least 10 point

Data obtained from spread sheet attachments is accurately transferred and checked

PP-7007 form is accurately completed

Purpose

Objectives meet the requirements of the Design Guide

Setpoint Classification is provided with justification

Equipment Table includes Tag #, System, Safety Class, Engineering Function

(NOT THE MPAC DESCRIPTION), Manufacturer, Model, Input, Output and CWD

Instrument loop function is accurate for all conditions

Loop diagram is provided as attachment

Method of Solution

Governing procedures and programs are listed and linked to references
Computer specifications and software is listed
Explanation of spread sheets is included for rounding errors
Discussion of manual verification of spread sheets is included
Explanation of uncertainty terms are provided (either in calc text or attachment)

Inputs and Assumptions

Environmental Data is clear (Location, Min and Max Parameters from EQ Manual or Design Guide)

Assumptions are clear and defendable with references provided

Component tables provide all data required for the calculation with references

Technical Specification values and calibration intervals are listed (Contact J. Lewis as necessary)

Improved Technical Specification calibration interval is listed (Contact J. Lewis as necessary)

Current plant calibration values and intervals are listed (Contact J. Lewis as necessary)

Analytic Limit is supported by reference

Normal Operation values are supported by reference

Calculation Detail

Results & Conclusions

VYPP-15 Criteria section provided
Table provided for:

Device uncertainties provide uncertainty term (e1) and values in %CS and calibration or field units.

Loop uncertainties in %CS and calibration or field units except for non-linear
Devices where final values shall be displayed as 1% of point of interest or field units.

MTE uncertainties with acceptable options from MTE inventory is listed (VY MTE Tag numbers should not be listed, just Manuf/Model/Range).

Necessary values to populate the PP-7007 form (AL,AV,LSp,Setpoint,Norm Operation, etc.).

Table for comparison of existing setpoint, CTS setpoint and ITS setpoint.

All values required to populate a setpoint change request should be present within the calculation text.

Required values for SCR:

Present Setpoint
New Setpoint
Device Uncertainties
Loop Uncertainties
Model Number

Manufacturers Accuracy
Technical Specification
LSp
Correction Factors (head, etc.)

Requirements shall be worded strongly enough to convey importance.

Recommendations should provide upside and downside of non-compliance.

Graphical representation of setpoint relationship should be provided for end user being careful not to provide too m
as to make confusing.

References
References to current rev. level
All references required are listed

Attachments
Provide number of pages in Attachment

LOOP DIAGRAM
Preferred as Attachment 1
Shown in sufficient detail to understand function of loop

ERFIS DATA TRENDS
A good visual tool is to provide trends from ERFIS data for applicable parameters

CALCULATION ATTACHMENT SPREADSHEETS
Uncertainty terms are defined - Pressure Transmitter (PT) = e1
Equations are shown and all terms defined
Bias terms are applied appropriately
Manual verification has been performed and indicated as such
Values are carried forward as necessary to provide for easy reviews
Significant digits displayed are reproducible with hand calculator - Experience with Excel requires 4.

UNDER NO CIRCUMSTANCES WILL MATH ERRORS BE TOLERATED!!!!!! - These are accuracy calculations.

Final values shall be displayed in %CS and calibration or field units except for non-linear devices
Where final values shall be displayed as % of point of interest or field units.

Assumptions within spreadsheets are listed in calculation Assumptions Section and referenced back.

REFERENCE ATTACHMENTS
Attachments should include references not easily retrievable (memos, telecons, vendor data, etc.)
Copies should be the best available for reproduction.

Attachments are numbered VYC –XXXX Attachment X Page X of XX and title, or provided stamp is used.

Normal Operation values are supported by reference

Calculation Detail

Results & Conclusions

VYPP-15 Criteria section provided

Table provided for:

Device uncertainties provide uncertainty term (e1) and values in %CS and calibration or field units.

Loop uncertainties in %CS and calibration or field units except for non-linear Devices where final values shall be displayed as 1% of point of interest or field units.

MTE uncertainties with acceptable options from MTE inventory is listed (VY MTE Tag numbers should not be listed, just Manuf/Model/Range).

Necessary values to populate the PP-7007 form (AL,AV,LSp,Setpoint,Norm Operation, etc.).

Table for comparison of existing setpoint, CTS setpoint and ITS setpoint.

All values required to populate a setpoint change request should be present within the calculation text.

Required values for SCR:

Present Setpoint
New Setpoint
Device Uncertainties
Loop Uncertainties
Model Number
Manufacturers Accuracy
Technical Specification
LSp
Correction Factors (head, etc.)

Requirements shall be worded strongly enough to convey importance.

Recommendations should provide upside and downside of non-compliance.

Graphical representation of setpoint relationship should be provided for end user being careful not to provide too much as to make confusing.

References

References to current rev. level
All references required are listed

Attachments
Provide number of pages in Attachment

LOOP DIAGRAM
Preferred as Attachment 1
Shown in sufficient detail to understand function of loop

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A good visual tool is to provide trends from ERFIS data for applicable parameters

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Values are carried forward as necessary to provide for easy reviews
Significant digits displayed are reproducible with hand calculator - Experience with Excel requires 4.

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Final values shall be displayed in %CS and calibration or field units except for non-linear devices Where final values shall be displayed as % of point of interest or field units.

Assumptions within spreadsheets are listed in calculation Assumptions Section and referenced back.

REFERENCE ATTACHMENTS
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Copies should be the best available for reproduction.

Attachments are numbered VYC –XXXX Attachment X Page X of XX and title, or provided stamp is used.

Attachment C: Process Corrections and Measurement Uncertainty

Discussion of corrections to limits or setpoints involves three locations. The first is the location where the process variable must be controlled. In some cases, such as those where flow is the significant process variable, the process variable is the same for a wide range of locations. In other cases, the process variable may vary continuously, but be of direct interest at only one point; for example, at the suction of a pump to insure minimum pressure to prevent cavitation. The second important location is the point of measurement. This is the location where the significant process variable is sensed. In the case of a flow variable, it is where the flow rate may be converted to a pressure difference. In the case of pressure measurement, it is the location of the taps to the process. The third important location is the instrument location. Differences between any of these three can cause differences in where a setpoint should be set.

Differences between the point of concern and the point of measurement and represent a change in the value of the limit or zero point of the measured variable. That is the process limit at the point of concern is translated to the point of measurement, and any appropriate adjustment in its value is made during the translation. If there are variations in the adjustment due to changes in process conditions, the most common or usable adjustment is used, and the variations around that adjustment are considered as process uncertainties.

Differences between the point of measurement and the instrument location generally will cause an adjustment to the final setpoint. This can either be by means of a change in the value of the setpoint or by changing the zero point of the instrument scale so the adjustment is considered but is calibrated out. The most common example of this is a head correction to account for pressure differences between the point of measurement and the location of the instrument. Elevation differences and density of the fluid cause the pressure differences. The most common or usable pressure difference is used as the head correction itself. Variations in the setpoint adjustment can occur if there are variations in conditions in the instrument tubing from the point of measurement to the instrument location. For example, environmental temperature around the instrument tubing can change which will cause a change in the density of the fluid in the tubing. The variation in density will cause a variation in the head correction that should be made.

In the case of switches connected directly to the process, to compensate for the head correction itself or for uncertainties in that correction, the setpoint will have to be shifted.

1. STATIC PRESSURE EFFECTS (SP_C)

1.1 Static Pressure Span Correction (SPC)

Exposure of an instrument to process static pressure may affect its span. Generally, this effect is a bias, directly dependent on pressure. This effect can be accounted for by calibrating the instrument at the operating pressure or by using a correction factor to compensate the calibration.

If the static pressure is not calibrated out, or if significant operation occurs at a pressure different than that for which it was calibrated, the static pressure effect should be included.

An example of this is where a transmitter provides input to both a trip unit and an indicator. The indicator is used during normal operation, and therefore, the pressure used for correction is the normal operations pressure. However, the switch is required during an accident condition that has a different pressure (higher or lower). There is a bias error caused by the difference between the calibration pressure (normal operations) and the accident pressure. This error should be considered in the setpoint calculation.

The static pressure span effect has both random and bias parts. The bias portion can be calibrated out by following the vendor instructions. There is an uncertainty of the bias term given by the random correction error term. If the adjustment is not made to the instrument, then the bias error should be used in the uncertainty analysis. Note that the sign of the correction is opposite that of the error that results if the correction is not made.

For Rosemount transmitters (models 1151, 1152, 1153), static pressure span correction is calculated as follows:

$$-SP_C = SPX_C \left(\frac{p_{op}}{1000} \right)$$

where,

$-SP_C$	=	static pressure correction in % of input differential pressure (p),
SPX_C	=	vendor's static pressure expression in % of input p per 1000 psi
p_{op}	=	operating static pressure

$$mA_{min,cal} = mA_{min} + \left(\frac{-SP_C\, dp_{min}}{dp_{span}} \right) mA_{span}$$

$$mA_{max,cal} = mA_{max} + \left(\frac{-SP_C\, dp_{max}}{dp_{span}} \right) mA_{span}$$

where,

$mA_{min,\,cal}$	=	corrected output mA at instrument zero (minimum output)
mA_{min}	=	nominal output mA at instrument zero (minimum output)
$mA_{max,\,cal}$	=	corrected output mA at full scale (minimum output)
mA_{max}	=	nominal output mA at full scale (minimum output)
dp_{min}	=	differential pressure at instrument zero (minimum input)
dp_{max}	=	differential pressure at instrument full scale (maximum input)

NOTE: Liquid level measurements with Rosemount transmitters are typically designed so that the reference leg is connected to the low (L) side of the transmitter. As used in the preceding formula, minimum input is then at a negative pressure, zero (pressure) is elevated, and the output (mA) increases with increasing level.

Example

A reactor level transmitter, Rosemount 1152, range code 4, has an input range of -112.8 inWC to -42.3 inWC (70.5 inWC span), for a nominal 4 - 20 mA output (16 mA span). The maximum static pressure is 1068 psia:

SPX_C	=	+0.87% input p per 1000 psi (from vendor manual)
p_{op}	=	1068 psia

$$-SP_C = SPX_C \left(\frac{p_{op}}{1000} \right) = 0.87 \left(\frac{1068}{1000} \right) = 0.929\%$$

$$mA_{min,cal} = mA_{min} + \left(\frac{-SP_C \, dp_{min}}{dp_{span}} \right) mA_{span} = 4 + \left(\frac{0.929\% \times -112.8}{70.5} \right) x16 = 3.762 \text{ mA}$$

$$mA_{max,cal} = mA_{max} + \left(\frac{-SP_C \, dp_{max}}{dp_{span}} \right) mA_{span} = 20 + \left(\frac{0.929\% \times -42.3}{70.5} \right) x16 = 19.911 \text{ mA}$$

If the correction is not applied to the calibration, then the resulting error is:

$$SP_C(\text{zero}) = -\left(\frac{3.762 - 4}{16} \right) * 100 = 1.49\% \text{ CS}$$

$$SP_C(\text{span}) = -\left(\frac{19.911 - 20}{16} \right) * 100 = 0.56\% \text{ CS}$$

Note: 1) VY does not normally correct for static pressure during the calibration process. 2) Use care when determining the actual operating pressure range for the specific application, it could be non-conservative to include the static pressure correction error if critical operations are at low-pressure conditions.

1.2 Static Pressure Span Correction Uncertainty (SP_U)

When a correction is made to an instrument's calibration by using a vendor supplied expression, there is an additional uncertainty due to the uncertainty of the vendor expression used to correct for static pressure. This is, in effect, the random variation around the bias, which occur during testing to determine the vendor correction expression. If the instrument is calibrated at the pressure at which it must later operate, there is no need to include this uncertainty. In that case, the instrument has been adjusted for that particular pressure in that particular installation and the vendor expression was not used. VY typically does not calibrate out the static pressure span effect.

1.3 Static Pressure Zero Effect (SP_Z)

Static pressure zero effect is the shift of the zero point of the calibrated scale due to operation at a process pressure different than the pressure at which the instrument was calibrated. The effect is generally not predictable between instruments so an expression cannot be used to correct for the difference in pressures. However, for a particular instrument the effect can be eliminated by calibrating at the desired operating pressure and adjusting the zero. A correction factor may also be shop determined, as defined in the Rosemount manuals, and applied to the field calibration. VY typically does not calibrate out the static pressure span effect.

1.4 Overpressure Effect (SP_O)

Over pressure effects should be considered when an instrument is operated outside of its normal operating limit. The normal operating limit is not the same as the design limit. Example: a transmitter may have an operating limit of 2000 psi, but its design limit may be 4500 psi. The effects above 2000 psi must be considered. For differential pressure instruments, there may be two operating limits, one for high static line (common mode) pressure and another for differential pressures. For Rosemount transmitters the overpressure rating applies to any differential pressure above the Upper Range Limit (URL).

2. LINE PRESSURE LOSS EFFECTS

2.1 Adjustment to Process Limit

The flow of liquids and gases through piping causes a drop in pressure from Point A to Point B (see **Figure 1**) due to fluid friction. Many factors are involved, including length of piping, diameter of piping, fluid viscosity, fluid velocity, etc. If, for setpoint calculation purposes, the setpoint is based on pressure at a point in the system that is different from the point of measurement, the pressure difference effect between those points must be considered.

This is most effectively done by transferring the limit from the point of concern to the point of measurement. In **Figure 1** Point A is the point of concern and Point B is the point of measurement.

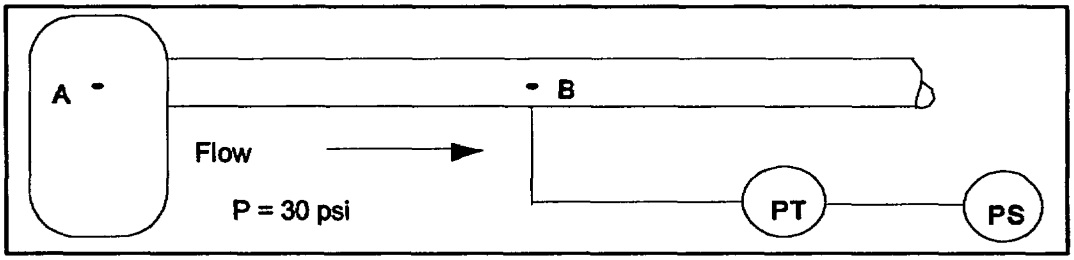


Figure 1: Pressure Drop

For this example, protective action must be taken before the pressure at Point A exceeds the process limit (PL) of 1500 psig. Therefore, the pressure switch setpoint must be below the process limit by at least the total loop uncertainty; in this example assumed to be 10 psi. The setpoint must also account for the pressure loss of 30 psi between Points A and B. For this example no other adjustments, such as those due to elevation differences in the instrument tubing, are considered significant.

The pressure drop between Points A and B are accounted for by transferring the limit at the point of concern to the point of measurement and adding the appropriate pressure change.

$$PL_{meas} = PL_{concern} + \Delta P = 1500 + (-30) = 1470 \text{ psig}$$

The channel equipment errors are then subtracted from the PL at the point of measurement.

If the change in pressure had not been considered, the setpoint would have been 1490 psig (= 1500 -10). With a setpoint of 1490 psig at Point B, the pressure at Point A when the switch trips at its nominal value would be 1520 psig. This exceeds the process limit and is a non-conservative result. The pressure change must be considered to obtain a setpoint that properly protects the process limit.

In some cases, the point of measurement is upstream from the point of concern. For example, a switch is upstream of a pump that is intended to protect the pump from low suction pressure. The pressure rise from point of concern (suction) to the point of measurement ($P > 0$) must also be added to the limit at the point of concern to prevent a non-conservative setpoint. In this case, the change was a pressure rise rather than a drop, but the process decreased to the limit rather than increased. The result was the same in that the effect of the pressure change in the process piping must be considered to properly protect the process limit.

There are cases where neglecting the pressure change results in an overly conservative rather than non-conservative setpoint, and may interfere with normal plant operations.

Note that the line losses are bias terms. The effect must be added or subtracted from the process limit, depending on the particular circumstances.

2.2 Uncertainty Due to Line Pressure Loss Effects

In Section 2.1, the pressure drop was assumed to be 30 psi. This was due to frictional losses between Points A and B. Frictional losses are very dependent upon flow rate, and somewhat dependent upon the fluid density. The general relation between density, flow rate, and pressure drop can be expressed as:

$$\Delta P = \rho K Q^2$$

The relative change in the pressure drop can be approximated from the relation:

$$\frac{\Delta P_A - \Delta P_B}{\Delta P_B} = \frac{\rho_A Q_A^2 - \rho_B Q_B^2}{\rho_B Q_B^2} = \frac{\rho_A Q_A^2}{\rho_B Q_B^2} - \frac{\rho_B Q_B^2}{\rho_B Q_B^2} = \frac{\rho_A Q_A^2}{\rho_B Q_B^2} - 1$$

If the 30 psi pressure drop was determined for a temperature of 100°F (= 61.996 lbm/ft^3) and 10,000 gpm, the relative pressure drop for 300°F (= 57.307 lbm/ft^3) and 8,000 gpm is:

$$\frac{\Delta P_A - \Delta P_B}{\Delta P_B} = \frac{57.307(8000)^2}{61.996(10000)^2} - 1 = 0.5921 - 1 = -40.8\%$$

30 psi - (40.8%*30 psi) = 17.76 psi

The relative change is 40.8% and the new pressure drop is 17.76 psi. This change

represents a possible uncertainty in the process correction and should be included as part of the process measurement uncertainty, PM. In determining the pressure variation for a given system, the flow equations for that system should be used rather than the approximations used in this example. Generally, Darcy's formula can be used to determine head loss in a piping system.

$$DP = \frac{\rho * f * L * v^2}{144 * D * 2 * g}$$

Where:

DP_n	= pressure change in psi
ρ	= Fluid Density
f	= Friction factor
v_n	= Mean velocity of flow, in feet per second
L	= Length of Pipe in feet
D	= Internal Diameter of pipe, in feet
g	= Acceleration of gravity.

Once the initial head loss has been determined, most of the equation can be assumed to be unchanged for conditional changes. The friction factor which is based on the Reynolds number for laminar flow and the Reynolds number and relative pipe roughness for turbulent flow, the density and the mean velocity of flow can be assumed as the only variables for changing flow conditions or evaluating measurement errors.

3. HEAD CORRECTION

Head correction is an adjustment made to the setpoint or transmitter zero to account for elevation differences between the instrument location and the location where the process is sensed, the point of measurement. This is most commonly of concern for pressure or level measurements. The adjustment is to either change the setpoint by amount of the head correction or to calibrate out the head correction so the zero point of the scale has been shifted to correspond to zero at the point of measurement. When the adjustment is determined, an elevation difference and density are used. The density may vary during normal operations or during an accident, most commonly due to temperature variations in the environment around the instrument tubing. The variation in density causes an uncertainty in the head correction. Variation in elevation could occur in some cases due to expansion of component due to heating. For most cases, this is considered to be negligible.

Since the changes are predictable, they are biases. The uncertainty, however, can have a range of errors from a negative bias to a positive bias, depending upon the environmental conditions. For example, a pressure transmitter could have been calibrated for a temperature in the instrument

tubing of 150°F. However, operation is such that the temperature can vary from 100°F to 250°F. When the temperature is 100°F, the error will be in one direction; when the temperature is 250°F, the error is in the opposite direction. These errors are not random since the direction and magnitude of the error is readily predictable from a readily measured quantity. This error is commonly expressed as percent of ideal output, not %CS. VY head corrections can normally be found in calculation VYC-1597 "Head Correction".

There are two general categories of head correction:

1. Those due simply to a difference between point of measurement and the location of the instrument. An example of this is discussed in Section 2.1, and

2. Those due to elevation and density differences which are a part of the measurement process. An example of this is discussed in Section 3.

3.1 Effect of Elevation Difference on Pressure Measurement

The system shown in **Figure 2** is similar to the system shown in **Figure 1** but now includes an elevation difference between the point of measurement and the instrument location. The pressure is sensed at Point B but the instrument is at Point C, which is an elevation Z below Point B. The switch associated with the instrument at Point C must trip before the process limit is exceeded. The process limit at Point B is 1470 psig and the TLU is 10 psi. Without considering the elevation difference, the setpoint would be 1460 psig. Both the process piping and the instrument tubing are filled with a fluid. The density of the fluid and the elevation difference together cause a pressure difference, which for this example will be assumed as 20 psi. Because the instrument is below the point of measurement, the pressure will be higher at the instrument than at the point of measurement. The proper setpoint when the elevation difference is considered is 1480 psig. If the setpoint is set at 1460 psig, the pressure at Point B when the switch trips at its nominal value would be 1440 psig. This is conservative, but may affect normal operations.

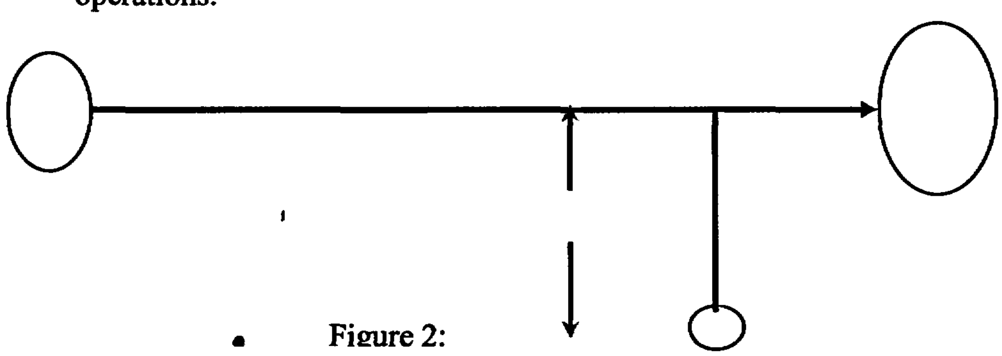


Figure 2:

If the instrument had been above the point of measurement then ignoring the elevation difference would have been non-conservative. If the fluid was a liquid, then there may have been larger problems. The instrument could have been installed incorrectly since the device should normally be mounted above gas lines and below liquid lines.

In either case, the numerical value of the setpoint need not necessarily be changed; the zero of the scale on the instrument could be increased so that the 20 psi pressure difference is calibrated out.

The head correction would be found using the basic relation

$$P_C = P_B + \rho Zg$$

where:

P_C = pressure at instrument (location C)
P_B = pressure at process tap (location B)
ρ = fluid density in sense line
Z = elevation change from C to B
g = acceleration of gravity

This can be generalized to:

$$hC = [(\rho_1 * g_1 * Z_1) + (\rho_2 * g_2 * Z_2) + (\rho_n * g_n * Z_n)$$

where for several sections of Z, either density (ρ) or acceleration (g) may be changing over sections of elevation (Z). In the usual case, g is considered a constant equal to 1, and the density is taken to be constant over segments of the line length.

$$hC = [(\rho_1 * Z_1) + (\rho_2 * Z_2) + (\rho_n * Z_n)$$

An increase in elevation from the instrument location to the process connection is a positive value and results in a positive head correction.

3.2 Head Correction Uncertainty (hU)

Head correction uncertainty is considered as a part of the overall process measurement uncertainty (PM) included in the total loop uncertainty. Because it is a common type of uncertainty, it has a more descriptive symbol, hU. The uncertainty of the head correction is the difference between the head correction which should be applied due to actual condition, hC_A, and the head correction which was applied at calibration conditions, hC_C. It is caused by the variation in density from the calibration conditions. The expression for head correction uncertainty as a fraction of the head correction is:

$$hU = \frac{hC_A - hC_C}{hC_C} = \frac{hC_A}{hC_C} - \frac{hC_C}{hC_C} = \frac{hC_A}{hC_C} - 1$$

If the density does not vary with elevation (i.e., all sections of tubing have the same density), the expression can be simplified to:

$$hU = \frac{\rho_A}{\rho_C} - 1 = \frac{1/V_A}{1/V_C} - 1 = \frac{V_C}{V_A} - 1$$

where:

V_A = specific volume for actual conditions
V_C = specific volume for nominal conditions for calibration.

4. LEVEL MEASUREMENT UNCERTAINTY

4.1 Basic Equations

When differential pressure transmitters are used to measure liquid level in vessels, changes in density of the reference leg fluid, or vessel fluid, or both, can cause uncertainties if the level measurement system is not automatically compensated for density changes. This occurs because differential pressure transmitters respond to hydrostatic pressures (head), which are directly proportional to the height of the liquid column multiplied by the liquid density. Therefore, measurement errors may be caused by the liquid density changes, as a function of temperature and pressure, while the actual level in the vessel or reference leg remains constant. This changes the pressure delivered to the differential pressure transmitters, which makes the indicated level appear different from the actual level since the transmitter by itself cannot distinguish the difference in pressure caused by the density changes

In level-measuring applications at Vermont Yankee, a variety of specific situations are encountered. It is not practical to cover the details of each; however, the situation described below encompasses the basic theory and method that may be applied to specific systems.

The level measuring system is calibrated for some assumed operating conditions (e.g., normal or accident). The differential pressure transmitter or switch may be in a distinctly different environment from the vessel. This is the case for reactor vessel level measurement. No automatic vessel or reference leg density compensation is provided.

The usual assumption is that the top of the vessel and the top of the reference leg are exposed to the same pressure. Often the reference leg fluid is a compressed liquid, assuming a saturated liquid may or may not introduce negligible error. However, the equations presented below do not require that the reference leg be filled with liquid, only that it remain either filled or empty at all temperatures.

Figure 3 shows a closed vessel containing a liquid with a gas (steam) blanket and a reference leg for level measurement. The transmitter produces a signal proportional to the pressure difference.

There are two parts to adjusting for temperature differences for level measurement. The first part is determination of the differential pressure that should exist for certain levels for the base conditions. This is similar to the head correction (hC) calculation. The second part is the determination of the uncertainty in the level due to variations in temperature and operating pressure. This is simply a variation of the head correction calculation using different density conditions.

The differential pressure transmitter is calibrated to read level correctly at the assumed base conditions. As long as the actual vessel and reference leg conditions remain the same as the base conditions, the indicated level is a linear function of the measured differential pressure and no vessel/reference leg density effects are created. However, when the actual conditions differ from the base conditions, a process level measurement uncertainty (PM) is created.

4.2 Reactor Vessel Level Measurement

Figure 3 is based upon an illustration from the present error analysis for Vermont Yankee reactor vessel level [VYC-332]. Vessel conditions are at saturation, the reference leg is normally at a lower temperature, but the same pressure, and therefore is compressed.

Explanation of Symbols:

h_S - height of steam to condensate pot water level (Z_u-Z)
h_L - height of liquid in vessel, above lower tap (Z-Z_Z)
h_{RD} - height change of reference leg in drywell
h_{VD} - height change of variable leg in drywell
h_{RR} - height change of reference leg in reactor building
h_{VR} - height change of variable leg in reactor building
Z - elevation of water level above reference point
Z_Z - elevation of 0% indicated level above reference point
Z_F - elevation of 100% indicated level above reference point
Z_U - elevation of condensate pot water above reference point
Z_L - elevation of lower tap above reference point

ρ_S - steam density in the vessel (= $1/v_S$)
ρ_D - water density in drywell portion of either leg (= $1/v_D$)
ρ_L - water density in the vessel (= $1/v_L$)
ρ_R - water density in the reactor building for either leg (= $1/v_R$)
P_A - pressure at point A.
P_B - pressure at point B.
P_R - pressure for the reference leg of the transmitter
P_V - pressure for the variable leg of the transmitter.

From geometry of the vessel and reference leg and basic equations relating elevation, density, and pressure, the following equations are valid.

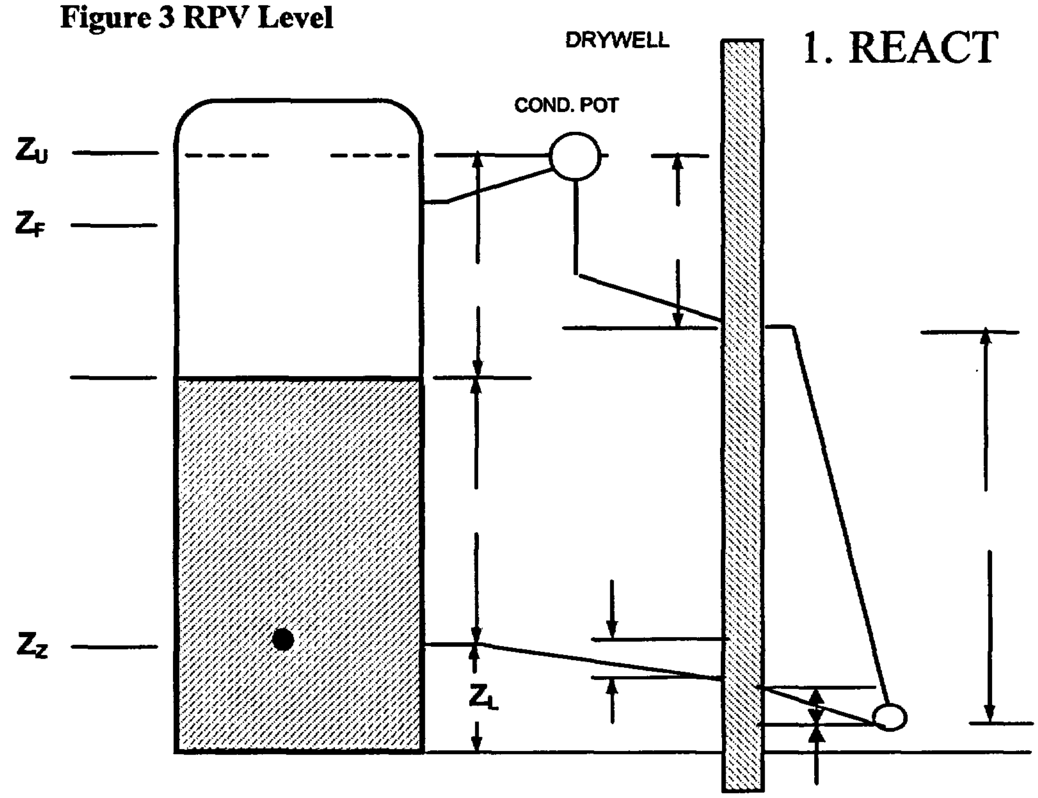
$$h_{RR} + h_{RD} = h_{VR} + h_{VD} + h_L + h_S$$

$$P_B = P_A + g\,(h_S \rho_S + h_L \rho_L)$$

$$P_R = P_A + g(h_{RR} \rho_R + h_{RD} \rho_D)$$

$$P_V = P_B + g(h_{VR} \rho_R + h_{VD} \rho_D)$$

Figure 3 RPV Level



To determine differential pressure the "LO" pressure side of the transmitter is subtracted from the "HI" pressure side of the transmitter. If the reference leg is attached to the "LO" side of the transmitter, then the differential pressure (P) is as follows:

$$\Delta P = P_V - P_R = g\{(h_S \rho_S + h_L \rho_L + h_{VD} \rho_D + h_{VR} \rho_R) - (h_{RD} \rho_D + h_R \rho_R)\}$$

Note: The reference leg is actually at a constant value equivalent to the maximum value of the variable leg. This means that as level decreases the differential pressure becomes more negative. For this application level equal to the condensate pot would result in a zero differential pressure.

If the reference leg is connected to the "HI" side of the transmitter or switch, then the sign of the pressure difference is reversed. However, the process measurement uncertainty calculated below is of the same sign since it involves a ratio in which the direction of the pressure difference cancel.

The ΔP which should exist for some indicated level (Z) is found by substituting $Z-Z_Z$ for h_L and Z_U-Z for h_S.

$$\Delta P = g\{(Z_U - Z)\rho_S + (Z - Z_Z)\rho_L + h_{VD}\rho_D + h_{VR}\rho_R) - (h_{RD}\rho_D + h_{RR}\rho_R)\}$$

Note that at the elevation and latitude of Vermont Yankee, g may be set to one (1).

Setting Z equal to Z_L, solving for P then setting Z equal to Z_U, solving for P, determines the pressure differentials at which the loop should be calibrated. The value for the densities, ρ_{LO}, ρ_{DO}, ρ_{RO}, and ρ_{SO}, should be the appropriate values for the calibration conditions.

Once the P's associated with the limits of calibration and normal level conditions have been determined, the equations may be revised for differences in elevations, densities, or gravity to determine the associated PM error.

These equations are valid for any consistent set of units; however, the Steam Tables provide specific volume in units of ft^3 per lbm, so if elevations are expressed in feet, resulting pressures will be in lb. per ft^2, which may be divided by 144 to find psi. If the result is desired in inches of water column (inWC), then from Crane's Flow of Fluids: 1 psi = 27.7276 inWC and:

$$1\frac{lb}{ft^2} = \frac{27.7276}{144} = 0.192553 \text{ inWC}$$

Example:

The Fuel Zone level measuring loops at Vermont Yankee have the following conditions (from VYC-332):

Base Conditions:

(1) Vessel Pressure = 1020 psia (saturated), $v_{S0} = 0.43620$, $_{S0} = 2.29253$ lb/ft^3, $v_{L0} = 0.02166$, $\rho_{L0} = 46.16166$ lb/ft^3

(2) Drywell temperature = 160 °F, $v_{D0} = 0.016343$, $\rho_{D0} = 61.18828$ lb/ft^3

(3) Reactor Building temperature = 100 °F, $v_{R0} = 0.016080$, $\rho_{R0} = 62.18905$ lb/ft^3

(4) $Z_Z = 151.5$ inches above vessel bottom = 12.625 ft.

(5) Z = 400 inches = 33.333 ft.

(6) $Z_U = 545.75$ inches = 45.479 ft.

(7) $Z_L = 129.0$ inches = 10.750 ft.

(8) Vessel lower tap @ 129 in., condensate pot @ 545.75 in.

(9) Drywell penetration: reference @ 373 in., variable @ 97 in.

(10) $\Delta h_D = h_{RD} - h_{VD} = (545.75 - 373) - (129 - 97) = 140.75$ in. = 11.729 ft.

(11) $\Delta h_R = h_{RR} - h_{VR} = 373 - 97 = 276$ in. = 23.0 ft. (both legs converge @ 97 in.)

Actual Conditions:

(12) Vessel pressure =1000 psia (saturated), $v_S = 0.44596$, $\rho_S = 2.24235$ lb/ft^3, vL = 0.021591, $\rho_L = 46.31559$ lb/ft^3

(13) Drywell temperature = 180 °F, $v_D = 0.016457$, $\rho_D = 60.76442$ lb/ft^3

(14) Reactor Building temperature = 120 °F, $v_R = 0.016155$, $\rho_{R0} = 61.90034$ lb/ft^3

To determine the differential pressure for the zero and full span condition, during calibration each segment of the liquid must be evaluated. For the zero span condition the elevations and conditions are as follows:

For the variable leg (inside the vessel and the variable leg connection):

From the condensing pot to the normal level 545.75 - 400 inches (12.1458 feet) at reactor steam density (2.2925 lbs/ft^3).

From the normal level to the instrument zero 400-151.5 inches (20.7083 feet) at reactor steam density (2.2925 lbs/ft^3).

From the instrument zero to the lower tap elevation 151.5-129 inches (1.875 feet) at reactor liquid density (46.1617 lbs/ft^3).

From the lower tap to the drywell penetration 129-97 inches (2.667 feet) at drywell liquid density (61.1883 lbs/ft^3).

From the drywell penetration to the instrument the variable and reference lines run parallel therefore, no calculation is required.

For the reference leg:

From the Condensing pot to the drywell penetration 545.75-373 inches (14.396 feet) at drywell liquid density (61.1883 lbs/ft^3).

From the drywell penetration to parallel with the variable leg 373-97 inches (23 feet) at reactor building density (62.1891 lbs/ft^3).

For the full span condition the elevations and conditions are as follows:

For the variable leg (inside the vessel and the variable leg connection):

From the condensing pot to the normal level 545.75 - 400 inches (12.1458 feet) at reactor liquid density (46.1617 lbs/ft^3).

From the normal level to the instrument zero 400-151.5 inches (20.7083 feet) at reactor liquid density (46.1617 lbs/ft^3).

From the instrument zero to the lower tap elevation 151.5-129 inches (1.875 feet) at reactor liquid density (46.1617 lbs/ft^3).

From the lower tap to the drywell penetration 129-97 inches (2.667 feet) at drywell liquid density (61.1883 lbs/ft^3).

From the drywell penetration to the instrument the variable and reference lines run parallel therefore, no calculation is required.

For the reference leg:

From the Condensing pot to the drywell penetration 545.75-373 inches (14.396 feet) at drywell liquid density (61.1883 lbs/ft^3).

From the drywell penetration to parallel with the variable leg 373-97 inches (23 feet) at reactor building density (62.1891 lbs/ft^3).

ΔP_{ZO} = (12.14583*2.2925) + (20.7083*2.2925) + (1.875*461617) +
(2.667*61.18828)-(14.39583*61.1883)-(23.0*62.1891) =
-1986.145 lb / ft^2 =
[-1986.145 lb/ft^2]/[144 in/ft^2] =
-13.793 psi *27.728 inwc/psi
-382.44 in WC

ΔP_{SO} = (12.14583*46.1617) + (20.7083*46.1617) + (1.875*461617) +
(2.667*61.18828)-(14.39583*61.1883)-(23.0*62.1891) =
- 544.86 lb / ft^2 =
[-544.86 lb/ft^2]/[144 in/ft^2] =
-3.784 psi *27.728 inwc/psi
-104.916 in WC

Then the zero and span shift are calculated using the same equations and replacing the applicable densities. These equations may be used to determine the differential pressure at any point in the span simply by changing the desired level and correcting the density for the desired conditions. Normally the fluid above the desired level will be steam and the fluid below the desired level will be liquid. The following example calculates the differential pressure for the 400 inch level:

ΔP_{Z400} = (12.14583*2.2925) + (20.7083*46.1617) + (1.875*461617) +
(2.667*61.18828)-(14.39583*61.1883)-(23.0*62.1891) =
-1077.689 lb / ft^2 =
[-1077.689 lb/ft^2]/[144 in/ft^2] =
-7.484 psi *27.728 inwc/psi
-207.515 in WC

5.0 FLOW MEASUREMENT PROCESS UNCERTAINTIES

In most flow applications at Vermont Yankee, process liquid and gas flow is measured using orifice plates, venturis, or elbow taps along with differential pressure transmitters. The measurement of concern is either the volumetric flow rate or the mass flow rate. The flow element converts flow rate to differential pressure. For most uncertainty calculations, the flow rate is specified and the uncertainty is associated with the differential pressure measurement. This is the condition when a process limit is specified. The general relation is:

$$\Delta P_x = K \rho_x Q_x^2$$

Where:

x can be A for actual or C for calibration or design conditions

ΔP	=	differential pressure at flow element taps
ρ	=	nominal (upstream) fluid density
K	=	constant depending on system of units and element type.
Q	=	volumetric flow rate

As shown above, the density of the fluid has a direct influence on the differential pressure that the pressure transmitter sees. A flow orifice is design to operate at a specified temperature. At these conditions, it provides its best accuracy. Operations at different temperatures affect the density of the fluid and therefore the differential pressure across the orifice. The remainder of the instrument loop will interpret this changed ΔP as a change in flow rate, Q, rather than a change in density. This is, therefore, a bias error for the instrument loop.

The actual, or indicated, pressure differential, DP_A, is that caused by the actual density, r_A, and the actual flow rate, Q_A. The calibration pressure differential, DPC, is caused by operation at the calibration density, r_C, and at the calibration flow rate, Q_C, which is held equal to the actual flow rate, Q_A, since the flow rate is specified as the process limit or some other point of interest. The error in the pressure difference can be expressed as a ratio of the difference between indicated (due to actual density) and as calibrated for a given flow rate. The relation between density, ρ, and specific volume, v, (ρ = 1/v) is also used.

$$\frac{\Delta P_A - \Delta P_C}{\Delta P_C} = \frac{\rho_A}{\rho_C} - 1 = \frac{v_C}{v_A} - 1$$

Because the temperature can increase above and decrease below the calibration temperature, there are both positive and negative biases possible. This error is expressed as a fraction of ideal output, not of calibrated span, in which the actual (indicated) DP_A differs from the expected DP_C for a given flow rate.

Example

As an example of the use of the equation above, assume an orifice plate is used to measure flow in a water system that is normally at 120°F. The orifice is sized to produce 100 inWC at 100 gpm flow at 120°F and 250 psia. Assume further that under accident conditions the temperature rises to 300 °F with saturated conditions at an actual flow of 50 gpm. It is desired to find the process measurement uncertainty, PM, for this change in process conditions, and the indicated flow.

The first step is to determine the relationship between Q and DP. From the basic relation:

$$\Delta P_X = K_{\rho X} Q_X^2$$

$$K_\rho = \frac{\Delta P_C}{Q_C^2}$$

$$= \frac{1}{100}$$

At an accident flow rate of 50 gpm the design differential pressure would be:

$$\Delta P = \frac{1}{100}(50)^2 = 25 \text{ inWC}$$

However, the density has changed. Using thermodynamic steam tables:

$v_C = 0.01619$ ft^3/lbm @ 120 °F and 250 psia.
$v_A = 0.01745$ ft^3/lbm @ 300 °F saturated

Substituting these values into the uncertainty equation results in a relative error of:

$$\frac{\Delta P_A - \Delta P_C}{\Delta P_C} = \frac{v_C}{v_A} - 1 = \frac{0.01619}{0.01745} - 1 = -7.22\%$$

This is a actual error of 1.81 inches of water (-7.22% of 25 inches).

Therefore, the rise in temperature reduces the actual differential pressure input to the transmitter to 23.19 inches of water (= 25 -1.81). Substituting this differential pressure into the flow equation and rearranging to solve for flow rate results in an indicated flow of:

$$Q = \sqrt{100\Delta P} = \sqrt{(100)23.19} = 48.16 \text{ gpm}$$

Attachment D: Flow Loop Scaling and Uncertainty

Flow orifices are non-linear devices; however, the errors can be written such that they can be combined with the uncertainties of linear devices as if they were linear devices, but only for specific points of interest. The errors are propagated from the input through the non-linear device and then combined with the errors of the instruments on the downstream side of the non-linear device. The methods of this Attachment effectively propagate any errors on the input side of the flow element to the output side. Therefore, when the equations of this Attachment are used, the flow orifice uncertainties and those of any square root converter can be combined with the uncertainties of other instruments as if they were linear but only at the specific point where the error propagation is performed.

1. BASIC EQUATIONS

This section is included to provide guidance on how the flow versus differential pressure relation should be developed for a flow orifice whenever a change in the calibration data for the transmitter is deemed appropriate. The primary reference will be the ASME standard "Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi" (ASME MFC-3M-1989). This is a recent publication and has considered several of the other common references used to obtain similar relations. Therefore, this standard will be considered as superseding earlier references. Other references may give similar results, but for consistency, this standard is to be used for future work.

The basic equation for determining flow rate is Eq 13 from the standard. The equations will be presented here, with possible variation in symbols to be consistent with other symbols used in this design guide.

$$w = 0.09970190\,CYd^2\sqrt{\frac{\Delta P\rho}{1-\beta^4}}$$

where:

w - mass flow rate (lbm/sec)
C - discharge coefficient
Y - expansion coefficient, for liquid this is 1
d - bore diameter of orifice plate or throat diameter of nozzle or venturi (inches)
ΔP - pressure difference across orifice or nozzle (in WC, see Note 2 of Table 1 in MFC-3M-1989, also entry for $\rho_{w,68\,F}$.
ρ - fluid density, for this design guide the density will be determined upstream of the orifice or nozzle (lbm/ft^3)
β - ratio of bore or throat diameter to pipe inside diameter, d/D, see Table 1 of the Standard.

This can be converted to measure volume flow rate in gallons per minute (gpm) by using the

appropriate unit conversions [5].

$$Q = (60) * (8.34517) * (0.09970190) CYd^2 \sqrt{\frac{\Delta P}{\rho(1-\beta^4)}} = 49.92176\, CYd^2 \sqrt{\frac{\Delta P}{\rho(1-\beta^4)}}$$

To determine the ΔP which will exist for a given flow rate, the equation above can be rearranged.

$$\Delta P = \left(\frac{Q}{49.92176\, CYd^2}\right)^2 \rho(1-\beta^4)$$

This type of rearrangement is needed to determine the calibration characteristics of a differential pressure transmitter that is used to measure flow rate. The transmitter is designed to produce a linear output signal (current) for a linear input signal (differential pressure). Two points are needed to define the line. The common points are the two endpoints of the line, zero differential pressure (zero flow) and the design differential pressure (from the design flow rate). At the design conditions, temperature and flow, the quantities ρ, β, d, Y, and C are evaluated. Common practice is then to consider that these quantities are constant. When that is done, the form of the equation is:

$$\Delta P = kQ^2$$

where k is the flow coefficient and is expressed by:

$$k = \frac{\rho(1\beta^4)}{\left(49.92176\, CYd^2\right)^2}$$

The density, ρ, is a function of temperature and pressure. The expansion factor, Y, can vary with pressure ratio for compressible fluids. For liquids it is constant at a value of one. Determination of the expansion factor for compressible flow is not discussed in this guide. Information is provided in the ASME standard for those who must consider compressible flow (e.g. steam). The bore diameter, d, and diameter ratio, β, can vary with temperature due to the expansion of the flow element and pipe with temperature. The discharge coefficient, C, is a function of pipe diameter, D, the diameter ratio, β, and Reynolds number. Reynolds number is, in turn, a function of flow rate, pipe diameter, and fluid properties at the flowing conditions. The Reynold number contribution to discharge coefficient is small, and therefore, discharge coefficient is nearly constant for most flow conditions. However, there is a small error associated with assuming that the discharge coefficient is constant. Equations will be presented later which will allow determination of that error. At very low Reynolds numbers, and at or near the transition

5 Example CRC Handbook of Mathematical Sciences 5th edition: From Pounds H_20 (39.2°F)/min to Gal(US)/min Multiply by 1/0.1198298)

point from laminar to turbulent flow, the equations for the determination of differential pressure may not be valid. Where operation is considered for low Reynolds number conditions (less than 2000) specific orifice calibration confirmation is required. Also the change in flow coefficient below Reynolds numbers of 10,000 becomes more and more non-linear with the flow decrease, due to this specific discharge coefficients should be calculated for flows in these regions.

Note that equations above do not include a thermal expansion correction factor, F_a, which is used in some publications. This correction factor is discussed in Section 4.2 of the Standard and is used for initial sizing of the bore. Once the primary element has been manufactured, the effect of thermal expansion on the bore and pipe diameter are included using Equations 19a and 19b of Section 4.3 of the Standard, which are repeated below, again with slight symbol changes.

$$d = [1 + \alpha_{PE}(T - T_{meas})]d_{meas}$$
$$D = [1 + \alpha_{PE}(T - T_{meas})]D_{meas}$$

Attachment E of the Standard provides some values for the thermal expansion coefficient, α, which may be useful. As stated in Section 4.3 (d) of the Standard, the measurement temperature, T_{meas}, is assumed to be 68°F. The diameters given from the equations above are to be used for further calculations to determine volume flow rate or differential pressure.

The determination of the discharge coefficient for an orifice plate in Section 7.3.1.1 of the Standard. The exact equation will depend upon the type of taps used, but all have a series of terms which are a function of the diameter ratio, β, and the pipe diameter, D, and an additional term which is a function of Reynolds number. The equations for the discharge coefficient can be expressed by the general form below, where "M" is the series of terms which are a function of β and D.

$$C = M + \frac{91.71\beta^{2.5}}{R_D^{0.75}}$$

The relation for Reynolds number in terms of the volume flow rate is:

$$R_D = \frac{50.657\,Q\,\rho}{\mu D}$$

Note: the discharge coefficient is relatively constant for Reynolds numbers above $2 * 10^5$. Transition of flow from turbulent to laminar occurs somewhere between Reynolds numbers of $2 * 10^3$ and $1 * 10^4$. In this region the relative change in uncertainty of the coefficient of discharge, for a given change in Reynolds number, is very large. These changes in the discharge coefficient can result in substantial errors in the flow measurement. Measurement of flow in these areas may require additional condition specific testing or a more extensive evaluation of the discharge coefficient and other flow condition errors. The calculation preparer must ensure

that the specific pipe conditions (e.g. pipe full, adequate flow profile, etc.) are know for the point of interest of the calculation.

2. FLOW ELEMENT ERRORS

There are three causes of errors in the flow measurement. First is the uncertainty of the coefficients used to determine the differential pressure or flow rate. This can be termed flow element accuracy. Second is a temperature and or pressure variation, which occurs during normal operation, which will affect material properties such as density (discussed in Attachment C) and pipe size (i.e., thermal expansion). The third is the flow rate itself, which will cause the discharge coefficient to vary slightly.

The relative change of differential pressure produced by the actual operating conditions, P_A, compared to the design conditions, P_D, for the same flow rate is:

$$\frac{\Delta P_A - \Delta P_D}{\Delta P_D} = \frac{k_A Q^2 - k_D Q^2}{k_D Q^2} = \frac{k_A - k_D}{k_D} = \frac{k_A}{k_D} - 1$$

This equation shows that for a decrease in the flow coefficient, the relative error will be negative. This means that the indicated flow will be less than the actual flow. The instrument loops are designed to interpret a change in differential pressure as a change in flow rate. For example, the differential pressure is less for a less dense fluid at the same volume flow rate (k_A is smaller). With a smaller differential pressure, the instrument loop indicates this as a smaller flow, since it does not know that the change was caused by a change in density rather than a change in flow.

2.1 Flow Element Accuracy

There are three primary components of the inaccuracy of a flow element: (1) uncertainty of the discharge coefficient, C; (2) bore diameter uncertainty, d; and (3) pipe diameter uncertainty. Section 10.2.2 of the Standard discusses how the uncertainties are to be combined. More uncertainties than the three just listed are presented in Section 10.2.2; however, they are treated elsewhere in this design guide, or considered insignificant (i.e., no uncertainty for expansion factor for liquids). Simplifying the equation of Section 10.2.2 to include only the three primary components of uncertainty (for liquids) results in the equation below.

$$PE_Q = \frac{\delta Q}{Q} = \sqrt{\left(\frac{\delta C}{C}\right)^2 + \left(\frac{2\beta^4}{1-\beta^4}\right)^2 * \left(\frac{\delta D}{D}\right)^2 + \left(\frac{2}{1-\beta^4}\right)^2 * \left(\frac{\delta d}{d}\right)^2}$$

where:

PE_Q = primary element uncertainty as a fraction of input

$\delta Q/Q$ = uncertainty of flow,
$\delta C/C$ = uncertainty of discharge coefficient,
$\delta D/D$ = uncertainty of upstream pipe diameter,
$\delta d/d$ = uncertainty of orifice bore diameter,
β = diameter ratio = d/D.

The uncertainty of the bore and pipe diameter should be obtained from vendor manufacturing data. Section 7.3.2.1 of the Standard provides an estimate of the uncertainty of the discharge coefficient. This information is reproduced below. However, this information assumes that turbulent flow exists at the associated Reynolds number.

2 in. ≤ D ≤ 36 in. (nominal sizes)	$0.2 \leq \beta \leq 0.6$	$0.6 \leq \beta \leq 0.75$
$10{,}000 < R_D \leq 10^8$	0.6%	β%
$2{,}000 \leq R_D \leq 10{,}000$	(0.6 + β)%	

Table D1: Discharge Coefficient Uncertainty

The standard presents additional information in its Sections 6.4.1, 6.4.2, and 6.4.3, which should be considered. In particular any additional uncertainty due to fittings (e.g., pipe elbows, tees, etc.) should be considered and included as part of PE.

The ASME Standard assumes a fixed differential pressure and an uncertainty in the flow rate. The uncertainty of the flow rate needs to be converted to an uncertainty of the differential pressure to be consistent with the other uncertainty terms in this design guide.

This error may be determined by solving the differential pressure equation for the base flow and then revising the equation to calculate the differential pressure difference based on the change in flow.

Given a one percent of full scale flow error, for a system with a 5000 gpm flow in a schedule 80-10 inch pipe with an installed orifice having a beta ratio of 0.725 and a calculated flow coefficient of 0.72, assuming a expansion factor of 1. Determine the error in percent of differential pressure.

$$\Delta P = \left(\frac{Q}{49.92176\, CYd^2} \right)^2 \rho (1 - \beta^4)$$

Solve the equation for the point of interest:

$$98.7059 = \left(\frac{5000}{49.92176 * 0.72 * 1 * 9.562^2}\right)^2 * 58.9214 * (1 - 0.725^4)$$

Solve the equation for the positive and negative application of the flow error (0.01*5000 = 50 gpm):

$$100.6898 = \left(\frac{5050}{49.92176 * 0.72 * 1 * 9.562^2}\right)^2 * 58.9214 * (1 - 0.725^4)$$

$$96.7416 = \left(\frac{4950}{49.92176 * 0.72 * 1 * 9.562^2}\right)^2 * 58.9214 * (1 - 0.725^4)$$

$$\frac{100.6898 - 98.7059}{98.7059} * 100 = +2.01\%$$

$$\frac{96.7416 - 98.7059}{98.7059} * 100 = -1.99\%$$

The differential pressure error is approximately ±2.0% at the point of interest. Note: since the flow error is 50 gpm at all times the effect in terms of % of reading or point of interest will be greater as flow rate decreases. The error must be evaluated at the point of interest for the flow element.

2.2 Temperature Variations

To account for any change in the normal operating temperature, a new constant k as defined in this Attachment or the ASME Standard should be determined, and at the same design flow as was used to determine the original constant. The relative error of differential pressure produced by the actual operating conditions, ΔP_A, to the design conditions, ΔP_D, for the same flow rate is given by the equation at the beginning of Section 2.

For many situations, the temperature variation is significant only for its effect on density, which is covered in Attachment C. That is the change in the diameter, d, and the diameter ratio, β, do not change significantly due to thermal expansion. Similarly, the discharge coefficient, which is a function of d, β, and Reynolds number (a function of flow, density and viscosity), does not change significantly. When all other terms, except density are considered as constant (all at the design flow rate), the expression for relative error can be expressed as shown below (from Attachment C).

$$\frac{\Delta P_A - \Delta P_C}{\Delta P_C} = \frac{\rho_A}{\rho_C} - 1 = \frac{\frac{1}{v_A}}{\frac{1}{v_C}} - 1 = \frac{v_C}{v_A} - 1$$

This error may also be evaluated by solving the equation in section 2.1 above for the effect of the change in temperature on each of the variables. Where a detailed knowledge of the errors associated with process conditions changes are required the ratio method may not have sufficient detail.

2.3 Flow Variations

The discharge coefficient can vary with flow rate and cause the flow coefficient, k, to vary. As explained above, most commonly used instruments only "know" about design conditions and, therefore, assume that k is constant. The relative error of differential pressure produced by the actual operating conditions, ΔP_A, where the discharge coefficient, C, and therefore, the flow coefficient, k, varies with flow as compared to the differential pressure that would have been produced if the discharge coefficient were constant at the design value. All terms in the flow coefficient, k, except the discharge coefficient are constant and can be factored out. The resulting equation is:

$$\frac{\Delta P_A - \Delta P_D}{\Delta P_D} = \left(\frac{C_D}{C_A}\right)^2 - 1$$

This equation shows that as discharge coefficient rises, the relative error becomes negative. Inspection of the basic flow equation shows that as the actual flow falls (decreases) below the design flow the Reynolds number falls also. From the discharge coefficient formula, it can be seen that as Reynolds number falls (decreases), the discharge coefficient rises (increases) above the value that existed for design flow. Therefore, flows below design flow induce a small negative bias error.

Example

The error due to variation in flow for a 12 inch schedule 80 pipe (id 11.374), with an orifice plate with a bore of 7.2 inches ($\beta = 0.6330$) and flange taps, with a design flow of 8,000 gpm. The temperature of the water is 100°F so μ is 0.66 centipoise and ρ is 61.996 lbm/ft^3. For flange taps the equation for the discharge coefficient is:

$$C = 0.5959 + 0.0312\beta^{2.1} - 0.1840\beta^8 + \frac{0.0900\beta^4}{D(1-\beta^4)} - \frac{0.0337\beta^3}{D} + \frac{91.71\beta^{2.5}}{R_D^{0.75}}$$

Substituting all values except R_D results in:

$$C = 0.5959 + 0.0312 * 0.6330^{2.1} - 0.1840 * 0.6330^{8}$$

$$+ \frac{0.0900 * 0.6330^{4}}{11.374 * (1 - 0.6330^{4})} - \frac{0.0337 * 0.6330^{3}}{11.374} + \frac{91.71 * 0.6330^{2.5}}{R_D^{0.75}}$$

$$C = 0.617484 + \frac{29.23916}{R_D^{0.75}}$$

Substituting all values except flow rate into the equation for Reynolds number results in:

$$R_D = \frac{50.657 * Q * \rho}{\mu * D}$$

$$R_D = \frac{(50.657) * Q * (61.996)}{(0.66) * (11.374)} = 418.4Q$$

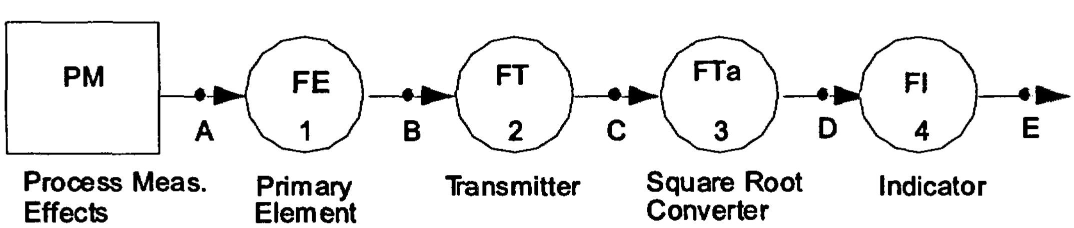
For a design flow rate of 8,000 gpm, the Reynolds number is determined to be 3,347,200 and the discharge coefficient, CD, is determined to be 0.617858. For an actual flow of 1,000 gpm, the Reynold number is determined to be 418,400, and the discharge coefficient, CA, is determined to be 0.619262. Therefore, the relative error is:

$$\frac{\Delta P_A - \Delta P_D}{\Delta P_D} = \left(\frac{C_D}{C_A}\right)^2 - 1 = \left(\frac{0.617858}{0.619262}\right)^2 - 1 = -0.004529$$

This is a -0.453 % error in the differential pressure at a flow rate of 1,000 gpm.

3. FLOW LOOP UNCERTAINTY PROPAGATION

3.1 Non-linear Devices



The loop displayed above has two non-linear conversions, the first a conversion from flow to differential pressure takes place in the flow element. The second non-linear process occurs in the square root extractor. For this loop, the conversion of process errors to differential pressure errors has been covered in the first part of this Attachment. The propagation of the errors associated with flow transmitter (and the converted process errors) is the purpose of this section.

Calculation model errors result from the use of a mathematical model to calculate a variable from measured process variables. These errors may be non-linear over the process range. To ensure that non-linear considerations do not produce non-conservative results in setpoint calculations the following error combination method may be used when a loop contains one or more non-linear devices.

1. Individual device uncertainties are calculated in the same manner as the existing methodology.

2. A total uncertainty for each device would be calculated then the error associated with all the devices on the input side of the non-linear devices would be combined (by SRSS usually) to determine a total uncertainty.

3. The input point of interest value and the input errors are converted to process values (e.g. milliamps).

4. Determine the transfer function for the non-linear device.

5. Using the transfer function substitute the point of interest for the applied value. The output value is the pure signal value.

6. Add the input error values determined above to the point of interest value. Substitute this value for the applied value in the transfer function. Subtract the value from step 5 above from this propagated value. The result is the positive error value.

7. Subtract the input error values determined above to the point of interest value. Substitute this value for the applied value in the transfer function. Subtract the value from step 5 above from this propagated value. The result is the negative error value.

8. The resultant uncertainty would be evaluated via the SRSS method with all the device uncertainties on the output side of the non-linear (or multiple-input device). Since current methodology is to measure errors on the output side of components, the propagated errors would be combined with the This value would be the Total Loop Uncertainty.

Because of the method of error combination used in the formulas, non-linear device errors cannot be made dependent with errors from other loop devices. The errors for the non-linear device must be combined only in the manner specified in the equations. Once the formula has been used and the error on the output side of the non-linear device has been determined the error may then be combined with the errors from the rest of the devices on the output side of the non-linear device.

Example

Determine the Total Loop Uncertainty for the following flow loop at a point of interest of 40 gpm:

DEVICE	DESCRIPTION	INPUT/OUTPUT RANGE	DEVICE UNCERTAINTY
FE	Orifice Plate	0-5000 GPM/0-100 INWC	0.8% of span
FT	Diff. Press. Xmtr.	0-100 INWC/4-20 MA	1.2% of span
I/E	Current to Voltage Converter	4-20 MA/1-5 V	0.7% of span
FY	Square-Root Converter	1-5 V/1-5 V	0.9% of span
FS	Bistable	1-5 V/0-5000 GPM	0.5% of span

Calculate Input Error to non-linear device

The input error to the FY is the SRSS of the FE, FT, and I/E device uncertainties is as follows: Note: this assumes that any process related errors (e.g. flow bases errors) have been propagated through the flow to differential pressure conversion as discussed above.

Input error =

$$e_a = \sqrt{(0.008)^2 + (0.012)^2 + (0.007)^2} = 0.016$$

Calculate Output Error from non-linear device

The transfer function for a square root device is

$$C = K * \sqrt{A}$$
$$e_c = \sqrt{A + e_a} - \sqrt{A}$$

where:

e_c = Output Error from non-linear device in output signal units.
e_a = Input Error to non-linear device in input signal units
A = Point of Interest (input signal in signal units) A in this case is the full transfer function as follows:
C = Output Value for the equivalent value of A
K = Any constant multiplier use to scale the output for the device.

To convert from an input value to an output value and therefore to determine the output error requires that we work with the

$$C = K * \sqrt{\frac{\text{AppliedValue} - \text{InputMinimum}}{\text{InputSpan}}} * \text{Output Span} + \text{Output - Minimum}$$

For this example,

e_a = 1.6 % of square root extractor input span (calculated above)

convert the flow point of interest to signal units

Point of Interest = $(400\ \text{gpm}/5000\text{gpm})^2 * 100$ inwc = 0.64 inwc

This is differential pressure value must be converted to a signal value at the input of the square root converter. Use the scaling vales to determine the input signal at the point of interest.

0.64 inwc/100 inwc span * 16 mA =0.1024 mA
0.1024mA/ 16 mA * 4 volts + 1 volt minimum output span = 1.0256 volts square root extractor input value

Convert the error to signal units

0.016* 4 volts = 0.064 volts

Substituting into the error propagation equation:

True Output =

$$C = \sqrt{\frac{1.0256-1}{4}} * 4+1$$

C = 1.32

Output with error =

$$C = \sqrt{\frac{1.0256+0.064)-1}{4}} * 4+1$$

C = 1.59867

$$C = \sqrt{\frac{1.0256-0.064)-1}{4}} * 4+1$$

$$C = \sqrt{\frac{-0.0384}{4}} * 4+1$$

Note: the propagation of the negative error results in imaginary numbers since the error is actually larger than the signal value. The error associated with the positive side of the propagation is 0.27867/0.32 *100

Therefore the error associated with this point of interest is: over 87% of the actual signal.

Calculate Total Loop Error (TLE)

The TLE is the SRSS of the non-linear device Output Error with the device uncertainties of the devices downstream and the output errors of the non-linear device. For this example, the Bistable and the output of the square root extractor act as the only downstream devices. The span errors are used to determine the total error in signal units.

Therefore:

Convert down stream errors to equivalent volts.

For the square root extractor error is 0.9% of 4 volts = 0.036 volts

For the bistable indication 0.5% of 4 volts = 0.02 volts

Evaluate the error as a fraction of expected signal or pure signal.

$$TLE=\sqrt{(0.2786)^2+(0.036)^2+(0.02)^2}$$

= 0.28163 volts error for a signal value of 0.32 volts. Error is 88 % of the signal value.

TLE = 0.88 * 400 = 352 gpm

Additional methods of calculating the modeling error for non-linear devices may be applied, two example methods are the use of Partial derivatives and perturbation techniques as discussed in Attachment K of Reference 2.1.6. It is acceptable to construct a Monte Carlo model of the loop and perform a statistical analysis of the error based upon the specific transfer function for each loop component.

Modeling error may be ignored for loops where the calibration is performed at the loop trip setpoint, or the point of interest for indicators and the input signal for calibration is on the input side of the non-linear device.

Attachment E: Special Considerations for Radiation Monitors

1. INTRODUCTION

When reduced to its essence, a setpoint calculation is simply an estimate of uncertainty. Protective actions are set to initiate as close to some limit as the total measurement uncertainty will allow. In a conventional instrument loop, this limit is expressed in units of a single process variable (i.e., gpm) for a single known substance (i.e., borated water). The estimated uncertainty is in turn found from relatively well understood environmental effects and other characteristics of the instrument loop which in principle can be measured or compensated for in routine calibrations.

Radiation monitors in stark contrast, respond to a characteristic radiation property, such as photon flux (photons/cm^2-s), in a plant area or effluent stream, while their setpoint limits may be calculated levels of off-site radioactivity (µCi/cc) or dose (rem). The uncertainties which need to be considered in performing radiation monitor setpoint calculations may include factors related to instrument linearity, detector geometry and energy response, source term composition, sample flow, process/vent flow, effluent dilution, and off-site dose assessment. Uncertainties related to processes downstream of the monitor, such as atmospheric diffusion, are beyond the scope of this guide and are assumed to be included in the process limit.

A common setpoint basis for radiation monitors is the detection of any significant radiation above background. From the perspective of this guide, the maximum expected background is a control limit and the positive (U+) uncertainty is applied to arrive at the setpoint. Other applications, such as effluent monitors, are calculated using the negative (U^-) uncertainty is applied to an upper process limit.

The discussion which follows provides guidance for evaluating uncertainty contributors that are largely unique to radiation monitors. Other contributors, generally applicable to all instrument systems, are discussed in the body of this guide and should be evaluated in the setpoint calculation. Response time allowances may be crucial to radiation monitor setpoint determination and the calculation preparer should carefully verify that appropriate allowances are included in the process/analytic limit.

1.1 Combining Uncertainties

The general output equation for digital radiation monitors is of the form:

$$OR = k(IV) = k(R\varepsilon)$$

where:

OR = output reading in engineering units
k = conversion and correction constants
IV = monitor input value

R = radiation variable of interest
ε = detector efficiency

The preferred method is to assume the value of (k) is without error at some reference condition and calculate the uncertainty as a function of (Rε). As can be seen in the following sections, the effective expression has many more terms; however, the basic product form is maintained.

For random, independent effects:

$$\{d(OR)\}^2 = U^2 = \left(\frac{\partial U}{\partial R}\right)^2 (\partial\varepsilon)^2 + \left(\frac{\partial U}{\partial \varepsilon}\right)^2 (\delta R)^2$$

which is more conveniently expressed as the ratio of uncertainty to output as:

$$\left(\frac{U}{OR}\right)_R^2 = \left(\frac{\delta\varepsilon_R}{\varepsilon}\right)^2 + \left(\frac{\delta R_R}{R}\right)^2$$

where:

$\delta\varepsilon$ = uncertainty in detector efficiency
δR = uncertainty in radiation value due to process effects

For systematic (bias) effects, the corresponding expression is:

$$\left(\frac{U}{OR}\right)_B = \frac{\delta\varepsilon_R}{\varepsilon} + \frac{\delta R_B}{R}$$

Unfortunately, unless the effects are small, the nonlinear nature of the monitor transfer function causes this equation to substantially overestimate the bias effects. An alternate approach, which is also consistently conservative but to a lesser extent, is to propagate the effects for each point of interest using the basic response function:

$$\left(\frac{U}{OR}\right) = \frac{\delta(OR)_R + \delta(OR)_B}{OR}$$

$$= \frac{[(R + \delta R_B + \delta R_R)(\varepsilon + \delta\varepsilon_B + \delta\varepsilon_R] - R\varepsilon}{R\varepsilon}$$

2. PROCESS CONSIDERATIONS

Radiation monitors are typically either particle counting systems (cpm) or operate in a current mode (pA) which is proportional to radiation flux, such as neutron fission chambers or gamma

ion chambers. When a setpoint is calculated, the quantity of interest is usually activity concentration (μCi/cc) or exposure (mR/hr). There are conversion factors in the monitor data base which allows the monitor to read directly in the unit of interest. If the conversion is performed digitally, math errors may be neglected.

3. PRIMARY CALIBRATION

When the sensitivity factors are derived from a one-time primary calibration, it can have a profound effect on total measurement uncertainty.

Ideally, a primary calibration would be based upon multiple measurements of mono-energetic, NITS traceable sources, over the complete counting and energy range of several monitors. The sources would be in precisely the same composition and geometry as the intended application. This form of calibration would allow statistical prediction of the mean detector response and tolerance band for the entire population of detectors with a 95% confidence.

Liquid and gaseous effluent monitors, however, are usually calibrated with a small number of nonideal sources which match the monitor geometry, supplemented by solid or liquid sources, which deviate in composition and geometry from the process sample. Relating the supplemental source response to the sample geometry often involves some significant leaps of faith. Particularly with beta detectors, simply multiplying the source response by a constant may introduce substantial error. This is true because the effective solid angle subtended by the detector and the sample self-absorption may not be constant with energy.

Data interpretation can be error prone for noble gas primary calibrations. ^{133}Xe has an average photon energy of 30 keV, however most calibration reports show the measurement plotted at 80 keV, arguing that it is "obvious" that the detector does not respond in the 30-35 keV region. If this assumption is unwarranted, then the low energy portion of the response curve is shifted. ^{85}Kr measurements for gamma detectors are complicated by the possibility that bremsstrahlung from beta emissions may contribute significantly to measured sensitivity, because the gamma abundance is very low.

When the supplemental sources differ substantially in composition from the process sample (i.e., solid for gas), then solid angle and scattering differences may result in both sensitivity errors and an apparent shift in energy.

Often, the primary calibration will attempt to cover the three-decade (0.03 to 3 MeV) energy range with one source in the first decade and one in the last. This lack of data contributes to sometimes severe extrapolation error.

Recognizing that noble gas calibrations using only ^{133}Xe and ^{85}Kr do not provide sufficient data concerning the overall shape of the energy response, some studies have been done using shielding codes such as ISOSHLD or QAD-CG to predict the response of the monitor. Due to a variety of effects, these codes are not accurate below 200 keV. This form of modeling contributes
an additional component to the extrapolation error.

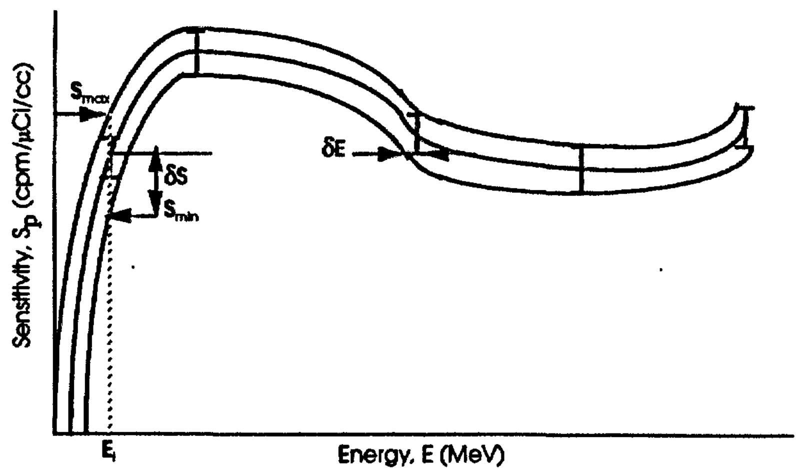


Figure 1: Hypothetical Primary Calibration Results

All measurements may have been performed on a single "prototype" monitor. As a consequence, the user has no measure of reproducibility and may be basing the monitor calibration upon an atypical sample. This, plus the fact that the calibration for all monitors will reflect any uncertainties in the primary calibration, indicates that those uncertainties be included in the setpoint calculation as additional terms.

The source concentration uncertainty and the counting uncertainty are normally evaluated explicitly in the primary calibration report. However, many of the other factors may only be inferred. As can be seen from **Figure 1**, the factors which cause an apparent energy shift are significant only when the sensitivity is rapidly changing usually at low energies. A method which is consistent with the uncertainties involved, is to estimate the magnitude of the effects at each energy of interest and graphically combine them as shown in **Figure 1**.

Much of this uncertainty may be avoided for normal effluents by routinely calibrating the monitor with dilute samples from primary coolant or waste gas holdup tanks. Under those conditions, the source term sensitivity is found by direct comparison to laboratory analysis, and the primary/transfer calibration uncertainties may be neglected. Since an accident source term would bear no simple relationship to normal effluents, NUREG-737 high range monitors must be calibrated using data from the primary calibration.

- **Transfer Calibration**

In order to avoid the complexity of liquid or gaseous calibrations, most sites use a secondary or tertiary set of solid sources. The source uncertainty and counting uncertainty involved in making the comparison between the prototype monitor and the final set of transfer sources are the obvious contributors. Additionally, the results for one monitor do not apply without uncertainty to any other monitor.

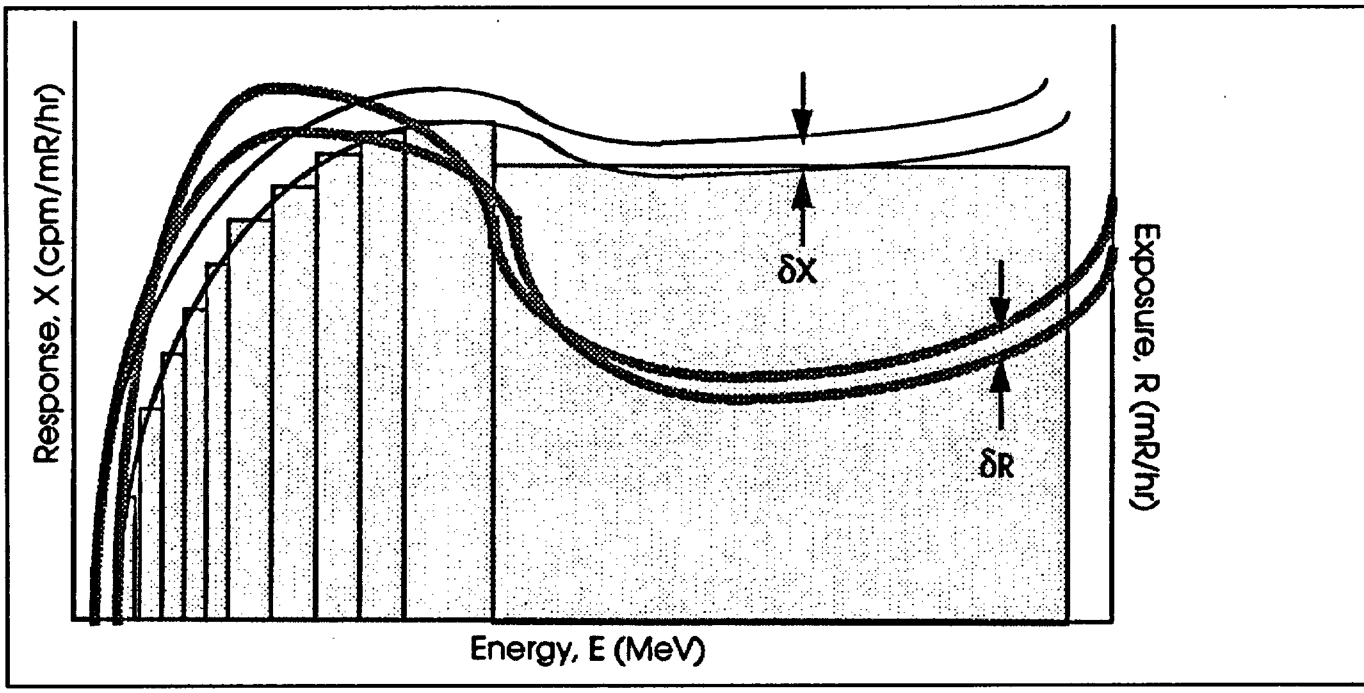
Off-line monitors experience a variety of effects which reduce the concentration of activity at the monitor. Leakage may cause the sample to be diluted, however, except under accident conditions, this effect should be negligible. Plateout, settling, and gas adsorption may cause buildup in the sample line. These factors may be estimates or measurements for specific operating conditions. Over the expected range of operating conditions, these factors are subject to large systematic variations. If the sample chamber is operating at a vacuum, then gas expansion would cause an error in concentration (or mass flow).

4. AREA TYPE MONITORS

As noted above, the typical radiation detector responds to the flux of particles reaching it. Scintillation counters respond more or less directly to betas and photons as they are absorbed. G-M tubes on the other hand respond to the secondary emission of electrons from the tube wall so that the gamma response (cpm or current) is roughly proportional to energy fluence (MeV-cm^2/s), which makes them well suited to area monitors calibrated in mR/hr.

If the composition of the source term is unknown but the energy distribution is known, then the uncertainty in the energy of the sample may be used to calculate the energy-dependent uncertainty in the output. **Figure 2** illustrates the hypothetical response for an area detector, superimposed on 11 energy groups along with a hypothetical exposure distribution.

Figure 2: Energy Group Analysis



Unlike the process sampling monitors, the area monitors are routinely calibrated using a source which is calibrated directly in mR/hr. Consequently the conversion factor may be readjusted to compensate for systematic sample to sample variations in the sensitivity at one energy (usually 661 keV).

Another example of this case would be a G-M tube post-accident monitor, when the expected source term energy is a function of time after an accident generated by a shielding code. If such a detector is calibrated in energy adjusted units, such as µCi-MeV/cc, ^{133}Xe-Equivalent µCi/cc, or Bq-MeV/cc, then this source of error is at least partially compensated, since the sensitivity is more nearly constant at each energy.

5. INSTRUMENT UNCERTAINTIES

5.1 Dead Time Uncertainty

Modern radiation counting systems generally have dead time characteristics approximated by the so called "nonparalysable" model:

$$n = \frac{m}{1 - m\tau}$$

where:

n = true interaction rate
m = observed count rate
τ = dead time

The count rate may be thought to be reduced by a variable factor (M_τ):

$$M_\tau = \frac{m}{n} = 1 - m\tau$$

If this effect is not corrected, it is a pure negative error term, which is predictable and consequently must be treated as a bias.

5.2 Efficiency Uncertainties

Drift (DR), accuracy or calibration effect (CA), voltage effect (VE), and the environmental effects all contribute to the uncertainty in instrument efficiency (or sensitivity). Humidity, IR loss, radiation effects and atmospheric pressure may all contribute significant uncertainties; however, for most applications, these factors may be neglected for normal conditions. Efficiency should be defined in the same terms as the efficiency measured during calibration.

5.2.1 Effective Accuracy

The effective accuracy for inclusion in setpoint calculations should generally be the calibration tolerance combined with the testing uncertainties. If the conversion factor is adjusted to match the measured efficiency, the uncertainty is simply the counting uncertainty and calibration source tolerance, neglecting the calibration tolerance.

5.2.2 Drift

Few manufacturers of radiation detectors specify long-term drift (DR), consequently the recommended source for drift information is the as-found/as-left surveillance data. Such data would also include the cumulative effects of radiation and other environmental factors.

5.2.3 Gain Uncertainty

For scintillation detectors, the discriminator threshold and amplifier gain may not be set to match the prototype monitor. This error (δG) may cause significant uncertainties at low energies, unless the calibration procedure includes verification of the threshold setting energy. The system gain is also a predictable function of temperature and high voltage fluctuations.

Scintillation detectors typically have a negative temperature effect, bounded by roughly -10 to -20% per 50°F.

Typically, the detector high voltage is adjusted at one energy such that the counting efficiency is on a "plateau", with a positive slope of from 5 to 10% per 100 V. At lower energies, the slope may be much more severe, and a change in voltage will cause a proportionally larger change in efficiency.

The temperature (TE) and voltage effects (VE) are complex functions, depending upon scintillation material, PM tube construction, and preamplifier design. Both factors are related to the threshold setting and gain error (δG).

For G-M tube detectors, the threshold has negligible effect on efficiency and the voltage effect may be estimated directly from the plateau slope. Temperature effect may be calculated directly from the resulting specific ionization changes inside the G-M tube[6]; however, for temperature swings normally encountered, the total effect is approximately 1% and may be estimated.

Preferably, the overall stability of the detector system should be obtained from vendor testing. Alternately, the effects may be calculated from published data[7]. Unless the detector is servo gain stabilized, these effects are biases or abnormally distributed.

6. TOTAL UNCERTAINTY

There is no single expression for total uncertainty that applies to all radiation monitors. The preceding equations are suggestive of how the individual effects may be evaluated. The specific form of the total uncertainty equation depends upon the analyst's evaluation of which effects are bias terms and which are random. If the effects are large (more typical), then the most reliable method available would be to evaluate the random effects using SRSS, and propagate random and bias uncertainties together using the response function.

For the typical monitor which is set as close to background as practical, a statistical evaluation of actual response may be all that is necessary.

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[6]W. J. Price, *Nuclear Radiation Detection*, 2nd Edition, McGraw-Hill, 1958.

[7]J. B. Birks, *The Theory and Practice of Scintillation Counting*, Pergamon Press, 1964.

Particular mention should be made of the Vermont Yankee main steam line monitors, which have been assigned in an allowable value of 3.6 times background, and a nominal setpoint of 3.0 times background by most BWR plants, entirely by precedent and regulatory approval, since there is no analytical limit associated with this channel in the safety analysis.

Attachment F: Statistical Considerations

There are two terms that will be used extensively in statistical discussion, these are confidence and proportion. The proportion of an occurrence is based on the frequency distribution. The frequency distribution defines how often a given event will have a specific outcome. Given a coin toss how often will the coin land heads up? The second term is confidence. The level of confidence is based on the size of the sample used to determine the frequency distribution. There is less confidence in the measurement if 5 coin tosses are used instead of 500 to determine a frequency distribution. For the purposes of the design guide a short hand term will be used for the discussion of statistical characteristics. This short hand is confidence/ proportion. The short hand 95/75 means we have a 95 percent confidence that at least 75 percent of the events will fall within our projected distribution. Proportion can be picked from a histogram or frequency distribution, confidence is based on the size of the sample set compared to the total population. The term confidence interval as used in this Attachment refers to the confidence and proportion as an integral value (e.g. 95/95) is a confidence interval.

1. COMBINING UNCERTAINTIES WITH DIFFERENT LEVELS OF CONFIDENCE INTERVAL

Equipment vendors usually provide uncertainty data that may be assumed to reflect at least a 95% confidence interval or a two standard deviation (2-sigma or 2σ) value. The uncertainty estimate resulting from combining the random terms by SRSS will reflect the least conservative statistical characteristics of the included terms. In other words, if all the terms except one are 3σ values (99.7% confidence interval) and that one is a 2σ value (~95% confidence interval), then the uncertainty estimate will be a 2σ value. For conservatism, it shall be assumed that published vendor specifications are no better than 2σ values unless specific information is available to indicate otherwise.

If there is **very strong evidence** that a particular error specification represents a higher confidence level, the individual preparing an uncertainty calculation may adjust that specification to be consistent with other uncertainty elements. This evidence should be equivalent to one or more of the following:

1. Manufacturer's testing data, demonstrating the statistical distribution and confidence interval.

2. Documented vendor statement of the confidence interval.

3. Third party or plant data demonstrating a minimum tolerance interval corresponding to the specification, which is at least 99/95 (see next section).

Table 1 in the following section, shows the K multipliers for a two-sided distribution for various proportions of the population. If the uncertainty is being determined using confidence interval values for a normal distribution, then a 99% confidence interval (2.58σ) uncertainty value may be multiplied by 1.96/2.58 = 0.760 to approximate the 95% (1.96σ) confidence interval value.

The combination with other error limits would yield an overall uncertainty calculation with a 95% confidence interval.

2. SINGLE SIDED DISTRIBUTIONS

For nearly all setpoints, interest is only in the possibility that a single value of the process parameter is not exceeded, and the single value is approached only from one direction. A good example of such a process parameter is reactor vessel low-low level. The analytical limit is a single value near the top of active fuel. It is approached only from the direction of decreasing level. In this case, the uncertainty of particular interest is unidirectional, and is the largest positive limit for errors that encompasses 95% of the population of instruments.

As generally calculated here and in ISA-RP67.04 Part II uncertainty is bidirectional, describing the limits in either direction, which encompass a particular confidence interval, for instance, 95% of a population of instruments, **around the mean.** In situations where it can be proven that the protection point is only approached from one side, accounting for a one-sided area of interest may reduce the magnitude of the random uncertainty component. In such a case, the random uncertainty may be reduced by a factor J/K, where the quantities J and K are distances from the mean, in standard deviations, for one- and two-tailed tests, respectively, to insure that a particular portion of the proportion is included. Values of J and K are shown in **Table 1** for representative confidence intervals [Ref. 6.1].

Nearly all-single input, bistable setpoints could fit into this category; however, for general indication and measurement, the two-tailed limits are appropriate. To avoid confusion among the users of uncertainty information, this adjustment generally should not be made unless needed to prevent operational impact.

Table 1: Proportion Factors for One and Two Sided Uncertainties

Proportion	One-Sided (J)	Two-Sided (K)
75%	0.68	1.15
90%	1.29	1.65
95%	1.65	1.96
99%	2.33	2.58

3. DEPENDENCY

Dependent errors can exist when there is an interaction between two or more effects. Those interactions could be intradevice (multiple effects acting on one instrument) or inter-device (an effect causing an interaction between devices). A combination of dependent effects is generally

assumed to have greater uncertainty than independent effects; though, theoretically the uncertainty could be smaller. Dependency is only a consideration when errors are not random and normally distributed.

3.1 Intra-device Dependency

Intra-device dependency exists when the effect of multiple external factors applied simultaneously is different from when the factors are applied individually and then combined analytically without consideration of any interaction.

An example of where an intra-device dependency might exist is that between temperature and pressure for a pressure transmitter using a bellows with a fill fluid. For a given plant event the pressure and temperature increase in a dependent manner (i.e. due to the single initiating event both pressure and temperature increase). The increased pressure caused a force on the outside of the measuring bellows. The increased temperature causes a change in the density of the fluid used to fill the bellows. In this case both errors are directional and possible have a specific linear relationship between the change and the error. Since a single event causes the increase in pressure and temperature and these changes both cause non-random changes in the device output, a dependency exists between the errors. Where non-normally distributed random errors are present dependency must be evaluated.

3.2 Inter-device Dependency

Inter-device dependency is of concern when a given change in some external factor, which affects two or more instruments (e.g., power supply voltage or temperature), may results in a larger error than when they were tested individually and then combined without concern for a common interaction. In general, there are only three mechanisms by which interaction can occur. The first is via the intended signal between the instruments. The second is via a common environment. And the third is via a common power supply.

As an example two switches are used to measure the difference in inlet and outlet pressure for a pump and display a pump differential pressure. If each switch has a temperature error which is a bias, then any temperature change would create a dependent error for the differential pressure measurement based on the bias change for each switch. Dependent errors will be treated, as bias or error combination by other than SRSS will be used.

4. DRIFT EVALUATIONS

A detailed summary is provided in each drift calculation describing the results of that analysis. The summary provided in the associated drift analysis should be included (all or in part) within the setpoint calculation. The Vermont Yankee drift calculations provide two-sided and one-sided

tolerance intervals where appropriate. The drift calculation values may be reduce to lesser confidence interval values in accordance with Table 1. For all other conditions values should be selected directly from the drift calculation. There shall be no interpretation of time dependence or drift value outside of the drift calculation with the exception of confidence interval adjustment.

Attachment G: Abnormal and Uniform Uncertainty Distributions

Not all random uncertainties are described by the gaussian or normal distribution. Possible theoretical distributions include the poisson, binomial, lagrangian, bi-modal, and the subject of this discussion, the uniform or rectangular distribution.

The uniform distribution is important because many uncertainty terms may be recognizably random but not understood in sufficient detail to rigorously establish 95/95 tolerance intervals using an underlying assumption of normality. In particular, for estimated uncertainties, only the upper bound for the magnitude of uncertainty is known, the frequency distribution remains unknown. However, it is often reasonable to assume that any uncertainty between the assumed plus and minus limits is equally probable, which describes the uniform distribution.

All the discussion which follows is based upon Chapter 4 of Uncertainty, Calibration and Probability, Second Edition, by C. F. Dietrich. **Figure 1** illustrates the proportion density function of a uniform distribution with a semi-range of ±h about the mean value (μ_x) of the random variable, x.

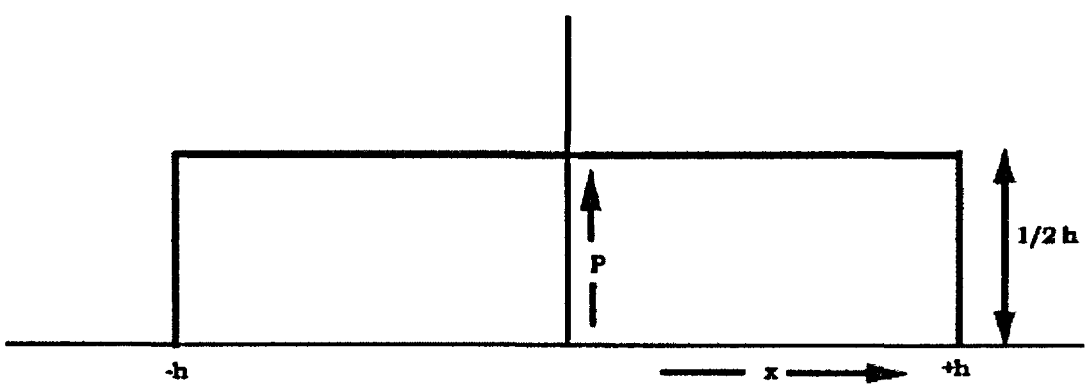

Figure 1: Uniform Distribution, Range = ±h

Since the area under a proportion distribution must be unity (1), the height of the rectangle must be equal to $\frac{1}{2h}$. For the uniform distribution, the standard deviation (σ_u) is:

$$\sigma_u^2 = \int_{-h}^{h} x^2 P dx = \frac{h^2}{3}$$

$$\sigma_u = \frac{h}{\sqrt{3}}$$

The proportion of an uncertainty lying between the limits of $\pm\ \sigma_u$, for the uniform distribution, is $1/\sqrt{3}$ = 0.5770, which means that the interval $\pm 2\sigma_u$ exceeds the range of the entire distribution and the chance that the uncertainty lies outside the range of $-2\sigma_u$ to $+2\sigma_u$ is zero. Dietrich has exhaustively evaluated the combination of uniform (rectangular) distributions with other uniform distributions and with normal distributions. The results of these evaluations are summarized below (from Table 4.68, Uncertainty, Calibration and Probability).

Type of Distribution	Probability of an Error Outside 2σ or 3σ	
	-2σ to +2σ	-3σ to +3σ
Uniform (rectangular)	0.00%	0.00%
Combination of 2 similar uniform distributions	3.37%	0.00%
Combination of 3 similar uniform distributions	4.17%	0.00%
Combination of 3 uniform distributions, standard deviations in ratio 3:2:1	3.29%	0.00%
Combination of 3 uniform distributions, standard deviations in ratio 3:1.5:1	2.87%	0.00%
Combination of 4 equal uniform distributions	4.20%	0.07%
Combination of 1 uniform distribution with 1 normal distribution of equal standard deviation	4.01%	
Combination of 1 uniform distribution with 1 normal distribution of 1/5 the standard deviation of the uniform distribution	0.36%	
Normal (Gaussian) distribution	4.55%	0.27%

Quoting from Dietrich:

> "The most important point to notice about the results is that the probabilities of an uncertainty outside either ±2σ or ±3σ are greater for a Gaussian distribution than for any of the combinations. This is a highly important point since it means that if we combine rectangular distributions both with themselves or with Gaussian distributions, we can always be sure that the probability of an uncertainty greater than ±2σ, ±3σ, etc., is always less than in the corresponding Gaussian case, and that the true probability will in general not be much less than the Gaussian one."

For the purposes of this guide, any random uncertainty, which is bounded by a uniform distribution of semi-range, h, may be combined with normally distributed uncertainties using SRSS and a uncertainty value (u_U) equal to:

$$u_u = \pm 2\sigma_u = \pm \frac{2h}{\sqrt{3}}$$

The principal caution to applying this rule is that the distribution cannot be bi-modal, that is the errors cannot cluster around the limits with very few cases near the mean, such as would be the case if the system were operated in one of two modes, with neither predominating, but the errors being mostly positive in one mode and mostly negative in the other.

1. UNCERTAINTIES WITH ESTIMATED LIMITS, DISTRIBUTION UNKNOWN

In many cases, for environmental error influences particularly, the uncertainty distribution is not known, only the upper and lower limits are available either by design or estimate. The ISA-RP67.04 Part II position is that in these cases, the resulting uncertainties are to be treated as biases. The methodology described by this guide generally follows this recommendation, which is intended to avoid underestimating the contribution of estimated uncertainties to the total loop uncertainty, by inappropriately combining non-normally distributed errors with normally distributed terms using the SRSS method. However, this approach may be overly conservative for some cases. This guide allows treatment of certain estimated uncertainties as uniform distributions, which satisfy the following criteria:

1.1. The uncertainty is a random effect or a systematic effect of an influence which is itself a random variable.

1.2. For the random influence variable under the specific operating conditions considered, either:

1.2.1. Is equally likely to assume any value within certain known limits or,

1.2.2. Is typically found near a single nominal operating point.

1.3. The random influence variable is symmetrically distributed around its mean value.

An example of such a case would be the process measurement uncertainty (PM) for reactor vessel level under normal operating conditions, as described in Attachment C. This effect is systematically related to liquid density, which is in turn dependent upon vessel pressure, vessel temperature, drywell temperature, and Reactor Building temperature. Since the vessel is at saturation, vessel density follows pressure, which during normal operations is held very close to 1020 psia. The drywell and Reactor Building temperatures fluctuate daily, seasonally and also in

response to varying heat loads in the buildings. The net result is that fluid densities in the measurement system fluctuate randomly around the mean, but not demonstrably according to a normal distribution. In this case, it would be appropriate to assume the PM_n uncertainty is a uniformly distributed, random variable.

Such is not the case for the same system during an accident. For a LOCA, reactor pressure falls predictably in response to the loss of coolant, eventually stabilizing at a new value depending upon the size of the break. Consequently, the vessel and sense line liquid densities would all decrease, at the limit resulting in a predictable error. In this case, the criteria for randomness are not satisfied and PM_a should be treated as a bias.

2. UNCERTAINTIES WITH KNOWN ABNORMAL DISTRIBUTION

For uncertainties which, as a result of statistical analysis, such as a drift study, are found to be abnormally distributed, but bounded by a uniform distribution, then the uncertainty may be treated as a uniform distribution and combined with other uncertainties using the SRSS method. The bounding distribution is not that which has the same sample standard deviation as the sample studied, but rather has the same semi-range from the mean as the most extreme (non-outlier) measurement.

Example

In a transmitter drift study, the mean analyzed drift is found to be 0.1% CS, the most positive drift value in the study sample is +1.4% CS, most negative is -0.9%. The sample distribution is not covered by a normal distribution of the same standard deviation. Neglecting the 0.1% mean offset from zero, the bounding rectangular distribution has a semi-range of ±1.4% and the effective uncertainty is:

ATTACHMENT H: IST Accuracy Calculation and Calibration Requirements.

In-Service Testing (IST) is intended to monitor degradation of components. The ASME Code does not require that pumps be tested at design basis conditions. Many plants use the ASME test to verify compliance with the ASME Code and the pump design basis requirements contained in the plant design basis documentation such as the FSAR. In this case, additional plant design basis accuracy considerations need to be properly integrated into surveillance test procedure acceptance criteria.

Instrument accuracy and full scale range limits are important to ensure that pump in-service testing obtains measurements that permits the detection of pump degradation. It is important to detect pump degradation during in-service testing so a pump with significant degradation can be repaired prior to the pump degrading to the point where there is the likelihood that it will not be capable of performing its safety function if called upon to do so to mitigate the consequences of an accident.

Instrument inaccuracy results in uncertainty in the test measurements. This uncertainty could result in a scatter of data which could be sufficient to mask changes in pump capability that is indicative of degradation. This could result in false positive results. To minimize the potential for false positive results ASME Section XI established criteria for testing instrumentation.

ASME Section XI (1989 Edition, OM-1987/OMa-1988 Addenda) requires testing to assess the operational readiness of selected centrifugal and positive displacement pumps. Testing criteria uses reference values established at points of operation readily duplicated during subsequent tests. All subsequent tests are compared to the initial reference values to monitor degradation. Deviations detected are symptoms of changes and, depending upon the degree of deviation, indicate need for further tests or corrective action. The instrumentation relied on to evaluate degradation is intended to be good commercial grade quality that are repeatable from one test to the next. The ASME OMa-1988 Addenda to the OM-1987 Code (Part 6) provides the acceptance criteria for instrumentation to be used in this application.

1. Accuracy: Per Section 4.6.1, "Instrumentation" refers to station instruments used to trend and predict pump degradation and must have an accuracy as stipulated in Table 1 as noted below:

Parameter	Accuracy - Percent Full Scale8
Pressure	±2%
Flow Rate	±2%
Speed	±2%
Vibration	±5%
Differential Pressure	±2%

8 Percent full scale for individual analog, percent total loop accuracy for a combination of instruments, or the calibrated range for digital instruments. Flow elements are not included in the flow rate accuracy determination.

2. Range:

   a. The full scale range of each analog device shall be ≤3-times the reference value. Reference values are established from the preservice testing or the first inservice test.

   b. When digital instrumentation is used, the reference value shall be ≤70% of the calibrated range.

3. Measurement:

   a. Static head based on a filled sensing line (or based on a voided sensing line) where the absence or presence of fluid could impact a pressure reading by more than 0.25% must be considered. The consideration could be that verification of the appropriate static head be made.

   b. A differential pressure sensor should be used when monitoring pressure difference across a pump (although this is not specifically required by the Code). If two separate pressure gauges are used instead (one at the suction side and one at the discharge side) to determine differential pressure, the accuracy of each gauge should be Root-Sum-Squared (RSS) to determine "loop" accuracy (the Code implies that only the individual pressure gauge accuracy needs to be considered; the RSS approach is a more conservative position and viewed as appropriate).

The criteria established assumes that conditions are repeatable from one test and the next. As such, applying a full instrument uncertainty analysis in accordance with ISA SP67.04 does not apply. OMa-1988, Part 6, Table 1 only considers instrument accuracy and does not take into account attributes such as orifice plate tolerance, tap locations, and process temperature (also refer to NUREG 1482 Section 5.5.4). ASME/ANSI OMa -1988, Part 6, Section 1.3 defines instrument accuracy as the allowable inaccuracy of an instrument loop based on the square root of the sum of the square of the inaccuracies of each instrument or component in the loop. Alternatively, the allowable inaccuracy of an instrument loop may be based on the output for a known input into the instrument loop. Accuracy is based on full scale range. Note that if the surveillance test includes the design basis criteria, than additional instrument uncertainty needs to be applied; design basis surveillance will be addressed as a separate subject.

Per Section 4.6.1.4, instruments shall be calibrated in accordance with the Owner's QA program. New or repaired instruments shall be calibrated before test use. Based on this, a calibration of test instruments is not required prior to each test (unless repaired or replaced) and instrument drift is not a required consideration.

It is anticipated that there will be gradual differences from one test and the next due to changes in performance. The differences are anticipated to be within predicted bounds. If there are deviations in the direction of degradation (or in the opposite direction) which are higher than predicted, then an evaluation of the instrumentation and the parameter being measured is warranted before determining operability.

Unless the cause of the excessive deviation is obvious, a calibration of the instrumentation loop should be performed. A comparison of the "as left" with the "as found" calibration data will determine instrument drift. If large enough, the instrument drift could be the major contributor to the excessive results. A successful retest would validate this conclusion. Other parameters which could cause the measurement system to provide excessive results are extreme differences from one test and the next of:

- Ambient temperature (electronic instrumentation)
- Process temperature (flow)

Example:

Pump differential pressure (DP) is monitored in the control room. An analog DP transmitter and an analog indicator are used. Reference value is 120 psid. IST on pump DP is performed quarterly; this is the third quarter test. The transmitter is connected to the process via filled impulse lines. The transmitter is located 10-feet below the process taps. The process taps are located at the pump discharge and suction along the horizontal plane. Instrument loop calibrations are performed yearly. The instrument component accuracy specifications are as follows:

Full scale range:	200 psid
Transmitter:	±0.5% of full scale range (Manufacturer's published data)
Indicator:	±2.0% of full scale range (Manufacturer's published data)
RSS Method:	$\pm(0.5\%^2 + 2.0\%^2)^{1/2} = \pm 2.06\%$ of full scale
Loop cal method:	Input pressure using highly accurate M&TE and reading output from board indicator. If an input pressure of 120 psid reads at the indictor 122 psid, then the full scale loop accuracy is 1%.

Evaluation:

1. The criteria of Table 1 is 2% of full scale. The calculated loop accuracy is ±2.05% of full scale. Therefore, the primary method of determining accuracy criteria is not satisfied. However, an alternative approach yields an acceptable full scale accuracy of 1%.

2. The transmitter is located below the process line and the tap is center of the pipe. It is maintained filled by gravity. Therefore, no additional considerations are needed.

3. A single pressure differential monitoring device is used.

4. Calibration has been performed within the past year.

5. The reference value is 120 psid. The full scale range is 200 psig. The full scale range is <3 times reference.

Therefore, use of this loop is acceptable for IST.

If a loop calibration is not available, an evaluation of component drift can be applied. In this case, the accuracy component would be considered to be fully representative by the drift evaluation results. When drift is used, it should be evaluated as a Class 3 setpoint and apply the 95%/75% criteria (95% probability with a 75% confidence level). This applies providing the calibration is performed in the direction of interest. Specifically, if the degradation is anticipated to trend in the decreasing direction, then the calibration must include a verification in the decreasing direction. However, it is preferable that the calibration be both in the increasing and decreasing direction.

ATTACHMENT I: Instrument Cross Comparison Averaging Methodology

The difference between a parameters actual (true) value and the value indicated to the operator is the instrument uncertainty associated with the loop. When the same parameter is being monitored by multiple loops, the outputs can be combined together to provide an average reading of the parameter

It stands to reason that the more independent readings provided for a given parameter that are averaged together the averaged loop uncertainty will diminish, For example:

> Taken to an extreme, a thousand instrument loops monitor the same temperature parameter. Each instrument loop exhibits and uncertainty of ± 4° F. This uncertainty is random in nature and at any time can be positive (+) or negative (-). Taken alone, each loop would be considered to be accurate to within ± 4°F. However, when the accuracy component of all 1000 instrument loops are average together, the random nature of this variation will essentially result in a negligible uncertainty.

This approach can be applied anytime a variable has multiple readings that are averaged to provide a single value. It must be recognized that as the number of independent readings decreases, the value of the uncertainty increases. The uncertainties are not averaged together in a true Average nor is the uncertainty halved as the monitoring points double. Instead, a nonlinear approach is applied. A comparison of the techniques discussed follows:

Two temperature readings of the same variable; each loop has an uncertainty of ± 5°F:

1. Adding uncertainties arithmetically:
   Total uncertainty = ± (5°F+5°F) = ± 10°F

2. Averaging uncertainties linearly:
   Total uncertainty = ± (5°F+5°F)/2 = ± 5°F

3. Averaging uncertainties linearly then dividing the square of the number of loops:
   Total uncertainty = $\pm (5°F+5°F)/2^2 = \pm 2.5°F$

4. Averaging uncertainties non-linearly:
   Total uncertainty = $\pm (5^{2o}F+5^{2o}F)^{1/2}/2 = \pm 3.54°F$

Extending the above example to include three temperature readings of the same variable; each again with an uncertainties of ± 5°F:

1. Adding uncertainties arithmetically:
   Total uncertainty = ± (5°F+5°F+5°F) = ± 15°F

2. Averaging uncertainties linearly:
   Total uncertainty = $\pm$ (5°F+5°F+5°F)/3 = $\pm$ 5°F
3. Averaging uncertainties linearly then dividing the square of the number of loops:
   Total uncertainty = $\pm$ (5°F+5°F+5°F)/3^2 = $\pm$ 1.7°F

4. Averaging uncertainties non-linearly:
   Total uncertainty = $\pm$ (5^{2o}F+5^{2o}F+5^{2o}F)$^{1/2}$/3 = $\pm$ 2.3°F

Options 3 & 4 both provide a method that supports the premise that as the sampling points increase the uncertainty contribution decreases. Option 3 is basically obtaining the average of the uncertainty of all the loops and then dividing the averaged uncertainty by the number of loops, or:

Total Uncertainty =$\pm$ (5°F+5°F+5°F)/3 = $\pm$ 5°F/3 = $\pm$ 1.7°F

However, the non-linear averaging technique (option 4) is a more conservative method. Taken to an extreme, the non-linear averaging performs as follows:

- 1 Sampling Point: Total Uncertainty = $\pm$ (1 * 5^{2o}F)$^{1/2}$/1 = $\pm$ 5°F
- 2 Sampling Points: Total Uncertainty = $\pm$ (2 * 5^{2o}F)$^{1/2}$/2 = $\pm$ 3.54°F
- 5 Sampling Points: Total Uncertainty = $\pm$ (5 * 5^{2o}F)$^{1/2}$/5 = $\pm$ 2.2°F
- 10 Sampling Points: Total Uncertainty = $\pm$ (10 * 5^{2o}F)$^{1/2}$/10 = $\pm$ 1.6°F
- 25 Sampling Points: Total Uncertainty = $\pm$ (25 * 5^{2o}F)$^{1/2}$/25 = $\pm$ 1.0°F
- 50 Sampling Points: Total Uncertainty = $\pm$ (50 * 5^{2o}F)$^{1/2}$/50 = $\pm$ 0.71°F
- 100 Sampling Points: Total Uncertainty = $\pm$ (100 * 5^{2o}F)$^{1/2}$/100 = $\pm$ 0.5°F
- 500 Sampling Points: Total Uncertainty = $\pm$ (500 * 5^{2o}F)$^{1/2}$/500 = $\pm$ 0..22°F
- 1000 Sampling Points: Total Uncertainty = $\pm$ (1000 * 5^{2o}F)$^{1/2}$/1000 = $\pm$ 0.16°F
- 10000 Sampling Points: Total Uncertainty = $\pm$ (10000 * 5^{2o}F)$^{1/2}$/10000 = $\pm$ 0.05°F

As is evident, the uncertainty approaches zero but can never reach it. The mathematical model for non-linear averaging is:

Non-linear Average = $\pm$ ($A1^2$ + $A2^2$ + AN^2)$^{1/2}$ /BN = $\pm$ C

Where: A1, A2, AN	=	Individual loop uncertainty
BN	=	Total number of loops monitoring the parameter
C	=	Average uncertainty

This same non-linear average would also be used to perform channel checks. For comparison of two different channels the two sample point calculation would be used to determine the maximum value of the difference between the two indications or recordings. The total loop uncertainty associated with the indications should be used. Where channel checks between multiple channels will be performed the difference between any two readings is defined as above, however the difference between multiple channels would be calculated based on the total number of channels evaluated.

ATTACHMENT J: Instrument Uncertainty and Performance Monitoring

There are several considerations when analyzing instrument uncertainty in regards performance monitoring.

1. Technical Specifications: Surveillance tests are required to validate operability of selected components.

2. Component Protection: Limiting conditions are identified which must be satisfied to ensure damage does not occur to components.

3. Analysis: Values (analytical limits) that are used in safety related analysis.

   Unless stipulated otherwise, the values are absolute limits, i.e., "not to be exceeded". These limits are not nominal values. The limits apply to both manual and automatic functions. Automatic functions are evaluated as setpoints and are addresses in detail in the Vermont Yankee Setpoint and Uncertainty Design Guide.

   Manual functions, such as Core Spray pump flow surveillance, rely on monitoring instrumentation to determine performance characteristics. The monitoring instrumentation inherently includes an accuracy component, which can cause the information presented to the operator to be erroneous, i.e., instrument uncertainty. To ensure limits are not exceeded, the acceptable value must consider instrument uncertainty.

   The following guidance will apply:

   1. Custom Technical Specifications (CTS): Limits identified in CTS apply during normal plant operation. Therefore, only normal operating parameters need to be considered. These limits fall into two categories:

      a. Limits associated with parameters used in safety related analysis, and
      b. Limits that are not associated with safety related analysis.

      When a parameter is used in a safety related analysis, the CTS operability test (surveillance test) verifies that the component will perform in a manner that will support assumptions of the analysis. However, the bases for the CTS values is that as long as the plant operates within those limits during normal operation, the components will perform as required when exposed to abnormal conditions.

      If a CTS parameter limit is also used in a safety related analysis, the instrument uncertainty evaluation will require a high degree of rigor. In this case, the uncertainty analysis would be evaluated as a Class 1 setpoint (95% probability that the true parameter value is validated by the surveillance test wit a 95% confidence).

      If the CTS parameter limit is *not* used in a safety related analysis, the instrument uncertainty

evaluation does not require as high a degree of rigor. In this case, the uncertainty analysis would be evaluated as a Class 3 setpoint (75% probability that the true parameter value is validated by the surveillance test with a confidence of 95%).

When not sure, the higher level of rigor should be applied. In addition, manufacturer's data is typically provided as 2 sigma (95%) probabillity. If only manufacturer's data is available, the 95%/95% criteria would have to be applied in either case. In all cases, the uncertainty analysis is to be prepared in accordance with ISA S67.04.

Example #1:

CTS require Core Spray pump surveillance. The CTS limit is 22700 gpm flow at a discharge pressure of ≤90 psig. Core Spray flow is a parameter used in a safety related analysis. The Analytical Limit is 2300 gpm at a discharge pressure of 80 psig.

a. A 95%/95% uncertainty analysis is required. Assume an indicated flow uncertainty of +200 gpm and an indicated pressure uncertainty of +7.5 psig.

b. To ensure an actual flow of 22700 gpm, the surveillance criteria must account for the 200 gpm uncertainty in the indicated reading. Therefore, the acceptance criteria must be 22900 gpm.

c. To ensure an actual pressure ≤90 psig, the surveillance criteria must account for the 7.5 psig uncertainty in the indicated reading. Therefore, the acceptance criteria must be ≤82.5 psig.

This approach ensures the Analytical Limit is not compromised. By proving the pump is operable during normal plant conditions, the pumps will be capable of providing the flow assumed in the analysis.

Example #2:

CTS require Core Spray pump surveillance. The CTS limit is 22700 gpm flow at a discharge pressure of ≤90 psig. Core Spray flow is *not* a parameter used in a safety related analysis.

a. A 95%/75% uncertainty analysis is required. Assume an indicated flow uncertainty of ±150 gpm and an indicated pressure uncertainty of ±5.0 psig.

b. To ensure an actual flow of 22700 gpm, the surveillance criteria must account for the 150 gpm uncertainty in the indicated reading. Therefore, the acceptance criteria must be 2850 gpm.

c. To ensure an actual pressure ≤90 psig, the surveillance criteria must account for the 5.0 psig uncertainty in the indicated reading. Therefore, the acceptance criteria must be <85.0 psig.

This approach ensures the CTS Limit is not compromised. The pump is operable during normal plant conditions. It would be expected to perform when called upon to do so.

2. Improved Technical Specifications (ITS): Values identified in ITS are Allowable Values. They are not limits, but are developed from the analytical limits used in safety related analysis. ITS includes only the parameters assumed in safety related analysis.

The ITS operability test (surveillance test) verifies that the component will perform in a manner which will support assumptions of the analysis. The Allowable Value takes into account the instrument uncertainty associated with the performance monitoring instrumentation. The uncertainty analysis would be evaluated as a Class 1 setpoint (95% probability that the true parameter value is validated by the surveillance test 95% of the time) and is prepared in accordance with ISA S67.04.

In the case of Allowable Value, there is no additional instrument uncertainty to be considered.

Example:

ITS requires Core Spray pump surveillance. The ITS Allowable Value is >2900 gpm flow at a discharge pressure of <80 psig. The surveillance test only needs to consider the Allowable Value as the final acceptance criteria for operability determination. This approach ensures the Analytical Limit is not compromised. By proving the pump is operable in within the Allowable Value during normal plant conditions, the pumps will be capable of providing the flow assumed in the analysis.

3. Component Protection: Limits are imposed on selected equipment to prevent component damage. These limits are imposed via Operator training and procedures. These limits are typically mandated by the equipment manufacturer but can also have been determined from operating experience. These limits are not part of any safety related analysis. However, it is necessary to conform to the operating limits imposed to ensure the equipment will be available when required to perform its safety related function.

Example:

The pump vendor requires a minimum Core Spray pump flow of >300 gpm for the first half hour of operation and >2000 gpm thereafter. The 300 gpm flow requirement is automatically satisfied by the design of the Core Spray pump minimum recirculation flow piping. A setpoint analysis ensures the pump minimum recirculation valve remains open until there is at least 300 gpm flow. At 2000 gpm, assume an instrument uncertainty of +250 gpm.

The 2000 gpm minimum flow is controlled by manual Operator action. The operating procedure must account for the 250 gpm instrument uncertainty. Therefore, to ensure the 2000 gpm pump minimum recirculation flow requirement is satisfied, the procedure must stipulate a minimum flow of >2500 gpm be maintained after the first half hour.

4. Safety Related Analysis: Unless otherwise noted, values applied in safety related analysis are Analytical Limits. Analytical Limits used in a safety related analysis require that the a high degree of rigor be imposed in the determination of the instrument uncertainty evaluation. In this case, the uncertainty analysis would be evaluated as a Class 1 setpoint (95% probability that the true parameter value is validated by the surveillance test 95% of the time). The uncertainty analysis is to be prepared in accordance with ISA S67.04.

Example:

Core Spray flow is an input to a safety relate analysis. The Analytical Limit is 2300 gpm based on Operator action during an accident.

a. A 95%/95% uncertainty analysis is required. Assume an indicated flow uncertainty of 200 gpm.

b. To ensure an actual flow of 22300 gpm, the Operator action must account for the 250 gpm uncertainty in the indicated reading. Therefore, the acceptance criteria must be ≥2550 gpm.

This approach ensures the Analytical Limit is not compromised. The Operator will provide the flow required to perform the required safety related function and there is assurance that the safety analysis remains valid.

5. In general, linear instrument loops will have a fixed uncertainty that will apply at any given reading (such as temperature or pressure). However, non-linear instrument loops will have a varying uncertainty dependent on where along the scale the reading is taken. To address flow loop performance operability a series of flow curves should be developed. The flow curve should consist of:

a. The pump curve associated with the analytical or performance limit. This curve is the minimum (or maximum) acceptable set of pump flow and head conditions. These conditions must be met or exceeded for pump operation. The Technical Specification limiting Condition for Operation condition. This condition is the Technical Specification limitations for pressure and flow. The pump curve design pressure (psig") vs. design flow (gpm), also referred to as the pump head curve.

b. The final curve to be developed is the required test curve to ensure conformance to the Technical Specification limit and the Analytical Limit. This curve is based on the the Technical Specification Limiting condition for operation and the errors associated with the flow and pressure measurement methods.

1. Determine the error associated with the pressure measurement and flow measurement methods. These errors may be constant over the range of measurement or may vary depending on scale position.

2. Select a point on the LCO condition curve. Determine the flow and pressure coordinates for this point on the curve. Apply the error calculated for the pressure measurement method to the pressure coordinates of the point and draw a line parallel to the x axis equivalent to this pressure plus error (assuming flow and pressure on the LCO curve are for minimum conditions. Perform the same steps for the flow coordinates. Where these two lines meet are the coordinates for the equivalent point on the required testing curve.

3. Repeat this process for representative points on the curve until a smooth required test curve can be drawn.

4. Table 1 shows selection of a point on the curve, the application of flow and pressure measurement errors and the resulting point on the required test curve. Note: where errors are not constant for the entire range of measurement, lines may either converge or diverge.

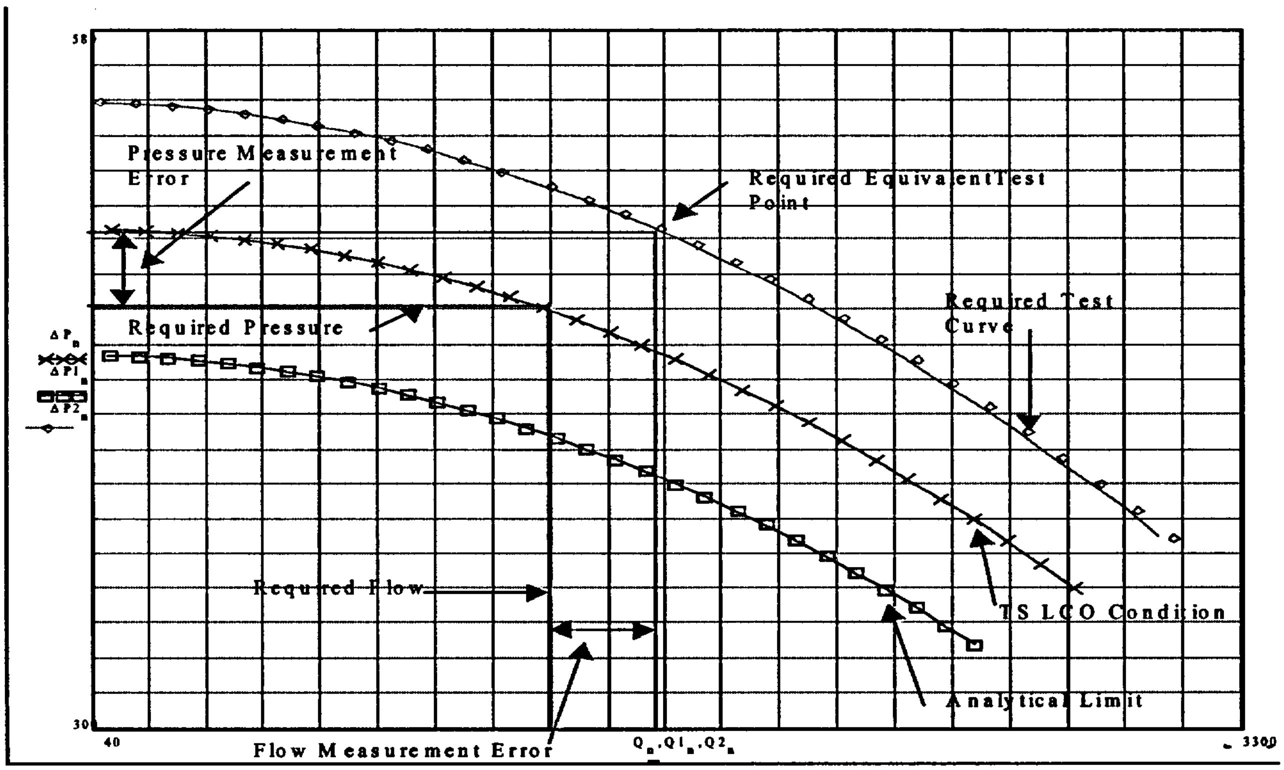

Table 1 Required Test Curve Single Limit

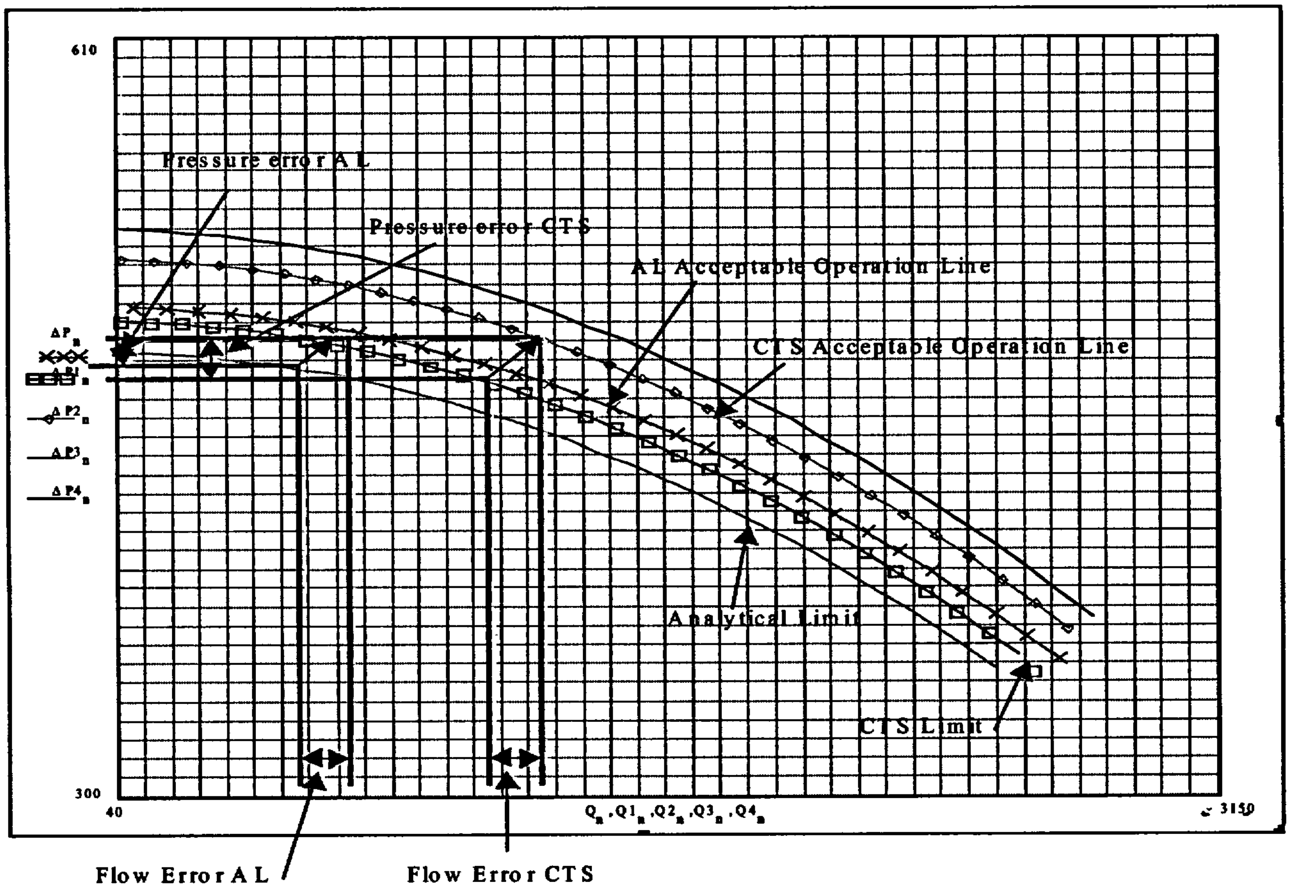

Table 2 Required Test Curve Analytical limit and Technical Specification Limit

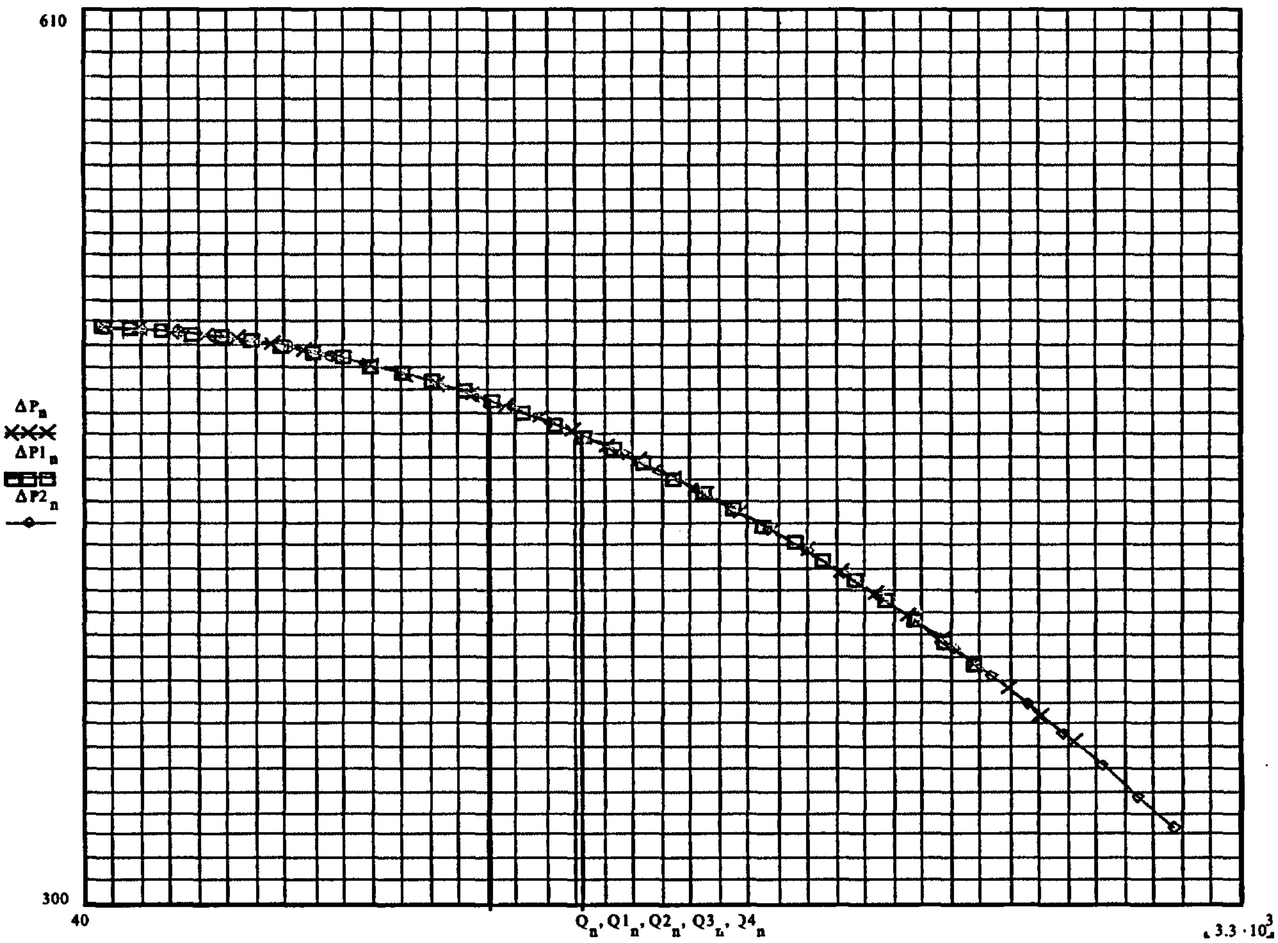

Figure 3
Gpm only adjusted results in no change in x axis only change in y axis

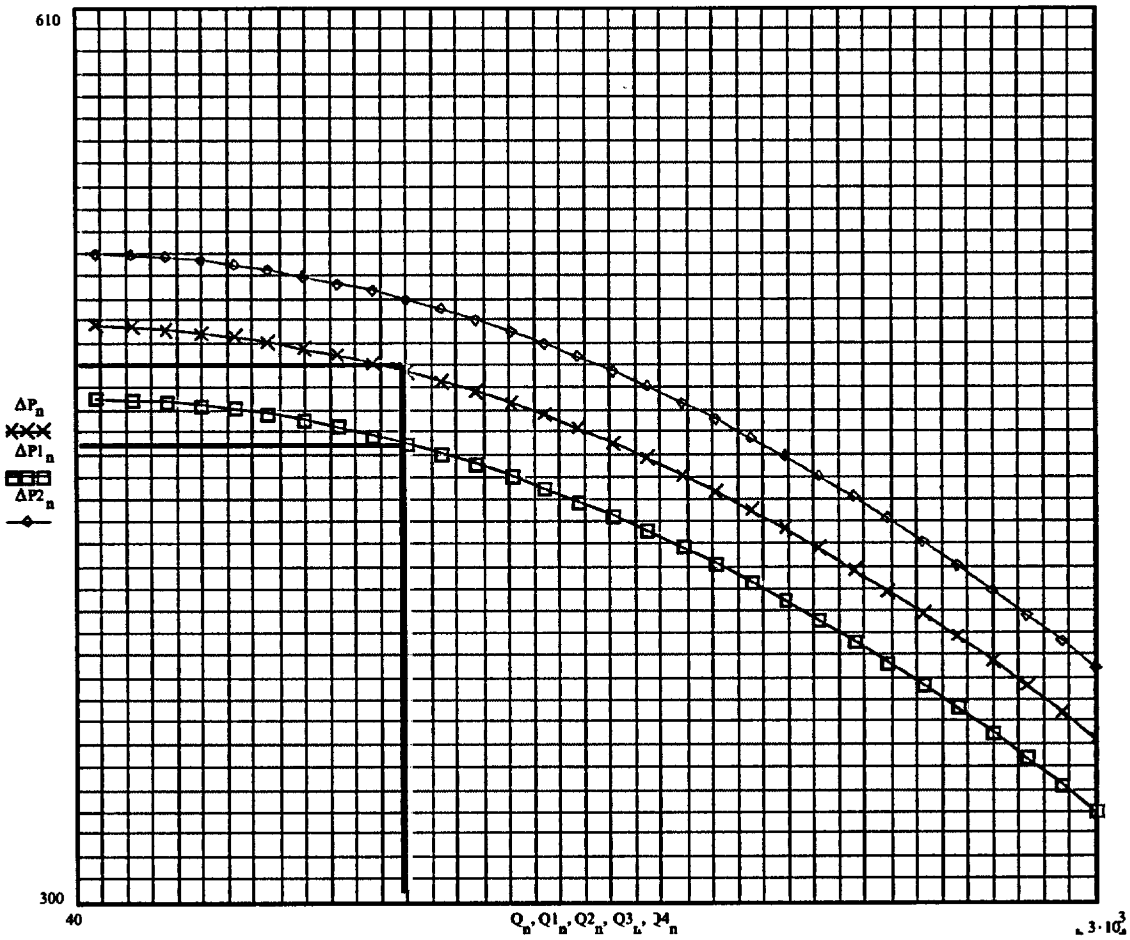

Figure 4

All errors have been converted to pressure errors. Note the the data points

6. For certain special testing conditions test personnel may be required to combine several different variables together to verify acceptability with a single performance criteria (i.e. flow, temperature, pressure and velocity to determine total developed head). When this occurs the error associated with each of the measurement methods must be considered as discussed previously. However, in these special conditions the method of combining the various inputs to provide a single acceptance criteria may also generate, significantly magnify or compress the measurement errors. One method to determine the specific contribution of the measurement and calculation errors associated with the testing method is discussed below.

a Perturbation of values to determine weighted values to be used in an SRSS error combination. This is best explained by a simple example.

Evaluating the following simplified flow formula:

$$Q = K * \sqrt{\Delta P}$$

It is obvious from the equation that an error associated with the K value would not have the same impact as an error associated with the delta P term. To determine the actual impact of errors, evaluate the equation for normal testing conditions. For this example we will assume that both K and delta P are equal to 100.

$1000 = 100 * \sqrt{100}$

To determine the actual effect of an error for each term, we test each term with an identical error and evaluate the impact of this error on the result. First assume a 10% error for K:

$1100 = 110 * \sqrt{100}$

$900 = 90 * \sqrt{100}$ an error of 100 for a positive or negative error

Next assume a 10% error for the delta P term. Note: the error magnitude selected for the test may not be realistic for all of the different terms. However, the test must use equivalent values to provide appropriate weighting.

$1048.80 = 100 * \sqrt{110}$

$948.68 = 100 * \sqrt{90}$ or an error of 48.8 for a positive error and of 51.32 for negative errors.

Based on this evaluation if we combined the errors together using an SRSS approach the delta P error would have a 0.488 or 0.513 (depending upon the direction of interest) multiplier while the error associated with K would have a multiplier of 1.

ATTACHMENT K: Maximum Allowable Deviation Limit

The Improved Technical Specifications (ITS) NUREG 1433 requires instrument channel checks. NUREG 1433 (Standard Technical Specifications General Electric Plants, BWR/4 NUREG-1433 R1 April 1995) defines CHANNEL CHECK as:

> "... the qualitative assessment, by observation, of channel behavior during operation. This determination shall include, where possible, comparison of the channel indication and status to the other indications or status derived from independent instrument channels measuring the same parameter".

The Standard Technical Specification Bases for the Channel Check Surveillance Requirement states,

> "Performance of the CHANNEL CHECK once every XXX hours ensures that a gross failure of the instrumentation has no occurred".

A Channel Check is normally a comparison of the parameter indicated on one calibrated channel to a similar parameter on other calibrated channels. It is based on the assumption that instrument channels monitoring the same parameter will read approximately the same value. Significant deviations between instrument channels could be indicative of excess instrument drift in one of the channels or a prelude to a more serious failure. A Channel Check will detect gross channel failure; thus, it is a key to verifying the instrumentation continues to operate properly between each channel calibration.

Channel Check acceptance criteria are determined by the plant staff based on a combination of the channel instrument uncertainties, including indication and readability. If a channel is outside the established criteria, it could be an indication that the instrument is performing outside its intended functional use.

For Vermont Yankee, the Maximum Allowable Deviation Limit (MADL) defines the allowable difference between readings of a common parameter. MADL is the largest value difference between channels measuring the same parameter which can exist before the operability of the channel is questioned. The industry has not adopted a standard for determining MADL. For MADL analysis, the smaller differences are the more conservative.

MADL will be determined by combining the random uncertainties associated with an instrument loop using the Root-Sum-Square methodology. This methodology of combining random and independent uncertainties is endorsed by ISA S67.04 for setpoint and uncertainty analysis. MADL criteria is to be based on the following:

1. More than two (2) identical instrument channels monitoring the same parameter - MADL will be defined as twice the random uncertainty associated with one instrument channel. When there are more than two instrument channels random errors should be clearly defined and it should be readily apparent which channel is in question.

   $MADL = 2 * \pm(A^2 + DR^2 + CE^2 + TE_N^2)^{1/2}$ Rounded up to the nearest minor division,

Where:

- A, DR, CE, & TE_N are the random uncertainties associated with one channel. Alternately, where multiple indications being verified are connected to a single transmitter, the terms should be limited to the errors associated with the unique loop components being compared. The uncertainty values are provided from manufacturers published specifications, or, where drift analysis is available,

- A, DR, CE, & TE_N (or portion thereof) is the standard deviation representing normal operating conditions associated with one channel.

2. Two (2) identical instrument channels monitoring the same parameter - MADL will be defined as the random uncertainty associated with one instrument channel. When there are only two (2) instrument channels, determining which channel is in question becomes more difficult. Additional investigation will be needed to determine which channel is not operable.

$MADL = 1 \times \pm(A^2 + DR^2 + CE^2 + TE_N^2)^{1/2}$ Rounded up to the nearest minor division,

Where:

- A + DR + CE + TE_N are the random uncertainties associated with one channel. Alternately, where multiple indications being verified are connected to a single transmitter, the terms should be limited to the errors associated with the unique loop components being compared. The uncertainty values are provided from manufacturers published specifications, or, where drift analysis is available.

- A, DR, CE, & TE_N (or portion thereof) is the standard deviation representing normal operating conditions associated with one channel.

3. Two (2) or more instrument channels monitoring the same parameter that differ from each other – MADL will be defined as a combination of the two channels exhibiting the smallest and largest random uncertainties. The combination of each channel uncertainty will be by using the standard RSS methodology.

An example would be to compare eight (8) level loops; four (4) identical channels that are ranged 100-inches, two (2) identical channels that are ranged 110-inches, and two (2) identical channels that are ranged 60-inches.

Step 1: Determine the random uncertainty associated with each set of identical channels.

$MADL\text{-}100 = 1 \times \pm(A_{100}^2 + DR_{100}^2 + CE_{100}^2 + TE_{N100}^2)^{1/2} = X$
$MADL\text{-}110 = 1 \times \pm(A_{110}^2 + DR_{110}^2 + CE_{110}^2 + TE_{N110}^2)^{1/2} = Y$ (largest random uncertainty)
$MADL\text{-}60 = 1 \times \pm(A_{60}^2 + DR_{60}^2 + CE_{60}^2 + TE_{N60}^2)^{1/2} = Z$ (smallest random uncertainty)

$MADL_{all\ 8} = 1 \times \pm(Y^2 + Z^2)^{1/2}$ Rounded up to the nearest one-half of a minor division where possible. In some cases, an adjustment might be required due to scaling differences. This adjustment should be based on engineering judgement keeping the MADL as close as practical to the value determined above yet providing a value that can be read from all scales.

Where:

- A, DR, CE, & TE_N are the random uncertainties associated with one channel. The uncertainty values are provided from manufacturers published specifications, or, where drift analysis is available,
- A, DR, CE, & TE_N (or portion thereof) is the standard deviation representing normal operating conditions associated with one channel.
- X, Y, & Z are the RSS values associated with the random uncertainties associated with each identical channel.
- $MADL_{all\ 8}$ is the RSS value associated with the channels exhibiting the smallest and largest random uncertainty.

Attachment B

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 257, ARTS/MELLLA

Additional Information in Response to RAI No. 9

Instrument Drift Analysis Design Guide

VERMONT YANKEE
NUCLEAR POWER STATION

INSTRUMENT DRIFT ANALYSIS
DESIGN GUIDE

Revision 1

APPENDIX E to SETPOINT PROGRAM MANUAL

Approvals: John H. Lewis 5/18/99
Prepared By/Date

5/27/99
Reviewed By/Date

Roger T. Vibert 5/30/99
Approved By/Date

Richard J. Fannay 7 June 1999
Design Engineering Manager/Date

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TABLES

FIGURES

ATTACHMENTS

History of Revisions

Rev. No.	Approval Date	Reason & Description Change
Original	10/31/96	Initial Issue
1	6/7/99	1. Incorporate the recommendations of the NRC review of EPRI TR 103335 (Reference 7.4.9) 2. Remove the Responsibilities Section that has been superceded by the Setpoint Program Manual. 3. Enhance the Time Dependency determinations and tools to use. 4. Add section for determining bias in the mean of the sample. 5. Expand Tables 1 & 2 to include more data points. 6. Include Failure Proportion equations. 7. Add discussion of Drift Uncertainty. 8. Streamline process based on lessons learned in performance of original Drift Calculations.

DRIFT ANALYSIS DESIGN GUIDE

1. OBJECTIVE/PURPOSE

The objective of this Design Guide is to provide the necessary detail and guidance to perform drift analysis using past calibration history data for the purposes of:

- Quantifying component/loop drift characteristics within defined probability limits to gain an understanding of the expected behavior for the component/loop by evaluating past performance.
- Estimating component/loop drift for integration into setpoint programs.
- Analysis aid for reliability centered maintenance practices (e.g., optimizing calibration frequency).
- Establishing a technical basis for extending calibration and surveillance intervals using historical calibration data.
- Evaluating extended surveillance intervals in support of longer fuel cycles.

2. DRIFT ANALYSIS SCOPE

The scope of this design guide is limited to the calculation of the expected performance for a component, group of components or loop utilizing past calibration data. The results obtained from a completed data analysis will be incorporated into a Drift Calculation in accordance with Yankee Procedure WE-103 or Vermont Yankee Procedure AP-0017. The Drift Calculation(s) are the final product of the data analysis and will document the use of the drift data for the purposes listed in Section 1. The Setpoint/Uncertainty calculations will incorporate the values documented in the Drift Calculations for the applications specific to a given loop or component (e.g. Tolerance Interval Factors for other than 95% /95%, single side of interest setpoints, combination of uncertainties for multiple components in a given loop, etc.). (Ref. 7.2.1 & 7.2.2)

This design guide is applicable to all devices which are surveilled or calibrated where as found and as left data is recorded. The scope of this design guide includes but is not limited to the following list of devices:

- Transmitters (Differential Pressure, Flow, Level, Pressure, Temperature, etc.)
- Bistables (Master & Slave Trip Units, Alarm Units, etc.)
- Indicators (Analog, Digital)
- Switches (Differential Pressure, Flow, Level, Position, Pressure, Temperature, etc.)
- Signal Conditioners/Converters (Summers, E/P Converters, Square Root Converters, etc.)
- Recorders (Temperature, Pressure, Flow, Level, etc.)
- Monitors & Modules (Radiation, Neutron, H_2O_2, Pre-Amplifiers, etc.)

- Relays (Time Delay, Undervoltage, Overvoltage, etc.)
- Power Supplies

3. DISCUSSION/METHODOLOGY

3.1 Methodology Options

This design guide is written to provide the methodology necessary for the analysis of as found versus as left calibration data as a means of characterizing the performance of a component or group of components via the following methods:

3.1.1 Electric Power Research Institute (EPRI) has developed a guideline to provide nuclear plants with practical methods for analyzing historic component calibration data to predict component performance via a simple spreadsheet program (e.g., Excel, Lotus 1-2-3). This design guide is written in close adherence to Report "EPRI TR-103335, Rev. 1, GUIDELINES FOR INSTRUMENT CALIBRATION EXTENSION/REDUCTION PROGRAMS" which meets the intent of the comments provided by the NRC review of the EPRI TR-103335. This design guide provides detailed instructions for use of Microsoft Excel to analyze the raw as found/as left calibration data.
(Ref. 7.1.1, 7.4.9 & 7.4.6)

3.1.2 Commercial Grade Software programs other than Microsoft Excel (e.g. IPASS, Lotus 1-2-3, SYSTAT, etc.) that will perform the functions necessary to evaluate drift may be utilized providing:

- the intent of this design guide is met as outlined in Reference 7.1.1.(Ref. 7.1.1)
- that software verification and validation is performed in accordance with WE-103 and WE-108. (Ref. 7.2.1 & 7.2.3)

2 Software Verification And Validation

3.2.1 The software selected to perform a data analysis must meet the requirements of WE-103 and WE-108. (Ref. 7.2.1 & 7.2.3)

3.2.2 The first drift analysis performed (VYC-1599 Rev. 0, Attachment 1) using Revision 0 of this Design Guide and Microsoft Excel Version 5.0 was 100% mathematically verified using a hand calculator. Subsequent drift analyses utilized the verified analysis as a template and performed random manual verifications of each spreadsheet. The upgrade from Microsoft Excel Version 5.0 to 97SR-2 was verified to provide the same results in both versions by rerunning VYC-1599 Rev. 0 using Microsoft Excel Version 97SR-2
(see Attachment 2).(Att. 1 & 2)

3.2.3 The final product of the data analysis is the hard copy Drift Calculation which is controlled by AP-0017 or WE-103 as a QA document. The electronic files are an intermediate step from raw data to final product and is not controlled as a QA file. All data contained in the electronic files is recoverable from QA calibration records controlled by DCC. (Ref. 7.2.1 & 7.2.2)

3.2.4 Microsoft Excel stores numbers with 15 digits of accuracy, all calculation outputs displayed within the calculations are rounded from the values stored by Microsoft Excel. Rounding errors induced by Microsoft Excel are assumed to be negligible within the calculations. (Ref. 7.4.6)

3.3 Data Analysis Discussion

The following data analysis methods were evaluated for use at Vermont Yankee; As Found Versus Setpoint, Worst Case - As Found Versus As Left, Combined Calibration Data Points Analysis and As Found Versus As Left. The evaluation concluded that the As Found versus As Left methodology provided results that were more representative of the data and has been chosen for use by this Design Guide. Statistical tests not covered by this design guide may be utilized providing the Engineer performing the analysis adequately justifies the use of the tests.

3.3.1 As Found Versus As Left Calibration Data Analysis

The as found versus as left calibration data analysis is based on calculating drift by subtracting the previous as left component setting from the current as found setting. Each calibration point is treated as an independent set of data for purposes of characterizing drift across the full calibrated span of the component/loop. By evaluating as found versus as left data for a component/loop or a similar group of components/loops, the following information may be obtained:

- The typical component/loop drift between calibrations (Random in nature).
- Any tendency for the component/loop to drift in a particular direction (Bias).
- Any tendency for the component/loop drift to increase in magnitude over time (Time Dependent).
- Confirmation that the selected setting or calibration tolerance is appropriate or achievable for the component/loop.

3.3.1.1 General Features Of As Found Versus As Left Analysis

- The methodology evaluates historical calibration data only. The method does not monitor on-line component output; data is obtained from component calibration records.

- Present and future performance is predicted based on statistical analysis of past performance.

- Data is readily available from component calibration records. Data can be analyzed from plant startup to the present or from time of device installation.

- Since only historical data is evaluated, the method is not intended as a tool to identify individual faulty components, although it can be used to demonstrate that a particular component model or application historically performs poorly.

- A similar class of components, i.e., same make, model, or application, is evaluated. For example, the method can determine the drift of all analog indicators of a certain type installed in the control room.

- The methodology is less suitable for evaluating the drift of a single component over time due to statistical analysis penalties that occur with smaller sample sizes.

- The methodology is based on actual calibration data and is thus traceable to calibration standards.

- The methodology obtains a value of drift for a particular component model that can be used in component uncertainty and setpoint calculations.

- The methodology is designed to support the analysis of longer calibration intervals due to fuel cycle extensions and is consistent with the NRC expectations described in Generic Letter 91-04, Changes in Technical Specification Surveillance Intervals to Accommodate a 24-Month Fuel Cycle. (Ref. 7.4.2)

3.3.1.2 Error And Uncertainty Content In As Found Versus As Left Calibration Data

The as found versus the as left data includes several sources of uncertainty over and above component drift. The following is a list of uncertainties which may be included in drift data obtained through analyzing the as found versus as left data:

- Accuracy errors present during the two calibrations.
- Measurement and test equipment error present during the two calibrations.
- Personnel-induced or human-related variation or error during the two calibrations.
- Normal temperature effects due to a difference in ambient temperature between the two calibrations.
- Power Supply variations between the two calibrations.
- Environmental effects on component performance, e.g., radiation, humidity, vibration, etc., between the two calibrations that cause a shift in component output.

- Misapplication, improper installation, or other operating effects that effect component calibration during the period between calibrations.

- True drift representing a change, time-dependent or otherwise, in component/loop output over the time period between calibrations.

3.3.1.3 Potential Impacts Of As Found Versus As Left Data Analysis

Many of the bulleted items listed in step 3.3.1.2 are not expected to have a significant effect on the measured as found and as left settings. Because there are so many independent parameters contributing to the possible variance in calibration data, they will all be considered together and termed the component's Analyzed Drift (ADR or DA) uncertainty. This approach has the following potential impacts on an analysis of the component's calibration data:

- The magnitude of the calculated variation may be conservative and thus may exceed any assumptions or manufacturer predictions regarding drift. Attempts to validate manufacturer's performance claims should consider the possible contributors listed in step 3.3.1.2 to the calculated drift.

- The magnitude of the calculated variation that includes all of the above sources of uncertainty may mask any "true" time-dependent drift. In other words, the analysis of as found versus as left data may not demonstrate any time dependency. This does not mean that time-dependent drift does not exist, only that it is so small that it is negligible in the cumulative effects of component uncertainty when all of the above sources of uncertainty are combined.

4 Assignment Of Rigor For The Analysis

3.4.1 What is Rigor?

The term "Rigor" is defined for the purposes of this Design Guide as the degree of strictness applied to the analysis and the results of the analysis. For example, a safety related component used to satisfy a Technical Specification value would have the highest degree of strictness applied when performing the analysis and associated calculations.

3.4.2 Rigor Levels

This Design Guide assigns four levels of rigor when performing data analyses and the associated calculations. See Reference 7.1.6 for further information. (Ref. 7.1.6)

NOTE: The default Tolerance Interval Factor (TIF) for all Drift Calculations performed using this Design Guide, regardless of Rigor Level, will be 95%/95% (Standard statistics term meaning that the results have a 95% confidence (γ) that at least 95% of the population will lie between the stated interval (P) for a sample size (n)). Any reduction in TIF will be shown in addition to the 95%/95% value with a detailed discussion provided for the basis of reducing the TIF.

3.4.2.1 Rigor Level 1 - Components that perform functions which satisfy a specific Technical Specification value. For example, PT-2-3-55A(M) and associated loop provides a Reactor SCRAM Signal through the RPS for High Reactor Pressure and is listed in the Technical Specifications with a specific trip value. Components/loops that fall into this level of rigor <u>must:</u>

- be included in the data group if the analyzed drift value is to be applied to the component/loop in a Setpoint/Uncertainty Calculation.
- use the 95 /95% TIF for determination of the Analyzed Drift term. (See step 0 and Table 1 - Equipment Summary)
- be evaluated in the Setpoint/Uncertainty Calculation for application of the Analyzed Drift term (e.g. The ADR term may include the normal temperature effects for a given device but, due to the impossibility of separating out that specific term an additional temperature uncertainty may be included in the Setpoint/Uncertainty Calculation).

3.4.2.2 Rigor Level 2 - Components/loops that perform functions that are required by; the Technical Specifications with no specific values listed, the FSAR, Reg. Guide 1.97, Appendix R and Electrical Coordination Equipment. Components/loops that fall into this level of rigor must meet the requirements of Rigor Level 1 with the exception of the TIF which may be reduced to 90%/95%. Design Engineering is responsible for determining if the use of less restrictive TIF is permissible for any given evaluation. (See step 0 and Attachment 3 for TIF's)

3.4.2.3 Rigor Level 3 - Components/loops that perform functions that are <u>not</u> covered by the Technical Specifications, FSAR, Reg. Guide 1.97, Appendix R or Electrical Coordination Equipment but provide a system related function (e.g. Pump Trip on High Vibration, Air Compressor Trip on High Temperature, etc.). Components/loops that fall into this level of rigor:

- do not need to be included in the data group provided they are adequately represented by the data in the analysis group. Refer to Section 3.6 for further clarification.

- may use less restrictive TIF for determination of the Analyzed Drift term up to and including 75/95%. Design Engineering is responsible for determining if the use of less restrictive TIF is permissible for any given evaluation. (See step 3.5.2.1 and Attachment 3 for TIF's)

- may use the Analyzed Drift term in the Setpoint/Uncertainty Calculation without taking additional uncertainty penalties for component accuracy errors, M&TE errors, personnel-induced or human related errors, ambient temperature and other environmental effects, power supply effects, misapplication errors and true component drift. Design Engineering is responsible for determining the need for additional uncertainty penalties for any given evaluation.

3.4.2.4 Rigor Level 4 - Components/loops that perform functions that do not fall into the other 3 levels of rigor. Components/loops that fall into this level of rigor <u>must</u> meet the requirements of Rigor Level 3.

3.5 Calibration Data Collection

3.5.1 Sources And Location Of Data

The sources of data to perform a drift analysis are Surveillance Tests, Calibration Procedures and other calibration processes (MPAC calibration files, calibration sheets for Balance of Plant devices, Preventative Maintenance Routes, VISI Cards, etc.). The location of the completed Surveillance Tests, Calibration Procedures and other calibration processes are listed below.

3.5.1.1 Completed Surveillance Tests and Calibration Procedures are stored in the following locations:

- Most recently completed surveillance tests or calibration procedures are maintained in filing cabinets located in the associated departments.

- Document Control Center (DCC) maintains the surveillance tests or calibration procedures that have not yet been scanned or microfilmed in filing cabinets in DCC.

- DCC maintains a database for the surveillance tests or calibration procedures that have been scanned and stored on optical disk. The data and or its location is retrievable through the "VYDCC" database on the network or by request to DCC. (Ref. 7.4.4)

- DCC maintains a database for the surveillance tests or calibration procedures that have been microfilmed. The location of the data is retrievable through the "DATAFIND" database on the network or by request to DCC. (Ref. 7.4.5)

3.5.1.2 MPAC Calibration Files and Calibration Sheets.

- The MPAC Calibration Files are accessible through the VY Custom Menu, I&C Custom Menu A, Calibration Data by Equipment Number selection. (Ref. 7.4.3)

- The Calibration Sheets prior to 1991 are stored on microfilm by Balance of Plant Procedure Number or on VISI Cards. The location of the data is retrievable through the "DATAFIND" database on the network or by request to DCC. (Ref. 7.4.5)

- The Calibration Sheets from 1991 to present are stored on microfilm or optical disk by device number and or work order number. The work order numbers that perform calibrations for any given device are accessible through page 4 (EQUIPMENT WORK ORDER INQUIRY) of EQUIPMENT INQUIRY under the MAINTENANCE PLANNING SYSTEM in MPAC. A search of the DATAFIND and VYDCC databases using the equipment number and associated work order numbers will provide the location of the data. (Ref. 7.4.3, 7.4.4 & 7.4.5)

3.5.2 How Much Data To Collect

3.5.2.1 The goal is to collect enough data for the instrument or group of instruments as to make a statistically valid pool. There is no hard fast number that must be attained for any given pool. Table 1 provides the 95%/95% TIF for various sample pool sizes, it should be noted that the smaller the pool the larger the penalty. A tolerance interval is a statement of probability that a certain proportion of the total population is contained within a defined set of bounds. The tolerance interval description also includes an assessment of the level of confidence in the statement of probability. For example, a 95%/95% TIF indicates a 95% level of confidence that 95% of the population is contained within the stated interval.

Table 1 – 95%/95% Tolerance Interval Factors

Sample Size	95%/95%	Sample Size	95%/95 %	Sample Size	95%/95 %
≥ 2	37.674	≥ 23	2.673	≥ 120	2.205
≥ 3	9.916	≥ 24	2.651	≥ 130	2.194
≥ 4	6.370	≥ 25	2.631	≥ 140	2.184
≥ 5	5.079	≥ 26	2.612	≥ 150	2.175
≥ 6	4.414	≥ 27	2.595	≥ 160	2.167
≥ 7	4.007	≥ 30	2.549	≥ 170	2.160
≥ 8	3.732	≥ 35	2.490	≥ 180	2.154
≥ 9	3.532	≥ 40	2.445	≥ 190	2.148
≥ 10	3.379	≥ 45	2.408	≥ 200	2.143
≥ 11	3.259	≥ 50	2.379	≥ 250	2.121
≥ 12	3.162	≥ 55	2.354	≥ 300	2.106
≥ 13	3.081	≥ 60	2.333	≥ 400	2.084
≥ 14	3.012	≥ 65	2.315	≥ 500	2.070
≥ 15	2.954	≥ 70	2.299	≥ 600	2.060
≥ 16	2.903	≥ 75	2.285	≥ 700	2.052
≥ 17	2.858	≥ 80	2.272	≥ 800	2.046
≥ 18	2.819	≥ 85	2.261	≥ 900	2.040
≥ 19	2.784	≥ 90	2.251	1000	2.036
≥ 20	2.752	≥ 95	2.241	∞	1.960
≥ 21	2.723	≥ 100	2.233		
≥ 22	2.697	≥ 110	2.218		

Note: Attachment 3 provides tolerance interval factors for 75%/75% through 99%/99.9%.

3.5.2.2 The end purpose of the analysis determines the types of components that require evaluation. Different information may be needed depending on the analysis purpose, therefore, the total population of components - all makes, models, and applications - that will be analyzed must be known. (e.g. All Rosemount Trip Units)

3.5.2.3 Once the total population of components is known, the components should be grouped into functionally equivalent groups. Each grouping is treated as a separate population for analysis purposes. (e.g. Starting with all Rosemount Trip Units as the initial group and breaking them down into various sub groups - 710 Masters, 710 Slaves, 510 Masters, 510 Slaves, Increasing Setpoints, Decreasing Setpoints, Monthly Calibrations, Quarterly Calibrations, etc.).

3.5.2.4 Not all components or available calibration data points need to be analyzed within each group in order to establish statistical performance limits for the group. However, devices contained in rigor levels 1 & 2 (see step 3.4.2) must be contained in the analysis group. Acquisition of data should be considered from different perspectives:

- For each grouping, a large enough sample of components should be randomly selected from the population so that there is assurance that the evaluated components are representative of the entire population. By randomly selecting the components and confirming that the behavior of the randomly selected components is similar, a basis for not evaluating the entire population can be established. For sensors, a random sample from the population should include representation of all desired component spans and functions. It may be difficult to justify the application of analysis results to a sensor whose span or function was not represented in the data set.

- For each selected component in the sample, enough historic calibration data should be provided to ensure that the component's performance over time is understood.

- The number of components as well as the number of years back in time to be evaluated for each component requires a careful balance. Ten year old information may not be as relevant as the most current calibration information, but it can be used to establish any time-dependent trends in the components' performance. For example, one approach to managing the quantity of data might be to analyze only the last as found versus as left value for each and every component within the grouped population. Although the population is completely represented in this case, there may not be adequate data to determine any more than the most cursory time-dependent analysis of the results.

- On the other hand, suppose the grouped population consists of 75 components for which monthly surveillance data is available. Choosing to analyze the last 10 years of monthly data for 2 components may provide as many as 240 data points which sounds like a lot of data. Unfortunately,

there is little diversity in the data and the 240 data points are not actually a random sample of the total population. In this case, more components should be selected for analysis with perhaps only the last 5 years of data included in the analysis for each component allowing a manageable sample size.

- A key consideration when selecting the data population is for what purpose is the analysis being performed. Data grouping and population sets for an analysis performed to gain insight into long-term drift variations will differ significantly from an analysis aimed at understanding the current behavior of a group of components.

3.6 Categorizing Calibration Data

3.6.1 Grouping Calibration Data

One analysis goal should be to combine functionally equivalent components (components with similar design and performance characteristics) into a single group. In some cases, all components of a particular manufacturer make and model can be combined into a single sample. In other cases, virtually no grouping of data beyond a particular component make, model, and specific span or application may be possible. Some examples of groupings that may be possible include but are not limited to the following:

3.6.1.1 Small Groupings

- All devices of same manufacturer, model and range covered by the same Surveillance Test.
- All trip units used to monitor a specific parameter (assuming that all trip units are the same manufacturer, model and range).

3.6.1.2 Larger Groupings

- All transmitters of a specific manufacturer, model that have similar spans and performance requirements.
- All Rosemount trip units with functionally equivalent model numbers.
- All control room analog indicators of a specific manufacturer and model.

3.6.2 Rationale For Grouping Components Into A Larger Sample

- A single component analysis may result in too few data points to make statistically meaningful performance predictions.

- Smaller sample sizes associated with a single component may unduly penalize performance predictions by applying a larger uncertainty factor to account for the smaller data set. Larger sample sizes reflect a greater understanding and assurance of representative data which in turn reduces the uncertainty factor.

- Large groupings of components into a sample set for a single population ultimately allows the user to state the plant-specific performance for a particular make and model of component. For example, the user may state, "Main Steam Flow Transmitters have historically drifted by less than 1%", or "All control room indicators of a particular make and model have historically drifted by less that 1.5%".

- An analysis of smaller sample sizes is more likely to be influenced by non-representative variations of a single component (outliers).

- Grouping similar components together rather than analyzing them separately is more efficient and minimizes the number of separate calculations that must be maintained. Each new calculation at a nuclear plant involves a certain ongoing operations and maintenance expense even if only because it is another quality document in the system.

3.6.3 Considerations When Combining Components Into A Single Group

Grouping components together into a sample set for a single population does not have to become a complicated effort. Most components can be categorized readily into the appropriate population. Consider the following guidelines when grouping functionally equivalent components together.

- If performed on a type-of -component basis, component groupings should usually be established down to the manufacturer make and model, as a minimum. For example, mixing Rosemount transmitters in the same analysis as General Electric or Barton transmitters should not be done. The principles of operation are different for the various manufacturers and combining the data might mask some trend for one type of component. This said, it may be desirable to combine groups of components for certain studies. If dissimilar component types are combined, a separate analysis of each component type should still be completed to ensure analysis results of the mixed population are not misinterpreted or misapplied.

- Sensors of the same manufacturer make and model, but with different calibrated spans or elevated zero points, can possibly still be combined into a single group. For example, a single analysis that determines the drift for all Rosemount 1153 pressure transmitters installed onsite might simplify the application of the results. Note that some manufacturers provide a predicted accuracy and drift value for a given component model, regardless of its span. However, the validity of

combining components with a variation of span ranging from tens of pounds to several thousand pounds should be confirmed. As part of the analysis, the performance of components within each span should be compared to the overall expected performance to determine if any differences are evident between components with different spans. See step 3.6.4 for more information.

- Components combined into a single grouping should be exposed to similar calibration or surveillance conditions, as applicable. Note that the term operating condition was not used in this case. Although it is desirable that the grouped components perform similar functions, the method by which the data is obtained for this analysis is also significant. If half the components are calibrated in the summer at 90°F and the other half in the winter at 40°F, a difference in observed drift between the data for the two sets of components may exist. In many cases, ambient temperature variations are not expected to have a large effect since the components are located in environmentally controlled areas.

- Avoid using historical calibration data for components that have been replaced or are no longer in service. The analysis results should be based on the performance of currently installed components.

3.6.4 Verification That Data Grouping Is Appropriate

- Combining functionally equivalent components into a single group for analysis purposes may simplify the scope of work; however, some level of verification should be performed to confirm that the selected component grouping is appropriate. As an example, the manufacturer may claim the same accuracy and drift specifications for two components of the same model, but with different ranges, e.g., 0-5 PSIG and 0-3000 PSIG. However, in actual application, components of one range may perform differently than components of another range.

- Standard statistics texts provide methods that can be used to determine if data from similar types of components can be pooled into a single group. If different groups of components have essentially equal variances and means at the desired statistical level, the data for the groups can be pooled into a single group.

- A t-Test (two samples assuming unequal variances) should also be performed on the proposed components to be grouped. The t-Test returns the probability associated with a Student's t-Test to determine whether two samples are likely to have come from the same two underlying populations that have unequal variances. If for example, the proposed group contains 5 sub-groups the t-Tests should be performed on all possible combinations for the groupings. The following formula is used to determine the test statistic value t.

$$t' = \frac{\overline{x}_1 - \overline{x}_2 - \Delta_0}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$ (Ref. 7.4.6)

Where ;

t'	- test statistic
n	- Total number of data points.
x	- Mean of the samples.
s^2	- Pooled variance
Δ_0	- Hypothesized mean difference.

3.6.5 Examples Of Proven Groupings:

- All control room indicators receiving a 4-20mADC (or 1-5VDC) signal. Notice that a combined grouping may be possible even though the indicators have different indication spans. For example, a 12 mADC signal should move the indicator pointer to the 50% of span position on each indicator scale regardless of the span indicated on the face plate (exceptions are non-linear meter scales).

- All control room bistables of similar make or model tested monthly for Technical Specification surveillances. Note that this assumes that all bistables are tested in a similar manner and have the same input range, e.g., a 1-5VDC or 4-20mADC spans.

- A specific type of pressure transmitter used for similar applications in the plant in which the operating and calibration environment does not vary significantly between applications or location.

- A group of transmitters of the same make and model, but with different spans, given that a review confirms that the transmitters of different spans have similar performance characteristics.

3.6.6 Using Data From Other Nuclear Power Plants:

- It is acceptable, although not recommended, to pool Vermont Yankee Plant specific data with data obtained from other utilities providing the requirements of step 3.6.4 are met and the data can be verified to be of high quality.

3.7 Outlier Analysis

An outlier is a data point significantly different in value from the rest of the sample. The presence of an outlier or multiple outliers in the sample of component or group data may result in the calculation of a larger than expected sample standard deviation and tolerance interval. Calibration data can contain outliers for several reasons that permit correction of the data or rejection of these data points from the sample. Examples include:

- *Data Transcription Errors* - Calibration data can be recorded incorrectly either on the original calibration data sheet or in the spreadsheet program used to analyze the data.

- *Calibration Errors* - Improper setting of a device at the time of calibration. Would indicate larger than normal drift during the next subsequent calibration.

- *Measuring & Test Equipment Errors* - Improperly selected or miscalibrated test equipment could indicate drift when little or no drift was actually present.

- *Scaling or Setpoint Changes* - Changes in scaling or setpoints can appear in the data as a larger than actual drift point unless the change is detected during the data entry or screening process.

- *Failed Instruments* - Calibrations are occasionally performed to verify proper operation due to erratic indications, spurious alarms, etc.. These calibrations may be indicative of component failure and not drift which would introduce errors that are not representative of the device performance during routine conditions.

- *Design or Application Deficiencies* - An analysis of calibration data may indicate a particular component that always tends to drift significantly more than all other similar components installed in the plant. In this case, the component may need an evaluation for the possibility of a design, application, or installation problem. Including this particular component in the same population as the other similar components may skew the drift analysis results.

3.7.1 Detection of Outliers

There are several methods for determining the presence of outliers. This design guide utilizes the Critical Values for t-Test (Extreme Studentized Deviate). The t-Test utilizes the values listed in Table 2 with an upper significance level of 5% to compare a given data point against. Note that the critical value of t increases as the sample size increases. This signifies that as the sample size grows, it is more likely that the sample is truly representative of the population. The t-Test assumes that the data is normally distributed which should be proven prior to performance of the t-Test.

Table 2 - Critical Values For t-Test

Sample Size	Upper 5% Significance Level	Sample Size	Upper 5% Significance Level
≤ 3	1.15	22	2.60
4	1.46	23	2.62
5	1.67	24	2.64
6	1.82	25	2.66
7	1.94	≤ 30	2.75
8	2.03	≤ 35	2.82
9	2.11	≤ 40	2.87
10	2.18	≤ 45	2.92
11	2.23	≤ 50	2.96
12	2.29	≤ 60	3.03
13	2.33	≤ 70	3.09
14	2.37	≤ 75	3.10
15	2.41	≤ 80	3.14
16	2.44	≤ 90	3.18
17	2.47	≤ 100	3.21
18	2.50	≤ 125	3.28
19	2.53	≤ 150	3.33
20	2.56	>150	4.00
21	2.58		

3.7.2 t-Test Outlier Detection Equation

$$t = \frac{|x_i - \bar{x}|}{s}$$ (Ref. 7.1.1)

Where;

X_i - An individual sample data point
$\bar{X}$ - Mean of all sample data points
s - Standard deviation of all sample data points
t - Calculated value of extreme studentized deviate that is compared to the critical value of t for the sample size

3.7.3 Outlier Expulsion

Outliers may be excluded from the sample pool providing justification is provided for each outlier. See some outlier examples provided in the bulleted items listed above in Section 3.7. Multiple outlier tests or passes is not recommended by this Design Guide.

3.8 Methods For Verifying Normality

A test for normality can be important because many frequently used statistical methods are based upon an assumption that the data is normally distributed. This assumption applies to the analysis of component calibration data also. For example, the following analyses may rely on an assumption that the data is normally distributed:

- Determination of a tolerance interval that bounds a stated proportion of the population based on calculation of mean and standard deviation.
- Identification of outliers.
- Pooling of data from different samples into a single population.

The normal distribution occurs frequently and is an excellent approximation to describe many processes. Testing the assumption of normality is important to confirm that the data appears to fit the model of a normal distribution, but tests will not prove that the normal distribution is a correct model for the data. At best, it can only be found that the data is reasonably consistent with the characteristics of a normal distribution. For example, some tests for normality will only allow the rejection of the hypothesis that the data is not normally distributed. This does not mean the data is normally distributed; it only means that there is no evidence to say that it is not normally distributed.

Distribution-free techniques are available when the data is not normally distributed; however, these techniques are not as well known and often result in penalizing the results by calculating tolerance intervals that are substantially larger than the normal distribution equivalent. There is a good reason to demonstrate that the data is normally distributed or can be bounded by the assumption of normality.

Analytically verifying that a sample appears to be normally distributed usually invokes a form of statistics known as hypothesis testing. In general, a hypothesis test includes the following steps:

1) Statement of the hypothesis to be tested and any assumptions.
2) Statement of a level of significance to use as the basis for acceptance or rejection of the hypothesis.
3) Determination of a test statistic and a critical region.
4) Calculation of the appropriate statistics to compare against the test statistic.
5) Statement of conclusions.

The following sections discuss various ways in which the assumption of normality can be verified to be consistent with the data or can be claimed to be a conservative representation of the actual data. Analytical hypothesis testing as well as more subjective graphical analyses are discussed. The following are methods for assessing normality:

3.8.1 Chi-Squared, x^2, Goodness of Fit Test

This well known test is stated as a method for assessing normality in ISA-RP67.04, Recommended Practice, Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation. The x^2 test compares the actual distribution of sample values to the expected distribution. The expected values are calculated by using the normal mean and standard deviation for the sample. If the distribution is normally or approximately normally distributed, the difference between the actual versus expected values should be very small. And, if the distribution is not normally distributed, the differences should be significant. (Ref. 7.1.2)

3.8.1.1 Equations To Perform The x^2 Test

1) First calculate the mean for the sample group

$$\bar{X} = \frac{\sum X_i}{n}$$ (Ref. 7.1.1)

Where;
X_i - An individual sample data point
$\bar{X}$ - Mean of all sample data points
n - Total number of data points

2) Second calculate the standard deviation for the sample group

$$s = \sqrt{\frac{n\sum x^2 - \left(\sum x\right)^2}{n(n-1)}}$$ (Ref. 7.1.1)

Where;
x - Sample data values (x1, x2, x3, ...)
s - Standard deviation of all sample data points
n - Total number of data points

3) Third the data must be divided into bins to aid in determination of a normal distribution. The number of bins selected is up to the individual performing the analysis. Refer to Reference 7.1.1 for further guidance.

4) Fourth calculate the x^2 value for the sample group

$$x^2 = \sum \frac{(O_i - E_i)^2}{n(n-1)} \qquad E_i = NP_i$$ (Ref. 7.1.1)

Where;
E_i - Expected values for the sample
N - Total number of samples in the population
P_i - Probability that a given sample will be contained in a bin
O_i - Observed sample values (O_1, O_2, O_3, ...)
x^2 - Chi squared result

3.8.2 W Test

This test is recommended by ANSI N15.15-1974, Assessment of the Assumption of Normality (Employing Individual Observed Values), for sample sizes less than 50. The W Test calculates a test statistic value for the sample population and compares the calculated value to the critical values for W which are tabulated in ANSI N15.15. The W test is a

lower-tailed test. Thus if the calculated value of W is less than the critical value of W, the assumption of normality would be rejected at the stated significance level. If the calculated value of W is larger than the critical value of W, there is no evidence to reject the assumption of normality. For the equations required to perform a W test refer to the reference listed. (Ref. 7.1.4)

3.8.3 D-Prime Test

This test is recommended by ANSI N15.15-1974, Assessment of the Assumption of Normality (Employing Individual Observed Values), for moderate to large sample sizes. The D′ Test calculates a test statistic value for the sample population and compares the calculated value to the values for the D′ percentage points of the distribution which are tabulated in ANSI N15.15. The D′ Test is two-sided, which effectively means that the calculated D′ must be bounded by the two-sided percentage points at the stated level of significance. For the given sample size, the calculated value of D′ must lie within the two values provided in the ANSI N15.15 table in order to accept the hypothesis of normality. (Ref. 7.1.4)

3.8.3.1 Equations To Perform The D′ Test

1) First calculate the linear combination of the sample group

$$T = \sum\left[\left(i - \frac{n+1}{2}\right) \times x_i\right]$$ (Ref. 7.1.4)

Where;
x_i - An individual sample data point
i - The number of the sample point
n - Total number of data points

2) Second calculate the S^2 for the sample group

$$S^2 = (n-1)s^2$$ (Ref. 7.1.4)

Where;
s^2 - Unbiased estimate of the sample population variance
n - Total number of data points

3) Third calculate the D′ value for the sample group

$$D' = \frac{T}{S}$$ (Ref. 7.1.4)

3.8.4 Probability Plots

Probability plots are discussed since a graphical presentation of the data can reveal possible reasons for why the data is or is not normal. A probability plot is a graph of the sample data

with the axes scaled for a normal distribution. If the data is normal, the data will tend to follow a straight line. If the data is non-normal, a nonlinear shape should be evident from the graph. The types of probability plots used by this design guide are as follows:

- *Cumulative Probability Plot* - an XY scatter plot of the outlier tested data plotted against the percent probability (P_i) for a normal distribution. P_i is calculated using the following equation:

$$P_i = \frac{100 \times \left(i - \frac{1}{2}\right)}{n} \qquad \text{(Ref. 7.1.1)}$$

where; i = sample number i.e. 1,2,...
n = sample size

NOTE: Refer, as necessary, to Appendix C Section C.4 of the EPRI TR-103335, GUIDELINES FOR INSTRUMENT CALIBRATION EXTENSION/ REDUCTION PROGRAMS.(Ref. 7.1.1)

- *Normalized Probability Plot* - an XY scatter plot of the outlier tested data plotted against the probability for a normal distribution expressed in multiples of the standard deviation.

3.8.5 Coverage Analysis

A coverage analysis is discussed for cases in which the data fails a test for normality, but the assumption of normality may still be a conservative representation of the data.

- *Coverage* - a histogram of the outlier tested data overlaid with the equivalent probability distribution curve for the normal distribution based on the data samples mean and standard deviation. This plot provides a very useful tool in determining normal distribution of the sample data.

3.8.6 Sample Counting Within 1σ and 2σ for the Group

A good method of verifying normality is to calculate the Standard Deviation of the group and count the number of times the absolute value of the samples are less than or equal to one Standard Deviation and repeat the process for two Standard Deviations. The counts would be divided by the total number of samples in the group to determine a percentage. The following table provides values for a normal distribution:

Table 3 – Values For A Normal Distribution

STDEV	Percentages for a Normal Distribution
1 Standard Deviation	68.27%
2 Standard Deviations	95.45%

3.9 Binomial Pass/Fail Analysis For Distributions Considered Not To Be Normal

A pass/fail criteria for component performance simply compares the as found versus as left surveillance drift data against a pre-defined acceptable value of drift. If the drift value is less than the pass/fail criteria, that data point passes; if it is larger than the pass/fail criteria, it fails. By comparing the total number of passes to the number of failures, a probability can be computed for the expected number of component passes in the population. Note that the term failure in this instance does not mean that the component actually failed, only that it exceeded the selected pass/fail criteria for the analysis. Often the pass/fail criteria will be established at a point that clearly demonstrates acceptable component performance. The equations used to determine the Failure Proportion, Normal, Minimum and Maximum Probabilities are as follows:

Failure Proportion

P_f = x/n where;

x = Number of values exceeding the pass/fail criteria (Failures)(Ref. 7.1.1)

n = Total number of drift values in the sample

Normal Probability that a value will pass

$P = 1 - P_f$ (Ref. 7.1.1)

Minimum Probability that a value will pass

$$P_l = 1 - \frac{x}{n} - z \times \sqrt{\left(\frac{1}{n}\right) \times \left(\frac{x}{n}\right) \times \left(1 - \frac{x}{n}\right)}$$ (Ref. 7.1.1)

Maximum Probability that a value will pass

$$P_u = 1 - \frac{x}{n} + z \times \sqrt{\left(\frac{1}{n}\right) \times \left(\frac{x}{n}\right) \times \left(1 - \frac{x}{n}\right)}$$ (Ref. 7.1.1)

where;

P_l = the minimum probability that a value will pass

P_u = the maximum probability that a value will pass

z = the standardized normal distribution value corresponding to the desired confidence level, e.g., z = 1.96 for a 95% confidence level.

The Binomial Pass/Fail Analysis is a good tool for verifying that drift values calculated for calibration extensions are appropriate for the interval. Refer to the EPRI TR-103335, GUIDELINES FOR INSTRUMENT CALIBRATION EXTENSION/ REDUCTION PROGRAMS for the necessary detail to perform a pass/fail analysis. (Ref. 7.1.1)

3.10 Time-Dependent Drift Analysis

The component/loop drift calculated in the previous sections represented a predicted performance limit without any consideration of whether the drift may vary with time between calibrations or component age. This section discusses the importance of understanding the time-dependent performance and the impact of any time-dependency on an analysis. Understanding the time dependency can be either important or unimportant, depending on the application. A time dependency analysis is important whenever the drift analysis results are intended to support an extension of calibration intervals.

3.10.1 Limitations of Time Dependency Analyses

EPRI TR-103335, GUIDELINES FOR INSTRUMENT CALIBRATION EXTENSION/ REDUCTION PROGRAMS performed drift analysis for numerous components at several nuclear plants as part of their project. The data evaluated did not demonstrate any significant time-dependent or age-dependent trends. Time dependency may have existed in all of the cases analyzed but was insignificant in comparison to other uncertainty contributors. Because time dependency cannot be completely ruled out, there should be an ongoing evaluation to verify that component drift continues to meet expectations whenever calibration intervals are extended. (Ref. 7.1.1)

3.10.2 Standard Deviations And Means at Different Calibration Intervals (Time Dependency Plot)

This analysis technique is the most recommended by the NRC's review of EPRI TR-103335 (Reference 7.4.9) method of determining time dependent tendencies in a given sample pool. The test consists simply of segregating the drift data into different groups corresponding to different ranges of calibration or surveillance intervals and comparing the standard deviations and means for the data in the various groups. The purpose of this type of calculation is to determine if the standard deviation or mean tends to become larger as the time between calibrations increases. This is best viewed by plotting the Mean and Standard Deviation against the Average Interval for each bin. (Ref. 7.4.9)

3.10.3 XY Scatter Plots

- *Drift Interval* - an XY scatter plot that shows the outlier tested % Drift data plotted against the time interval between tests for the data points. This plot method relies upon the human eye to discriminate the plot for any trend in the data to exhibit a time dependency.

- *Drift Interval Regression* - an XY scatter plot that fits a line through the outlier tested % Drift data plotted against the time interval between tests for the data points using the "least squares" method to predict values for the given data set. The predicted line is plotted through the actual data for use in predicting drift over time. It is important to note that data outliers can have dramatic effect upon the regression line.

- *Absolute Value Drift Interval* - an XY scatter plot that shows the Absolute Value of the outlier tested % Drift data plotted against the time interval between tests for the data points. This plot is intended to demonstrate any tendency for a given group to drift, in either direction, over time. This plot method relies upon the human eye to discriminate the plot for any trend in the data to exhibit a time dependency.

- *Absolute Value Drift Interval Regression* - an XY scatter plot that fits a line through the Absolute Value of the outlier tested % Drift data plotted against the time interval between tests for the data points using the "least squares" method to predict values for the given data set. The predicted line is plotted through the actual data for use in predicting drift, in either direction, over time. It is important to note that data outliers can have dramatic effect upon the regression line.

3.10.4 Additional Time Dependency Analyses

- *Instrument Resetting Evaluation* - For data sets that consist of a single calibration interval the time dependency determination may be accomplished simply by evaluating the frequency at which instruments require resetting. This type of analysis is particularly useful when applied to extend monthly Technical Specification surveillances to quarterly. However, is less useful for instruments such as sensors or relays that may be reset at each calibration interval regardless of whether the instrument was already in calibration.

  The Instrument Resetting Evaluation may be performed only if the devices in the sample pool are shown to be stable, not requiring adjustment (i.e. less than 5% of the data shows that adjustments were made). Methodology for calculating the drift is as follows:

Monthly As Found/As Left
(As Found Current Calibration - As Left Previous Calibration)
or $AF_1 - AL_2$ (Ref. 7.1.1)

Quarterly As Found/As Left using Monthly Data
$(AF_1 - AL_2) + (AF_2 - AL_3) + (AF_3 - AL_4)$ (Ref. 7.1.1)

3.10.5 Age-Dependent Drift Considerations

Age-dependency is the tendency for a component's drift to increase in magnitude as the component ages. This can be assessed by plotting the as found value for each calibration minus the previous calibration as left value of each component over the period of time for which data is available. Random fluctuations around zero may obscure any age-dependent drift trends. By plotting the absolute values of the as found versus as left calibration data, the tendency for the magnitude of drift to increase with time can be assessed.

3.10.6 Application of Time Dependent Tendencies to Setpoint/Uncertainty Calculations

When a group is determined to have Time Dependent tendencies using the tools and tests outlined in Section 0 and the interval is to be extended beyond the current calibration interval the following must be performed:

Determine the Time Dependency strength (Strong, Moderate, None) by reviewing the Time Dependency Plot, XY Scatter Plots and ANOVA Statistics associated with the Regression Lines.

3.10.6.1 Data exhibiting no Time Dependency requires no manipulation of the Analyzed Drift Value for the extendend calibration interval with the exception noted in section 0.

3.10.6.2 Data exhibiting a Moderate Time Dependency requires the Analyzed Drift Value and applicable bias be extended to the new interval using the following equation:

$$DA_x = DA_a \sqrt{\frac{t_x}{t_a}}$$

where,
DA_x = analyzed drift in %CS for new interval
DA_a = analyzed drift in %CS for analyzed interval
t_x = instrument test interval (including 125% of nominal test interval for technical specification devices).
t_a = drift interval of analyzed data.

3.10.6.4 Data exhibiting a Strong Time Dependency requires the Analyzed Drift Value and applicable bias be extended to the new interval using the following equation:

$$DA_x = DA_a \frac{t_x}{t_a}$$

where,

DA_x = analyzed drift in %CS for new interval

DA_a = analyzed drift in %CS for analyzed interval

t_x = instrument test interval (including 125% of nominal test interval for technical specification devices).

t_a = drift interval of analyzed data.

3.11 Calibration Point Drift

For devices with multiple calibration points (e.g., transmitters, indicators, etc.) the Drift-Calibration Point Plot is a useful tool for comparing the amount of drift exhibited by the group of devices at the different calibration points. The plot consists of a line graph of tolerance interval as a function of calibration point.

3.12 Drift Bias Determination

If an instrument or group of instruments consistently drifts predominately in one direction the drift is assumed to have a bias. When the absolute value of the calculated average for the sample pool exceeds the values in Table 4 for the given sample size and calculated standard deviation the average is treated as a bias to the drift term. The application of the bias must be carefully considered so that the overall drift term is not reduced in the non-conservative direction. Refer to Example 1 below.

Table 4 – Maximum Values of Non-Biased Mean

Sample Size (n)	Normal Deviate (t) @ 0.025 for 95% Confidence	Maximum Value of Non-Biased Mean (x_{crit}) For Given STDEV (s)								
		s ≥ 0.10%	s ≥ 0.25%	s ≥ 0.50%	s ≥ 0.75%	s ≥ 1.00%	s ≥ 1.50%	s ≥ 2.00%	s ≥ 2.50%	s ≥ 3.00%
≤5	2.571	0.115	0.287	0.575	0.862	1.150	1.725	2.300	2.874	3.449
≤10	2.228	0.070	0.176	0.352	0.528	0.705	1.057	1.409	1.761	2.114
≤15	2.131	0.055	0.138	0.275	0.413	0.550	0.825	1.100	1.376	1.651
≤20	2.086	0.047	0.117	0.233	0.350	0.466	0.700	0.933	1.166	1.399
≤25	2.060	0.041	0.103	0.206	0.309	0.412	0.618	0.824	1.030	1.236
≤30	2.042	0.037	0.093	0.186	0.280	0.373	0.559	0.746	0.932	1.118
≤40	2.021	0.032	0.080	0.160	0.240	0.320	0.479	0.639	0.799	0.959
≤60	2.000	0.026	0.065	0.129	0.194	0.258	0.387	0.516	0.645	0.775
≤120	1.980	0.018	0.045	0.090	0.136	0.181	0.271	0.361	0.452	0.542
>120	1.960	See Equation Below								

The maximum values of non-biased mean (Xcrit) for a given standard deviation (s) and sample size (n) is calculated using the following formula:

$$x_{crit} = t \times \frac{s}{\sqrt{n}}$$ (Ref. 7.4.8)

Where;

Xcrit	=	Maximum value of non-biased mean for a given s & n, expressed in %
T	=	Normal Deviate for a t-distribution @ 0.025 for 95% Confidence
S	=	Standard Deviation of sample pool
n	=	Sample pool size

Example of determining and applying bias to the analyzed drift term:

1) Transmitter Group With a Biased Mean - A group of transmitters are calculated to have a standard deviation of 1.150%, average of –0.355% with a count of 47. From table 4 the maximum value that the average could be is ± 0.258%. The analyzed drift term for a 95%/95% tolerance interval level is shown as DA = –0.355% ± 1.150% x 2.408 (TIF from Table 1 for 47 samples) or DA = –0.355% ± 2.769%. For conservatism the DA term for the positive direction is not reduced by the bias value where as the negative direction is summed with the bias value so; DA = + 2.769%, – 3.124%

2) Transmitter Group With a Non-Biased Mean - A group of transmitters are calculated to have a standard deviation of 1.150%, average of 0.100% with a count of 47. From table 4 the maximum value that the average could be is ± 0.258%. The analyzed drift term for a 95%/95% tolerance interval level is shown as DA = ± 1.150% x 2.408 (TIF from Table 1 for 47 samples) or DA = ± 2.769%.

3.13 Time Dependent Drift Uncertainty

When calibration intervals are extended beyond the range for which historical data is available, the statistical confidence in the ability to predict drift is reduced. This reduced confidence is translated to a higher drift uncertainty and is not dependent upon the observation of time dependency within the original sample. This Design Guide recommends increasing the Tolerance Interval Factor to account for the higher drift uncertainty at extended intervals.

For example: components that perform functions which satisfy a specific Technical Specification value (rigor level 1), the normal tolerance interval factor is 95%/95% indicating a 95% level of confidence that 95% of the population is contained within the stated interval. To account for the drift uncertainty associated with extension of the calibration interval the confidence level would be increased to 99% or 99%/95%. An increased confidence level shall be applied to calibration interval extensions regardless of detected time dependency.

3.14 Shelf Life Of Analysis Results

Any analysis result based on performance of existing components has a shelf life. In this case, the term shelf life is used to describe a period of time extending from the present into the future during which the analysis results are considered valid. Predictions for future component/loop performance are based upon our knowledge of past calibration performance. This approach assumes that changes in component/loop performance will occur slowly or not at all over time. For example, if evaluation of the last ten years of data shows the component/loop drift is stable with no observable trend, there is little reason to expect a dramatic change in performance during the next year. However, it is also difficult to claim that an analysis completed today is still a valid indicator of component/loop performance ten years from now. For this reason, the analysis results should be re-verified periodically (every 5-7 years).

Depending on the type of component/loop, the analysis results are also dependent on the method of calibration, the component/loop span, and the M&TE accuracy. Any of the following program or component/loop changes should be evaluated to determine if they affect the analysis results:

- Changes to M&TE accuracy.
- Changes to the component or loop (e.g. span, environment, manufacturer, model, etc.)
- Calibration procedure changes which alter the calibration methodology.

4 PERFORMING AN ANALYSIS

The E & C Department initiated a data collection effort in November 1995. The collected data was entered into Microsoft Excel workbooks grouped by surveillance test or calibration procedure. Each workbook contains a spreadsheet tab for each sub-group of components contained by the surveillance test or calibration procedure (e.g. OP4310.XLS contains a spreadsheet tab for the Master Trip Unit trips, Master Trip Unit indicators, Slave Trip Unit trips, Transmitters and Indicators covered by the surveillance test). In order to evaluate a group of components (e.g. all Rosemount Trip Units) data from multiple workbooks would have to be consolidated to a new workbook.

4.1 Populating The Spreadsheet

4.1.1. Determine the component group to be analyzed (e.g., all Rosemount Trip Units).
4.1.2. Develop a list of component numbers, manufacturers, models, component types, brief descriptions, surveillance tests, calibration procedures and calibration information (spans, setpoints, etc.).
4.1.3. Determine the data to be collected following the guidance of sections 3.4 through 3.6 of this Design Guide.
4.1.4. Identify, locate and collect data for the component group to be analyzed (e.g., all Surveillance Tests for the Rosemount Trip Units completed to present).
4.1.5. Sort the data by surveillance test or calibration procedure if more than one test/procedure is involved.
4.1.6. Obtain and enter on an index sheet the Surveillance or Calibration Procedure Number, Tag Number, Manufacturer and Model Number, Spans, Required Trips, Indications or Outputs for all devices to analyzed.
4.1.7. Enter the Date, as found and as left values on the appropriate component/group sheet starting with the most recent data using the example formats provided in Figures 1&2.
4.1.8. Review the notes on each calibration data sheet to determine possible contributors for a given data point being an outlier. The notes should be condensed and entered on to the excel spreadsheet for the applicable calibration points.
4.1.9. Calculate the time interval by subtracting the second date from the first date for the data set as shown in the example formats provided in Figures 1&2.
4.1.10. Calculate the % Drift by subtracting the second dates as left value from the first dates as found value divided by the device span for the data set. Format the spreadsheet cells to show the value in percent span (0.0000%).
4.1.11. Flag the calibration points that are suspected to be outliers due to the calibration notes reviewed in step 4.1.8.

Figure 1 - Sample Spreadsheet (Switches, Trip Units & Other Tripping Devices)

OP 4310: SCRAM DISCHARGE INSTRUMENT VOLUME
HIGH WATER FUNCT/CAL
DRIFT ANALYSIS LT-3-231A(M) SPAN = 16 mADC

Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP
	Required Trip 50.0 "H20 (=16.70 mADC)			
2/22/96	As Found		16.68	
	As Left	94	16.68	0.0000%
11/20/95	As Found		16.68	
	As Left	25	16.68	0.0000%
10/26/95	As Found		16.68	
	As Left	64	16.68	0.0000%
8/23/95	As Found		16.68	
	As Left		16.68	

Value represents the number of days between 2/22/96 and 11/20/95.

Value represents the 2/22/96 As Found minus the 11/20/95 As Left divided by the device span.

Note: The shaded areas show where data from surveillance tests or calibration procedures are inputted on the spreadsheet.

Figure 2 - Sample Spreadsheet (Transmitters, Indicators, Recorders & Other Non-Tripping Devices)

OP 4312: REACTOR VESSEL HIGH PRESSURE SCRAM FUNCTIONAL TEST/CAL

DRIFT ANALYSIS   PT-2-3-55A   COMPONENT CALIBRATION   SPAN = 16 mADC

Date	Status	Interval (Days)	Initial Data 13 PSI	763 PSI	1513 PSI	Raw Drift Data 13 PSI	763 PSI	1513 PSI
		Required	4 mADC	12 mADC	20 mADC	4 mADC	12 mADC	20 mADC
3/28/95	As Found		4.01	12.02	20.06			
	As Left	575	4.00	11.99	20.00	0.1250%	0.3750%	0.5000%
8/30/93	As Found		3.99	11.96	19.98			
	As Left	526	3.99	11.96	19.98	-0.0620%	-0.2500%	-0.3750%
3/22/92	As Found		1.00	3.00	5.01			
	As Left	731	1.00	3.00	5.01	0.0000%	0.0000%	0.2500%
3/22/90	As Found		1.000	3.000	5.000			
	As Left		1.000	3.000	5.000			

Value represents the number of days between 3/28/95 and 8/30/93.

Values represent the 3/28/95 As Found minus the 8/30/93 As Left divided by the device span.

Note: The shaded areas show where data from surveillance tests or calibration procedures are inputted on the spreadsheet.

4.2. Spreadsheet Performance Of Basic Statistics

Basic statistics include, at a minimum, determining the number of data points in the sample, the average, standard deviation, variance, minimum, maximum, kurtosis, skewness and the Tolerance Interval Factor contained in each data column. This section provides the specific details for using Microsoft Excel. Other spreadsheet programs that are similar in function are acceptable for use to perform the data analysis providing all analysis requirements are met.

4.2.1. For each sub-group of components create and name a new spreadsheet tab titled Group Raw Drift.

Example: OP-4311 contains the calibration data for the Drywell High Pressure Scram/Isolation Instrumentation which includes 4 pressure transmitters and 4 trip units of the same spans, setpoints, manufacturer and model numbers. For a drift calculation covering the trip units the data outlined in step 4.2.2 would be copied to a new spreadsheet titled OP4311 MTU Group.

4.2.2. Copy the raw drift expressed in % Span, the test interval in days and the tag number from each of the component spreadsheet tabs to the appropriate Group Drift worksheet tab.

4.2.3. Determine the number of data points contained in each column for each initial group by using the "COUNT" function. Example cell format =COUNT(C2:C133); The Count function returns the number of all populated cells within the range of cells C2 through C133.

4.2.4. Determine the average for the data points contained in each column for each initial group by using the "AVERAGE" function. Example cell format =AVERAGE(C2:C133); The Average function returns the average of the data contained within the range of cells C2 through C133.

4.2.5. Determine the standard deviation for the data points contained in each column for each initial group by using the "STDEV" function. Example cell format =STDEV(C2:C133); The Standard Deviation function returns the measure of how widely values are dispersed from the mean of the data contained within the range of cells C2 through C133. Formula used by Microsoft Excel to determine the standard deviation:

$$s = \sqrt{\frac{n\sum x^2 - \left(\sum x\right)^2}{n(n-1)}}$$ (Ref. 7.4.6)

Where;

x	- Sample data values (x_1, x_2, x_3, ...)
s	- Standard deviation of all sample data points
n	- Total number of data points

4.2.6. Determine the variance for the data points contained in each column for each initial group by using the "VAR" function or "VARP" if the entire population is contained within the spreadsheet. Example cell format =VAR(C2:C133); The Variance function returns the measure of how widely values are dispersed from the mean of the data contained within the range of cells C2 through C133. Formula used by Microsoft Excel to determine the variance:

VAR (Variance of the sample population): (Ref. 7.4.6)

$$s^2 = \frac{n\sum x^2 - \left(\sum x\right)^2}{n(n-1)}$$

VARP (Variance of the population): (Ref. 7.4.6)

$$\sigma^2 = \frac{n\sum x^2 - \left(\sum x\right)^2}{n^2}$$

Where;

x	- Sample data values (x_1, x_2, x_3, ...)
s^2	- Variance of the sample population.
σ^2	- Variance of the entire population.
n	- Total number of data points

4.2.7. Determine the kurtosis for the data points contained in each column for each initial group by using the "KURT" function. Example cell format =KURT(C2:C133); The Kurtosis function returns the relative peakedness or flatness of the distribution within the range of cells C2 through C133. Formula used by Microsoft Excel to determine the kurtosis:

$$KURT = \left\{ \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum \left(\frac{x_i - \bar{x}}{s} \right)^4 \right\} - \frac{3(n-1)^2}{(n-2)(n-3)}$$ (Ref. 7.4.6)

Where ;

x	- Sample data values ($x_1, x_2, x_3, ...$)
n	- Total number of data points.
S	- Sample Standard Deviation.

4.2.8. Determine the skewness for the data points contained in each column for each initial group by using the "SKEW" function. Example cell format =SKEW(C2:C133); The Skewness function returns the degree of symmetry around the mean of the cells contained within the range of cells C2 through C133. Formula used by Microsoft Excel to determine the skewness:

$$SKEW = \frac{n(n+1)}{(n-1)(n-2)}\sum\left(\frac{x_i - \overline{x}}{s}\right)^3$$

(Ref. 7.4.6)

Where;

x	- Sample data values ($x_1, x_2, x_3, ...$)
n	- Total number of data points.
s	- Sample Standard Deviation.

4.2.9. Determine the maximum value for the data points contained in each column for each initial group by using the "MAX" function. Example cell format =MAX(C2:C133); The Maximum function returns the largest value of the cells contained within the range of cells C2 through C133.

4.2.10. Determine the minimum value for the data points contained in each column for each initial group by using the "MIN" function. Example cell format =MIN(C2:C133); The Minimum function returns the smallest value of the cells contained within the range of cells C2 through C133.

4.2.11. Determine the median value for the data points contained in each column for each initial group by using the "MEDIAN" function. Example cell format =MEDIAN(C2:C133); The median is the number in the middle of a set of numbers; that is, half the numbers have values that are greater than the median, and half have values that are less. If there is an even number of numbers in the set, then MEDIAN calculates the average of the two numbers in the middle.

4.2.12. Create and name a new workbook titled after the group of components to be analyzed. (e.g. MTU.XLS for Rosemount Master Trip Units)

4.2.13. Copy the Group Drift spreadsheets from the applicable workbooks to the new group workbook.

4.2.14. Review the statistics and component data of the sub-groups to determine the acceptability for combination. This would entail looking at the manufacturer, model, calibration span, setpoints, time intervals, stdev, avg, location, environment, etc. Refer to Section 3.6.

4.2.15. Perform a t-Test in accordance with step 3.6.4 on each possible sub-group combination to test for the acceptability of combining the data.

Acceptability for combining the data is indicated when the absolute value of the Test Statistic (t Stat) is greater than the absolute value of the probability for a two tailed distribution [P(T<=t) two-tail]. Example: t Stat for combining sub-group A & B may be 0.703 which is larger than the P(T<=t) two-tail of 0.485.

4.2.16. Combine the sub-groups that passed the required tests in steps 4.2.14 & 4.2.15 into a larger group or groups as necessary.

4.2.17. Repeat steps 4.2.3 through 4.2.11 on the group(s) formed in step 4.2.16.

4.2.18. Where multiple groups are formed from the initial sub-groups additional testing in accordance with step 4.2.14 and 4.2.15 may be performed to determine the suitability of further combinations.

4.3 Outlier Detection And Expulsion

Refer to Section 3.7 for a detailed explanation of Outliers.

4.3.1. Following the guidance in Section 3.8 or if necessary Section 3.9 verify that the raw data is normally distributed or approximately normally distributed.

4.3.2. Obtain the Critical Values for the t-Test from Table 2 which is based on the sample size of the data contained within the specified range of cells, use the COUNT value to determine the sample size.

4.3.3. Use the "Conditional Formatting Tool" or manually format the spreadsheet cells for the outlier test using the following:

= If{Absolute Value(Raw Trip Value - Group Average) + Group Standard Deviation < Critical Value for t, Then the Raw Trip Value is True}
Sample = IF(ABS(C2-C$135) / C$136 < 3.28,C2,"")

4.3.4. Perform the outlier test for all the samples.

4.3.5. Recalculate the Average, Median, Standard Deviation, Variance, Minimum, Maximum, Kurtosis, Skewness and Count for the outlier tested data.

4.3.6. Calculate the percentage of samples expelled as outliers from the original sample population (Example = $COUNT_{outlier\ tested}$ / $COUNT_{original}$). Up to 5% of the original sample population may be expelled as outliers providing justification is provided for each outlier.

4.3.7. Once the outliers are statistically determined each sample point identified as an outlier must be justified prior to expulsion. Justification examples are provided in Section. If no justification can be found the sample point cannot be expelled from the pool.

4.3.8. Calculate the Absolute Value for each outlier tested data point within the group in a separate column.

4.4. Calculate The Analyzed Drift Value (DA)

The Analyzed Drift Value is calculated by multiplying the standard deviation of the outlier tested group by the Tolerance Interval Factor for the sample size. The Analyzed Drift Value is not comprised of drift alone, this value also contains errors from M&TE, normal temperature variations, device reference accuracy, human errors, normal humidity effects, normal radiation effects, normal vibration effects, misapplication, improper installation, or other operating effects that effect component calibration.

4.4.1. Use the COUNT value of the outlier tested data to determine the sample size and refer to Section 3.4 for the rigor level of the data.

4.4.2. Obtain the appropriate Tolerance Interval Factor (TIF) for the rigor level and size of the sample set. Table 1 lists the 95%/95% TIFs, refer to Attachment 3 for other TIF multipliers. Note: TIFs other than 95%/95% must be evaluated by Design Engineering prior to use.

4.4.3. For a generic data analysis multiple Tolerance Interval Factors may be used providing a clear tabulation of results is included in the analysis showing each value for the multiple levels of rigor. (e.g. Rigor Level 1 - TIF = 95%/95%, Rigor Level 4 - TIF = 75%/95%, etc.)

4.4.4. Multiply the Tolerance Interval Factor by the standard deviation for the data points contained in each column of the group (e.g. 0%, 50%, 100%, etc.).

4.4.5. Determine if the sample pool contains a bias in the average following the guidance provided in Section 3.12.

4.4.6. If the analyzed drift term calculated above is applied to the existing calibration interval application of additional drift uncertainty is not necessary.

4.4.7. When calculating drift for calibration intervals that exceed the historical calibration intervals a Drift Uncertainty allowance must be considered even if the data does not exhibit a time dependency. Refer to step 3.13.

4.5 Time Dependency Test

This test segregates the data into groups based on the time intervals (e.g. 0-6, 6-12, 12-18, 18-24 and 24-30 months). The standard deviation is then determined for each group and compared to the remaining groups. This test is useful to confirm the regression plots.

4.5.1. Create a new spreadsheet tab titled "Time Dependency".
4.5.2. Copy the outlier tested % drift and associated time interval to the Time Dependency tab.
4.5.3. Sort the data ascending by the time interval.
4.5.4. Group the data in logical time intervals (e.g. 0-6, 6-12, 12-18, 18-24 and 24-30 months).
4.5.5. Determine the Standard Deviation and Mean of each group.
4.5.6. Plot and compare the Standard Deviations and Means of each group to determine if the Standard Deviation increases as the time interval increases.

4.6 Normality Test

This test calculates the Standard Deviation of the Outlier Tested data and counts how many samples fall within 1σ and 2σ.

4.6.1. Create a new spreadsheet tab titled "STDEV" or "Standard Deviation".
4.6.2. Copy the outlier tested %Drift to the new tab.
4.6.3. Sort the data ascending.
4.6.4. Calculate the standard deviation for the group using the formula given in step
4.6.5. Calculate the absolute value of the %Drift column.
4.6.6. Determine if a given sample is within 1σ by using the following test: If the absolute value of the sample is ≤ the standard deviation then show the value [IF(ABS(Sample)) ≤ STDEV, ""].
4.6.7. Determine if a given sample is within 2σ by using the following test: If the absolute value of the sample is ≤ 2 standard deviations then show the value [IF(ABS(Sample)) ≤ 2*STDEV, ""].
4.6.8. Count the number of samples that are within 1σ and 2σ.
4.6.9. Divide the counts by the total number of samples in the group to determine a percentage. Values for a normal distribution are provided in Table 3.

4.7 Plot The Spreadsheet Data

The ability to perform regression analysis, histograms and other descriptive statistics tools in Microsoft Excel requires that the "add-ins" include the Data Analysis Tool Pack. The descriptive statistics tools reside under the Tools - Data Analysis pull down menu. Microsoft Excel may need to be reinstalled on the computer performing the data analysis to include the Data Analysis Tool Pack. (Ref. 7.4.6)

4.7.1. Drift Interval Plot

4.7.1.1. Organize the data in columns so that the outlier tested group can be plotted against the time intervals for the group.

4.7.1.2. Select and calculate, if necessary, the time interval representation for the group. For monthly surveillances the time interval may be represented best in days where refueling interval calibrations may be represented in months.

4.7.1.3. Insert the upper and lower limit columns for the data to be plotted. The upper limit is the Tolerance Interval adjusted Standard Deviation or DA term. The lower limit is the negative of the upper limit.

4.7.1.4. Use an XY scatter plot or the Regression Tool to display the % Drift of the sample group over the time intervals for the group bounded by its upper and lower limits.

4.7.2. Absolute Value Drift Interval Plot

4.7.2.1. Organize the data in columns so that the absolute value of the outlier tested group determined in step 4.3.8 can be plotted against the time intervals for the group.

4.7.2.2. Select and calculate if necessary the time interval representation for the group. For monthly surveillance's the time interval may be represented best in days where refueling interval calibrations may be represented in months.

4.7.2.3. Insert the upper limit column for the data to be plotted. The upper limit is the Tolerance Interval adjusted Standard Deviation or DA term.

4.7.2.4. Use an XY scatter plot or the Regression Tool to display the Absolute Value of the % Drift of the sample group over the time intervals for the group bounded by its upper and lower limits.

4.7.3. Cumulative Probability Plot

4.7.3.1. Create a new spreadsheet tab titled "Probability".

4.7.3.2. Copy the outlier tested data to the Probability tab.

4.7.3.3. Sort the outlier tested % Drift data ascending.

4.7.3.4. Create a column titled "Sample #" and assign a counter to each % Drift data point (e.g. 1,2,3...).

4.7.3.5. Create a column titled "Probability" and calculate the probability term for each data point using the equation provided in step 3.8.4.

4.7.3.6. To create the Probability Plot use the regression tool selecting the line fit chart. Y Input Range = calculated probability; X Input Range = % Drift.

4.7.4. Normalized Probability Plot

4.7.4.1. Calculate the multiple of the standard deviation for each point based on a normal distribution using the probability terms calculated in step 4.7.2.5 from the Probability Tab. See EPRI TR-103335, GUIDELINES FOR INSTRUMENT CALIBRATION EXTENSION/ REDUCTION PROGRAMS pages C-21 & 22 for probability vs. stdev tables. (Ref. 7.1.1)

4.7.4.2. After calculating the multiple of the STDEV round to nearest interval e.g. -3, -2.9, -2.8, etc.

4.7.4.3. Use the Regression Tool with the line fit to create the normalized probability plot of drift Vs multiple of the stdev using the % Drift as the x range and the rounded multiple as the y range.

4.7.5. Coverage Plot (Histogram)

4.7.5.1. Plot a histogram using the sorted outlier tested % Drift data from the Probability Tab and the Histogram Tool from the Data Analysis Tool Pack defining the bin ranges or allowing Excel to select the bin ranges.

4.7.5.2. Create an overlay of a normal distribution and plot over the histogram for the data set.

4.7.6. Regression Statistics

4.7.6.1. Raw Regression Statistics – From the tools menu in Excel select "Data Analysis", then "Regression". Using the Regression tool determine the ANOVA statistics for the Raw data column (Y axis) versus the date interval column (X axis).

4.7.6.2. Absolute Value Regression Statistics – From the tools menu in Excel select "Data Analysis", then "Regression". Using the Regression tool determine the ANOVA statistics for the Absolute Value Raw data column (Y axis) versus the date interval column (X axis).

4.7.7. Adjust the page setup for each page of the data analysis to ensure that printing is grouped appropriately and easily understood. Ensure that the date, title, file name and page number is displayed in the Header/Footer of each page.

4.7.8. Print the following work sheets and plots:

4.7.8.1. Raw Data

4.7.8.2. Grouped Data

4.7.8.3. t-Tests

4.7.8.4. Statistics Summary

4.7.8.5. XY Scatter Plots – Raw Data

4.7.8.6. XY Scatter Plots with Regression Line – Raw Data

4.7.8.7. Absolute Value XY Scatter Plots

4.7.8.8. Absolute Value XY Scatter Plots with Regression Line

4.7.8.9. Cumulative Probability Plots

4.7.8.10. Normalized Probability Plots

4.7.8.11. Histograms

4.7.8.12. Time Dependency Plots (STDEV & Mean vs. Time)

4.7.8.13. ANOVA Regression Statistics – Raw Data

4.7.8.14. ANOVA Regression Statistics – Absolute Value Data

4.7.8.15. Standard Deviation Binning for 1σ and 2σ to determine Normalcy

4.7.8.16. Pass/Fail worksheet – if applicable

4.7.8.17. Other worksheets used for data evaluation as necessary

4.8 Analyzing The Data & Charts

This Design Guide is intended to be used in conjunction with various statistical analysis texts. This Design Guide does not provide step by step instruction in the analysis of the data, plots and graphs. The Responsible Engineer performing the data analyses shall have the necessary training, knowledge and understanding of basic statistics to interpret the data, plots and graphs.

Refer to the EPRI TR-103335, GUIDELINES FOR INSTRUMENT CALIBRATION EXTENSION/REDUCTION PROGRAMS as a guide to perform the analysis of the various plots and graphs.

4.8.1. Probability plots are discussed in Section 3.8.4 of this Design Guide.

4.8.2. Coverage Analysis (Histograms) are discussed in Section 3.8.5 of this Design Guide.

4.8.3. The XY scatter plots and regression plots are discussed in Section 3.10.2 of this Design Guide.

4.8.4. Section 3.8 discusses the verification of normality.

4.8.5. Section 3.9 discusses the option of a pass/fail analysis for distributions considered not normal.

4.8.6. Section 3.10 discusses time dependency evaluations. It is recommended that for time dependency calls multiple tools are utilized (Time Dependency Plot, XY Scatter Raw and Absolute Value and the ANOVA Statistics).

4.8.7. Application of the Analyzed Drift (DA) term is discussed in the Instrument Uncertainty and Setpoints Design Guide. (Ref. 7.3.2)

4.8.8. Application of bias in the Analyzed Drift (DA) term is discussed in Section 0

4.8.9. Application of Drift Uncertainty is discussed in Section 3.13

5 CALCULATIONS

5.1. Drift Calculations

Perform a Drift Calculation in accordance with WE-103 or AP-0017 ensuring that the following minimum requirements are met: (Ref. 7.2.1 & 7.2.3)

5.1.1. The title includes the terms Drift Calculation and the Manufacturer/Model number of the component group analyzed.

5.1.2. The calculation objective shall:

5.1.2.1. Describe, at a minimum, that the objective of the calculation is to document the drift analysis results for the component group.

5.1.2.2. Provide a list for the group of all pertinent information in tabular form (e.g. Tag Numbers, Manufacturer, Model Numbers, ranges and calibration spans).

5.1.3. The method of solution shall describe, at a minimum, a summary of the methodology used to perform the drift analysis outlined by this Design Guide. Exceptions taken to this Design Guide shall be included in this section including basis and references for exceptions.

5.1.4. The actual calculation/analysis shall provide:

5.1.4.1. The Statistics Summary for the analyzed group.

5.1.4.2. The applicable Tolerance Interval Factors (provide detailed discussion and justification if other than 95%/95%).

5.1.4.3. The calculated Analyzed Drift (DA) Term(s).

5.1.4.4. Bias contained in the average if applicable.

5.1.4.5. The hard copy of drift analysis as an attachment to the calculation.

5.1.5. The results and conclusions section shall provide detailed discussions on:

5.1.5.1. The analysis data.

5.1.5.2. Application of any bias terms.

5.1.5.3.The analysis plots and graphs.

5.1.5.4.Time dependency.

5.1.5.5.Normality.

5.1.5.6.Acceptability of the data for use in Setpoint/Uncertainty Calculations.

5.1.5.7.DEP-15 Criteria

DEP-15 requires the impact to plant programs, procedures, licensing and design documents are considered. The calculations shall be reviewed for impact considerations. To fully satisfy DEP-15 requirements, the calculations undergo reviews by all departments and Programs that could be impacted by the results and conclusions. [Ref. 7.2.5]

The drift calculations are used as a design input by the Setpoint and Uncertainty calculations performed by Design Engineering. The following will be considered and will be addressed by the setpoint uncertainty calculation or via the Interdepatmental review process:

FSAR changes
Technical Specifications
Procedures
Technical Programs
Prints
Related Design Basis Calculations (input/output)
Design Basis Documents

5.2. Setpoint/Uncertainty Calculations

To apply the results of the drift analyses and drift calculations to a specific device or loop will require, in most cases, that a setpoint/uncertainty calculation be performed or revised in accordance with WE-103 or AP-0017. (Ref. 7.2.1 & 7.2.3)

6. DEFINITIONS

95%/95% -	Standard statistics term meaning that the results have a 95% confidence (γ) that at least 95% of the population will lie between the stated interval (P) for a sample size (n).	Ref. 7.1.1
Analyzed Drift (DA) – Synonymous with ADR	A term representing the errors determined by a completed drift analysis for a group. Uncertainties which may be represented by the analyzed drift term are component accuracy errors, M&TE errors, personnel-induced or human related errors, ambient temperature and other environmental effects, power supply effects, misapplication errors and true component drift.	Step 3.3.1.3
As Found (FT) -	The condition in which a channel, or portion of a channel, is found after a period of operation and before recalibration.	Ref. 7.1.3
As Left (CT) -	The condition in which a channel, or portion of a channel, is left after calibration or final setpoint device verification.	Ref. 7.1.3
Bias (B) -	A shift in the signal zero point by some amount.	Ref. 7.1.1
Calibrated Span (CS) -	The maximum calibrated upper range value less the minimum calibrated lower range value.	Ref. 7.1.1
Calibration Interval -	The elapsed time between the initiation or successful completion of calibrations or calibration checks on the same component or loop.	Ref. 7.1.1
Chi-Square Test -	A test to determine if a sample appears to follow a given probability distribution. This test is used as one method for assessing whether a sample follows a normal distribution.	Ref. 7.1.1
Commercial Grade Software -	Software that is not unique to, or used only in nuclear facilities, and which may be purchased on the basis of the vendor's published description, such as in a catalog.	Ref. 7.2.3
Confidence Interval -	An interval that contains the population mean to a given probability.	Ref. 7.1.1
Coverage Analysis -	An analysis to determine whether the assumption of a normal distribution effectively bounds the data. A histogram is used to graphically portray the coverage analysis.	Ref. 7.1.1
Cumulative Distribution -	An expression of the total probability contained within an interval from $-\infty$ to some value x.	Ref. 7.1.1
D-Prime Test -	A test to verify the assumption of normality for moderate to large sample sizes.	Ref. 7.1.1
Dependent -	In statistics, dependent events are those for which the probability of all occurring at once is different than the product of the probabilities of each occurring separately. In setpoint determination, dependent uncertainties are those uncertainties for which the sign or magnitude of one uncertainty affects the sign or magnitude of another uncertainty.	Ref. 7.1.1
Drift -	An undesired change in output over a period of time where change is unrelated to the input, environment, or load.	Ref. 7.1.2

Error -	The algebraic difference between the indication and the ideal value of the measured signal.	Ref. 7.1.2
Functionally Equivalent -	Components with similar design and performance characteristics that can be combined to form a single population for analysis purposes.	Ref. 7.1.1
Histogram -	A graph of a frequency distribution.	Ref. 7.1.1
Independent -	In statistics, independent events are those in which the probability of all occurring at once is the same as the product of the probabilities of each occurring separately. In setpoint determination, independent uncertainties are those for which the sign or magnitude of one uncertainty does not effect the sign or magnitude of any other uncertainty.	Ref. 7.1.1
Instrument Channel -	An arrangement of components and modules as required to generate a single protective action signal when required by a plant condition. A channel loses its identity where single protective action signals are combined.	Ref. 7.1.2
Instrument Range -	The region between the limits within which a quantity is measured, received or transmitted, expressed by stating the lower and upper range values.	Ref. 7.1.2
Kurtosis -	A characterization of the relative peakedness or flatness of a distribution compared to a normal distribution. A large kurtosis indicates a relatively peaked distribution and a small kurtosis indicates a relatively flat distribution.	Ref. 7.1.1
M&TE -	Measuring and Test Equipment.	Ref. 7.1.1
Maximum Span -	The component's maximum upper range limit less the maximum lower range limit.	Ref. 7.1.1
Mean -	The average value of a random sample or population.	Ref. 7.1.1
Median -	The value of the middle number in an ordered set of numbers. Half the numbers have values that are greater than the median and half have values that are less than the median. If the data set has an even number, the median is the average of the two middle numbers.	Ref. 7.1.1
Module -	Any assembly of interconnected components that constitutes an identifiable device, instrument or piece of equipment. A module can be removed as a unit and replaced with a spare. It has definable performance characteristics that permit it to be tested as a unit.	Ref. 7.1.2
Normality Test -	A statistics test to determine if a sample is normally distributed.	Ref. 7.1.1
Outlier -	A data point significantly different in value from the rest of the sample.	Ref. 7.1.1
Population -	The totality of the observations with which we are concerned. A true population consists of all values, past, present and future.	Ref. 7.1.1
Probability -	Is that branch of mathematics which deals with the assignment of relative frequencies of occurrence (confidence) of the possible outcomes of a process or experiment according to some mathematical function.	Ref. 7.4.8
Prob. Density	An expression of the distribution of probability for a continuous	Ref. 7.1.1

Function -	function.	
Probability Plot -	A type of graph scaled for a particular distribution in which the sample data will plot as approximately a straight line if the data follows that distribution. For example, normally distributed data will plot as a straight line on a probability plot scaled for a normal distribution; the data may not appear as a straight line on a graph scaled for a different type of distribution.	Ref. 7.1.1
Proportion -	A segment of a population that is contained by an upper and lower limit. Tolerance intervals determine the bounds or limits of a proportion of the population, not just the sampled data. The proportion (P) is the second term in the tolerance interval value (e.g. 95%/99%).	Ref. 7.4.8
Random -	Describing a variable whose value at a particular future instant cannot be predicted exactly, but can only be estimated by a probability distribution function.	Ref. 7.1.1
Raw Data -	As found minus as left calibration data used to characterize the performance of a functionally equivalent group of components.	Ref. 7.1.1
Reference Accuracy -	A number or quantity that defines a limit that errors will not exceed when a device is used under specified operating conditions.	Ref. 7.1.2
Rigor -	The degree of strictness applied to a given analysis.	Step 0
Sample -	A subset of a population.	Ref. 7.1.1
Sensor -	The portion of an instrument channel that responds to changes in a plant variable or condition and converts the measured process variable into a signal. e.g., electric or pneumatic	Ref. 7.1.2
Signal Conditioning -	One or more modules that perform signal conversion, buffering , isolation or mathematical operations on the signal as needed.	Ref. 7.1.2
Skewness -	A measure of the degree of symmetry around the mean.	Ref. 7.1.1
Span -	The algebraic difference between the upper and lower values of a calibrated span.	Ref. 7.1.2
Standard Deviation -	A measure of how widely values are dispersed from the population mean.	Ref. 7.1.1
Surveillance Interval -	The elapsed time between the initiation or successful completion of a surveillance or surveillance check on the same component, channel, instrument loop, or other specified system or device.	Ref. 7.1.1
Time-Dependent Drift -	The tendency for the magnitude of component drift to vary with time.	Ref. 7.1.1
Time-Dependent Drift Uncertainty -	The uncertainty associated with extending calibration intervals beyond the range of available historical data for a given instrument or group of instruments.	Ref. 7.1.1
Time-Independent Drift -	The tendency for the magnitude of component drift to show no specific trend with time.	Ref. 7.1.1
Tolerance -	The allowable variation from a specified or true value.	Ref. 7.1.2
Tolerance Interval -	An interval that contains a defined proportion of the population to a given probability.	Ref. 7.1.1

Trip Setpoint -	A predetermined value for actuation of the final actuation device to initiate protective action.	Ref. 7.1.2
t-Test -	For this Design Guide the t-Test is used to determine: 1) if a sample is an outlier of a sample pool. 2) if two groups of data originate from the same pool.	Ref. 7.1.1
Uncertainty -	The amount to which an instrument channel's output is in doubt (or the allowance made therefore) due to possible errors either random or systematic which have not been corrected for. The uncertainty is generally identified within a probability and confidence level.	Ref. 7.1.1
Variance -	A measure of how widely values are dispersed from the population mean.	Ref. 7.1.1
W Test -	A test to verify the assumption of normality for sample size less than 50.	Ref. 7.1.1

7. REFERENCES

7.1. Industry Standards

7.1.1. EPRI TR-103335, Rev. 1, Guidelines For Instrument Calibration Extension/Reduction Programs.

7.1.2. ISA-RP67.04, Rev. 0, Recommended Practice, Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation.

7.1.3. ISA-67.04, Rev. 0, Standard, Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation.

7.1.4. ANSI N15.15-1974, Rev. 0, Assessment of the Assumption of Normality (Employing Individual Observed Values).

7.1.5. REGULATORY GUIDE 1.105, Rev. 2, "Instrument Setpoints" USNRC.

7.1.6. ISA-dTR67.04.09, DRAFT 1, Graded Approaches to Setpoint Determination.

7.2. Procedures

7.2.1. WE-103, Rev. 18, Analyses and Calculations.

7.2.2. AP-0017, Rev. 4, Calculations and Analyses.

7.2.3. WE-108, Rev. 6, Computer Codes.

7.2.4. AP-0022, Rev. 11, Setpoint Change Request.

7.2.5. DEP-15, Vermont Yankee Design Engineering Procedure, "Calculations," Rev. 2.

7.3. Programs

7.3.1. Setpoint Control Program.

7.3.2. Instrument Uncertainty and Setpoints Design Guide.

7.4. Miscellaneous

7.4.1. IPASS (Instrument Performance Analysis Software System), Revision 2.02, created by EDAN Engineering in conjunction with EPRI.

7.4.2. NRC Generic Letter 91-04, Changes in Technical Specification Surveillance Intervals to Accommodate a 24-Month Fuel Cycle.

7.4.3. MPAC, Maintenance Planning and Control System.

7.4.4. VYDCC, Vermont Yankee's Document Control Database.

7.4.5. Datafind, Yankee Atomic's Document Control Database.

7.4.6. Microsoft Excel Version 97SR-2, Spreadsheet Program.

7.4.7. Microsoft Access Version 97SR-2, Database Program.

7.4.8. Statistics for Nuclear Engineers and Scientists Part 1: Basic Statistical Inference, William J. Beggs, February, 1981.

7.4.9. Letter from Thomas Essig (USNRC) to Revis James (EPRI) 12/1/1997 regarding: Status Report on the Staff Review of EPRI Technical Report TR-103335, "Guidelines for Instrument Calibration Extension/Reduction Programs," Dated 3/94.

7.5. Attachments

7.5.1. Attachment 1 – VYC-1599 Rev. 0, Drift Calculation for Fenwal Temp. Sw. Models 01-170020-090 & 01-170230-090. Calculation was 100% manually verified using a hand calculator to provide verification of the math performed by Microsoft Excel version 5.0.

7.5.2. Attachment 2 - VYC-1599 Rev. 0, Drift Calculation for Fenwal Temp. Sw. Models 01-170020-090 & 01-170230-090. Calculation was re-run to provide verification of the math performed by Microsoft Excel version 97-SR2 vs. version 5.0.

7.5.3. Attachment 3 - Tolerance Interval Factors for 75%/75% through 99%/99.9%.

CALCULATION/ANALYSIS REVIEW FORM

CALCULATION NO. VYC-1599 REVISION NO. Ø

COMMENTS	RESOLUTION
Reviewed in accordance with WE-103 and the VY Drift design Guide (Rev Ø).	
1. V&V attached	1. None required
2. Independent Review of Main Steam Line Flow calls 100%. No errors identified. Random hand calculation performed on remainder of points. No errors identified. The 100% portion of the review was performed coincident with the V&V and is attached.	2. None required
3. It is assumed the Raw Data (AS Found / AS LEFT) is correct. Minor variations will be identified as outliers or within the variance of the population - insignificant impact.	3. None Required

Identify method(s) of review:

- ☑ Calculation/analysis review
- ☑ Alternative calculational method
- ☐ Qualification testing

Resolution By: John Lewis 2/13/97
Preparer/Date

Comments Continued on Page: See attached

Concurrence with Resolution [signature] 2-13-97
Reviewer/Date

FORM WE-103-3
Revision 4

R90\97

Use of Spreadsheet to Calculate Standard Deviation
in Accordance With the VY Drift Design Guide
(Verification & Validation of VYC-1599 Revision 0)

Spreadsheets offer a unique tool in the determination of standard deviation from plant specific "As Left" v.s. "As Found" calibration data. It is desirable to have the ability to utilize multiple PC's and multiple spreadsheet types to perform this type of calculation. Described below is the process to validate the appropriateness of the PC and spreadsheet used.

1. First Drift Analysis

The first drift analysis was performed for the Fenwall temperature switches (VYC-1599). A portion of that analysis was associated with the Main Steam Line High Temperature Isolation (Calibration Procedure OP-4322). EXCEL 5.0 was used. One hundred fourteen (114) drift components were initially established. The standard deviation was 0.5863%. The Mean (average) was 0.008%. The 114 count did not eliminate outliers.

2. V & V

The V&V was intended to show that:

- EXCEL 5.0 correctly performed the Count, Average, Variance, and Standard Deviation functions.
- EXCEL 5.0 on different PC's would provide the same analysis in a consistent manner.
- A different spreadsheet format (e.g., Lotus) can be used

The following steps were performed to support these two objectives:

1. An independent review of the formulas used in the original evaluation was performed. Results were acceptable.

2. The differences between "As Left" and "As Found" were independently developed (using EXCEL) under row "F" and compared with the results in row "E". Results were acceptable.

3. The square of the results in row "G" were developed (using EXCEL). Results were acceptable.

4. The differences between "As Left" and "As Found" were independently developed (hand calculation) and compared to the results under rows "E" and "F". The results in row "G" were also verified correct by hand calculation. Results were acceptable.

Use of Spreadsheet to Calculate Standard Deviation
in Accordance With the VY Drift Design Guide
(Verification & Validation of VYC-1599 Revision 0)

5a. A standard deviation was determined using the row "G" results (using EXCEL) and the count (114) in the equation:

Stdev = [total of row "G"/(114-1)]^.5

A standard deviation of 0.5864% resulted and compared acceptably to the 0.5863% provided using the EXCEL command function for standard deviation.

5b. An Average (Mean) was determined using the row "F" results (using EXCEL) and the count (114) in the equation:

Mean = [total of row "F"/114

A Mean of 0.008% resulted and compared acceptably to the 0.008% provided using the EXCEL command function for Average.

5c. The Variance was determined using the Step 5a results (standard deviation) and the count (114) in the equation (using EXCEL results):

$$\text{Variance} = (\text{Standard Deviation})^2/[114/114\text{-}1)]$$

A Variance of 0.003% resulted and compared acceptably to the 0.003% provided using the EXCEL command function for VAR (Variance)

6a. The total in row "G" was obtained using hand calculation as well as identifying the total count (114). The results were added to the formula for determining standard deviation:

Stdev = [total of row "G"/(114-1)]^.5

The standard deviation developed by hand was 0.5864% which compared acceptably to the 0.5864% using EXCEL via manual calculation and the 0.5863% provided using the EXCEL command function for standard deviation.

6b. The total in row "F" was obtained using hand calculation. The Count was determined in Step 6a. The results were added to the formula for determining the Average:

Average = [total of row "F"/114]

Use of Spreadsheet to Calculate Standard Deviation
in Accordance With the VY Drift Design Guide
(Verification & Validation of VYC-1599 Revision 0)

The Average developed by hand was 0.008% which compared acceptably to the 0.008% using EXCEL via manual calculation and the 0.008% provided using the EXCEL command AVERAGE.

6c. The standard deviation was manually determined in Step 6a. The Count was determined manually by counting (114). The results were added to the formula for determining the Variance:

$$\text{Variance} = [0.5864\%^2 * 114/(114-1)]$$

The Variance developed by hand was 0.003% which compared acceptably to the 0.003% using EXCEL via manual calculation and the 0.003% provided using the EXCEL command function for VARIATION.

7. The EXCEL spread sheet for the Fenwall temperature switches associated with the Main Steam Line high temperature isolation function was originally developed on a 486 with a math-coprocessor. The spreadsheet was loaded onto a second PC (#33001) located at YNSD. The results were acceptable (no difference in results).

8. Other EXCEL functions (e.g., T-Test, Normality, etc) are for verification of the appropriateness of the data. A separate V&V is not required; appropriateness of data can be verified during each review based on observation by the Preparer and the Independent Reviewer.

3. V&V of EXCEL 5.0 on a different PC

It is desirable to not have to perform a software V&V each time a spreadsheet is used. To satisfy the intent of WE-103, an EXCEL 5.0 spreadsheet developed on PC #33001 (YNSD) or on PC-JL (Vermont Yankee) must be used as an acceptable baseline. The spreadsheet must be re-run on the new PC to be used for this application. The results must be compared between the two runs (baseline v.s. re-run) and the results must be acceptable. This effort must be documented in the calculation, identifying:

a. The baseline spreadsheet
b. The PC used to develop the baseline spreadsheet
c. The results of the re-run spreadsheet
d. The PC used to re-run the spreadsheet, identifying the PC number and the version of the spreadsheet used.

Use of Spreadsheet to Calculate Standard Deviation
in Accordance With the VY Drift Design Guide
(Verification & Validation of VYC-1599 Revision 0)

4. V&V of a version of EXCEL other than 5.0 or use of a different type of spreadsheet

The steps described in (3) above must be taken. The difference is that the EXCEL 5.0 spreadsheet to be used as the baseline might require conversion into a format compatible with the new spreadsheet type to be used. The new results must still be compared with the baseline and acceptability of the results documented.

5. Conclusion

EXCEL 5.0 is an acceptable tool to determine the Average, Standard Deviation, and Count (functions) in support of the Vermont Yankee Drift analysis effort. The methods described above provide acceptable guidance to allow the use of EXCEL 5.0 on other PC's or the use of other versions of EXCEL or the use of other spreadsheet types to support the drift analysis effort.

George J. Hengerle
Senior I&C Engineer
Vermont Yankee Design Engineering

Drift Calculation For Fenwal TS Models 01-170020(230)-090
OP4322.XLS - Raw Data/Independent Verification

VYC-1599
Attachment 7.5.1

	A	B	C	D	E	F	G	H	I
1	OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
2	DRIFT ANALYSIS		TS-2-121A		OP 4322	Manual	Manual		Independant
3		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
4	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
5		Required Trip = 185 PSIG				180 - 190°F			
6	10/12/96	As Found		182.5					
7		As Left	567	182.5	-0.214%	-0.002142857	4.59184E-06	✓	
8	3/25/95	As Found		184.0					
9		As Left	556	184.0	-0.286%	-0.002857143	8.16327E-06	✓	
10	9/15/93	As Found		186.0					
11		As Left	526	186.0	0.143%	0.001428571	2.04082E-06	✓	
12	4/7/92	As Found		185.0					
13		As Left	552	185.0	0.400%	0.004	1.6E-05	✓	
14	10/3/90	As Found		182.2					
15		As Left	561	182.2	-0.186%	-0.001857143	3.44898E-06	✓	
16	3/21/89	As Found		183.5					
17		As Left	552	183.5	0.214%	0.002142857	4.59184E-06	✓	
18	9/16/87	As Found		182.0					
19		As Left	523	182.0	-0.743%	-0.007428571	5.51837E-05	✓	
20	4/11/86	As Found				"no A/F data recorded"	9.402E-5		
21		As Left		187.2					
22	DRIFT ANALYSIS		TS-2-122A		OP 4322	Manual	Manual		Independant
23		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
24	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
25		Required Trip = 185 PSIG							
26	10/12/96	As Found		184.6					
27		As Left	567	184.6	-0.057%	-0.000571429	3.26531E-07	✓	
28	3/25/95	As Found		181.0					
29		As Left	556	185.0	-0.714%	-0.007142857	5.10204E-05	✓	
30	9/15/93	As Found		186.0					
31		As Left	526	186.0	0.543%	0.005428571	2.94694E-05	✓	
32	4/7/92	As Found		182.2					
33		As Left	552	182.2	-0.486%	-0.004857143	2.35918E-05	✓	
34	10/3/90	As Found		172.3					
35		As Left	561	185.6	-1.600%	-0.016	0.000256	✓	
36	3/21/89	As Found		192.0					
37		As Left	552	183.5	0.657%	0.006571429	4.31837E-05	✓	
38	9/16/87	As Found		187.4					
39		As Left	523	187.4	-0.200%	-0.002	4E-06	✓	
40	4/11/86	As Found				"no A/F data recorded"	4.07591E-4		
41		As Left		188.8					
42	DRIFT ANALYSIS		TS-2-123A		OP 4322	Manual	Manual		Independant
43		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
44	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
45		Required Trip = 185 PSIG							
46	10/12/96	As Found		188.1		A/F data out of tolerance			
47		As Left	567	188.1	0.300%	0.003	9E-06	✓	
48	3/25/95	As Found		179.8					
49		As Left	556	186.0	-0.257%	-0.002571429	6.61224E-06	✓	
50	9/15/93	As Found		181.6					
51		As Left	526	181.6	-0.300%	-0.003	9E-06	✓	
52	4/7/92	As Found		183.7					
53		As Left	552	183.7	0.529%	0.005285714	2.79388E-05	✓	
54	10/3/90	As Found		180.0					
55		As Left	561	180.0	-0.643%	-0.006428571	4.13265E-05	✓	
56	3/21/89	As Found		192.3					
57		As Left	552	184.5	0.671%	0.006714286	4.50816E-05	✓	
58	9/16/87	As Found		187.6					
59		As Left	523	187.6	0.043%	0.000428571	1.83673E-07	✓	
60	4/11/86	As Found				"no A/F data recorded"			
61		As Left		187.3			1.33142E-4		

Drift Calculation For Fenwal TS Models 01-170020(230)-090
OP4322.XLS - Raw Data/Independent Verification

VYC-1599
Attachment D 7.5.1

	A	B	C	D	E	F	G	H	I
1	OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
62	DRIFT ANALYSIS		TS-2-124A		OP 4322	Manual	Manual		Independant
63		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
64	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
65		Required Trip = 185 PSIG							
66	10/12/96	As Found		184.6					
67		As Left	567	184.6	-0.300%	-0.003	9E-06	✓	
68	3/25/95	As Found		186.7					
69		As Left	556	186.7	-0.071%	-0.000714286	5.10204E-07	✓	
70	9/15/93	As Found		187.2					
71		As Left	526	187.2	0.314%	0.003142857	9.87755E-06	✓	
72	4/7/92	As Found		185.0					
73		As Left	552	185.0	0.057%	0.000571429	3.26531E-07	✓	
74	10/3/90	As Found		184.6					
75		As Left	561	184.6	-0.486%	-0.004857143	2.35918E-05	✓	
76	3/21/89	As Found		188.0					
77		As Left	552	188.0	-0.071%	-0.000714286	5.10204E-07	✓	
78	9/16/87	As Found		188.5					
79		As Left	523	188.5	0.329%	0.003285714	1.07959E-05	✓	
80	4/11/86	As Found				"no A/F data recorded"	5.4612E-5		
81		As Left		186.2					
82	DRIFT ANALYSIS		TS-2-121B		OP 4322	Manual	Manual		Independant
83		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
84	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
85		Required Trip = 185 PSIG							
86	10/12/96	As Found		186.5					
87		As Left	567	186.5	0.171%	0.001714286	2.93878E-06	✓	
88	3/25/95	As Found		185.3					
89		As Left	556	185.3	-0.100%	-0.001	1E-06	✓	
90	9/15/93	As Found		186.0					
91		As Left	526	186.0	0.429%	0.004285714	1.83673E-05	✓	
92	4/7/92	As Found		183.0					
93		As Left	552	183.0	0.043%	0.000428571	1.83673E-07	✓	
94	10/3/90	As Found		182.7					
95		As Left	561	182.7	0.314%	0.003142857	9.87755E-06	✓	
96	3/21/89	As Found		180.5					
97		As Left	552	180.5	-0.857%	-0.008571429	7.34694E-05	✓	
98	9/16/87	As Found		186.5					
99		As Left	523	186.5	0.386%	0.003857143	1.48776E-05	✓	
100	4/11/86	As Found				"no A/F data recorded"	1.20714E-4		
101		As Left		183.8					
102	DRIFT ANALYSIS		TS-2-122B		OP 4322	Manual	Manual		Independant
103		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
104	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
105		Required Trip = 185 PSIG							
106	10/12/96	As Found		187.7					
107		As Left	567	187.7	0.486%	0.004857143	2.35918E-05	✓	
108	3/25/95	As Found		184.3					
109		As Left	556	184.3	0.029%	0.000285714	8.16327E-08	✓	
110	9/15/93	As Found		184.1					
111		As Left	526	184.1	0.286%	0.002857143	8.16327E-06	✓	
112	4/7/92	As Found		182.1					
113		As Left	552	182.1	-0.300%	-0.003	9E-06	✓	
114	10/3/90	As Found		175.6					
115		As Left	561	184.2	-0.914%	-0.009142857	8.35918E-05	✓	
116	3/21/89	As Found		191.0					
117		As Left	552	182.0	0.229%	0.002285714	5.22449E-06	✓	
118	9/16/87	As Found		189.4					
119		As Left	523	189.4	0.529%	0.005285714	2.79388E-05	✓	
120	4/11/86	As Found				"no A/F data recorded"			
121		As Left		185.7			1.5591E-4		

Drift Calculation For Fenwal TS Models 01-170020(230)-090
OP4322.XLS - Raw Data/Independent Verification

VYC-1599
Attachment 7.5.1

	A	B	C	D	E	F	G	H	I
1	OP 4322; MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
122	DRIFT ANALYSIS		TS-2-123B		0P 4322	Manual	Manual		Independant
123		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
124	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
125		Required Trip = 185 PSIG							
126	10/12/96	As Found		188.1					
127		As Left	567	188.1	0.729%	0.007285714	5.30816E-05	✓	
128	3/25/95	As Found		183.0					
129		As Left	556	183.0	-0.514%	-0.005142857	2.6449E-05	✓	
130	9/15/93	As Found		186.6					
131		As Left	526	186.6	0.471%	0.004714286	2.22245E-05	✓	
132	4/7/92	As Found		183.3					
133		As Left	552	183.3	0.200%	0.002	4E-06	✓	
134	10/3/90	As Found		181.9					
135		As Left	561	181.9	-0.514%	-0.005142857	2.6449E-05	✓	
136	3/21/89	As Found		185.5					
137		As Left	551	185.5	-0.400%	-0.004	1.6E-05	✓	
138	9/17/87	As Found		188.3					
139		As Left	1	188.3	0.471%	0.004714286	2.22245E-05	✓	
140	9/16/87	As Found		185.0					
141		As Left	523	185.0	0.143%	0.001428571	2.04082E-06	✓	
142	4/11/86	As Found				"no A/F data recorded"			
143		As Left		184.0			1.72469E-4		
144	DRIFT ANALYSIS		TS-2-124B		0P 4322	Manual	Manual		Independant
145		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
146	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
147		Required Trip = 185 PSIG							
148	10/12/96	As Found		188.1					
149		As Left	567	188.1	0.271%	0.002714286	7.36735E-06	✓	
150	3/25/95	As Found		186.2					
151		As Left	556	186.2	-0.029%	-0.000285714	8.16327E-08	✓	
152	9/15/93	As Found		186.4					
153		As Left	526	186.4	0.171%	0.001714286	2.93878E-06	✓	
154	4/7/92	As Found		177.5					
155		As Left	552	185.2	-1.300%	-0.013	0.000169	✓	
156	10/3/90	As Found		186.6					
157		As Left	561	186.6	0.657%	0.006571429	4.31837E-05	✓	
158	3/21/89	As Found		182.0					
159		As Left	552	182.0	-0.714%	-0.007142857	5.10204E-05	✓	
160	9/16/87	As Found		194.9					
161		As Left	523	187.0	1.157%	0.011571429	0.000133898	✓	
162	4/11/86	As Found				"no A/F data recorded"			
163		As Left		186.8			4.07489E-4		
164	DRIFT ANALYSIS		TS-2-121C		0P 4322	Manual	Manual		Independant
165		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
166	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
167		Required Trip = 185 PSIG							
168	10/12/96	As Found		185.3					
169		As Left	567	185.3	-0.286%	-0.002857143	8.16327E-06	✓	
170	3/25/95	As Found		180.4					
171		As Left	556	187.3	-0.514%	-0.005142857	2.6449E-05	✓	
172	9/15/93	As Found		184.0					
173		As Left	526	184.0	0.186%	0.001857143	3.44898E-06	✓	
174	4/7/92	As Found		182.7					
175		As Left	552	182.7	0.071%	0.000714286	5.10204E-07	✓	
176	10/3/90	As Found		182.2					
177		As Left	561	182.2	-0.186%	-0.001857143	3.44898E-06	✓	
178	3/21/89	As Found		183.5					
179		As Left	552	183.5	0.071%	0.000714286	5.10204E-07	✓	
180	9/16/87	As Found		192.4					
181		As Left	523	183.0	0.771%	0.007714286	5.95102E-05	✓	
182	4/11/86	As Found				"no A/F data recorded"			
183		As Left		187.0			1.0204E-4		

Drift Calculation For Fenwal TS Models 01-170020(230)-090
OP4322.XLS - Raw Data/Independent Verification

VYC-1599
Attachment 7.5.1

	A	B	C	D	E	F	G	H	I
1	OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
184	DRIFT ANALYSIS		TS-2-122C		0P 4322	Manual	Manual		Independant
185		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
186	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
187		Required Trip = 185 PSIG							
188	10/12/96	As Found		185.4					
189		As Left	567	185.4	-0.086%	-0.000857143	7.34694E-07	✓	
190	3/25/95	As Found		180.3					
191		As Left	556	186.0	-0.629%	-0.006285714	3.95102E-05	✓	
192	9/15/93	As Found		184.7					
193		As Left	526	184.7	-0.429%	-0.004285714	1.83673E-05	✓	
194	4/7/92	As Found		199.9					
195		As Left	552	187.7	2.414%	0.024142857	0.000582878	✓	
196	10/3/90	As Found		183.0					
197		As Left	561	183.0	-0.143%	-0.001428571	2.04082E-06	✓	
198	3/21/89	As Found		184.5					
199		As Left	552	184.0	-0.129%	-0.001285714	1.65306E-06	✓	
200	9/16/87	As Found		196.2				-	
201		As Left	523	185.4	1.457%	0.014571429	0.000212327	✓	
202	4/11/86	As Found				"no A/F data recorded"			
203		As Left		186.0			5.575116E-4		
204	DRIFT ANALYSIS		TS-2-123C		0P 4322	Manual	Manual		Independant
205		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
206	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
207		Required Trip = 185 PSIG							
208	10/12/96	As Found		187.5					
209		As Left	567	187.5	0.714%	0.007142857	5.10204E-05	✓	
210	3/25/95	As Found		182.5					
211		As Left	556	182.5	-0.371%	-0.003714286	1.37959E-05	✓	
212	9/15/93	As Found		185.1					
213		As Left	526	185.1	0.657%	0.006571429	4.31837E-05	✓	
214	4/7/92	As Found		180.5					
215		As Left	552	180.5	-0.614%	-0.006142857	3.77347E-05	✓	
216	10/3/90	As Found		176.0					
217		As Left	561	184.8	-0.643%	-0.006428571	4.13265E-05	✓	
218	3/21/89	As Found		180.5					
219		As Left	551	180.5	-0.143%	-0.001428571	2.04082E-06	✓	
220	9/17/87	As Found		190.3					
221		As Left	1	181.5	0.043%	0.000428571	1.83673E-07	✓	
222	9/16/87	As Found		190.0					
223		As Left	523	190.0	0.386%	0.003857143	1.48776E-05	✓	
224	4/11/86	As Found				"no A/F data recorded"			
225		As Left		187.3			3.04163E-4		

Drift Calculation For Fenwal TS Models 01-170020(230)-090
OP4322.XLS - Raw Data/Independent Verification

VYC-1599
Attachment ~~D~~ 7.5.1

	A	B	C	D	E	F	G	H	I
1	OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
226	DRIFT ANALYSIS		TS-2-124C		0P 4322	Manual	Manual		Independant
227		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
228	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
229		Required Trip = 185 PSIG							
230	10/12/96	As Found		184.5					
231		As Left	567	184.5	-0.286%	-0.002857143	8.16327E-06	✓	
232	3/25/95	As Found		174.6					
233		As Left	556	186.5	-1.229%	-0.012285714	0.000150939	✓	
234	9/15/93	As Found		190.9					
235		As Left	526	183.2	0.143%	0.001428571	2.04082E-06	✓	
236	4/7/92	As Found		189.9					
237		As Left	552	189.9	0.257%	0.002571429	6.61224E-06	✓	
238	10/3/90	As Found		188.1					
239		As Left	561	188.1	0.086%	0.000857143	7.34694E-07	✓	
240	3/21/89	As Found		187.5					
241		As Left	552	187.5	-0.229%	-0.002285714	5.22449E-06	✓	
242	9/16/87	As Found		193.5					
243		As Left	523	189.1	1.129%	0.011285714	0.000127367	✓	
244	4/11/86	As Found				"no A/F data recorded"			
245		As Left		185.6			3.01081E-4		
246	DRIFT ANALYSIS		TS-2-121D		0P 4322	Manual	Manual		Independant
247		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
248	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
249		Required Trip = 185 PSIG							
250	10/12/96	As Found		182.0					
251		As Left	567	182.0	-0.343%	-0.003428571	1.17551E-05	✓	
252	3/25/95	As Found		184.4					
253		As Left	556	184.4	0.129%	0.001285714	1.65306E-06	✓	
254	9/15/93	As Found		183.5					
255		As Left	526	183.5	-0.029%	-0.000285714	8.16327E-08	✓	
256	4/7/92	As Found		183.7					
257		As Left	552	183.7	-0.100%	-0.001	1E-06	✓	
258	10/3/90	As Found		184.4					
259		As Left	561	184.4	0.057%	0.000571429	3.26531E-07	✓	
260	3/21/89	As Found		184.0					
261		As Left	552	184.0	0.114%	0.001142857	1.30612E-06	✓	
262	9/16/87	As Found		183.2					
263		As Left	523	183.2	-0.414%	-0.004142857	1.71633E-05	✓	
264	4/11/86	As Found				"no A/F data recorded"			
265		As Left		186.1			3.3285E-5		
266	DRIFT ANALYSIS		TS-2-122D		0P 4322	Manual	Manual		Independant
267		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
268	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
269		Required Trip = 185 PSIG							
270	10/12/96	As Found		193.3		A/F data out of tolerance			
271		As Left	567	182.5	0.900%	0.009	8.1E-05	✓	
272	3/25/95	As Found		177.4					
273		As Left	556	187.0	-1.014%	-0.010142857	0.000102878	✓	
274	9/15/93	As Found		178.4					
275		As Left	526	184.5	-0.229%	-0.002285714	5.22449E-06	✓	
276	4/7/92	As Found		180.0					
277		As Left	552	180.0	-0.700%	-0.007	4.9E-05	✓	
278	10/3/90	As Found		184.9					
279		As Left	561	184.9	-0.229%	-0.002285714	5.22449E-06	✓	
280	3/21/89	As Found		186.5					
281		As Left	552	186.5	0.371%	0.003714286	1.37959E-05	✓	
282	9/16/87	As Found		183.9					
283		As Left	523	183.9	-0.186%	-0.001857143	3.44898E-06	✓	
284	4/11/86	As Found				"no A/F data recorded"			
285		As Left		185.2			2.60571E-4		

Drift Calculation For Fenwal TS Models 01-170020(230)-090
OP4322.XLS - Raw Data/Independent Verification

VYC-1599
Attachment Ø 7.5.1

	A	B	C	D	E	F	G	H	I
1	OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
286	DRIFT ANALYSIS		TS-2-123D		0P 4322	Manual	Manual		Independant
287		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
288	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
289		Required Trip = 185 PSIG							
290	10/12/96	As Found		188.4					
291		As Left	567	188.4	0.957%	0.009571429	9.16122E-05	✓	
292	3/25/95	As Found		181.7					
293		As Left	556	181.7	-1.129%	-0.011285714	0.000127367	✓	
294	9/15/93	As Found		189.6					
295		As Left	526	189.6	1.057%	0.010571429	0.000111755	✓	
296	4/7/92	As Found		182.2					
297		As Left	552	182.2	-0.429%	-0.004285714	1.83673E-05	✓	
298	10/3/90	As Found		185.2					
299		As Left	561	185.2	0.529%	0.005285714	2.79388E-05	✓	
300	3/21/89	As Found		181.5					
301		As Left	552	181.5	-0.429%	-0.004285714	1.83673E-05	✓	
302	9/16/87	As Found		190.8					
303		As Left	523	184.5	0.343%	0.003428571	1.17551E-05	✓	
304	4/11/86	As Found				"no A/F data recorded"			
305		As Left		188.4			4.071626		
306	DRIFT ANALYSIS		TS-2-124D		0P 4322	Manual	Manual		Independant
307		Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
308	Date	Status	(Days)	TRIP	TRIP	(AL - AF)	Fx^2		
309		Required Trip = 185 PSIG							
310	10/12/96	As Found		185.5					
311		As Left	567	185.5	0.157%	0.001571429	2.46939E-06	✓	
312	3/25/95	As Found		184.4					
313		As Left	556	184.4	-0.343%	-0.003428571	1.17551E-05	✓	
314	9/15/93	As Found		186.8					
315		As Left	526	186.8	0.143%	0.001428571	2.04082E-06	✓	
316	4/7/92	As Found		185.8					
317		As Left	552	185.8	0.643%	0.006428571	4.13265E-05	✓	
318	10/3/90	As Found		181.3					
319		As Left	561	181.3	-0.886%	-0.008857143	7.8449E-05	✓	
320	3/21/89	As Found		187.5					
321		As Left	552	187.5	0.514%	0.005142857	2.6449E-05	✓	
322	9/16/87	As Found		183.9					
323		As Left	523	183.9	-0.186%	-0.001857143	3.44898E-06	✓	
324	4/11/86	As Found				"no A/F data recorded"			
325		As Left		185.2			1.669386	✓	
326									
327						Count	114	✓	
328	Using EXCEL Function to determine					STDEV BY FUNCTION			
329	Standard Deviation				STDEV($E$7:$E$325)	✓			
330					0.5863%	✓			
331									
332	Mathematically determining			Count	114	✓ STDEV/MANUAL RSS			
333	Standard Deviation using RSS						(SUM($G$7:$G$325)/(114-1))^0.5		✓
334							0.5864%	✓	
335									
336	Using EXCEL Function to determine			0.008%	AVERAGE(F7:F325)	✓	Total 'G' = [0.003885378/(114-1)]		✓
337	Average (Mean)						STDEV = 0.005863777 = 0.5864%		✓
338									
339	Mathematically determining			0.008%	Sum of (F7:F325)/114 = 0.857/114 ✓				
340	Average								
341									2-6-97
342	Using EXCEL Function to determine			0.003%	VAR($F$7:$F$325)	✓			
343	Variance								
344									
345	Mathematically determining			0.003%	STDEV^2*(114/(114-1)) = 0.005863777^2(114/113)				
346	Variance								

DRIFT DESIGN GUIDE
Revision 1
Attachment 2

Purpose

The purpose of this attachment is to verify that Microsoft® version EXCEL 97-SR2 provides the same results as Microsoft® version EXCEL 5.0.

Scope

This verification is composed of ensuring the values developed during the validation process of the drift analysis, VYC-1599 Revision 0 (provided in Attachment 1), are the same when calculated on this operating platform using the newer EXCEL software.

The method of performing the validation is described in Attachment 1. The verification has been conducted on the following platform:

Gateway, Intel Pentium II Processor, Intel MMX Technology, Windows 98 operating system

Conclusion

The results of the verification process are acceptable.

EXCEL 97-SR2 is an acceptable tool to determine the Average, Standard Deviation, and Count (functions) in support of the Vermont Yankee Drift Analysis effort. The methods described above (and in Attachment 1) provide acceptable guidance to allow the use of EXCEL 97-SR2 on other PC's or the use of other versions of EXCEL or the use of other spreadsheet types to support the drift analysis effort.

[signature] / 5-27-99
GEORGE J. HENGERLE
PRINCIPAL ENGINEER
VERMONT YANKEE DESIGN ENG.

DRIFT DESIGN GUIDE
Revision 1
Attachment 2

Drift Calculation For Fenwal TS
OP4322.XLS - Raw Data

(From VYC-1599)

OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
DRIFT ANALYSIS		TS-2-121A		OP 4322	Manual	Manual		Independent
	Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
Date	Status	(Days)	TRIP	TRIP	(AF-AL)	(Fx^2)		
	Required Trip = 185 PSIG				180 - 190°F			
10/12/96	As Found		182.5					
	As Left	567	182.5	-0.214%	-0.002142857	4.59184E-06	✓	[initials]
3/25/95	As Found		184.0					
	As Left	556	184.0	-0.286%	-0.002857143	8.16327E-06	✓	[initials]
9/15/93	As Found		186.0					
	As Left	526	186.0	0.143%	0.001428571	2.04082E-06	✓	[initials]
4/7/92	As Found		185.0					
	As Left	552	185.0	0.400%	0.004000000	1.60000E-05	✓	[initials]
10/3/90	As Found		182.2					
	As Left	561	182.2	-0.186%	-0.001857143	3.44898E-06	✓	[initials]
3/21/89	As Found		183.5					
	As Left	552	183.5	0.214%	0.002142857	4.59184E-06	✓	[initials]
9/16/87	As Found		182.0					
	As Left	523	182.0	-0.743%	-0.007428571	5.51837E-05	✓	[initials]
4/11/86	As Found				"no A/F data recorded"			
	As Left		187.2					
DRIFT ANALYSIS		TS-2-122A		OP 4322	Manual	Manual		Independent
	Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
Date	Status	(Days)	TRIP	TRIP	(AF-AL)	(Fx^2)		
	Required Trip = 185 PSIG							
10/12/96	As Found		184.6					
	As Left	567	184.6	-0.057%	-0.000571429	3.26531E-07	✓	[initials]
3/25/95	As Found		181.0					
	As Left	556	185.0	-0.714%	-0.007142857	5.10204E-05	✓	[initials]
9/15/93	As Found		186.0					
	As Left	526	186.0	0.543%	0.005428571	2.94694E-05	✓	[initials]
4/7/92	As Found		182.2					
	As Left	552	182.2	-0.486%	-0.004857143	2.35918E-05	✓	[initials]
10/3/90	As Found		172.3		A/F data out of tolerance			
	As Left	561	185.6	-1.600%	-0.016000000	2.56000E-04	✓	[initials]
3/21/89	As Found		192.0		A/F data out of tolerance			
	As Left	552	183.5	0.657%	0.006571429	4.31837E-05	✓	[initials]
9/16/87	As Found		187.4					
	As Left	523	187.4	-0.200%	-0.002000000	4.00000E-06	✓	[initials]
4/11/86	As Found				"no A/F data recorded"			
	As Left		188.8					
DRIFT ANALYSIS		TS-2-123A		OP 4322	Manual	Manual		Independent
	Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
Date	Status	(Days)	TRIP	TRIP	(AF-AL)	(Fx^2)		
	Required Trip = 185 PSIG							
10/12/96	As Found		188.1		A/F data out of tolerance			
	As Left	567	188.1	0.300%	0.003000000	9.00000E-06	✓	[initials]
3/25/95	As Found		179.8		A/F data out of tolerance			
	As Left	556	186.0	-0.257%	-0.002571429	6.61224E-06	✓	[initials]
9/15/93	As Found		181.6					
	As Left	526	181.6	-0.300%	-0.003000000	9.00000E-06	✓	[initials]
4/7/92	As Found		183.7					
	As Left	552	183.7	0.529%	0.005285714	2.79388E-05	✓	[initials]
10/3/90	As Found		180.0					
	As Left	561	180.0	-0.643%	-0.006428571	4.13265E-05	✓	[initials]
3/21/89	As Found		192.9		A/F data out of tolerance			
	As Left	552	184.5	0.671%	0.006714286	4.50816E-05	✓	[initials]
9/16/87	As Found		187.6					
	As Left	523	187.6	0.043%	0.000428571	1.83673E-07	✓	[initials]
4/11/86	As Found				"no A/F data recorded"			
	As Left		187.3					

[initials] 5/27-99

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Drift Calculation For Fenwal TS
OP4322.XLS - Raw Data

(From VYC-1599)

OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
DRIFT ANALYSIS		TS-2-124A		0P 4322	Manual	Manual		Independent
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP	Verification (AF-AL)	Verification (Fx^2)		Review
	Required Trip = 185 PSIG							
10/12/96	As Found		184.6					
	As Left	567	184.6	-0.300%	-0.003000000	9.00000E-06	✓	
3/25/95	As Found		186.7					
	As Left	556	186.7	-0.071%	-0.000714286	5.10204E-07	✓	
9/15/93	As Found		187.2					
	As Left	526	187.2	0.314%	0.003142857	9.87755E-06	✓	
4/7/92	As Found		185.0					
	As Left	552	185.0	0.057%	0.000571429	3.26531E-07	✓	
10/3/90	As Found		184.6					
	As Left	561	184.6	-0.486%	-0.004857143	2.35918E-05	✓	
3/21/89	As Found		188.0					
	As Left	552	188.0	-0.071%	-0.000714286	5.10204E-07	✓	
9/16/87	As Found		188.5					
	As Left	523	188.5	0.329%	0.003285714	1.07959E-05	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		186.2					
DRIFT ANALYSIS		TS-2-121B		0P 4322	Manual	Manual		Independent
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP	Verification (AF-AL)	Verification (Fx^2)		Review
	Required Trip = 185 PSIG							
10/12/96	As Found		186.5					
	As Left	567	186.5	0.171%	0.001714286	2.93878E-06	✓	
3/25/95	As Found		185.3					
	As Left	556	185.3	-0.100%	-0.001000000	1.00000E-06	✓	
9/15/93	As Found		186.0					
	As Left	526	186.0	0.429%	0.004285714	1.83673E-05	✓	
4/7/92	As Found		183.0					
	As Left	552	183.0	0.043%	0.000428571	1.83673E-07	✓	
10/3/90	As Found		182.7					
	As Left	561	182.7	0.314%	0.003142857	9.87755E-06	✓	
3/21/89	As Found		180.5					
	As Left	552	180.5	-0.857%	-0.008571429	7.34694E-05	✓	
9/16/87	As Found		186.5					
	As Left	523	186.5	0.386%	0.003857143	1.48776E-05	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		183.8					
DRIFT ANALYSIS		TS-2-122B		0P 4322	Manual	Manual		Independent
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP	Verification (AF-AL)	Verification (Fx^2)		Review
	Required Trip = 185 PSIG							
10/12/96	As Found		187.7					
	As Left	567	187.7	0.486%	0.004857143	2.35918E-05	✓	
3/25/95	As Found		184.3					
	As Left	556	184.3	0.029%	0.000285714	8.16327E-08	✓	
9/15/93	As Found		184.1					
	As Left	526	184.1	0.286%	0.002857143	8.16327E-06	✓	
4/7/92	As Found		182.1					
	As Left	552	182.1	-0.300%	-0.003000000	9.00000E-06	✓	
10/3/90	As Found		175.6		A/F data out of tolerance			
	As Left	561	184.2	-0.914%	-0.009142857	8.35918E-05	✓	
3/21/89	As Found		191.0		A/F data out of tolerance			
	As Left	552	182.0	0.229%	0.002285714	5.22449E-06	✓	
9/16/87	As Found		189.4					
	As Left	523	189.4	0.529%	0.005285714	2.79388E-05	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		185.7					

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Drift Calculation For Fenwal TS
OP4322.XLS - Raw Data

(From VYC-1599)

OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
DRIFT ANALYSIS		TS-2-123B		OP 4322	Manual Verification (AF-AL)	Manual Verification (Fx^2)		Independent Review
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP				
	Required Trip = 185 PSIG							
10/12/96	As Found		188.1					
	As Left	567	188.1	0.729%	0.007285714	5.30816E-05	✓	
3/25/95	As Found		183.0					
	As Left	556	183.0	-0.514%	-0.005142857	2.64490E-05	✓	
9/15/93	As Found		186.6					
	As Left	526	186.6	0.471%	0.004714286	2.22245E-05	✓	
4/7/92	As Found		183.3					
	As Left	552	183.3	0.200%	0.002000000	4.00000E-06	✓	
10/3/90	As Found		181.9					
	As Left	561	181.9	-0.514%	-0.005142857	2.64490E-05	✓	
3/21/89	As Found		185.5					
	As Left	551	185.5	-0.400%	-0.004000000	1.60000E-05	✓	
9/17/87	As Found		188.3					
	As Left	1	188.3	0.471%	0.004714286	2.22245E-05	✓	
9/16/87	As Found		185.0					
	As Left	523	185.0	0.143%	0.001428571	2.04082E-06	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		184.0					
DRIFT ANALYSIS		TS-2-124B		OP 4322	Manual Verification (AF-AL)	Manual Verification (Fx^2)		Independent Review
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP				
	Required Trip = 185 PSIG							
10/12/96	As Found		188.1					
	As Left	567	188.1	0.271%	0.002714286	7.36735E-06	✓	
3/25/95	As Found		186.2					
	As Left	556	186.2	-0.029%	-0.000285714	8.16327E-08	✓	
9/15/93	As Found		186.4					
	As Left	526	186.4	0.171%	0.001714286	2.93878E-06	✓	
4/7/92	As Found		177.5		A/F data out of tolerance			
	As Left	552	185.2	-1.300%	-0.013000000	1.69000E-04	✓	
10/3/90	As Found		186.6					
	As Left	561	186.6	0.657%	0.006571429	4.31837E-05	✓	
3/21/89	As Found		182.0					
	As Left	552	182.0	-0.714%	-0.007142857	5.10204E-05	✓	
9/16/87	As Found		194.9		A/F data out of tolerance			
	As Left	523	187.0	1.157%	0.011571429	1.33898E-04	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		186.8					
DRIFT ANALYSIS		TS-2-121C		OP 4322	Manual Verification (AF-AL)	Manual Verification (Fx^2)		Independent Review
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP				
	Required Trip = 185 PSIG							
10/12/96	As Found		185.3					
	As Left	567	185.3	-0.286%	-0.002857143	8.16327E-06	✓	
3/25/95	As Found		180.4					
	As Left	556	187.3	-0.514%	-0.005142857	2.64490E-05	✓	
9/15/93	As Found		184.0					
	As Left	526	184.0	0.186%	0.001857143	3.44898E-06	✓	
4/7/92	As Found		182.7					
	As Left	552	182.7	0.071%	0.000714286	5.10204E-07	✓	
10/3/90	As Found		182.2					
	As Left	561	182.2	-0.186%	-0.001857143	3.44898E-06	✓	
3/21/89	As Found		183.5					
	As Left	552	183.5	0.071%	0.000714286	5.10204E-07	✓	
9/16/87	As Found		192.4		A/F data out of tolerance			
	As Left	523	183.0	0.771%	0.007714286	5.95102E-05	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		187.0					

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Drift Calculation For Fenwal TS
OP4322.XLS - Raw Data

(From VYC-1599)

OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
DRIFT ANALYSIS		TS-2-122C		OP 4322	Manual	Manual		Independent
	Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
Date	Status	(Days)	TRIP	TRIP	(AF-AL)	(Fx^2)		
	Required Trip = 185 PSIG							
10/12/96	As Found		185.4					
	As Left	567	185.4	-0.086%	-0.000857143	7.34694E-07	✓	[initials]
3/25/95	As Found		180.9					
	As Left	556	186.0	-0.629%	-0.006285714	3.95102E-05	✓	[initials]
9/15/93	As Found		184.7					
	As Left	526	184.7	-0.429%	-0.004285714	1.83673E-05	✓	[initials]
4/7/92	As Found		199.9		A/F data out of tolerance			
	As Left	552	187.7	2.414%	0.024142857	5.82878E-04	✓	[initials]
10/3/90	As Found		183.0					
	As Left	561	183.0	-0.143%	-0.001428571	2.04082E-06	✓	[initials]
3/21/89	As Found		184.5					
	As Left	552	184.0	-0.129%	-0.001285714	1.65306E-06	✓	[initials]
9/16/87	As Found		196.2		A/F data out of tolerance			
	As Left	523	185.4	1.457%	0.014571429	2.12327E-04	✓	[initials]
4/11/86	As Found				"no A/F data recorded"			
	As Left		186.0					
DRIFT ANALYSIS		TS-2-123C		OP 4322	Manual	Manual		Independent
	Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
Date	Status	(Days)	TRIP	TRIP	(AF-AL)	(Fx^2)		
	Required Trip = 185 PSIG							
10/12/96	As Found		187.5					
	As Left	567	187.5	0.714%	0.007142857	5.10204E-05	✓	[initials]
3/25/95	As Found		182.5					
	As Left	556	182.5	-0.371%	-0.003714286	1.37959E-05	✓	[initials]
9/15/93	As Found		185.1					
	As Left	526	185.1	0.657%	0.006571429	4.31837E-05	✓	[initials]
4/7/92	As Found		180.5					
	As Left	552	180.5	-0.614%	-0.006142857	3.77347E-05	✓	[initials]
10/3/90	As Found		176.0		A/F data out of tolerance			
	As Left	561	184.8	-0.643%	-0.006428571	4.13265E-05	✓	[initials]
3/21/89	As Found		180.5					
	As Left	551	180.5	-0.143%	-0.001428571	2.04082E-06	✓	[initials]
9/17/87	As Found		190.3		A/F data out of tolerance			
	As Left	1	181.5	0.043%	0.000428571	1.83673E-07	✓	[initials]
9/16/87	As Found		190.0					
	As Left	523	190.0	0.386%	0.003857143	1.48776E-05	✓	[initials]
4/11/86	As Found				"no A/F data recorded"			
	As Left		187.3					
DRIFT ANALYSIS		TS-2-124C		OP 4322	Manual	Manual		Independent
	Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review
Date	Status	(Days)	TRIP	TRIP	(AF-AL)	(Fx^2)		
	Required Trip = 185 PSIG							
10/12/96	As Found		184.5					
	As Left	567	184.5	-0.286%	-0.002857143	8.16327E-06	✓	[initials]
3/25/95	As Found		174.6		A/F data out of tolerance			
	As Left	556	186.5	-1.229%	-0.012285714	1.50939E-04	✓	[initials]
9/15/93	As Found		190.9		A/F data out of tolerance			
	As Left	526	183.2	0.143%	0.001428571	2.04082E-06	✓	[initials]
4/7/92	As Found		189.9					
	As Left	552	189.9	0.257%	0.002571429	6.61224E-06	✓	[initials]
10/3/90	As Found		188.1					
	As Left	561	188.1	0.086%	0.000857143	7.34694E-07	✓	[initials]
3/21/89	As Found		187.5					
	As Left	552	187.5	-0.229%	-0.002285714	5.22449E-06	✓	[initials]
9/16/87	As Found		193.5		A/F data out of tolerance			
	As Left	523	189.1	1.129%	0.011285714	1.27367E-04	✓	[initials]
4/11/86	As Found				"no A/F data recorded"			
	As Left		185.6					

[initials] 5/27/99

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(From VYC-1599)

OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION								
DRIFT ANALYSIS		TS-2-121D		OP 4322	Manual	Manual		Independent
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP	Verification (AF-AL)	Verification (Fx^2)		Review
	Required Trip = 185 PSIG							
10/12/96	As Found		182.0					
	As Left	567	182.0	-0.343%	-0.003428571	1.17551E-05	✓	
3/25/95	As Found		184.4					
	As Left	556	184.4	0.129%	0.001285714	1.65306E-06	✓	
9/15/93	As Found		183.5					
	As Left	526	183.5	-0.029%	-0.000285714	8.16327E-08	✓	
4/7/92	As Found		183.7					
	As Left	552	183.7	-0.100%	-0.001000000	1.00000E-06	✓	
10/3/90	As Found		184.4					
	As Left	561	184.4	0.057%	0.000571429	3.26531E-07	✓	
3/21/89	As Found		184.0					
	As Left	552	184.0	0.114%	0.001142857	1.30612E-06	✓	
9/16/87	As Found		183.2					
	As Left	523	183.2	-0.414%	-0.004142857	1.71633E-05	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		186.1					
DRIFT ANALYSIS		TS-2-122D		OP 4322	Manual	Manual		Independent
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP	Verification (AF-AL)	Verification (Fx^2)		Review
	Required Trip = 185 PSIG							
10/12/96	As Found		193.3		A/F data out of tolerance			
	As Left	567	182.5	0.900%	0.009000000	8.10000E-05	✓	
3/25/95	As Found		177.4		A/F data out of tolerance			
	As Left	556	187.0	-1.014%	-0.010142857	1.02878E-04	✓	
9/15/93	As Found		178.4		A/F data out of tolerance			
	As Left	526	184.5	-0.229%	-0.002285714	5.22449E-06	✓	
4/7/92	As Found		180.0					
	As Left	552	180.0	-0.700%	-0.007000000	4.90000E-05	✓	
10/3/90	As Found		184.9					
	As Left	561	184.9	-0.229%	-0.002285714	5.22449E-06	✓	
3/21/89	As Found		186.5					
	As Left	552	186.5	0.371%	0.003714286	1.37959E-05	✓	
9/16/87	As Found		183.9					
	As Left	523	183.9	-0.186%	-0.001857143	3.44898E-06	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		185.2					
DRIFT ANALYSIS		TS-2-123D		OP 4322	Manual	Manual		Independent
Date	Data Status	Interval (Days)	Initial Data TRIP	Raw Drift Data TRIP	Verification (AF-AL)	Verification (Fx^2)		Review
	Required Trip = 185 PSIG							
10/12/96	As Found		188.4					
	As Left	567	188.4	0.957%	0.009571429	9.16122E-05	✓	
3/25/95	As Found		181.7					
	As Left	556	181.7	-1.129%	-0.011285714	1.27367E-04	✓	
9/15/93	As Found		189.6					
	As Left	526	189.6	1.057%	0.010571429	1.11755E-04	✓	
4/7/92	As Found		182.2					
	As Left	552	182.2	-0.429%	-0.004285714	1.83673E-05	✓	
10/3/90	As Found		185.2					
	As Left	561	185.2	0.529%	0.005285714	2.79388E-05	✓	
3/21/89	As Found		181.5					
	As Left	552	181.5	-0.429%	-0.004285714	1.83673E-05	✓	
9/16/87	As Found		190.8		A/F data out of tolerance			
	As Left	523	184.5	0.343%	0.003428571	1.17551E-05	✓	
4/11/86	As Found				"no A/F data recorded"			
	As Left		188.4					

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OP4322.XLS - Raw Data

(From VYC-1599)

OP 4322: MAIN STEAM LINE HIGH TEMP FUNCTIONAL/CALIBRATION									
DRIFT ANALYSIS		TS-2-124D		OP 4322	Manual	Manual		Independent	
	Data	Interval	Initial Data	Raw Drift Data	Verification	Verification		Review	
Date	Status	(Days)	TRIP	TRIP	(AF-AL)	(Fx^2)			
	Required Trip = 185 PSIG								
10/12/96	As Found		185.5						
	As Left	567	185.5	0.157%	0.001571429	2.46939E-06	✓		
3/25/95	As Found		184.4						
	As Left	556	184.4	-0.343%	-0.003428571	1.17551E-05	✓		
9/15/93	As Found		186.8						
	As Left	526	186.8	0.143%	0.001428571	2.04082E-06	✓		
4/7/92	As Found		185.8						
	As Left	552	185.8	0.643%	0.006428571	4.13265E-05	✓		
10/3/90	As Found		181.3						
	As Left	561	181.3	-0.886%	-0.008857143	7.84490E-05	✓		
3/21/89	As Found		187.5						
	As Left	552	187.5	0.514%	0.005142857	2.64490E-05	✓		
9/16/87	As Found		183.9						
	As Left	523	183.9	-0.186%	-0.001857143	3.44898E-06	✓		
4/11/86	As Found				"no A/F data recorded"				
	As Left		185.2						
Using EXCEL function to determine					Standard Deviation by Function				
Standard Deviation				STDEV:($E$7:$E$325)					
				0.5863%	✓				
Mathematically determining			Count	114	✓	STDEV/Manual RSS			
Standard Deviation using RSS						(SUM($G$7:$G$325)/(114-1))^.5			
						0.5864%	✓		
Using EXCEL Function to determine			0.008%	Average(F7:F325)		Total 'G' = [0.003885378/(114-1)]			
Average (Mean)			✓			STDEV = 0.005863777 = 0.5864%		✓	
Mathematically determining			0.008%	SUM(F7:F325)/114 = 0.857/114					
average			✓						
Using EXCEL Function to determine			0.003%	VAR($F$7:$F$325)					
Variance			✓						
Mathematically determining			0.003%	STDEV^2*(114/(114-1))					
Variance			✓						

5/27/99

Drift Analysis Design Guide Rev. 1 TIF Multipliers Attachment 3

	Probability Range Multipliers (TIF)									
	0.75					0.90				
Sample Size	0.750	0.900	0.950	0.990	0.999	0.750	0.900	0.950	0.990	0.999
2	4.498	6.301	7.414	9.531	11.920	11.407	15.978	18.800	24.167	30.227
3	2.501	3.538	4.187	5.431	6.844	4.132	5.847	6.919	8.974	11.309
4	2.035	2.892	3.431	4.471	5.657	2.932	4.166	4.943	6.440	8.149
5	1.825	2.599	3.088	4.033	5.117	2.454	3.494	4.152	5.423	6.879
6	1.704	2.429	2.889	3.779	4.802	2.196	3.131	3.723	4.870	6.188
7	1.624	2.318	2.757	3.611	4.593	2.034	2.902	3.452	4.521	5.750
8	1.568	2.238	2.663	3.491	4.444	1.921	2.743	3.264	4.278	5.446
9	1.525	2.178	2.593	3.400	4.330	1.839	2.626	3.125	4.098	5.220
10	1.492	2.131	2.537	3.328	4.241	1.775	2.535	3.018	3.959	5.046
11	1.465	2.093	2.493	3.271	4.169	1.724	2.463	2.933	3.849	4.906
12	1.443	2.062	2.456	3.223	4.110	1.683	2.404	2.863	3.758	4.792
13	1.425	2.036	2.424	3.183	4.059	1.648	2.355	2.805	3.682	4.697
14	1.409	2.013	2.398	3.148	4.016	1.619	2.314	2.756	3.618	4.615
15	1.395	1.994	2.375	3.118	3.979	1.594	2.278	2.713	3.562	4.545
16	1.383	1.977	2.355	3.092	3.946	1.572	2.246	2.676	3.514	4.484
17	1.372	1.962	2.337	3.069	3.917	1.552	2.219	2.643	3.471	4.430
18	1.363	1.948	2.321	3.048	3.891	1.535	2.194	2.614	3.433	4.382
19	1.355	1.936	2.307	3.030	3.867	1.520	2.172	2.588	3.399	4.339
20	1.347	1.925	2.294	3.013	3.846	1.506	2.152	2.564	3.368	4.300
21	1.340	1.915	2.282	2.998	3.827	1.493	2.135	2.543	3.340	4.264
22	1.334	1.906	2.271	2.984	3.809	1.482	2.118	2.524	3.315	4.232
23	1.328	1.898	2.261	2.971	3.793	1.471	2.103	2.506	3.292	4.203
24	1.322	1.891	2.252	2.959	3.778	1.462	2.089	2.489	3.270	4.176
25	1.317	1.883	2.244	2.948	3.764	1.453	2.077	2.474	3.251	4.151
26	1.313	1.877	2.236	2.938	3.751	1.444	2.065	2.460	3.232	4.127
27	1.309	1.871	2.229	2.929	3.740	1.437	2.054	2.447	3.215	4.106
30	1.297	1.855	2.210	2.904	3.708	1.417	2.025	2.413	3.170	4.049
35	1.283	1.834	2.185	2.871	3.667	1.390	1.988	2.368	3.112	3.974
40	1.271	1.818	2.166	2.846	3.635	1.370	1.959	2.334	3.066	3.917
45	1.262	1.805	2.150	2.826	3.609	1.354	1.935	2.306	3.030	3.871
50	1.255	1.794	2.138	2.809	3.588	1.340	1.916	2.284	3.001	3.833
55	1.249	1.785	2.127	2.795	3.571	1.329	1.901	2.265	2.976	3.801
60	1.243	1.778	2.118	2.784	3.556	1.320	1.887	2.248	2.955	3.774
65	1.239	1.771	2.110	2.773	3.543	1.312	1.875	2.235	2.937	3.751
70	1.235	1.765	2.104	2.764	3.531	1.304	1.865	2.222	2.920	3.730
75	1.231	1.760	2.098	2.757	3.521	1.298	1.856	2.211	2.906	3.712
80	1.228	1.756	2.092	2.749	3.512	1.292	1.848	2.202	2.894	3.696
85	1.225	1.752	2.087	2.743	3.504	1.287	1.841	2.193	2.882	3.682
90	1.223	1.748	2.083	2.737	3.497	1.283	1.834	2.185	2.872	3.669
95	1.220	1.745	2.079	2.732	3.490	1.278	1.828	2.178	2.863	3.657
100	1.218	1.742	2.075	2.727	3.484	1.275	1.822	2.172	2.854	3.646
110	1.214	1.736	2.069	2.719	3.473	1.268	1.813	2.160	2.839	3.626
120	1.211	1.732	2.063	2.712	3.464	1.262	1.804	2.150	2.826	3.610
130	1.208	1.728	2.059	2.705	3.456	1.257	1.797	2.141	2.814	3.595
140	1.206	1.724	2.054	2.700	3.449	1.252	1.791	2.134	2.804	3.582
150	1.204	1.721	2.051	2.695	3.443	1.248	1.785	2.127	2.795	3.571
160	1.202	1.718	2.047	2.691	3.437	1.245	1.780	2.121	2.787	3.561
170	1.200	1.716	2.044	2.687	3.432	1.242	1.775	2.116	2.780	3.552
180	1.198	1.713	2.042	2.683	3.427	1.239	1.771	2.111	2.774	3.543
190	1.197	1.711	2.039	2.680	3.423	1.236	1.767	2.106	2.768	3.536
200	1.195	1.709	2.037	2.677	3.419	1.234	1.764	2.102	2.762	3.529
250	1.190	1.702	2.028	2.665	3.404	1.224	1.750	2.085	2.740	3.501
300	1.186	1.696	2.021	2.656	3.393	1.217	1.740	2.073	2.725	3.481
400	1.181	1.688	2.012	2.644	3.378	1.207	1.726	2.057	2.703	3.453
500	1.177	1.683	2.006	2.636	3.368	1.201	1.717	2.046	2.689	3.434
600	1.175	1.680	2.002	2.631	3.360	1.196	1.710	2.038	2.678	3.421
700	1.173	1.677	1.998	2.626	3.355	1.192	1.705	2.032	2.670	3.411
800	1.171	1.675	1.996	2.623	3.350	1.189	1.701	2.027	2.663	3.402
900	1.170	1.673	1.993	2.620	3.347	1.187	1.697	2.023	2.658	3.396
1000	1.169	1.671	1.992	2.617	3.344	1.185	1.695	2.019	2.654	3.390
Infinity	1.150	1.645	1.960	2.576	3.291	1.150	1.645	1.960	2.576	3.291

	Probability Range Multipliers (TIF)									
	0.95					0.99				
Sample Size	0.750	0.900	0.950	0.990	0.999	0.750	0.900	0.950	0.990	0.999
2	22.858	32.019	37.674	48.430	60.573	114.363	160.193	188.491	242.300	303.054
3	5.922	8.380	9.916	12.861	16.208	13.378	18.930	22.401	29.055	36.616
4	3.779	5.369	6.370	8.299	10.502	6.614	9.398	11.150	14.527	18.383
5	3.002	4.275	5.079	6.634	8.415	4.643	6.612	7.855	10.260	13.015
6	2.604	3.712	4.414	5.775	7.337	3.743	5.337	6.345	8.301	10.548
7	2.361	3.369	4.007	5.248	6.676	3.233	4.613	5.488	7.187	9.142
8	2.197	3.136	3.732	4.891	6.226	2.905	4.147	4.936	6.468	8.234
9	2.078	2.967	3.532	4.631	5.899	2.677	3.822	4.550	5.966	7.600
10	1.987	2.839	3.379	4.433	5.649	2.508	3.582	4.265	5.594	7.129
11	1.916	2.737	3.259	4.277	5.452	2.378	3.397	4.045	5.308	6.766
12	1.858	2.655	3.162	4.150	5.291	2.274	3.250	3.870	5.079	6.477
13	1.810	2.587	3.081	4.044	5.158	2.190	3.130	3.727	4.893	6.240
14	1.770	2.529	3.012	3.955	5.045	2.120	3.029	3.608	4.737	6.043
15	1.735	2.480	2.954	3.878	4.949	2.060	2.945	3.507	4.605	5.876
16	1.705	2.437	2.903	3.812	4.865	2.009	2.872	3.421	4.492	5.732
17	1.679	2.400	2.858	3.754	4.791	1.965	2.808	3.345	4.393	5.607
18	1.655	2.366	2.819	3.702	4.725	1.926	2.753	3.279	4.307	5.497
19	1.635	2.337	2.784	3.656	4.667	1.891	2.703	3.221	4.230	5.399
20	1.616	2.310	2.752	3.615	4.614	1.860	2.659	3.168	4.161	5.312
21	1.599	2.286	2.723	3.577	4.567	1.833	2.620	3.121	4.100	5.234
22	1.584	2.264	2.697	3.543	4.523	1.808	2.584	3.078	4.044	5.163
23	1.570	2.244	2.673	3.512	4.484	1.785	2.551	3.040	3.993	5.098
24	1.557	2.225	2.651	3.483	4.447	1.764	2.522	3.004	3.947	5.039
25	1.545	2.208	2.631	3.457	4.413	1.745	2.494	2.972	3.904	4.985
26	1.534	2.193	2.612	3.432	4.382	1.727	2.469	2.941	3.865	4.935
27	1.523	2.178	2.595	3.409	4.353	1.711	2.446	2.914	3.828	4.888
30	1.497	2.140	2.549	3.350	4.278	1.668	2.385	2.841	3.733	4.768
35	1.462	2.090	2.490	3.272	4.179	1.613	2.306	2.748	3.611	4.611
40	1.435	2.052	2.445	3.213	4.104	1.571	2.247	2.677	3.518	4.493
45	1.414	2.021	2.408	3.165	4.042	1.539	2.200	2.621	3.444	4.399
50	1.396	1.996	2.379	3.126	3.993	1.512	2.162	2.576	3.385	4.323
55	1.382	1.976	2.354	3.094	3.951	1.490	2.130	2.538	3.335	4.260
60	1.369	1.958	2.333	3.066	3.916	1.471	2.103	2.506	3.293	4.206
65	1.359	1.943	2.315	3.042	3.886	1.455	2.080	2.478	3.257	4.160
70	1.349	1.929	2.299	3.021	3.859	1.440	2.060	2.454	3.225	4.120
75	1.341	1.917	2.285	3.002	3.835	1.428	2.042	2.433	3.197	4.084
80	1.334	1.907	2.272	2.986	3.814	1.417	2.026	2.414	3.173	4.053
85	1.327	1.897	2.261	2.971	3.795	1.407	2.012	2.397	3.150	4.024
90	1.321	1.889	2.251	2.958	3.778	1.398	1.999	2.382	3.130	3.999
95	1.315	1.881	2.241	2.945	3.763	1.390	1.987	2.368	3.112	3.976
100	1.311	1.874	2.233	2.934	3.748	1.383	1.977	2.355	3.096	3.954
110	1.302	1.861	2.218	2.915	3.723	1.369	1.958	2.333	3.066	3.917
120	1.294	1.850	2.205	2.898	3.702	1.358	1.942	2.314	3.041	3.885
130	1.288	1.841	2.194	2.883	3.683	1.349	1.928	2.298	3.019	3.857
140	1.282	1.833	2.184	2.870	3.666	1.340	1.916	2.283	3.000	3.833
150	1.277	1.825	2.175	2.859	3.652	1.332	1.905	2.270	2.983	3.811
160	1.272	1.819	2.167	2.848	3.638	1.326	1.896	2.259	2.968	3.792
170	1.268	1.813	2.160	2.839	3.627	1.320	1.887	2.248	2.955	3.774
180	1.264	1.808	2.154	2.831	3.616	1.314	1.879	2.239	2.942	3.759
190	1.261	1.803	2.148	2.823	3.606	1.309	1.872	2.230	2.931	3.744
200	1.258	1.798	2.143	2.816	3.597	1.304	1.865	2.222	2.921	3.731
250	1.245	1.780	2.121	2.788	3.561	1.286	1.839	2.191	2.880	3.678
300	1.236	1.767	2.106	2.767	3.535	1.273	1.820	2.169	2.850	3.641
400	1.223	1.749	2.084	2.739	3.499	1.255	1.794	2.138	2.809	3.589
500	1.215	1.737	2.070	2.721	3.475	1.243	1.777	2.117	2.783	3.555
600	1.209	1.729	2.060	2.707	3.458	1.234	1.764	2.102	2.763	3.530
700	1.204	1.722	2.052	2.697	3.445	1.227	1.755	2.091	2.748	3.511
800	1.201	1.717	2.046	2.688	3.434	1.222	1.747	2.082	2.736	3.495
900	1.198	1.712	2.040	2.682	3.426	1.218	1.741	2.075	2.726	3.483
1000	1.195	1.709	2.036	2.676	3.418	1.214	1.736	2.068	2.718	3.472
Infinity	1.150	1.645	1.960	2.576	3.291	1.150	1.645	1.960	2.576	3.291

Attachment C

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 257, ARTS/MELLLA

Additional Information in Response to RAI No. 9

VYC-467, Reactor System High Pressure Trip Loop Accuracy Review

VY CALCULATION CHANGE NOTICE (CCN)

CCN Number: 01 Calculation Number: VYC-0467 Rev. No. 5

Calculation Title: REACTOR SYSTEM HIGH PRESSURE TRIP LOOP ACCURACY REVIEW

Initiating Document: N/A
VYDC/MM/TM/Spec. No./ other

Safety Evaluation Number: N/A

Superseded Document: N/A

Implementation Required: ☑ Yes ☑ No

Reason for Change: To correct the CTS Limiting Setpoint (LSp) value from 1066 to 1038 psig.
Description of Change: Revise various sheets to show LSp value of 1038 psig.
Technical Justification for Change: VY Instrument Uncertainty and Setpoints Design Guide, Rev. 1, Appendix D, Section 4.6.1.
Conclusions: 1. The LSp value of 1038 psig supports the existing Technical Specification and Analysis Limits. 2. This Calculation or CCN is not an implementing document. Therefore, this CCN does not require a safety evaluation.

Prepared By/Date	Interdiscipline Review By/Date	Independent Review By/Date	Approved By/Date
Joseph C. Garozzo 1/17/01	N/A	James W. Allen 1/17/01	Richard G. [illegible] 1/17/2001

Installation Verification/Final Turnover to DCC:

Open Items Associated with CCN ☐ Yes ☑ No ☐ Closed (Section 2.3.2)

Installation Verification (Section 2.3.4)

☑ Calculation accurately reflects plant as-built configuration, OR
☐ N/A, calculation does not affect plant configuration

Resolution of documents identified in the Design Output Documents Section of VYAPF 0017.07 (Section 2.3.6)

Joseph C. Garozzo / [signature] / 1/12/01 SLE per QB 1-18-01
Print Name Signature Date

Total number of pages in package including all attachments

Note: VYAPF 0017.07 should be included immediately following this form.

VY CALCULATION DATABASE INPUT FORM

VYC-0467 CCN-01	5		
VY Calculation/CCN Number	Revision Number	Vendor Calculation Number	Revision Number

Vendor Name: ______________________ PO Number:

Originating Department: Design Engineering

Critical References Impacted: ☐ FSAR ☐ DBD ☐ Reload. "Check" the appropriate box if any critical document is identified in the tables below.

EMPAC Asset/Equipment ID Number(s): PT-2-3-55A(M), 55B(M), 55C(M), 55D(M)

EMPAC Asset/System ID Number(s): NB, Nuclear Boiler

Keywords:

For Revision/CCN only: Are deletions to General References, Design Input Documents or Design Output Documents required? ☐ Yes† ☑ No

General References

* Reference #	** DOC #	REV #	*** Reference Title (including Date, if applicable) (See App. A, Section 3.2.7 for Guidance)	**** Affected Program	Critical Reference (✓)

Design Input Documents - The following documents provide design input to this calculation. (Refer to Appendix A, section 4)

* Reference #	** DOC #	REV #	Document Title (Including Date, if applicable)	**** Affected Program	Critical Reference (_)

Design Output Documents - This calculation provides output to the following documents. (Refer to Appendix A, section 5)

* Reference #	** DOC #	REV #	Document Title (Including Date, if applicable)	**** Affected Program	Critical Reference (_)

* Reference # - Assigned by preparer to identify the reference in the body of the calculation.
** Doc # - Identifying number on the document, if any (e.g., 5920-0264, G191172, VY6-1286)
*** Reference Title - List the specific documentation in this column. "See attached list" is not acceptable. Design Input/Output Documents should identify the specific design input document used in the calculation or the specific document affected by the calculation and not simply reference the document (e.g., VYDC, MM) that the calculation was written to support.
**** Affected Program - List the affected program or the program that reference is related to or part of. If the reference is FSAR, DBD or Reload (IASD or OPL), check Critical Reference column and check FSAR, DBD or Reload, as appropriate, on this form (above).

† If "yes," attach a copy of "VY Calculation Data" marked-up to reflect deletion (See Section 3.1.8 for Revision and 5.2.3.18 for CCNs).

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TABLE 11

Total Loop Uncertainty Results

Output Instrument	Interval	Normal/LOCA		HELB		Seismic	
		% CS	psig	% CS	psig	% CS	psig
PT-2-3-55A(M), 55B(M), 55C(M), 55D(M)	Monthly	1.12	16.73	1.74	26.05	1.22	18.33
PT-2-3-55A(M), 55B(M), 55C(M), 55D(M)	Quarterly	1.12	16.73	1.74	26.05	1.22	18.33

5.2. Setpoint Evaluation

Results are presented below for the Limiting Setpoint (LSp), Allowable Value (AV), and Technical Specifications Limit. Also calculated is the Acceptance Value (ACV) by algebraically adding the as-found tolerances for the loop devices to the existing setpoints. The calculation of this value and the margin from Allowable Value (AV) ensures that the Allowable Value (AV) will not be exceeded during surveillance. All the available margins are shown below. Comparison of the calculated AV to the present Technical Specification value of 1055 psig shows that the setpoint will support the Technical Specifications for Improved Technical Specifications (ITS), and for Current Technical Specifications (CTS).

TABLE 12

Setpoint Results

Description	Results (psig)	
	CTS	ITS
Analytical Limit (AL)	1085	1085
Allowable Value (AV)	N/A	1082
Technical Specifications Limit (TS)	1055[1]	
Acceptance Value (ACV)	N/A	1056
Limiting Setpoint (LSp)	~~1066~~ 1038	1066
Setpoint (SP)	1038	
Margin LSP to SP ~~(M1)~~ – Monthly	~~28~~ NEGLIGIBLE	N/A
Margin LSP to SP ~~(M1)~~ – Quarterly	~~28~~ NEGLIGIBLE	28
Margin TS to SP (M2)	Negligible	Negligible
Margin AV to ACV (M3)	N/A	26
Spurious Trip Margin – HELB (M4)	N/A	11

[1] The actual Technical Specification limit is 1055 psig, however the actual setting value in OP-4312 is 1054.69 (equivalent to 15.25 mA). For ITS the Technical Specification limit would be revised to the AV or limit of operability.

These results are presented graphically in Figure 1 and 2.

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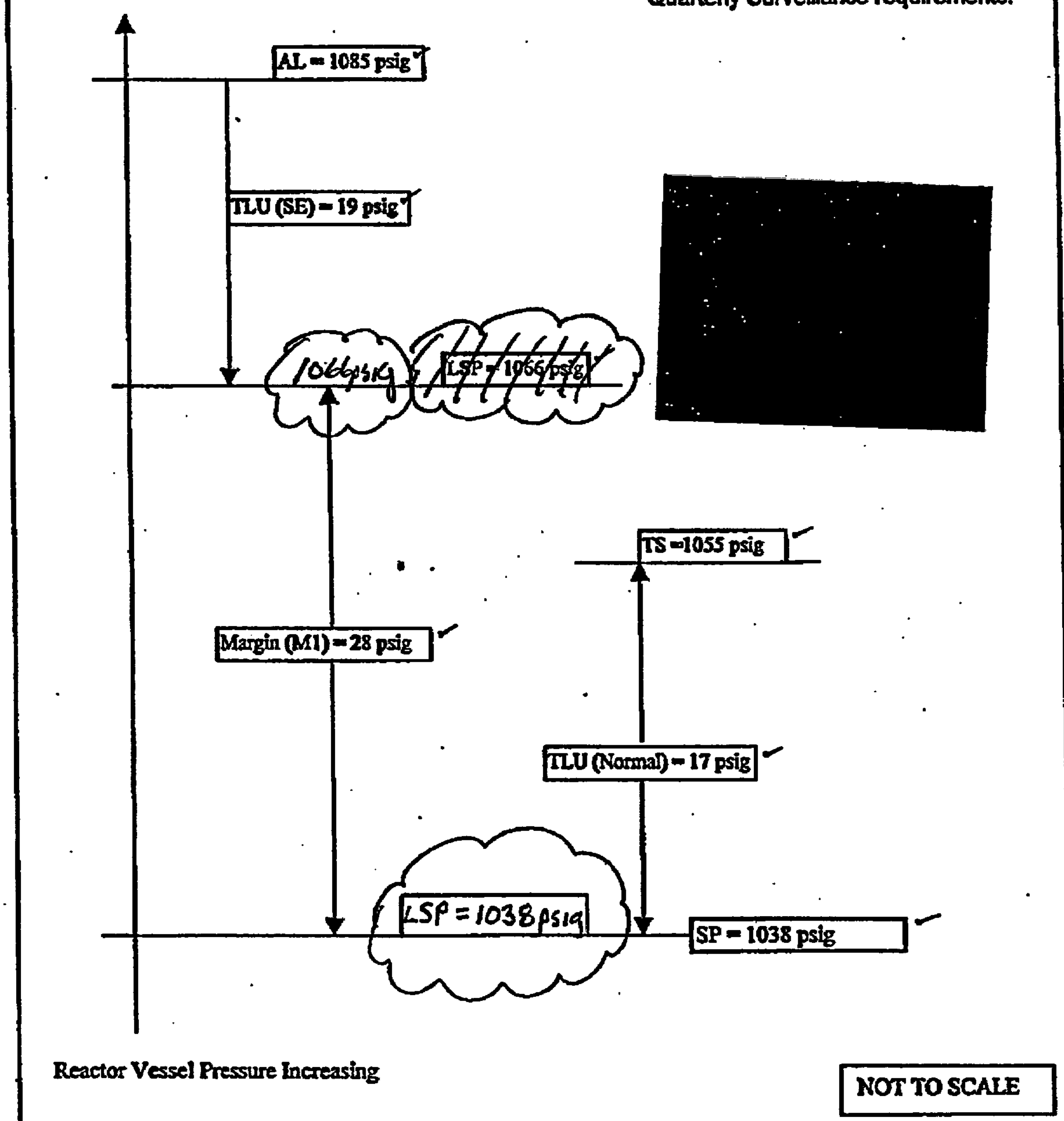
5.3. Graphic Representation of the Custom and Improved Technical Specification Setpoints.

Figure 1 - Custom Technical Specifications

Values shown reflect both Monthly & Quarterly Surveillance requirements.



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5.4. Calibration and Test Results

In order to support and implement the results of this calculation, the loop instruments are to be calibrated according to the following table:

TABLE 13

Calibration Setpoints and Ranges

Description	Value	Units
Transmitter input range	12-1512 ✓	PSIG
Transmitter output range for calibration	4 - 20 ✓	mA
Trip unit setpoint 1038 psig	15.07 ±0.03 ✓	mA
Trip unit reset	0.08 to 1.2	mA

✓x3 04/26/99

Test as-found tolerances (FT) and as-left tolerances (CT) are shown below.

TABLE 14

Calibration Tolerances[5]

		As-Found	As-Left	Months
Transmitter'	PT-2-3-55 A,B,C,D	0.16 mA ✓	0.04 mA ✓	18
Master Trip Unit	PT-2-3-55 (M) A,B,C,D	0.03 mA ✓	0.03mA ✓	3
Master Trip Unit	PT-2-3-55 (M) A,B,C,D	0.03 mA ✓	0.03 mA ✓	1

✓x6 04/26/99

5.5. Summary of Recommendations

{IS 1038psig}

The calculated limiting setpoint for Custom Technical Specifications and Improved Technical Specifications is 1066 psig. The current Plant setpoint is 1038 psig. For both the Custom Technical Specification and Improved Technical Specification programs, use of the existing setpoint provides adequate margin from the analytical limit of 1085 psig.

Since the setpoint value did not change from the value established in revision 4 of this calculation, the setpoint values found in the calibration procedure (OP-4312, Rev 21) and in the Alarm Response Sheets (5-K-3, Rev 5 (Ref. 6.40)) do not need to be revised. Although the As-Left calibration tolerances did not

[5] The as-found tolerances have been rounded off to two decimal places for ease of calibration. See attachment B for additional information.

5.1.1 Custom Technical Specifications

Although these loops are required to remain operable for up to 6 hours following HELB events, operability is limited to not causing a spurious trip or failing in such a manner as to cause a loss of RPS functions. Therefore, the evaluation will consist of ensuring that a HELB event will not cause a spurious trip and will not be used to determine the Limiting Setpoint. Vermont Yankee's Design Bases establishes that that Reactor Vessel Pressure is required for a Design Basis Eathquake. Therefore, the Limiting Setpoint will be developed using the seismic uncertainty. In addition actuation of the desired setpoint is for increasing pressure, therefore the most limiting, positive, Total Loop Uncertainty ($TLU_{Seismic}$) will be used.

~~CTS - Monthly Testing~~

$TLU_{NORMAL} = 17\,psi$

~~$TLU_{Seismic\_Monthly} = 18.33\,psi$~~

~~$TLU_{Seismic\_Monthly\_Rnd} := 19\,psi$~~

$TS = 1055\,psi$ ~~AL = 1038 psi~~

LSP_{M_CTS} := $TS - TLU_{NORMAL}$ ~~AL − TLU Seismic_Monthly_Rnd~~

LSP_{M_CTS} = 1038 psi ~~1060 psi~~ — Limiting Setpoint, for PT-2-3-55A, B, C, & D at a Monthly surveillance interval.

Margin From Existing Setpoint (Monthly)

LSP_{M_CTS} = 1038 psi ~~1060 psi~~ $SP = 1038\,psi$

$M1_{m\_CTS} := LSP_{M\_CTS} - SP$

$M1_{m\_CTS}$ = 0 psi ~~22 psi~~ — Margin from the existing setpoint

~~CTS - Quarterly Testing~~

$TLU_{NORMAL} = 17\,psi$

~~$TLU_{Seismic\_Quarterly} = 18.33\,psi$~~

~~$TLU_{Seismic\_Quarterly\_Rnd} := 19\,psi$~~

$TS = 1055\,psi$ ~~AL = 1038 psi~~

LSP_{Q_CTS} := $TS - TLU_{NORMAL}$ ~~AL − TLU Seismic_Quarterly_Rnd~~

LSP_{Q_CTS} = 1038 psi ~~1060 psi~~ — Limiting Setpoint, for PT-2-3-55A, B, C, & D at a Quarterly surveillance interval.

Margin From Existing Setpoint (Quarterly)

LSP_{Q_CTS} = 1038 psi ~~1060 psi~~ $SP = 1038\,psi$

$M1_{Q\_CTS} := LSP_{Q\_CTS} - SP$

$M1_{Q\_CTS}$ = 0 psi ~~22 psi~~ — Margin from the existing setpoint

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VERMONT YANKEE SETPOINT CONTROL PROGRAM
INTERDEPARTMENTAL REVIEW OF CALCULATION:

VYC- 467 Revision 5 has been prepared and independently reviewed. The Departments impacted by this calculation are requested to review the results of this calculation, concur with the results and/or recommendations, and document the department's acceptance prior to the calculation being approved.

1. Summary: This calculation evaluates the uncertainty & setpoints for Reactor System High Pressure Trip Loop

2. Calculation Open Items: AP-0028 to be Assigned

Not Applicable — N/A R.W.A[illegible] 3/2/00

3. Department Review - contact the Setpoint Program Manager (G. Hengerle) if not in agreement with the conclusions/statements.

3.1. Vermont Yankee E&C

3.1.a. Procedure; OP4312 "Reactor Vessel High Pressure Scram Function Test/Calibration" will require the following :

		From	To	Disagree	Agree
1.	Calibration Tolerances:				
	PT-2-3-55A/B/C/D				
	a. As Found values:	+/- 0.17 mA	+/- 0.16 mA	☐	☑
	b. As Left values:	+/- 0.04 mA	+/- 0.04 mA	☐	☑
	PT-2-3-55A/B/C/D (M)				
	a. As Found values:	+/- 0.04 mA	+/- 0.03 mA	☐	☑
	b. As Left values:	+/- 0.03 mA	+/- 0.03 mA	☐	☑
2.	Nominal Setpoint	1038 psig	1038 psig	☐	☑
		15.07 mA	~~15.07 mA~~	☐	☑
3.	Limiting Setpoint	1068 psig	~~1066 psig~~ 1038 psig	☐	☑
4.	Head Correction	12 psig	12 psig	☐	☑

5. Insert the following M&TE requirements:

M&TE	Ranges	Resolution
Heise Gage 901B	0-2000	0.1 psig
Heise CM & CMM	0-2000	2 psig (Minor Div)
HP 34401A Digital Multimeter	0-100	0.0001 mA
Rosemount Readout Assembly	0-28	0.01 mA

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VY CALCULATION REVIEW FORM

Calculation Number: VYC-0467 Revision Number: 5 CCN Number: 01

Title: REACTOR SYSTEM HIGH PRESSURE TRIP LOOP ACCURACY REVIEW

Reviewer Assigned: ____________ Required Date: ____________

☐ Interdiscipline Review ☑ Independent Review

VYC-0467, Rev. 5 CCN-01
Page 9 of ____

Comments*

No comments

Resolution

James W. Allen / 1/17/01
Reviewer Signature / Date

____________ / ____________
Calculation Preparer (Comments Resolved) / Date

Method of Review:
☑ Calculation/Analysis Review
☐ Alternative Calculation
☐ Qualification Testing

____________ / ____________
Reviewer Signature (Comments Resolved) / Date

*Comments shall be specific, not general. Do not list questions or suggestions unless suggesting wording to ensure the correct interpretation of issues. Questions should be asked of the preparer directly.

VY CALCULATION CHANGE NOTICE (CCN)

CCN Number: 02 Calculation Number VYC-0467 Rev. No. 5

Calculation Title: REACTOR SYSTEM HIGH PRESSURE TRIP LOOP ACCURACY REVIEW

Initiating Document: ER 2001-2151_01
VYDC/MM/TM/Spec. No./ other

Safety Evaluation Number: N/A

Superseded Calculation: N/A Superceded by: N/A

Implementation Required: ☐ Yes ☒ No

Computer Codes: N/A

Reason for Change: Commitment ER 2001-2151_01.
Description of Change: Corrected normal reactor pressure value from 1000 psig to a conservative 1010 psig per ER 2001-2151 response.
Technical Justification for Change: Normal reactor pressure is procedurally controlled to 1005+/-5 psig. Sufficient margin is available to accommodate the increase in the pressure value.
Conclusions: Normal reactor pressure value corrected per commitment ER 2001-2151_01. Increase in pressure will not result in inadvertent reactor trip in the event of a HELB.

Are there any open items in this CCN? ☐ Yes ☒ No

Prepared By/Date	Interdiscipline Review By/Date	Independent Review By/Date	Approved By/Date
Joseph Garozzo 3/25/02 JOSEPH GAROZZO	N/A	Harry T Hyer 3/25/02 Harry T Hyer 3/25/02	Richard G. Januzzi 3/25/02 Richard G. Januzzi

Final Turnover to DCC (Section 2):

1) All open items, if any, have been closed.

2) Implementation Confirmation (Section 2.3.4)

☒ Calculation accurately reflects existing plant configuration, (confirmation method indicated below)
☐ Walkdown ☐ As-Build input review ☒ Discussion with Joseph Garozzo (print name)
OR
☐ N/A, calculation does not reflect existing plant configuration

3) Resolution of documents identified in the Design Output Documents Section of VYAPF 0017.07 has been initiated as required (Section 2.3.6, 2.3.7)

JOSEPH GAROZZO, Joseph Garozzo, 3/25/02
Print Name, Signature, Date

Total number of pages in package including all attachments

VY CALCULATION DATABASE INPUT FORM

Place this form in the calculation package immediately following the Title page or CCN form.

VYC-0467, Rev. 5, CCN-02
Page 2 of 7

VYC-0467, CCN-02 — VY Calculation/CCN Number
5 — Revision Number
Vendor Calculation Number:
Revision Number:
Vendor Name:
PO Number:
Originating Department:
Critical References Impacted: ☐ UFSAR ☐ DBD ☐ Reload. "Check" the appropriate box if any critical document is identified in the tables below.
EMPAC Asset/Equipment ID Number(s):
EMPAC Asset/System ID Number(s):
Keywords:
For Revision/CCN only: Are deletions to General References, Design Input Documents or Design Output Documents required? ☐ Yes† ☒ No

Design Input Documents and General References - The following documents provide design input or supporting information to this calculation. (Refer to Appendix A, sections 3.2.7 and section 4)

* Reference #	** DOC #	REV #	***Document Title (including Date, if applicable)	Significant Difference Review ††	**** Affected Program	Critical Reference (✓)
6.43.	ER 2001-2151		Incorrect value assumed for normal reactor pressure.			

VY CALCULATION DATABASE INPUT FORM (Continued)

Design Output Documents - This calculation provides output to the following documents. (Refer to Appendix A, section 5)

* Reference #	** DOC #	REV #	Document Title (including Date, if applicable)	**** Affected Program	†††Critical Reference (✓)

* Reference # - Assigned by preparer to identify the reference in the body of the calculation.

** Doc # - Identifying number on the document, if any (e.g., 5920-0264, G191172, VYC-1286)

*** Document Title - List the specific documentation in this column. "See attached list" is not acceptable. Design Input/Output Documents should identify the specific design input document used in the calculation or the specific document affected by the calculation and not simply reference the document (e.g., VYDC, MM) that the calculation was written to support. If a DBD is used as a general reference, include the most current interim change number after the title.

**** Affected Program - List the affected program or the program that reference is related to or part of.

† If "yes," attach a copy of "VY Calculation Data" marked-up to reflect deletion (See Section 3.1.8 for Revision and 5.2.3.18 for CCNs).

†† If the listed input is a calculation listed in the calculation database that is not a calculation of record (see definition), place a check mark in this space to indicate completion of the required significant difference review. (see Appendix A, section 4.1.4.4.3). Otherwise, enter "N/A."

††† If the reference is UFSAR, DBD or Reload (IASD or OPL), check Critical Reference column and check UFSAR, DBD or Reload, as appropriate, on this form (above).

CCN-02
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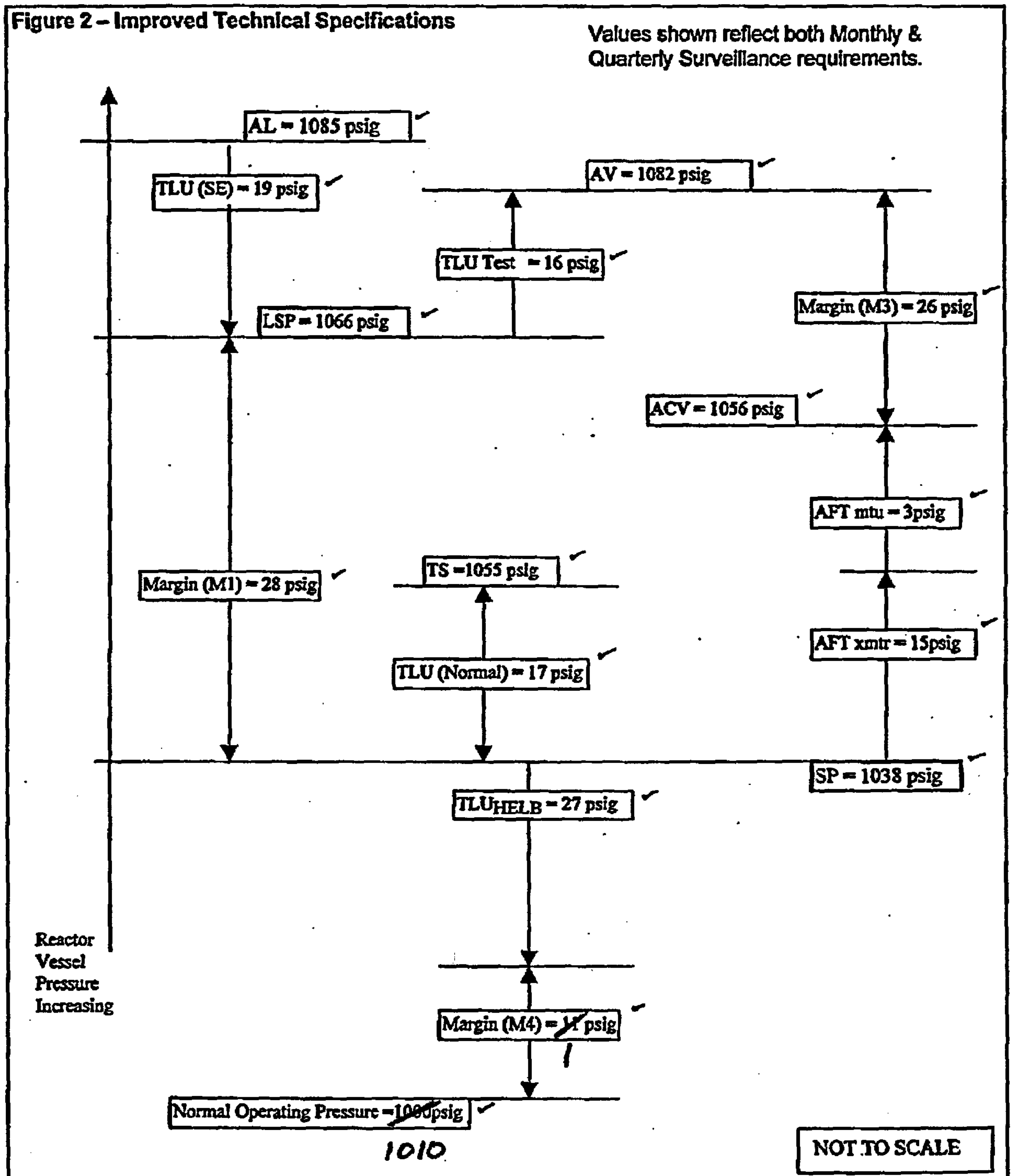
Figure 2 – Improved Technical Specifications



6.33. System P&ID - "Flow Diagram - Nuclear Boiler Vessel Instrumentation, G191267, sheet 2, Rev. 3.

6.34. **Control Wiring Diagrams:**

6.34.1. Drawing B-191301, Sh. 805, "Reactor Protection System Auto Scram & Auxiliary Circuit Channel 'A1', Rev. 11.

6.34.2. Drawing B-191301, Sheet 808, "Reactor Protection System Auto Scram & Auxiliary Circuit Channel 'A2', Rev. 12.

6.34.3. Drawing B-191301, Sheet 812, "Reactor Protection System Auto Scram & Auxiliary Circuit Channel 'B1', Rev. 12.

6.34.4. Drawing B-191301, Sheet 815, "Reactor Protection System Auto Scram & Auxiliary Circuit Channel 'B2', Rev. 11.

6.34.5. Drawing B-191301, Sheet 803, "Reactor Protection System Reactor Scram Sensors Channel 'A1', Rev. 17.

6.34.6. Drawing B-191301, Sheet 806, "Reactor Protection System Reactor Scram Sensors Channel 'A2', Rev. 14.

6.34.7. Drawing B-191301, Sheet 810, "Reactor Protection System Reactor Scram Sensors Channel 'B1', Rev. 18.

6.34.8. Drawing B-191301, Sheet 813, "Reactor Protection System Reactor Scram Sensors Channel 'B2', Rev. 14.

6.34.9. Drawing B-191301, Sheet 834, "Reactor Protection System Annunciator, sheet 1", Rev. 4.

6.34.10. Drawing B-191301, Sheet 837, "Channel "A" Computer Inputs, Rev. 14.

6.34.11. Drawing B-191301, Sheet 838, "Channel "B" Computer Inputs, Rev. 16.

6.34.12. Drawing B-191301, Sheet 850, "RPS Analog Trip A1", Rev. 5.

6.34.13. Drawing B-191301, Sheet 851, "RPS Analog Trip B1", Rev. 3.

6.34.14. Drawing B-191301, Sheet 855, "RPS Analog Trip A2", Rev. 5.

6.34.15. Drawing B-191301, Sheet 856, "RPS Analog Trip B2", Rev. 7.

6.35. ~~Vermont Yankee Procedure~~ AP 0150 "Conduct of Operations and Operator Rounds" Rev. ~~31~~ 35 Issue Date ~~07/05/00~~ 7/31/2001

6.36. ~~Selected Definitions and~~ Clarifications Associated with the Vermont Yankee Technical Specification "Typical Surveillance Intervals"

6.37. DELETED DURING REV 5. ~ Test equipment information captured by VYC-1758.

6.38. VYC -332 Revision 2 Page 26-29 "Reactor Water Level and Pressure Head and DP Head Correction calculated and recommended at 12.70 psi for calibration.

6.39. ~~Input Assumptions~~ Source Document, Vermont Yankee Nuclear Power Station Cycle ~~20~~ 22 Revision ~~1~~ 0 ~~May 1998~~ MARCH 2001

6.40. ~~Alarm Response~~ Sheet 5-K-3, Rev.4 Reactor Protection System.

6.41. VY Design Engineering Procedure No. 15, Review and Approval of Design Engineering Procedures, Rev.2.

6.42. Memo, VYI 92/97, Rev 1. G. J. Hengerle to Distribution, "Application of CT,CE and A for single point devices", dated June 26, 1998.

6.43 ER 2001-2151, INCORRECT VALUE ASSUMED FOR NORMAL REACTOR PRESSURE

5.1.3 HELB Spurious Trip Margin

All RPS components are required to remain functional and not cause a reactor scram for six hours following a HELB outside of the primary containment. For the Reactor Pressure High Trip, this operability is verified by evaluating the affect of HELB errors with a normal reactor pressure reading. The normal operating pressure is selected and HELB errors are added to the normal pressure to determine if a spurious trip could occure. M4 is the margin to spurious trip.

The RPS system must remain functional for 6 hours after a HELB event to allow for a controlled shutdown of the Reactor. This requires that the Reactor Vessel Pressure Trip instruments not generate a spurious trip during this six hour time. The errors associated with a HELB event wil be added to normal Reactor pressure to determine the margin to spurious trip.

REF, 6.35 AND 6.39

$TLU_{HELB\_Quarterly} = 26.05 \cdot psi$ ✓

$TLU_{~~HELB\_Quarterly~~\_Rnd} := 27 \cdot psi$ ✓

$P_n := ~~1000~~$ 1010 $\cdot psi$ ✓ $\quad SP = 1038 \cdot psi$ ✓

$P_n + TLU_{HELB\_Quarterly\_Rnd} = ~~1027~~$ 1037 $\cdot psi$ ✓

$M4 := SP - (P_n + TLU_{HELB\_Quarterly\_Rnd})$

$M4 = ~~11~~$ 1 $\cdot psi$ ✓

Margin from spurious RPS trip during 6 hrs after HELB event = SP-(Normal DW Pr+TLU(HELB)

5.1.4 Setpoint Results

All of the margins associated with the existing setpoint of 1038 psig were positive, therefore the existing setpoint is acceptable and no setpoint change is required.

Setpoint Conversion from PSI to mA

Setpoint

$SP = 1038 \cdot psi$ ✓ $\quad CS_{xmtr} = 1500 \cdot psi$ ✓

$SP\_mA := SP \cdot \left(\frac{16 \cdot mA}{CS_{xmtr}}\right) + 4 \cdot mA$

$SP\_mA = 15.07 \cdot mA$ ✓ Setpoint value in mA

Tech Spec Value

$TS = 1055 \cdot psi$ ✓ $\quad CS_{xmtr} = 1500 \cdot psi$ ✓

$TS\_mA := TS \cdot \left(\frac{16 \cdot mA}{CS_{xmtr}}\right) + 4 \cdot mA$

$TS\_mA = 15.25 \cdot mA$ ✓ Tech Spec value in mA

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VY CALCULATION REVIEW FORM

Calculation Number: VYC-0467 Revision Number: 5 CCN Number: 2

Title: REACTOR SYSTEM HIGH PRESSURE TRIP LOOP ACCURACY REVIEW

Reviewer Assigned: ____________ Required Date: ____________

VYC-0467, Rev. 5, CCN-02
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☐ Interdiscipline Review ☒ Independent Review

Comments*	Resolution
No Comments Noted	

Harry T. Hyan / 3-25-02
Reviewer Signature Date

____________ / ______
Calculation Preparer (Comments Resolved) Date

Method of Review:
☒ Calculation/Analysis Review
☐ Alternative Calculation
☐ Qualification Testing

____________ / ______
Reviewer Signature (Comments Resolved) Date

*Comments shall be specific, not general. Do not list questions or suggestions unless suggesting wording to ensure the correct interpretation of issues. Questions should be asked of the preparer directly.

TOTAL NUMBER OF PAGES = ~~207~~ 210 J.W. Allen 3/2/00

Original: PAGE 1 of 26 PAGES
Revision 4: PAGE 1 of 24 PAGES
Revision 5: PAGE 1 of 22 PAGES
Revision 6: PAGE of __ PAGES

QA RECORD?

X YES

__ NO

RECORD TYPE NO. 09C16004

Safety Class/P.O. NO. (if applicable) . SC2/SCE

YANKEE ATOMIC ELECTRIC COMPANY
CALCULATION/ANALYSIS FOR
Safety Class Instrument Accuracy Review

TITLE Reactor System High Pressure Trip Loop Accuracy Review

PLANT: VERMONT YANKEE CYCLE 20

CALCULATION NUMBER VYC- 467

	PREPARED BY/DATE	REVIEWED BY/DATE	APPROVED BY/DATE	SUPERSEDES CALC./REV. NO.
Revision 4	Jerry Voss 5-16-97	Michael W. Anderson 5-21-97	George J. Hengerle 2-27-98	VYC-467 Rev 3
Revision 5	Timothy J. Binder 04/26/99 Timothy Binder	Michael W. Anderson 5/2/99 Michael W. Anderson	James W. Allen 3/2/00 James W. Allen	VYC-467 Rev 4
Revision 6				
Revision 7				

KEYWORDS Reactor Vessel/ Over Pressure /Reactor Protection System / SCRAM/ Transient/ Setpoint/ Instrument Uncertainty

COMPUTER CODES: None

EQUIP/TAG NOs.: PT-2-3-55A, PT-2-3-55B, PT-2-3-55C, PT-2-3-55D, ES-25-5A-A1, ES-25-5A-B1, ES-25-6A-A2, ES-25-6A-B2, PT-2-3-55A(M), PT-2-3-55B(M), PT-2-3-55C(M) and PT-2-3-55D(M).

SYSTEMS: Nuclear Boiler Vessel Instrumentation (2-3)

REFERENCES: Technical Specification Section 2.2.A, Bases Section 1.2, and Tables 3.1.1, 4.1.1, 4.1.2, FSAR Section 14.4.1, and Table 7.2.1. Additional References are captured in Section 6.0

Table of Contents

LIST OF TABLES

History of Revisions

Rev. No.	Approval Date	Reason & Description of Change
0	06/18/86	Initial issue.
1	08/13/86	
2	08/18/88	
3	03/07/91	Generated to incorporate new vendor information and incorporate the replacement power supplies
4	2/27/98*	Revision 4 generated to support Improved Technical Specifications and to incorporate a new setpoint methodology document. This is a major rewrite.
5	3/2/00	Revision 5 generated to support recent revision to the EQ manual (Rev. 38), FSAR (Rev. 15), and Technical Specification manual (through Amendment 169). Revised sections regarding development of the Limiting setpoint to reflect the newly established Analytical Limit and revision to the calibration procedure. Also revised sections to reflect most recent versions of references and additional comments made during the PP-7007 in house review.

*Minor additional changes have been incorporated since calculation approval but prior to distribution (i.e. Interdepartmental Review Form).

1. PURPOSE

1.1. Calculation Objectives

This calculation has been developed in support of the Vermont Yankee Setpoints program and covers instrument loops for Reactor Vessel High Pressure Scram and has the following major objectives:

1. Document the instrument loop functions and the basis for the setpoints and operator decision points associated with those functions.
2. Establish the total loop uncertainty for each output function and verify consistency with the design basis.
3. Calculate the limiting setpoints and operator decision points.
4. Evaluate the adequacy of existing Setpoint Administrative Limits and procedural decision points.
5. Provide as-left and as-found tolerances for use in instrument calibration and functional test procedures. Verify and document process corrections, instrument scaling, and calibration methods.
6. VYDEP-15 Section 2.2 requires that applicable operating procedures, EOPs, surveillance procedures, and maintenance procedures be included in the evaluation. This calculation will evaluate the accuracy of loop components, including indicators and recorders where applicable. The accuracy determined by this calculation will be used as an input for generic evaluations for alarm response, operating procedure, off normal operating procedure, surveillance procedures and EOP impact. Therefore, the scope of this calculation will not evaluate the impact of the setpoints or accuracy determined on the operating procedures or the alarm responses. Refer to Attachment P (Interdepartmental Review Form) for impact considerations.

1.2. System & Components

This calculation applies to the Reactor System High Pressure Trip of the Reactor Protective System. The specific components to be addressed are captured in Table 1:

TABLE 1
COMPONENT IDENTIFICATION

REF.	TAG NUMBER	RACK/ CABINET	SYS	DESCRIPTION	MFG	MODEL NO.	CWD
6.10.1	PT-2-3-55A, B, C, D	25-5 A&B 25-6 C&D	NB	Transmitter	Rosemount	1152GP9E2 2TO280PB	850, 851, 855, 856
6.10.2	PT-2-3-55A(M), B(M), C(M), and D(M)	25-5A, A&B 25-6A C&D	NB	Master Trip Unit	Rosemount	710DUOTT3 7157	850, 851, 855, 856
6.10.3	ES-25-5A-A1, 5A-B1, 6A-A2, and 6A-B2	25-5A, A&B 25-6A C&D	RPS	Power Supply RPS Channels	Techni-power	227-8563	850, 851, 855, 856

Revision 5 has been generated to incorporate changes to the EQ manual, FSAR, and Technical Specifications.

1.3. Instrument Loop Function

Attachment A has a simplified loop diagram of the instruments and components described below.

TABLE 2

CHANNEL IDENTIFICATION

Channel	A1	B1	A2	B2
Transmitter	PT-2-3-55A	PT-2-3-55B	PT-2-3-55C	PT-2-3-55D
Trip Unit	PT-2-3-55A(M)	PT-2-3-55B(M)	PT-2-3-55C(M)	PT-2-3-55D(M)
First Relay	2-3-55A	2-3-55B	2-3-55C	2-3-55D
Scram Relay	K13A, K13E	K13B, K13F	K13C, K13G	K13D, K13H
Computer Point	D516	D517	D518	D519
Annunciator (Rx Pressure High)	Panel 9-5 loc K-3 (requires A&C or B&D trips)	Panel 9-5 loc K-3 (requires A&C or B&D trips)	Panel 9-5 loc K-3 (requires A&C or B&D trips)	Panel 9-5 loc K-3 (requires A&C or B&D trips)
Reference	6.34.1, 6.34.9, 6.34.10, 6.34.12	6.34.3, 6.34.9, 6.34.11, 6.34.13	6.34.2, 6.34.9, 6.34.10, 6.34.14	6.34.4, 6.34.9, 6.34.11, 6.34.15

1.3.1. Normal Operations

There are no indications or anticipatory alarms associated with these instruments. Therefore, these instruments have no normal operational function.

1.3.2. Functions During an Accident/ Abnormal Operational Transient

As defined in FSAR Section 14.4.4.2 "Nuclear System Process Barrier Damage" and Technical Specification Bases Section 1.2, the Reactor Vessel High Pressure trip provides protection from exceeding Safety design limit 2 for abnormal operational transients. The 1375 psig value is assumed to be the safety limit for high pressure transients. The pressure safety limit of 1335 psig as measured by the vessel steam space pressure indicator is equivalent to the 1375 psig safety limit at the lowest elevation of the reactor coolant system (Ref. 6.39).

The Reactor High Pressure Trip scram is not required for any design basis accident, however, the trip is required for the following limiting transient events that result directly in a nuclear system pressure increase by rapidly decreasing the steam flow from the vessel. The events that result in the most significant transients in this category are:

1. Generator Load Rejection From High Power Without Bypass(Ref. 6.3 Section 14.5.1.1.1).
2. Generator Trip (Turbine Control Valve Fast Closure) (Ref. 6.3 Section 14.5.1.1).
3. Turbine Trip (Turbine Stop Valve Closure) (Ref. 6.3 Section 14.5.1.2).
4. Turbine Trip From High Power Without Bypass (Ref. 6.3 Section 14.5.1.2.1).
5. Main Steam Line Isolation Valve Closure (Ref. 6.3 Section 14.5.1.3.1).

For Vermont Yankee the limiting transient is either the Turbine trip without bypass or the Generator Load Rejection From High Power Without bypass depending upon the specific reload analysis parameters.

Reference 6.6 GEK-32430 RPS 2-30 States a rise in reactor pressure could result in the collapse of core steam voids. A collapse of core steam voids results in a power increase that could cause fuel damage. If the reactor vessel pressure increases to 1070 psia (1055.3 psig), pressure sensors PT-2-3-55 (A-D) cause sensor relays in the reactor protection system to drop, which in turn cause the scram contactors to drop.

As discussed in the Instrument Uncertainty and Setpoints Design Guide (Ref. 6.1 and Ref. 6.17) relays have no accuracy associated with them. Therefore, the loop analysis will include a review of all components up to, but not including, the relays.

1.3.3. Post-Accident or EOP Functions

For the components of these loops, following is the Equipment Qualification Matrix Data [VY EQ Matrix](Ref. 6.10.6).

TABLE 3

EQ MATRIX DATA

COMPONENTS	LOCATION	ACCIDENT	CAT	TBN1	TBN2	F1,F2 ,F3	DURATION
Transmitters	VOL 20 & 21	LOCA	D	29		2	–
Master Trip Units	VOL 20 & 22	MS	D	83		2	–
	SERVICES	HPCI	A	30		2	6 HRS
	Reactor Vessel Pressure High/RPS	RCIC	E			2	–
		RWCU	A	30		2	6 HRS
		HHS	A	30		2	6 HRS
Power Supplies	VOL 20	LOCA	D	12	29	2,6,3	--
	SERVICES	MS	D	83		2	--
	Reactor Vessel Pressure High/RPS	HPCI	A	30		2	6HRS
		RCIC	E			2	--
		RWCU	A	30		2	6 HRS
		HHS	A	30		2	6 HRS

Category A requirement exists for these loops during HELB events (HPCI, RWCU and HHS). In accordance with section 5.4.3 of EQ Manual (Ref. 6.10.4), category A is "Equipment that will

experience harsh environmental conditions of this design basis accident and must function to mitigate such accidents. ..".

Since these loops are required to remain operable for up to 6 hours following HELB events, operability is limited to not causing a spurious trip or failing in such a manner as to cause a loss of RPS functions per technical basis note 30. Also, since the licensing design basis does not require the concurrent or subsequent occurrence of any other design basis event with a HELB, the evaluation will consist of ensuring that a HELB event will not cause a spurious trip. The process is assumed to be at it's normal value, since the HELB outside of containment will not increase Reactor Vessel Pressure.

For LOCA event, the category is listed as D. Category D refers to equipment that will experience harsh environmental conditions of this design basis accident but the time period this equipment is relied upon to function (or not fail) is prior to the time when harsh conditions develop. Technical basis notes 12 and 29 further identify that RPS is only required within ten (10) minutes after LOCA. The post - LOCA environment in the Reactor Building does not become harsh until four to six hours after a large break LOCA. Once the reactor is shutdown, failure of reactivity control equipment is not detrimental to safety. Therefore, there is no automatic Post-Accident function associated with these loops. Additionally these loops do not support a Post Accident or Reg. Guide 1.97 indication (Ref. 6.5).

2. METHODS AND ASSUMPTIONS

This calculation has been prepared in accordance with the "Vermont Yankee Instrument Uncertainty and Setpoint Design Guide" [Ref. 6.1] and WE-103 Yankee Nuclear Services Engineering Instruction, "Engineering Calculations and Analysis." [Ref. 6.2]. This calculation is performed using the Class 1 graded approach since the functions performed by these loops are classified as Class 1, Nuclear Safety Related. Standard methods employed in this calculation are explained in the Design Guide, special techniques and criteria are explained below.

2.1. Criteria

No Additional criteria

2.2. Assumptions

2.2.1. Calibration of instruments is assumed to be at a temperature within the ranges shown in the following table (Ref.6.1)

Table 4

Normal Area Temperatures

Ref.	Plant Area	Minimum	Maximum
6.1 Section 3.6.7	Reactor Building -Occupied Areas Elevation 280', Vol. 20, 21,22	62 °F	106 °F

2.2.2. The temperature variation within a cabinet is the same as the variation of the room in which it is located. The temperature difference between the room and the cabinet is therefore constant. Calibration data are collected with the equipment at the operating temperature of the cabinet.

2.2.3. At Vermont Yankee, environmentally qualified instrumentation have been evaluated for IR loss in VYC-700, "Post-Accident Insulation Resistance Effects on the Accuracy of Selected

Environmentally Qualified Instrumentation"[Ref. 6.29], and the effects found to be negligible. For the purposes of this calculation, the IR effects on channel accuracy will be considered negligible.

2.2.4. Rosemount does not provide separate seismic and post-seismic uncertainties for the Model 710 DU Trip Units. Therefore, the seismic uncertainty stated for Rosemount Trip Units is assumed to be applicable both during and after the shaking. Accordingly, the seismic effect is included in post-seismic uncertainties. Since only a single value is provided by the Trip Unit test reports, this value will be assumed to apply for any acceleration level.

2.2.5. For Custom Technical Specifications, the Technical Specification value is assumed based upon the normal conditions.

2.2.6. Drift, setting tolerance, M&TE and other errors associated with the calibration process are assumed to be random, normally distributed errors. Therefore, this calculation assumes that errors are randomly distributed and that calibration tolerances are also random and normally distributed.

2.2.7. OP 4312 has a head correction of 12 PSI applied to each transmitter. However VYC-1596 "Selected Pressure Instrument Static Head Correction" calculates a value of 12.11 psig for the A and B transmitters and a value of 12.06 psig for the C and D transmitters. Use of 12 psi for head correction was evaluated and is considered acceptable based on the following:

a. The difference between the established head correction value of 12 psi and the head correction value for transmitters A & B produces the largest deviation at 0.11 psi. This deviation of 0.11 psi represents 0.0073% of calibrated span ([(0.11 psig/ 1500 psig) * 100%]), and is considered negligible.

b. Calibration to 12 psi vice 12.06 psi or 12.11 psi provides additional conservatism when the transmitters are placed back into system operation. When placed back into service the transmitters experience the pressure from the difference in head correction, which causes actuation at a slightly lower pressure value.

2.2.8. The effects of radiation are taken for normal conditions only since there is no consideration of radiation effects during HELB and for LOCA, the RPS trip occurs prior to harsh environment. For the normal conditions, it is assumed recalibration zeros the radiation effects for each calibration cycle. The radiation dose is conservatively calculated for a period of 2 years to cover the time interval of once/operating cycle and the 25% grace period. However, radiation effect is assumed to be contained in the as-left to as-found difference and therefore included in the plant specific drift analysis values. However, since a plant specific drift analysis has been performed for these devices, radiation associated error will be assumed to be included in the plant specific drift value.

2.2.9. To account for current calibration techniques, in accordance with section 3.6.2.A of "Vermont Yankee Instrument Uncertainty and Setpoint Design Guide" [Ref. 6.1], calibration effect (CE) for the transmitters is determined by the relation CE=CT+A (CT = Calibration Tolerance / A = Accuracy). The MTU's are single point devices used in a single direction application, and repeatability is the primary contributor of the reference accuracy. Therefore, the plant specific drift is evaluated in accordance with Ref. 6.42 to determine if CE=CT+A or CE=CT can be used.

2.2.10. It is assumed that the M&TE components will be limited to those devices which support the QA requirement that M&TE accuracy is greater than or equal to the accuracy of the device being calibrated.

2.2.11. The analyzed drift value for the transmitters is assumed for 100% calibration point for 1152GP9 transmitters (Ref. 6.26). Following considerations apply in the assumption of this value.

a) The analyzed drift shows an increasing trend from 0% to 100%. The ADR value at 100% has been used. The current plant setpoint is set at 1038 psig (69.2% of Calibrated Span). Although the trip setpoint is closer to the 50% analyzed drift value the 100% analyzed drift value, is larger and rather than extrapolate a value for the 70% point of interest the values at 100% have been used as a conservative drift value.

b) From review of this drift analysis and the scatter plots, the data is bounded by a normal distribution. The F-Significance at 100% is 0.541 identifying that there is no strong time dependency. Inspection of the X Y scatter plots at 100% of span shows most data falls between 500 and 600 days, and that there is a slight time dependency at this interval. To ensure conservatism, since there is weak indication of a drift to time relationship, the SRSS method will be used to extrapolate the Analyzed Drift value to 684 days from the 530 day average.

c) The average drift value for this group (100% calibration point) is 0.001%. Since this is less than 0.1%, this term is negligible and hence no bias effects are considered (Ref. 6.25).

d) The ADR value for the operating cycle is calculated using the following SRSS relationship:

$ADR_{684\text{-}Days} = ADR_{530\text{-}Days} \times (684/530)^{1/2} = 0.796\% \times (684/530)^{1/2} = 0.904\%CS$

2.2.12. The analyzed drift values for the Master Trip Units comes from VYC-1615, All groups (except OP-4362 Data), and are calculated using following considerations (Ref. 6.27).

a) From review of this drift analysis and the scatter plots, the data exhibits closeness to a normal distribution, and is random. The F-Significance is 0.11 identifying that there is no strong time dependency. Inspection of the X Y scatter plots identifies a spread of data points between 0 and 90 days (4749 samples average 30 days, and 760 samples average 77 days), with no indication of time dependency. Beyond this time interval there are additional 38 data points with a longer time interval (i.e. 180 days). Although the data at this interval exhibits a slight time dependency, this is the result of a single data point. Therefore, since drift is not time dependent for the monthly and quarterly intervals the same value will be used for both time intervals.

b) The average drift value is 0.000%. This indicates there is no bias present.

c) The ADR value for the operating cycle is directly transferable due to the lack of time dependence and the random nature of the drift distribution.:

$ADR_{38\text{-}Days} = ADR_{38\text{-}days} = 0.104\% = 0.104\%CS$

$ADR_{114\text{-}Days} = ADR_{38\text{-}Days} \times = 0.104\%CS$

2.2.13. Rosemount provides two methods for determining the effects associated with increased temperature and pressure around the transmitters. The Steam Pressure /Chemical spray performance value (0.75% accuracy) is based on a specific enveloping environmental conditions. For the Rosemount 1152 transmitter this profile is 70 psig, 316 degrees F for 1 hour, 55.4 psig, 303 degrees F for 7 hours and 6 psig and 230 degrees F for 42 hours. This environment would result in condensation and increased heat transfer to the transmitter. The time period would also

allow the transmitter to be at the environmental temperature before the room environment decreased. These tests were normally performed to provide calibration, which enveloped PWR in containment conditions. The temperature profile for the limiting HELB (RWCU-21) (Ref. 6.10.4) indicates an increase to the maximum temperature of 167°F in less than 120 seconds and a decrease within the next 18 minutes to less than 130°F. Therefore, the normal temperature error calculation method is more appropriate for the environmental conditions experienced by the instruments in this calculation.

3. INPUT DATA

Data used to calculate loop uncertainties, process corrections, setpoints, and decision points are tabulated below with the applicable reference or basis.

3.1. Process and Loop Data

Presented below are the input values required to calculate the process measurement uncertainty and those parameters such as calibration frequency which are common to all loop components.

Table 5:

Process/Loop Inputs

Reference	Description	Data
MPAC	Design Pressure Design Temperature	1250 psig 575 °F
6.39	Analytical/Process Limit	≤ 1085 psig ≤ 1055 psig
6.4. Table 3.1.1	Technical Specification Limit	≤ 1055 psig
6.10.6 & 6.30 Attachment 1(g) and 1(h)	Reference Elevation <floor, vessel, etc.> Process Tap Elevation Drywell Penetration Elevation Rack Installation	Rx Bldg 280' ~ Vol. 20 (55A&B) & Vol. 21 (55C&D) 312'5" 312'5" 298' 298' 284'3" 284'4"
6.4 Table 4.1.2, 4.1.1, and 6.36	Calibration Interval Functional Test Interval	18/22.5 Months 30/38 Days Monthly 90/114 Days Quarterly

3.2. Environmental Conditions

The following information provides the limiting environmental conditions expected for each loop instrument and the plant spaces traversed by the instrument sense lines. The transmitters and trip units are located outside the Drywell and the applicable accidents are HPCI, RWCU and HHS. The transmitters are located in Volume 20 and 21 (Ref.6.10.1), the power supplies are located in volume 20 (Ref. 6.10.3) and the trip units are located in vol. 20 and 22 (Ref. 6.10.2). Although the worst case HELB for the transmitters is a Main Steam HELB for volume 20 , a Main Steam HELB results in a Reactor trip prior to the environment where the transmitter and power supplies are located becomes harsh. Therefore, this accident is not applicable. The next most limiting HELB for the power supplies and the transmitters is a RWCU in volume 21 (Max Temp 167°F see Ref. 6.10.4, Table 7.5.1). The HELB which the master trip units are subjected to is RWCU-22 (Max Temp 196°F see Ref. 6.10.4, Table 7.5.1).

Although subjected to a HELB environment, the high reactor pressure trip is only assumed to function to mitigate limiting pressure excursion transients. The environments in all of the compartment volumes are mild for the limiting pressure excursion transient. The HELB analysis requires that all RPS components remain functional for six hours after the line break to allow for a controlled plant shutdown. The setpoint for the high reactor pressure trip has no function in the detection or mitigation of a HELB. The uncertainty

values during HELB are calculated to ensure that these channels will not cause a spurious trip during 6 hours of HELB event.

Table 6:

Environmental Input Data

Reference	Description	Data
6.10.4 Vol 1 Section 7.4.1 & Table 7.5.3	Normal Reactor Building Temperature Normal Reactor Building Pressure Accident RB Temperature (Transmitters & Power Supplies) Accident RB Temperature (MTU)	84°F Ambient 167°F 196°F
6.10.4 Vol. 1 Table A1	40 year Normal Exposure Reactor Building 280' Elev. (Remainder)	3.5×10^3 R
6.10.4 Vol. 1 Appendix. B	Radiation Dose Specification Worksheets, for Cabinets 25-5B and 25-6B (Normal Operation)	3.5×10^3 R
6.10.4 Vol. 1 Appendix. B	Radiation Dose Specification Worksheet, Power Supplies 25-5A-A1 & B1, 25-6A-A2 & B2. (Normal Operation)	3.5×10^3 R

As a result of EQ manual revision 38 the limiting HELB for the Transmitters and the Power Supplies changed. With this change the most limiting temperature that the associated volumes are exposed to during the HELB changed from 170°F to 167°F. In addition to HELB changes the Normal Radiation exposure experienced by all of the loop components changed. Previous 40 year Normal Exposure was 8.8×10^4 R, 2 year Normal Exposure was 4.4×10^3 R., and Total Radiation dose to be evaluated (Normal) was determined to be 4.4×10^3 R. As captured above the present EQ manual values for Normal Operating Dose is less than those previously used. These newer EQ parameters produce smaller overall uncertainty values and provide inherent margin to existing setpoint values. Therefore, for ease of calculation the previous temperature of 170°F (Transmitters and Power supplies) and the calculated Total Radiation dose of 4.4×10^4R will be used.

3.3. Primary Element Data

There is no primary element associated with this function

3.4. Transmitter PT-2-3-55A, PT-2-3-55B, PT-2-3-55C, & PT-2-3-55D Data

TABLE 7

Transmitter Input Data

Reference	Description	Data
6.11	Maximum span (Upper Range Limit)	3000 psig
6.11	Minimum span (Lower Range Limit)	0 psig
6.11	Maximum zero suppression	500 % of calibrated span (CS)
6.11	Maximum zero elevation	600 % of calibrated span (CS)
6.11	Accuracy Rating	± 0.25 % of calibrated span (CS)
6.13	Rated Drift	± 0.20 % of upper range limit (URL) (30 month specification)
6.11	Rated temperature effect	± {0.5 % of upper range limit (URL) + 0.5 % calibrated span (CS)}/100°F Ambient Temperature change
6.11	Rated static pressure span effect	N/A
6.11	Rated static pressure zero effect	N/A
6.11	Rated overpressure effect	< ± 0.25% of upper range limit (URL)/2000 psig
6.11	Rated deadband (sensitivity)	None
6.9	Existing calibrated input span Existing calibrated output span	12 - 1512 PSIG 4 - 20 mA
6.11	Static pressure span correction Static pressure correction uncertainty	N/A N/A
6.1	Radiation effect	0% CS; R≤1000 rad 0.5% CS; 1000 rad <R<1.0 Mrad 5.0% URL; 1.0 Mrad <R<17 Mrad
6.11	Steam/Pressure Temperature Performance	± 0.75 % of upper range limit (URL) to 70 psig/316°F
6.11	Seismic Performance	± 0.25 % accuracy during and after seismic testing to 3g over a range of 5-100 Hz in 3 major axes
Assumption 2.2.11	Analyzed drift	± 0.904% of calibrated span (CS)

3.5. Trip Units PT-2-3-55A(M), PT-2-3-55B(M), PT-2-3-55C(M), PT-2-3-55D(M), Data

TABLE 8
Trip Unit Input Data

Reference	Description	Data
6.20	Input Span (CS_i)	4 - 20 mA
6.9	Existing nominal setpoint	15.07 +/- 0.03 mA 1038psig.
6.20	Accuracy rating Temperature effect (Normal) Temperature effect (Accident) Seismic effect Radiation effect	± 0.13% CS[1] ± 0.20% CS/100 °F[2] ± 0.40% CS[3] ± 0.13% CS ± 0.50% CS

[1] This includes some amount of stability since this value is provided for 6 months. However, for the purpose of this calculation, this value is conservatively taken as an accuracy value.

[2] The Trip output repeatability is defined as + 0.13 % (60 to 90 °F + 0.20 % /100 °F) this is interpreted to mean that the temperature effect should be applied for variations below 60 or above 90 °F. (Ref. 6.20).

[3] The temperature effect provided for the trip units is given in Rosemount report for the Temperature event (Max temp 210°F) the units were subjected to during testing. (Ref. 6.20).

TABLE 8
Trip Unit Input Data

Reference	Description	Data
6.20	Reset Specifications	Reset differential adjustable from 0.5% to 7.5% of span or from 0.5% to 15% of span for the 15% reset differential option
Assumption 2.2.12	Analyzed drift (DA) used - Monthly Analyzed drift (DA) used - Quarterly	± 0.104 % CS ± 0.104 % CS

3.6. Power Supplies ES-25-5A-A1, ES-25-5A-B1, ES-25-6A-A2, ES-25-6A-B2, Data

TABLE 9

Power Supply Input Data

Reference	Description	Data
6.21	Output supply voltage	24 Vdc
6.21 and 6.22	Combined Source and Load Effect (Regulation) Seismic Effect (Evaluated)[4]	± 0.5% ± 4.64287 %

3.7. Calibration M&TE Input data

TABLE 10

Calibration and M&TE Input Data

Ref.	Description	Location	Range	Required Accuracy	Total Device Error (TDE)
6.23	Heise 901B Pressure Gauge	Rx Bldg	0 to 2000 psig	3.29 psig	3.0503 psig
6.23	Heise Model CM, CMM	Rx Bldg	0 to 2000 psig	3.29 psig	3.2440 psig
6.23	HP 34401A Digital Multimeter	Rx Bldg	100 mA	0.02 mA	0.0191 mA
6.23	Rosemount Readout Assembly	Rx Bldg	28 mA	0.0141 mA	0.0141 mA

4. CALCULATION DETAIL

The detailed calculation of loop uncertainties, setpoints, testing tolerances, and margins have been done using MathCad and are documented as Attachment B. Mathcad values are displayed to at 2, 3, and 4 decimal places to support hand verification, while actual Mathcad values are maintained to a precision of 15 decimal places.

5. RESULTS AND CONCLUSIONS

5.1. Total Loop Uncertainty

Total Loop Uncertainty (TLU) has been evaluated for each output device and the results are presented in the table below.

[4] The test report shows the worst case error of 1.3 Vdc (Pre- Test value 28.9 Vdc - Post Test value 27.6 Vdc) for a 28 Vdc Technipower Power supply. This amounts to an error of 1.3x100/28 or 4.64287 % of supply voltage.

TABLE 11

Total Loop Uncertainty Results

Output Instrument	Interval	Normal/LOCA		HELB		Seismic	
		% CS	psig	% CS	psig	% CS	psig
PT-2-3-55A(M), 55B(M), 55C(M), 55D(M)	Monthly	1.12 ✓	16.73 ✓	1.74 ✓	26.05 ✓	1.22 ✓	18.33 ✓
PT-2-3-55A(M), 55B(M), 55C(M), 55D(M)	Quarterly	1.12 ✓	16.73 ✓	1.74 ✓	26.05 ✓	1.22 ✓	18.33 ✓

✓x12 04/26/99

5.2. Setpoint Evaluation

Results are presented below for the Limiting Setpoint (LSp), Allowable Value (AV), and Technical Specifications Limit. Also calculated is the Acceptance Value (ACV) by algebraically adding the as-found tolerances for the loop devices to the existing setpoints. The calculation of this value and the margin from Allowable Value (AV) ensures that the Allowable Value (AV) will not be exceeded during surveillance. All the available margins are shown below. Comparison of the calculated AV to the present Technical Specification value of 1055 psig shows that the setpoint will support the Technical Specifications for Improved Technical Specifications (ITS), and for Current Technical Specifications (CTS).

TABLE 12

Setpoint Results

Description	Results (psig)	
	CTS	ITS
Analytical Limit (AL)	1085 ✓	1085 ✓
Allowable Value (AV)	N/A	1082 ✓
Technical Specifications Limit (TS)	1055[1] ✓	
Acceptance Value (ACV)	N/A	1056 ✓
Limiting Setpoint (LSp)	1066 ✓	1066 ✓
Setpoint (SP)	1038 ✓	
Margin LSP to SP (M_1) ~ Monthly	28 ✓	N/A
Margin LSP to SP (M_1) ~ Quarterly	28 ✓	28 ✓
Margin TS to SP (M2)	Negligible ✓	Negligible ✓
Margin AV to ACV (M3)	N/A	26 ✓
Spurious Trip Margin ~ HELB (M4)	N/A	11 ✓

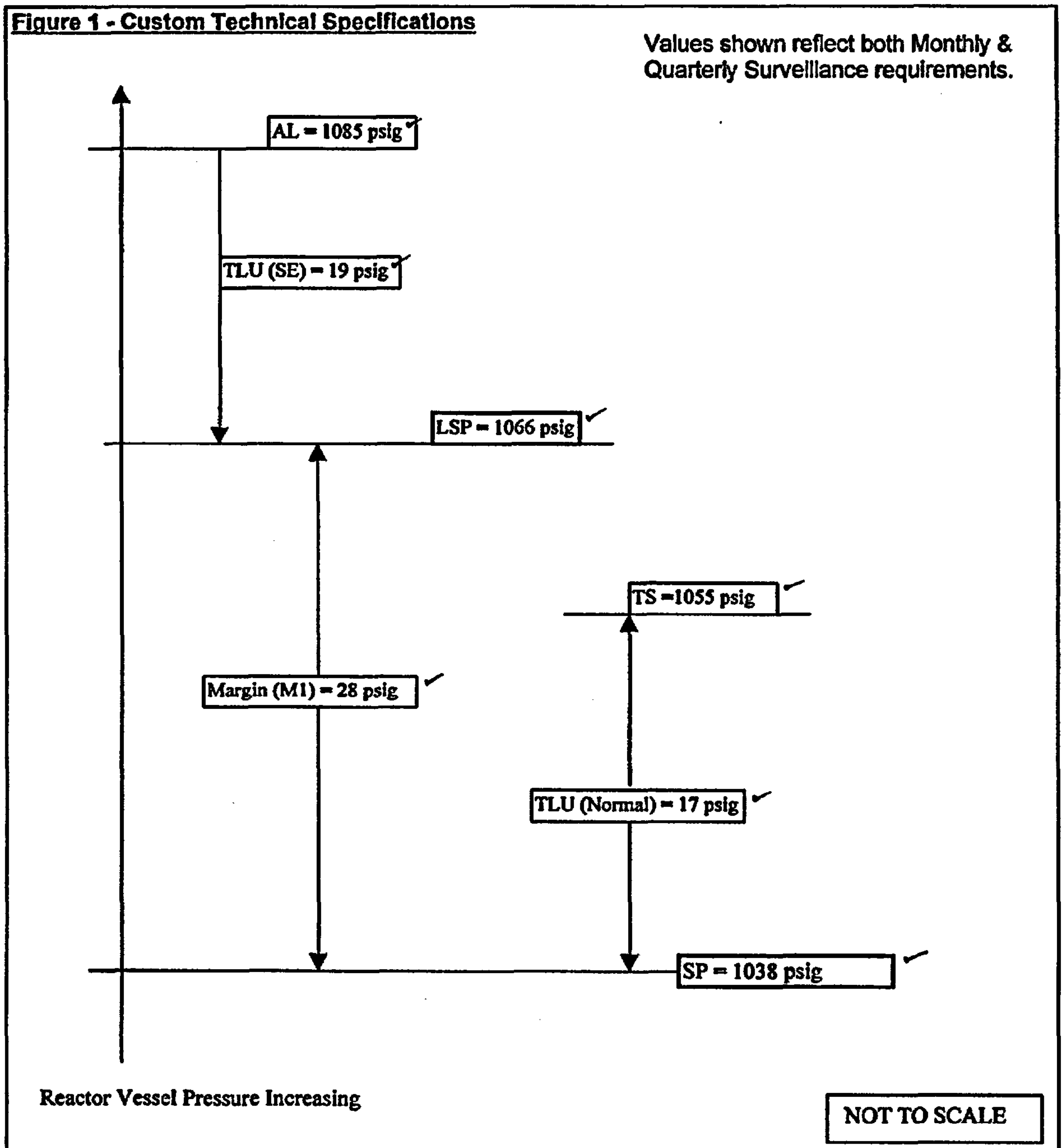
✓x15 04/26/99

[1] The actual Technical Specification limit is 1055 psig, however the actual setting value in OP-4312 is 1054.69 (equivalent to 15.25 mA). For ITS the Technical Specification limit would be revised to the AV or limit of operability.

These results are presented graphically in Figure 1 and 2.

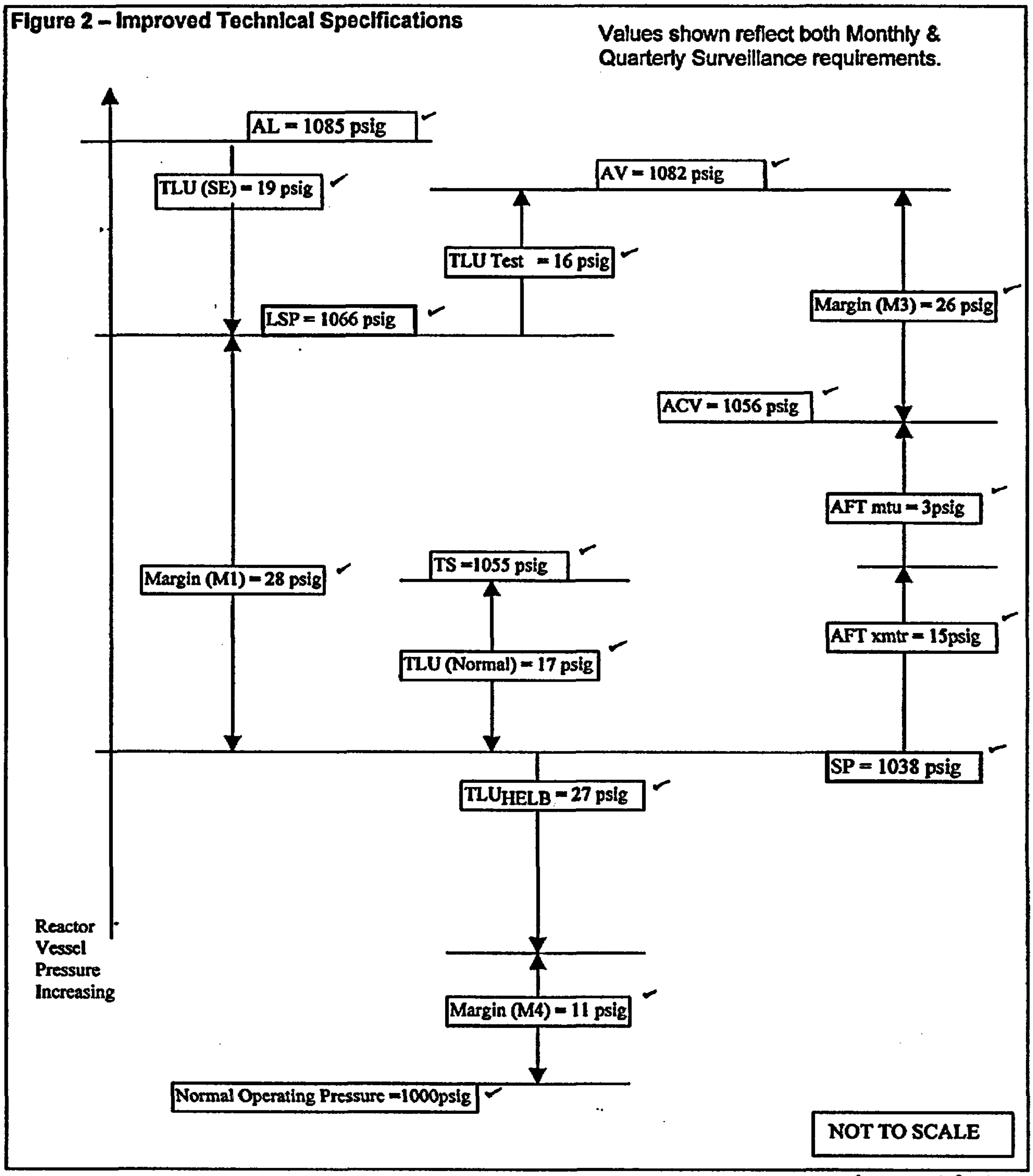
5.3. Graphic Representation of the Custom and Improved Technical Specification Setpoints.

Figure 1 - Custom Technical Specifications



04/26/99

Figure 2 – Improved Technical Specifications



5.4. Calibration and Test Results

In order to support and implement the results of this calculation, the loop instruments are to be calibrated according to the following table:

TABLE 13

Calibration Setpoints and Ranges

Description	Value	Units
Transmitter input range	12-1512 ✓	PSIG
Transmitter output range for calibration	4 - 20 ✓	mA
Trip unit setpoint 1038 psig	15.07 ±0.03 ✓	mA
Trip unit reset	0.08 to 1.2	mA

✓x3 Y. [illegible] 04/26/99

Test as-found tolerances (FT) and as-left tolerances (CT) are shown below.

TABLE 14

Calibration Tolerances[5]

		As-Found	As-Left	Months
Transmitter	PT-2-3-55 A,B,C,D	0.16 mA ✓	0.04 mA ✓	18
Master Trip Unit	PT-2-3-55 (M) A,B,C,D	0.03 mA ✓	0.03mA ✓	3
Master Trip Unit	PT-2-3-55 (M) A,B,C,D	0.03 mA ✓	0.03 mA ✓	1

✓x6 Y. [illegible] 04/26/99

5.5. Summary of Recommendations

The calculated limiting setpoint for Custom Technical Specifications and Improved Technical Specifications is 1066 psig. The current Plant setpoint is 1038 psig. For both the Custom Technical Specification and Improved Technical Specification programs, use of the existing setpoint provides adequate margin from the analytical limit of 1085 psig.

Since the setpoint value did not change from the value established in revision 4 of this calculation, the setpoint values found in the calibration procedure (OP-4312, Rev 21) and in the Alarm Response Sheets (5-K-3, Rev 5 (Ref. 6.40)) do not need to be revised. Although the As-Left calibration tolerances did not

[5] The as-found tolerances have been rounded off to two decimal places for ease of calibration. See attachment B for additional information.

change the As-Found calibration tolerances did. Therefore, the calibration tolerances established in the procedure OP4312, Rev 21 require revision.

5.5.1. Revise FSAR Table 7.2.1 for ITS setpoint and accuracy (see Attachment O). Change associated with accuracy has already been captured as part of commitment VYC-0467R4_05 and requires no further action. In revision 4 of this calculation it was identified that VYC-332 Rev.2 needed to be revised to correct the Head Correction and Scaling values Although this action has not been completed to date, this action has been captured as part of the commitment VYC-0467R4. Therefore, no further action is required.

5.6. VY DEP - 15, Review and Approval of Design Engineering Procedures.

5.6.1 VY DEP-15 impact considerations are addressed in Section 1.1.

5.6.2 A review of the Vermont Yankee Event Report Database was conducted to identify any Event Reports written against Reactor Vessel Pressure and Reactor Protective System, that could impact this calculation. During this review no ER's were identified that could impact this calculation.

5.6.3 In addition to reviewing the ER Data Base, WE-100 Table 1 "Design Input Considerations" was reviewed and evaluated against impact on this calculation.

6. REFERENCES

6.1. "Instrument Uncertainty and Setpoint Design Guide," Vermont Yankee, Rev. 0.

6.2. WE-103, Yankee Procedure, "Engineering Calculations and Analyses." Rev. 18

6.3. "Vermont Yankee Updated Final Safety Analysis Report" Rev. 15, Sections 14.4.1, 14.4.4.2, 14.5.1.1.1 and Table 7.2.1

6.4. Vermont Yankee Technical Specifications, Tables 3.1.1, 4.1.1, and 4.1.2, Section 2.2.A, and Bases 1.2. Through Amendment 169.

6.5. Vermont Yankee Reactor Protection System Design Basis Document, Rev.0

6.6. General Electric Nuclear Instrumentation Department GEK-32430 "Vermont Yankee Reactor Protection System".

6.7. DELETED DURING REV 5. ~ Safety Analysis Calculation is captured as part of the Input Assumptions Source Document, Cycle 20, and Rev.1.

6.8. DELETED DURING REV 5. ~ NED Analysis Parameters captured as part of the Input Assumptions Source Document, Cycle 20, and Rev.1.

6.9. Functional/Calibration Procedure - OP-4312, Rev. 21, Reactor Vessel High Pressure Scram Functional/Test Calibration.

6.10. "Vermont Yankee Environmental Qualification Program Manual," Rev. 38.

6.10.1. QDR 8.12, Appendix II, Rev. 11, ID No. PT-2-3-55A, B, C, D (Part of Attachment C)

6.10.2. QDR 5.1, Appendix II, Rev. 12, ID No. PT-2-3-55A(M), B(M), C(M), D(M) (Part of Attachment D)

6.10.3. QDR 32.1, Appendix II, Rev.3, ID No. ES-25-5A-A1, B1, ES-25-6A-A1, B1.(Part of Attachment E)

6.10.4. Vermont Yankee Environmental Qualification Program Manual Vols. 1 and 2

6.10.5. DELETED DURING REV 5. ~ EQDI 95-55 Info captured as Part of EQ Manual Rev 38

6.10.6. Vermont Yankee Equipment Qualification Matrix Revision 18.

6.11. VYEM-0049 - "Rosemount Model 1152 Alphaline Nuclear Pressure Transmitters," Rosemount Publication 2235, 1983.

6.12. Product Data Sheet 2396, Model 1152-T0280, Alphaline Nuclear Pressure Transmitters, Rosemount.

6.13. Rosemount Report D8900126, Revision A, 30-Month Stability Specification for Rosemount Models 1152, 1153, and 1154 Pressure Transmitters.

6.14. Rosemount Report D8600063, Revision 0, "Low Level Radiation Dose Rate Test - Small Break LOCA Test."

6.15. Rosemount Report 8805A "Low Level Radiation Test Report for Rosemount Model 1152 Pressure Transmitter,".

6.16. Memo, VYI 220/87, G. J. Hengerle to R. G. January, "Radiation Review, Rosemount 1152 Series Transmitters," dated October 6, 1987.

6.17. Memo, VYI 212/85, "Supplement to VYI 129/85: Additional Equipment to Which Instrument Accuracies do not Apply," December 12, 1985.

6.18. Meeting Notes, June 9 and 11, 1986, Between Harry Savage and Jane Sandstrom (Rosemount) and George Hengerle (YNSD).

6.19. Letter, Bob Bach (Rosemount) to George Hengerle (YNSD), June 12, 1986.

6.20. VYEM-0053 - "Rosemount Model 710DU Trip/Calibration System", Rosemount Publication 2471.

6.21. Power Supply Vendor Manual - Technipower "MIL-QUAL", Modular Power Supplies, QDR - 32.1, Rev. 0.

6.22. Technipower Test Report ST-4375-00C, "Report of Tests on DC Power Supply Environmental Testing, and associated Certificate of Compliance, dated May 30, 1989".

6.23. VYC-1758, Rev. 0, "Measuring & Test equipment Uncertainty Calculation" .

6.24. DELETED DURING REV 5. ~ Test equipment information captured by VYC-1758.

6.25. Memo VYI 31/97 Rev. 1, from G. Hengerle, "Improved Setpoint Program/Application of Analyzed Drift Values in Setpoint Determination". 5/15/97.

6.26. Vermont Yankee Transmitter Analyzed Drift Calculation, VYC-1614, Rev.1, Attachment K.

6.27. Vermont Yankee Trip Unit Analyzed Drift Calculation, VYC-1615, Rev.0, Attachment L.

6.28. DELETED DURING REV 5. ~ VYC-193 results are captured in EQ manual Vol. 1

6.29. VYC-700, "Post-Accident Insulation Resistance Effects on the Accuracy of Selected Environmentally Qualified Instrumentation". Rev. 0.

6.30. VYC-1596, "Selected Pressure Instrument Static Head Correction", Yankee Atomic Electric Company Calculation, Rev. 0, 2/15/97.

6.31. Memo, TAG 86-163, "Review of High Pressure Scram and RPT Setpoints," June 17, 1986.

6.32. System P&ID - "Flow Diagram - Nuclear Boiler Vessel Instrumentation, G191267, sheet 1, Rev. 25.

6.33. System P&ID - "Flow Diagram - Nuclear Boiler Vessel Instrumentation, G191267, sheet 2, Rev. 3.

6.34. **Control Wiring Diagrams:**

6.34.1. Drawing B-191301, Sh. 805, "Reactor Protection System Auto Scram & Auxiliary Circuit Channel 'A1', Rev. 11.

6.34.2. Drawing B-191301, Sheet. 808, "Reactor Protection System Auto Scram & Auxiliary Circuit Channel 'A2', Rev. 12.

6.34.3. Drawing B-191301, Sheet. 812, "Reactor Protection System Auto Scram & Auxiliary Circuit Channel 'B1', Rev. 12.

6.34.4. Drawing B-191301, Sheet. 815, "Reactor Protection System Auto Scram & Auxiliary Circuit Channel 'B2', Rev. 11.

6.34.5. Drawing B-191301, Sheet. 803, "Reactor Protection System Reactor Scram Sensors Channel 'A1', Rev. 17.

6.34.6. Drawing B-191301, Sheet. 806, "Reactor Protection System Reactor Scram Sensors Channel 'A2', Rev. 14.

6.34.7. Drawing B-191301, Sheet. 810, "Reactor Protection System Reactor Scram Sensors Channel 'B1', Rev. 18.

6.34.8. Drawing B-191301, Sheet. 813, "Reactor Protection System Reactor Scram Sensors Channel 'B2', Rev. 14.

6.34.9. Drawing B-191301, Sheet. 834, "Reactor Protection System Annunciator, sheet 1", Rev. 4.

6.34.10. Drawing B-191301, Sheet. 837, "Channel "A" Computer Inputs, Rev. 14.

6.34.11. Drawing B-191301, Sheet. 838, "Channel "B" Computer Inputs, Rev. 16.

6.34.12. Drawing B-191301, Sheet. 850, "RPS Analog Trip A1", Rev. 5.

6.34.13. Drawing B-191301, Sheet. 851, "RPS Analog Trip B1", Rev. 3.

6.34.14. Drawing B-191301, Sheet. 855, "RPS Analog Trip A2", Rev. 5.

6.34.15. Drawing B-191301, Sheet. 856, "RPS Analog Trip B2", Rev. 7.

6.35. Vermont Yankee Procedure AP 0150 "Conduct of Operations and Operator Rounds" Rev. 31 Issue Date 07/05/96

6.36. Selected Definitions and Clarifications Associated with the Vermont Yankee Technical Specification "Typical Surveillance Intervals"

6.37. DELETED DURING REV 5. ~ Test equipment information captured by VYC-1758.

6.38. VYC -332 Revision 2 Page 26-29 "Reactor Water Level and Pressure Head and DP" Head Correction calculated and recommended at 12.70 psi for calibration.

6.39. Input Assumptions Source Document, Vermont Yankee Nuclear Power Station Cycle 20 Revision 1 May 1998.

6.40. Alarm Response Sheet 5-K-3, Rev.4 Reactor Protection System.

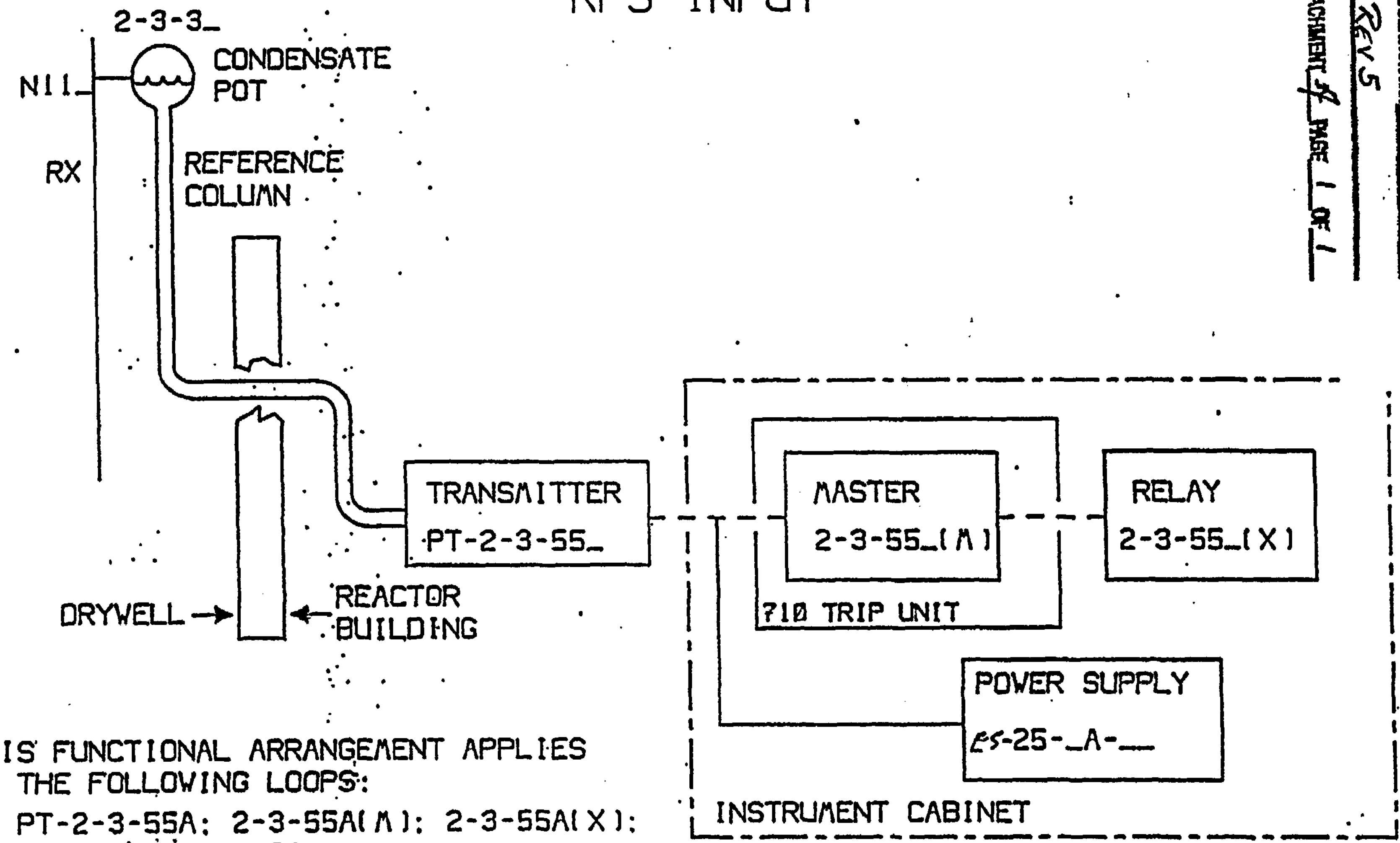
6.41. VY Design Engineering Procedure No. 15, Review and Approval of Design Engineering Procedures, Rev.2.

6.42. Memo, VYI 92/97, Rev 1. G. J. Hengerle to Distribution, "Application of CT,CE and A for single point devices", dated June 26, 1998.

7. ATTACHMENTS

REACTOR SYSTEM PRESSURE/ RPS INPUT

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
ATTACHMENT A PAGE 1 OF 1



THIS FUNCTIONAL ARRANGEMENT APPLIES TO THE FOLLOWING LOOPS:

PT-2-3-55A; 2-3-55A(M); 2-3-55A(X); 25-5A-A1; 2-3-3A
PT-2-3-55B; 2-3-55B(M); 2-3-55B(X); 25-5A-B1; 2-3-3A
PT-2-3-55C; 2-3-55C(M); 2-3-55C(X); 25-6A-A2; 2-3-3B
PT-2-3-55D; 2-3-55D(M); 2-3-55D(X); 25-6A-B2; 2-3-3B

VYC-467

Service: Reactor System High Pressure Trip Loop Accuracy Review

Equipment I. D.: PT-2-3-55A, PT-2-3-55B, PT-2-3-55C, PT-2-3-55D, ES-25-5A-A1, ES-25-5A-B1, ES-25-6A-A2, ES-25-6A-B2, PT-2-3-55A(M), PT-2-3-55B(M), PT-2-3-55C(M), PT-2-3-55D(M),

1. Instrument Calibration Conditions

$LRL_{xmtr} := 0 \cdot psi$

$URL_{xmtr} := 3000 \cdot psi$

Transmitter Upper and Lower Range Limits

$CS_{xmtrmin} := 12 \cdot psi$

$CS_{xmtrmax} := 1512 \cdot psi$

Limits of Calibration Reference Procedure OP-4312

$CS_{xmtr} := (CS_{xmtrmax} - CS_{xmtrmin})$

$CS_{xmtr} = 1500 \cdot psi$ Transmitter Calibrated Span

$CS_{mtumin} := 4.00 \cdot mA$

$CS_{mtumax} := 20.00 \cdot mA$

$CS_{mtu} := (CS_{mtumax} - CS_{mtumin})$

$CS_{mtu} = 16.00 \cdot mA$ Master Trip Unit Calibrated Span

$$CT_{xmtr} := 0.04 \cdot mA \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$$

$CT_{xmtr} = 3.750 \cdot psi$ Calibration Tolerance Transmitter

$$CT_{mtu} := 0.03 \cdot mA \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$$

$CT_{mtu} = 2.812 \cdot psi$ Calibration Tolerance MTU

$hC_1 := -12.11 \cdot psi$

$hC_2 := -12.06 \cdot psi$

$hC := 12.00 \cdot psi$

VYC-1596 Head Correction for PT-2-3-55A&B is equal to 12.11 and the Head Correction for PT-2-3-55C, D is equal to 12.06. While OP-4312 uses a head correction value of 12.0. Therefore, the OP-4312 value will be used.

04/20/99

1. Instrument Calibration Conditions (Contd.)

Surveillance time intervals are found as follows where tc_n = months x days x hrs

$tc_{xmtr} := 22.5 \cdot 30 \cdot 24 \cdot hr$ — $tc_{xmtr} = 16200 \cdot hr$ ✓ — Maximum Time between calibrations, where the calibration interval is 1.25% of 18 months for a cycle.

$tc_{mtuCTS\_m} := 1.25 \cdot 30 \cdot 24 \cdot hr$ — $tc_{mtuCTS\_m} = 900 \cdot hr$ ✓ — Maximum Time between calibrations, for CTS where the calibration interval is monthly.

$tc_{mtuCTS\_Q} := 1.25 \cdot 90 \cdot 24 \cdot hr$ — $tc_{mtuCTS\_Q} = 2700 \cdot hr$ ✓ — Maximum Time between calibrations, for CTS where the calibration interval is quarterly.

$tc_{mtuITS} := 1.25 \cdot 90 \cdot 24 \cdot hr$ — $tc_{mtuITS} = 2700 \cdot hr$ ✓ — Maximum Time between calibrations, for ITS where the calibration interval is quarterly.

$tr := 0.001 \cdot hr$ — tr = Maximum Time after accident when actuation is required

2.0 Process Measurement Effects

$PMA := 0$ — There are no process measurement effects associated with this function

3.0 Module Errors

3.1 Primary Element

There is no primary element associated with the measurement of this variable.

3.2 Transmitters PT-2-3-55A, PT-2-3-55B, PT-2-3-55C, PT-2-3-55D

3.2.1 Uncertainty Elements

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3.2.1.1 Reference Accuracy (A)

$A = (AX^2 + h^2 + l^2 + r^2)^{1/2}$
Where:
A = Reference accuracy of instrument
AX = vendor's stated basic accuracy expression
h = hysteresis
l = linearity
r = repeatability

$AX_{xmtr} := 0.25 \cdot \% \cdot CS_{xmtr}$ ✓ $\quad l_{xmtr} := 0 \cdot \% \cdot CS_{xmtr}$

$h_{xmtr} := 0 \cdot \% \cdot CS_{xmtr}$ $\quad r_{xmtr} := 0 \cdot \% \cdot URL_{xmtr}$

$CS_{xmtr} = 1500 \cdot psi$ $\quad URL_{xmtr} = 3000 \cdot psi$ ✓

0.25% accuracy specification includes the combined effects of linearity, hysteresis and repeatability. The deadband is zero.

$A_{xmtr} := \sqrt{AX_{xmtr}^2 + h_{xmtr}^2 + l_{xmtr}^2 + r_{xmtr}^2}$

$A_{xmtr} = 3.750 \cdot psi$ ✓ Transmitter Accuracy

3.2.1.2 Calibration Effect (CE)

CT > A: CE = CT
CT = MTI + MTo
Where:
MTI = The tolerance of the test input adjustment in percent of span
MTo = The tolerance on loop device's output adjustment in percent of span
A = Instrument Reference (vendor) accuracy

OP 4312 indicates a nine point calibration for the transmitter which would verify hysteresis, linearity or repeatability. However the transmitters have not been calibrated to this recent procedure change requiring anine point calibration. Therefore, CE=CT+A.

$CT_{xmtr} = 3.75 \cdot psi$ ✓ $\quad A_{xmtr} = 3.75 \cdot psi$ ✓

$CE_{xmtr} := CT_{xmtr} + A_{xmtr}$

$CE_{xmtr} = 7.500 \cdot psi$ ✓

3.2.1.3 Dead Band (DB) or Readability (RD)

$DB_{xmtr} := 0 \cdot psi$ ✓ The deadband specified by Rosemount for 1152 Transmitters.

3.2.1.4 MEASUREMENT & TEST EQUIPMENT

$MTE = (m_1^2 + m_2^2)^{1/2}$
Where:
A = Accuracy of the Transmitter
CS = Calibrated span of the Transmitter.
m_1, m_2 = uncertainty of input and output test instruments
MTE =M&TE uncertainty in percent of calibrated span of the instrument being tested.

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3.2.1.4 MEASUREMENT & TEST EQUIPMENT (Contd.)

$m_{DMM\_TDE} := 0.0191 \cdot mA$ $CS_{mtu} = 16 \cdot mA$ $CS_{xmtr} = 1500 \cdot psi$

$A_{xmtr} = 3.750 \cdot psi$ In this section, the required accuracy of pressure measurement is calculated based on the accuracy of the current measurement.

$$m_{2xmtr} := \left(\frac{m_{DMM\_TDE}}{CS_{mtu}}\right) \cdot CS_{xmtr}$$

$m_{2xmtr} = 1.791 \cdot psi$ Assumes the use of a HP 34401A DMM

$$m_{1xmtr} := \sqrt{A_{xmtr}^2 - m_{2xmtr}^2}$$

$m_{1xmtr} = 3.295 \cdot psi$ Desired accuracy of pressure measurement- psig. Use of a HEISE Model CM, CMM, or HEISE 901B meets this Total Device Error.

$$MTE_{xmtr} := \sqrt{(m_{1xmtr})^2 + (m_{2xmtr})^2}$$

$MTE_{xmtr} = 3.750 \cdot psi$ Using the established M&TE results in a MTE value equal to the accuracy of the Transmitter.

3.2.1.5 Analyzed Drift (DA)

$CS_{xmtr} = 1500 \cdot psi$

$DA_{xmtr} := 0.904 \cdot \% \cdot CS_{xmtr}$

$DA_{xmtr} = 13.560 \cdot psi$ 95/95 Analyzed Drift for 18 months. Includes DR, TE_n, MTE, PB, VE, HE, RE_n(VYC-1614) Assumption 2.2.11

3.2.1.6 Temperature Effect (TE)

$TE_n = TEX * (T_{nmax} - T_{nmin})$
$TEa = TEX*(T_{amax} - T_{nmin})$
Where:
TE_n = temperature effect during Normal conditions
TE_{a1} = temperature effect during accident conditions (HELB)
TE_{a2} = temperature effect during limiting transient Conditions=TE_n
T_{nmax} = Maximum temperature during normal conditions - 106°F
T_{amax} = Maximum temperature during accident conditions -170°F
T_{nmin} = Minimum temperature during calibration conditions-62°F
ΔT_{cal}=Temperature difference between calibrations - 20°F
TEX = Vendors temperature effects expression per °F.

The temperature effect during HELB is calculated to determine the margin from the setpoint of any spurious trip which might occur during 6 hrs after the accident. This is only applicable to loops which cause RPS trip.

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3.2.1.6 Temperature Effect (Contd.)

$\Delta T_{cal} := 20$ $T_{nmin} := 62$ $T_{nmax} := 106$

$T_{a1max} := 170$ $CS_{xmtr} = 1500 \cdot psi$ $URL_{xmtr} = 3000 \cdot psi$

$$TE_{nxmtr} := \frac{(0.5 \cdot \% \cdot URL_{xmtr}) + (0.5 \cdot \% \cdot CS_{xmtr})}{100} \cdot \left[(T_{nmax} - T_{nmin}) - \Delta T_{cal} \right]$$

$TE_{nxmtr} = 5.400 \cdot psi$ — Temperature effect during normal conditions

$$TE_{a1xmtr} := \frac{(0.5 \cdot \% \cdot URL_{xmtr}) + (0.5 \cdot \% \cdot CS_{xmtr})}{100} \cdot (T_{a1max} - T_{nmin} - \Delta T_{cal})$$

$TE_{a1xmtr} = 19.800 \cdot psi$ — Temperature effect during HELB. The standard temperature effect equation was selected instead of the steam pressure chemical performance equation since the SPC applies to 70 psig 316 degree condensing conditions, while the limiting HELB max temperature is 167°F (RWCU Vol 21). 170°F used during calculation.

3.2.1.7 Barometric Pressure Effect (PB)

Barometric pressure effect is either the effect on the vented side of gage pressure transmitters, or is associated with the error associated with calibration of an absolute pressure transmitter using a gauge pressure transmitter.

$PB := 0 \cdot psi$ — Changes in Barometric pressure are assumed to be insignificant based on the Technical Specification limit of 1055 psig and a trip setpoint of 1038 psig.

3.2.1.8 Humidity Effect (HE)

$HE = HEX * (H_{max} - H_{min})$

Where:

H_{max} = Maximum humidity difference from calibration for the conditions of concern

H_{min} = Minimum humidity during calibration or testing conditions

HEX = Vendors humidity effects expression in % CS per % relative humidity.

No humidity effect is specified for Rosemount 1152 transmitter or the Master Trip Unit. A materials review did not indicate the existence of organic components. Therefore, humidity effects are not applicable.

$HE_{xmtr} := 0$

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3.2.1.9 Radiation Effect (RE)

TID_{40n} = Total integrated dose 40 year Normal = 8.8 x 10⁴ (VYC-193 Rev.2)
TID_{2n} = Total integrated dose: 2 years Normal Exposure= 4.4x10³
R_n = Total Normal Radiation dose to be evaluated = TID_{2n}

The Radiation doses used are from VYC-193 Rev 2, which are larger than the new values captured in the EQ manual as a result of subsequent revisions to VYC-193.

$TID_{40n} := 8.8 \cdot 10^4$

The two year dosage is calculated since each refueling cycle has an interval of 18 months + 25% which equals 22.5 months. This is rounded off to 24 months for conservatism.

$TID_{2n} := \frac{TID_{40n}}{20}$ $TID_{2n} = 4400$

$R_n := TID_{2n}$ $URL_{xmtr} = 3000 \cdot psi$ $CS_{xmtr} = 1500 \cdot psi$

Only the normal radiation is applicable since the accident applicable is HELB and the limiting pressure transients do not produce a harsh environment. Radiation error is assumed to be included in the plant specific drift value and is only calculated to verify that the drift values calculated are reasonable for this loop.

$$RE_{nxmtr} := \begin{cases} 0 & \text{if } R_n < 1000 \\ 0.5 \cdot \% \cdot CS_{xmtr} & \text{if } 1000 < R_n < 1 \cdot 10^6 \\ 5.0 \cdot \% \cdot URL_{xmtr} & \text{if } 1 \cdot 10^6 < R_n < 17 \cdot 10^6 \end{cases}$$

therefore $RE_{nxmtr} := 0.5 \cdot \% \cdot CS_{xmtr}$

$RE_{nxmtr} = 7.500 \cdot psi$

3 2.1.10 Seismic Effect (SE)

SE = 0.25% accuracy during and after seismic testing to 3g over a range of 5-100 Hz in 3 major axes. Since there is no information provided for the testing up to 0.07g (OBE) and 0.14g (SSE), the full effect is assumed. Moreover, since Rosemount does not specify the % term, URL is selected for conservatism.

$URL_{xmtr} = 3000 \cdot psi$

$SE_{xmtr} := 0.25 \cdot \% \cdot URL_{xmtr}$ $SE_{xmtr} = 7.500 \cdot psi$

3.2.1.11 PROCESS PRESSURE EFFECTS

- Over Pressure Effect (SPo)

$SP_{oxmtr} := 0$ These instrument channels measure the process pressure. Therefore, there are no process pressure effects.

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3. 2.1.12 Power Supply Voltage Effect (VE)

The voltage stability effect of the transmitters is 0.005% of span per volt (Ref6.12), and they are supplied by regulated power supplies. In accordance with the VY Design Guide the error induced by the power supply is negligible

3.2.2 Transmitter Uncertainty

3.2.2.1 Normal/Testing

Uncertainty during the limiting pressure transient conditions is same as normal.

$CE_{xmtr} = 7.500 \cdot psi$ ✓ $DA_{xmtr} = 13.560 \cdot psi$ ✓

$DB_{xmtr} = 0 \cdot psi$ ✓ $TE_{nxmtr} = 5.400 \cdot psi$ ✓

Bias term $en_B = 0$

$$e_{nRxmtr} := \sqrt{CE_{xmtr}^2 + DB_{xmtr}^2 + DA_{xmtr}^2 + TE_{nxmtr}^2}$$

$e_{nRxmtr} = 16.410 \cdot psi$ ✓ Module Uncertainty during Normal Operations.

$$e_{tRxmtr} := \sqrt{CE_{xmtr}^2 + DB_{xmtr}^2 + DA_{xmtr}^2}$$

$e_{tRxmtr} = 15.496 \cdot psi$ ✓ Module Uncertainty during Test Conditions.

3.2.2.2 Accident 1 - HELB (RWCU-21)

$CE_{xmtr} = 7.500 \cdot psi$ ✓ $DA_{xmtr} = 13.560 \cdot psi$ ✓

$DB_{xmtr} = 0 \cdot psi$ ✓ $TE_{a1xmtr} = 19.800 \cdot psi$ ✓

$$e_{a1R1xmtr} := \sqrt{CE_{xmtr}^2 + DB_{xmtr}^2 + DA_{xmtr}^2 + TE_{a1xmtr}^2}$$

$e_{a1R1xmtr} = 25.143 \cdot psi$ ✓ Module Uncertainty during a HELB.

3.2.2.3 Accident 2 - Seismic Event

$CE_{xmtr} = 7.500 \cdot psi$ ✓ $DA_{xmtr} = 13.560 \cdot psi$ ✓

$DB_{xmtr} = 0 \cdot psi$ ✓ $TE_{nxmtr} = 5.400 \cdot psi$ ✓

$SE_{xmtr} = 7.500 \cdot psi$ ✓

$$e_{a2R1xmtr} := \sqrt{CE_{xmtr}^2 + DB_{xmtr}^2 + DA_{xmtr}^2 + SE_{xmtr}^2 + TE_{nxmtr}^2}$$

$e_{a2R1xmtr} = 18.043 \cdot psi$ ✓ Module Uncertainty during a Seismic Event.

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3.3.0 MASTER TRIP UNITS PT-2-3-55A(M), 55B(M), 55C(M), 55D(M)

3.3.1. Uncertainty Elements

3.3.1.1 Reference Accuracy (A)

$A = (AX^2 + h^2 + l^2 + r^2)^{1/2}$

Where:

A = Reference accuracy of instrument
AX = vendor's stated basic accuracy expression
h = hysteresis
l = linearity
r = repeatability

$AX_{mtu} := 0 \cdot \% \cdot CS_{mtu}$ $\quad l_{mtu} := 0 \cdot \% \cdot CS_{mtu}$ $\quad CS_{xmtr} = 1500 \cdot psi$

$h_{mtu} := 0 \cdot \% \cdot CS_{mtu}$ $\quad r_{mtu} := 0.13 \cdot \% \cdot CS_{mtu}$ $\quad CS_{mtu} = 16 \cdot mA$

$$A_{mtu} := \sqrt{AX_{mtu}^2 + h_{mtu}^2 + l_{mtu}^2 + r_{mtu}^2} \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$$

$A_{mtu} = 1.950 \cdot psi$ Master Trip Unit Accuracy

3.3.1.2 Dead Band (DB) or Readability (RD)

$DB_{mtu} := 0 \cdot psi$ The deadband specified by Rosemount for 710DU Trip Units.

3.3.1.3 MEASUREMENT & TEST EQUIPMENT

$MTE = (m_1^2 + m_2^2)^{1/2}$

Where:

A = Accuracy of the Master Trip Unit
CS = Calibrated span.
m_1, m_2 = uncertainty of input and output test instruments
MTE = M&TE uncertainty in percent of calibrated span of the instrument being tested.

$CS_{mtu} = 16 \cdot mA$ $\quad CS_{xmtr} = 1500 \cdot psi$ $\quad m_{ReadoutAssy\_TDE} := 0.0141 \cdot mA$

$A_{mtu} = 1.950 \cdot psi$ The combination of the input and output M&TE must meet the accuracy of the MTU.

$$m1_{mtu} := m_{ReadoutAssy\_TDE} \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$$

$m1_{mtu} = 1.322 \cdot psi$ The Total Device error associated with the Rosemount Readout Assembly is the maximum TDE allowed for the input M&TE to support the MTU accuracy.

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3.3.1.3 MEASUREMENT & TEST EQUIPMENT

$m2_{mtu} := 0 \cdot psi$

The output for the Rosemount Readout Assembly is captured by the input TDE.

$MTE_{mtu} := \sqrt{(m1_{mtu})^2 + (m2_{mtu})^2}$ $MTE_{mtu} = 1.322 \cdot psi$

Total M&TE uncertainty for the MTU is less than accuracy of the MTU and is accepatable.

3.3.1.4 Analyzed Drift (DA)

3.3.1.4.1 Monthly

$CS_{mtu} = 16 \cdot mA$ $CS_{xmtr} = 1500 \cdot psi$

$DAM_{mtu} := 0.104 \cdot \% \cdot CS_{mtu} \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$ $DAM_{mtu} = 1.560 \cdot psi$

95/95 Analyzed Drift for 1 month. Includes DR, TE_n, MTE, PB, VE, HE, RE_n (VYC-1615). Assumption 2.2.12

3.3.1.4.2 Quarterly

$CS_{mtu} = 16 \cdot mA$ $CS_{xmtr} = 1500 \cdot psi$

$DAQ_{mtu} := 0.104 \cdot \% \cdot CS_{mtu} \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$ $DAQ_{mtu} = 1.560 \cdot psi$

95/95 Analyzed Drift for 3 months. Includes DR, TE_n, MTE, PB, VE, HE, RE_n(VYC-1615). Assumption 2.2.12

3.3.1.5 Calibration Effect (CE)

As captured in VYI 92/97 Rev.1
If Plant specific Drift < $(RA^2 + DA^2 + CT^2 + M\&TE^2)^{1/2}$; CE=CT
If Plant specific Drift ≥ $(RA^2 + DA^2 + CT^2 + M\&TE^2)^{1/2}$;
CE=CT+A
Where;
Plant Specific Drift = DAQmtu or DAMmtu
RA = Reference Accuracy
CT = Calibration Tolerance
M&TE = Measurement and Test Equipment Error
DA = Vendor Stated Drift Term

$DAQ_{mtu} = 1.560 \cdot psi$
$DAM_{mtu} = 1.560 \cdot psi$
$MTE_{mtu} = 1.322 \cdot psi$

The CT term is larger than the Plant Specific Drift term. When RSS combined with all of the other terms used for the test, the product is considerably larger than the Plant Specific Drift. As a result CE=CT will be used.

$CT_{mtu} = 2.812 \cdot psi$ $A_{mtu} = 1.950 \cdot psi$

$CE_{mtu} := CT_{mtu}$ $CE_{mtu} = 2.812 \cdot psi$ Master Trip Unit calibration Effect

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3.3.1.6 Temperature Effect (TE)

TE_n = TEX * (T_{nmax} - T_{nmin})
TEa = TEX*(T_{amax} - T_{nmin})
Where:
TE_n = temperature effect during Normal conditions
TE_{a1} = temperature effect during accident conditions (HELB)
TE_{a2} = temperature effect during accident conditions (LOCA)=TE_n
T_{nmax} = Maximum temperature during normal conditions - 106°F
T_{amax} = Maximum temperature during accident conditions -196°F
T_{nmin} = Minimum temperature during calibration conditions-62°F
ΔT_{cal} = Temperature band assumed in Reference Accuracy 60-90 °F
TEX = Vendors temperature effects expression per °F.
TEX = 0.2% of Calibrated Span per 100 °F change
TEX = 0.4% of Calibrated Span

Rosemount report D8200037 documents harsh environmental testing for the Rosemount 710DU trip units. The temperature profile for the test was 210 degrees for six hours and then reduced to 165 degrees for 8 hours. This profile envelopes the worst case profile for the LOCA and HELB events.

$CS_{mtu} = 16 \cdot mA$ ✓ $CS_{xmtr} = 1500 \cdot psi$ ✓

$$TE_{nmtu} := \frac{0.2 \cdot \% \cdot CS_{mtu} \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)}{100} \cdot (106 - 90)$$

$TE_{nmtu} = 0.480 \cdot psi$ ✓

The repeatability value for six months includes stability and the Temperature effect between 60 and 90 Degrees. The temperature above 90 for normal conditions only is calculated.

$$TE_{a1mtu} := 0.4 \cdot \% \cdot CS_{mtu} \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$$

$TE_{a1mtu} = 6.000 \cdot psi$ ✓

Temperature effect during HELB - Max Temp 196 °F. Rosemount specifies temperature effect of 0.4% during the temperature event in Rosemount report D8200037.

3.3.1.7 Humidity Effect (HE)

HE = HEX * (H_{max} - H_{min})
Where:
H_{max}= Maximum humidity difference from calibration for the conditions of concern
H_{min}= Minimum humidity during calibration or testing conditions
HEX= Vendors humidity effects expression in % CS per % relative humidity.

$HE_{mtu} := 0$ ✓ No humidity effects are specified for Rosemount 710DU Trip Unit.

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3.3.1.8 Radiation Effect (RE)

$CS_{mtu} = 16 \cdot mA$ $CS_{xmtr} = 1500 \cdot psi$

$RE_{nmtu} := 0.0 \cdot \% \cdot CS_{mtu} \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$

$RE_{nmtu} = 0 \cdot psi$

There is no radiation effect specified for the normal condition. Assumed to be negligible. The limiting transient for high pressure does not cause a harsh environment. Normal Radiation effects are also assumed to be included in the plant specific drift evaluations.

3.3.1.9 Seismic Effect (SE)

$SE_{mtu} := 0 \cdot psi$

$SE_{mtu} = 0 \cdot psi$

The seismic analysis indicates no additional error due to seismic acceleration.

3. 3.2 Module Uncertainty

3.3.2.1 Normal/Testing

3.3.2.1.1 Monthly - Normal/Testing

$CE_{mtu} = 2.812 \cdot psi$ $TE_{nmtu} = 0.480 \cdot psi$ $DB_{mtu} = 0 \cdot psi$

$DAM_{mtu} = 1.560 \cdot psi$

Uncertainty during the limiting Transient event conditions is same as normal

$e_{nMRmtu} := \sqrt{CE_{mtu}^2 + DB_{mtu}^2 + DAM_{mtu}^2 + TE_{nmtu}^2}$

$e_{nMRmtu} = 3.252 \cdot psi$

Module Uncertainty during Normal Operations.

$e_{tMRmtu} := \sqrt{CE_{mtu}^2 + DB_{mtu}^2 + DAM_{mtu}^2}$

$e_{tMRmtu} = 3.216 \cdot psi$

Module Uncertainty during Test Conditions.

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3.3.2.1.2 Quarterly - Normal/Testing

$CE_{mtu} = 2.812 \cdot psi$ ✓ $TE_{nmtu} = 0.480 \cdot psi$ ✓ $DB_{mtu} = 0 \cdot psi$ ✓

$DAQ_{mtu} = 1.560 \cdot psi$ ✓

$$e_{nQRmtu} := \sqrt{CE_{mtu}^2 + DB_{mtu}^2 + DAQ_{mtu}^2 + TE_{nmtu}^2}$$

$e_{nQRmtu} = 3.252 \cdot psi$ ✓ Module Uncertainty during Normal Operations.

$$e_{tQRmtu} := \sqrt{CE_{mtu}^2 + DB_{mtu}^2 + DAQ_{mtu}^2}$$

$e_{tQRmtu} = 3.216 \cdot psi$ ✓ Module Uncertainty during Test Conditions.

3.3.2.2 Accident 1 - HELB (RWCU-22)

3.3.2.2.1 Monthly - HELB

$CE_{mtu} = 2.812 \cdot psi$ ✓ $DB_{mtu} = 0 \cdot psi$ ✓ $TE_{a1mtu} = 6.000 \cdot psi$ ✓

$DAM_{mtu} = 1.560 \cdot psi$ ✓

The bias term $en_B = 0$, since there are no bias effects present for this loop.

$$e_{a1MR1mtu} := \sqrt{CE_{mtu}^2 + DB_{mtu}^2 + DAM_{mtu}^2 + TE_{a1mtu}^2}$$

$e_{a1MR1mtu} = 6.808 \cdot psi$ ✓ Module Uncertainty during a HELB.

3.3.2.2.2 Quarterly - HELB

$CE_{mtu} = 2.812 \cdot psi$ ✓ $DB_{mtu} = 0 \cdot psi$ ✓ $TE_{a1mtu} = 6.000 \cdot psi$ ✓

$DAQ_{mtu} = 1.560 \cdot psi$ ✓

$$e_{a1QR1mtu} := \sqrt{CE_{mtu}^2 + DB_{mtu}^2 + DAQ_{mtu}^2 + TE_{a1mtu}^2}$$

$e_{a1QR1mtu} = 6.808 \cdot psi$ ✓ Module Uncertainty during a HELB.

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3.3.2.3 Accident 2 - Seismic Event

3.3.2.3.1 Monthly-Seismic

$CE_{mtu} = 2.812 \cdot psi$ $DB_{mtu} = 0 \cdot psi$ $TE_{nmtu} = 0.480 \cdot psi$

$SE_{mtu} = 0 \cdot psi$ $DAM_{mtu} = 1.560 \cdot psi$

$$e_{a2MR1mtu} := \sqrt{CE_{mtu}^2 + DB_{mtu}^2 + DAM_{mtu}^2 + SE_{mtu}^2 + TE_{nmtu}^2}$$

$e_{a2MR1mtu} = 3.252 \cdot psi$ Module Uncertainty during a Seismic Event.

3.3.2.3.2 Quarterly-Seismic

$CE_{mtu} = 2.812 \cdot psi$ $DB_{mtu} = 0 \cdot psi$ $TE_{nmtu} = 0.480 \cdot psi$

$SE_{mtu} = 0 \cdot psi$ $DAQ_{mtu} = 1.560 \cdot psi$

$$e_{a2QR1mtu} := \sqrt{CE_{mtu}^2 + DB_{mtu}^2 + DAQ_{mtu}^2 + SE_{mtu}^2 + TE_{nmtu}^2}$$

$e_{a2QR1mtu} = 3.252 \cdot psi$ Module Uncertainty during a Seismic Event.

4.0 Total Loop Uncertainty

4.1 Normal

4.1.1 Monthly Test Interval - Testing

$e_{tRxmtr} = 15.496 \cdot psi$ $e_{tMRmtu} = 3.216 \cdot psi$

$$TLU_{testing\_Monthly} := \sqrt{e_{tRxmtr}^2 + e_{tMRmtu}^2}$$

$TLU_{testing\_Monthly} = 15.83 \cdot psi$ Testing Uncertainty for Monthly Surveillances

4.1.2 Quarterly Test Interval - Testing

$e_{tRxmtr} = 15.496 \cdot psi$ $e_{tQRmtu} = 3.216 \cdot psi$

$$TLU_{testing\_Quarterly} := \sqrt{e_{tRxmtr}^2 + e_{tQRmtu}^2}$$

$TLU_{testing\_Quarterly} = 15.83 \cdot psi$ Testing Uncertainty for Quarterly Surveillances

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4.1.3 Monthly Interval - Normal

$e_{nRxmtr} = 16.410 \cdot psi$ $e_{nMRmtu} = 3.252 \cdot psi$

$TLU_{normal\_Monthly} := \sqrt{e_{nRxmtr}^2 + e_{nMRmtu}^2}$

$TLU_{normal\_Monthly} = 16.73 \cdot psi$ Normal Uncertainty for Monthly Surveillances

4.1.4 Quarterly Interval - Normal

$e_{nRxmtr} = 16.410 \cdot psi$ $e_{nQRmtu} = 3.252 \cdot psi$

$TLU_{normal\_Quarterly} := \sqrt{e_{nRxmtr}^2 + e_{nQRmtu}^2}$

$TLU_{normal\_Quarterly} = 16.73 \cdot psi$ Normal Uncertainty for Quarterly Surveillances

4.2 Accident 1 - HELB

4.2.1 Monthly Test Interval - HELB

$e_{a1R1xmtr} = 25.143 \cdot psi$ $e_{a1MR1mtu} = 6.808 \cdot psi$

$TLU_{HELB\_Monthly} := \sqrt{e_{a1R1xmtr}^2 + e_{a1MR1mtu}^2}$

$TLU_{HELB\_Monthly} = 26.05 \cdot psi$ Accident Uncertainty for Monthly Surveillances

4.2.1 Quarterly Test Interval - HELB

$e_{a1R1xmtr} = 25.143 \cdot psi$ $e_{a1QR1mtu} = 6.808 \cdot psi$

$TLU_{HELB\_Quarterly} := \sqrt{e_{a1R1xmtr}^2 + e_{a1QR1mtu}^2}$

$TLU_{HELB\_Quarterly} = 26.05 \cdot psi$ Accident Uncertainty for Quarterly Surveillances

4.3 Accident 2 - Seismic Event

4.3.1 Monthly Test Interval - Seismic

$e_{a2R1xmtr} = 18.043 \cdot psi$ $e_{a2MR1mtu} = 3.252 \cdot psi$

$TLU_{Seismic\_Monthly} := \sqrt{e_{a2R1xmtr}^2 + e_{a2MR1mtu}^2}$

$TLU_{Seismic\_Monthly} = 18.33 \cdot psi$ Accident Uncertainty for Monthly Surveillances

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4.3.1 Quarterly Test Interval - Seismic

$e_{a2R1xmtr} = 18.043 \cdot psi$ ✓ $e_{a2QR1mtu} = 3.252 \cdot psi$ ✓

$TLU_{Seismic\_Quarterly} := \sqrt{e_{a2R1xmtr}^2 + e_{a2QR1mtu}^2}$

$TLU_{Seismic\_Quarterly} = 18.33 \cdot psi$ ✓ Accident Uncertainty for Quarterly Surveillances

4.4 Summary of Results:

4.4.1 As Left and As Found Tolerances

The calculated as found tolerance is converted to mA as follows:

Transmitter

$e_{tRxmtr} = 15.496 \cdot psi$ ✓

$AFT_{xmtr\_psig} := e_{tRxmtr}$ $CS_{xmtr} = 1500 \cdot psi$ ✓

$AFT_{xmtr\_psig} = 15.496 \cdot psi$ ✓ Calculated As found tolerance - psig

$AFT_{xmtr\_mA} := e_{tRxmtr} \cdot \frac{16 \cdot mA}{CS_{xmtr}}$

$AFT_{xmtr\_mA} = 0.165 \cdot mA$ ✓ Calculated As found tolerance - mA

$ALT_{xmtr\_mA} := .04 \cdot mA$ ✓

$ALT_{xmtr\_psig} := ALT_{xmtr\_mA} \cdot \frac{CS_{xmtr}}{16 \cdot mA}$

$ALT_{xmtr\_psig} = 3.750 \cdot psi$ ✓ Assigned As Left tolerance - psig

MTU - Monthly

$e_{tMRmtu} = 3.216 \cdot psi$ ✓

$AFT_{Mmtu\_psig} := e_{tMRmtu}$ $CS_{xmtr} = 1500 \cdot psi$ ✓

$AFT_{Mmtu\_psig} = 3.216 \cdot psi$ ✓ Calculated As found tolerance - psig

$AFT_{Mmtu\_mA} := e_{tMRmtu} \cdot \frac{16 \cdot mA}{CS_{xmtr}}$

$AFT_{Mmtu\_mA} = 0.034 \cdot mA$ ✓ Calculated As found tolerance - mA

$ALT_{Mmtu\_mA} := .03 \cdot mA$ ✓

$ALT_{Mmtu\_psig} := ALT_{Mmtu\_mA} \cdot \frac{CS_{xmtr}}{16 \cdot mA}$

$ALT_{Mmtu\_psig} = 2.812 \cdot psi$ ✓ Assigned As left tolerance - psig

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4.4.1 As Left and As Found Tolerances (Contd)

MTU - Quarterly

$e_{tQRmtu} = 3.216 \cdot psi$ ✓

$AFT_{Qmtu\_psig} := e_{tQRmtu}$ $CS_{xmtr} = 1500 \cdot psi$ ✓ $AFT_{Qmtu\_psig} = 3.216 \cdot psi$ ✓ Calculated As found tolerance - psig

$AFT_{Qmtu\_mA} := e_{tQRmtu} \cdot \frac{16 \cdot mA}{CS_{xmtr}}$ $AFT_{Qmtu\_mA} = 0.034 \cdot mA$ ✓ Calculated As found tolerance - mA

$ALT_{Qmtu\_mA} := .03 \cdot mA$ ✓

$ALT_{Qmtu\_psig} := ALT_{Qmtu\_mA} \cdot \frac{CS_{xmtr}}{16 \cdot mA}$ $ALT_{Qmtu\_psig} = 2.812 \cdot psi$ ✓ Assigned As left tolerance - psig

As Found Tolerances to be used ~ psig

Component	Calculated	Rounded to support Calibration
Transmitter	$AFT_{xmtr\_psig} = 15.496 \cdot psi$ ✓	$AFT_{xmtr\_psig} := 15 \cdot psi$ ✓
Master Trip Unit - Monthly	$AFT_{Mmtu\_psig} = 3.216 \cdot psi$ ✓	$AFT_{Mmtu\_psig} := 3 \cdot psi$ ✓
Master Trip Unit - Quarterly	$AFT_{Qmtu\_psig} = 3.216 \cdot psi$ ✓	$AFT_{Qmtu\_psig} := 3 \cdot psi$ ✓

As captured in Assumption 2.2.12 the Master Trip Units do not show time dependency. Therefore, the resulting As-Found Tolerance is only slightly larger than the As-Left Calibration Tolerance (0.03 mA).

As Found Tolerances to be used ~ mA

Component	Calculated	Rounded to support Calibration
Transmitter	$AFT_{xmtr\_mA} = 0.165 \cdot mA$ ✓	$AFT_{xmtr\_mA} := 0.16 \cdot mA$ ✓
Master Trip Unit - Monthly	$AFT_{Mmtu\_mA} = 0.034 \cdot mA$ ✓	$AFT_{Mmtu\_mA} := 0.03 \cdot mA$ ✓
Master Trip Unit - Quarterly	$AFT_{Qmtu\_mA} = 0.034 \cdot mA$ ✓	$AFT_{Qmtu\_mA} := 0.03 \cdot mA$ ✓

Since the impact of drift on the Master Trip Units is negligible, the As - Found tolerance (FT) used during calibration will be set to the same value as the As - Left tolerance (CT).

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4.4.2 Total Loop Uncertainty

$CS_{xmtr} = 1500 \cdot psi$

Test Interval	Normal	HELB	Seismic Event
Monthly	$TLU_{normal\_Monthly} = 16.73 \cdot psi$	$TLU_{HELB\_Monthly} = 26.05 \cdot psi$	$TLU_{Seismic\_Monthly} = 18.33 \cdot psi$
	$\frac{TLU_{normal\_Monthly}}{CS_{xmtr}} \cdot 100 \cdot \% = 1.12 \cdot \%$	$\frac{TLU_{HELB\_Monthly}}{CS_{xmtr}} \cdot 100 \cdot \% = 1.74 \cdot \%$	$\frac{TLU_{Seismic\_Monthly}}{CS_{xmtr}} \cdot 100 \cdot \% = 1.22 \cdot \%$
Quarterly	$TLU_{normal\_Quarterly} = 16.73 \cdot psi$	$TLU_{HELB\_Quarterly} = 26.05 \cdot psi$	$TLU_{Seismic\_Quarterly} = 18.33 \cdot psi$
	$\frac{TLU_{normal\_Quarterly}}{CS_{xmtr}} \cdot 100 \cdot \% = 1.12 \cdot \%$	$\frac{TLU_{HELB\_Quarterly}}{CS_{xmtr}} \cdot 100 \cdot \% = 1.74 \cdot \%$	$\frac{TLU_{Seismic\_Quarterly}}{CS_{xmtr}} \cdot 100 \cdot \% = 1.22 \cdot \%$

These loops do not perform any function during normal plant operation. The only applicable accuracy is during limiting transient conditions.

5.0 Setpoint Evaluation

5.1 Developing New Setpoint

5.1.0 Generic Setpoint Information Applicable to CTS and ITS

Some of the acceptable M&TE which can be used during the calibration of this loop has a readability of 1 psig. Therefore, Total Loop Uncertainty values were rounded up to the nearest whole number. Rounding in this manner establishes additional conservatism into the calculated setpoint values.

<u>Existing Values</u>

Analytical Limit	$AL := 1085 \cdot psi$
Tech Spec. Limit	$TS := 1055 \cdot psi$
Existing Setpoint	$SP := 1038 \cdot psi$

5.1.1 Custom Technical Specifications

Although these loops are required to remain operable for up to 6 hours following HELB events, operability is limited to not causing a spurious trip or failing in such a manner as to cause a loss of RPS functions. Therefore,the evaluation will consist of ensuring that a HELB event will not cause a spurious trip and will not be used to determine the Limiting Setpoint. Vermont Yankee's Design Bases establishes that that Reactor Vessel Pressure is required for a Design Basis Eathquake. Therefore, the Limiting Setpoint will be developed using the seismic uncertainty. In addition actuation of the desired setpoint is for increasing pressure, therefore the most limiting, positive, Total Loop Uncertainty ($TLU_{Seismic}$) will be used.

CTS- Monthly Testing

$TLU_{Seismic\_Monthly} = 18.33 \cdot psi$ ✓

$TLU_{Seismic\_Monthly\_Rnd} := 19 \cdot psi$ ✓ $AL = 1085 \cdot psi$ ✓

$LSP_{M\_CTS} := AL - TLU_{Seismic\_Monthly\_Rnd}$ $LSP_{M\_CTS} = 1066 \cdot psi$ ✓ Limiting Setpoint, for PT-2-3-55A, B, C, & D at a Monthly surveillance interval.

Margin From Existing Setpoint (Monthly)

$LSP_{M\_CTS} = 1066 \cdot psi$ ✓ $SP = 1038 \cdot psi$ ✓

$M1_{m\_CTS} := LSP_{M\_CTS} - SP$

$M1_{m\_CTS} = 28 \cdot psi$ ✓ Margin from the existing setpoint

CTS - Quarterly Testing

$TLU_{Seismic\_Quarterly} = 18.33 \cdot psi$ ✓

$TLU_{Seismic\_Quarterly\_Rnd} := 19 \cdot psi$ ✓ $AL = 1085 \cdot psi$ ✓

$LSP_{Q\_CTS} := AL - TLU_{Seismic\_Quarterly\_Rnd}$ $LSP_{Q\_CTS} = 1066 \cdot psi$ ✓ Limiting Setpoint, for PT-2-3-55A, B, C, & D at a Quarterly surveillance interval.

Margin From Existing Setpoint (Quarterly)

$LSP_{Q\_CTS} = 1066 \cdot psi$ ✓ $SP = 1038 \cdot psi$ ✓

$M1_{Q\_CTS} := LSP_{Q\_CTS} - SP$

$M1_{Q\_CTS} = 28 \cdot psi$ ✓ Margin from the existing setpoint

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5.1.1 Custom Technical Specifications (Contd)

Evaluation of Setpoint Relative to Tech Spec. Limit

The Technical Specification setpoint value is based on normal environmental parameters. Therefore, the setpoint developed using the Total Loop Uncertainty at normal conditions (TLU_{normal}) will be compared to the existing setpoint.

Monthly

$TLU_{normal\_Monthly} = 16.73 \cdot psi$

$TLU_{normal\_Monthly\_Rnd} := 17 \cdot psi$ $TS = 1055 \cdot psi$

$SP_{CTS\_Monthly} := TS - TLU_{normal\_Monthly\_Rnd}$ $SP_{CTS\_Monthly} = 1038 \cdot psi$

This Setpoint value is the same as the existing setpoint, which has sufficient margin from the Limiting Setpoint and Analytical Limit.

Quarterly

$TLU_{normal\_Quarterly} = 16.73 \cdot psi$

$TLU_{normal\_Quarterly\_Rnd} := 17 \cdot psi$ $TS = 1055 \cdot psi$

$SP_{CTS\_Quarterly} := TS - TLU_{normal\_Quarterly\_Rnd}$ $SP_{CTS\_Quarterly} = 1038 \cdot psi$

This Setpoint value is the same as the existing setpoint, which has sufficient margin from the Limiting Setpoint and Analytical Limit.

Margin from Tech Spec (TS) value to Setpoint (SP) (M2)

The only available margin from the Setpoint to the Technical Specification Limit is due to rounding. Therefore, M2 is negligible.

5.1.2 Improved Technical Specifications

- Quarterly Testing

Limiting Setpoint

$LSP_{Q\_ITS} := LSP_{Q\_CTS}$ $LSP_{Q\_ITS} = 1066 \cdot psi$

The Limiting Setpoint is based off of the Analytical Limit and the most Limiting TLU. For both CTS and ITS the Limiting Setpoint is the same.

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5.1.2 Improved Technical Specifications (Contd)

Allowable Value

$TLU_{testing\_Quarterly} = 15.83 \cdot psi$

$TLU_{testing\_Quarterly\_Rnd} := 16 \cdot psi$ $LSP_{Q\_ITS} = 1066 \cdot psi$

$AV := LSP_{Q\_ITS} + TLU_{testing\_Quarterly\_Rnd}$ $AV = 1082 \cdot psi$ Allowable value = Limiting setpoint+Loop Testing Uncertainty

Margin From Existing Setpoint

$LSP_{Q\_ITS} = 1066 \cdot psi$ $SP = 1038 \cdot psi$

$M1_{ITS} := LSP_{Q\_ITS} - SP$ $M1_{ITS} = 28 \cdot psi$ Margin between Limiting setpoint and the actual setpoint

Acceptance Value (ACV)

$AFT_{xmtr\_psig} = 15 \cdot psi$ $AFT_{Qmtu\_psig} = 3 \cdot psi$

$SP = 1038 \cdot psi$

$ACV := SP + AFT_{xmtr\_psig} + AFT_{Qmtu\_psig}$ $ACV = 1056 \cdot psi$ Acceptance value is obtained by adding the As-found values of the Transmitter and Trip unit to the setpoint. This ensures that under no circumstances, the allowable value be exceeded during surveillance.

Margin from Tech Spec (TS) value to Setpoint (SP)

The only available margin from the Setpoint to the Technical Specification Limit is due to rounding. Therefore, M2 is negligible.

Margin From AV and ACV

$AV = 1082 \cdot psi$ $ACV = 1056 \cdot psi$

$M3_{ITS} := AV - ACV$ $M3_{ITS} = 26 \cdot psi$ Margin between the allowable value and the acceptance value

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5.1.3 HELB Spurious Trip Margin

All RPS components are required to remain functional and not cause a reactor scram for six hours following a HELB outside of the primary containment. For the Reactor Pressure High Trip, this operability is verified by evaluating the affect of HELB errors with a normal reactor pressure reading. The normal operating pressure is selected and HELB errors are added to the normal pressure to determine if a spurious trip could occure. M4 is the margin to spurious trip.

The RPS system must remain functional for 6 hours after a HELB event to allow for a controlled shutdown of the Reactor. This requires that the Reactor Vessel Pressure Trip instruments not generate a spurious trip during this six hour time. The errors associated with a HELB event wil be added to normal Reactor pressure to determine the margin to spurious trip.

$TLU_{HELB\_Quarterly} = 26.05 \cdot psi$ ✓

$TLU_{HELB\_Quarterly\_Rnd} := 27 \cdot psi$ ✓

$P_n := 1000 \cdot psi$ ✓ $SP = 1038 \cdot psi$ ✓ $P_n + TLU_{HELB\_Quarterly\_Rnd} = 1027 \cdot psi$ ✓

$M4 := SP - (P_n + TLU_{HELB\_Quarterly\_Rnd})$ $M4 = 11 \cdot psi$ ✓

Margin from spurious RPS trip during 6 hrs after HELB event = SP-(Normal DW Pr+TLU(HELB))

5.1.4 Setpoint Results

All of the margins associated with the existing setpoint of 1038 psig were positive, therefore the existing setpoint is acceptable and no setpoint change is required.

Setpoint Conversion from PSI to mA

Setpoint

$SP = 1038 \cdot psi$ ✓ $CS_{xmtr} = 1500 \cdot psi$ ✓

$SP\_mA := SP \cdot \left(\frac{16 \cdot mA}{CS_{xmtr}}\right) + 4 \cdot mA$ $SP\_mA = 15.07 \cdot mA$ ✓ Setpoint value in mA

Tech Spec Value

$TS = 1055 \cdot psi$ ✓ $CS_{xmtr} = 1500 \cdot psi$ ✓

$TS\_mA := TS \cdot \left(\frac{16 \cdot mA}{CS_{xmtr}}\right) + 4 \cdot mA$ $TS\_mA = 15.25 \cdot mA$ ✓ Tech Spec value in mA

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5.1.4 Setpoint Results (Contd.)

Evaluation Of Existing Calibration Values

Calibration procedure OP-4312 establishes setpoints by the following calibration values:

Setpoint Calibration Value

$Trip\_Setting\_Max := 15.10 \cdot mA$ ✓ $Trip\_Setting\_Min := 15.04 \cdot mA$ ✓

$$SP\_mA := \frac{Trip\_Setting\_Max + Trip\_Setting\_Min}{2}$$

$SP\_mA = 15.07 \cdot mA$ ✓ Existing Setpoint value

$CS_{xmtr} = 1500 \cdot psi$ ✓

$$SP\_psi := \frac{SP\_mA - CS_{mtumin}}{(CS_{mtu})} \cdot CS_{xmtr}$$

$SP\_psi = 1037.81 \cdot psi$ ✓ The value determined from the Calibration procedure supports the existing setpoint value of 1038 psig.

Tech Spec Limit Value

$TS\_Setting := 15.25 \cdot mA$ ✓ $CS_{xmtr} = 1500 \cdot psi$ ✓

$$TS := \frac{TS\_Setting - CS_{mtumin}}{(CS_{mtu})} \cdot CS_{xmtr}$$

$TS = 1054.69 \cdot psi$ ✓ The value determined from the Calibration procedure supports the Tech Spec value of 1055 psig.

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6.0 Scaling

The M&TE used to determine the input pressure during calibration is readable to 1 psig. Therefore, for ease of calibration the output current value was established to the nearest whole number, and the resultant input pressure was determined.

$n := 0..16$ ✓ $Inmin := 12$ ✓ $Inmax := 1512$ ✓ $outmin := 4$ ✓ $outmax := 20$ ✓

$Inspan := Inmax - Inmin$ $outspan := outmax - outmin$

$$Input\_psig_n := \frac{Output\_mA_n - outmin}{outspan} \cdot Inspan + Inmin$$

$Output\_mA_n :=$ (mA)	$Input\_psig_n =$ (psig)
4.00 ✓	12 ✓
5.00	106
6.00	200
7.00	293
8.00	387
9.00	481
10.00	575
11.00	668
12.00	762
13.00	856
14.00	950
15.00	1043
16.00 ✓	1137 ✓
17.00	1231
18.00	1325
19.00	1418
20.00 ✓	1512 ✓

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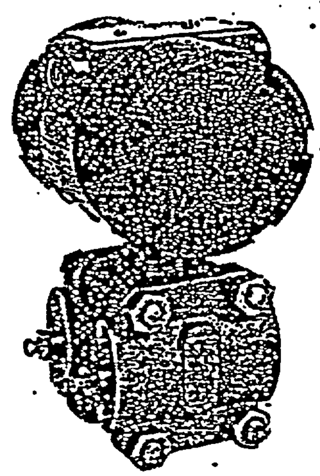
MODEL 1152 - T0280 ALPHALINE NUCLEAR PRESSURE TRANSMITTERS



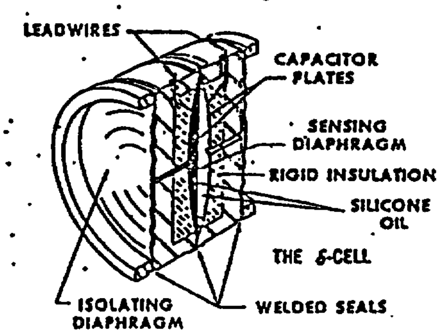
Nuclear service qualified
Design base event (D.B.E.) qualified
Differential, gage and absolute models
Traceability of pressure retaining parts
Cleaned for nuclear service
Qualified to 1.7 X 10^7 TID gamma radiation
0.25% accuracy

FEATURES

Rosemount's Model 1152-T0280 *Alphaline®* Pressure Transmitters* are designed for precision pressure measurements in nuclear applications requiring reliable performance and safety over an extended service life. These transmitters are qualified per IEEE-323, (1971) and IEEE-344, (1975) to levels of 1.7 X 10^7 rads TID gamma radiation, seismic levels of 3g's and for steam-pressure/chemical-spray performance. Stringent quality control during the manufacturing process includes traceability of pressure retaining parts, special nuclear cleaning, and hydrostatic testing.

Model 1152-T0280 Transmitters are similar in construction and performance to Rosemount's proven Model 1152 Transmitters. The Model 1152-T0280 incorporates several modifications of the standard Model 1152 Transmitter which include the use of an O-Ring neck seal and Dow Corning 704 oil in the sensor cell. Units are available in Absolute (AP), Gage (GP), and Differential (DP) configurations, with a variety of pressure range options.

Direct electronic sensing with the completely sealed δ-CELL™ capacitance sensing element eliminates mechanical force transfer and problems associated with shock and vibration. Installation and commissioning are simplified by compact design, 2-wire system compatibility and external span and zero adjustments. Wiring terminals and electronics are in separate compartments, so the electronics remain sealed during installation.



OPERATION

Process pressure is transmitted through an isolating diaphragm and silicone oil fill fluid to a sensing diaphragm in the center of the δ-CELL. The reference pressure is transmitted in like manner to the other side of the sensing diaphragm. The displacement of the sensing diaphragm, a maximum motion of 0.004 inches, is proportional to the pressure differential across it. The position of the sensing diaphragm is detected by capacitor plates on both sides of the sensing diaphragm. The differential capacitance between the sensing diaphragm and the capacitor plates is converted electronically to a 2-wire, 4-20 mADC signal.

Rosemount

NUCLEAR SPECIFICATIONS ALL MODELS

(Qualified to IEEE-323-1971 and IEEE-344-1975 per RMT Report 98017A)

Radiation Performance
±5.0% accuracy during and after testing to 1.7×10^7 rads, total integrated dosage gamma radiation at 0.4 Mrad/hr. dose rate: ±0.25% of span after recalibration.

Seismic Performance
±0.25% accuracy during and after seismic testing to 3g's over a range of 5-100 Hz in 3 major axes.

Steam Pressure/Chemical Spray Performance
Accuracy equal to the temperature effect accuracies listed below under Performance Specifications after sequential exposure to steam pressure of 15 psig, 212°F for 6 hours, 15 psig, 105°F for 100 days.

Quality Assurance Program in accordance with 10CFR50, Appendix B.
Nuclear Cleaning to 1 ppm chloride content.
Hydrostatic testing to 150% of maximum working pressure or 2000 psi, whichever is greater.
Traceability in accordance with 10CFR50, Appendix B; chemical and physical material certification of pressure retaining parts.

PERFORMANCE SPECIFICATIONS MODEL 1152AP AND 1152GP

(Zero-based Spans, Reference Conditions)

Accuracy
±0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability.

Deadband
None

Stability
±0.25% of Upper Range Limit for 6 months.

Temperature Effect at Maximum Span (e.g. 0-100 psig for 0-17/100 psig range)
Zero Error: ±0.75% of span per 100°F.
Total effect including span and zero errors: ±1.25% of span per 100°F.
NOTE: Double the specified effect for Range Code 3.

Temperature Effect at Minimum Span (e.g. 0-17 psig for 0-17/100 psig range)
Zero Error: ±4.5% of span per 100°F.
Total effect including span and zero errors: ±5.0% of span per 100°F.
NOTE: Double the specified effect for Range Code 3.

Overpressure Effect
Overpressure of 2000 psig will cause a zero shift of less than ±0.25% of Upper Range Limit (Range Codes 3 & 4); ±1% of Upper Range Limit (Range Code 5); ±3% of Upper Range Limit (Range Codes 6 & 7); ±1% of Upper Range Limit (Range Code 8); ±0.5% of Upper Range Limit (Range Code 9, to 4500 psi).

Power Supply Effect
Less than 0.005% of span per volt.

Load Effect
No load effect other than the change in voltage supplied to the transmitter.

Mounting Position Effect
Zero shift of up to 1.5 inch H_2O which can be calibrated out. No effect in plane of diaphragm. No span effect.

Span error is systematic and can be calibrated out for a particular pressure before installation.

PERFORMANCE SPECIFICATIONS MODEL 1152DP

(Zero-based Spans, Reference Conditions)

Accuracy
±0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability.

Deadband
None

Stability
±0.25% of Upper Range Limit for 6 months.

Temperature Effect at Maximum Span (e.g. 0-150 in. for 0-25/150 in. H_2O range)
Zero Error: ±0.75% of span per 100°F.
Total Effect including Span and Zero Errors: ±1.25% of span per 100°F.
NOTE: Double the specified effect for Range Code 3.

Temperature Effect at Minimum Span (e.g. 0-25 in. for 0-25/150 in. H_2O range)
Zero Error: ±4.5% of span per 100°F.
Total Effect including Span and Zero Errors: ±5.0% of span per 100°F.
NOTE: Double the specified effect for Range Code 3.

Overpressure Effect
Model 1152DP: 2000 psig overpressure will cause a zero shift of less than ±0.25% of Upper Range Limit (Range Codes 3 & 4); less than ±1.0% of Upper Range Limit (Range Code 5); less than ±3.0% of Upper Range Limit (Range Codes 6 & 7); less than ±6.0% of Upper Range Limit (Range Code 8).

Static Pressure Effect
Model 1152DP Zero Error: ±0.25% of Upper Range Limit per 2000 psi (Range Codes 4 & 5); ±0.5% of Upper Range Limit per 2000 psi (Range Codes 3, 6, 7, 8).
Span Error: −1.0 ± 0.25% of reading per 1000 psi (Range Codes 4, 5, 6, 7, 8); −1.5 ± 0.25% of reading per 1000 psi (Range Code 3).

Span error is systematic and can be calibrated out for a particular pressure before installation.

Power Supply Effect
Less than 0.005% of span per volt.

Load Effect
No load effect other than the change in voltage supplied to the transmitter.

Mounting Position Effect
Zero shift of up to 1.5 in. H_2O which can be calibrated out. No span effect. No effect in plane of diaphragm.

PHYSICAL SPECIFICATIONS ALL MODELS

Materials of Construction

Isolating Diaphragms and Drain/Vent Valves: 316SS

Process Flanges: 316SS

O-Rings: Ethylene Propylene

Fill Fluid: Dow Corning 704 oil

Flange Bolts: Plated Alloy Steel, per ASTM A-540

Electronics Housing: Low-copper aluminum polyester-epoxy painted

Process Connections: 1/4-18 NPT

Electrical Connections: 1/2-14 NPT conduit. Slotted and 0.104" diameter jack-type screw terminals.

Weight: 12 lbs. with aluminum housing

FUNCTIONAL SPECIFICATIONS MODEL 1152AP AND 1152GP

Ranges
(3) 0-5/30 in. H_2O (GP Units Only)
(4) 0-25/150 in. H_2O; 0-2/11 in. HgA
(5) 0-125/750 in. H_2O; 0-10/55 in. HgA
(6) 0-17/100 psig/psia
(7) 0-50/300 psig/psia
(8) 0-170/1000 psig/psia
(9) 0-500/3000 psig (GP Units Only)

Output
4-20 mADC

Power Supply
External power supply required, up to 45 VDC. Transmitter operates on 12 VDC with no load.

Span and Zero
Continuously adjustable externally.

Elevation and Suppression
Maximum Zero Elevation: 600% of calibrated span down to 0.5 psia (GP only).
Maximum Zero Suppression: 500% of calibrated span. Neither calibrated span nor end points can exceed ±100% of Upper Range Limit.

Temperature Limits
40 to 212°F Amplifier operating.
40 to 212°F Sensing Element operating.
−60 to 250°F Storage.

Maximum Working Pressure
Upper Range Limit

Overpressure Limits
0.5 psia to 2000 psig (Range Codes 3, 4, 5, 6, 7, 8); 4500 psig (Range Code 9); without damage to transmitter. 10,000 psig proof pressure on the flanges.

Humidity Limits
0-100% RH.

Turn-on Time
2 seconds. No warmup required.

Damping
Minimum time constant measured at 100°F does not exceed 2 seconds (Range 3), 0.5 seconds (Range 4), or 0.2 seconds (Range 5-9). Time constant is adjustable (Range 4-9) to a maximum of 1.67 seconds.

FUNCTIONAL SPECIFICATIONS MODEL 1152DP

Ranges
(3) 0-5 to 0-30 in. H_2O
(4) 0-25 to 0-150 in. H_2O
(5) 0-125 to 0-750 in. H_2O
(6) 0-17 to 0-100 psi
(7) 0-50 to 0-300 psi
(8) 0-170 to 0-1000 psi

Output
4-20 mADC

Power Supply
External power supply required, up to 45 VDC. Transmitter operates on 12 VDC with no load.

Span and Zero
Continuously adjustable externally.

Elevation and Suppression
Maximum Zero Elevation: 600% of calibrated span.
Maximum Zero Suppression: 500% of calibrated span. Neither calibrated span nor end points can exceed ±100% of Upper Range Limit.

Temperature Limits
40 to 212°F Amplifier operating.
40 to 212°F Sensing Element operating.
−60 to 250°F Storage.

Maximum Working Pressure
Upper Range Limit

Static Pressure and Overpressure Limits
0.5 psia to 2000 psig static pressure for operation within specifications. 2000 psig overpressure on either side without damage to the transmitter.
10,000 psig proof pressure on the flanges.

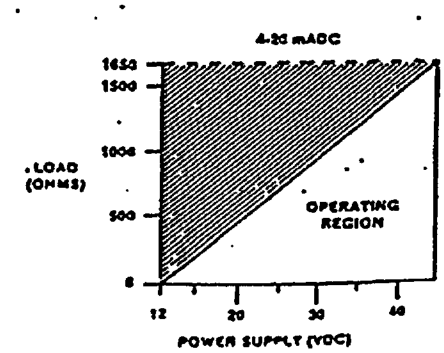
Humidity Limits
0-100% RH.

Volumetric Displacement
Less than 0.01 cubic inches.

Turn-on Time
2 seconds. No warmup required.

Damping
Minimum time constant measured at 100°F does not exceed 2 seconds (Range 3), 0.5 seconds (Range 4), or 0.2 seconds (Ranges 5-8). Time constant is adjustable (Range 4-8) to a maximum of 1.67 seconds.

LOAD LIMITATIONS



Ordering Information

MODEL 1152	ALPHALINE PRESSURE TRANSMITTERS FOR NUCLEAR APPLICATIONS

CODE	PRESSURE MEASUREMENT
DP	Differential Pressure, 2000 psig Static Pressure Rating
AP	Absolute Pressure
GP	Gage Pressure

PRESSURE RANGES

CODE	MODEL 1152DP (DIFFERENTIAL)	MODEL 1152AP (ABSOLUTE)	MODEL 1152GP (GAGE)
3	0-5 to 0-30 in. H_2O (0-127 to 0-762 mm H_2O)	N/A N/A	0-5 to 0-30 in. H_2O (0-127 to 0-762 mm H_2O)
4	0-25 to 0-150 in. H_2O (0-635 to 0-3810 mm H_2O)	N/A	0-25 to 0-150 in. H_2O (0-635 to 0-3810 mm H_2O)
5	0-125 to 0-750 in. H_2O (0-3175 to 0-19050 mm H_2O)	0-10 to 0-55 in. HgA (0-0.345 to 0-1.883 kg/cm²)	0-125 to 0-750 in. H_2O (0-3175 to 0-19050 mm H_2O)
6	0-17 to 0-100 psid (0-1.2 to 0-7.0 kg/cm²)	0-17 to 0-100 psia (0-1.2 to 0-7.0 kg/cm²)	0-17 to 0-100 psig (0-1.2 to 0-7.0 kg/cm²)
7	0-50 to 0-300 psid (0-3.5 to 0-21 kg/cm²)	0-50 to 0-300 psia (0-3.5 to 0-21 kg/cm²)	0-50 to 0-300 psig (0-3.5 to 0-21 kg/cm²)
8	0-170 to 0-1000 psid (0-12 to 0-70 kg/cm²)	0-170 to 0-1000 psia (0-12 to 0-70 kg/cm²)	0-170 to 0-1000 psig (0-12 to 0-70 kg/cm²)
9	N/A	N/A	0-500 to 0-3000 psig (0-35 to 0-210 kg/cm²)

CODE	OUTPUT
E	4-20 mADC with Adjustable Damping

MATERIALS OF CONSTRUCTION

CODE	FLANGES	DRAIN/ VENT VALVES	ISOLATING DIAPHRAGMS	ELECTRONICS HOUSING/ COVERS
22	316SS	316SS	316SS	Aluminum

CODE	SPECIALS
T0280	Radiation capability to 1.7 X 10⁸ rads TID gamma radiation.
T0455	Same as T0280 except has undergone 96 hrs. burn-in procedure.

CODE	OPTIONS
PB	Panel Mounting Bracket

1152	DP	4	E	22	T0280	PB ←— TYPICAL MODEL NUMBER

STANDARD ACCESSORIES All Models are shipped with vent/drain valves and one instruction manual per shipment.

CALIBRATION Transmitters are factory calibrated to customer's specified range. If calibration is not specified, transmitters are calibrated at maximum range. Calibration is at ambient temperature and pressure.

TAGGING *Alphaline* Pressure Transmitters will be supplied with SST tagging in accordance with customer requirements.

DOCUMENTATION Certification of compliance will be provided for each 1152-T0280 transmitter for nuclear qualification, accuracy, special cleaning, hydrostatic testing, and traceability. Chemical and physical reports and identification of pressure boundary materials will be on file at Rosemount.

NOTE: Model 1152-T0455 is identical to Model 1152-T0280 except the T0455 option has undergone a burn-in procedure.

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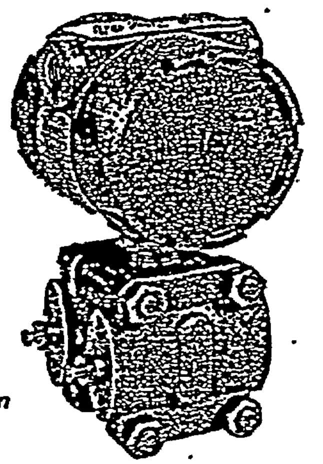
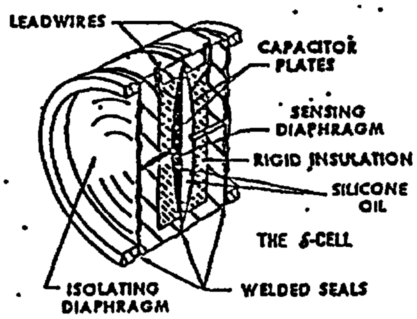
MODEL 1152 ALPHALINE® NUCLEAR PRESSURE TRANSMITTERS



Nuclear service qualified
Design base event (D.B.E.) qualified
Differential, gage and absolute models
Traceability of pressure retaining parts
Cleaned for nuclear service
SST housing option
Qualified to 5 × 10⁶ rads TID gamma radiation
0.25% accuracy



FEATURES

Model 1152 *Alphaline®* *Pressure Transmitters** are designed for precision pressure measurements in nuclear applications requiring reliable performance and safety over an extended service life. These transmitters are qualified per IEEE Std. 323-1971 and IEEE Std. 344-1975 to levels of 5×10^6 rads TID gamma radiation, seismic levels of 3 g's and for steam-pressure/chemical-spray performance. Stringent quality control during the manufacturing process includes traceability of pressure retaining parts, special nuclear cleaning, and hydrostatic testing.

Model 1152 Transmitters are similar in construction and performance to the proven Rosemount® Model 1151 Transmitters. Units are available in Absolute (AP), Gage (GP), Differential (DP) and High-Line Differential (HP) configurations, with a variety of pressure range options.

Direct electronic sensing with the completely sealed δ-Cell™ capacitance sensing element eliminates mechanical force transfer and problems associated with shock and vibration. Installation and commissioning are simplified by compact design, 2-wire system compatibility and external span and zero adjustments. Wiring terminals and electronics are in separate compartments, so the electronics remain sealed during installation.

OPERATION

Process pressure is transmitted through an isolating diaphragm and silicone oil fill fluid to a sensing diaphragm in the center of the δ-Cell. The reference pressure is transmitted in like manner to the other side of the sensing diaphragm. The displacement of the sensing diaphragm, a maximum motion of 0.004 inches, is proportional to the pressure differential across it. The position of the sensing diaphragm is detected by capacitor plates on both sides of the sensing diaphragm. The differential capacitance between the sensing diaphragm and the capacitor plates is converted electronically to a 2-wire, 4-20 mA dc signal.

Rosemount

NUCLEAR SPECIFICATIONS ALL MODELS

(Qualified to IEEE Std. 323-1971 and IEEE Std. 344-1975 per RMT Reports 38019, 58225)

Radiation Performance ±8.0% accuracy during and after testing to 5×10^6 rads, total integrated dosage gamma radiation at 0.4 Mrad-hr. dose rate.

Seismic Performance ±0.25% accuracy during and after seismic testing to 3g over a range of 5-100 Hz in 3 major axes.

Steam Pressure/Chemical Spray Performance ±0.75% accuracy after sequential exposure to steam pressure of 70 psig (21.14 kPa), 316°F (157.8°C) for 1 hour; 55.4 psig (17.5 kPa), 303°F (150.5°C) for 7 hours and 6 psig (5.2 kPa), 230°F (110°C) for 42 hours. For SST housing option, ±0.75% accuracy after chemical spray concurrent with above steam pressure cycle.

Quality Assurance Program in accordance with 10CFR50, Appendix B.

Nuclear Cleaning to 1 ppm chlorine content. **Hydrostatic Testing** to 150% of rated line pressure or 2000 psi (13.8 MPa), whichever is greater.

Traceability in accordance with 10CFR50, Appendix B; chemical and physical material certification of pressure retaining parts.

PERFORMANCE SPECIFICATIONS MODEL 1152AP AND 1152GP

(Zero-based Spans, Reference Conditions)

Accuracy ±0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability.

Deadband None

Stability ±0.25% of Upper Range Limit for 6 months.

Temperature Effect AP & GP
Range Codes 4-9: ±(0.5% Upper Range Limit +0.5% span) per 100°F (55.6°C) ambient temperature change.

Range Code 3: ±(1.0% Upper Range Limit +1.0% span) per 100°F (55.6°C) ambient temperature change.

Overpressure Effect
Overpressure of 2000 psig (13.8 MPa) will cause a zero shift of less than ±0.25% of Upper Range Limit (Range Codes 3 & 4); ±1% of Upper Range Limit (Range Code 5); ±3% of Upper Range Limit (Range Codes 6 & 7); ±6% of Upper Range Limit (Range Code 8); ±0.5% of Upper Range Limit (Range Code 9) to 4500 psi (31.0 MPa).

Power Supply Effect Less than 0.005% of span per volt.

Load Effect No load effect other than the change in voltage supplied to the transmitter.

Mounting Position Effect Zero shift of up to 1 inch H_2O which can be calibrated out. No effect in plane of diaphragm. No span effect.

PERFORMANCE SPECIFICATIONS MODEL 1152DP AND 1152HP

(Zero-based Spans, Reference Conditions)

Accuracy ±0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability.

Deadband None

Stability ±0.25% of Upper Range Limit for 6 months.

Temperature Effect DP & HP
Range Codes 4-8: ±(0.5% Upper Range Limit +0.5% span) per 100°F (55.6°C) ambient temperature change.

Range Code 3: ±(1.0% Upper Range Limit +1.0% span) per 100°F (55.6°C) ambient temperature change.

Overpressure Effect
Model 1152DP: 2000 psig (13.8 MPa) overpressure will cause a zero shift of less than ±0.25% of Upper Range Limit (Range Codes 3 & 4); less than ±1.0% of Upper Range Limit (Range Code 5); less than ±3.0% of Upper Range Limit (Range Codes 6 & 7); less than ±6.0% of Upper Range Limit (Range Code 8).

Model 1152HP: 4500 psi (31.0 MPa) overpressure will cause a zero shift of less than ±1.0% of Upper Range Limit (Range Code 4); less than ±2.0% of Upper Range Limit (Range Code 5); less than ±5.0% of Upper Range Limit (Range Codes 6 & 7).

Static Pressure Effect
Model 1152DP Zero Error: ±0.25% of Upper Range Limit per 2000 psi (13.8 MPa)(Range Codes 4 & 5); ±0.5% of Upper Range Limit per 2000 psi (13.8 MPa)(Range Codes 3, 6, 7, 8).

Model 1152HP Zero Error: ±2.0% of Upper Range Limit per 4500 psi (31.0 MPa)(all ranges).

Power Supply Effect Less than 0.005% of span per volt.

Load Effect No load effect other than the change in voltage supplied to the transmitter.

Mounting Position Effect Zero shift of up to 1 inch H_2O which can be calibrated out. No effect in plane of diaphragm. No span effect.

PHYSICAL SPECIFICATIONS ALL MODELS

MATERIALS OF CONSTRUCTION

Isolating Diaphragms and Drain/Vent Valves: 316SS

Process Flanges: 316SS

O-Rings: Ethylene Propylene

Fill Fluid: Silicone Oil

Flange Bolts: Plated Alloy Steel, per ASTM A-540

Electronics Housing: Low-copper aluminum polyester-epoxy painted; or austenitic stainless steel.

Process Connections: 1/4-18 NPT

Electrical Connections: 1/2-14 NPT conduit with screw terminals.

Weight: 12 lbs. with aluminum housing; 16 lbs. with stainless steel housing (excluding bracket).

FUNCTIONAL SPECIFICATIONS MODEL 1152AP AND 1152GP

Ranges
(3) 0-5 to 0-30 in. H_2O (0-1.24 to 0-7.46 kPa)(GP Units Only)
(4) 0-25 to 0-150 in. H_2O (0-6.22 to 0-37.50 kPa)
(5) 0-125 to 0-750 in. H_2O (0-31.08 to 0-186.50 kPa)
(6) 0-17 to 0-100 psig/psia (0-0.12 to 0-0.69 MPa)
(7) 0-50 to 0-300 psig/psia (0-0.34 to 0-2.07 MPa)
(8) 0-170 to 0-1000 psig/psia (0-1.17 to 0-6.89 MPa)
(9) 0-500 to 0-3000 psig (0-3.45 to 0-20.68 MPa)(GP Units Only)

Output 4-20 mADC

Power Supply External power supply required, up to 45 VDC. Transmitter operates on 12 VDC with no load.

Span and Zero Continuously adjustable externally.

Elevation and Suppression
Maximum Zero Elevation: 600% of calibrated span (GP only).
Maximum Zero Suppression: 500% of calibrated span.
Neither calibrated span nor end points can exceed ±100% of Upper Range Limit.

Temperature Limits
−20 to 200°F (−28.9 to 93.3°C) Amplifier Operating.
−20 to 200°F (−28.9 to 104.4°C) Sensing Element Operating.
−60 to 250°F (−51.1 to 121.1°C) Storage.

Max. Working Pressure Upper Range Limit

Overpressure Limits 0.5 psia (3.4 kPa) to 2000 psig (13.8 MPa) (Range Codes 3, 4, 5, 6, 7, 8); 4500 psig (31.0 MPa)(Range Code 9); without damage to transmitter.

Humidity Limits 0-100% RH.

Turn-on Time 2 seconds. No warmup required.

Damping Time constant continuously adjustable between 0.2 and 1.67 seconds.

FUNCTIONAL SPECIFICATIONS MODEL 1152DP AND 1152HP

Ranges
(3) 0-5 to 0-30 in. H_2O (0-1.24 to 0-7.46 kPa)(DP Units Only)
(4) 0-25 to 0-150 in. H_2O (0-6.22 to 0-37.50 kPa)
(5) 0-125 to 0-750 in. H_2O (0-31.08 to 0-186.50 kPa)
(6) 0-17 to 0-100 psi (0-0.12 to 0-0.69 MPa)
(7) 0-50 to 0-300 psi (0-0.34 to 0-2.07 MPa)
(8) 0-170 to 0-1000 psi (0-1.17 to 0-6.89 MPa)(DP Units Only)

Output 4-20 mADC

Power Supply External power supply required, up to 45 VDC. Transmitter operates on 12 VDC with no load.

Span and Zero Continuously adjustable externally.

Elevation and Suppression
Maximum Zero Elevation: 600% of calibrated span.
Maximum Zero Suppression: 500% of calibrated span.
Neither calibrated span nor end points can exceed ±100% of Upper Range Limit.

Temperature Limits
−20 to 200°F (−28.9 to 93.3°C) Amplifier Operating.
−20 to 220°F (−28.9 to 104.4°C) Sensing Element Operating.
−60 to 250°F (−51.1 to 121.1°C) Storage.

Static Pressure and Overpressure Limits
Model 1152DP: 0.5 psia (3.4 kPa) to 2000 psig (13.8 MPa) static pressure for operation within specifications. 2000 psig (13.8 MPa) overpressure on either side without damage to the transmitter.
Model 1152HP: 0.5 psia (3.4 kPa) to 4500 psig (31.0 MPa) static pressure for operation within specifications. 4500 psig (32.0 MPa) overpressure on either side without damage to the transmitter.

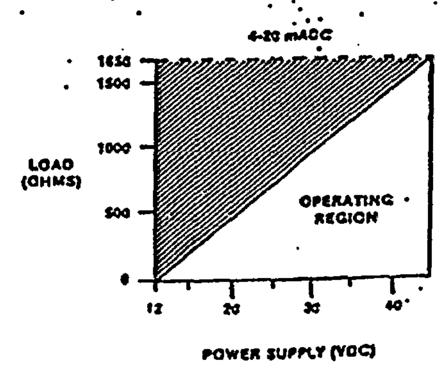
Humidity Limits 0-100% RH.

Volumetric Displacement Less than 0.01 cubic inches (0.16 cm^3).

Turn-on Time 2 seconds. No warmup required.

Damping Time constant continuously adjustable between 0.2 and 1.67 seconds.

LOAD LIMITATIONS



Ordering Information

MODEL 1152	ALPHALINE PRESSURE TRANSMITTERS FOR NUCLEAR APPLICATIONS

CODE	PRESSURE MEASUREMENT
DP	Differential Pressure, 2000 psig Static Pressure Rating
HP	Differential Pressure, 4500 psig Static Pressure Rating
AP	Absolute Pressure
GP	Gage Pressure

PRESSURE RANGES

CODE	MODEL 1152DP (DIFFERENTIAL)	MODEL 1152HP (DIFFERENTIAL)	MODEL 1152AP (ABSOLUTE)	MODEL 1152GP (GAGE)
3	0-5 to 0-30 in. H_2O (0-1.24 to 0-7.46 kPa)	N/A	N/A	0-5 to 0-30 in. H_2O (0-1.24 to 0-7.46 kPa)
4	0-25 to 0-150 in. H_2O (0-6.22 to 0-37.50 kPa)	0-25 to 0-150 in. H_2O (0-6.22 to 0-37.50 kPa)	N/A	0-25 to 0-150 in. H_2O (0-6.22 to 0-37.50 kPa)
5	0-125 to 0-750 in. H_2O (0-31.08 to 0-186.50 kPa)	0-125 to 0-750 in. H_2O (0-31.08 to 0-186.50 kPa)	0-125 to 0-750 in. H_2O (0-31.08 to 0-186.50 kPa)	0-125 to 0-750 in. H_2O (0-31.08 to 0-186.50 MPa)
6	0-17 to 0-100 psid (0-0.12 to 0-0.69 MPa)	0-17 to 0-100 psid (0-0.12 to 0-0.69 MPa)	0-17 to 0-100 psia (0-0.12 to 0-0.69 MPa)	0-17 to 0-100 psig (0-0.12 to 0-0.69 MPa)
7	0-50 to 0-300 psid (0-0.35 to 0-2.07 MPa)	0-50 to 0-300 psid (0-0.35 to 0-2.07 MPa)	0-50 to 0-300 psia (0-0.35 to 0-2.07 MPa)	0-50 to 0-300 psig (0-0.35 to 0-2.07 MPa)
8	0-170 to 0-1000 psid (0-1.15 to 0-6.89 MPa)	N/A	0-170 to 0-1000 psia (0-1.15 to 0-6.89 MPa)	0-170 to 0-1000 psig (0-1.15 to 0-6.89 MPa)
9	N/A	N/A	N/A	0-500 to 0-3000 psig (0-3.45 to 0-20.82 MPa)

CODE	OUTPUT
N	4-20 mADC with Adjustable Damping

MATERIALS OF CONSTRUCTION

CODE	FLANGES	DRAIN/VENT VALVES	ISOLATING DIAPHRAGMS	ELECTRONICS HOUSING/COVERS
22	316SS	316SS	316SS	Aluminum
92	316SS	316SS	316SS	Austenitic SS

CODE	OPTIONS
PB	Panel Mounting Bracket

1152	DP	4	N	22	PB	← TYPICAL MODEL NUMBER

STANDARD ACCESSORIES All Models are shipped with vent/drain valves and one instruction manual per shipment.

CALIBRATION Transmitters are factory calibrated to customer's specified range. If calibration is not specified, transmitters are calibrated at maximum range. Calibration is at ambient temperature and pressure.

TAGGING ALPHALINE Pressure Transmitters will be supplied with SST tagging in accordance with customer requirements.

DOCUMENTATION Certification of compliance will be provided for each 1152 transmitter for nuclear qualification, accuracy, special cleaning, hydrostatic testing, and traceability. Chemical and physical reports and identification of pressure boundary materials will be on file at Rosemount.

Rosemount Inc. POST OFFICE BOX 35129 MINNEAPOLIS, MINNESOTA 55435
PHONE: (612) 941-5560 TWX: 910-576-3103 TELEX: 29-0183 CABLE: ROSEMOUNT

MEMORANDUM

YANKEE ATOMIC - FRAMINGHAM

To R. G. January
From G. J. Hengerle
Subject LONG-TERM STABILITY RESULTS: ROSEMOUNT TRANSMITTERS

Date July 13, 1987
Group # VYI 139/87
W.O. # 4100
I.M.S. #

REFERENCES

(a) YAEC-1562, Instrument Accuracy Report of Selected Class 1E Equipment at Vermont Yankee Nuclear Power Station
(b) Rosemount Report 78223, Revision A, Long-Term Test Results for Pressure Transmitters, Rosemount Model 1151 (Enclosure 1)
(c) Letter, Ms. J. Sandstrom (Rosemount) to G. Hengerle (YNSD) dated July 6, 1987 (Enclosure 2)
(d) Meeting Notes Between J. Sandstrom/H. Savage (Rosemount) and G. Hengerle (YNSD), dated June 9-11, 1986

EXECUTIVE SUMMARY

Long-term stability testing was conducted by Rosemount for their 1151 series transmitters. Their report states that the results apply to the 1152 and 1153 series transmitters. An evaluation of the Rosemount stability test results indicate that a worst case stability error of ±0.25% of upper range limit for 18 months can be utilized for the transmitters installed at Vermont Yankee.

BACKGROUND

Rosemount's published stability error is ±0.25% of Upper Range Limit (URL) per each six months of operation. This stability error was used in determining instrument loop errors presented in YAEC-1562 (Reference (a)). For a one-year operating cycle, this was found to be acceptable.

However, the operating cycle following the 1989 refueling outage will be 18 months. Using Rosemount's published stability specification will result in unacceptable instrument loop errors. An alternative to Rosemount's published stability specification was deemed necessary.

Rosemount provided a report on long-term stability testing (Reference (b)), which can be applied to the 1152 and 1153 transmitters installed at Vermont Yankee.

DISCUSSION

Summary

Rosemount performed long-term stability testing on the 1151 series transmitters. In their report, Rosemount concludes the following:

"Long-term stability of the Model 1151 Range 4 pressure transmitter is much better than ±0.2% URL per six months at reference conditions. The

Model 1152 and 1153 series pressure transmitters are only slightly different from the 1151, and none of these changes affect stability."

From their conclusion and subsequent concurrence from Rosemount (Reference (c)), the results obtained from the 1151 testing can be applied to the 1152 and 1153 series transmitters installed at Vermont Yankee.

Evaluation

Rosemount actually performed two independent stability tests.

The first test used a single 1151 transmitter mounted on their building's roof. Test data was obtained intermittently over a 12-year period. The data indicated good stability over the entire period. However, the transmitter was not pressurized and was energized only while test data was being obtained. This does not adequately represent the transmitters installed at Vermont Yankee. Therefore, the test data obtained cannot be directly applied to the Vermont Yankee transmitters.

The second test used six 1151 transmitters installed outside on a roof. They were maintained energized and at pressure. Test data was obtained over a five-year period. These transmitters closely represent the transmitters installed at Vermont Yankee in that; 1) they are continuously energized, 2) they are maintained at pressure, and 3) they will experience a variation in their environment.

As such, the test data obtained from these transmitters can be applied to the Vermont Yankee transmitters.

The stability test report (Reference (b)) was reviewed. The test data included stability errors superimposed by errors caused by temperature effects. To obtain only stability errors, Rosemount, using the least squares method, determined a best-fit straight line. This method gives a good indication of average stability over time.

Based on the above, the worst average shift observed was 0.057% span per six months. This is a far superior specification than the 0.25% URL per six months published by Rosemount (for the 1152 and 1153 series transmitters) and presently used in determining instrument loop accuracies.

Justification exists to use an improved stability specification of ±0.057% of span per six months. Over an 18-month cycle, a total stability error of ±0.171% of span would apply. However, prudency dictates that additional conservatism should be imposed. Therefore, the ±0.057% of span per six months specification will be increased by a factor of 1.4, to ±0.08% of span per six months. In addition, the URL will be used in lieu of span, resulting in a stability specification of ±.08% of URL per six months. For an 18-month cycle, this will result in a total stability specification of ±.24% of URL. For additional conservatism, a stability specification of ±.25% of URL will be used for 18-month cycles.

It is also worth noting that Rosemount integrates their accuracy specification (±0.25% of span) within the published stability specification (Reference (d)). Per concurrence with Rosemount (Reference (c)), the accuracy specification can also be treated as an integral part of the evaluated stability specification.

CONCLUSION

The Rosemount five year long-term stability test results can be applied to the 1152 and 1153 series transmitters installed at Vermont Yankee. Based on the above evaluation, a stability specification of ±0.25% of URL for 18 months is conservative and adequate for future instrument loop accuracy reviews. Furthermore, the Rosemount published accuracy specification is still to be treated as an integral part of the evaluated stability specification.

G. J. Hengerle
Senior Engineer
Vermont Yankee Project

R. T. Vibert
Senior Engineer
Vermont Yankee Project

GJH/RTV/dlb

Enclosures

cc: S. R. Miller
J. K. Thayer
R. L. Smith
M. J. Cofske

LOW LEVEL RADIATION DOSE RATE TEST
SMALL BREAK LOCA TEST

ROSEMOUNT NUCLEAR PRESSURE TRANSMITTERS MODEL 1153 SERIES B

WITH SIMILARITY CONCLUSIONS FOR 1153 SERIES D AND 1154

ROSEMOUNT TYPE TEST REPORT D8600063

Rosemount Inc
12001 TECHNOLOGY DRIVE EDEN PRAIRIE, MINNESOTA 55344 U.S.
PHONE: (612) 941-5560 TELEX: 4310024, 4310012 CABLE: ROSEMOUNT

4.0 GENERAL RESULTS

4.1 Radiation Test

The radiation test data supports a specification, for Model 1153 Series B transmitters, of ± 1.0% of Upper Range Limit (URL) when exposed to dose rates of less than 1 MRad/hr and a TID of less than 5 MRads. This improved specification applies to both the P and R output code electronics installed in Model 1153 Series B transmitters.

Since Radiation effects are due to the electronics and the electronics used in the Model 1153 Series D / Model 1154 are identical (except on the Series D requires the use of jumper wire for large elevation/suppression calibration instead of a switch as the Series B uses) to the Output codes tested, these test results and the improved specification can be applied to the Models 1153 Series D and 1154. The additional shielding will have no detrimental effect on the radiation performance of the Models 1153 Series D and 1154.

4.2 LOCA Test

The LOCA test data supports an improved performance specification of ± 3.6% URL during an 185°F LOCA profile as described in Section 3.2. This is a 2% URL improvement in the ± 5% URL specification defined for a 250°F LOCA profile. The data is supplied in Section 3.2 to allow the user to evaluate the data and determine the applicability of the data to their installed equipment.

ROSEMOUNT INC.
12001 Technology Drive
Eden Prairie, MN 55344 U.S.A.
(612) 941-5560
TWX: 4310012 or 4310024
FAX: (612) 828-3088

ATTACHMENT C
VYC- 467 REV: 5

Rosemount

July 28, 1987

George Hengerle
Yankee Atomic Electric Co.
1671 Worcester Road
Framingham, MA 01701

Dear Mr. Hengerle,

In response to your question on the D8600063 Low level Radiation and LOCA Test report, section 4.2 LOCA Test should in fact read:

"The LOCA test data supports an improved performance specification of ± 3.0% URL ......"

The ± 3.6% is in error. We will change this in the next revision.

If you have any further questions please feel free to call me.

Sincerely,

Jane Sandstrom
Sr. Marketing Engineer

/jka

Meeting notes 6-9-86 and 6-11-86 WO 8112

Between: Harry Savage & Jane Sanderson (Rosemount) and G. Hengelle (YNSD)

Subject: Rosemount Transmitters

Q. If stability is accounted for do you also have to include the accuracy specification as a separate error?

A. No Accuracy is included with the stability spec.

Q. If span error is not calibrated out do you still include a correction uncertainty factor?

A. No it only applies if you calibrate it out

Q. Can a transmitter be provided with an upper Range Limit between 1000 & 3000

A. An option is available to provide the URL transmitter of 1000 with a 1050 Upper Range Limit.

Q. Can additional temperature effect relief be obtained for the 1152T0280's?

A. No. [as substantiated by Telecon between G. Hengerle & Dick La Salle (Rosemount) on 9-10-86]. A great deal of time & effort would be required. If any data was available it would most probably not help sufficiently?

Q. Can the stability factor of ±.25% / 6 mo and ±.5% / year be extended to ±.25% / year?

A. Not optomistic but we'll check on it.

Q. Is the way we're using the data correct. [Review of Typical calculation]

A. YES

Q. Do the performance specs for temperature represent equilibrium temperature effects?

A. YES

George J. Hengerle
6-11-86

Telecon 3-20-86 WO 4112

Between Jane Sandstrom (Rosemount)
and
George Hengelle (YNSD)

1- Verified with Jane that overpressure effects do not apply providing the transmitters do not exceed their upper range limit. She concurred.

2. Verified with Jane the effects of static pressure:
- Zero error can only be calibrated out if a zero DP is used in the calibrated range (not done at VY)
- Span error of -1% can be calibrated out (as previously discussed)
- A correction uncertainty for span error of ± .25% / 1000 PSI would still apply.

Jane concurred.

George J. Hengelle
3-20-86

ROSEMOUNT INC.
12001 West 78th Street
Eden Prairie, Minnesota 55344 U.S.A.
Tel. (612) 941-5560
TWX 910-576-3103 TELEX 29-0183

June 12, 1986

Rosemount

Mr. George Hengerle
Yankee Atomic Electric Co.
1671 Worcester Road
Framingham, MA 01701

Dear Mr. Hengerle:

This letter will confirm our telephone conversation of yesterday regarding your application of the Rosemount Model 1152GP9T0280 transmitter.

The T0280 option for the 1152 transmitter is intended primarily to improve radiation performance; there are other minor differences which do not affect specifications. All specifications for the standard 1152 transmitter, as detailed in the attached Product Data Sheet #2235, apply to the 1152T0280 transmitter as well except for radiation performance. The radiation performance specification for the 1152T0280 is as described in Product Data Sheet #2396, which you have. All other specifications in that Product Data Sheet are superceded by those in Product Data Sheet #2235.

The correct temperature effect specification for your 1152GP9T0280, therefore, is $\pm$ (0.5% Upper Range Limit + 0.5% span) per 100°F ambient temperature change. For a 0/1500 PSIG calibration, the specification is $\pm$ 1.5% span (2:1 rangedown). Our testing indicates that results for individual units may vary within the specification, so I suggest that you not try to reduce the specification for your setpoint calculations.

I hope this information is helpful. If you have further questions, please feel free to contact Jane Sandstrom or myself.

Sincerely,

Robert Bach
Senior Manufacturing Engineer
Nuclear Products Group

ccc: Jane Sandstrom 805
Bob VandenBoom 805

Enclosure: PDS 2235

ATTACHMENT C
VYC- 467 REV: 5
PAGE 7 OF 30

MEMORANDUM

YANKEE ATOMIC - FRAMINGHAM

To R. G. January

From G. J. Hengerle

Subject RADIATION REVIEW, ROSEMOUNT 1152 SERIES TRANSMITTERS

Date October 6, 1987
Group # VYT 220/87
W.O. # 4100
I.M.S. #

REFERENCES

(a) Letter, J. Sandstrom (Rosemount) to G. Hengerle (YNSD), dated July 6, 1987 (Enclosure 1)
(b) Rosemount Report No. 8805A, Low Level Radiation Test Report for Rosemount Model 1152 Pressure Transmitter (Enclosure 2)

EXECUTIVE SUMMARY

Low level radiation testing was conducted by Rosemount for their 1152 series transmitters. An evaluation of the Rosemount Report determined that a worst case error of $\pm.125\%$ will result when exposed to a radiation field of 1.2×10^5 rads TID. To provide a degree of conservatism in the EQ-related accuracy calculations $\pm.2\%$ will be used.

BACKGROUND

Rosemount's published radiation error is $\pm 8\%$ up to 5.0×10^6 rads (Model 1152) and $\pm 5\%$ up to 1.7×10^7 rads (Model 1152T0280). A correlation to lower radiation requirements is difficult. Therefore, Rosemount tested their 1152 series transmitter to 1.2×10^5 rads. An evaluation of their test is discussed below.

DISCUSSION

Rosemount selected four 1152 series transmitters for the low level radiation test. These transmitters were exposed to 1.2×10^5 rads. At various times during and after the test, the transmitters were monitored for maximum deviation as a percent of span as compared with preradiation values. The worst case error was $\pm.125\%$ of span. For the test specimens, span was equal to the transmitters upper range limit.

As only four transmitters were tested, it is deemed prudent to provide a degree of conservatism. As such, the worst case error will be increased to $\pm.20\%$ of upper range limit.

ATTACHMENT C
VYC-467 REV: 5

October 6, 1987

CONCLUSIONS

The use of ±.20% of upper range limit for values up to 1.2 x 10^5 rads is conservative and reasonable as it applies to the Rosemount 1152 series transmitters exposed to low level radiation.

G. J. Hengerle
Senior Engineer
Vermont Yankee Project

R. T. Vibert
Senior Electrical Engineer
Vermont Yankee Project

GRH/RTV/15.250

Enclosure

cc: S. R. Miller
J. K. Thayer
R. L. Smith
M. J. Cofske
M. P. Saniuk

ENCLOSURE 1

ROSEMOUNT INC.
12001 Technology Drive
Eden Prairie, MN 55344 U.S.A.
(612) 941-5560
TWX: 4310012 or 4310024
FAX: (612) 828-3088

ATTACHMENT C
VYC-467 REV: 5

Rosemount

July 6, 1987

George Hengerle
Yankee Atomic Electric Co.
1671 Worcester Road
Framingham, MA 01701

Dear George,

As per your recent request for information please note the following:

1. The long term stability Rosemount test report 78223 can be applied to both 1152's and 1152T0280's in terms of long term stability only. In this report accuracy is included in the stability measurement.

2. The Report on low-level radiation and LOCA testing can not be applied to the Models 1152 and 1152T0280 due to major differences in components. Rosemount has however completed separate low-level radiation testing on the Model 1152, these results can be applied to the Model 1152T0280. A copy of this report is enclosed.

3. Model 1152 specifications apply to the Model 1152T0280 (including Steam/Temperature spec) except for the radiation specification.

4. Functional cycling has been eliminated as a limiting factor in the Qualified life of the Model 1153 Series B's and D's and Model 1154's. Rosemount does not specify or support any Qualified Life for the Model 1152 or 1152T0280.

If you have any further questions or just want to exchange salutations please feel free to call me.

Sincerely,

Jane Sandstrom
Sr. Marketing Engineer

Attachment: 8805A

YANKEE ATOMIC ELECTRIC COMPANY

PROJECT: VERMONT YANKEE
QDR NO.: 8.12
PACKAGE TITLE: ROSEMOUNT 1152 TRANSMITTER

APPROVAL COVER PAGE

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REV.	PREPARED BY/DATE	REVIEWED BY/DATE	APPROVED BY/DATE
4	M. Saniuk 10/21/86	S. Joseph 10/21/86	R. January 11/24/86
5	M. Saniuk 4/24/87	S. Joseph 4/24/87	R. Vibert for R. January 4/27/87
6	M. Saniuk 8/13/87	S. Joseph 8/17/87	R. January 8/18/87
7	M. Saniuk 10/7/87	H. Hyams 10/8/87	R. January 10/8/87
8	M. P. Saniuk 6/27/90	H. T. Hyams 6/28/90	R. T. Vibert 6/28/90
9	H. T. Hyams 3/11/91	G. J. Hengerle 3/13/91	R. T. Vibert 3/14/91
10	R. T. Vibert 9/14/92	W. C. Provencher, Jr. 9/16/92	R. T. Vibert 9/17/92
11	William C. Provencher Jr. 6/9/97	Harry T Hyams 6/23-97	R.T. Vibert 6/30/97

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
ATTACHMENT C PAGE 22 OF 30

R90\350

QDR NO. 8.12
REVISION 8

FACILITY: VERMONT YANKEE
DOCKET NO.: 50-271

APPENDIX II

B33
ID NO.: PT-2-3-55A

SYSTEM COMPONENT EVALUATION WORKSHEET

ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
PARAMETER	SPECIFIED	QUALIFIED	SPECIFIED	QUALIFIED		
Operating Time	HPCI-6H RWCU-6H MHS-6H	1Y	001	004	Simultaneous Test and Eng. Analysis	No
Temperature	RWCU-20	250°F (Peak)	002	004	Simultaneous Test	No
Pressure	HPCI-20	15 psig (Peak)	002	004	Simultaneous Test	No
Relative Humidity	100%	100%	002	004	Simultaneous Test	No
Chemical Spray	N/A	--	--	--	--	--
Radiation	7×10^4R	1.7×10^7R	003	004	Sequential Test	No
Aging	40Y	20Y Notes 2 and 3	Note 1	004	Test and Engineering Analysis	No
Submergence	N/A	--	--	--	--	--

Component:
Pressure Transmitter

Manufacturer:
Rosemount

Model or Type:
1152GP9E22T0280PB

Location:
Area: Reactor Building - Vol. 20
Elevation: 280'

Flood Level:
Elevation: N/A
Above Flood Level: N/A

Previous Worksheet No.: N/A

System:
Nuclear Boiler Vessel Instrumentation

Function:
Reactor Pressure

Service:
PT-2-3-55A

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
ATTACHMENT C PAGE 23 OF 30

R90\350

FACILITY: VERMONT YANKEE I.D. NO. PT-2-3-55A
DOCKET NO.: 50-271

APPENDIX II

ENVIRONMENTAL QUALIFICATION WORKSHEET: DOCUMENTATION REFERENCES

001 Vermont Yankee Environmental Qualification Matrix.

002 Vermont Yankee Summary Report of Plant Environmental Conditions for Environmental Qualification Program.

003 Vermont Yankee Design Basis Environmental Radiation Dose Specification, VYC-193.

004 Qualification Documentation Review Package (QDR No. 8.12).

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
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QDR NO. 8.12
REVISION 8

111

FACILITY: VERMONT YANKEE
DOCKET NO.: 50-271

APPENDIX II

B37
ID NO.: PT-2-3-55B

SYSTEM COMPONENT EVALUATION WORKSHEET

ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
PARAMETER	SPECIFIED	QUALIFIED	SPECIFIED	QUALIFIED		
Operating Time	HPCI-6H RWCU-6H HHS-6H	1Y	001	004	Simultaneous Test and Eng. Analysis	No
Temperature	RWCU-20	250°F (Peak)	002	004	Simultaneous Test	No
Pressure	HPCI-20	15 psig (Peak)	002	004	Simultaneous Test	No
Relative Humidity	100%	100%	002	004	Simultaneous Test	No
Chemical Spray	N/A	--	--	--	--	--
Radiation	7×10^4R	1.7×10^7R	003	004	Sequential Test	No
Aging	40Y	20Y Notes 2 and 3	Note 1	004	Test and Engineering Analysis	No
Submergence	N/A	--	--	--	--	--

Component:
Pressure Transmitter

Manufacturer:
Rosemount

Model or Type:
1152GP9E22T0280PB

Location:
Area: Reactor Building - Vol. 20
Elevation: 280'

Flood Level:
Elevation: N/A
Above Flood Level: N/A

Previous Worksheet No.: N/A

System:
Nuclear Boiler Vessel Instrumentation

Function:
Reactor Pressure

Service:
PT-2-3-55B

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
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R90\350

FACILITY: VERMONT YANKEE
DOCKET NO.: 50-271

I.D. NO. PT-2-3-55B

APPENDIX II

ENVIRONMENTAL QUALIFICATION WORKSHEET: DOCUMENTATION REFERENCES

001 Vermont Yankee Environmental Qualification Matrix.

002 Vermont Yankee Summary Report of Plant Environmental Conditions for Environmental Qualification Program.

003 Vermont Yankee Design Basis Environmental Radiation Dose Specification, VYC-193.

004 Qualification Documentation Review Package (QDR No. 8.12).

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
ATTACHMENT C PAGE 26 OF 30

FACILITY: VERMONT YANKEE
DOCKET NO.: 50-271

APPENDIX II

ID NO.: PT-2-3-55C

SYSTEM COMPONENT EVALUATION WORKSHEET

ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
PARAMETER	SPECIFIED	QUALIFIED	SPECIFIED	QUALIFIED		
Operating Time	HPCI-6H RWCU-6H HHS-6H	1Y	001	004	Simultaneous Test and Eng. Analysis	No
Temperature	RWCU-21	250°F (Peak)	002	004	Simultaneous Test	No
Pressure	RWCU-21	15 psig (Peak)	002	004	Simultaneous Test	No
Relative Humidity	100%	100%	002	004	Simultaneous Test	No
Chemical Spray	N/A	---	---	---	---	---
Radiation	8.8×10^4R	1.7×10^7R	003	004	Sequential Test	No
Aging	40Y	20Y Notes 2 and 3	Note 1	004	Test and Eng. Analysis	No
Submergence	N/A	---	---	---	---	---

Component:
Pressure Transmitter

Manufacturer:
Rosemount

Model or Type:
1152GP9E22T0280PB

Location:
Area: Reactor Building - Vol. 21
Elevation: 280'

Flood Level:
Elevation: N/A
Above Flood Level: N/A

Previous Worksheet Number: N/A

System:
Nuclear Boiler Vessel Instrumentation

Function:
Reactor Pressure

Service:
PT-2-3-55C

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
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QDR NO. 8.12
REVISION 3

B43

FACILITY: VERMONT YANKEE
DOCKET NO.: 50-271

I.D. NO. PT-2-3-55C

APPENDIX II

ENVIRONMENTAL QUALIFICATION WORKSHEET: DOCUMENTATION REFERENCES

001 Vermont Yankee Environmental Qualification Matrix.

002 Vermont Yankee Summary Report of Plant Environmental Conditions for Environmental Qualification Program.

003 Vermont Yankee Design Basis Environmental Radiation Dose Specification, VYC-193.

004 Qualification Documentation Review Package (QDR No. 8.12).

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
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FACILITY: VERMONT YANKEE
DOCKET NO.: 50-271

APPENDIX II

ID NO.: PT-2-3-55D

SYSTEM COMPONENT EVALUATION WORKSHEET

ENVIRONMENT			DOCUMENTATION REFERENCE		QUALIFICATION METHOD	OUTSTANDING ITEMS
PARAMETER	SPECIFIED	QUALIFIED	SPECIFIED	QUALIFIED		
Operating Time	HPCI-6H RWCU-6H HHS-6H	1Y	001	004	Simultaneous Test	No
Temperature	RWCU-21	250°F (Peak)	002	004	Simultaneous Test	No
Pressure	RWCU-21	15 psig (Peak)	002	004	Simultaneous Test	No
Relative Humidity	100%	100%	002	004	Simultaneous Test	No
Chemical Spray	N/A	---	---	---	---	---
Radiation	8.8×10^4R	1.7×10^7R	003	004	Sequential Test	No
Aging	40Y	20Y Notes 2 and 3	Note 1	004	Test and Eng. Analysis	No
Submergence	N/A	---	---	---	---	---

Component:
Pressure Transmitter

Manufacturer:
Rosemount

Model or Type:
1152GP9E22T0280PB

Location:
Area: Reactor Building - Vol. 21
Elevation: 280'

Flood Level:
Elevation: N/A
Above Flood Level: N/A

Previous Worksheet Number: N/A

System:
Nuclear Boiler Vessel Instrumentation

Function:
Reactor Pressure

Service:
PT-2-3-55D

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
ATTACHMENT C PAGE 29 OF 30

FACILITY: VERMONT YANKEE
DOCKET NO.: 50-271

I.D. NO. PT-2-3-55D

APPENDIX II

ENVIRONMENTAL QUALIFICATION WORKSHEET: DOCUMENTATION REFERENCES

001 Vermont Yankee Environmental Qualification Matrix.

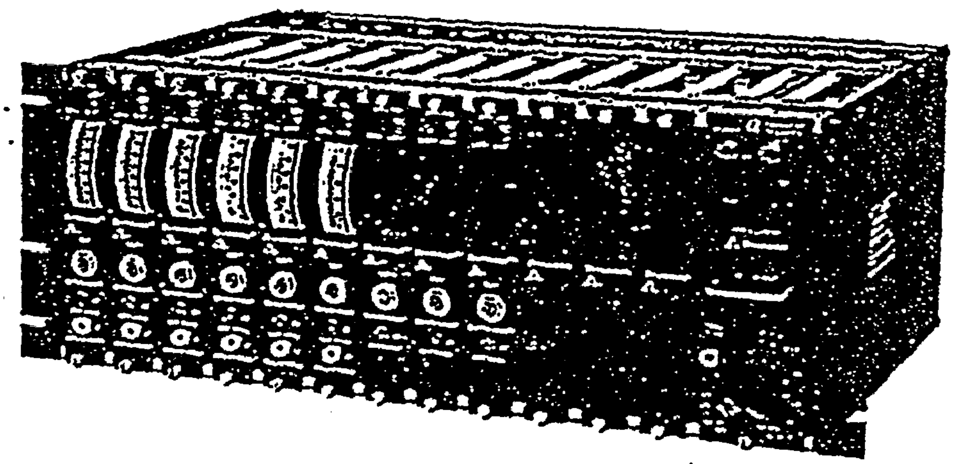
002 Vermont Yankee Summary Report of Plant Environmental Conditions for Environmental Qualification Program.

003 Vermont Yankee Design Basis Environmental Radiation Dose Specification, VYC-193.

004 Qualification Documentation Review Package (QDR No. 8.12).

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
REV 5
ATTACHMENT C PAGE 30 OF 30

..ODEL 710DU TRIP/CALIBRATION SYSTEM



'alified for nuclear applications.

For use with 4-20 mA process transmitters and three wire 100 ohm platinum RTD's.

Provides up to 8 precision trip points per sensor signal.

Master trip points repeatable within 0.13% of calibrated span for 4-20 mA process transmitters.

Unique calibration unit permits rapid display and adjustment of trip points.

Exceptionally reliable modular design.

Rosemount's Model 710DU Trip/Calibration Systems continuously monitor critical process parameters and provide highly accurate alarm action. As many as eight precision-calibrated trip points can be assigned to a single sensor channel. Any trip point ı be quickly verified or changed.

The system consists of a Card File with a plug in Calibration Unit and space for up to twelve interchangeable Trip Unit modules. These features make Model 710DU Systems highly flexible, simple to install or reconfigure, and easy to calibrate.

SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

Power Supply: 24 VDC (nominal) power required.

Inputs: Two-wire or four-wire 4-20 mA transmitters or three-wire 100 ohm platinum RTD.

Current Drain

Master Trip Unit: 260 mA
Slave Trip Unit: 225 mA
Calibration Unit: 225 mA
Readout Assembly: 475 mA
Transmitter Loop: Limited to 100 mA

Outputs: Independent 24 volt signals for each trip output and each gross failure output circuit can drive external relays (24 ohms, minimum).
1 to 5 VDC auxiliary analog signals proportional to each sensor input can drive external loads (1500 ohms, minimum).

TRIP UNIT ADJUSTMENT AND CONTROLS

Trip Point: 10-turn, screwdriver-slotted, precision wire-wound potentiometer on faceplate.

Trip Reset Differential: Single-turn potentiometer on circuit card.

Trip Logic: Switches on circuit card select trip output above or below trip current level and permit trip status lamp to be on or off in tripped mode.

Gross Failure Limits: Single-turn potentiometers on circuit card for high and low current levels.

Gross Failure Reset: Push-button switch resets gross failure circuit.

Frequency Response: Single-turn potentiometer on circuit card for 4-20 mA Master Trip Unit.

Zero and Span: 25 turn screwdriver-slotted, precision metal film potentiometer on circuit card on RTD Master Trip Unit only.

Linearity: Single turn potentiometer on circuit card on RTD Master Trip Unit only.

Indicator LEDs: Trip status and gross failure LED on faceplate.

Test Jacks: Signal input and Auxiliary analog output voltages may be read with external meters on Master Trip Units and slave input signal on slave trip units.

CALIBRATION UNIT ADJUSTMENTS AND CONTROLS

Power: On/off toggle switch for 24 volt power to Calibration Unit and Readout Assembly.

Transient Polarity: Positive/negative toggle switch for transient current.

Transient Current: Single-turn push/pull potentiometer sets and engages transient calibration current.

Stable Current: Ten-turn potentiometer adjusts current which replaces sensor input to Master Trip Unit.

Channel Selector: Dual push/pull and rotary switch selects Master Trip Unit channel, applies calibration current, and selects Master or Slave Trip Unit for trip current readout.

Digital Display: Readout Assembly displays calibration current and trip current.

Display Reset: A trip current display reset button reverses the latching logic for the trip current display and trip status LED so trip current can be read for reversed trip status logic.

Indication: LED on Calibration Unit lighted when system is in calibration mode. LED on Readout Assembly lighted by trip status signal.

Test Jacks: Signal return, trip status output, and transient trigger may be monitored for time response measurements.

PERFORMANCE SPECIFICATIONS

Trip Points: Adjustable from 4 to 20 mA±0.01 mA. Repeatable within 0.13% (0.20% for Slave Trip Unit and 0.75% for RTD Master Trip Unit) of calibrated span for 6 months under normal conditions. Reset differential adjustable from 0.5 to 7.5% of span or from 0.5 to 15% of span for the 15% reset differential option.

Gross Failure Limits: Adjustable from 0.5 to 4 mA (low limit) and 19.5 to 40.5 mA (high Limit).

Analog Meter: ± 3% full-scale accuracy.

Auxiliary Analog Output: 0 to 10 VDC, accurate to within 0.15% of span of the calibrated 1 to 5 VDC under normal conditions. Frequency response adjustable from 0.8 to 8.0 Hz on 4-20 mA Master Trip Unit only.

Stable Current: 3.50 to 20.50 mA + 0.005 mA.

Transient Current: 0.50 to 20.50 mA ± 0.05 mA.

Digital Readout: Display Accuracy:
00.00 – 20.00 ± 0.01 mA
20.01 – 30.00 ± 0.05 mA
30.01 – 45.00 ± 0.10 mA
Resolution: 0.01 mA

Power Supply Range: 22-28 VDC.

PHYSICAL SPECIFICATIONS

Card File Dimensions: 19" W × 6-31/32" H × 11" D.

File Space: 1.2" file centers for up to 12 Master or Slave Trip Units plus a Calibration Unit. All units have captive screws for securing to Card File.

Field Terminals: All connections are made to barrier strips on the rear of the Card File. Screw terminals are sized for #6 spade lugs.

Analog Indication: Master Trip Units have 1-3/4" vertical meters scaled in appropriate engineering units.

Finish: Flat black with white letters, baked enamel paint.

ERR

P. 01
P. 1/2

Rosemount Nuclear Instruments, Inc.
12001 Technology Drive
Eden Prairie, MN 55344-5695
USA

217 - 0861

DATE: May 7, 1997 **PAGE(S) INCLUDING LEAD SHEET:** 1

COMPANY:		**FAX NUMBER:**	(612) 828-8280
ATTENTION:	Jerry Voss	**SENDER:**	Mike Dougherty
FAX NUMBER:	301-984-7600	**PHONE NUMBER:**	(612) 828-3390
SUBJECT:	Rosemount Model 710 Trip Unit		

Jerry:

Attached is an excerpt from the Model 710 instruction manual which also lists the Master Trip Unit repeatability specification table. Please note the trip point repeatability specs are valid for up to six months, which would incorporate drift during the same period for this unit.

Please call if you have further questions.

B. Regards

Mike Dougherty

TRIP POINT REPEATABILITY:

- See Table 7. Repeatability is based on an input signal of 4 to 20 mA (equivalent to 10 to 60% of span), or equivalent RTD resistance. (See Table 5 for definition of plant operating conditions.) The trip point repeatability requirements listed are valid for up to six months of operation.

(would therefore incorporate drift during this time frame)

TABLE 7

TRIP POINT REPEATABILITY
Master Trip Units

Operating Condition	Trip Output Repeatability
4-20 mA Input Normal	±0.13% (60° to 90°F) ±0.20%/100°F
RTD Input Normal	±0.75% (60° to 90°F) ±1.5%/100°F
4-20 mA Input Accident	±0.40%
RTD Input* Accident	±2.0%

*Fully ranged down.

SLAVE TRIP UNIT SPECIFICATIONS

General

The following specifications apply to all Slave Trip Units in the 710DU Trip/Calibration System.

Mechanical Specifications

CONSTRUCTION:

The Slave Trip Unit can be removed from the Card File or reinserted when Power is applied, without damage to any electronic components.

Electrical Specifications

MASTER TRIP UNIT INTERFACE:

Slave Trip Units are driven by a 0 to 10 Vdc analog signal (calibrated from 1 to 5 Vdc) from a Master Trip Unit. This signal is monitored by Test Jack J1 on the front panel of the Slave Trip Unit. Up to seven Slave Trip Units may be connected to a single analog-to-Slave signal.

TRIP OUTPUT AND GROSS FAILURE OUTPUT:

Each output is +24 Vdc nominal for logic level 1 and less than +1 Vdc for logic level 0. Either output is capable of driving a resistive load from 24 ohms and up, or an inductive load of up to 4 Henries. Two or more trip outputs or gross failure outputs can drive the same load.

SLAVE TRIP UNIT/CALIBRATION UNIT INTERFACE:

The only active interface signal when the Slave Trip Unit is being calibrated is:

1. Trip Status Signal: 0 to 12 Vdc nominal logic signal from the Slave Trip Unit to the Calibration Unit which changes state with the trip output signal. The trip status signal latches the trip current display on the Readout Assembly at the trip point of the Slave Trip Unit.

Performance Specifications

TRIP POINT REPEATABILITY:

See Table 8. Repeatability is based on a 4 to 20 mA input signal (equivalent to 0 to 100% of span). Performance is specified for normal and accident plant operating conditions (see Table 5). The trip point repeatability requirements listed are valid for up to six months of operation when driven by a properly functioning Master Trip Unit.

TABLE 8

TRIP POINT REPEATABILITY
Slave Trip Unit

Operating Condition	Trip Output Repeatability
Normal	±0.20% (60° to 90°F) ±0.35%/100°F
Accident	±0.60%

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Table 2
Trip Point Repeatability Specification
During the Seismic Event

Trip Unit Type	Trip Point Repeatability Specification
4-20mA Master	±0.13%
RTD Master	±0.75%
Slave of 4-20mA Master	±0.20%
Slave of RTD Master	±0.80%

PJ

6.2 Temperature Event

The qualification test modules were subjected to a simulated high temperature event. The event temperatures were 210 °F/95% RH (Relative Humidity) for six hours followed by 165 °F/95% RH for eight hours.

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Co.	Co. ROSEMOUNT
Dept.	Phone # 612-828-3390
Fax # 301-984-7600	Fax #

6.2.1 Test Deviations

6.2.1.1 Test Performance Deviations

Several times during the test, the trip output of the trip units in positions 4, 9, and 11 changed state and remained in that condition until they were reset at the next calibration check. These trips were a result of having the operating points set to close to the trip points and do not compromise the qualification of the 710DU.

Table 3 shows the trip point repeatability specifications and the distance between the operating point and the trip point in each trip unit during the temperature event test.

Table 3
Temperature Event Test
Operating Points

Trip Unit Type	Trip Point Repeatability Specification-	Distance From Operating Point
4-20mA Master	±0.4%	+0.5%
RTD Master	±2.0%	+0.75%
Slave of 4-20mA Master	±0.6%	+0.5%
Slave of RTD Master	±2.1%	+0.75%

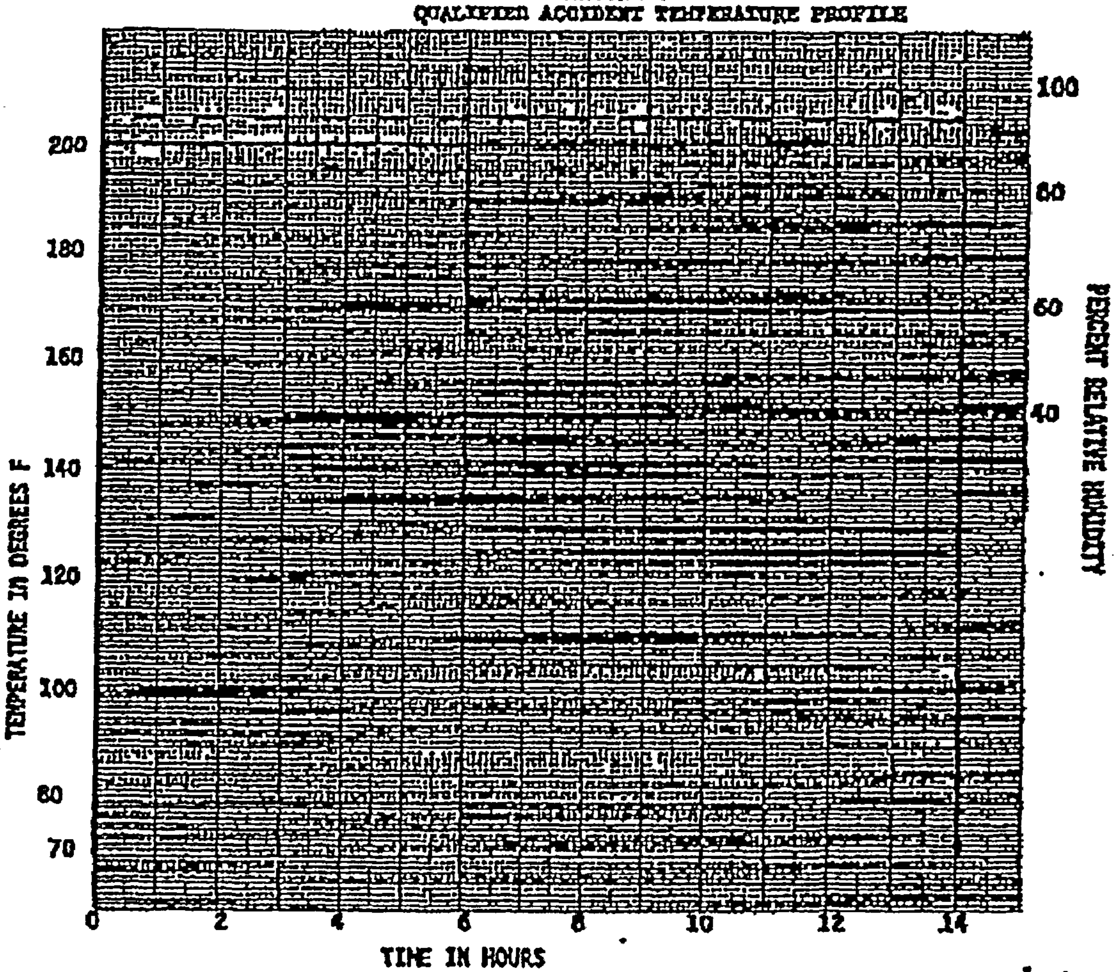
The trip units which tripped during the temperature event test were operating closer to the trip point than the trip point repeatability specification for that trip unit.

The results of this test show that it is possible for a trip unit with a stable input to trip when it is operating closer to the trip point than its specified repeatability. This is true even when the input signal has not actually passed through the trip point as measured by intentionally causing a trip. Because the trip points measured during the temperature event test were within the required limits of repeatability, the 710DU qualification is not compromised by the false trips during the temperature event test.

6.2.2 Temporature Event Qualification

The 710DU is qualified to the temperature event profile shown in figure 6. The profile in figure 6 does not include the 15°F margin required in IEEE Std 323-1974. Trip point repeatability specifications during the temperature event are shown in Table 3.

FIGURE 6
QUALIFIED ACCIDENT TEMPERATURE PROFILE



TEMPERATURE CURVE
RELATIVE HUMIDITY CURVE

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Table 4
Trip point Repeatability
During the Radiation Event

Trip Unit Type	Trip Point Repeatability
4-20mA Master	±0.5%
RTD Master	±4.0%
Slave of 4-20mA Master	±0.6%
Slave of RTD Master	±5.0%

You'll Think They're Custom Built

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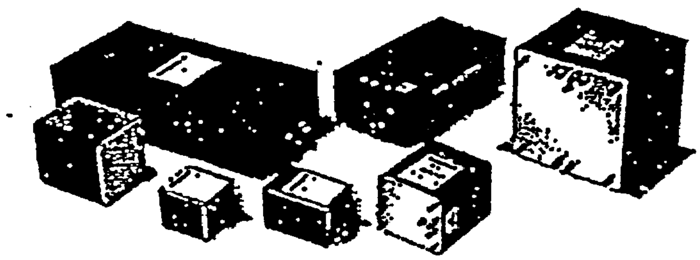
A Penril COMPANY



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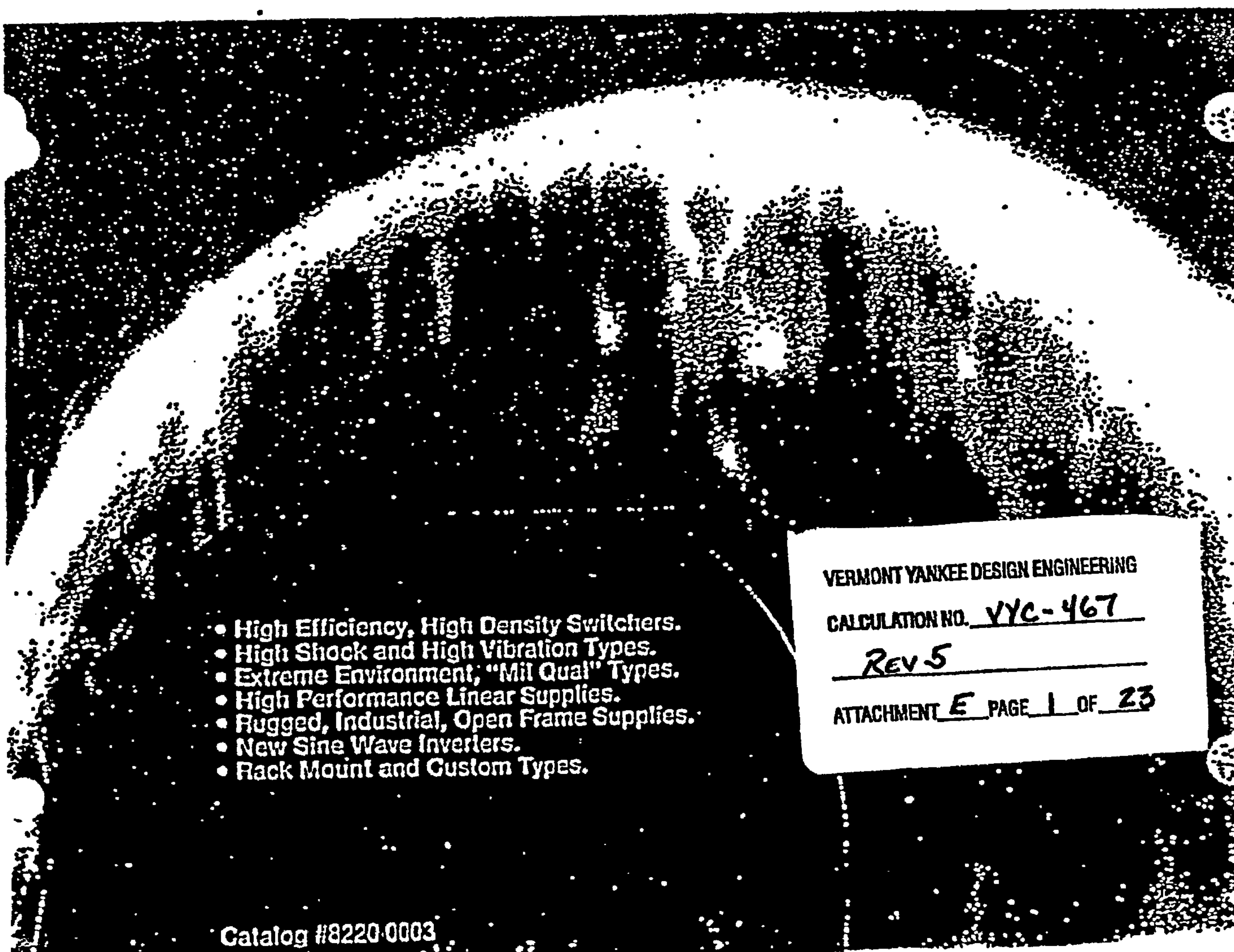
"MIL-QUAL" MODULAR POWER SUPPLIES



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In addition, a preliminary screening of a partial Qualification Report raised many questions concerning the qualification. Finally, the NRC has conducted an inspection of the Nutherm facilities on November 16 to November 20, 1987. The Inspection Report (Reference 4), Docket No. 99900779/87-01, states that, "The implementation of your Quality Assurance (QA) Program failed to meet certain NRC requirements."

Based on the above, it is concluded that Regulatory Guide 1.89, Position C.6(d), which states, "Replacement equipment qualified in accordance with the provisions of Section 50.49 does not exist," applies to the Vermont Yankee power supplies. Therefore, the qualification of the Technipower Power Supplies will be demonstrated in accordance with the Department of Operating Reactor Guidelines (Attachment 4 of IE Bulletin 79-01B).

Part 2 - Equipment Description

The reviewers have prepared the following description of the equipment being reviewed. Source of data is:

1. Technipower "Mil-Qual" Modular Power Supply Catalog No. 8220-0003.

The Technipower power supplies qualified by this QDR are PM-95 series units. The power supplies are the same as Catalog No. PM23.3-6.0 supplies, except they have screw terminations in place of standard solder terminations. Technipower has assigned P/N 227-8563 to this configuration (see QDR Page F2).

The PM-95 series are series-stabilized ac-dc modular power supplies qualified for extreme MIL environments.

In addition, they are fully encapsulated and sealed against moisture and dust (see QDR Page A14). It will be shown by this QDR that the extreme MIL standard testing performed on these power supplies (see QDR Page A9) envelopes the Vermont Yankee plant requirements with margin. Traceability of the tested power supplies to the installed PM-25 series power supplies is found in the Certificate of Compliance and associated documents in Tab F (QDR Pages F2 to F6).

The Technipower PM-95 series power supplies provide 24 V dc output required for the Rosemount trip/calibration unit and Agastat relays in the Reactor Protection System.

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MIL-QUALIFIED LINEAR SUPPLIES
High Reliability for Military and Industrial Harsh Environments

Fully Encapsulated AC-DC Series Stabilizers (Regulators) For Extreme Environments with as low as 0.05% Source/Load Effects, 1 mv rms PARD and 50 Micro second recovery.

LINEAR SUPPLIES
Industrial/Military/Commercial Applications

Partially Encapsulated AC-DC Series Stabilizers (Regulators) For Moderate Environments with as low as 0.05% Source/Load Effects.
1 mv rms PARD and 50 Micro second recovery.
Exception is the NP-80 Non-Stabilized Series.

SINE WAVE INVERTERS
Military/Industrial Applications

SWITCHERS
HIGH EFFICIENCY/HIGH DENSITY
Industrial/Military/Commercial Applications

Open Construction, Full and Partially Encapsulated Switching Supplies for Tight Packaging.
High Thermal Applications
with as low as 0.1% Overall Source/Load Effects.
0.1% rms PARD and 500 Microseconds recovery.

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ACCESSORIES

SUPPLEMENTARY INFORMATION

All specifications are subjec

VERMONT YANKEE DESIGN ENGINEERING
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EIGHT MIL-STANDARD REQUIREMENTS WERE TESTED UNDER SPECIFIC ENVIRONMENTAL CONDITIONS

Representative models were submitted to appropriate qualifying tests. Applicable modules have been designed to meet the intent of NAV-MAT-P4855. Determination of the test procedures was made by analyzing the requirements of eight applicable MIL specifications: MIL-STD-202C, MIL-STD-810A, MIL-E-4970A, MIL-E-5272C, MIL-E-5400G, H, MIL-E-16400F, MIL-T-202000 and MIL-STD-461A.

Each environment condition was tested under the most rigorous specifications, assuring that the applicable requirements would be fully met. Technipower manufactures in accordance with MIL-I-45208.

ELECTROMAGNETIC INTERFERENCE (EMI/RFI) — Samples tested indicate that the PM-95, F-FD-115 Series will meet the following:

MIL-STD-461A per Test Method MIL-STD 462 viz:
Conducted and Radiated EMI/RFI — Limit CEO3, Notice 1, 3; Limit CEO4, Notice 4; Limit REO2, Notice 1, 3, 4.

Susceptibility to Conducted & Radiated EMI/RFI — Limit CSO1, Notice 1, 3; Limit CSO2, Notice 1, 3; Limit CSO6, Notice 1, 3, 4; Limit RSO1, Notice 1, 3, 4; Limit RSO2, Notice 1, 3, 4; RSO3, Notice 1.

MIL-1-16910C, Paragraph 3.6.1 and 3.6.2, and MIL-1-6181D, Paragraph 4.3.4.1.1 viz:

Conducted and Radiated EMI/RFI — In a properly shielded enclosure, interference measuring antennas were positioned for maximum pick-up. With module operating, readings were taken in the peak function of the measuring instruments. Conducted RF interference was measured in the frequency range 0.15 to 30 MHz; radiated RF interference over the range 14 KHz to 1 GHz.

Measurements were within the limits prescribed in the referenced specifications.

Susceptibility to Conducted EMI/RFI — In the same shielded enclosure 100,000 μv modulated 30% over a frequency range 15 KHz to 10 GHz with 400 Hz applied to the input lines of the operating test modules. The samples were monitored for change in DC output and increase in ripple.

Tests indicated no degradation, deterioration, or malfunction of the modules.

SHOCK — Modules were tested in accordance with procedures given in MIL-E-5400H, MIL-E-16400F, and MIL-S-901C, Class 1, lightweight, Type B. Modules tested were mounted using both header studs and case inserts.

High Impact — With apparatus as described in Fig. 1, MIL-S-901C, 400-lb. hammer drops of 1, 3, and 5 feet were applied to test modules in directions of their three major axes.

Sand drop — Modules were subjected to three 15G shocks of 11 ms each, in both directions of the three major axes (a total of 18 shocks).

Test modules showed no evidence of variation in output levels, nor any evidence of exterior damage.

VIBRATION — Modules were tested in accordance with procedures given in MIL-E-5400H, Figure 5, Curve 1, and in MIL-E-16400F (MIL-STD 167, Type 1.) Modules tested were mounted using both header studs and case inserts.

Test modules were vibrated in the directions of their three major axes, at 5 to 10 Hz, .060" double amplitude, and at 10 to 500 Hz at 10G, extended to 2000 Hz at 10G. Resonant points were determined and vibration carried on at those points and at swept frequencies as specified. The modules were further vibrated in 3 planes, 5 to 33 Hz, .060" double amplitude. Input and output voltage, and ripple, were monitored before and during the testing.

Regulation, ripple, drop out voltage, and insulation resistance of the modules were not affected by the vibration.

TEMPERATURE — Modules were tested in accordance with procedures given in MIL-E-16400F, Class 1, and in MIL-E-5272C, Procedure II, viz.:

Non-operating — Test modules were held at −62°C for 72 hours, +75°C for 4 hours, then +25°C for 4 hours, then put in operation. Measurements for regulation, ripple, dropout voltage, and insulation resistance were made before and after exposure.

Operational values showed no change before and after exposure.

Operating — Test modules in operation were held at −54°C for 24 hours, then by 10°C/30-minute steps to +65°C for 4 hours, then by 10°C/30-minute steps to +25°C for 4 hours. Measurements for regulation, ripple, dropout voltage, and insulation resistance were made before and after exposure.

Operational values showed no change before and after exposure.

High temperature operating — Operating modules were tested at +25°C for regulation, ripple, dropout voltage, and insulation resistance, then placed for 48 hours in a +71°C test chamber and similarly tested. The modules were then allowed to return to +25°C and again tested.

The modules were unaffected by cycling through a high temperature environment.

TEMPERATURE-ALTITUDE — Modules were tested in accordance with procedures given in MIL-E-5272C, Procedure 1 (extended to 100,000' altitude), viz.:

Modules were checked at +25° for regulation, ripple, dropout voltage, and insulation. They were then subjected to the prescribed reduced-temperature/time ambients, ranging to −62°C, and operated, showing no variation from pretest data.

Modules were then subjected to prescribed high-temperature/time cycles, ranging to +65°C, and operated, showing no variation.

Modules were now subjected to cycles equivalent to 30°C/40,000', 35°C/50,000', and 20°C/100,000', operated and tested after each cycle.

There was no indication of any variation in the operation of the modules due to changed environmental conditions described.

TEMPERATURE SHOCK — Modules were tested in accordance with procedures given MIL-E-5272C, Procedure 1, viz.:

Test modules were subjected to +85°C/4-hours, then −40°C/4-hours, 3 cycles. The units were operated and measurements taken for regulation, ripple, dropout voltage, and insulation resistance before and after the environmental shock.

At conclusion of test there was no appreciable change from pre-test values.

HUMIDITY — Modules were tested in accordance with procedures given in MIL-E-5272C, Procedure 1 (240 hours), viz.:

Test modules were subjected to 85% relative humidity with temperatures ranging from +20°C to +71°C and back to +20°C, 10 cycles.

Measurements for regulation, ripple, dropout voltage, and insulation resistance indicated no change before and after exposure.

SALT SPRAY — Modules were tested in accordance with procedures given in MIL-E-5272C (Fed. Std. 151, Method 811, Procedure 1), viz.:

Test modules were exposed to 50 hours of continuous 5% salt spray at +35°C. They were then washed in fresh water and tested, then tested again after a 48-hour drying period.

No before-after variation in operation was noted.

IMMERSION — Modules were tested in accordance with procedures given in MIL-STD-202C (Condition A), Method 104A, viz:

Test modules were immersed in fresh water at 65°C for 15 minutes, then fresh water at 25°C for 15 minutes. The procedure was repeated and the units allowed to dry for 24 hours.

Before and after tests showed no variation in operation.

The results of the testing product are given in York Research Corporation Report Y-5646 and Norden Test 3944R0001 and thus certify that the PM-95, F-FD-115 Series modules are fully qualified for operating military environmental applications. Copies of these reports giving detailed descriptions of the test programs are on file at Technipower and copies are available on request.

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PM-95 SERIES

MODELS

ermal Reference Data—See Pages 54-55.

Output Voltage Adjust. Range	Output Current (amps)	Case Size (see dwg)	"A" Models ±0.05% Accuracy Model	Standard Models ±0.5% Accuracy Model	Thermal Ref. No.	O.V. Ref.
15.2-16.5	0.100	A	PM-15.8-0.100A	PM-15.8-0.100	1	C
15.2-16.5	0.200	B	PM-15.8-0.200A	PM-15.8-0.200	1	C
15.2-16.5	0.375	C	PM-15.8-0.375A	PM-15.8-0.375	2	C
15.2-16.5	0.750	D	PM-15.8-0.750A	PM-15.8-0.750	3	C
15.2-16.5	1.5	F	PM-15.8-1.5A	PM-15.8-1.5	6	C
15.2-16.5	3.0	GA	PM-15.8-3.0A	PM-15.8-3.0	7	C
15.2-16.5	6.0	GB	PM-15.8-6.0A	PM-15.8-6.0	8	C
15.2-16.5	12.0	GC	PM-15.8-12.0A	PM-15.8-12.0	9	H
15.2-16.5	25.0	GD	PM-15.8-25.0A	PM-15.8-25.0	10	H
16.5-18.5	0.100	A	PM-17.5-0.100A	PM-17.5-0.100	1	C
16.5-18.5	0.200	B	PM-17.5-0.200A	PM-17.5-0.200	1	C
16.5-18.5	0.375	C	PM-17.5-0.375A	PM-17.5-0.375	2	C
16.5-18.5	0.750	D	PM-17.5-0.750A	PM-17.5-0.750	4	C
16.5-18.5	1.5	G	PM-17.5-1.5A	PM-17.5-1.5	6	C
16.5-18.5	3.0	GA	PM-17.5-3.0A	PM-17.5-3.0	7	C
16.5-18.5	6.0	GB	PM-17.5-6.0A	PM-17.5-6.0	8	C
16.5-18.5	12.0	GC	PM-17.5-12.0A	PM-17.5-12.0	9	H
16.5-18.5	25.0	GD	PM-17.5-25.0A	PM-17.5-25.0	10	H
18.5-20.2	0.100	A	PM-19.2-0.100A	PM-19.2-0.100	1	C
18.5-20.2	0.200	B	PM-19.2-0.200A	PM-19.2-0.200	1	C
18.5-20.2	0.375	C	PM-19.2-0.375A	PM-19.2-0.375	2	C
18.5-20.2	0.750	D	PM-19.2-0.750A	PM-19.2-0.750	4	C
18.5-20.2	1.5	G	PM-19.2-1.5A	PM-19.2-1.5	6	C
18.5-20.2	3.0	GA	PM-19.2-3.0A	PM-19.2-3.0	7	C
18.5-20.2	6.0	GB	PM-19.2-6.0A	PM-19.2-6.0	8	C
18.5-20.2	12.0	GC	PM-19.2-12.0A	PM-19.2-12.0	9	H
18.5-20.2	25.0	GD	PM-19.2-25.0A	PM-19.2-25.0	10	H
20.2-22.3	0.100	A	PM-21.2-0.100A	PM-21.2-0.100	1	E
20.2-22.3	0.200	B	PM-21.2-0.200A	PM-21.2-0.200	1	E
20.2-22.3	0.375	C	PM-21.2-0.375A	PM-21.2-0.375	2	E
20.2-22.3	0.750	E	PM-21.2-0.750A	PM-21.2-0.750	4	E
20.2-22.3	1.5	G	PM-21.2-1.5A	PM-21.2-1.5	6	E
20.2-22.3	3.0	GA	PM-21.2-3.0A	PM-21.2-3.0	7A	E
20.2-22.3	6.0	GB	PM-21.2-6.0A	PM-21.2-6.0	8	E
20.2-22.3	12.0	GC	PM-21.2-12.0A	PM-21.2-12.0	9	H
20.2-22.3	25.0	GD	PM-21.2-25.0A	PM-21.2-25.0	10	H
22.3-24.4	0.100	A	PM-23.3-0.100A	PM-23.3-0.100	1	E
22.3-24.4	0.200	B	PM-23.3-0.200A	PM-23.3-0.200	1	E
22.3-24.4	0.375	C	PM-23.3-0.375A	PM-23.3-0.375	2	E
22.3-24.4	0.750	E	PM-23.3-0.750A	PM-23.3-0.750	4	E
22.3-24.4	1.5	G	PM-23.3-1.5A	PM-23.3-1.5	6	E
22.3-24.4	3.0	GA	PM-23.3-3.0A	PM-23.3-3.0	7A	E
22.3-24.4	6.0	GB	PM-23.3-6.0A	PM-23.3-6.0	8	E
22.3-24.4	12.0	GC	PM-23.3-12.0A	PM-23.3-12.0	9	H
22.3-24.4	25.0	GD	PM-23.3-25.0A	PM-23.3-25.0	10A	H
24.4-26.8	0.100	B	PM-25.7-0.100A	PM-25.7-0.100	1	E
24.4-26.8	0.200	C	PM-25.7-0.200A	PM-25.7-0.200	1	E
24.4-26.8	0.375	D	PM-25.7-0.375A	PM-25.7-0.375	3	E
24.4-26.8	0.750	E	PM-25.7-0.750A	PM-25.7-0.750	4	E
24.4-26.8	1.5	G	PM-25.7-1.5A	PM-25.7-1.5	6A	E
24.4-26.8	3.0	GA	PM-25.7-3.0A	PM-25.7-3.0	7A	E
24.4-26.8	6.0	GB	PM-25.7-6.0A	PM-25.7-6.0	8A	E
24.4-26.8	12.0	GC	PM-25.7-12.0A	PM-25.7-12.0	9A	H
24.4-26.8	25.0	GD	PM-25.7-25.0A	PM-25.7-25.0	10A	H
26.8-29.2	0.100	B	PM-28.0-0.100A	PM-28.0-0.100	1	G
26.8-29.2	0.200	C	PM-28.0-0.200A	PM-28.0-0.200	1	G
26.8-29.2	0.375	D	PM-28.0-0.375A	PM-28.0-0.375	3	G
26.8-29.2	0.750	E	PM-28.0-0.750A	PM-28.0-0.750	5	G
26.8-29.2	1.5	G	PM-28.0-1.5A	PM-28.0-1.5	6A	G
26.8-29.2	3.0	GA	PM-28.0-3.0A	PM-28.0-3.0	7A	G
26.8-29.2	6.0	GB	PM-28.0-6.0A	PM-28.0-6.0	8A	G
26.8-29.2	12.0	GC	PM-28.0-12.0A	PM-28.0-12.0	9A	H
26.8-29.2	25.0	GD	PM-28.0-25.0A	PM-28.0-25.0	10A	H
29.2-32.7	0.050	A	PM-31.5-0.050A	PM-31.5-0.050	1	G
29.2-32.7	0.100	B	PM-31.5-0.100A	PM-31.5-0.100	1	G
29.2-32.7	0.200	C	PM-31.5-0.200A	PM-31.5-0.200	2	G
29.2-32.7	0.375	D	PM-31.5-0.375A	PM-31.5-0.375	3	G
29.2-32.7	0.750	F	PM-31.5-0.750A	PM-31.5-0.750	5	G
29.2-32.7	1.5	G	PM-31.5-1.5A	PM-31.5-1.5	6A	G
29.2-32.7	3.0	GA	PM-31.5-3.0A	PM-31.5-3.0	7A	G
29.2-32.7	6.0	GB	PM-31.5-6.0A	PM-31.5-6.0	8A	H
29.2-32.7	12.0	GC	PM-31.5-12.0A	PM-31.5-12.0	9A	H
32.7-36.2	0.050	A	PM-34.5-0.050A	PM-34.5-0.050	1	G
32.7-36.2	0.100	B	PM-34.5-0.100A	PM-34.5-0.100	1	G
32.7-36.2	0.200	C	PM-34.5-0.200A	PM-34.5-0.200	2	G
32.7-36.2	0.375	D	PM-34.5-0.375A	PM-34.5-0.375	3	G
32.7-36.2	0.750	F	PM-34.5-0.750A	PM-34.5-0.750	5	G
32.7-36.2	1.5	G	PM-34.5-1.5A	PM-34.5-1.5	6A	G
32.7-36.2	3.0	GA	PM-34.5-3.0A	PM-34.5-3.0	7A	G
32.7-36.2	6.0	GB	PM-34.5-6.0A	PM-34.5-6.0	8A	H
32.7-36.2	12.0	GC	PM-34.5-12.0A	PM-34.5-12.0	9A	H
36.2-40.0	0.050	A	PM-38.0-0.050A	PM-38.0-0.050	1	G
36.2-40.0	0.100	B	PM-38.0-0.100A	PM-38.0-0.100	1	G
36.2-40.0	0.200	C	PM-38.0-0.200A	PM-38.0-0.200	2	G
36.2-40.0	0.375	D	PM-38.0-0.375A	PM-38.0-0.375	3	G
36.2-40.0	0.750	F	PM-38.0-0.750A	PM-38.0-0.750	5	G
36.2-40.0	1.5	G	PM-38.0-1.5A	PM-38.0-1.5	6A	G
36.2-40.0	3.0	GA	PM-38.0-3.0A	PM-38.0-3.0	8	G
36.2-40.0	6.0	GB	PM-38.0-6.0A	PM-38.0-6.0	9	H
36.2-40.0	12.0	GC	PM-38.0-12.0A	PM-38.0-12.0	10	H
40.0-44.0	0.050	B	PM-42.0-0.050A	PM-42.0-0.050	1	
40.0-44.0	0.100	C	PM-42.0-0.100A	PM-42.0-0.100	1	
40.0-44.0	0.200	D	PM-42.0-0.200A	PM-42.0-0.200	2	
40.0-44.0	0.375	E	PM-42.0-0.375A	PM-42.0-0.375	3	
40.0-44.0	0.750	F	PM-42.0-0.750A	PM-42.0-0.750	6	
40.0-44.0	1.5	GA	PM-42.0-1.5A	PM-42.0-1.5	7	
40.0-44.0	3.0	GB	PM-42.0-3.0A	PM-42.0-3.0	8	
40.0-44.0	6.0	GB	PM-42.0-6.0A	PM-42.0-6.0	9	
40.0-44.0	12.0	GC	PM-42.0-12.0A	PM-42.0-12.0	10	
44.0-48.0	0.050	B	PM-46.0-0.050A	PM-46.0-0.050	1	
44.0-48.0	0.100	C	PM-46.0-0.100A	PM-46.0-0.100	1	
44.0-48.0	0.200	D	PM-46.0-0.200A	PM-46.0-0.200	2	
44.0-48.0	0.375	E	PM-46.0-0.375A	PM-46.0-0.375	4	
44.0-48.0	0.750	F	PM-46.0-0.750A	PM-46.0-0.750	6	
44.0-48.0	1.5	GA	PM-46.0-1.5A	PM-46.0-1.5	7	
44.0-48.0	3.0	GB	PM-46.0-3.0A	PM-46.0-3.0	8	
44.0-48.0	6.0	GC	PM-46.0-6.0A	PM-46.0-6.0	9	
44.0-48.0	12.0	GD	PM-46.0-12.0A	PM-46.0-12.0	10	
48.0-52.0	0.050	B	PM-50.0-0.050A	PM-50.0-0.050	1	
48.0-52.0	0.100	C	PM-50.0-0.100A	PM-50.0-0.100	1	
48.0-52.0	0.200	D	PM-50.0-0.200A	PM-50.0-0.200	2	
48.0-52.0	0.375	E	PM-50.0-0.375A	PM-50.0-0.375	4	
48.0-52.0	0.750	F	PM-50.0-0.750A	PM-50.0-0.750	6	
48.0-52.0	1.5	GA	PM-50.0-1.5A	PM-50.0-1.5	7	
48.0-52.0	3.0	GB	PM-50.0-3.0A	PM-50.0-3.0	8	
48.0-52.0	6.0	GC	PM-50.0-6.0A	PM-50.0-6.0	9	
48.0-52.0	12.0	GD	PM-50.0-12.0A	PM-50.0-12.0	10	
52.0-59.0	0.050	B	PM-56.0-0.050A	PM-56.0-0.050	1	
52.0-59.0	0.100	C	PM-56.0-0.100A	PM-56.0-0.100	1	
52.0-59.0	0.200	E	PM-56.0-0.200A	PM-56.0-0.200	3	
52.0-59.0	0.375	F	PM-56.0-0.375A	PM-56.0-0.375	4	
52.0-59.0	0.750	G	PM-56.0-0.750A	PM-56.0-0.750	6	
52.0-59.0	1.5	GA	PM-56.0-1.5A	PM-56.0-1.5	7	
52.0-59.0	3.0	GB	PM-56.0-3.0A	PM-56.0-3.0	8	
52.0-59.0	6.0	GC	PM-56.0-6.0A	PM-56.0-6.0	9	
52.0-59.0	12.0	GD	PM-56.0-12.0A	PM-56.0-12.0	10	
59.0-63.0	0.050					
59.0-65.0	0.100					
59.0-65.0	0.200					
59.0-65.0	0.375					
59.0-65.0	0.750					
59.0-65.0	1.5					
59.0-65.0	3.0					
59.0-65.0	6.0					
59.0-65.0	12.0					

CONSULT FACTORY

VERMONT YANKEE DESIGN ENGINEERING

CALCULATION NO. VYC-467

REV 5

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QDR-32.1
REV. 0

A14

CRIPTION

rical options: SUFFIX

Improved source and load effect (Regulation)	AA
Source voltage 210-250 VAC	BB
Reduced size and weight, 400 Hz input	D
Operation with lamp loads	E
Fixed output voltage	F
External output voltage control	H
Remote sensing	R
Reduced temperature coefficient	T1, T2
Off ground operation	U
Wide source voltage range	W
External output voltage control with remote sensing	Y
Mechanical options:	
Shock mounting brackets	G
Full epoxy encapsulation	K
Sealed internal potentiometer	P
Threaded inserts for mounting	V
Optional cases, multiple outputs, special shapes	Consult Factory

IMPROVED SOURCE AND LOAD EFFECT (REGULATION) "AA" SUFFIX

Stabilization accuracies of ±0.01% for source effect and ±0.025% or 1 mv for load effect, are possible for the ±0.05% stabilized models in the following series:

MC-65 P-60 PM-95 F-115 FD-115

When ordering this option, please add the suffix "AA" to the model number (e.g. P23.3-0.200 AA and FD23.3-0.200 AA).

URCE VOLTAGE -250 VAC "BB" SUFFIX

Modification for a source voltage of 210-250 VAC only. Size and weight of modules remain unchanged. Consult factory for HF Series.

REDUCED SIZE AND WEIGHT, 400 Hz INPUT "D" SUFFIX

Modification for a source frequency of 380-420 Hz only applies to the following series: P-60, PM-95 and NP-60. The size and weight of the power modules will be reduced as follows: models with an output power rating of 250 watts or less are reduced by one full case size if ordered with the "D" suffix (e.g. P23.3-0200 D – Case "A"). Models with an output power rating of greater than 250 watts are reduced by one-half case size (e.g. P28.0-12.0 D – Case size "GCS". See page 82: Low Silhouette Style)

OPERATION WITH FILAMENT TYPE LOADS "E" SUFFIX

When modules are operated with a filament load, or with other types of non-linear loads, the overcurrent (short circuit) protective circuits of the module may be activated. Depending upon the load characteristics, this could cause the module to "hang up" at a voltage less than its rated output. Modules can be modified at the factory to avoid this problem.

The "E" suffix is applicable to series P-60, MC-65, PM-95, F-115 and FD-115 modules, with the following limitations: those with a maximum output of 28 volts; modules with a maximum current rating of three amperes; modules with a power rating of 36 watts or less. If this option is required for models with higher voltage, current, or power ratings, please consult factory.

This feature is standard on the RA-60 and SCR-60 series.

XED OUTPUT VOLTAGE "F" SUFFIX

e output of the power module that is ordered with the "F" suffix will have the output control potentiometer removed, and the output voltage fixed within ±1% setting accuracy. This also seals the module against moisture, dust, or sand. Please note that this feature is standard on the NP-60 series modules, and that the setting accuracy for this series is ±5%. If closer setting accuracies are required for any series, please consult the factory.

When ordering this suffix, please add the suffix "F" to the basic model number and indicate the voltage setting desired (e.g. P23.3-0.200 F/24.0).

SHOCK MOUNTING BRACKETS "G" SUFFIX

Mounting brackets for high shock applications can be furnished for all modules in case sizes "A" through "GD". The "G" suffix automatically incorporates full epoxy encapsulation to provide reliable operation under higher shock applications, such as MIL-S-901C. If this option is required, please add the suffix "G" to the model number and request the indicated drawing for detailed mechanical specifications.

Case Size	Drawing No.	Case Size	Drawing No.
A to G	140-111	GC	140-680
GA	140-676	GD	140-682
GB	140-678	GE	Consult factory

If modules with less stringent application than MIL-S-901C are required, the "V" suffix may be sufficient. Consult factory for possible variation of hardware for medium shock applications.

EXTERNAL OUTPUT VOLTAGE CONTROL "H" SUFFIX

This option permits control of the output voltage with an external potentiometer. It also provides sealing against moisture, sand or dust. This option is applicable to the series listed below. To order, add the suffix "H" to the desired model number and request the drawing indicated for detailed mechanical specifications.

Series	Drawing No.	Series	Drawing No.
MC-65 P-60 PM-95	140-953	OPM/TOPM-95	140-1397
PL-60	140-1117	F/FD-115	140-126
SCR-60	140-269	TOP-60	140-792 (MA case)
HF/HFC-60	140-740	TOP-60	140-794 (MB case)
CO/COC-95	140-1176	DP-60	140-684 (MA case)
		DP-60	140-686 (MB case)

FULL EPOXY ENCAPSULATION "K" SUFFIX

This option is recommended for higher shock and vibration applications. Power supplies which incorporate this option will be completely encapsulated. This option is available for the following series:

MC-65 P-60 DP-60 NP-60 RA-60 SCR-60 TDP-60 HF-60 HFC-60 "C" "CC"* Style OVP

The "K" suffix is standard on the PM-95, F-115, FD-115, CD-95, DPM-95 and TDPM-95 series.

*Full encapsulation of "C" and "CC" style overvoltage protector modules will restrict the trip point adjustment range to 5-40 VDC.

SEALED INTERNAL POTENTIOMETER "P" SUFFIX

Any module of the series listed below can be modified to incorporate a sealed, MIL-R-19 type output control potentiometer. This option also provides sealing against moisture, sand or dust. Note the "F", "H", or "Y" suffixes also provide sealing. To order this option, add the suffix "P" to the desir... ...and request the drawing indicated for detailed me...

Series	Draw
P-60, MC-65	140-1
SCR-60	140-2
HF-60, HFC-60	140-7

The "P" suffix is standa... CDC-95, DPM-95 and TOPI...

VERMONT YANKEE DESIGN ENGINEERING
CALCULATION NO. VYC-467
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STANFORD TECHNOLOGY CORP.
P.O. BOX 2100D
ONE RESEARCH DRIVE • GLENBROOK, CONN. 06906
(212) 478-2010 (203) 348-4080

G3-001

REPORT OF TESTS

on

D.C. POWER SUPPLY

ENVIRONMENTAL TESTING

QDR-32.1
REV. 0

for

TECHNIPOWER
COMMERCE DRIVE
COMMERCE PARK
P. O. BOX 222
DANBURY, CT 06810

VERMONT YANKEE DESIGN ENGINEERING
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ST-4375-00C

September 2, 1984

REPORT NO. ST4375-00C

G3-'02

SIGNATURES FOR

STANFORD TECHNOLOGY CORPORATION

Fred Esposito — 9-7-84

Fred Esposito
Test Engineer

Date

Gerald T. Ciccone — 9-7-84

Gerald T. Ciccone
Vice President

Date

VERMONT YANKEE DESIGN ENGINEERING
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G3-005

FACTUAL DATA

1.0 TEST EQUIPMENT

1.1 Temperature Chamber
Webber Eng.
Model: TF-15-100+350
Last calibration: March 17, 1984
Next calibration: September 17, 1984

1.2 Temperature-Humidity Chamber
Tenney
Model: T15UF-100240
Last calibration: April 2, 1984
Next calibration: October 2, 1984

1.3 Accelerometer
Endevco
Model: 2272
Last calibration: July 12, 1984
Next calibration: January 12, 1985

1.4 Dial-A-Gain
Unholtz-Dickie
Model: 603
Calibration: Before use

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1.5 Accelerometer
Endevco
Model: 2213
Last calibration: July 12, 1984
Next calibration: January 12, 1985

1.6 Charge Amplifier
Unholtz-Dickie
Model: 8PCVA
Last calibration: July 12, 1984
Next calibration: January 12, 1985

1.7 Vibration System
MB Electronics
Model: C-126
Last calibration: July 12, 1984
Next calibration: January 12, 1985

1.8 Digital Vibration Control System
Hewlett Packard
Model: 5427A
Calibration: Before use

VERMONT YANKEE DESIGN ENGINEERING
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1.9 Graphics Terminal
Hewlett Packard
Model: 2648A
Calibration: Before use

1.10 Digital Plotter
Hewlett Packard
Model: 7225A
Calibration: Before use

1.11 Accelerometer
Endevco
Model: 2272
Last calibration: July 12, 1984
Next calibration: January 12, 1985

1.12 Zero Drive Amplifier
MB Electronics
Model: N-400
Last calibration: July 12, 1984
Next calibration: January 12, 1985

1.13 Shock Machine
Avco
Model: SM-110-3
Calibration: Before use

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1.14 Accelerometer
Endevco
Model: 2224C
Last calibration: July 12, 1984
Next calibration: January 12, 1985

1.15 Oscilloscope
Tektronix
Model: 564B
Last calibration: May 7, 1984
Next calibration: November 7, 1984

1.16 Band Pass Filter
Krohn-Hite
Model: 330N
Last calibration: May 7, 1984
Next calibration: May 7, 1985

1.17 Digital Multimeter
John Fluke Mfg.
Model: 8020A
Last calibration: April 23, 1984
Next calibration: April 23, 1985

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1.18 Digital Temperature Indicator
Omega Eng.
Model: 410A-THF
Last calibration: May 7, 1984
Next calibration: May 7, 1985

1.19 Salt Spray Chamber
Singleton
Model: SCCH No. 21
Last calibration: May 12, 1984
Next calibration: November 12, 1984

All instrumentation and equipment calibration conducted in accordance with and as defined in MIL-STD-45662, "Calibration Systems Requirements" and are traceable to the National Bureau of Standards.

2.0 TEST SEQUENCE AND COMPLETION DATES

2.1 High Temperature Test - Completed August 13, 1984

2.2 Low Temperature Test - Completed August 14, 1984

2.3 Humidity Test - Completed August 22, 1984

2.4 Vibration Test - Completed August 27, 1984

2.5 Shock Test - Completed August 30, 1984

2.6 Salt Fog Test - Completed September 2, 1984

NOTE: Whenever specified herein, the DC Power Supply was subjected to an Operational Test consisting of measuring the four (4) DC output voltages at rated load with rated input power applied. All electrical test data may be seen in Appendix A of this report.

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3.0 TEST PROGRAM

3.1 High Temperature Test

3.1.1 Test Procedure

The test item was subjected to a High Temperature Test as described in MIL-STD-810C, Method 501.1, Procedure I. This procedure was as follows:

Step 1 - The test unit was placed within a high temperature chamber in a manner simulating actual service conditions.

Step 2 - The test chamber temperature was raised to +75°C.

Step 3 - The internal temperature of the test chamber was maintained at +75°C for a period of forty-eight (48) hours.

Step 4 - The test unit was then stabilized at +50°C.

Step 5 - While at +50°C, an Operational Test was performed.

Step 6 - The chamber temperature was adjusted to room ambient conditions and stabilized.

Step 7 - The test unit was stabilized at room ambient conditions and then visually examined for evidence of physical deterioration. An Operational Test was then performed.

3.1.2 Test Results

There was no visual evidence of physical deterioration or electrical malfunction as a result of this test.

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3.2 Low Temperature Test

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3.2.1 Test Procedure

The test item was subjected to a Low Temperature Test as described in MIL-STD-810C, Method 502.1, Procedure I. This procedure was as follows.

Step 1 - The test unit was mounted on a test fixture and placed within a Low Temperature Chamber.

Step 2 - The test chamber temperature was reduced to -62°C.

Step 3 - The internal temperature of the test chamber was maintained at -62°C for a period of four (4) hours minimum.

Step 4 - The Power Supply was then stabilized at 0°C.

Step 5 -While at 0°C, an Operational Test was performed.

Step 6 - The chamber temperature was adjusted to room ambient conditions and stabilized.

Step 7 - The test unit was then stabilized at room ambient conditions and then visually examined for evidence of physical deterioration. An Operational Test was then performed.

3.2.2 Test Results

There was no visual evidence of physical deterioration or electrical malfunction as a result of this test.

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G3-010

3.3 Humidity Test

3.3.1 Test Procedure

The Humidity Test was conducted in accordance with MIL-STD-810C, Method 507.1, Procedure IV.

The test unit was placed within a temperature-humidity chamber in a manner simulating actual service usage. The chamber was sealed and the test unit was initially dried at 40°C to 50°C for not less than two (2) hours. The unit was then conditioned at +25°C and 50% RH for twenty-four (24) hours and electrical measurements were performed.

Following the above conditioning, the test unit was subjected to five (5) 24-hour cycles. Each cycle consisted of sixteen (16) hours at +50°C and approximately eight (8) hours at +30°C. The relative humidity was maintained at 95% or greater at both temperatures. Each transition time between 30°C and 50°C was not greater than 1.5 hours. The relative humidity during each transition was not controlled. During the second cycle, while at +50°C, immediately prior to decreasing to +30°C, electrical measurements were performed.

At the completion of the fifth cycle and while at +30°C and 95% RH, electrical measurements were made. Following this the test unit was conditioned at +25°C and 50% RH for not less than twelve (12) hours nor more than twenty-four (24) hours. While at these conditions the electrical measurements were repeated.

At the completion of the entire test the test unit was visually examined for evidence of deterioration or corrosion.

3.3.2 Test Results

There was no visual evidence of deterioration, corrosion or electrical malfunction as a result of the Humidity Test, with the exception that minor rust was observed on the top mounting hardware on one of the Transformers.

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3.4 Vibration Test

3.4.1 Test Procedure

The Vibration Test was conducted in accordance with MIL-STD-202F, Method 201A, as modified herein.

The test item was securely fastened to a flat aluminum plate by normal mounting means and mounted to the table of a vibration machine. The Vibration Test was conducted as follows.

Resonance Survey

Resonant modes were determined by varying the frequency of applied vibration slowly through the range specified in Figure 1. Individual resonance searches were conducted with vibration applied along each of the three (3) mutually perpendicular axes.

Vibration Cycling

The unit was subjected to sinusoidal cycling at a logarithmic rate between the frequency limits and at the vibratory acceleration levels specified in Figure 1 and the time schedule of Table I, in each of the three (3) mutually perpendicular axes.

At the completion of each axis of vibration, the unit was visually examined for evidence of physical damage.

During vibration, at each level and each axis, the Power Supply was electrically energized and test data was recorded.

TABLE I

Time Schedule

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Cycling Time per Axis	Sweep Time 4-33-4 Hz
2.0 Hours	One (1) minute

3.4.2 Test Results

There was no visual evidence of physical damage or electrical malfunction as a result of this test.

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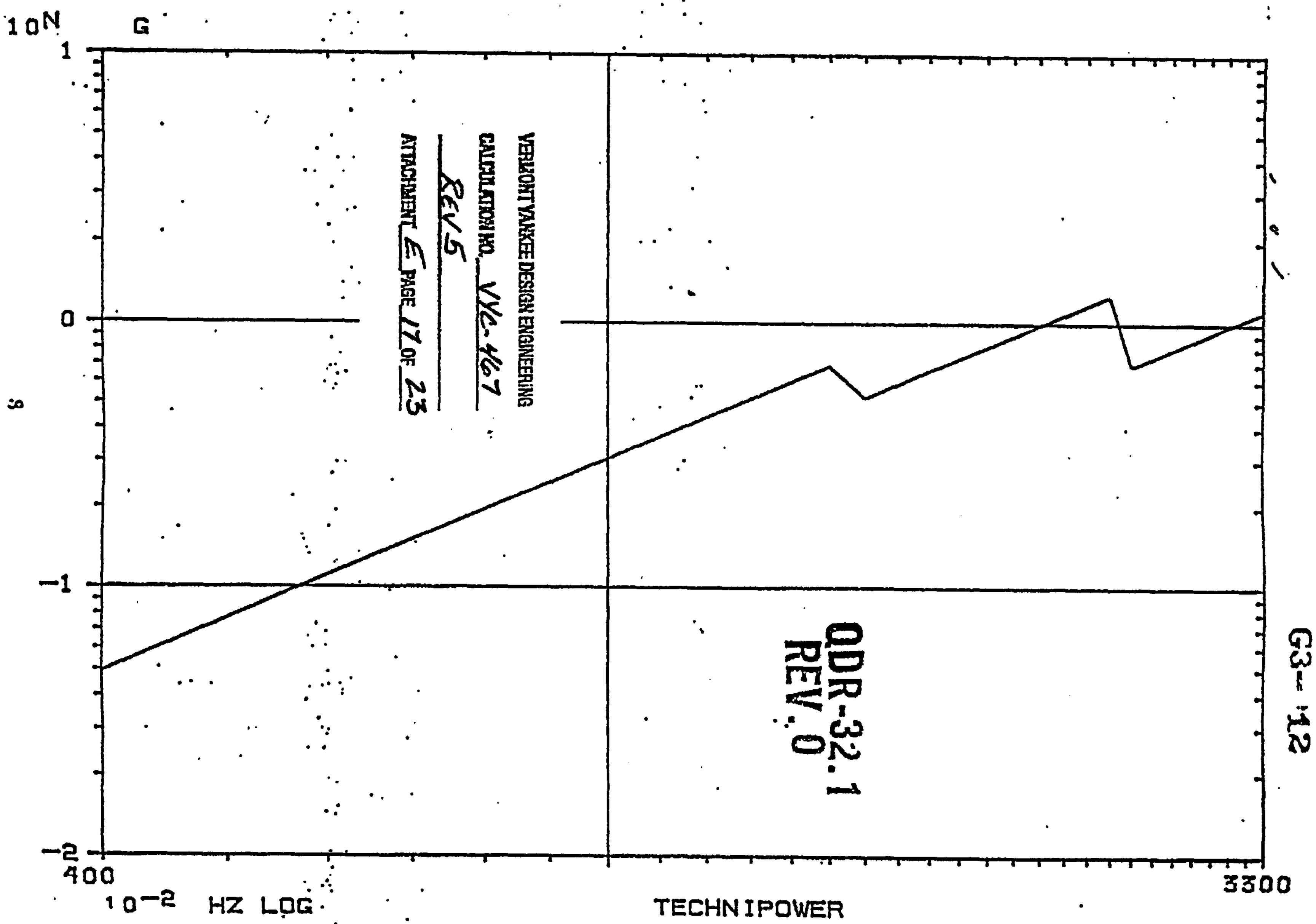
FIGURE: 1.
REFERENCE:



TECHNIPOWER

G3-12

G3-?13

3.5 Shock Test

3.5.1 Test Procedure

The Shock Test was conducted in accordance with MIL-STD-202F, Method 213B, Test Condition I.

While operating, the Power Supply was securely fastened to the table of an impact shock machin and subjected to a total of eighteen (18) shock impacts. Each shock pulse approximated a sawtoc wave having a nominal time duration of six (6) milliseconds. Three (3) shocks were applied in each direction along each of the three (3) mutua perpendicular axes. The magnitude of the shock pulses were 100 g's peak. During each shock impa the DC output voltages were monitored.

At the completion of the Shock Test the Power Supp was visually examined for evidence of physical dam

3.5.2 Test Results

There was no visual evidence of physical damage or electrical malfunction as a result of this test.

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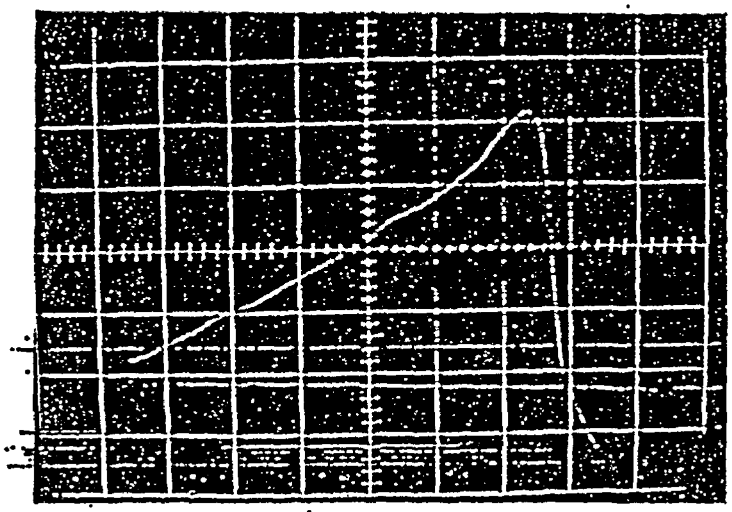

(100 g's, 6.0ms, sawtooth)

Vertical Sensitivity: 25.0 g's/major division
Horizontal Sensitivity: 1.0 ms/major division

FIGURE 2

Calibration Photograph of Shock Pulse

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G3-015

3.6 Salt Fog Test

3.6.1 Test Procedure

The Salt Fog Test was conducted in accordance with MIL-STD-810C, Method 509.1, Procedure I.

The Power Supply was positioned within the chamber at an angle of approximately fifteen (15) degrees from the vertical so that corrosion products and condensate would not fall upon the item under test. The chamber was sealed and the chamber temperature was increased to +95°F. The test unit was then subjected to the specified salt spray for a period of forty-eight (48) hours.

A 5% salt solution, prepared by dissolving five (5) parts be weight of sodium chloride in 95 parts by weight of distilled water, was used to produce the salt spray fog. The sodium chloride contained, on the dry basis, not more than 0.1% of sodium iodide and less than 0.3% of total impurities. The solution was adjusted to, and maintained at, a specified gravity between 1.0268 and 1.0413 and a pH value between 6.5 and7.2 when measured at +95°F.

Upon completion of the forty-eight (48) hour period, the test unit was removed from the test chamber and visually examined. The Power Supply was then allowed to dry for a period of forty-eight (48) hours following which a visual examination and an electrical functional test was conducted.

3.6.1 Test Results

There was no visual evidence of deterioration or corrosion as a result of the Salt Fog Test. The Power Supply was then returned to Technipower for further electrical tests.

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APPENDIX A

Test Data

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STANFORD TECHNOLOGY CORP.

G3-J17

TEST DATA SHEET-1

Test Condition ABBREVIATED ELECTRICAL TESTS Date 8/15 - 9/2/84 Job. No. ST-4375-00C

Specification TPTP NO. R 877 Para. No. ____ Test Operation F.E.

Test Item D.C. POWER SUPPLY Part No. 229-1050 Approved by [signature]

TEST CONDITION			D.C. OUTPUT VOLTAGES (VDC)			
			-25.0 ±3%	+25.0 ±3%	+28.0 ±6%	+550 ±3%
INITIAL		+25°C	-25.0	+25.0	+28.9	+556.0
HIGH TEMPERATURE		+50°C	-25.0	+25.0	+28.8	+561.0
POST TEST		+25°C	-25.0	+25.0	+28.9	+557.0
[illegible]IPERATURE		0°C	-25.0	+25.0	+28.8	+558.0
POST TEST		+25°C	-25.0	+25.0	+28.9	+556.0
HUMIDITY						
PRE-TEST		+25°C	-25.0	+25.0	+28.9	+555.0
POST 24-HR. CONDITIONING	50% R.H.	+25°C	-25.0	+25.0	+28.9	+555.0
DURING SECOND CYCLE	95% R.H.	+50°C	-25.0	+25.0	+28.8	+561.0
DURING FIFTH CYCLE	95% R.H.	+30°C	-25.0	+25.0	+28.2	+556.0
POST HUMIDITY	50% R.H.	+25°C	-25.0	+25.0	+28.9	+556.0

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TEST DATA SHEET – 2

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Test Condition ABBREVIATED ELECTRICAL TESTS Date 8/15- 9/2/84 Job. No. ST-4375-00C

Specification TPTP NO. R 877 Para. No. ______ Test Operation F.E.

Test Item D.C. POWER SUPPLY Part No. 229-1050 Approved by [signature]

TEST CONDITION			D.C. OUTPUT VOLTAGES (VDC)				
			-25.0 ±3%	+25.0 ±3%	+28.0 ±6%	+550 ±3%	
VIBRATION							
PRE-TEST		+25°C	-25.0	+25.0	+28.9	+556.0	
AXIS X	0.06" DA		-25.0	+25.0	+27.6	+555.0	
	0.04" DA		-25.0	+25.0	+27.6	+555.0	
	0.02" DA		-25.0	+25.0	+27.6	+555.0	
AXIS Y	0.06" DA		-25.0	+25.0	+27.6	+555.0	
	0.04" DA		-25.0	+25.0	+27.6	+555.0	
	0.02" DA		-25.0	+25.0	+27.6	+555.0	
AXIS Z	0.06" DA		-25.0	+25.0	+27.6	+555.0	
	0.04" DA		-25.0	+25.0	+27.6	+555.0	
	0.02" DA		-25.0	+25.0	+27.6	+555.0	
POST TEST			-25.0	+25.0	+27.6	+556.0	
SHOCK							
AXIS X_1		+25°C	-25.0	+25.0	+28.4	+558.0	
AXIS X_2			-25.0	+25.0	+28.4	+558.0	
AXIS Y_1			-25.0	+25.0	+28.4	+558.0	
AXIS Y_2			-25.0	+25.0	+28.4	+558.0	
AXIS Z_1			+25.0	+25.0	+28.4	+558.0	
AXIS Z_2			-25.0	+25.0	+28.4	+558.0	
POST TEST		+25°C	-25.0	+25.0	+28.4	+558.0	
T SPRAY							
POST TEST		+25°C	-25.0	+25.0	+28.4	+558.0	

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VERMONT YANKEE ENVIRONMENTAL QUALIFICATION PROGRAM MANUAL

SECTION NO.: 5.0
TITLE: ELECTRICAL COMPONENT MATRIX REPORT

REV.	AFFECTED PAGES	PREPARED BY/ DATE	REVIEWED BY/ DATE	APPROVED BY/ DATE
15	General Update. See Effective Page Summary.	J. Pappas for R. E. Swenson 8/13/93	J. H. Callaghan 8/13/93 P. R. Johnson 8/20/93 R. T. Vibert 8/20/93 P. S. Littlefield 9/10/93 R. Sundaram 9/23/93	J. R. Hoffman 10/4/93
16	General Update. See Effective Page Summary.	R. E. Swenson 4/29/94	P. S. Littlefield 5/16/94 R. Sundaram 6/17/94 R. T. Vibert 6/24/94 J. H. Callaghan 6/24/94 P. R. Johnson 7/12/94	J. R. Hoffman 6/29/94
17	General Update. See Effective Page Summary.	R. E. Swenson 10/2/95	J. R. Hoffman 10/16/95 R. Sundaram 10/23/95 P. S. Littlefield 10/23/95 R. T. Vibert Elec/I&C 10/25/95 J. H. Callaghan SEG 11/6/95	J. R. Hoffman 10/16/95
18	General Update. See Effective Page Summary.	[signature] 9/1/98	[signature] 12/11/98 [signature] 12/18/98 P. Littlefield 12/18/98 [signature] 12/18/98 R-T-Vibert 12/19/98	[signature] 21 December 1998

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SYSTEM ID: NBVI, NUCLEAR BOILER VESSEL INSTRUMENTATION SYSTEM

TAG NO.	SERVICES	LOCATION	EQUIPMENT QUALIFICATION MATRIX DATA	CAT	TBN1	TBN2	F1	F2	F3	DURATION
2-3-55B(X)	RX VESSEL PRESSURE/(RPS)	VOL 20	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
2-3-55C(M)	RX VESSEL PRESSURE/(RPS)	VOL 22	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
2-3-55C(X)	RX VESSEL PRESSURE/(RPS)	VOL 22	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
2-3-55D(M)	RX VESSEL PRESSURE/(RPS)	VOL 22	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
2-3-55D(X)	RX VESSEL PRESSURE/(RPS)	VOL 22	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
2-3-56A(M)	RX VESSEL PRESSURE	VOL 22	LOCA:	A	9	25	6	10		LT
			MS :	A	9	25	6	7	10	LT
			HPCI:	A	9	25	6	7	10	LT
			RCIC:	E	39		6	7	10	-
			RWCU:	A	9	25	6	7	10	LT
			HHS :	A	9	25	6	7	10	LT
2-3-56A(X)	RX VESSEL PRESSURE	VOL 22	LOCA:	A	9	25	6	10		LT
			MS :	A	9	25	6	7	10	LT
			HPCI:	A	9	25	6	7	10	LT
			RCIC:	E	39		6	7	10	-
			RWCU:	A	9	25	6	7	10	LT
			HHS :	A	9	25	6	7	10	LT

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PRINTED: 10/20/97 | VERMONT YANKEE EQUIPMENT QUALIFICATION MATRIX (SORTED BY SYSTEM & TAG NO) | REVISION: 17 REV DATE: 10/24/97

SYSTEM ID: NBVI, NUCLEAR BOILER VESSEL INSTRUMENTATION SYSTEM

TAG NO.	SERVICES	LOCATION		EQUIPMENT QUALIFICATION MATRIX DATA						
				CAT	TBN1	TBN2	F1	F2	F3	DURATION
2-3-52C(M)	LOW RX PRESS INT'L/ECCS INJ VALVES	VOL 22	LOCA:	A	9		6			LT
			MS :	A	39	9	7	6		LT
			HPCI:	A	39	9	7	6		LT
			RCIC:	E	39		7			-
			RWCU:	A	39	9	7	6		LT
			HHS :	A	39	9	7	6		LT
2-3-52C(X)	LOW RX PRESS INT'L/ECCS INJ VALVES	VOL 22	LOCA:	A	9		6			LT
			MS :	A	39	9	7	6		LT
			HPCI:	A	39	9	7	6		LT
			RCIC:	E	39		7	6		-
			RWCU:	A	39	9	7	6		LT
			HHS :	A	39	9	7	6		LT
2-3-52D(M)	LOW RX PRESS INT'L/ECCS I NJ VALVES	VOL 20	LOCA:	A	9		6			LT
			MS :	A	39	9	7	6		LT
			HPCI:	A	39	9	7	6		LT
			RCIC:	E	39		7	6		-
			RWCU:	A	39	9	7	6		LT
			HHS :	A	39	9	7	6		LT
2-3-52D(X)	LOW RX PRESS INT'L/ECCS I NJ VALVES	VOL 20	LOCA:	A	9		6			LT
			MS :	A	39	9	7	6		LT
			HPCI:	A	39	9	7	6		LT
			RCIC:	E	39		7	6		-
			RWCU:	A	39	9	7	6		LT
			HHS :	A	39	9	7	6		LT
2-3-55A(M)	RX VESSEL PRESSURE/(RPS)	VOL 20	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
2-3-55A(X)	RX VESSEL PRESSURE/(RPS)	VOL 20	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
2-3-55B(M)	RX VESSEL PRESSURE/(RPS)	VOL 20	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS

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SYSTEM ID: NBVI, NUCLEAR BOILER VESSEL INSTRUMENTATION SYSTEM

TAG NO.	SERVICES	LOCATION		EQUIPMENT QUALIFICATION MATRIX DATA						
				CAT	TBN1	TBN2	F1	F2	F3	DURATION
PT-2-3-52D	LOW RX PRESS INT'L/ECCS INJ VALVES	VOL 38	LOCA:	A	9		6			LT
			MS :	A	39	9	7	6		LT
			HPCI:	A	39	9	7	6		LT
			RCIC:	A	39	9	7	6		LT
			RWCU:	A	39	9	7	6		LT
			HHS :	A	39	9	7	6		LT
PT-2-3-54A	RX VESSEL PRESS	VOL 21	LOCA:	C	29		0			-
			MS :	C	30		0			-
			HPCI:	C	30		0			-
			RCIC:	E	30		0			-
			RWCU:	C	30		0			-
			HHS :	C	30		0			-
PT-2-3-54B	RX VESSEL PRESS	VOL 20	LOCA:	C	29		0			-
			MS :	C	30		0			-
			HPCI:	C	30		0			-
			RCIC:	E	30		0			-
			RWCU:	C	30		0			-
			HHS :	C	30		0			-
PT-2-3-54C	RX VESSEL PRESS	VOL 21	LOCA:	C	29		0			-
			MS :	C	30		0			-
			HPCI:	C	30		0			-
			RCIC:	E	30		0			-
			RWCU:	C	30		0			-
			HHS :	C	30		0			-
PT-2-3-54D	RX VESSEL PRESS	VOL 20	LOCA:	C	29		0			-
			MS :	C	30		0			-
			HPCI:	C	30		0			-
			RCIC:	E	30		0			-
			RWCU:	C	30		0			-
			HHS :	C	30		0			-
PT-2-3-55A	RX VESSEL PRESS	VOL 20	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
PT-2-3-55B	RX VESSEL PRESS	VOL 20	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS

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SYSTEM ID: NBVI, NUCLEAR BOILER VESSEL INSTRUMENTATION SYSTEM

TAG NO.	SERVICES	LOCATION		EQUIPMENT QUALIFICATION MATRIX DATA CAT	TBN1	TBN2	F1	F2	F3	DURATION
PT-2-3-55C	RX VESSEL PRESS	VOL 21	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
PT-2-3-55D	RX VESSEL PRESS	VOL 21	LOCA:	D	29		2			-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
PT-2-3-56A	VESSEL PRESS	VOL 21	LOCA:	A	9	25	6	10		LT
			MS :	A	9	25	6	7	10	LT
			HPCI:	A	9	25	6	7	10	LT
			RCIC:	E	39		6	7	10	-
			RWCU:	A	9	25	6	7	10	LT
			HHS :	A	9	25	6	7	10	LT
PT-2-3-56B	VESSEL PRESS	VOL 20	LOCA:	A	9	25	6	10		LT
			MS :	A	9	25	6	7	10	LT
			HPCI:	A	9	25	6	7	10	LT
			RCIC:	E	39		6	7	10	-
			RWCU:	A	9	25	6	7	10	LT
			HHS :	A	9	25	6	7	10	LT
PT-2-3-56C	VESSEL PRESS	VOL 21	LOCA:	A	9	25	6	10		LT
			MS :	A	9	25	6	7	10	LT
			HPCI:	A	9	25	6	7	10	LT
			RCIC:	E	39		6	7	10	-
			RWCU:	A	9	25	6	7	10	LT
			HHS :	A	9	2	6	7	10	LT
PT-2-3-56D	VESSEL PRESS	VOL 20	LOCA:	A	9	25	6	10		LT
			MS :	A	9	25	6	7	10	LT
			HPCI:	A	9	25	6	7	10	LT
			RCIC:	E	39		6	7	10	-
			RWCU:	A	9	25	6	7	10	LT
			HHS :	A	9	25	6	7	10	LT

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SYSTEM ID: PRS, REACTOR PROTECTION SYSTEM

TAG NO.	SERVICES	LOCATION		CAT	TBN1	TBN2	F1	F2	F3	DURATION
25-5A-A1	CAB 25-5A/A1 PWR SUPPLY	VOL 20	LOCA:	D	12	29	2	6	3	-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
25-5A-B1	CAB 25-5A/B1 PWR SUPPLY	VOL 20	LOCA:	D	12	29	2	6	3	-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
25-6A-A2	CAB 25-6A/A2 PWR SUPPLY	VOL 20	LOCA:	D	12	29	2	6	3	-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
25-6A-B2	CAB 25-6A/B2 PWR SUPPLY	VOL 20	LOCA:	D	12	29	2	6	3	-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
5-12A(M)	DW PRESSURE/RPS	VOL 20	LOCA:	D	12	29	2	6		-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
5-12A(X)	DW PRESSURE/RPS	VOL 20	LOCA:	D	12	29	2	6		-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS
5-12B(M)	DW PRESSURE/RPS	VOL 20	LOCA:	D	12	29	2	6		-
			MS :	D	83		2			-
			HPCI:	A	30		2			6HRS
			RCIC:	E			2			-
			RWCU:	A	30		2			6HRS
			HHS :	A	30		2			6HRS

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TB8 Failure of these components could disable one or more RHR pumps.

TB9 RX low press interlock instrumentation associated with ECCS injection valves must be qualified for time period associated with applicable safety function(s). Failure could prevent injection valve opening. For HELB events, only two redundant ECCS Subsystems need to be qualified. As a minimum, A and B Core Spray Systems will be qualified. Therefore, the LPCI injection valves need not be qualified for HELB events. All ECCS Subsystems must be qualified for a LOCA.

Note: For 2-3-56A through D analog trip units (master(M) and slave(S)), see TB-72.

TB10 ECCS injection valve limit switches that provide an interlock to associated injection valve in series, must be qualified for time period associated with applicable safety function(s). Failure could prevent opening of associated injection valve.

TB11 The RHR alternate shutdown transfer switch provides electrical isolation from local control on the RHR alternate shutdown panel. For safety functions/accidents requiring "A" loop of RHR valves(s) to actively function (or not inadvertently change position), the transfer switch must be qualified for time period of applicable safety functions, since control circuits of several "A" loop RHR valves are wired through the transfer switch.

TB12 These components are associated with valves that are required to close on accident signal (ECCS or PC Isol.) if open at time of LOCA. To account for small break LOCAs that do not cause immediate isolation, the valves must be qualified to close for ten (10) minutes post-LOCA (see Reference 10). These components must be qualified for ten (10) minutes post-LOCA to insure valve closure. Components outside the PC will not experience a harsh environment within ten (10) minutes after LOCA. Subsequent failure of these components will not cause valve to reopen.

Note: Although some components are just outside the torus (Volumes 42, 44, 46, 48), the post-LOCA thermal and radiation effects from the torus should not be significant in the first ten (10) minutes. (See References 17 and 18).

TB13 Motor Control Centers (MCCs) that experience a harsh environment must be qualified for time period associated with safety function(s) of all load devices (valve, motor, etc). Worst case failure of an MCC is assumed to include short circuits such that motor-operated valves could change position undesirably.

TB14 The valve associated with this component is normally closed and need not actively function for an HELB. However, the valve is required to remain closed for an HELB. Failure of this co the valve to change position.

TB15 The valve associated with this component perfo for this accident. However, the valve is requ normal position for this accident. Failure of cause the valve to change position.

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TB23 Per Safety Function Number 6, for HELB mitigations, HPCI and RCIC are not relied upon to actively function for reactor vessel level control for any HELB. HPCI and RCIC components need not be qualified to HELBs except components required for HELB detection and isolation.

TB24 See "Post-Accident Monitoring" Safety Function Number 10 descriptions. These instruments are located in the Reactor Building and are required for only six hours post small break LOCA, less time for larger breaks. For DBA source term, the integrated radiation dose does not become harsh (10^4R) in less than four to six hours in the Reactor Building. It is assumed that for any size LOCA, the reactor will be depressurized and this PAM parameter will no longer be required before the environment for this component is harsh.

TB25 These components are required for "Post Accident Monitoring" safety function. Per Safety Function description Number 10, the parameter(s) associated with these components are required long term for LOCAs and HELB events. See Safety Function No. 10 description for exceptions.

TB26 DELETED

TB27 The RHR cross tie header valve, MOV-10-20, is not electrically operated. The power cable has been disconnected, and the valve is locked closed.

TB28 The main steam relief valves can be pilot operated at reactor pressures greater than 100 psig. Solenoid operated valves energize to supply air to the RV pilot and causes the RV to open. For a small break LOCA or HELB, after the reactor is depressurized, the RVs may be relied upon to control reactor pressure for a long period. For a small break LOCA, the ADS function (backup to HPCI and/or RCIC) is only required to be qualified for 6 hours and the Reactor Building is assumed to remain non-harsh. However, remote manual opening of the relief valves is required to be qualified long-term for backup shutdown cooling mode to limit harsh temperatures in drywell. For an HELB, the ADS function is not required but must be qualified to prevent inadvertent actuation. Remote manual opening of the relief valves is required to be qualified until the RHR S/D cooling system can be placed in operation (see TB17).

TB29 Per Reactivity Control Safety Function description Number 2, RPS is only required within ten (10) minutes after a LOCA. The post-LOCA environment in the Reactor Building does not become harsh until four to six hours after a large break LOCA, therefore, RPS components in the Reactor Building will function prior to harsh environment. Once the reactor is shutdown, failure of reactivity control equipment is not detrimental to safety.

The backup scram solenoids (SN 3-140A and B) do not require environmental qualification per Reference (21).

SLC components are not required for LOCA (see Safety Function Number 2).

Alternate Rod Insertion (ARI) and Recirculation Pump Trip (RPT)

The ARI and RPT functions are provided to mitigate "Anticipated Transients Without Scram (ATWS)," events. These functions are not relied upon for the design basis LOCA in which harsh environments develop. The scram solenoids at each hydraulic control unit (SO-3-117/118) which are environmentally qualified actuate reactor scram for design basis accidents.

Signals to the ARI and RPT components are derived from instrument loops for reactor vessel level (LT-2-3-68A, B, C, and D) and pressure (PT-2-3-54A, B, C, and D). As described above, ARI/RPT components are not relied upon for the design basis LOCA in which harsh environments develop.

Associated trip modules share card files with other components required to accomplish safety functions. However, these card files are located in a mild environment and do not require environmental qualification. In addition, ARI/RPT components are classified as safety-related and it has been determined that failures of ARI/RPT components will not cause failure of safety-related equipment. The applicable associated components and Safety Functions are included in Volume 2 of the EQ Program Manual.

→TB30 Reactivity control is required for HELB events. The RPS components must be qualified for HELB if subject to a harsh environment and if failure could prevent or adversely affect a manual or automatic reactor scram. 18

Backup Scram Solenoids

The backup scram solenoids (SN 3-140A and B) do not require environmental qualification per Reference 21.

Scram Solenoid Fuse Panels

The scram solenoid fuses, fuse holders, and wire inside fuse panels (PNL 5-7A, B, C, D, E, F, G, and H) are associated electrical components to the scram solenoid valves (SO 3-13-117/118), and are located in the same Volumes (34 and 38).

For the RWCU HELB event only, these components require qualification to assure that no failure(s) could cause a reactor scram (and consequent loss of power) prior to closing of the RWCU System isolation valves. This requirement provides assurance that given a worst case single failure of the dc isolation valve (MOV 12-18) the RWCU HELB will be isolated without a 13 second emergency diesel startup delay for using the ac isolation valve (MOV 12-15). 18

This is necessary to insure that the resulting environments do not exceed the analyzed environments for a RWCU HELB which do not account for a loss of off-site power (13 second power interruption). For all other HELB events, a failure that results in a loss of off-site power will not impact the analyzed environments, therefore the scram solenoid fuse panel components need only be qualified not to fail for the RWCU HELB event. No scram solenoid fuse panel failure will prevent a scram. 18

The scram fuses, consistent with design criterion (i) in Section 5.2, are considered to be in a mild environment for the RWCU HELB event as justified by the following exception to design criterion (i) guidelines. The RWCU HELB environment for the scram fuses is 185°F peak. This temperature is not significantly more severe than normal operating design conditions for fuses. Typical fuse characteristics are illustrated on Page 20 of the BUSS, Bulletin SFB, dated August 1981. 18

Per the "Effect of Ambient Temperature on Operating Characteristics of Time Delay and Non-Time Delay Fuse" curves, a worst case reduction in current carrying capability of fuses is approximately 30% for an ambient temperature of 185°F (85°C). Since the normal operating current of the scram solenoids if 0.2 amps and the scram solenoid fuses are rated at 3.0 amps, significant margin exits in the sizing of these fuses, such that the 30% reduction will have negligible impact and will not cause inadvertent opening of the fuse. 18

Scram Solenoids Metal Oxide Varistors

Metal Oxide Varistors manufactured by General Electric Company are installed across scram solenoid coil for arc suppression to reduce relay contact wear. These components are considered associated electrical components of the scram solenoid valves (SO 3-13-117/118). It is a requirement that these components not fail during any accident so that the proper function of the scram solenoid valves can be assured.

For the LOCA accident, these components, located outside containment near the scram solenoids (Volumes 34 and 38) will function within 10 minutes per Safety Function Number 2 Description in Section 5.7. This is prior to harsh environment per Section 7.0. Subsequent failure will not impact any safety functions since once a scram occurs the scram solenoids are not needed. Therefore, these Metal Oxide Varistors (like the scram solenoids themselves) are Category D for LOCA. (See TB-29).

For HELB events, the environmental conditions for the Metal Oxide Varistors is not significantly more severe than normal operating design conditions for these devices. Consistent with design criterion (i) in Section 5.2, these are considered to be in a mild environment for HELBs as justified by the following exception to design criterion (i) guidelines.

Per the General Electric "SCR Manual" Fifth Edition, Copyright 1972, Page 656, the General Electric Family of Metal Oxide Varistors have the following ratings:

1) Maximum Operating Ambient Temperature

   (Without derating) of 85°C (185°F)

2) Maximum Operating Surface Temperature of 115°C (239°F)

3) Maximum Storage Temperature 125°C (257°F)

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The Metal Oxide Varistors are only operating (i.e., conducting at the instant a scram signal (contact opening) is applied. At all other times, these components, although installed in a circuit, are in the same state as if they were in "STORAGE".

The maximum HELB temperature in vicinity of these components is 242°F worst case and this is not a sustained temperature since per Section 7.0, HELB conditions return to normal within one (1) hour after isolation. Therefore, it is concluded that the environmental conditions of worst case HELB events are not stressful to General Electric Metal Oxide Varistors and are thus mild per 10CFR50.49 (i.e., "not significantly more severe than normal").

Standby Liquid Control System

The SLC components are not required for HELB events. (See Safety Function Number 2 description.)

Alternate Rod Insertion (ARI) and Recirculation Pump Trip (RPT)

The ARI and RPT functions are provided to mitigate "Anticipated Transients Without Scram (ATWS)." These functions are not relied upon for the design basis High Energy Line Break (HELB) accidents in which harsh environments develop. The scram solenoids at each hydraulic control unit (SO-3-117/118) which are environmentally qualified actuate reactor scram for design basis accidents.

Signals to the ARI and RPT components are derived from instrument loops for reactor vessel level (LT-2-3-68A, B, C, and D) and pressure (PT-2-3-54A, B, C, and D). As described above, these components are not relied upon for the design basis High Energy Line Break (HELB) accidents in which harsh environments develop.

Associated trip modules share card files with other components required to accomplish safety functions. However, these card files are located in a mild environment and do not require environmental qualification. In addition, ARI/RPT components are classified as safety-related and it has been determined that failures of ARI/RPT components will not cause failure of safety-related equipment. The applicable associated components and Safety Functions are included in Volume 2 of the EQ Program Manual.

Also, as discussed above for scram solenoid fuses, qualification must be such that no failures of nonqualified components could result in an inadvertent actuation of the ARI solenoids (SE-3-ARI-A/B) and scram the reactor during a reactor water clean-up HELB. Since the ARI solenoids themselves must energize to cause scram, they do not require environmental qualification.

TB31 The VAC-B subpanel provides vital ac power to reactor recirc pump controls and SRV position monitoring instruments. The reactor recirc pump controls are not required for any safety functions. However, per "Post-Accident Monitoring," Safety Function Number 10 description and in accordance with TB24, SRV position monitoring is required for six hours post-LOCA and HELB. Once the reactor is depressurized, relief valve operation can be determined by reactor pressure indication, and failure of SRV position monitoring components is not detrimental.

TB32 The IAC-A subpanel provides instrument ac power to numerous instruments in the Reactor Building. These include: RHR and RWCU conductivity, RWCU reject valve, CRD temperature recorder, SRM/IRM detector drives, HCU accumulator monitoring panels, and RX Building radiation audio alarms. Failure of these components for any event will not affect the safety functions required.

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TB83 The power supplies furnish power to trip cards in Cabinets 25-5A and 26-6A. The reactor trip function is accomplished by de-energizing the trip card output, thus a loss of power will also result in a trip condition. The main steam HELB itself will result in a trip condition which occurs prior to a harsh environment developing at the power supply location. Subsequent power supply failure will not adversely affect safety function as reactor scram will have already been accomplished. For this reason, the power supplies are classified Category D for MS HELB. Similarly, those RPS components powered form these power supplies which initiate or could affect reactor scram are also Category D.

TB84 These components provide a Control Room alarm of an analog instrument failure associated with the card file monitored. The design of the card file circuit boards is such that input-to-input isolation exists to prevent an output component from causing a failure of the associated card file. Therefore, component qualification is not required.

TB85 This valve is normally open and need not actively function for this accident. However, the valve is required to remain open for this accident.

TB86 This equipment provides the means to isolate the RB airlock door seal supply solenoid vales (SE-105-2A and 2B) from the nonqualified control panels. SE-105-2A and 2B are normally open, normally de-energized solenoid valves that allow instrument air to pressurize the airlock door seals. SE-105-2A and 2B are Safety Class 3 and SCE components. The control logic/components that control the solenoid valves are non-SCE and are not qualified. The Series 24 switches isolate the solenoid valves from the nonqualified equipment. This assures that a failure of the nonqualified components cannot inadvertently energize the door seals and cause a loss of secondary containment integrity.

TB87 This equipment causes an automatic isolation of the nonessential service water loads located in the Turbine Building and Reactor Building by closing V70-19A, V70-19B and V70-20. Automatic isolation occurs when the service water header pressure decreases below the setpoint for a sustained period of time. These conditions are indicative of service water pump run-out or of inadequate cooling flow to the diesel generators. Following a LOCA the operator is instructed to manually isolate these nonessential loads. Once isolated, the need for the automatic logic has been removed. If conditions were to require automatic isolation as a result of separation from the grid, combined with failure of a diesel generator to accept load, this would occur immediately following the accident, therefore, before the environment in the RHR corner rooms becomes harsh. Provisions have been made for the operator to bypass the automatic isolation circuit if required to re-open or maintain open these valves.

TB88 This component shares a common power supply with components that are required for this accident but has its own separate fuse to protect the power supply, therefore its failure will not impact the power source to other required equipment.

TB89 The transfer switch affects control of RV2-71A and RV2-71B. Failure during long term post-LOCA could result in inadvertent opening of valves, or could prevent valve opening when desired. The switch provides electrical isolation from local power and control at the ADS alternate control station in the RCIC Room.

TB90 The MSIVs do not directly isolate the RWCU o[illegible] the analysis assumes a FW temperature transi[illegible] due to high steam tunnel temperature. The s[illegible] sensors and the MSIVs must, therefore, be qu[illegible] RWCU/FW HELB in the steam tunnel but are not outside the steam tunnel.

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SAFETY FUNCTION	ACCIDENT	DISCUSSION
→ 2) REACTIVITY CONTROL	LOCA	RPS equipment must be qualified to function and scram the reactor by both automatic and manual signals following a LOCA. The Standby Liquid Control System is not required to be qualified since it is never expected to be needed for plant safety following a DBA (see FSAR Section 3.8.4). Failure of SLC components will not affect safety functions. It is assumed that the reactivity control safety function is performed within 10 minutes after a LOCA. Subsequent failure of RPS equipment will not affect plant safety.
	HELB	RPS equipment must be qualified to function and scram the reactor by both automatic and manual signals following any HELB event. A normal shutdown following a HELB is assumed to take no longer than 6 hours following break isolation before the reactor is subcritical. RPS equipment should be qualified for 6 hours following a HELB. On a case-by-case basis, justification may be developed to reduce the qualification duration for certain RPS components under certain HELB events. These justifications will be contained in the Technical Basis Notes (Section 5.6). The SLC System is not required for HELB events since no degraded core geometry is postulated for HELBs and the control rods will stop criticality.
3) PRIMARY AND SECONDARY CONTAINMENT ISOLATION	LOCA	PC and SC isolation equipment must be qualified to function and achieve isolation by both automatic and manual signals following a LOCA. Unless otherwise documented in technical basis notes, even normally closed valves must be qualified if they receive automatic isolation signals.

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SAFETY FUNCTION	ACCIDENT	DISCUSSION
	HELB	Provided they do not impact manual start of ECCS, automatic ECCS initiation components are not required for a HELB. Although the HPCI and RCIC systems would auto start (if available) should the level reach the low-low level, the most limiting HELB scenario assumes a loss of off-site power and HPCI and RCIC unavailable due to the HELB . For this case, the operator is relied upon to manually actuate ADS and low pressure core cooling systems. Manual initiation of appropriate ECCS is relied upon. Manual initiation components are included as part of the "Reactor Vessel Level and Pressure Control" safety function.
6) REACTOR VESSEL LEVEL AND PRESSURE CONTROL	LOCA	Reactor vessel level and pressure control is required long-term following any size LOCA. (See general EQ matrix Note 2.) The following systems/subsystems must be qualified: <u>HPCI</u> - small breaks - two hours <u>SRV/ADS</u> - small and intermediate breaks - six hours, backup to HPCI with margin* <u>A and B LPCI</u> - all breaks - long-term <u>A and B Core Spray</u> - all breaks - long-term *(See TB-28 for SRV requirements.) Sufficient valve position information to determine flow path is required for all above listed systems.

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SAFETY FUNCTION	ACCIDENT	DISCUSSION
		The RCIC System is not essential for LOCA mitigation. Its small capacity is designed for reactor isolation conditions rather than LOCA events. However, the RCIC System environment, if operated following a small break LOCA (2 hours), would not be significantly more severe than RCIC operation following a loss of off-site power anticipated operational occurrence. For TMI-type accidents where core damage occurs before the reactor pressure is reduced below the low pressure ECCS injection point, the ADS/SRV System alone can be relied upon to depressurize the reactor and allow LP Systems to flood vessel.
	HELB	Reactor vessel level and pressure control is required for all HELB events. At least two (2) redundant systems/subsystems must be qualified for each HELB. As a minimum, the following system/subsystems must be qualified for the listed HELBs.

HELB	REDUNDANT SYSTEMS/SUBSYSTEMS*
MAIN STEAM	SRV-ADS/A and B Core Spray
HPCI	SRV-ADS/A and B Core Spray
RCIC	SRV-ADS/A and B Core Spray
RWCU	SRV-ADS/A and B Core Spray

*(See TB-28 for SRV/ADS requirements.)

Although the relief valves/core spray path is the qualified path relied upon for all HELBs, blowdown through the relief valves would only be used if HPCI and RCIC are not available.

Per General EQ Matrix Note 3, unless otherwise noted, components shall be qualified for 7 days after the HELB.

Sufficient valve position information to determine flow path is required.

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5.4.3 Equipment Qualification Category Letter Code

A. Equipment that will experience harsh environmental conditions of this design basis accident and must function to mitigate such accidents. This equipment will be qualified to demonstrate operability in the accident environment for the time required for accident mitigation (as specified in Associated Technical Basis note(s)) with safety margin to failure.

B. Equipment that will experience harsh environmental conditions of this design basis accident within which it need not function for mitigation of this accident but through which it must not fail in a manner detrimental to plant safety or accident mitigation. This equipment will be qualified to demonstrate the capability to withstand any accident environment for the time during which it must not fail (as specified in Associated Technical Basis note(s)) with safety margin to failure.

The Category B qualification category includes those components that are relied upon to actively function prior to a harsh environment developing only, but whose failure due to subsequent harsh environment cannot be tolerated. The components must be qualified to withstand the subsequent harsh environment without experiencing a failure that could adversely impact any safety function.

C. Equipment that will experience harsh environmental conditions of this design basis accident within which it need not function for mitigation of this accident and whose failure (in any mode) is deemed not detrimental to plant safety or accident mitigation. This equipment need not be qualified for this accident environment, but will be qualified for its normal service environment as well as any other acciients for which this equipment is designated as Category A or B.

D. Equipment that will experience harsh environmental conditions of this design basis accident but the time period this equipment is relied upon to function (or not fail) is prior to the time when harsh environmental conditions develop.

This equipment need not function in the subsequent harsh environment for mitigation of this accident and its failure (in any mode) due to the subsequent harsh environmental conditions is deemed not detrimental to plant safety or accident mitigation. This equipment need not be qualified for this accident, but will be qualified for its normal service environment as well as any other accidents for which this equipment is designated as Category A or B.

E. Equipment that will not experience harsh environmental conditions of this design basis accident. This equipment will be qualified to demonstrate operability under the expected extremes of its normal service environment as well as any other accidents for which this equipment is designated as Category A or B.

TABLE 7.5.1 (Continued)

Reactor Building High Energy Line Break Environments

Location & RB Floor Elevation	Main Steam HELB Peak Temp.(F) Fig. No.	Main Steam HELB Press. Fig. No.	Main Steam HELB Humidity Fig. No.	HPCI HELB Peak Temp.(F) Fig. No.	HPCI HELB Press. Fig. No.	HPCI HELB Humidity Fig. No.	RCIC HELB Peak Temp.(F) Fig. No.	RCIC HELB Press. Fig. No.	RCIC HELB Humidity Fig. No.	RWCU HELB Peak Temp.(F) Fig. No.	RWCU HELB Press. Fig. No.	RWCU HELB Humidity Fig. No.	HHS HELB Peak Temp.(F) Fig. No.	HHS HELB Press. Fig. No.	HHS HELB Humidity Fig. No.
Vol. 11 El. 318'	M	M	M	M	M	M	114 HELB-11	M	100%	M	M	M	M	M	M
Vol. 12 El. 303'	125 HELB-12	M	100%	124 HELB-12	M	100%	120 HELB-12	M	100%	131 HELB-12	M	100%	112 HELB-12	M	100%
Vol. 13 El. 303'	117 HELB-13	M	100%	116 HELB-13	M	100%	113 HELB-13	M	100%	114 HELB-13	M	100%	111 HELB-13	M	100%
Vol. 14 El. 303'	114 HELB-14	M	100%	115 HELB-14	M	100%	M	M	M	M	M	M	M	M	M
Vol. 15 El. 303'	128 HELB-15	M	100%	126 HELB-15	M	100%	[illegible] HELB-15	M	100S	209 HELB-15	M	100%	112 HELB-15	M	100%
Vol. 16 Ph. Sep. El. 303'	M	M	M	M	M	M	M	M	M	214 HELB-16	M	100%	111 HELB-16	M	100%
Vol. 17 El. 303'	149 HELB-17	M	100%	140 HELB-17	M	100%	126 HELB-17	M	100%	173 HELB-17	M	100%	111 HELB-17	M	100%
Vol. 19 FP Hxs. El. 303'	139 HELB-19	M	100%	130 H3LB-19	M	100%	122 HELB-19	M	100%	128 HELB-19	M	100%	110 HELB-19	M	100%
Vol. 20 El. 280'	169 HELB-20	M	100%	160 HELB-20	M	100%	132 HELB-20	M	100%	138 HELB-20	M	100%	129 HELB-20	M	100%
Vol. 21 El. 280'	134 HELB-21	M	100%	137 HELB-21	M	100%	129 HELB-21	M	100%	167 HELB-21	M	100%	131 HELB-21	M	100%

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TABLE 7.5. (Continued)

Reactor Building High Energy Line Break Environments

Location & RB Floor Elevation	Main Steam HELB			HPCI HELB			RCIC HELB			RWCU HELB			HHS HELB		
	Peak Temp.(F) Fig. No.	Press. Fig. No.	Humidity Fig. No.	Peak Temp.(F) Fig. No.	Press. Fig. No.	Humidity Fig. No.	Peak Temp.(F) Fig. No.	Press. Fig. No.	Humidity Fig. No.	Peak Temp.(F) Fig. No.	Press. Fig. No.	Humidity Fig. No.	Peak Temp.(F) Fig. No.	Press. Fig. No.	Humidity Fig. No.
Vol. 22 El. 280'	133 HELB-22	M	100%	133 HELB-22	M	100%	126 HELB-22	M	100%	196 RWCU-22	M	100%	134 HELB-22	M	100%
Vol. 23 El. 280'	131 HELB-23	M	100%	131 HELB-23	M	100%	124 HELB-23	M	100%	212 HELB-23	M	100%	133 HELB-23	M	100%
Vol. 24 RWCU Hx. El. 280'	128 HELB-24	M	100%	129 HELB-24	M	100%	122 HELB-24	M	100%	213 HELB-24	M	100%	129 HELB-24	M	100%
Vol. 25 RWCU PP El. 280'	133 HELB-25	M	100%	133 HELB-25	M	100%	126 HELB-25	M	100%	213 HELB-25	M	100%	133 HELB-25	M	100%
Vol. 26 RWCU PP El. 280'	133 HELB-26	M	100%	133 HELB-26	M	100%	126 HELB-26	M	100%	196 HELB-26	M	100%	133 HELB-26	M	100%
Vol. 27 El. 280'	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6	Note 6
Vol. 28 El. 280'	141 HELB-28	M	100%	132 HELB-28	M	100%	122 HELB-28	M	100%	129 HELB-28	M	100%	136 HELB-28	M	100%
Vol. 29 El. 280'	159 HELB-29	M	100%	153 HELB-29	M	100%	128 HELB-29	M	100%	133 HELB-29		100%	130 HELB-29	M	100%
Vol. 30 El. 252'	187 HELB-30	M	100%	186 HELB-30	M	100%	184 HELB-30	M	100%	175 HELB-30	M	100%	177 HELB-30	M	100%
Vol. 31 HM Rm. El. 252'	M	M	M	M	M	M	111 HELB-31	M	100%	M	M	M	M	M	M

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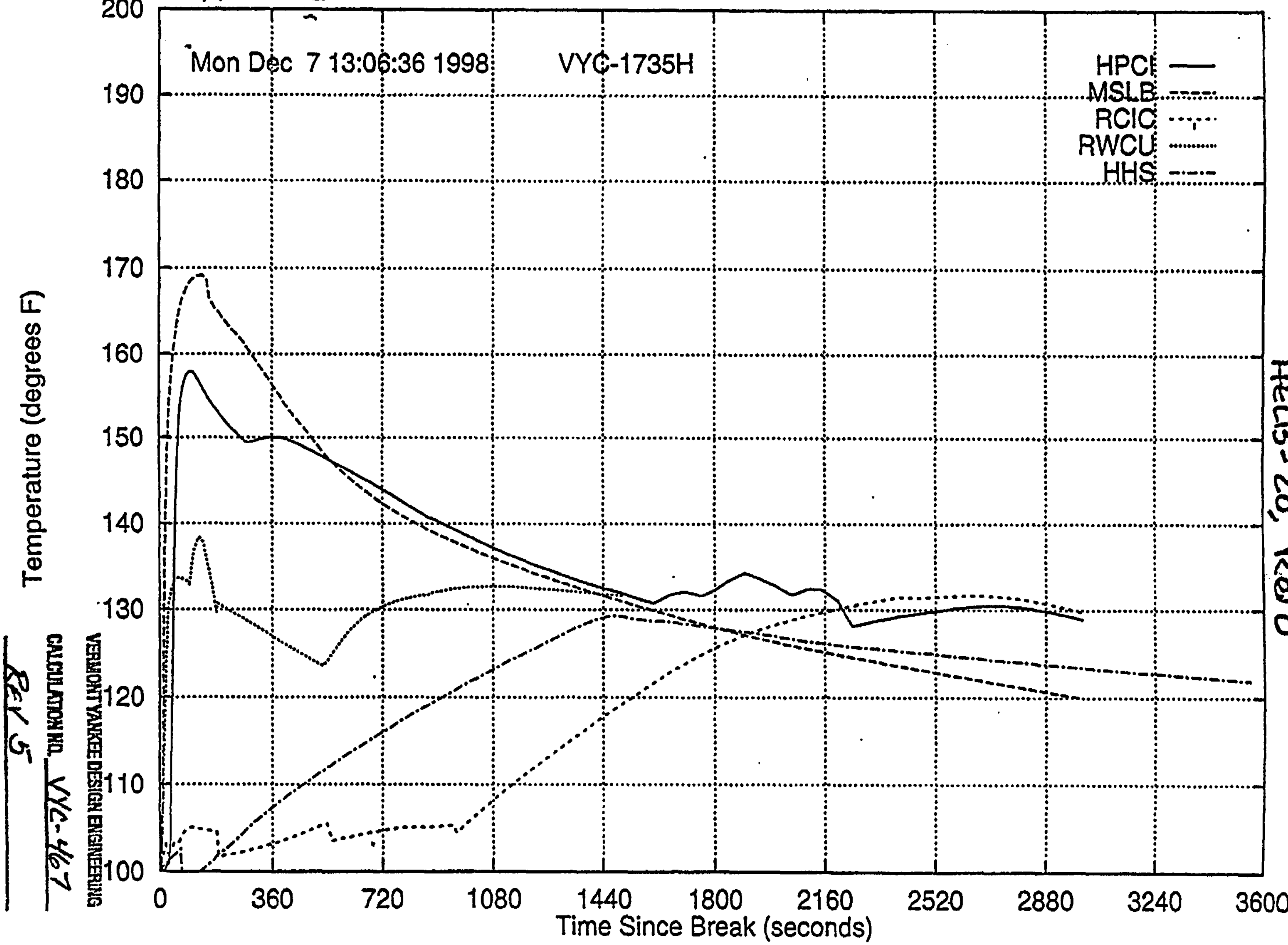
Volume 20 Temperature versus Time



HELB-20, Rev 0

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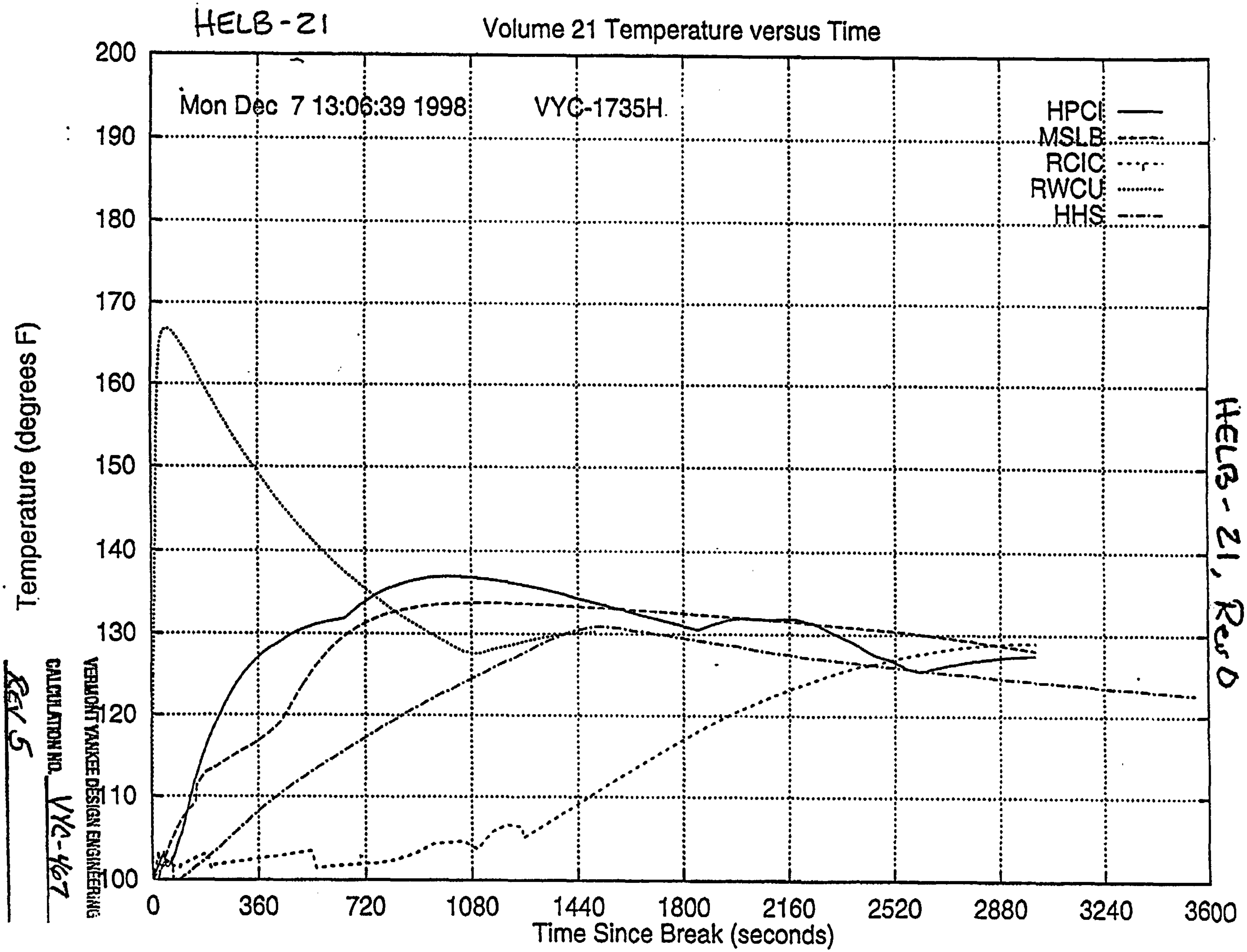
HELB-21



HELB-21, Rev 0

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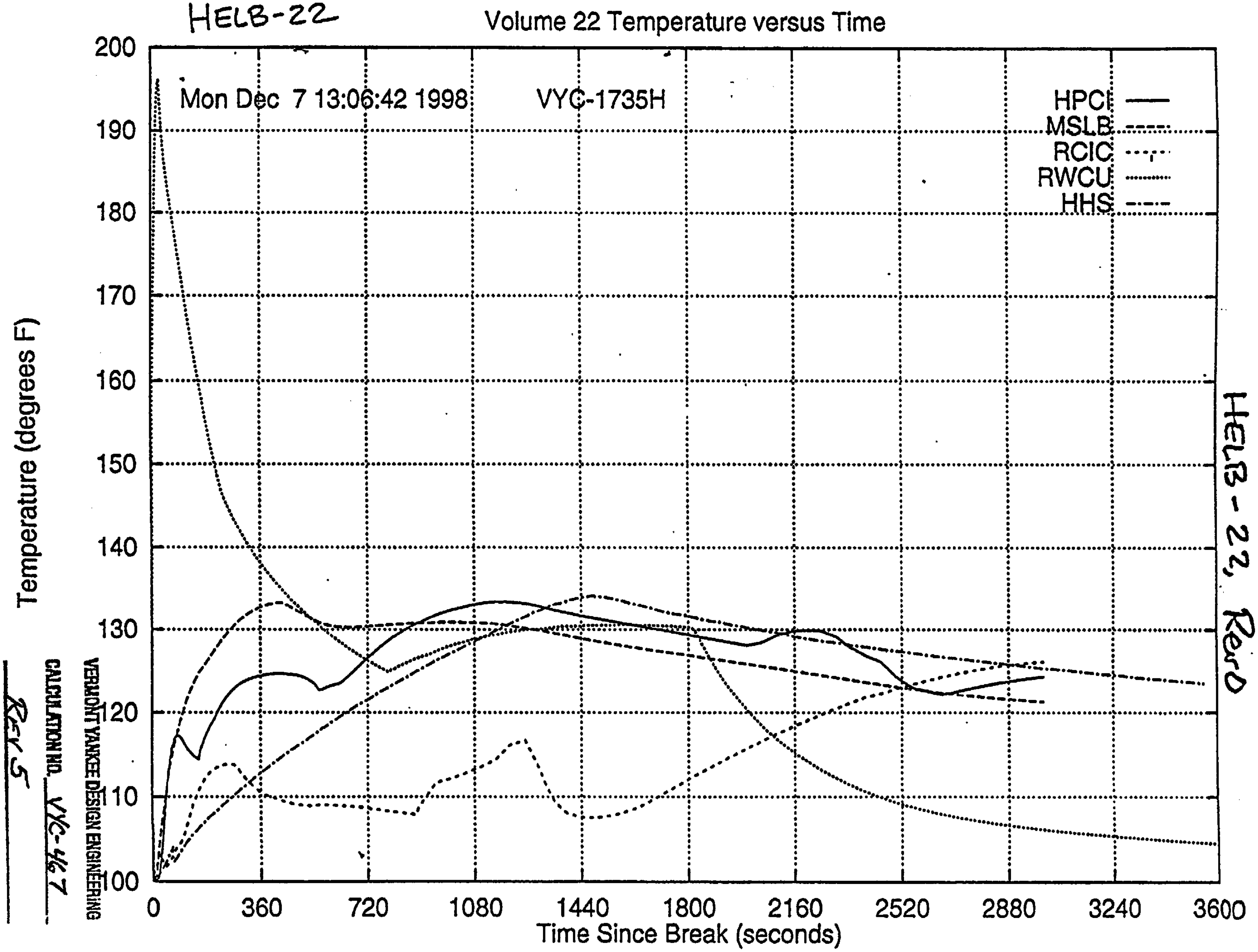
HELB-22



HELB-22, Rev0

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TABLE A1

Limiting Reactor Building And Drywell Normal Operating Doses And Dose Rates At VYNPS For Equipment Qualification

ELEV.	AREA	RAD/hr	RAD/40yr
213'-9"	Torus<10' Above Floor	.1	35000
	NE Corner	.5	175000
	SE Corner	.5	175000
	SW Corner	.1	35000
	NW Corner	.1	35000
	HPCI Room	.1	35000
232'-6"	NE Corner	.05	17500
	SE Corner	.05	17500
	SW Corner	.01	3500
	NW Corner	.01	3500
250'	Steam Tunnel	10.	3.5 E6
252'-6"	Neut Monitor Room	10.	3.5 E6
	RHR Piping Area	.02	7000
	(Pers. Access Lock)		
	CRD Repair	.10	35000
	PC Personnel Hatch	.005*	1800*
	>8' Off Floor	5.0	1.75 E6
	Remainder	.05	17500
280'	RWCU Pumps & Lines	.5	175000
	SGTS Room & Outer Area	.01	3500
	Heat Ex Room & Lines	1.0	3.5 E5
	Instrument Line Penetrations	.2	70000
	Spent Fuel Pool Lines	.25	88000
	Floor Drain Line	.10	35000
	→ Remainder	.01	3500
303'	RWCU Phase SEP. RM	5.0	1.75 E6
	Hot Maintenance Shop	.1γ/.5β	3.5E4 γ/1.75E4 β
	Spent Fuel Heat Ex	2.0	7.0 E5
	Dryer Separator Drain Line	.10	35000
	Remainder	.05	17500
318'	RWC Holding Pumps	1.0	
	Skimmer Pump RM	1.0	
	Fuel Pool Piping	.10	
	Remainder	.01	
345'-2"	Spent Fuel Pool	.01	
	Remainder	.01	

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* Neutron Dose Only – γ Dose is equal to "Remainder"

NOTE: All doses are for gamma rays only, unless otherwise noted.

Vermont Yankee Limiting Radiation Dose Specifications
(Extracted from Reference 3)

Area: Building and Floor Elevation	Area: Volume	Area: Description	Radiation Dose (Notes 1 and 2): No Beta Shield(7)	Radiation Dose (Notes 1 and 2): Beta Shield(7)
RB 280 (6)	20,21,22,28 29 (remaining portion)	All Except:	1.2×10^6	8×10^5
	23,25,26,27	RWCU Pump Rooms	1.5×10^6	1×10^6
	24	RWCU Heat Ex. Room	1.7×10^6	1.2×10^6
	29 SGTS Room Only	SGTS Room	7×10^8 (3)	7×10^8 (3)
	29 SGTS Outer Area Only	SGTS Outer Area	1.9×10^6	1.5×10^6
RB 303 (6)	12,13,15,17 (except near dryer sep. drain line)	All Except:	6×10^5	8×10^4
	16	RWCU Phase Sep. Room	3.1×10^6	3×10^6

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Attachments:								
1	3	Pgs	14	1	Pg	27	3	Pgs
2	1	Pg	15	4	Pgs	28	6	Pgs
3	14	Pgs	16	2	Pgs	29	6	Pgs
4	58	Pgs	17	3	Pgs	30	4	Pgs
5	11	Pgs	18	4	Pgs	31	7	Pgs
6	25	Pgs	19	4	Pgs	32	4	Pgs
7	1	Pg	20	4	Pgs	33	5	Pgs
8	18	Pgs	21	8	Pgs	34	1	Pg
9	1	Pg	22	8	Pgs	35	1	Pg
10	5	Pgs	23	2	Pgs	36	1	Pg
11	7	Pgs	24	3	Pgs	37	1	Pg
12	19	Pgs	25	4	Pgs	38	*6	Pg
13	4	Pgs	26	12	Pgs			

Total Pages: 53 + ~~266~~ 271* = ~~319~~ 324*

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YANKEE NUCLEAR SERVICES DIVISION
CALCULATION/ANALYSIS FOR

TITLE: MEASURING & TEST EQUIPMENT UNCERTAINTY CALCULATION

PLANT: VERMONT YANKEE CYCLE: 20

CALCULATION NUMBER: VYC-1758

	PREPARED BY /DATE	REVIEWED BY /DATE	APPROVED BY /DATE	SUPERSEDES CALC. /REV. NO.
ORIGINAL	JH Lewis 5/29/98 (signed) JH Lewis 5/29/98	(signed) Dave Willis 5/31/98	(signed) 10-28-98 George Hengele	N/A
REVISION 1				
REVISION 2				
REVISION 3				

KEYWORDS: Calculation/Uncertainty/Test/Equipment/Multimeter/Gauge/Thermometer/Voltage/Source

COMPUTER CODES: Microsoft Excel 97 SR-1

EQUIP/TAG NOs.: Refer to Table 1 Equipment Summary

SYSTEMS: M&TE

REFERENCES: Refer to Section 6

MODELS: Ashcroft 1082AS; Brooklyn Thermometer; Electro-Scientific Inc. DB-52, 62, 655, 877, DC-57; Fluke 27, 77, 87, 8062A, 8520A; Heise CM, CMM, 730, 901; HP 3466A, 34401A; Jofra 600S, Omega 4A, 8A, CL-505A, 868F, 2176A; Rosemount Readout Assembly; Transmation 1040

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Transmitted by CA
To. Stpt Coordinator

Tag Number	Description	Sys	Manufacturer	Model	Range	Ref
VY-5568	Digital Pressure Gauge	M&TE	Heise	901B	0-200 PSIG	Att. 24
VY-L-2775	Digital Pressure Gauge	M&TE	Heise	901B	0-2000 PSIG	Att. 24
VY-5656	Digital Pressure Gauge	M&TE	Heise	901B	0-600 PSIG	Att. 24
VY-5591	Digital Pressure Gauge	M&TE	Heise	901B	0-100"H_2O	Att. 24
VY-5566	Digital Pressure Gauge	M&TE	Heise	901B	0-1000"H_2O	Att. 24
VY-5592	Digital Pressure Gauge	M&TE	Heise	901B	0-1500 PSIG	Att. 24
VY-6124	Digital Pressure Gauge	M&TE	Heise	901B	0-400"H_20	Att. 24
VY-5663	Digital Pressure Gauge	M&TE	Heise	901B	30"Hg VAC	Att. 24
VY-L-2706	Dial Pressure Gauge	M&TE	Heise	CM-120219	0-30 PSIG/0-830"H2O	Att. 22
VY-6567	Dial Pressure Gauge	M&TE	Heise	CM-124323	0-30 PSIG/0-800"H_2O	Att. 22
VY-6575	Dial Pressure Gauge	M&TE	Heise	CM-124324	0-30"Hg VAC/0-15 PSIA	Att. 22
VY-6576	Dial Pressure Gauge	M&TE	Heise	CM-124325	0-30"Hg VAC/0-15 PSIA	Att. 22
VY-L-2382	Dial Pressure Gauge	M&TE	Heise	CMM-111518	0-100 PSIG	Att. 22
VY-L-2473	Dial Pressure Gauge	M&TE	Heise	CMM-114952	0-50 PSIG	Att. 22
VY-L-2468	Dial Pressure Gauge	M&TE	Heise	CMM-114953	0-100 PSIG	Att. 22
VY-L-2469	Dial Pressure Gauge	M&TE	Heise	CMM-114954	0-300 PSIG	Att. 22
VY-L-2467	Dial Pressure Gauge	M&TE	Heise	CMM-114955	0-600 PSIG	Att. 22
VY-L-2675	Dial Pressure Gauge	M&TE	Heise	CMM-118096	0-2000 PSIG	Att. 22
VY-L-2707	Dial Pressure Gauge	M&TE	Heise	CMM-120218	0-1500 PSIG	Att 22
VY-L-2783	Dial Pressure Gauge	M&TE	Heise	CMM-122276	0-200 PSIG	Att. 22
VY-L-2784	Dial Pressure Gauge	M&TE	Heise	CMM-122277	0-600 PSIG	Att. 22
VY-6562	Dial Pressure Gauge	M&TE	Heise	CMM-124308	0-60 PSIG	Att. 22
VY-6568	Dial Pressure Gauge	M&TE	Heise	CMM-124309	0-60 PSIG	Att. 22
VY-6563	Dial Pressure Gauge	M&TE	Heise	CMM-124310	0-150 PSIG	Att. 22
VY-6559	Dial Pressure Gauge	M&TE	Heise	CMM-124311	0-150 PSIG	Att. 22
VY-6569	Dial Pressure Gauge	M&TE	Heise	CMM-124312	0-150 PSIG	Att. 22
VY-6564	Dial Pressure Gauge	M&TE	Heise	CMM-124313	0-200 PSIG	Att. 22
VY-6560	Dial Pressure Gauge	M&TE	Heise	CMM-124314	0-300 PSIG	Att. 22
VY-6570	Dial Pressure Gauge	M&TE	Heise	CMM-124315	0-400 PSIG	Att. 22
VY-6565	Dial Pressure Gauge	M&TE	Heise	CMM-124316	0-400 PSIG	Att. 22
VY-6561	Dial Pressure Gauge	M&TE	Heise	CMM-124317	0-600 PSIG	Att. 22
VY-6571	Dial Pressure Gauge	M&TE	Heise	CMM-124318	0-1500 PSIG	Att. 22
VY-6572	Dial Pressure Gauge	M&TE	Heise	CMM-124319	0-2000 PSIG	Att. 22
VY-6573	Dial Pressure Gauge	M&TE	Heise	CMM-124320	0-5000 PSIG	Att. 22
VY-6566	Dial Pressure Gauge	M&TE	Heise	CMM-124321	0-30"Hg VAC - 30 PSIG	Att. 22
VY-6574	Dial Pressure Gauge	M&TE	Heise	CMM-124322	0-30"Hg VAC - 30 PSIG	Att. 22
VY-5749	Digital Multimeter	M&TE	HP DMM	34401A	VDC/VAC/Ohms/Amps	Att. 26
VY-5832	Digital Multimeter	M&TE	HP DMM	34401A	VDC/VAC/Ohms/Amps	Att. 26
VY-5833	Digital Multimeter	M&TE	HP DMM	34401A	VDC/VAC/Ohms/Amps	Att. 26
VY-6554	Digital Multimeter	M&TE	HP DMM	34401A	VDC/VAC/Ohms/Amps	Att. 26
VY-6555	Digital Multimeter	M&TE	HP DMM	34401A	VDC/VAC/Ohms/Amps	Att. 26
VY-6556	Digital Multimeter	M&TE	HP DMM	34401A	VDC/VAC/Ohms/Amps	Att. 26
VY-6557	Digital Multimeter	M&TE	HP DMM	34401A	VDC/VAC/Ohms/Amps	Att. 26
VY-6558	Digital Multimeter	M&TE	HP DMM	34401A	VDC/VAC/Ohms/Amps	Att. 26
VY-5559	Digital Multimeter	M&TE	HP DMM	3466A	VDC/VAC/Ohms/Amps	Att. 25
VY-5570	Digital Multimeter	M&TE	HP DMM	3466A	VDC/VAC/Ohms/Amps	Att. 25
VY-5571	Digital Multimeter	M&TE	HP DMM	3466A	VDC/VAC/Ohms/Amps	Att. 25
VY-5572	Digital Multimeter	M&TE	HP DMM	3466A	VDC/VAC/Ohms/Amps	Att. 25
VY-5672	Digital Multimeter	M&TE	HP DMM	3466A	VDC/VAC/Ohms/Amps	Att. 25
	r	M&TE	Jofra	EVJ-600-S	70-1112°F/21.1-600°C	Att. 27
		M&TE	Omega	2176A	Multiple Temp Rngs	Att. 31
		M&TE	Omega	2176A	Multiple Temp Rngs	Att. 31
		M&TE	Omega	4A-110	Multiple Temp Rngs	Att. 28
		M&TE	Omega	868F	Multiple Temp Rngs	Att. 30

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Tag Number	Description	Sys	Manufacturer	Model	Ranges	Ref
~~VY-L-2549~~	~~Digital Thermometer~~	~~M&TE~~	~~Omega~~	~~868F~~	~~Multiple Temp Rngs~~	~~Att. 30~~
VY-L-2550	Digital Thermometer	M&TE	Omega	868F	Multiple Temp Rngs	Att. 30
VY-5737	Digital Thermometer	M&TE	Omega	8A-110	Multiple Temp Rngs	Att. 28
~~VY-6577~~	~~Digital Thermometer~~	~~M&TE~~	~~Omega~~	~~CL-505A~~	~~Multiple Temp Rngs~~	~~Att. 28~~
VY-5635	Readout Assembly - Trip Unit Calibrator	M&TE	Rosemount	710DUORA1	0-28mADC	Att. 32
VY-5636	Readout Assembly - Trip Unit Calibrator	M&TE	Rosemount	710DUORA1	0-28mADC	Att. 32
~~VY-2553~~	~~Digital Calibrator~~	~~M&TE~~	~~Transmation~~	~~1040~~	~~0-110mV/0-11V/~~ 0-22mA/0-54mA	~~Att. 33~~
VY-6551	Digital Calibrator	M&TE	Transmation	1040	0-110mV/0-11V/ 0-22mA/0-54mA	Att. 33
VY-6552	Digital Calibrator	M&TE	Transmation	1040	0-110mV/0-11V/ 0-22mA/0-54mA	Att. 33
VY-6553	Digital Calibrator	M&TE	Transmation	1040	0-110mV/0-11V/ 0-22mA/0-54mA	Att. 33
VY-L-0649	Digital Calibrator	M&TE	Transmation	1040	0-110mV/0-11V/ 0-22mA/0-54mA	Att. 33
VY-L-0650	Digital Calibrator	M&TE	Transmation	1040	0-110mV/0-11V/ 0-22mA/0-54mA	Att. 33
VY-L-2676	Digital Calibrator	M&TE	Transmation	1040	0-110mV/0-11V/ 0-22mA/0-54mA	Att. 33
VY-L-492	Digital Calibrator	M&TE	Transmation	1040	0-110mV/0-11V/ 0-22mA/0-54mA	Att. 33
VY-L-493	Digital Calibrator	M&TE	Transmation	1040	0-110mV/0-11V/ 0-22mA/0-54mA	Att. 33

1.3. Instrument Function (Abbreviated)

M&TE is required for surveillance or maintenance of Technical Specifications, Safety-Related, In-service Testing, and Environmental Qualification equipment throughout the plant. M&TE is traceable to NIST through Vermont Yankee Working standards or approved calibration facility standards. E & C M&TE is also used to calibrate other M&TE, Operations Department M&TE and other Special Test equipment as required. Special Test equipment is specifically calibrated for special tests, e.g., gauges, etc.

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3.2.6. Heise Test Gauges

Table 17 - Heise 901 Gauge Uncertainties (Attachments 5 & 24)

Model	Range	Resolution	RA	CT
901A	(-)28 TO +30"HG	0.001	0.070% span	0.100% span
901A	0-150 PSIG	0.01	0.070% span	0.100% span
901A	0-300 PSIG	0.01	0.070% span	0.100% span
901A	0-400 PSIG	0.1	0.070% span	0.100% span
901B	0-10 PSIG	0.001	0.035% span	0.050% span
901B	30"Hg VAC	0.001	0.035% span	0.100% span
901B	0-50"H_2O	0.01	0.035% span	0.040% span
901B	0-100"H_2O	0.01	0.035% span	0.050% span
901B	0-150"H_2O	0.01	0.035% span	0.050% span
901B	0-200 PSIG	0.01	0.035% span	0.050% span
901B	0-400"H_20	0.01	0.035% span	0.050% span
901B	0-600 PSIG	0.01	0.035% span	0.050% span
901B	0-1000"H_2O	0.1	0.035% span	0.050% span
901B	0-1500 PSIG	0.1	0.035% span	0.050% span
901B	0-2000 PSIG	0.1	0.035% span	0.050% span

Notes for Table 17:

1. RA = Reference Accuracy includes sensitivity, linearity, repeatability and hysteresis.
2. CT = Calibration Tolerance
3. CE = Calibration Effect = CT
4. RE = Resolution Error (Resolution/Span)
5. TE = Temperature Effect (±0.004% of Reading x Max Delta T)/Span
6. Zero Temperature Effects are assumed to be calibrated out at time of use.
7. Temperature Errors: Zero = ± 0.004% of span/Deg F; Span = ± 0.004% of reading based on a ref temp of 70 over specified rng 45-95 or 20-120°F.

Table 18 - Heise 730 Gauge Uncertainties (Attachments 5 & 23)

Range	Resolution	RA	CT
(-)4-31 PSIG	0.01	0.100% span	0.100% span
(-)100-860"H_2O	0.1	0.100% span	0.100% span

Notes for Table 18:

1. RA = Reference Accuracy (±0.100% Span) includes sensitivity, linearity, repeatability and hysteresis.
2. CT = Calibration Tolerance (±0.100% Span
3. CE = Calibration Effect = CT
4. RE = Resolution Error (Resolution/Span)
5. TE = Temperature Effect (±0.004% of Span x Max Delta T)/Span
6. Vendor specified TE is based on a 73°F reference calibration temperature this calculation assumes calibration temperature of 70°F.
7. Temperature Errors: Maximum = ± 0.004% of span/Deg F based on a reference temp of 73 over the temperature span 45-95 or 25-125°F.

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Table 19 - Heise CM & CMM Gauge Uncertainties (Attachments 5 & 22)

Range	Minor Division	RA	CT	HYS	RPT	SENS
0-15 PSIA	0.02	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-30 PSIG	0.05	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-30"Hg VAC	0.05	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-50 PSIG	0.05	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-60 PSIG	0.05	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-100 PSIG	0.1	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-150 PSIG	0.1	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-200 PSIG	0.2	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-300 PSIG	0.2	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-400 PSIG	0.5	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-600 PSIG	0.5	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-800"H_2O	1	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-830"H_2O	1	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-1500 PSIG	1	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-2000 PSIG	2	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
0-5000 PSIG	5	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
30"Hg VAC - 30 PSIG	0.1 "Hg	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span
30"Hg VAC - 30 PSIG	0.05 PSIG	0.1% span	0.1% span	0.1% span	0.02% span	0.01% span

Notes for Table 19:

1. RA = Reference Accuracy (±0.100% Span).
2. CT = Calibration Tolerance (±0.100% Span)
3. CE = Calibration Effect = CT
4. RE = Resolution Error (Minor Division/4) /Span
5. HYS = Hysteresis (±0.100% Span)
6. RPT = Repeatability (±0.02% Span)
7. SENS = Sensitivity (±0.01% Span)
8. TE = Temperature Effect [0.1% of Span x (Max Delta T/50°F)]/Span

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Table 21 - HP 34401A Digital Multimeter Uncertainties (Attachments 6 & 26)

Units	Range	Max Display	Accuracy (1 year)	Nom Temp	Temperature Effect
VDC	100 mVDC	100.0000mV	±0.005% rdg + 0.0035% rng	23 ± 5°C	±(0.0005% rdg + 0.0005% rng)/°C if out nml rng
VDC	1 VDC	1.000000V	±0.004% rdg + 0.0007% rng	23 ± 5°C	±(0.0005% rdg + 0.0001% rng)/°C if out nml rng
VDC	10 VDC	10.00000V	±0.0035% rdg + 0.0005% rng	23 ± 5°C	±(0.0005% rdg + 0.0001% rng)/°C if out nml rng
VDC	100 VDC	100.0000V	±0.0045% rdg + 0.0006% rng	23 ± 5°C	±(0.0005% rdg + 0.0001% rng)/°Cif out nml rng
VDC	1000 VDC	1000.000V	±0.0045% rdg + 0.001% rng	23 ± 5°C	±(0.0005% rdg + 0.0001% rng)/°C if out nml rng
VAC	100 mVAC	100.0000 mVAC	Frequency Dependent	23 ± 5°C	Frequency Dependent
VAC	1 VAC	1.000000 VAC	Frequency Dependent	23 ± 5°C	Frequency Dependent
VAC	10 VAC	10.00000 VAC	Frequency Dependent	23 ± 5°C	Frequency Dependent
VAC	100 VAC	100.0000 VAC	Frequency Dependent	23 ± 5°C	Frequency Dependent
VAC	750 VAC	750.000 VAC	Frequency Dependent	23 ± 5°C	Frequency Dependent
Hz	3 - 5 Hz	100 mVAC	±1.0% rdg + 0.04% rng	See VAC	±(0.1% rdg + 0.004% rng)/°C if out nml rng
Hz	5 - 10 Hz	100 mVAC	±0.35% rdg + 0.04% rng	See VAC	±(0.035% rdg + 0.004% rng)/°C if out nml rng
Hz	10Hz - 20kHz	100 mVAC	±0.06% rdg + 0.04% rng	See VAC	±(0.005% rdg + 0.004% rng)/°Cif out nml rng
Hz	20-50 kHz	100 mVAC	±0.12% rdg + 0.05% rng	See VAC	±(0.011% rdg + 0.005% rng)/°Cif out nml rng
Hz	50-100 kHz	100 mVAC	±0.6% rdg + 0.08% rng	See VAC	±(0.06% rdg + 0.008% rng)/°C if out nml rng
Hz	100-300kHz	100 mVAC	±4.0% rdg + 0.5% rng	See VAC	±(0.2% rdg + 0.02% rng)/°C if out nml rng
Hz	3 - 5 Hz	1 - 750 VAC	±1.0% rdg + 0.03% rng	See VAC	±(0.1% rdg + 0.003% rng)/°C if out nml rng
Hz	5 - 10 Hz	1 - 750 VAC	±0.35% rdg + 0.03% rng	See VAC	±(0.035% rdg + 0.003% rng)/°C if out nml rng
Hz	10Hz - 20kHz	1 - 750 VAC	±0.06% rdg + 0.03% rng	See VAC	±(0.005% rdg + 0.003% rng)/°C if out nml rng
Hz	20-50kHz	1 - 750 VAC	±0.12% rdg + 0.05% rng	See VAC	±(0.011% rdg + 0.005% rng)/°C if out nml rng
Hz	50-100kHz	1 - 750 VAC	±0.6% rdg + 0.08% rng	See VAC	±(0.06% rdg + 0.008% rng)/°C if out nml rng
Hz	100-00 kHz	1 - 750 VAC	±4.0% rdg + 0.5% rng	See VAC	±(0.2% rdg + 0.02% rng)/°C if out nml rng
ADC	10 mADC	10.00000 mA	±0.05% rdg + 0.02% rng	23 ± 5°C	±(0.002% rdg + 0.002% rng)/°Cif out nml rng
ADC	100 mADC	100.0000 mA	±0.05% rdg + 0.005% rng	23 ± 5°C	±(0.002% rdg + 0.0005% rng)/°Cif out nml rng
ADC	1 ADC	1.000000 A	±0.1% rdg + 0.01% rng	23 ± 5°C	±(0.005% rdg + 0.001% rng)/°C if out nml rng
ADC	3 ADC	3.000000 A	±0.12% rdg + 0.02% rng	23 ± 5°C	±(0.005% rdg + 0.002% rng)/°Cif out nml rng
Ohms	100Ω	100.0000Ω	±0.01% rdg + 0.004% rng	23 ± 5°C	±(0.0006% rdg + 0.0005% rng)/°Cif out nml rng
Ohms	1kΩ	1.000000kΩ	±0.01% rdg + 0.001% rng	23 ± 5°C	±(0.0006% rdg + 0.0001% rng)/°C if out nml rng
Ohms	10kΩ	10.00000kΩ	±0.01% rdg + 0.001% rng	23 ± 5°C	±(0.0006% rdg + 0.0001% rng)/°C if out nml rng
Ohms	100kΩ	100.0000kΩ	±0.01% rdg + 0.001% rng	23 ± 5°C	±(0.0006% rdg + 0.0001% rng)/°Cif out nml rng
Ohms	1MΩ	1.000000MΩ	±0.01% rdg + 0.001% rng	23 ± 5°C	±(0.001% rdg + 0.0002% rng)/°Cif out nml rng
Ohms	10MΩ	10.00000MΩ	±0.04% rdg + 0.001% rng	23 ± 5°C	±(0.003% rdg + 0.0004% rng)/°C if out nml rng
Ohms	100MΩ	100.0000MΩ	±0.8% rdg + 0.01% rng	23 ± 5°C	±(0.15% rdg + 0.0002% rng)/°C if out nml rng
AAC	1A	1.000000 A	Frequency Dependent	23 ± 5°C	Frequency Dependent
AAC	3A	3.000000 A	Frequency Dependent	23 ± 5°C	Frequency Dependent
Hz	3 - 5 Hz	1A	±1.0% rdg + 0.04% rng	See AAC	±(0.1% rdg + 0.006% rng)/°C if out nml rng
Hz	5 Hz - 10 Hz	1A	±0.3% rdg + 0.04% rng	See AAC	±(0.035% rdg + 0.006% rng)/°Cif out nml rng
Hz	10 Hz - 5 kHz	1A	±0.1% rdg + 0.04% rng	See AAC	±(0.015% rdg + 0.006% rng)/°Cif out nml rng
Hz	3 - 5 Hz	3A	±1.1% rdg + 0.06% rng	See AAC	±(0.1% rdg + 0.006% rng)/°C if out nml rng
Hz	5 Hz - 10 Hz	3A	±0.35% rdg + 0.06% rng	See AAC	±(0.035% rdg + 0.006% rng)/°C if out nml rng
Hz	10 Hz - 5 kHz	3A	±0.15% rdg + 0.06% rng	See AAC	±(0.015% rdg + 0.006% rng)/°C if out nml rng

Notes for Table 20 & 21:

1. RE = Resolution/Reading
2. SENS = Sensitivity is assumed to be included in the RA & Resolution Errors
3. RA = Reference Accuracy is based on Max Reading of desired cal span (Not Range of DMM).
4. TE = Temperature Effect is based on Max Reading of desired cal span (Not Range of DMM).

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3.2.10. Rosemount Readout Assembly

Table 31 Rosemount Readout Assembly Uncertainties (Attachments 9 & 32)

Range	Max Display	Accuracy	Temperature Effect	Resolution
0-10mA	10.00mA	± 0.01mA	No effect if within operating temp range	± 0.01mA
9-19mA	19.00mA	± 0.01mA	No effect if within operating temp range	± 0.01mA
18-28mA	28.00mA	± 0.01mA	No effect if within operating temp range	± 0.01mA

Notes for Table 30:
1. RE = Resolution/Reading
2. Normal Operating Temperature Range 40 - 104°F
3. The operating temperature range is assumed to bound all testing temperatures at Vermont Yankee.
4. RA = Reference Accuracy is based on Max Reading of desired calibration span (Not Range).
5. Total Units (TDE_{rdout}) is based on Max Reading of desired calibration span (Not Range).

3.2.11. Transmation 1040S & SP

Table 32 Transmation 1040S & SP Uncertainties (Attachments 10 & 33)

Output Range	Max Display	Accuracy	Temperature Effect	Sensitivity (Full Scale)	Repeatability (Range)	Pwr Supply Effect
0-110mV	110.00mV	± 0.06% of rng + 0.06% of rdg max	± 0.0015% rng/°F	0.01%	0.02%	< ± 2 Count shift (5.3 - 4.7v)
0-11V	11.000V	± 0.04% of rng + 0.03% of rdg max	± 0.0015% rng/°F	0.01%	0.02%	< ± 2 Count shift (5.3 - 4.7v)
0-22mA	22.00mA	± 0.12% of rng + 0.06% of rdg max	± 0.0015% rng/°F	0.05%	0.02%	< ± 2 Count shift (5.3 - 4.7v)
0-54mA	54.00mA	± 0.06% of rng + 0.06% of rdg max	± 0.0015% rng/°F	0.02%	0.02%	< ± 2 Count shift (5.3 - 4.7v)

Notes for Table 30:
1. RA = Reference Accuracy, based on Max Reading of desired calibration span (Not Range).
2. RE = Resolution Error (Resolution/Reading).
3. TE = Temperature Effect, based on Max Reading of desired calibration span (Not Range).
4. SENS = Sensitivity (% of Full Scale)
5. PS = Power Supply Effect (±2 Count Shift for variations 5.3 to 4.7VDC).
6. Repeat = Repeatability (% Range).
7. Recommended Ambient Temperature Range 0 - 110°F

4. CALCULATION DETAIL

The detailed calculation of the module uncertainties and loop uncertainties has been done using Microsoft Excel Version 97 SR-1 and is documented as Attachments 1 through 10. For greater detail of the values presented in the body of this calculation refer to the attachments listed. [Att. 1-10, Ref. 6.1.2]

Standard Terms used within this calculation

CE = Calibration Effect
CT = Calibration Tolerance
HYS = Hysteresis
RA = Reference Accuracy
RE = Resolution Error
RPT = Repeatability
TDE = Total Device Error
TE = Temperature Effect or Temperature Coef.

Max ΔT = Maximum temperature differential between reference calibration temperature and room or area temperature where MTE is to be used.

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Table 62 Fluke Model 8520A Digital Multimeter Ohmic Ranges Total Device Errors (Attachment 4)

Fluke 8520A	Area of Plant		Control Room		RB RHR Cnr Rm 232		TB Occupied Areas		RB Occupied Areas		RB RHR Cnr Rm 213'	
ΔT from ref temp of 21°C			2.44°C ΔT		12°C ΔT		12.56°C ΔT		13.11°C ΔT		14.78°C ΔT	
Reading	Units	Range	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units
10	Ω	19.9999	0.0261%	0.00261	0.0282%	0.00282	0.0284%	0,00284	0.0286%	0.00286	0.0292%	0.00292
100	Ω	199.999	0.0157%	0.01569	0.0189%	0.01892	0.0192%	0.01921	0.0195%	0.01951	0.0204%	0.02045
1000	Ω	1999.99	0.0157%	0.15687	0.0189%	0.18918	0.0192%	0.19208	0.0195%	0.19506	0.0204%	0.20448
10	kΩ	19.9999	0.0157%	0.00157	0.0189%	0.00189	0.0192%	0.00192	0.0195%	0.00195	0.0204%	0.00204
100	kΩ	199.999	0.0174%	0.01737	0.0239%	0.02392	0.0245%	0.02447	0.0250%	0.02504	0.0268%	0.02680
1	MΩ	1.99999	0.0236%	0.00024	0.0350%	0.00035	0.0360%	0.00036	0.0369%	0.00037	0.0398%	0.00040
		19.999	0.0766%	0.00766	0.0966%	0.00966	0.0983%	0.00983	0.1001%	0.01001	0.1058%	0.01058

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ise Test Gauges [Att. 5, Ref. 6.1.2]

Table 63 Heise 901A Digital Pressure Gauge Total Device Errors (Attachment 5)

Area of Plant	Control Room		RB RHR Cnr Rm 232		TB Occupied Areas		RB Occupied Areas		RB RHR Cmr Rm 213'	
of 70°F	10°F ΔT		34°F ΔT		35°F ΔT		36°F ΔT		39°F ΔT	
Span	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units
58	0.1021%	0.0592	0.1223%	0.0709	0.1235%	0.0716	0.1247%	0.0723	0.1285%	0.0745
150	0.1079%	0.1619	0.1689%	0.2534	0.1722%	0.2583	0.1754%	0.2632	0.1854%	0.2781
300	0.1078%	0.3233	0.1688%	0.5065	0.1721%	0.5162	0.1753%	0.5260	0.1853%	0.5560
400	0.1106%	0.4423	0.1706%	0.6826	0.1739%	0.6954	0.1771%	0.7084	0.1870%	0.7479

Table 64 Heise 901B Digital Pressure Gauge Total Device Errors (Attachment 5)

Heise 901B	Area of Plant	Control Room		RB RHR Cnr Rm 232		TB Occupied Areas		RB Occupied Areas		RB RHR Cmr Rm 213'	
ΔT from ref temp of 70°F		10°F ΔT		34°F ΔT		35°F ΔT		36°F ΔT		39°F ΔT	
Range	Span	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units
0-10 PSIG	10	0.0648%	0.0065	0.1452%	0.0145	0.1490%	0.0149	0.1528%	0.0153	0.1641%	0.0164
30"Hg VAC	30	0.1078%	0.0323	0.1688%	0.0507	0.1721%	0.0516	0.1753%	0.0526	0.1853%	0.0556
0-50"H_2O	50	0.0600%	0.0300	0.1432%	0.0716	0.1470%	0.0735	0.1508%	0.0754	0.1623%	0.0811
0-100"H_2O	100	0.0648%	0.0648	0.1452%	0.1452	0.1490%	0.1490	0.1528%	0.1528	0.1641%	0.1641
0-150"H_2O	150	0.0644%	0.0966	0.1451%	0.2176	0.1488%	0.2232	0.1526%	0.2289	0.1640%	0.2459
0-200 PSIG	200	0.0642%	0.1285	0.1450%	0.2900	0.1487%	0.2975	0.1525%	0.3050	0.1639%	0.3278
0-400"H_2O	400	0.0641%	0.2563	0.1449%	0.5797	0.1487%	0.5947	0.1525%	0.6098	0.1638%	0.6553
0-600 PSIG	600	0.0641%	0.3843	0.1449%	0.8695	0.1487%	0.8920	0.1524%	0.9147	0.1638%	0.9830
0-1000"H_2O	1000	0.0648%	0.6481	0.1452%	1.4524	0.1490%	1.4900	0.1528%	1.5276	0.1641%	1.6412
0-1500 PSIG	1500	0.0644%	0.9657	0.1451%	2.1758	0.1488%	2.2322	0.1526%	2.2887	0.1640%	2.4593
0-2000 PSIG	2000	0.0642%	1.2845	0.1450%	2.8997	0.1487%	2.9749	0.1525%	3.0503	0.1639%	3.2779

Table 65 Heise 730 Digital Pressure Calibrator Total Device Errors (Attachment 5)

Heise 730	Area of Plant	Control Room		RB RHR Cnr Rm 232		TB Occupied Areas		RB Occupied Areas		RB RHR Cnr Rm 213	
ΔT from ref temp of 70°F		10 °F ΔT		84 °F ΔT		35 °F ΔT		36 °F ΔT		39 °F ΔT	
Range	Span	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units
(-)4-31 PSIG	35	0.1114%	0.0390	0.1712%	0.0599	0.1744%	0.0610	0.1776%	0.0622	0.1875%	0.0656
(-)100-860"H_2O	960	0.1082%	1.0388	0.1691%	1.6236	0.1724%	1.6547	0.1756%	1.6860	0.1856%	1.7817

Table 66 Heise CM & CMM Dial Pressure Gauge Total Device Errors (Attachment 5)

Heise CM & CMM	Area of Plant	Control Room		RB RHR Cnr Rm 232		TB Occupied Areas		RB Occupied Areas		RB RHR Cnr Rm 213	
ΔT from ref temp of 70°F		10 °F ΔT		84 °F ΔT		35 °F ΔT		36 °F ΔT		39 °F ΔT	
Range	Span	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units
0-15 PSIA	15	0.1484%	0.0223	0.1620%	0.0243	0.1628%	0.0244	0.1637%	0.0246	0.1664%	0.0250
0-30 PSIG	30	0.1505%	0.0451	0.1639%	0.0492	0.1647%	0.0494	0.1656%	0.0497	0.1683%	0.0505
0-30"Hg VAC	30	0.1505%	0.0451	0.1639%	0.0492	0.1647%	0.0494	0.1656%	0.0497	0.1683%	0.0505
0-50 PSIG	50	0.1467%	0.0734	0.1605%	0.0802	0.1613%	0.0807	0.1622%	0.0811	0.1650%	0.0825
0-60 PSIG	60	0.1461%	0.0876	0.1599%	0.0959	0.1607%	0.0964	0.1616%	0.0970	0.1644%	0.0986
0-100 PSIG	100	0.1467%	0.1467	0.1605%	0.1605	0.1613%	0.1613	0.1622%	0.1622	0.1650%	0.1650
0-150 PSIG	150	0.1455%	0.2183	0.1594%	0.2391	0.1602%	0.2404	0.1611%	0.2417	0.1639%	0.2458
0-200 PSIG	200	0.1467%	0.2934	0.1605%	0.3209	0.1613%	0.3226	0.1622%	0.3244	0.1650%	0.3299
0-300 PSIG	300	0.1455%	0.4366	0.1594%	0.4781	0.1602%	0.4807	0.1611%	0.4834	0.1639%	0.4917
0-400 PSIG	400	0.1479%	0.5916	0.1616%	0.6462	0.1624%	0.6496	0.1633%	0.6531	0.1660%	0.6641
0-600 PSIG	600	0.1461%	0.8764	0.1599%	0.9592	0.1607%	0.9644	0.1616%	0.9697	0.1644%	0.9862
0-800"H_2O	800	0.1479%	1.1833	0.1616%	1.2925	0.1624%	1.2993	0.1633%	1.3062	0.1660%	1.3281
0-830"H_2O	830	0.1477%	1.2257	0.1613%	1.3391	0.1622%	1.3462	0.1631%	1.3535	0.1658%	1.3762
0-1500 PSIG	1500	0.1455%	2.1829	0.1594%	2.3907	0.1602%	2.4036	0.1611%	2.4169	0.1639%	2.4584
0-2000 PSIG	2000	0.1467%	2.9343	0.1605%	3.2093	0.1613%	3.2265	0.1622%	3.2440	0.1650%	3.2990
0-5000 PSIG	5000	0.1467%	7.3357	0.1605%	8.0232	0.1613%	8.0661	0.1622%	8.1100	0.1650%	8.2476
30"Hg VAC - 30 PSIG	75.816	0.1483%	0.1124	0.1619%	0.1227	0.1627%	0.1234	0.1636%	0.1240	0.1663%	0.1261
30"Hg VAC - 30 PSIG	44.736	0.1472%	0.0659	0.1609%	0.0720	0.1618%	0.0724	0.1627%	0.0728	0.1654%	0.0740

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Table 74 HP 34401A Digital Multimeter Amp DC Ranges Total Device Errors (Attachment 6)

HP 34401A	Area of Plant		Control Room		RB RHR Cnr Rm 232'		TB Occupied Areas		RB Occupied Areas		RB RHR Cnr Rm 213'	
ΔT from ref temp of 21±1°C			2.44°C ΔT		12°C ΔT		12.56°C ΔT		13.11°C ΔT		14.78°C ΔT	
Reading	Units	Range	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units
20	mADC	100	0.0758%	0.015161	0.0924%	0.018484	0.0939%	0.018780	0.0954%	0.019085	0.1002%	0.020047
50	mADC	100	0.0604%	0.030223	0.0700%	0.034986	0.0708%	0.035422	0.0717%	0.035872	0.0746%	0.037301
10	mADC	10	0.0707%	0.007068	0.0849%	0.008488	0.0862%	0.008615	0.0875%	0.008747	0.0916%	0.009162
100	mADC	100	0.0553%	0.055339	0.0626%	0.062650	0.0633%	0.063327	0.0640%	0.064027	0.0663%	0.066256
1	ADC	1	0.1110%	0.001110	0.1315%	0.001315	0.1333%	0.001333	0.1352%	0.001352	0.1413%	0.001413
3	ADC	3	0.1410%	0.004231	0.1633%	0.004898	0.1653%	0.004959	0.1674%	0.005022	0.1741%	0.005222

Table 75 HP 34401A Digital Multimeter Ohmic Ranges Total Device Errors (Attachment 6)

HP 34401A	Area of Plant		Control Room		RB RHR Cnr Rm 232'		TB Occupied Areas		RB Occupied Areas		RB RHR Cnr Rm 213'	
ΔT from ref temp of 21±1°C			2.44°C ΔT		12°C ΔT		12.56°C ΔT		13.11°C ΔT		14.78°C ΔT	
Reading	Units	Range	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units
100	Ω	100	0.0143%	0.014256	0.0192%	0.019242	0.0197%	0.019666	0.0201%	0.020100	0.0215%	0.021454
1	kΩ	1	0.0111%	0.000111	0.0138%	0.000138	0.0141%	0.000141	0.0143%	0.000143	0.0151%	0.000151
10	kΩ	10	0.0111%	0.001113	0.0138%	0.001384	0.0141%	0.001408	0.0143%	0.001433	0.0151%	0.001510
100	kΩ	100	0.0111%	0.011133	0.0138%	0.013841	0.0141%	0.014080	0.0143%	0.014326	0.0151%	0.015100
1	MΩ	1	0.0114%	0.000114	0.0181%	0.000181	0.0187%	0.000187	0.0192%	0.000192	0.0209%	0.000209
10	MΩ	10	0.0418%	0.004183	0.0578%	0.005784	0.0592%	0.005919	0.0606%	0.006057	0.0648%	0.006485
100	MΩ	100	0.8893%	0.889327	1.9760%	1.976043	2.0524%	2.052440	2.1294%	2.129366	2.3628%	2.362800

Table 76 HP 34401A Digital Multimeter Amp AC (10Hz - 5kHz) Ranges Total Device Errors (Attachment 6)

HP 34401A	Area of Plant		Control Room		RB RHR Cnr Rm 232'		TB Occupied Areas		RB Occupied Areas		RB RHR Cnr Rm 213'	
ΔT from ref temp of 21±1°C			2.44°C ΔT		12°C ΔT		12.56°C ΔT		13.11°C ΔT		14.78°C ΔT	
Reading	Units	Range	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units	TDE %	TDE Units
1	Amp AC	1	0.1491%	0.001491	0.2883%	0.002883	0.2985%	0.002985	0.3089%	0.003089	0.3405%	0.003405
3	Amp AC	3	0.2162%	0.006485	0.3280%	0.009841	0.3371%	0.010112	0.3463%	0.010388	0.3747%	0.011241

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Table 86 Omega 2176A Temperature Indicator Total Device Errors (Attachment 8)

2176A	Area of Plant	Control Room	RB RHR Crnr Rm 232	TB Occupied Areas	RB Occupied Areas	RB RHR Crnr Rm 213
ΔT from ref temp of 21.11°C		[illegible]	5°C ΔT	5.56°C ΔT	6.11°C ΔT	7.78°C ΔT
T/C Type	Temp Rng	TDE	TDE	TDE	TDE	TDE
J	(-)99.8 to 0°C	1.312°C	1.343°C	1.347°C	1.352°C	1.367°C
	0 to 777.8°C	1.213°C	1.261°C	1.269°C	1.278°C	1.307°C
K	(-)99.8 to 0°C	1.609°C	1.635°C	1.639°C	1.642°C	1.655°C
	0 to 999.8°C	1.51°C	1.557°C	1.566°C	1.575°C	1.606°C
T	(-)99.8 to 0°C	1.715°C	1.762°C	1.768°C	1.775°C	1.798°C
	0 to 400°C	1.025°C	1.106°C	1.117°C	1.129°C	1.168°C
E	(-)99.8 to 0°C	1.814°C	1.858°C	1.865°C	1.871°C	1.893°C
	0 to 999.8°C	1.517°C	1.589°C	1.601°C	1.613°C	1.656°C
ΔT from ref temp of 70°F		[illegible]	9°F ΔT	10°F ΔT	11°F ΔT	14°F ΔT
T/C Type	Temp Rng	TDE	TDE	TDE	TDE	TDE
J	(-)99.8 to 32°F	2.316°F	2.373°F	2.381°F	2.39°F	2.417°F
	32 to 999.8°F	1.821°F	1.909°F	1.923°F	1.937°F	1.986°F
K	(-)99.8 to 32°F	2.813°F	2.86°F	2.867°F	2.874°F	2.897°F
	32 to 999.8°F	2.019°F	2.099°F	2.111°F	2.124°F	2.169°F
T	(-)99.8 to 32°F	3.122°F	3.206°F	3.217°F	3.23°F	3.27°F
	32 to 752°F	1.741°F	1.895°F	1.917°F	1.94°F	2.014°F
E	(-)99.8 to 32°F	3.222°F	3.303°F	3.314°F	3.326°F	3.365°F
	32 to 999.8°F	2.035°F	2.175°F	2.195°F	2.217°F	2.287°F

5.1.11. Rosemount Readout Assembly [Att. 9, Ref. 6.1.2]

Table 87 Rosemount Readout Assembly Total Device Errors (Attachment 9)

Reading/Units	Range	Total % (TDErdout)	Total Units (TDErdout)
4 mA	10	0.3536%	0.0141
12 mA	19	0.1179%	0.0141
20 mA	28	0.0707%	0.0141

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Dept. Mgr.	[signature]	Proc. No.	OP 4312
PORC 98-053	[signature]	Rev. No.	21
Plant Mgr.	[signature]	Issue Date	05/18/98
		Review Date	05/18/03

REACTOR VESSEL HIGH PRESSURE SCRAM FUNCTIONAL TEST/CALIBRATION

PURPOSE

| To provide the information necessary for department personnel to perform a functional and/or calibration of the Reactor Vessel High Pressure Scram instruments.

Performance of the Functional Calibration (Section A) section of this procedure satisfies the Functional Test requirements as specified by the following Technical Specifications:

Table 4.1.1 RPS High Reactor Pressure Scram

Performance of the Functional Calibration and Transmitter Calibration sections of this procedure satisfy the Calibration Test requirements as specified by the following Technical Specifications:

Table 4.1.2 RPS High Reactor Pressure Scram

The use classification of this procedure is Continuous Use.

DISCUSSION

The high pressure scram instrumentation consists of Rosemount Pressure Transmitters which sense reactor pressure through the constant head reference chambers. The outputs of these transmitters are connected to Rosemount trip/calibration units which change state when their parameters are exceeded. This action de-energizes relays which provide alarm and trip signals to the Control Room.

Each of the below listed transmitters provide signal input to associated master trip units which in turn provide trip functions and indication. The functional test is performed using the installed calibration unit and portable Readout Assembly. During the transmitter calibration, the below listed transmitters will be calibrated.

| A head correction of 12 PSI has been applied to the transmitter calibration.

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The Reactor Vessel High Pressure Scram instruments are designated as follows:

Instrument Number	Location	Scram Subchannel	Scram Relay and Location
PT-2-3-55A	Rack 25-5 Cab 25-5A	A-1	5A-K5A CRP 9-15
PT-2-3-55B	Rack 25-5 Cab 25-5A	B-1	5A-K5B CRP 9-17
PT-2-3-55C	Rack 25-6 Cab 25-6A	A-2	5A-K5C CRP 9-15
PT-2-3-55D	Rack 25-6 Cab 25-6A	B-2	5A-K5D CRP 9-17

SURVEILLANCE SETPOINT CRITERIA

Instrument Number	Measured Parameter	Action	VYC LSP/Tech Spec	VY Trip Setting	VYC-467 As-Found
PT-2-3-55A-D(M)	Rx Press Hi	Scram	1038 psig/≤1055 PSIG (≤15.25 mA)	15.04 to 15.10 mA	±.04 mA (MTU) ±.17 mA (Xmtr)

ATTACHMENTS

1. VYOPF 4312.01 Reactor Vessel High Pressure Scram Functional Calibration Data Sheet
2. VYOPF 4312.02 Reactor Vessel High Pressure Scram Transmitter Calibration Data Sheet

REFERENCES

1. Technical Specifications
   a. Tables 3.1.1, 4.1.1 and 4.1.2
2. Administrative Limits
   a. AP 0125, Plant Equipment Control
3. Other
   a. GEK-32430 - VY Reactor Protection System
   b. VYEM-0048 Rosemount 1152GP Transmitters
   c. VYEM-0053 Rosemount 710DU Trip System
   d. GE Elem. Dwgs. 730E365, Shts. 1-19
   e. VYNPS FSAR Section 7.2
   f. CWD 803, 805, 806, 808, 810, 812, 813, 815
   g. EQ Files #2-3-5 and 2-3-7
   h. VYC-467, Rx Hi Press Trip Loop Accuracy Review

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i. Calibration Calculation VYC-332
j. VY Technical Specification Logic System Functional Methodology
k. AP 0021, Work Orders
l. AP 0310, Surveillance, Preventative and Corrective Maintenance Program
m. AP 6807, Collection, Temporary Storage and Retrieval of QA Records

PRECAUTIONS

1. De-energizing any one instrument will cause a Relay Channel Trip (HALF SCRAM).

2. Exercise care when returning the instrument to service so as to preclude a sudden pressure surge on the instrument sensing line which is common to other instrumentation.

3. Only one (1) instrument will be calibrated or functionally tested at a time.

4. If this procedure cannot be completed as written, hold at the most secure point, notify the Shift Supervisor and discuss the problem and possible resolution with an I/C supervisor.

5. If the need for corrective maintenance is determined within the performance of this procedure, initiate a Work Order Request (WOR) per AP 0021.

6. Ensure that there is no other surveillance testing involving the RPS or PCIS systems in progress at this time.

PREREQUISITES

1. Measuring and Test Equipment required:

   a. Gauge, Heise Model 901B, Span ≤2000 psi (transmitter cal) or Heise Model CM or CMM gauge, Span ≤2000 psi (transmitter cal)

PROCEDURE

A. Functional Calibration

1. The Shift Supervisor is fully knowledgeable of the scope of this procedure and by initialing the data sheet, grants his permission to perform the work.

NOTE

Master Indicator readings (Step 10) can be recorded anytime input conditions are met.

---

2. Establish phone communications between CRP 9-15/17 and Racks 25-5/6.

3. Verify that the referenced CRP 9-15/17 RPS relays are energized and that the CRP 9-15/17 CRD Scram Solenoid Group 1-4 lights are ON.

NOTE

During the performance of this procedure, individual module GROSS FAILURE lights may energize, but immediate reset should be possible by momentarily depressing the reset button.

---

4. Install the Readout Assembly as follows:

   a. Ensure the center knob of the Command/Calibrate switch and the Transient Current knob are pulled out.

   b. Install the Readout Assembly in the Calibration Unit in Card File 25-5A-A1/B1 or 6A-A2/B2 as applicable.

   c. Energize the Calibration Unit.

   d. Allow approximately 2 minutes warm up time.

NOTE

The COMMAND Calibrate switch is a two part switch on the calibration unit. The outer switch selects the trip unit under calibration, the inner switch selects the master trip unit which drives its associated slave unit. To calibrate a master unit, both switches point at the same position, i.e., position 1,1.

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5. Using the Command Calibrate switch, select master unit to be tested in Cab 25-5A/6A according to the following table:

Trip Unit	Command/Cal Sw. Inner/Outer Posn	Location
PT 2-3-55A(M)	1-1	Cab 25-5A-A1
PT 2-3-55B(M)	1-1	Cab 25-5A-B1
PT 2-3-55C(M)	1-1	Cab 25-6A-A2
PT 2-3-55D(M)	1-1	Cab 25-6A-B2

6. Adjust Stable Current knob for a cal current indication on the readout assembly to 14.67 mA ± .1 mA (1000 psig).

7. Press the center knob of the Command/Calibrate switch in to enable the calibration unit.

   a. Verify calibration unit cal status LED - ON.

   b. Verify Associated Annun:

      9-4-N-3 RPS 5A-A1/6A-A2 GROSS FAILURE - ALARM
      9-4-P-3 RPS 5A-B1/6A-B2 GROSS FAILURE - ALARM

   c. Ensure Readout Assembly trip LED is OFF. Reset if necessary.

8. Increase the Cal Current indication until the Readout Assembly Trip Status LED comes ON and the trip current display latches. Verify:

   a. Associated Master Units Trip LED - ON,

   b. Associated CRP 9-15/9-17 relays - DE-ENERGIZE,

   c. Annun 9-5-K-3 REACTOR PRESS HI - ALARM,

   d. Associated Annun:

      9-5-K-1 AUTO SCRAM CH A - ALARM
      9-5-L-1 AUTO SCRAM CH B - ALARM

   e. CRP 9-15/9-17 CRD Scram Solenoid Group 1-4 Lights - OFF,

   f. record the As-Found trip current.

9. Decrease the cal current until the readout trip LED goes OFF.

   a. Adjust the trip point on the front of the master unit under test and repeat Steps 8 and 9 as necessary for a trip point of 15.07 ±.03 mA (approx. 1038 psi) as indicated on the Readout Assembly.

   b. Record the As-Left trip current on the data sheet.

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10. Using the cal current indication, apply the below listed milliamp values and record the associated master unit As-Found indications on the data sheet.

    a. Adjust the master unit zero adjustment (internal) as necessary to bring the indications within the tolerance and record the As-Left values.

Test Current	Required Master Indication
5.6 mA	150 ± 75 psig
12.0 mA	750 ± 75 psig
18.4 mA	1350 ± 75 psig

11. Adjust the Stable Current knob for a cal current indication on the readout assembly to 14.67 mA ± .1 mA (1000 psig).

12. Request the Control Room Operator reset the half scram condition. Verify:

    a. Associated Master Trip LED - OFF,

    b. Associated CRP 9-15/9-17 relays - ENERGIZE,

    c. Annun 9-5-K-3 REACTOR PRESS HI - CLEAR,

    d. CRP 9-15/9-17 CRD Scram Solenoid Group 1-4 Lights - ON,

    e. Associated Annun:

    9-5-K-1 AUTO SCRAM CH A - CLEAR
    9-5-L-1 AUTO SCRAM CH B - CLEAR

13. Remove the Readout Assembly as follows:

    a. Pull the center knob of the Command/Calibrate switch OUT.

    b. Return the inner and outer switches to OFF.

    c. Depress the Master Gross Fail pushbutton.

    d. De-energize the Calibration Unit.

    e. Remove the Readout Assembly.

14. Verify the following:

    a. Associated Master Unit Gross Failure LED - OFF,

    b. Calibration Unit Cal Status LED - OFF,

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c. Associated Annun:

9-4-N-3 RPS 5A-A1/6A-A2 GROSS FAILURE - CLEAR
9-4-P-3 RPS 5A-B1/6A-B2 GROSS FAILURE - CLEAR

15. Repeat Steps 3 through 14 for Master Units 55B, 55C, and 55D.

16. When testing is complete, proceed to Final Conditions.

B. Transmitter Calibration

1. The Shift Supervisor is fully knowledgeable of the scope of this procedure, and by initialing the data sheet, grants his permission to perform the work.

2. Remove the cover from the terminal side (left side of transmitter when adjustment access cover is on top) of the transmitter to be tested and install a DMM (100 mA range) across the transmitter "Test" connections, observing polarity.

3. Ensure that the center knob of the Command/Calibrate switch and the Transient Current knob are pulled OUT.

NOTE

During the performance of this procedure, individual module GROSS FAILURE lights may energize, but immediate reset should be possible by momentarily depressing the reset button.

4. Install the Readout Assembly into the Calibration Unit for the applicable unit being tested (see Table 1), and perform the following:

a. Energize the Calibration Unit.

b. Adjust Stable Current knob (± .01 mA) for the existing transmitter loop current value, as displayed on the DMM. If DMM is <4 mA, adjust to 4.00 mA, of >20 mA, adjust to 20.00 mA.

c. Using the two-part Command/Calibrate switch, select the master unit for the transmitter to be tested according to the table below:

Table 1

Trip Unit	Switch Position Outer-Inner	Location
PT 2-3-55A(M)	1-1	25-5A-A1
PT 2-3-55B(M)	1-1	25-5A-B1
PT 2-3-55C(M)	1-1	25-6A-A2
PT 2-3-55D(M)	1-1	25-6A-B2

d. Press the center knob of the Command/Calibrate switch IN.

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5. Isolate the transmitter to be tested as follows:

   a. SHUT the Isolation valve.

   b. Second party verify Step 5.a.

   c. OPEN the Test valve.

6. Connect the test pressure source to the test connection.

TABLE 2

Input	Desired Output
12 psi	4.00 ±.04 mA
387 psi	8.00 ±.04 mA
762 psi	12.00 ±.04 mA
1137 psi	16.00 ±.04 mA
1512 psi	20.00 ±.04 mA
1137 psi	16.00 ±.04 mA
762 psi	12.00 ±.04 mA
387 psi	8.00 ±.04 mA
12 psi	4.00 ±.04 mA

7. Apply input pressures per Table 2 and record the As-Found mA data as indicated on the DMM.

8. If As-Found data is in tolerance, record the required As-Left data in Step 10 and proceed to Step 11.

9. If the As-Found data is out of tolerance, alternately apply pressures of 12, 762, and 1512 psig and adjust the transmitter zero, linearity, and span as necessary.

10. Apply input pressures per Table 2 and record the As-Left mA data as indicated on the DMM.

11. Remove the test pressure source from the test connection.

12. Return the transmitter to service as follows:

   a. SHUT the Test valve.

   b. OPEN the Isolation valve.

   c. Second party verify Steps 12.a and b.

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13. Ensure that the transmitter output has returned to normal (near the mA value of Step 4.b). Remove the DMM and reinstall the transmitter cover.

14. Verify applicable Environmental Qualification requirements listed in the referenced file have been satisfied.

15. Remove the Readout Assembly as follows:

    a. Pull the center knob of the Command/Calibrate switch OUT.

    b. Return the inner and outer switches to OFF.

    c. Depress the Master Gross Fail pushbutton.

    d. De-energize the Calibration Unit.

    e. Remove the Readout Assembly.

16. Notify the Control Room operator upon completion of each transmitter calibration and prior to beginning the next transmitter to be calibrated. Repeat Steps 2 through 15 for the remaining transmitters to be tested.

17. Proceed to Final Conditions.

ACCEPTANCE CRITERIA

1. Successful operation of all instruments, relays, alarms and annunciators as applicable for existing plant conditions.

2. All calibration and setpoint values shall be within the specified values stated on VYOPF 4312.01 or .02.

FINAL CONDITIONS

1. Notify the Shift Supervisor on completion of functional/calibration test and of any discrepancies.

2. EQ maintenance, if performed, is documented on an equipment specific sub-work order.

3. Return the completed VYOPF 4312.01 or .02 to an E/C supervisor for review (AP 0310) and filing in accordance with AP 6807.

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TITLE: REACTOR VESSEL HIGH PRESSURE SCRAM FUNCTIONAL CALIBRATION DATA SHEET

LOCATION: CONTROL ROOM

STEP	REQUIRED	2-3-55A(M)		2-3-55B(M)		2-3-55C(M)		2-3-55D(M)	
1.	SS Permission								
3	Relays ENERGIZED	5A-K5A throug h D		5A-K5A throug h D		5A-K5A throug h D		5A-K5A throug h D	
	CRP 9-15/17 Lights ON								
7.b	Annun Alarm	9-4 N-3		9-4 P-3		9-4 N-3		9-4 P-3	
8.b	Relay DE-ENERGIZED	5A-5KA		5A-K5B		5A-K5C		5A-K5D	
8.c	Annun 9-5-K-3 ALARM								
8.d	Annun ALARM	9-5 K-1		9-5 L-1		9-5 K-1		9-5 L-1	
8.e	CRP 9-15/17 Lights OFF								
12.b	Relay ENERGIZED	5A-K5A		5A-K5B		5A-K5C		5A-K5D	
12.c	Annun 9-5-K-3 CLEAR								
12.d	CRP 9-15/17 Lights ON								
12.e	Annun CLEAR	9-5 K-1		9-5 L-1		9-5 K-1		9-5 L-1	
14.c	Annun CLEAR	9-4 N-3		9-4 P-3		9-4 N-3		9-4 P-3	

Discrepancies/Remarks:

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TITLE: REACTOR VESSEL HIGH PRESSURE SCRAM FUNCTIONAL CALIBRATION DATA SHEET (Continued)

LOCATION: RPS CAB 25-5A/6A

STEP	REQUIRED	2-3-55A(M)	2-3-55B(M)	2-3-55C(M)	2-3-55D(M)
7.a	LED ON				
8.a	LED ON				
8.f	As-Found 15.04-15.10 mA				
9.b	As-Left 15.04-15.10 mA				
10	As-Found 75-225 psi				
	As-Found 675-825 psi				
	As-Found 1275-1425 psi				
10.a	As-Left 75-225 psi				
	As-Left 675-825 psi				
	As-Left 1275-1425 psi				
12.a	LED OFF				
14.a	LED OFF				
14.b	LED OFF				

M/TE Used (VY SN/Due Date):

Discrepancies/Remarks:

Tested By: Date:

Shift Supervisor: Date:

E/C Supervisor Review: Date:

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TITLE: REACTOR VESSEL HIGH PRESSURE SCRAM TRANSMITTER CALIBRATION DATA SHEET

STEP		REQUIRED				
1.		SS Permission				
INSTRUMENT NUMBER			PT-2-3-55A	PT-2-3-55B	PT-2-3-55C	PT-2-3-55D
5.	a	Performed By				
	b	Verified By				
7. As-Found		@12 psi 3.96 to 4.04 mA				
		@387 psi 7.96 to 8.04 mA				
		@762 psi 11.96 to 12.04 mA				
		@1137 psi 15.96 to 16.04 mA				
		@1512 psi 19.96 to 20.04 mA				
		@1137 psi 15.96 to 16.04 mA				
		@762 psi 11.96 to 12.04 mA				
		@387 psi 7.96 to 8.04 mA				
		@12 psi 3.96 to 4.04 mA				
10. As-Found		@12 psi 3.96 to 4.04 mA				
		@387 psi 7.96 to 8.04 mA				
		@762 psi 11.96 to 12.04 mA				
		@1137 psi 15.96 to 16.04 mA				
		@1512 psi 19.96 to 20.04 mA				
		@1137 psi 15.96 to 16.04 mA				
		@762 psi 11.96 to 12.04 mA				
		@387 psi 7.96 to 8.04 mA				
		@12 psi 3.96 to 4.04 mA				

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TITLE: REACTOR VESSEL HIGH PRESSURE SCRAM TRANSMITTER CALIBRATION DATA SHEET (Continued)

STEP		REQUIRED				
12.	a b	Performed By				
	c	Verified By				
14.		EQ Req. Satisfied				
15.	a-e	Trip Unit to Normal				
		Date Completed				

M/TE Used (VY SN/Due Date):

Discrepancies/Remarks:

Tested By: Date:

Shift Supervisor: Date:

E/C supervisor Review: Date:

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ATTACHMENTS
1 27 Pages
2 4 Pages
3 10 Pages
4 4 Pages
TOTAL PAGES: 10 + 45 = 55

ORIGINAL: PAGE 1 OF ~~54~~ 10 PAGES
Rev. 1: PAGE 1 OF ____ PAGES
Rev. 2: PAGE 1 OF ____ PAGES
Rev. 3: PAGE 1 OF ____ PAGES

QA RECORD?
_x_ YES
___ NO

IMS NO. 09.016.004
RECORD TYPE M 02.01.05
W.O./P.O. NO. W.O. # 4894

YANKEE ATOMIC ELECTRIC COMPANY
ANALYSIS/CALCULATION FOR

TITLE Selected Pressure Instrument Static Head Correction

PLANT Vermont Yankee CYCLE 19

CALCULATION NUMBER VYC-1596

	PREPARED BY/DATE	REVIEWED BY/DATE	APPROVED BY/DATE
ORIGINAL	[signature] 1/30/97	[signature] 2-14-97	[signature] 2/15/97
REVISION 1			
REVISION 2			
REVISION 3			

KEYWORDS Pressure; Static Head; Transmitter; Switch; PS- , PT-;

FORM WE-103-1
Revision 2

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CALCULATION NO. VYC-467
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WE-103-20

1.0 CALCULATION NUMBER VYC-1596 / OBJECTIVE

Calculation has been formulated to refine and enhance previous assumptions for selected Vermont Yankee plant pressure instrument static head corrections. Where the sensor is located below the process being monitored and the process line is filled with fluid a head of water will exist. Much of the existing data used to calculate this value has been based on imprecise evaluations of "as-built" instrument, process line and condensate chamber elevations. Calculations within will be utilized for plant instrument setpoint revisions being generated in support of the Vermont Yankee Instrument Setpoint program.

2.0 AFFECTED COMPONENTS

The components addressed by this calculation include all pressure transmitters and switches as listed in the Setpoint Matrix of YAEC-1700, *Accuracy Report of Selected Instrumentation Loops associated with Functions Important to safety Installed at Vermont Yankee Nuclear Power* Station, *Phase II,* and addressed in YAEC-1562, *Accuracy Report of Selected Class 1E Equipment.* Instruments mounted on the same Racks as the aforementioned were also evaluated, by virtue of their location and in the interest of encompassing a significant number of these devices. Listed below are applicable instruments with their associated Racks:

Rack 25-1	Rack 25-59	Rack 25-62	Rack 25-58	Rack 25-51
PS-14-44A	PS-10-105A	PS-10-105B	PS-13-87A	PT-2-3-52D
PS-14-44C	PS-10-105C	PS-10-105D	PS-13-87B	Rack 25-52
PT-14-38A	PS-10-105E	PS-10-105F	PT-13-60	PT-2-3-52C
PS-14-47A	PS-10-105G	PS-10-105H	PS-13-87C	
Rack 25-50	PS-10-122A	PS-10-122B	PS-13-87D	Rack 10AA
PT-23-86	PS-10-156A	PS-10-156B	PS-13-78	PS-19-80A
PT-23-95	Rack 25-5	Rack 25-6	PS-13-67	PT-19-81A
PT-23-83	PT-2-3-55A	PT-2-3-55C	PS-13-67-1	Rack 10AB
PT-23-89	PT-2-3-55B	PT-2-3-55D	PS-13-72A	PS-19-80B
PS-23-84	PT-2-3-56B	PT-2-3-56A	PS-13-72B	PT-19-81B
PS-23-84-1	PT-2-3-56D	PT-2-3-56C	PS-13-68	Rack 25-23
PS-23-97A	PS-2-102	PT-6-58	PT-13-70	PS-2-128A
PS-23-97B	PT-6-53A	PT-6-53B	PT-13-65	Rack 25-24
PS-23-68A	PT-2-3-54B	PT-2-3-54A	Rack 25-60	PS-2-128B
PS-23-68B	PT-2-3-54D	PT-2-3-54C	PS-14-47B	
PS-23-68C	PT-10-101B	PT-10-101A	PS-14-44B	
PS-23-68D	PT-10-101D	PT-10-101C	PS-14-44D	
PS-23-106	PT-5-12A	PT-5-12C	PT-14-38B	
PS-23-100	PT-5-12B	PT-5-12D		
	PT-16-19-28	PT-16-19-29A		
	PT-16-19-29B			

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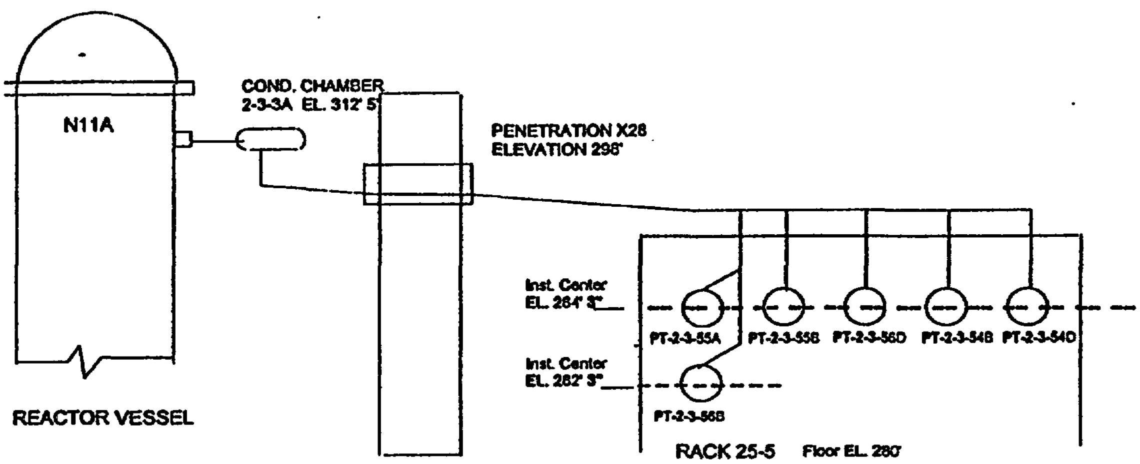
PT-2-3-55A ATTACHMENT 1(g) PT-2-3-54B
PT-2-3-55B PT-2-3-54D
PT-2-3-56B <u>WORKING SKETCH - Rack 25-5</u> PT-2-3-56D



<u>Static Head Determination (Normal Conditions- Drywell)</u>

Head (in. H_2O) = L - P (penetration elevation) x (.01605/.01629)
+ P - I (instrument elevation) x (.01605/.01600)

Head (in. H_2O)(.03606) = Static hd.(psig)

Instrument	L	P	I	HD.(in. H_2O)	HD.(Psig)
PT-2-3-55A[1]	312' 5"	298	284' 3"	336	12.11
PT-2-3-55B[1]	312' 5"	298	284' 3"	336	12.11
PT-2-3-56B[2]	312' 5"	298	282' 3"	360	12.98
PT-2-3-56D[2]	312' 5"	298	284' 3"	336	12.11
PT-2-3-54B[3]	312' 5"	298	284' 3	336	12.11
PT-2-3-54D[3]	312' 5"	298	284' 3"	336	12.11

All instrument elevations field verified; ref. Instrument Installation Details B-191261 sht. 7A. Ref. VYC-332 for head correction data, VY OP-4312[1], 4342[2], 43109[3] for calibration.

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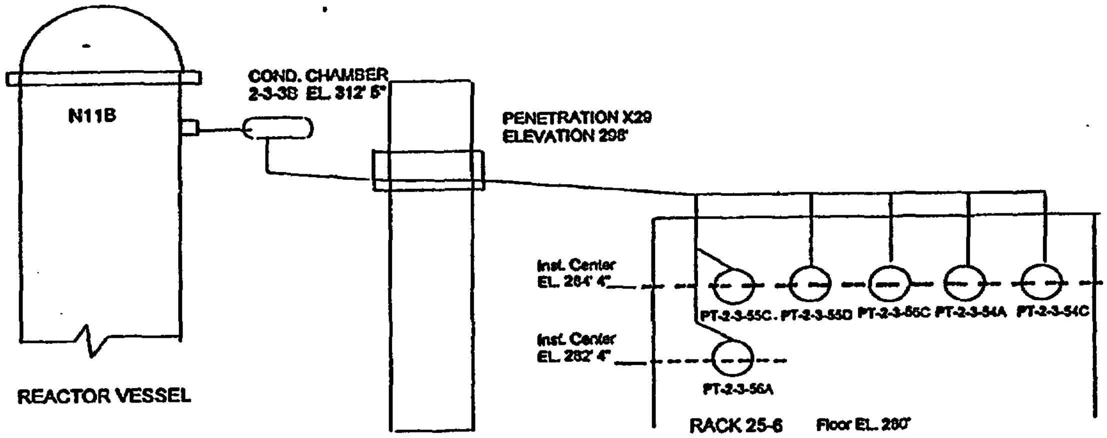
PT-2-3-55C ATTACHMENT 1(h) PT-2-3-54A

PT-2-3-55D PT-2-3-54C

PT-2-3-56A <u>WORKING SKETCH - Rock 25-6</u> PT-2-3-56C



<u>Static Head Determination (Normal Conditions- Drywell)</u>

Head (in. H_2O) = L - P (penetration elevation) x (.01605/.01629)
+ P - I (instrument elevation) x (.01605/.01600)

Head (in. H_2O)(.03606) = Static hd..(psig)

Instrument	L	P	I	HD(in. H_2O)	HD.(Psig)
PT-2-3-55C[1]	312' 5"	298	284' 4"	334	12.06
PT-2-3-55D[1]	312' 5"	298	284' 4"	334	12.06
PT-2-3-56A[2]	312' 5"	298	282' 4"	358	12.93
PT-2-3-56C[2]	312' 5"	298	284' 4"	334	12.06
PT-2-3-54A[3]	312' 5"	298	284' 4"	334	12.06
PT-2-3-54C[3]	312' 5"	298	284' 4"	334	12.06

All instrument elevations field verified; ref. Instrument Installation Details B-191261 sht. 8A, Rev. 12. Ref. VYC-332 for head correction data, VY OP-4312[1], 4342[2], 43109[3] for calibration.

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MEMORANDUM

YANKEE ATOMIC - BOLTON

To:	File	**Date:**	May 15, 1997
		Group #:	VYI 31/97 Rev. #1
From:	G.J. Hengerle	**WO #:**	4894
Subject:	ISP Application of Analyzed Drift Values in Setpoint Determination, Rev. 1	**IMS #:**	
		File #:	SETPOINTMEMO-10a.489

References:

a. Vermont Yankee Setpoint Design Guide, Rev. 0
b. Selected Definitions and Clarifications Associated with the Vermont Yankee Technical Specifications
c. VYC-1599, Drift Calculation for Fenwall Temp. Sw. Models 01-170020-090 & 01-170230-90, Rev. 0
d. VYC-1604, Drift Calculation for Time Delay Relays, Rev. 0
e. VYC-1606, Drift Calculation for Barksdale Pressure Switches, Rev. 0
f. VYC-1614, Drift Calculation for Rosemount Transmitters Models 1151, 1152 & 1153, Rev. 0
g. VYC-1615, Drift Calculation for Rosemount Trip Units Models 510DU & 710DU, Rev. 0
h. VYC-1615A, Drift Calculation for Rosemount Trip Unit Master Indicators, Rev. 0
i. VYC-1617, Drift Calculation for Static-O-Ring (SOR) Pressure Switches, Rev. 0
j. W. J. Beggs, Statistics for Nuclear Engineers and Scientists, Part 1: Basic Statistical Inference, WAPD-TM-1292, NTIS, 1981.

Background:

The Vermont Yankee Setpoint Design Guide (reference a) addresses the use of analyzed drift in setpoint determinations. The drift value is determined based on Vermont Yankee specific "as left"/"as found" calibration data. The drift value is based on the observed difference between the "as-found" value and the previous "as-left" value on a point per point basis. The resulting "analyzed drift" value is valid for the number of intervening days observed between calibrations. The setpoint analysis needs to take this "raw" drift value and apply it in a manner which supports its use for the required surveillance cycle. The manner in which this should be addressed is discussed below.

Discussion:

In general, a detailed summary is provided in each drift calculation describing the

results of that analysis. Included in the summary is discussion on time dependency, distribution (normal or not normal), etc.. In addition, data is provided which specifies the statistical results of the drift analysis associated with Kurtosis, mean, standard deviation, and the TIF used. The analyzed drift (in % calibrated span and in engineering units) is a 95%/95% value.

The Preparer of the setpoint calculation needs to determine the appropriateness of applying the analyzed drift value. The summary provided in the associated drift analysis should be included (all or in part) within the setpoint calculation as well as any other portion or the drift calculation which provides an input to the setpoint calculation. The following guidance is provided:

I. <u>Analyzed drift obtained from monthly surveillance cycles:</u>

A. When applied to monthly calibration cycles the analyzed drift value needs very little justification for its use. The monthly cycle (+25%, for a total allowed surveillance interval of 38 days per reference b.) can typically be justified directly by the summary or regression and histograms in the attachments. This approach is acceptable providing there are no statistically significant time dependent characteristics. For example, if the average surveillance interval for the analyzed monthly drift was 25 days:

$$DA_{Monthly} = DA_{38\text{-}Days} = DA_{25\text{-}Days}$$

Acceptable justifications include:

1. Determination that DA is a normally distributed random variable.

2. Determination that DA is random non-normal, but bound by a normal distribution of the same standard deviation.

B. The preparer should consider additional analysis if significant time dependent characteristics exist. The prefered method is to apply the regression analysis results included in the drift calculation directly to calculate a bias component of drift.

$$DA_{38\text{-}Days}(bias) = b_1 \times 38$$

where b_1 = regression rate of change coefficient (slope)

For example, from reference i., attachment 10, page 8, the OP4352 group of SOR pressure switches is demonstrated to be time dependent at the 98.3% significance level. The calculated slope for these switches is −0.023% per day, consequently the bias component of drift is then :

$$DA_{38\text{-}Days}(bias) = -0.023 \times 38 = -0.874\%$$

The calculated intercept values should be neglected, since they are usually not significant and would non-conservatively effect the result. Calculated effects of magnitude less than 0.1% can generally be ignored, however in this case, the total drift at 38 days would be the analyzed drift (ADR) value from the drift calculation (±2.124%) plus the bias value of -0.874%.

C. The analyzed drift value can be extended to support a quarterly surveillance cycle (90 days +25% tolerance for a total allowed surveillance interval of 114 days). If the conditions of I.A (above) are satisfied, then applying the SRSS methodology described in the Setpoint Design Guide can be applied. Justification for this approach should be stated, as described in I.A (above) referencing back to the time dependency regression discussed in the drift analysis and histograms. For example, to determine an equivalent drift value for a quarterly surveillance interval:

1. The $DA_{Monthly}$ could be applied as a surveillance interval inherently including the +25% tolerance, which amounts to 38 days.

2. Apply SRSS methodology to the ratio of time interval limits as follows:

$$DA_{Quarterly} = (114/38 \times DA^2_{Monthly})^{0.5}$$

D. If the time dependency conditions of I.B (above) apply, the analyzed drift value can still be extended to support a quarterly surveillance cycle (114 days). In this case, the Preparer should consider two (2) options.

1. Try to obtain analyzed drift values which were obtained from actual quarterly surveillance intervals obtained from the same type of components. The results could be used as a bases for selecting an approach for manipulating the monthly analyzed drift data. If quarterly analyzed drift values are available, it might be possible to:

   a. Justify directly applying the quarterly analyzed drift results in lieu of manipulating the monthly analyzed drift values originally provided, or

   b. Justify a SRSS approach using the monthly drift values (per I.C above) by showing the regression results are invalid due to small sample size or presence of anomalous data, or

   c. Justify using combined monthly and quarterly data to arrive at a DA term which bounds the expected behavior of the population for both monthly and quarterly testing.

2. Apply the results of the regression analysis included in the drift calculation directly to calculate the bias component and SRSS of monthly ADR to find the random component of drift for 114 days:

$$DA_{114\text{-}Days}\,(\text{bias}) = b_1 \times 114$$

where b_1 = regression rate of change coefficient (slope)

The preparer must justify use of the slope by ensuring that the value is statistically significant. This is done by ensuring that the regression is based upon an adequate number of samples (30 to 40), with sufficient spread in the range of time intervals (25%) to ensure the result is conservative. For example, from reference i., the OP4352 group of SOR pressure switches has a calculated slope of −0.023% per day. This is based upon 483 observations, with a interval data spread of 10 to 38 days for a mean of 30 days (93%), consequently the bias component of drift is justified as:

$$DA_{114\text{-}Days}(\text{bias}) = -0.023 \times 114 = -2.622\%$$

The random component of drift is found from the ADR in the same way as the non-time dependent example:

$$DA_{Quarterly}\,(\text{random}) = (114/38 \times DA^2_{Monthly})^{0.5}$$

Using the SOR switch example, substituting the monthly ADR of ±2.124% results in:

$$DA_{Quarterly}\,(\text{random}) = (114/38 \times 2.124^2)^{0.5} = (3 \times 4.51138)^{0.5} = 3.679\%$$

Neglecting the calculated intercept values, the total drift at 114 days would be the random term from the SRSS of analyzed drift (±3.679%) plus the bias value of −2.622%.

II. <u>Analyzed drift obtained from quarterly surveillance cycles:</u>

A. When applied to quarterly calibration cycles the quarterly analyzed drift value needs very little justification for its use. The quarterly cycle (+25%, for a total allowed surveillance interval of 114 days) can typically be justified directly by the summary and histograms as per I.A (above), emphasizing the impact of any time dependent characteristics. This approach is acceptable providing there are no significant time dependent characteristics. For example, if the analyzed quarterly drift value was based on an average of 85 days:

$$DA_{Quarterly} = DA_{114\text{-}Days} = DA_{85\text{-}Days}$$

As an alternative, the preparer may justify using combined monthly and quarterly data to arrive at a DA term which bounds the expected behavior of the population for both monthly and quarterly testing. This is the recommended approach for the Rosemount model 710 & 510 trip units, based upon the expected behavior of the group when all similar devices are calibrated to the same tolerances.

B. The Preparer should consider additional analysis if significant time dependent characteristics exist. The prefered method is to apply the regression analysis results included in the drift calculation directly to calculate a bias component of drift. The preparer must justify use of the slope by ensuring that the value is statistically significant.

$$DA_{114\text{-}Days}(bias) = b_1 \times 114$$

where b_1 = regression rate of change coefficient (slope)

III. Analyzed drift obtained from each operating cycles:
(note: operating cycle should be treated as equivalent to a refueling cycle unless noted otherwise)

A. When applied to an operational calibration cycle the analyzed drift value needs very little justification for its use. The operating cycle (+25%, for a total allowed surveillance interval of 684 days) can typically be justified. directly by the summary, emphasizing the impact of any time dependent characteristics. This approach is acceptable providing there are no strong time dependent characteristics. For example, if the analyzed operating cycle drift value was based on an average of 600 days:

$$DA_{Operating\ Cycle} = DA_{684\text{-}Days} = DA_{600\text{-}Days}$$

B. The Preparer should consider additional analysis if significant time dependent characteristics exist. The prefered method is to apply the regression analysis results included in the drift calculation directly to calculate a bias component of drift. The preparer must justify use of the slope by ensuring that the value is statistically significant.

$$DA_{684\text{-}Days}(bias) = b_1 \times 684$$

where b_1 = regression rate of change coefficient (slope) in percent per day. The process is similar to that employed for other calibration intervals.

IV. Evaluation of Time Dependency

The existence of time dependency in drift data is evaluated by regression analysis for each data grouping in the drift calculation. The regression always

calculates a slope for the fitted line, the significance of that slope is determined by the F-test contained in the attachments showing the regression tables and evaluation of the scatter plots in the same attachments. To indicate significance at the 95% level for the slope, the entry for significance should be less than 0.05. Each of the referenced calculations (c. through i.) have been reviewed for significant time dependency and those identified in the following table have been shown to exhibit time dependency at greater than the 95% confidence level, however two groups identified in the footnotes have an insufficient sample size to use the regression results with confidence.

Calculation	Group	Slope %per Day	Significance
VYC-1599: Fenwal Temp. Switches	OP4358 & 70	-2.59×10^{-4}	99.3%
VYC-1606: Barksdale Press. Switches	B2S-M48SS	-3.47×10^{-4}	99.5%
	B1T-A32SS	-1.69×10^{-3}	99.9+%
	E1S-H-15 FS	-1.33×10^{-3}	99.2%
	P1H-F30SS	-2.27×10^{-3}	99.9+%
	D2H-A150SS	+0.0244	99.1%[1]
VYC-1614: Rosemount Models 1151, 1152 & 1153	1153GB5 (0% point)	$+4.12 \times 10^{-3}$	95.7%[2]
	1153GB9[3] (0% point) (50% point)	-1.35×10^{-3} -1.33×10^{-3}	99.94% 98.0%
VYC-1617: SOR Press. Switches	OP4307 Group	-0.0293%	99.9+%
	OP4352 Group	-0.0230%	98.7%

V. Applying Bias other than time dependency

The drift calculations provide a 95%/95% tolerance interval termed the ADR. based upon the sample standard deviation (s). Use of this value in setpoint and uncertainty calculations requires a bit of analysis of the population to determine the presence of any bias. Depending upon the number of samples in the data

[1] Based upon 12 samples only, slope has a large confidence interval, may be better to treat as a uniform distribution.

[2] Based upon 14 samples and applies to zero point only, slope has a large confidence interval, may be better to treat as a uniform distribution or neglect entirely based upon Rosemount testing.

[3] May be possible to argue that the apparent time dependency is an anomaly of testing and neglect based upon Rosemount testing.

and the standard deviation, when the absolute value of the sample mean is greater than the critical values shown in the table below, the presence of bias is probable and should be included in the uncertainty calculation. This table is based upon the 95% confidence interval for the mean which includes zero.

N ≤	t	$t/N^{0.5}$	Maximum Value of Non-Biased Mean								
			s ≥ 0.10%	s ≥ 0.25%	s ≥ 0.5%	s ≥ 0.75%	s > 1.0%	s ≥ 1.5%	s ≥ 2.0%	s ≥ 2.5%	s ≥ 3.0%
20	2.086	0.47	0.05%	0.12%	0.23%	0.35%	0.47%	0.70%	0.93%	1.17%	1.40%
30	2.042	0.37	0.04%	0.09%	0.19%	0.28%	0.37%	0.56%	0.75%	0.93%	1.12%
40	2.021	0.32	0.03%	0.08%	0.16%	0.24%	0.32%	0.48%	0.64%	0.80%	0.96%
60	2.000	0.26	0.02%	0.06%	0.13%	0.19%	0.26%	0.39%	0.52%	0.65%	0.77%
120	1.980	0.18	0.01%	0.05%	0.09%	0.14%	0.18%	0.27%	0.36%	0.45%	0.54%

Note: If the sample size exceeds 120, use the last row for conservatism or calculate the critical value using x = 1.98s/N.

If the absolute value of the mean exceeds these values, then the mean (with sign) is taken as a bias term in accordance with the design guide and arithmetically combined with other bias uncertainties to determine total loop uncertainty. In most cases values within ±0.1% may be ignored entirely.

Example 1:

The sample population for the Rosemount Trip Unit Monthly group provides the following statistics:

COUNT	4749
AVERAGE	0.0002%
STDEV	0.0428%
VARIANCE	0.0000%
KURTOSIS	0.114
SKEWNESS	-0.008
MAXIMUM	0.1250%
MINIMUM	-0.1250%
95%/95% TIF	2.036
STDEV x 95/95 TIF = ADR	0.0871%
CAL UNITS mADC	0.014
% OF ORIGINAL COUNT	99.27%

The average (mean) for the 2nd Outlier tested data set is 0.0002% of calibrated span, count (N) is 4749, and standard deviation (s) is 0.04%, indicating no bias present in the data set. The ADR term is acceptable to use for an interval of 30 days as specified at ± **0.0871%** of span without any bias correction. As per other sections of this memo, additional considerations must be made for time intervals of greater than 30 days. The Kurtosis value is significantly larger than the Skewness value which indicates that the distribution is highly peaked about the center (0%).

Example 2:

Note: Barksdale specifications are based on Upper Range Limit (URL) not calibrated span.

The sample population for the Barksdale B1T-E1S-H-15DPS group (from VYC-1606) provides the following statistical summary:

COUNT	86
AVERAGE DAYS	489
AVERAGE	1.143%
STDEV	1.9550%
VARIANCE	0.0382%
KURTOSIS	3.747
SKEWNESS	1.705
MAXIMUM	8.6667%
MINIMUM	-2.0000%
95%/95% TIF	2.261

STDEV x 95/95 TIF = ADR	4.4203%
CAL UNITS PSIG (URL)	0.6630
% OF ORIGINAL COUNT	96.63%

The the absolute value of the mean is 1.143% of upper range limit (URL) which exceeds the critical value for ≤ 120 samples and s ≥ 1.5% URL, of 0.27% indicating a positive bias present in the data set.

The Kurtosis value is not significantly larger than the Skewness value which indicates that the distribution is not highly peaked about zero (0%) or the mean, and that the distribution may not be normally distributed. This example was chosen because it is one of the few cases of drift calculations completed to date which show evidence of bias, without also showing time dependency.

Conclusion:

The above discussion provides general guidance for the more common applications of analyzed drift. Other methods are acceptable. It is at the discretion of the Preparer to determine if the methods discussed above, or another approach (with bases), should be applied for their specific application. Acceptability of the method(s) applied shall be determined by concurrence with the independent reviewer.

The engineer performing the Setpoint/ Uncertainty calculation is responsible for reviewing the data, charts and plots contained in the applicable Drift Calculation(s) for the data groupings contained in his/her Setpoint/ Uncertainty calculation prior to submitting for review.

The guidance provided in this memorandum will be incorporated into a future revisions of the Vermont Yankee Setpoint Design Guide and the Vermont Yankee Instrument Drift Analysis Design Guide. Until then, this memorandum is an interim change to these design guides.

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Interim Design Guide References

1. Memo VYI 31/97 Rev. #1, "Improved Setpoint Program/Application of Analyzed Drift Values in Setpoint Determination", May 15, 1997.
2. Memo VYI 32/97, "Improved Setpoint Program/Relationship of HELB Environments to RPS Setpoints", DRAFT
3. Memo VYI 41/97, "Improved Setpoint Program/FSAR Table Revisions and M&TE Accuracy", April 23, 1997.

C:

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Attachments:					
7.1	37	Pgs	7.10	33	Pgs
7.2	35	Pgs	7.11	33	Pgs
7.3	24	Pgs	7.12	33	Pgs
7.4	18	Pgs	7.13	29	Pgs
7.5	27	Pgs	7.14	25	Pgs
7.6	27	Pgs	7.15	25	Pgs
7.7	33	Pgs	7.16	29	Pgs
7.8	33	Pgs	7.17	2	Pgs
7.9	33	Pgs			

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YANKEE NUCLEAR SERVICES DIVISION
CALCULATION/ANALYSIS FOR

TITLE DRIFT CALCULATION FOR ROSEMOUNT TRANSMITTERS MODELS 1151, 1152 & 1153

PLANT VERMONT YANKEE CYCLE 20

CALCULATION NUMBER VYC-1614

	PREPARED BY /DATE	REVIEWED BY /DATE	APPROVED BY /DATE	SUPERSEDES CALC. /REV. NO.
ORIGINAL	JH Lewis 3/24/97	GJ Hengerle 4/7/97	RT Vibert 4/12/97	N/A
REVISION 1	John H Lewis 5/18/98 JH Lewis 5/18/98	GJ Hengerle 5/20/98	R-T-Vibert 5/20/98 R-T-VIBERT	VYC-1614 Revision 0
REVISION 2				
REVISION 3				

KEYWORDS: Calculation/Rosemount/Transmitter/Flow/Level/Pressure

COMP CODES: Microsoft Excel Version 97 SR-1 & Version 5.0.c

EQUIP/TAG NO: DPT-10-91A,B; DPT-19-76A, B; DPT-2-116A-119D; DPT-20-376; FT-104-80A, B; FT-12-1A, B; FT-6-51A-D; LT-103-23A-D; LT-103-24A-D; LT-107-12A, B; LT-16-19-10A-C; LT-16-19-38A, B; LT-19-63A, B; LT-2-3-57(8)A, B; LT-2-3-68A-D; LT-2-3-72A-D; LT-2-3-73A,B; LT-3-231A-H; PT-10-101A-D; PT-104-20A, B; PT-19-81A, B; PT-2-3-52C, D; PT-2-3-54A-D; PT-2-3-55A-D; PT-2-3-56A-D; PT-5-12A-D; PT-6-58

REFERENCES: See Section 6

SYSTEMS: 103/104/107/CRD/FPC/FWC/NB/PCAC/RDW/RHR/RPS/RWCU

T/S or FSAR: TS Tables 3.1.1, 3.2.1, 3.2.2, 3.2.3, 3.2.5, 3.2.6, 3.2.9, Sections 3.12.C, 4.5.A.1.c, FSAR 4.8, 6.2, 7.2, 7.3, 7.4, 7.9 and Table 7.15.1

MODELS: Rosemount 1151, 1152, and 1153

FORM WE-103-1
Revision 4

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TAG NO.	SYS	DESCRIPTION	S/C	MANUFACT	MODEL	INPUT	OUTPUT	TOL	PROC
LT-3-231B	CRD	North SCRAM Discharge Instr Vol Lvl Xmtr	2/E	ROSEMOUNT	1153DB4PG	0-63"H20	4-20 mA	±0.06mA	OP-4310
LT-3-231C	CRD	North SCRAM Discharge Instr Vol Lvl Xmtr	2/E	ROSEMOUNT	1153DB4PG	0-63"H20	4-20 mA	±0.06mA	OP-4310
LT-3-231D	CRD	North SCRAM Discharge Instr Vol Lvl Xmtr	2/E	ROSEMOUNT	1153DB4PG	0-63"H20	4-20 mA	±0.06mA	OP-4310
LT-3-231E	CRD	South SCRAM Discharge Instr Vol Lvl Xmtr	2/E	ROSEMOUNT	1153DB4PG	0-63"H20	4-20 mA	±0.06mA	OP-4310
LT-3-231F	CRD	South SCRAM Discharge Instr Vol Lvl Xmtr	2/E	ROSEMOUNT	1153DB4PG	0-63"H20	4-20 mA	±0.06mA	OP-4310
LT-3-231G	CRD	South SCRAM Discharge Instr Vol Lvl Xmtr	2/E	ROSEMOUNT	1153DB4PG	0-63"H20	4-20 mA	±0.06mA	OP-4310
LT-3-231H	CRD	South SCRAM Discharge Instr Vol Lvl Xmtr	2/E	ROSEMOUNT	1153DB4PG	0-63"H20	4-20 mA	±0.06mA	OP-4310
PT-10-101A	RHR	Drywell High Pres Xmtr	2/E	ROSEMOUNT	1152GP4N22PB	0-5 PSIG	4-20 mA	±0.04mA	OP-4338
PT-10-101B	RHR	Drywell High Pres Xmtr	2/E	ROSEMOUNT	1153GB4PA	0-5 PSIG	4-20 mA	±0.04mA	OP-4338
PT-10-101C	RHR	Drywell High Pres Xmtr	2/E	ROSEMOUNT	1152GP4N22PB	0-5 PSIG	4-20 mA	±0.04mA	OP-4338
PT-10-101D	RHR	Drywell High Pres Xmtr	2/E	ROSEMOUNT	1152GP4N22PB	0-5 PSIG	4-20 mA	±0.04mA	OP-4338
PT-104-20A	104	SW Pmps Header Press	3/N	ROSEMOUNT	1151GP7E22B2	0.62-150.62"H20	4-20 mA	±0.08mA	MPAC
PT-104-20B	104	SW Pmps Header Press	3/N	ROSEMOUNT	1151GP7E22B2	0.62-150.62"H20	4-20 mA	±0.08mA	MPAC
PT-19-81A	FPC	Standby FPC Sys Disch Press	3/E	ROSEMOUNT	1153GB7PA	0-200 PSIG	4-20 mA	±0.04mA	MPAC
PT-19-81B	FPC	Standby FPC Sys Disch Press	3/E	ROSEMOUNT	1153GB7PA	0-200 PSIG	4-20 mA	±0.04mA	MPAC
PT-2-3-52C	NB	Reactor Press Xmtr	2/E	ROSEMOUNT	1153GB9PA	26-1526 PSIG	4-20 mA	±0.04mA	OP-4340
PT-2-3-52D	NB	Reactor Press Xmtr	2/E	ROSEMOUNT	1153GB9PA	26-1526 PSIG	4-20 mA	±0.04mA	OP-4340
PT-2-3-54A	NB	Rx Press Recirc Pmp Trip & Alt Rod Insertion Xmtr	2/E	ROSEMOUNT	1152GP9N22PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-43109
PT-2-3-54B	NB	Rx Press Recirc Pmp Trip & Alt Rod Insertion Xmtr	2/E	ROSEMOUNT	1152GP9N22PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-43109
PT-2-3-54C	NB	Rx Press Recirc Pmp Trip & Alt Rod Insertion Xmtr	2/E	ROSEMOUNT	1152GP9N22PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-43109
PT-2-3-54D	NB	Rx Press Recirc Pmp Trip & Alt Rod Insertion Xmtr	2/E	ROSEMOUNT	1152GP9N22PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-43109
→ PT-2-3-55A	NB	Reactor Vessel Hi Press SCRAM Xmtr	2/E	ROSEMOUNT	1152GP9E22T0280PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-4312
PT-2-3-55B	NB	Reactor Vessel Hi Press SCRAM Xmtr	2/E	ROSEMOUNT	1152GP9E22T0280PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-4312
PT-2-3-55C	NB	Reactor Vessel Hi Press SCRAM Xmtr	2/E	ROSEMOUNT	1152GP9E22T0280PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-4312
PT-2-3-55D	NB	Reactor Vessel Hi Press SCRAM Xmtr	2/E	ROSEMOUNT	1152GP9E22T0280PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-4312
PT-2-3-56A	NB	Rx Press ECCS Xmtr	2/E	ROSEMOUNT	1152GP9E22T0280PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-4342
PT-2-3-56B	NB	Rx Press ECCS Xmtr	2/E	ROSEMOUNT	1152GP9E22T0280	13-1513 PSIG	4-20 mA	±0.04mA	OP-4342
PT-2-3-56C	NB	Rx Press ECCS Xmtr	2/E	ROSEMOUNT	1152GP9E22T080PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-4342
PT-2-3-56D	NB	Rx Press ECCS Xmtr	2/E	ROSEMOUNT	1152GP9E22T0280PB	13-1513 PSIG	4-20 mA	±0.04mA	OP-4342
PT-5-12A	RPS	Drywell Hi Pres Xmtr	2/E	ROSEMOUNT	1152GP4N22PB	0-5 PSIG	4-20 mA	±0.04mA	OP-4311
PT-5-12B	RPS	Drywell Hi Pres Xmtr				0-5 PSIG	4-20 mA	±0.04mA	OP-4311
PT-5-12C	RPS	Drywell Hi Pres Xmtr				0-5 PSIG	4-20 mA	±0.04mA	OP-4311
PT-5-12D	RPS	Drywell Hi Pres Xmtr				0-5 PSIG	4-20 mA	±0.04mA	OP-4311
PT-6-38	PWC	Rx Press			[illegible]3	863-1063 PSIG	10-50mA	±0.2mA	MPAC

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5. RESULTS AND CONCLUSIONS

5.1. Groupings

Refer to Table 4A-C (Statistical Summary) for the summary of the statistical analysis for each surveillance and the resulting groupings. The Rosemount Transmitters were combined into the following groups based on all components having essentially equal standard deviations, variances and passing the t-Tests performed in step 2.4.3. The model number and spans are discussed in each of the following grouping sections.

5.1.1. Rosemount 1151DP4 Capillary (LT-16-19-38A & B)

The transmitters have the same model numbers, spans and services.

5.1.2. Rosemount 1151DP5 & 1153DB5 Capillary (LT-16-19-10A-C)

The transmitters have the same services, similar spans and the decision was made to group the 1151 and 1153 range code 5 based on the testing discussed in step 2.4.4.

5.1.3. Rosemount 1152DP4 (LT-2-3-57(58)A, B, LT-2-3-72A-D, LT-2-3-68B & D)

The transmitters have the same model numbers, spans and services.

5.1.4. Rosemount 1152DP7 (FT-6-51A-D, DPT-2-116A-119D)

The transmitters have very similar model numbers and input spans.

5.1.5. Rosemount 1152GP4 (PT-5-12A-D, PT-10-101A, C & D)

The transmitters have the same model numbers, spans and services.

→ 5.1.6. Rosemount 1152GP9 (PT-2-3-54A-D, PT-2-3-55-A-D & PT-2-3-56A-D)

The transmitters have the same model numbers, spans and services.

5.1.7. Rosemount 1153DB4 (FT-12-1A, B, LT-2-3-68A, C, FT-104-80A & B)

The transmitters have the same model numbers and similar spans.

5.1.8. Rosemount 1153DB4 Capillary (LT-19-63A, B & LT-3-231A-H)

The transmitters have the same model numbers and similar spans.

5.1.9. Rosemount 1153DB5 (LT-2-3-73A, B)

The transmitters have the same model numbers, spans and services.

5.1.10. Rosemount 1153DB6 & 7 (DPT-10-91A, B, DPT-19-76A & B)

The transmitters have similar model numbers and spans.

5.1.11. Rosemount 1153GB5 (LT-107-12A & B)

The transmitters have the same model numbers, spans and services.

5.1.12. Rosemount 1153GB9 (PT-2-3-52C & D)

The transmitters have the same model numbers, spans and services.

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5.2.5. Rosemount 1152GP4 (PT-5-12A-D, PT-10-101A, C & D)

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 9 it can be concluded that the data is evenly distributed about zero and from the table below the Significance F values all exceed 0.05 which indicates that no strong time dependency exists. [Att. 9]

1152GP4	0%	50%	100%
F	0.174	0.045	0.300
Significance F	0.678	0.833	0.586

✓

5.2.6. Rosemount 1152GP9 (PT-2-3-54A-D, PT-2-3-55-A-D & PT-2-3-56A-D)

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 10 it can be concluded that the data is evenly distributed about zero and from the table below the Significance F values all exceed 0.05 which indicates that no strong time dependency exists. [Att. 10]

1152GP9	0%	50%	100%
F	0.994	0.030	0.377
Significance F	0.322	0.864	0.541

✓

5.2.7. Rosemount 1153DB4 (FT-12-1A, B, LT-2-3-68A, C, FT-104-80A & B)

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 11 it can be concluded that the data is evenly distributed about zero and from the table below the Significance F values all exceed 0.05 which indicates that no strong time dependency exists. [Att. 11]

1153DB4	0%	50%	100%
F	3.192	0.672	1.186
Significance F	0.083	0.418	0.284

✓

5.2.8. Rosemount 1153DB4 Capillary (LT-19-63A, B & LT-3-231A-H)

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 12 it can be concluded that the data is evenly distributed about zero and from the table below the Significance F values all exceed 0.05 which indicates that no strong time dependency exists. [Att. 12]

1153DB4 Capillary	0%	50%	100%
F	2.035	1.998	2.636
Significance F	0.158	0.161	0.108

✓

5.2.9. Rosemount 1153DB5 (LT-2-3-73A, B)

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 13 it can be concluded that the data is evenly from the table below the Significance F values all exceed strong time dependency exists.

1153DB5	0%	50%
F	0.058	0.137
Significance F	0.810	0.713

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5.3.5. Rosemount 1152GP4 (PT-5-12A-D, PT-10-101A, C & D)

As seen from the Probability plots, Probability statistics and Histogram in Attachment 9 it can be concluded that the data is normally distributed with a highly peaked narrow distribution. The following table provides the percentage of points that fall within 1σ and 2σ for a normal distribution and for the 0-100% points. [Att. 9]

1152GP4	Normal Distribution	0%	50%	100%
1 Standard Deviation	68.27%	73.53%	76.06%	78.87%
2 Standard Deviations	95.45%	95.59%	94.37%	92.96%

5.3.6. Rosemount 1152GP9 (PT-2-3-54A-D, PT-2-3-55-A-D & PT-2-3-56A-D)

As seen from the Probability plots, Probability statistics and Histogram in Attachment 10 it can be concluded that the data is normally distributed. The following table provides the percentage of points that fall within 1σ and 2σ for a normal distribution and for the 0-100% points. [Att. 10]

1152GP9	Normal Distribution	0%	50%	100%
1 Standard Deviation	68.27%	66.18%	64.71%	70.59%
2 Standard Deviations	95.45%	98.53%	97.06%	95.59%

5.3.7. Rosemount 1153DB4 (FT-12-1A, B, LT-2-3-68A, C, FT-104-80A & B)

As seen from the Probability plots, Probability statistics and Histogram in Attachment 11 it can be concluded that the data is normally distributed with a highly peaked narrow distribution. The following table provides the percentage of points that fall within 1σ and 2σ for a normal distribution and for the 0-100% points. [Att. 11]

1153DB4	Normal Distribution	0%	50%	100%
1 Standard Deviation	68.27%	77.78%	77.78%	80.56%
2 Standard Deviations	95.45%	91.67%	91.67%	94.44%

5.3.8. Rosemount 1153DB4 Capillary (LT-19-63A, B & LT-3-231A-H)

As seen from the Probability plots, Probability statistics and Histogram in Attachment 12 it can be concluded that the data is normally distributed with a highly peaked narrow distribution. The following table provides the percentage of points that fall within 1σ and 2σ for a normal distribution and for the 0-100% points. [Att. 12]

1153DB4 Capillary	Normal Distribution	0%	50%	100%
1 Standard Deviation	68.27%	80.49%	82.93%	82.35%
2 Standard Deviations	95.45%	91.46%	89.02%	90.59%

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5.4.5.2. The data is normally distributed and exhibits no strong time dependency. The values presented are representative of the performance of the components as installed and tested. Improved calibration techniques, more accurate MTE and additional data will improve the performance of this group. [Att. 9] ok ✓

5.4.5.3. This data is acceptable for use in Setpoint/Uncertainty Calculations.

5.4.6. Rosemount 1152GP9 (PT-2-3-54A-D, PT-2-3-55-A-D & PT-2-3-56A-D)

5.4.6.1. The pooled data provides the following:

	0% Point	50% Point	100% Point
Count	68	68	68
Average Days	530	530	530
STDEV	0.142%	0.200%	0.344%
ADR	0.329%	0.463%	0.796%
CAL UNITS	4.93 PSIG	6.95 PSIG	11.94 PSIG

5.4.6.2. The data is normally distributed and exhibits no strong time dependency. The values presented are representative of the performance of the components as installed and tested. Improved calibration techniques, more accurate MTE and additional data will improve the performance of this group. [Att. 10]

5.4.6.3. This data is acceptable for use in Setpoint/Uncertainty Calculations.

5.4.7. Rosemount 1153DB4 (FT-12-1A, B, LT-2-3-68A, C, FT-104-80A & B)

5.4.7.1. The pooled data provides the following:

	0% Point	50% Point	100% Point
Count	36	36	36
Average Days	498	498	498
STDEV	0.294%	0.406%	0.551%
ADR	0.732%	1.011%	1.371%
CAL UNITS FT-12-1A, B FT-104-80A, B	0.73"H20	1.01"H20	1.37"H20
CAL UNITS LT-2-3-68A, C	0.57"H20	0.78"H20	1.06"H20

5.4.7.2. The data is normally distributed and exhibits no strong time dependency. The values presented are representative of the performance of the components as installed and tested. Improved calibration techniques, more accurate MTE and additional data will improve the performance of this group. [Att. 11] ok ✓

5.4.7.3. This data is acceptable for use in Setpoint/Uncertainty Calculations.

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Table 4C - Statistical Summary - 100% Calibration Point

	1151DP4 Capillary	1151DP5 & 1153DB5 Capillary	1152DP4	1152DP7	1152GP4	1152GP9	1153DB4	1153DB4 Capillary	1153DB5	1153DB6 & 7	1153GB5	1153GB9
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
COUNT	19	16	71	66	71	68	36	85	47	19	14	41
AVERAGE DAYS	395	507	489	512	479	530	498	482	166	362	545	172
AVERAGE	1.207%	0.086%	-0.051%	-0.066%	-0.004%	0.001%	-0.078%	0.152%	-0.063%	-0.093%	0.079%	-0.001%
STDEV	3.194%	0.662%	1.220%	0.592%	0.383%	0.344%	0.551%	1.346%	0.553%	0.510%	0.309%	0.140%
VARIANCE	0.102%	0.004%	0.015%	0.004%	0.001%	0.001%	0.003%	0.018%	0.003%	0.003%	0.001%	0.000%
KURTOSIS	0.048	-0.257	1.625	6.500	0.791	0.322	3.910	3.036	8.819	0.418	-1.699	0.979
SKEWNESS	-0.091	-0.550	0.090	-1.425	-0.270	-0.439	-0.741	0.884	-2.599	0.565	0.153	-0.243
MAXIMUM	7.250%	1.044%	3.500%	1.063%	1.000%	0.750%	1.250%	4.313%	0.750%	1.125%	0.500%	0.350%
MINIMUM	-5.062%	-1.313%	-3.200%	-2.875%	-1.025%	-1.000%	-2.000%	-3.563%	-2.250%	-0.875%	-0.250%	-0.375%
95%/95% TIF	2.784	2.903	2.299	2.315	2.299	2.315	2.49	2.261	2.408	2.784	3.012	2.445
STDEV x 95/95 TIF = ADR	8.892%	1.923%	2.806%	1.371%	0.879%	0.796%	1.371%	3.042%	1.331%	1.418%	0.929%	0.343%
CAL UNITS	3.20 "H20	5.77 "H20	2.17" H20	1.20 PSIG	0.04 PSIG	11.94 PSIG	1.37 "H20	1.92 "H20	5.11 "H20	1.42 PSIG	3.62 "H20	6.15 PSIG
CAL UNITS			1.98" H20	1.65 PSIG			1.06 "H20	0.76 "H20				
% OF ORIGINAL COUNT	100.00%	94.12%	95.95%	95.65%	100.00%	98.55%	94.74%	98.84%	95.92%	100.00%	100.00%	97.62%

2.17"H20 Applicable to: LT-2-3-68B & D
1.98"H20 Applicable to: LT-2-3-57,58A, B, 72A-D

1.20 PSIG Applicable to: FT-6-51A-D
1.65 PSIG Applicable to: DPT-2-116A-119D

1.69 "H20 Applicable to: LT-3-231A-H
0.67 "H20 Applicable to: LT-19-63A, B

1.37 "H20 Applicable to: FT-12-1A, B, FT-104-80A, B
1.06 "H20 Applicable to: LT-2-3-68A, C

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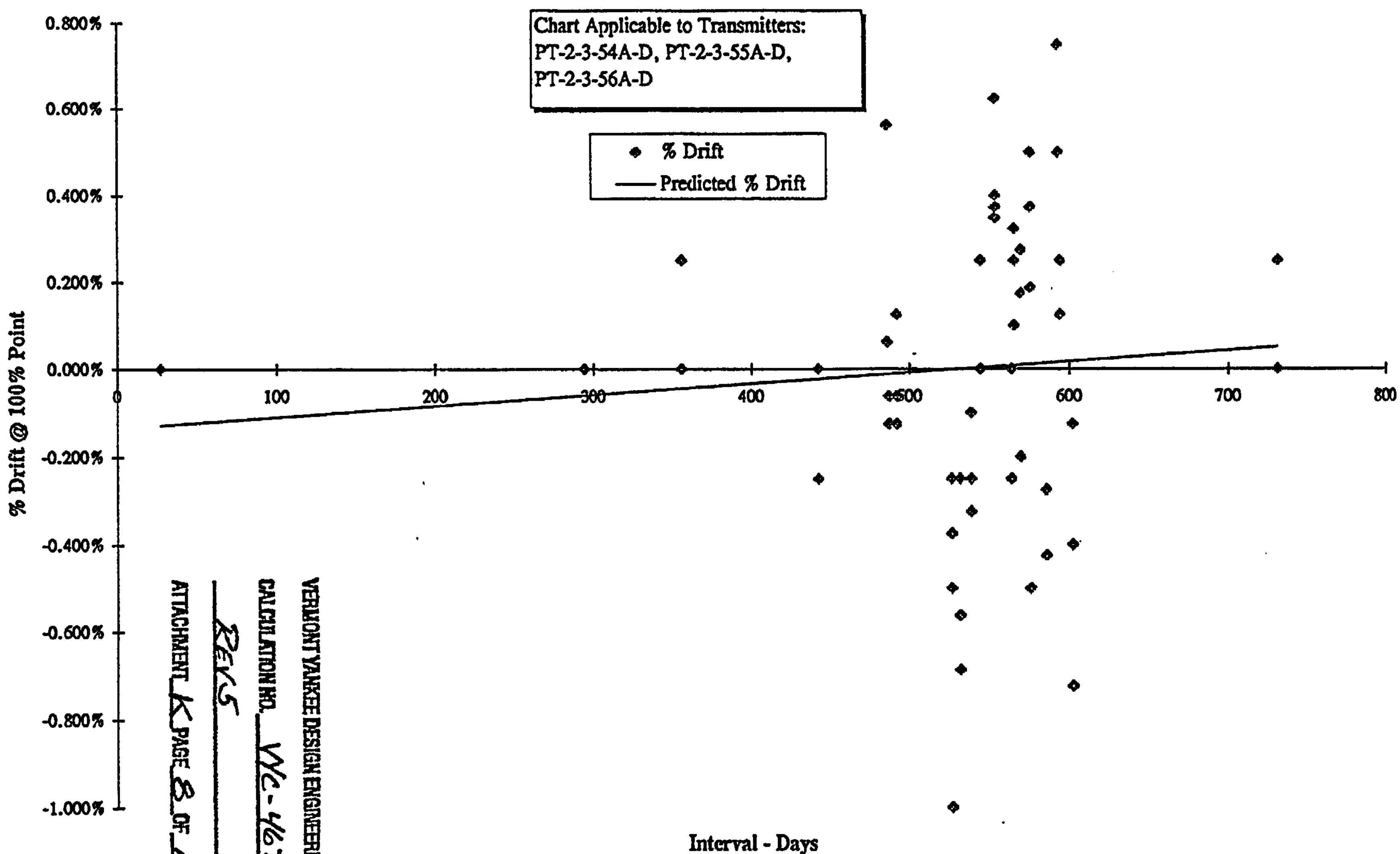
Regression Line (Raw Data) - Rosemount Transmitter Model 1152GP9 - 100% Point



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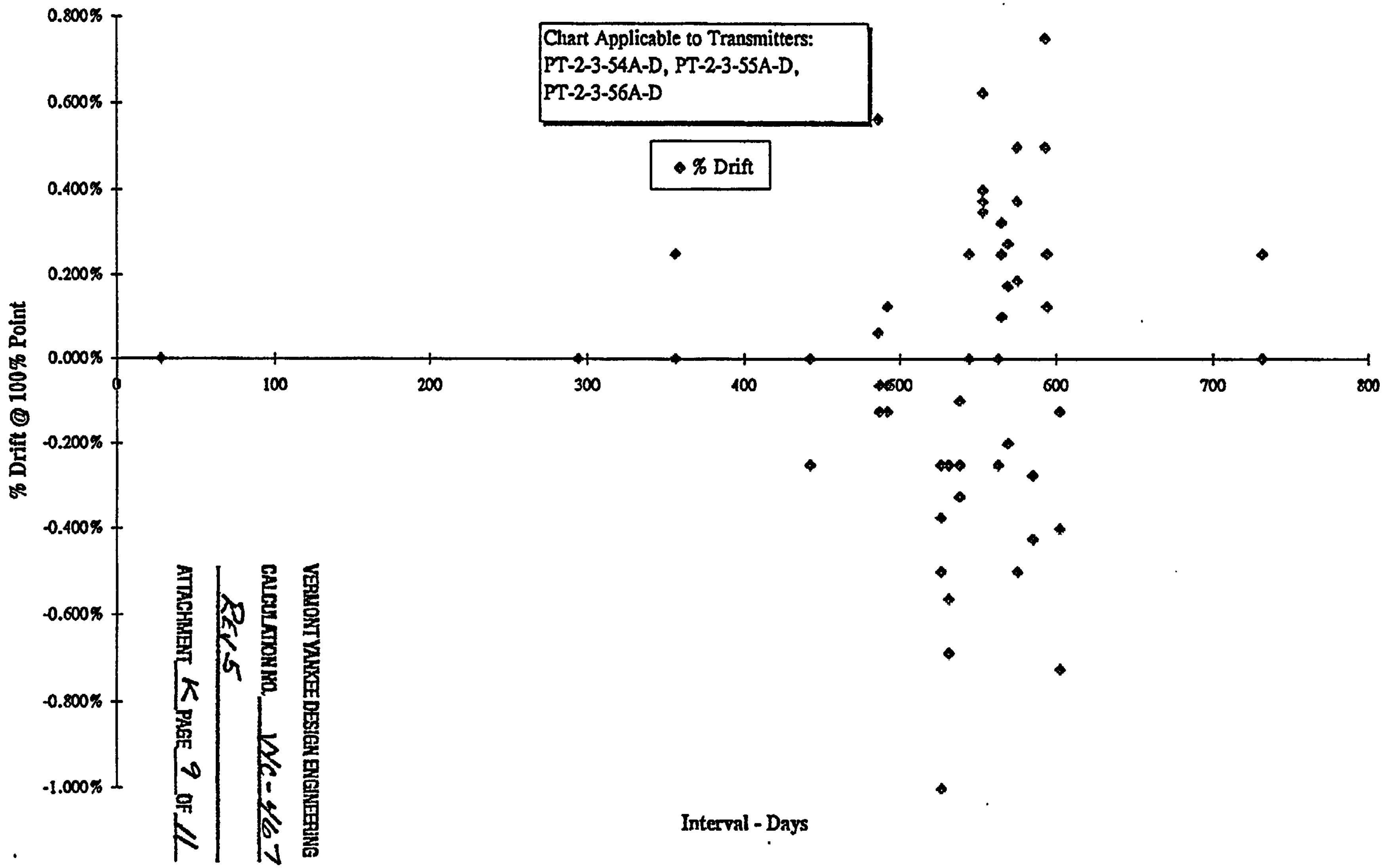
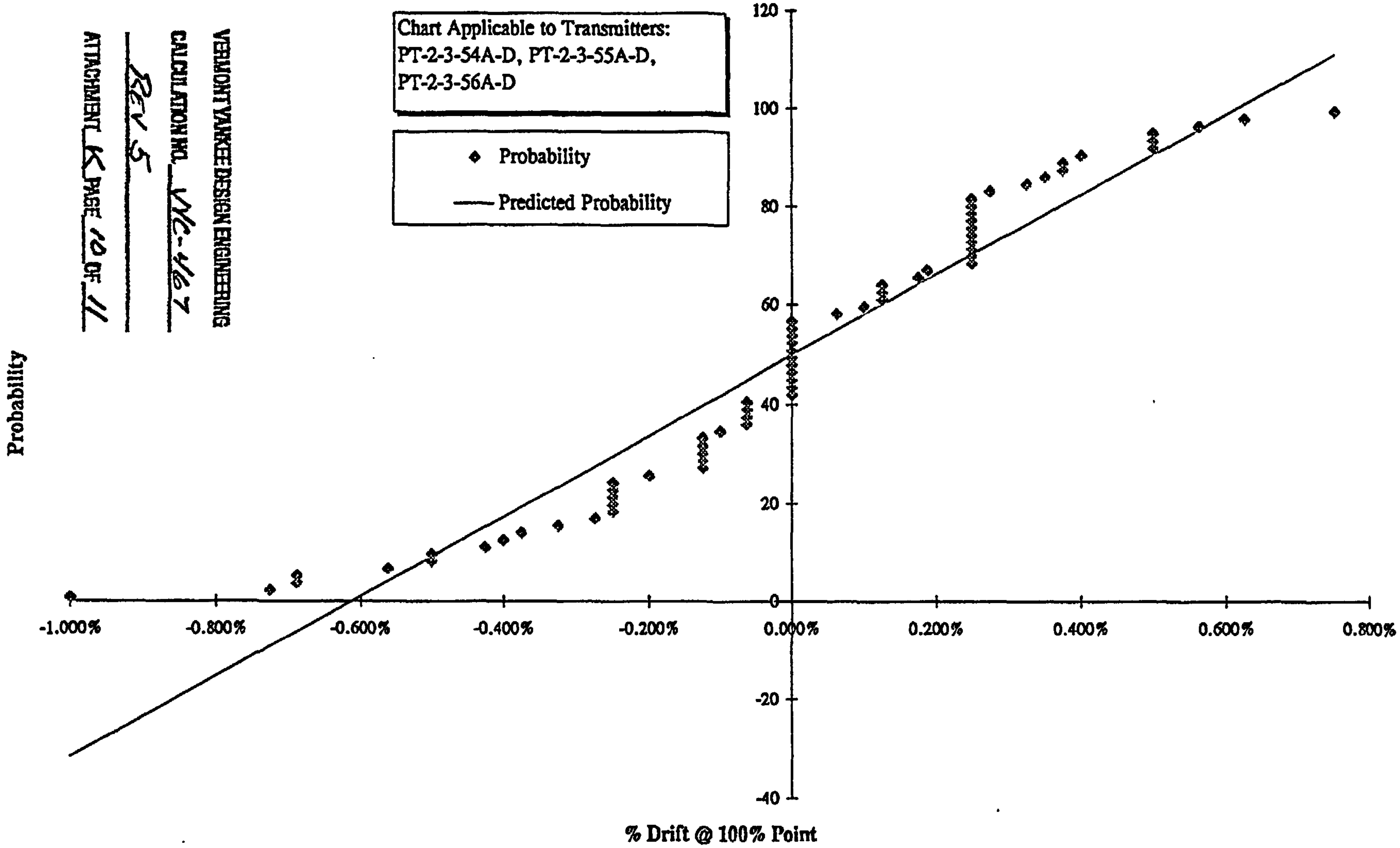
XY Scatter (Raw Data) - Rosemount Transmitter Model 1152GP9 - 100% Point



Cumulative Probability Plot - Rosemount Transmitter Model 1152GP9 - 100% Point



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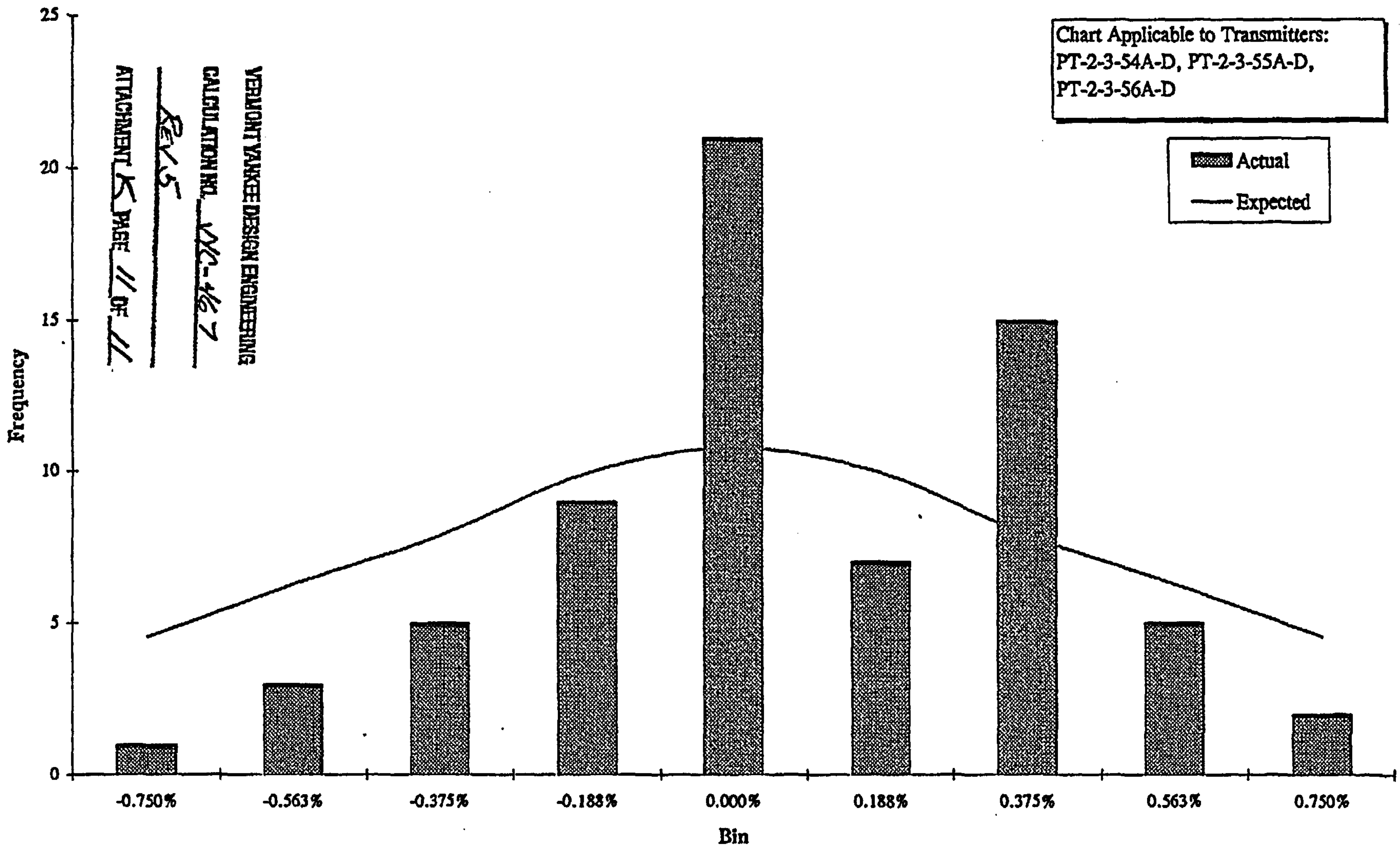
Histogram - Rosemount Transmitter Model 1152GP9 - 100% Point



Attachments:		
7.1	172	Pages
7.2	112	Pages
7.3	12	Page
7.4	170	Pages
7.5	1	Page
7.6	39	Pages
7.7	23	Pages
7.8	11	Pages
7.9	63	Pages
7.10	11	Pages
7.11	1	Page

Total Pages: 22 + 615 = 637

ORIGINAL: PAGE 1 OF 22 PAGES
Rev 1: PAGE 1 OF ____ PAGES
Rev 2: PAGE 1 OF ____ PAGES
Rev 3: PAGE 1 OF ____ PAGES

QA RECORD?

☒ YES

☐ NO

IMS NO. 09.018.004

RECORD TYPE M02.01.05

W.O. / P.O. NO. 4894

YANKEE NUCLEAR SERVICES DIVISION
CALCULATION/ANALYSIS FOR

TITLE DRIFT CALCULATION FOR ROSEMOUNT TRIP UNITS MODELS 510DU & 710DU

PLANT VERMONT YANKEE CYCLE 19

CALCULATION NUMBER VYC-1615

	PREPARED BY /DATE	REVIEWED BY /DATE	APPROVED BY /DATE	SUPERSEDES CALC. /REV. NO.
ORIGINAL	JHLewis 3/3/97 JH Lewis 3/3/97	[signature] 3-31-97	R.T. Vibert 4/5/97	—
REVISION 1				
REVISION 2				
REVISION 3				

KEYWORDS: Calculation/Rosemount/Trip/CRD/FPC/NB/RHR/RWCU/107/Level/Pressure/Flow

INSTRUMENTS: DPT-2-116A-119D(M); DPT-2-116A, 117B, 118C & 119D(S1); FT-12-1A, B(M); LT-107-12A, B(M); LT-19-63A,B(M, S1 & S2); LT-2-3-57(58)A,B(M, S1 & S2); LT-2-3-72A-D(M); LT-2-3-72A, B(S1,S3, S4 & S5); C, D(S1 & S3); LT-2-3-73A,B(M); LT-3-231A-H(M); LT-3-231A,B,G,H(S1); PT-10-101A-D(M & S1); PT-2-3-52C,D(M); PT-2-3-55A-D(M); PT-2-3-56A-D(M); PT-5-12A-D(M)

DESIGN DOCS: None

MODELS: Rosemount 510DU & 710DU Trip Units

T/S or FSAR: TS Table 3.1.1, 3.2.1, 3.2.2, 3.2.3, 3.2.9
FSAR 7.2.3.6.7, 7.2.3.6.8, 7.3.2.6.2, 7.3.4.7.4; 7.4, 7.3.4.7.6

PROCEDURES: OP-4310, OP-4311, OP-4312, OP-4313, OP-4323, OP-4336, OP-4337, OP-4338, OP-4340, OP-4342, OP-4355, OP-4362, OP-43106

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FORM WE-103-1
Revision 2

TAG NO.	SYS	DESCRIPTION	S/C	MANUF	MODEL	SPAN	SETPT	TOL	PROC
PT-2-3-52C(M)	NB	Rx Lo Press ECCS	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	7.47 mADC	± 0.04 mADC	OP-4340
PT-2-3-52D(M)	NB	Rx Lo Press ECCS	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	7.47 mADC	± [illegible] mADC	OP-4340
PT-2-3-55A(M)	NB	Rx Vsl Hi Press SCRAM	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	15.12 mADC	(-) 0.03, + 0 mADC	OP-4312
PT-2-3-55B(M)	NB	Rx Vsl Hi Press SCRAM	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	15.12 mADC	(-) 0.03, + 0 mADC	OP-4312
PT-2-3-55C(M)	NB	Rx Vsl Hi Press SCRAM	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	15.12 mADC	(-) 0.03, + 0 mADC	OP-4312
PT-2-3-55D(M)	NB	Rx Vsl Hi Press SCRAM	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	15.12 mADC	(-) 0.03, + 0 mADC	OP-4312
PT-2-3-56A(M)	NB	Rx Press ECCS Perm	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	7.47 mADC	± 0.05 mADC	OP-4342
PT-2-3-56B(M)	NB	Rx Press ECCS Perm	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	7.47 mADC	± 0.05 mADC	OP-4342
PT-2-3-56C(M)	NB	Rx Press ECCS Perm	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	7.47 mADC	± 0.05 mADC	OP-4342
PT-2-3-56D(M)	NB	Rx Press ECCS Perm	SCE	ROSEMOUNT	710DUOTT37157	4-20 mADC	7.47 mADC	± 0.05 mADC	OP-4342
PT-5-12A(M)	RPS	Drywell Hi Press SCRAM & PCIS	SCE	ROSEMOUNT	710DUOTT36005	4-20 mADC	11.36 mADC	± 0.16 mADC	OP-4311
PT-5-12B(M)	RPS	Drywell Hi Press SCRAM & PCIS	SCE	ROSEMOUNT	710DUOTT36005	4-20 mADC	11.36 mADC	± 0.16 mADC	OP-4311
PT-5-12C(M)	RPS	Drywell Hi Press SCRAM & PCIS	SCE	ROSEMOUNT	710DUOTT36005	4-20 mADC	11.36 mADC	± 0.16 mADC	OP-4311
PT-5-12D(M)	RPS	Drywell Hi Press SCRAM & PCIS	SCE	ROSEMOUNT	710DUOTT36005	4-20 mADC	11.36 mADC	± 0.16 mADC	OP-4311

1.2. Instrument Loop Function (Abbreviated)

1.2.1. The Trip Units for OP-4310 provide SCRAM Discharge Instrument Volume High Level SCRAM (Setpoint=16.7 mA↑, 17.56 Gallons), High Level Rod Block (Setpoint=10.35 mA↑, 9.8 Gallons), and SCRAM Discharge Instrument Volume Water Hi Annunciation (Setpoint=4.76 mA↑, 2.95 Gallons).

1.2.2. The Trip Units for OP-4311 provide Drywell High Pressure SCRAM & PCIS Isolation (Setpoint=11.36 mA↑, 2.3 PSIG).

1.2.3. The Trip Units for OP-4312 provide the Reactor High Pressure SCRAM (Setpoint=15.12 mA↑, 1042.5 PSIG) trip function.

1.2.4. The Trip Units for OP-4313 provide the Reactor Water Level Low SCRAM and PCIS Isolation functions (Setpoint=12.80 mA↓, 132"H20), Reactor Water Level LO-LO PCIS Isolation functions (Setpoint=5.60 mA↓, 87"H20), Reactor Water Level High Alarm (Setpoint=18.88 mA↑, 170"H20).

1.2.5. The Trip Units for OP-4323 provide the Main Steam High Flow PCIS Isolation Signal (Setpoint=17.87 mA↑, 104 PSI), and Main Steam Line High Flow Reduced PCIS Isolation Signal (Setpoint=4.89 mA↑, 6.675 PSI).

1.2.6. The Trip Units for OP-4336 provide Reactor Vessel Shroud Level and Containment Spray Low Water Level Interlock functions (Setpo

1.2.7. The Trip Units for OP-4337 provide a Reactor Wa Trip (Setpoint=19.36 mA↑, 173"H20), Reactor Ve Isolation & Feed Pump Trip (Setpoint=19.68 mA↑ Low-Low Water Level ECCS Initiation (Setpoint=!

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4.2.3. The Analyzed Drift value is listed in Table 4 (Statistical Summary) for each surveillance test and the grouped data.

4.2.4. The statistics summary for each surveillance test and the groupings can be found in Table 4 (Statistical Summary) and at the beginning of Attachments 2 and 4 . [Att. 2, 4]

4.3. Plots

4.3.1. The XY scatter plots, Regression lines, Histograms and P determining the characteristics of the data are contained i (Monthly Group), Attachment 7 (Quarterly Group), Attachi Group), Attachment 9 (All Groups - Except OP-4362 Data 4362 Group).

~~4.3.2. The plot statistics are located at the end of the plot group~~ 10.

.... data used for
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5. RESULTS AND CONCLUSIONS

5.1. Groupings

5.1.1. Refer to Attachment 2 for statistical summary of each surveillance and Table 4 for the resulting groupings.

5.1.2. The data from the Rosemount Trip Units for the monthly surveillance (Attachment 6) was able to be pooled into one group due to the components passing the t-Test performed in step 2.4.3, having the same input ranges, similar model numbers, and essentially equal standard deviations and variances. Refer to Table 1 (Equipment Summary) for component information and Table 4 (Statistical Summary) for statistical information.

5.1.2.1. The pooled data provides a group of 4,749 sample points with a standard deviation of 0.043% of span with an average time interval of 30 days. As determined in Section 4.2 of this calculation a 95%/95% TIF will be applied to the standard deviation for the group which equates to an ADR term of 0.087% of span (0.01 mADC). Refer to Table 4 (Statistical Summary).

5.1.3. The data from the Rosemount Trip Units for the quarterly surveillance (Attachment 7) was able to be pooled into one group due to the components passing the t-Test performed in step 2.4.3, having the same input ranges, similar model numbers, and essentially equal standard deviations and variances. Refer to Table 1 (Equipment Summary) for component information and Table 4 (Statistical Summary) for statistical information.

5.1.3.1. The pooled data provides a group of 760 sample points with a standard deviation of 0.146% of span with an average time interval of 77 days. As determined in Section 4.2 of this calculation a 95%/95% TIF will be applied to the standard deviation for the group which equates to an ADR term of 0.299% of span (0.05 mADC). Refer to Table 4 (Statistical Summary).

5.1.4. The data from the Rosemount Trip Units for the Semi-Annual surveillance (Attachment 8) was able to be pooled into one group due to the components passing the t-Test performed in step 2.4.3, having the same input ranges, similar model numbers, and essentially equal standard deviations and variances. Refer to Table 1 (Equipment Summary) for component information and Table 4 (Statistical Summary) for statistical information.

5.1.4.1. The pooled data provides a group of 38 sample points with a standard deviation of 0.034% of span with an average time interval of 182 days. As determined in Section 4.2 of this calculation a 95%/95% TIF will be applied to the standard deviation for the group which equates to an ADR term of 0.085% of span (0.01 mADC). Refer to Table 4 (Statistical Summary).

5.1.5. The data from the group of All Rosemount Trip Units except OP-4362 (Attachment 9) was able to be pooled into one group due to the components passing the t-Test performed in step 2.4.3, having the same input ranges, similar model numbers, and essentially equal standard deviations and variances. Refer to Table 1 (Equipment Summary) for component information and Table 4 (Statistical Summary) for statistical information.

5.1.5.1. The pooled data provides a group of 5457 sample points with a standard deviation of 0.051% of span with an average time interval of 38 days. As determined in Section 4.2 of this calculation a 95%/95% TIF will be applied to the standard deviation for the group which equates to an ADR term of 0.104% of span (0.02 mADC). Refer to Table 4 (Statistical Summary).

5.1.6. The data from OP-4362 (Attachment 10) was able to be pooled into one group due to the components passing the t-Test performed in step 2.4.3, having the same ranges, model numbers and services. Refer to Table 1 (Equipment Summary) for component information and Table 4 (Statistical Summary) for statistical information.

5.1.6.1. The pooled data provides a group of 59 sample points with a standard deviation of 0.146% of span with an average time interval of 142 days. As determined in Section 4.2 of this calculation a 95%/95% TIF will be applied to the standard deviation for the group which equates to an ADR term of 0.408% of span (0.07 mADC). Refer to Table 4 (Statistical Summary).

5.2. Time Dependency

5.2.1. Rosemount Trip Units - Monthly Group

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 6 it can be concluded that the data is evenly distributed about zero with a slope on the regression lines equivalent to < 0.01 % / ~55 days. [Att. 6]

5.2.2. Rosemount Trip Units - Quarterly Data

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 7 it can be concluded that the data is evenly distributed about zero with an insignificant slope on the regression lines line indicating a negligible time dependency. [Att. 7]

5.2.3. Rosemount Trip Units - Semi Annual Group

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 8 it can be concluded that the data is evenly distributed about zero with an insignificant slope on the regression lines indicating a negligible time dependency. [Att. 8]

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5.2.4. Rosemount Trip Units - All Groups (Except Op-4362 Data)

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 9 it can be concluded that the data is evenly distributed about zero with a slope on the regression lines equivalent to < 0.01 % / ~180 days. [Att. 9]

→ 5.2.5. Rosemount Trip Units - OP-4362 Group

As seen from the XY Scatter plots, Regression lines and Regression statistics in Attachment 10 it can be concluded that the data is evenly distributed about zero with a slope on the regression lines equivalent to < 0.05 % / ~200 days. [Att. 10]

5.3. Normality

5.3.1. Rosemount Trip Units - Monthly Group

As seen from the Probability plots, Probability statistics and Histogram in Attachment 6 it can be concluded that the data is normally distributed with a highly peaked narrow distribution. [Att. 6]

5.3.2. Rosemount Trip Units - Quarterly Group

As seen from the Probability plots, Probability statistics and Histogram in Attachment 7 it can be concluded that the data is normally distributed with a highly peaked narrow distribution. [Att. 7]

5.3.3. Rosemount Trip Units - Semi Annual Group

As seen from the Probability plots, Probability statistics and Histogram in Attachment 8 it can be concluded that the data is normally distributed with a highly peaked narrow distribution. [Att. 8]

→ 5.3.4. Rosemount Trip Units - All Groups (Except Op-4362 Data)

As seen from the Probability plots, Probability statistics and Histogram in Attachment 9 it can be concluded that the data is normally distributed with a highly peaked narrow distribution. [Att. 9]

5.3.5. Rosemount Trip Units - OP-4362 Group

As seen from the Probability plots, Probability statistics and Histogram in Attachment 10 it can be concluded that the data is normally distributed with a highly peaked narrow distribution. [Att. 10]

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5.4. Summary

The data contained is normally distributed, showing little time dependency and is acceptable for use in Setpoint/Uncertainty calculations.

5.4.1. Rosemount Trip Units - Monthly Group consisting of components DPT-2-116A-119D(M), A-D(S1); LT-2-3-57(58)A, B(M), A, B(S1&S2); LT-2-3-72A-D(M), A-D(S1 & S3), A,B(S4 & S5); LT-2-3-73A, B(M): LT-107-12A, B(M): PT-2-3-52C, D(M): PT-2-3-56A-D(M); PT-10-101A-D(M), A-D(S1) = 0.087% of span (0.01 mADC).

5.4.2. Rosemount Trip Units - Quarterly Group consisting of components LT-3-231A-H(M), A, B, G, H(S1) = 0.299% of span (0.05 mADC).

5.4.3. Rosemount Trip Units - Semi Annual Group consisting of components LT-191-63A, B(M), A, B(S1 & S2) = 0.085% of span (0.01 mADC).

→ 5.4.4. Rosemount Trip Units - All Groups (Except Op-4362 Data) consisting of all components except FT-12-1A, B(M) = 0.104% of span (0.02 mADC).

5.4.5. Rosemount Trip Units - OP-4362 Group consisting of components FT-12-1A, B (M) = 0.408% of span (0.07 mADC).

Table 4 - Statistical Summary

	MONTHLY GROUPING	QUARTERLY GROUPING	SEMI ANNUAL GROUPING	ALL TU GROUPINGS EXCEPT DATA FROM OP-4362	OP-4362 GROUP
COUNT	4749	760	38	5457	61
AVERAGE	0.000%	0.000%	0.002%	0.000%	-0.025%
STDEV	0.043%	0.146%	0.034%	0.051%	0.175%
VARIANCE	0.000%	0.000%	0.000%	0.000%	0.000%
KURTOSIS	0.114	2.019	0.694	1.829	2.711
SKEWNESS	-0.008	0.332	0.023	0.025	-0.884
MAXIMUM	0.125%	0.500%	0.063%	0.188%	0.375%
MINIMUM	-0.125%	-0.562%	-0.063%	-0.188%	-0.562%
95%/95% TIF	2.036	2.052	2.49	2.036	2.333
STDEV x 95/95 TIF=ADR	0.087%	0.299%	0.085%	0.104%	0.408%
CAL UNITS mADC	0.01	0.05	0.01	0.02	0.07
% OF ORIGINAL COUNT	99.27%	99.61%	97.44%	97.69%	96.83%

Note: The statistical summaries for each of the individual surveillance tests is listed in Attachment 2 Statistical Summary.

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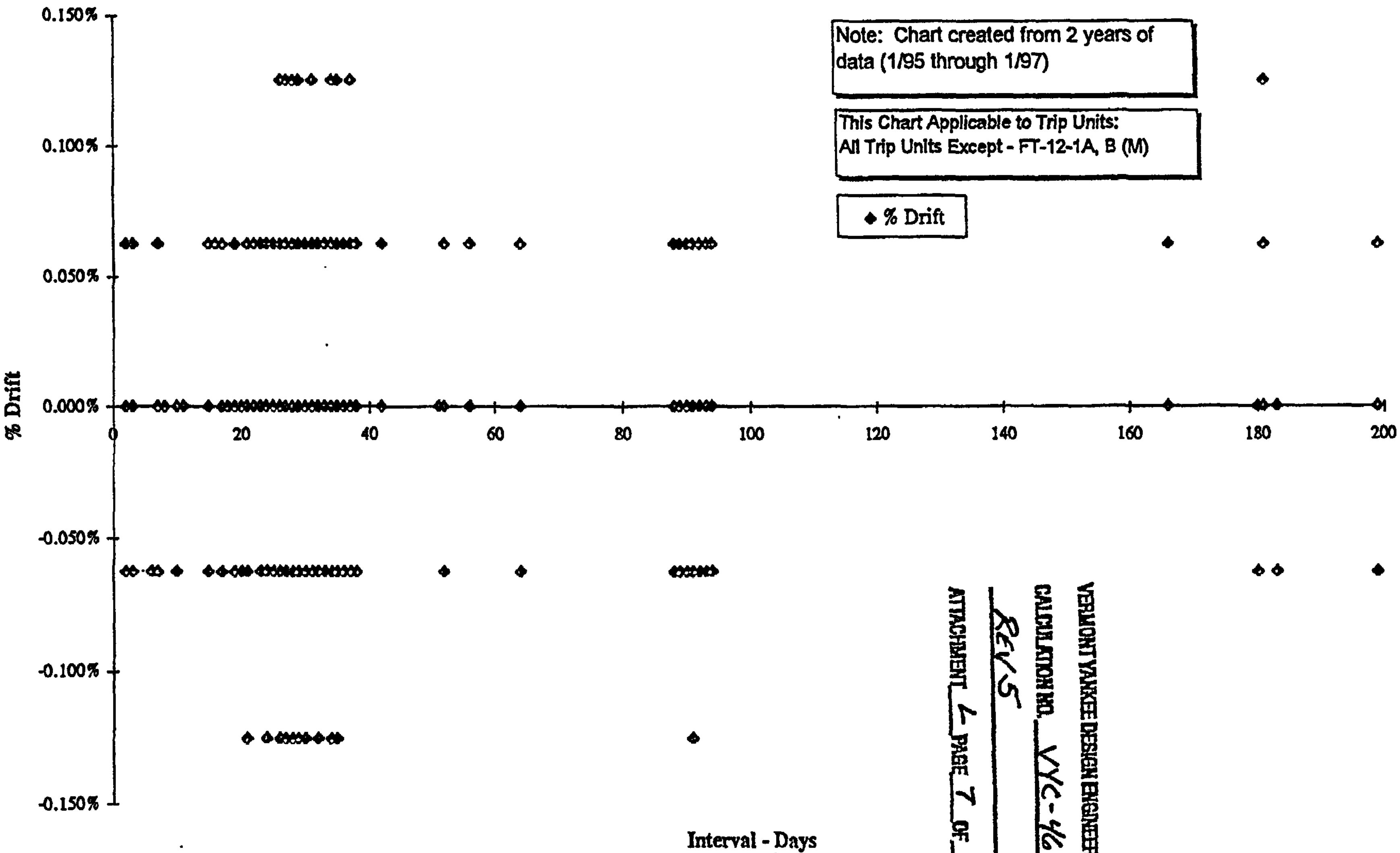
XY Scatter - Rosemount Trip Units - All Groups (Except OP-4362 Data)



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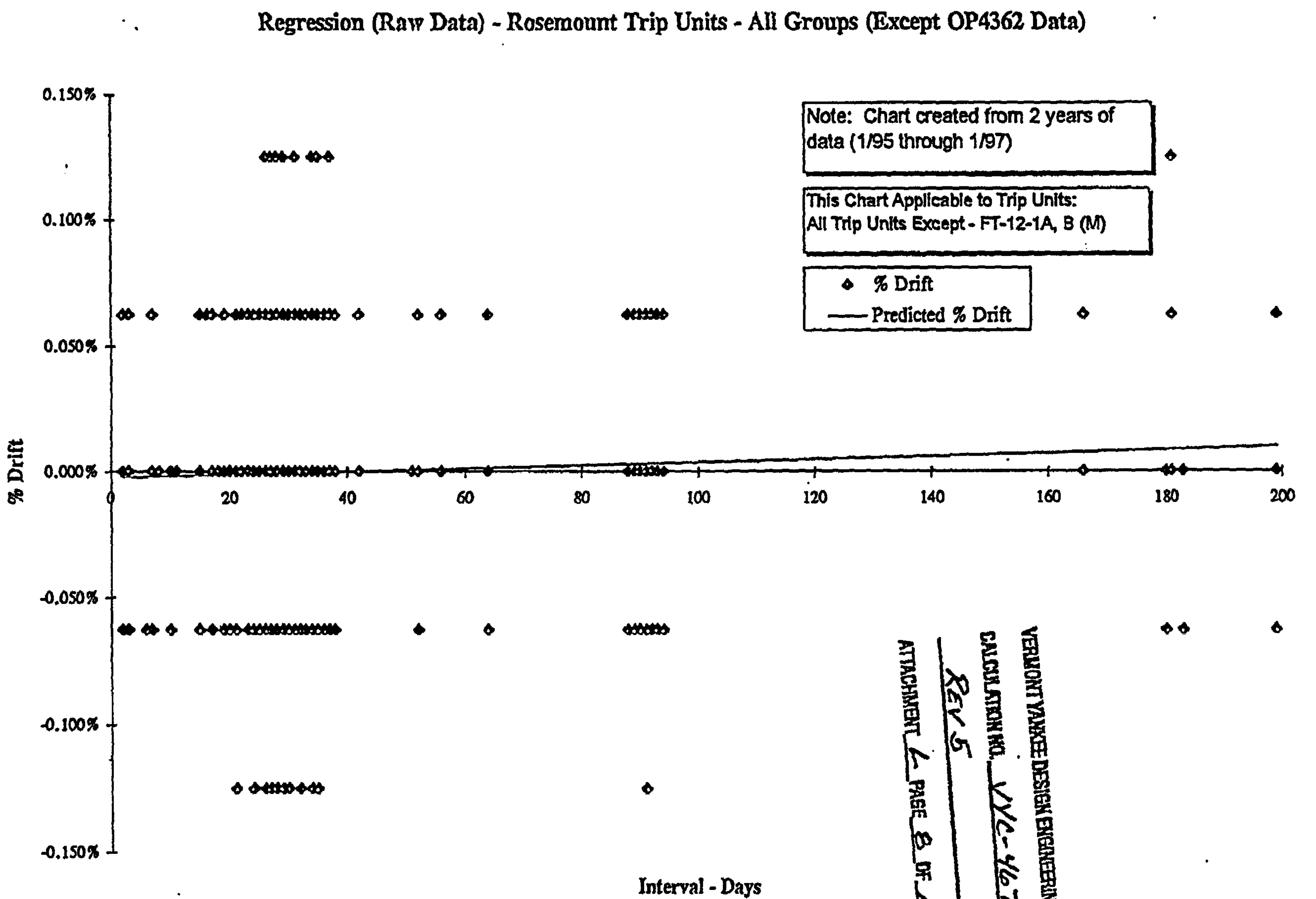

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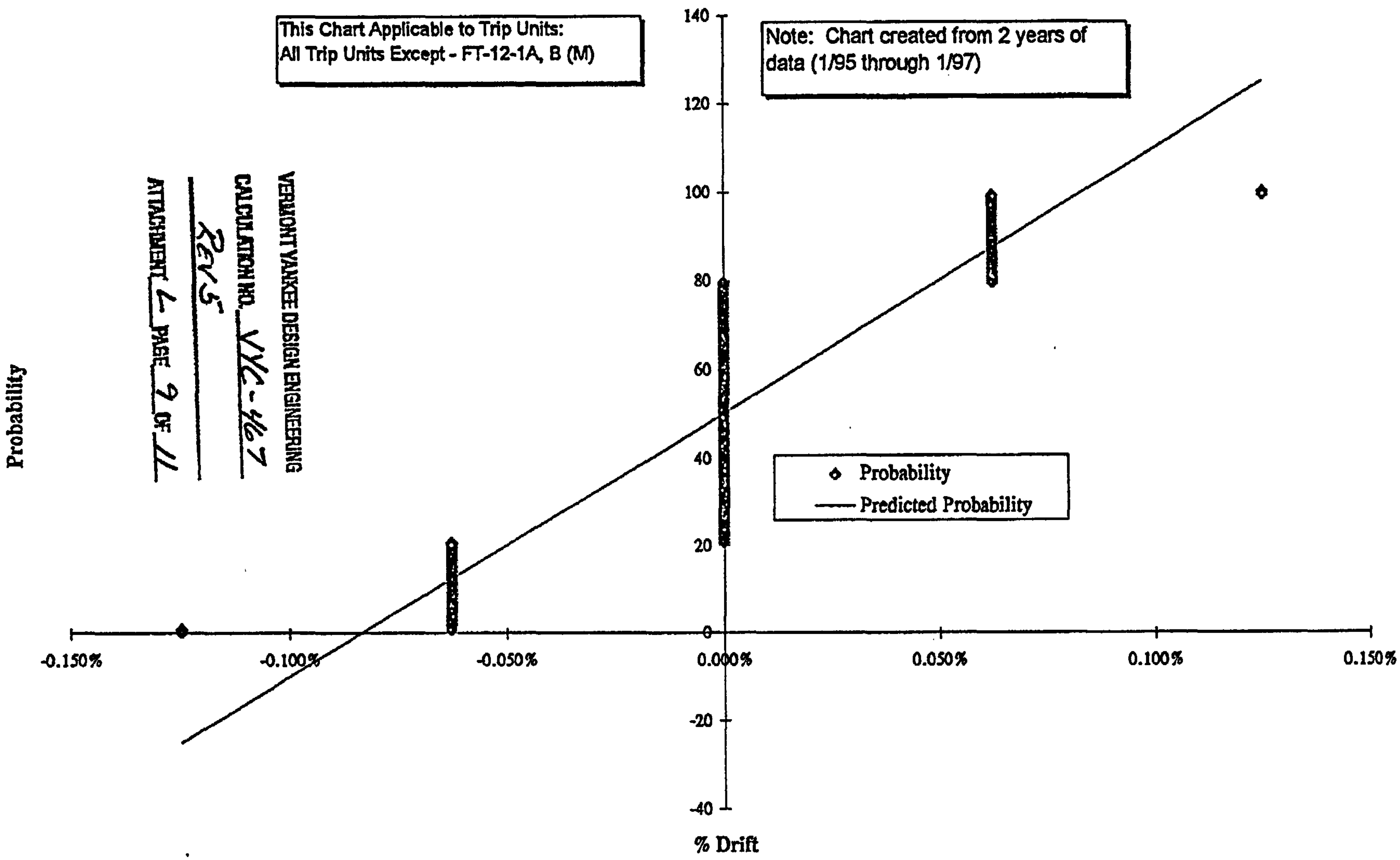
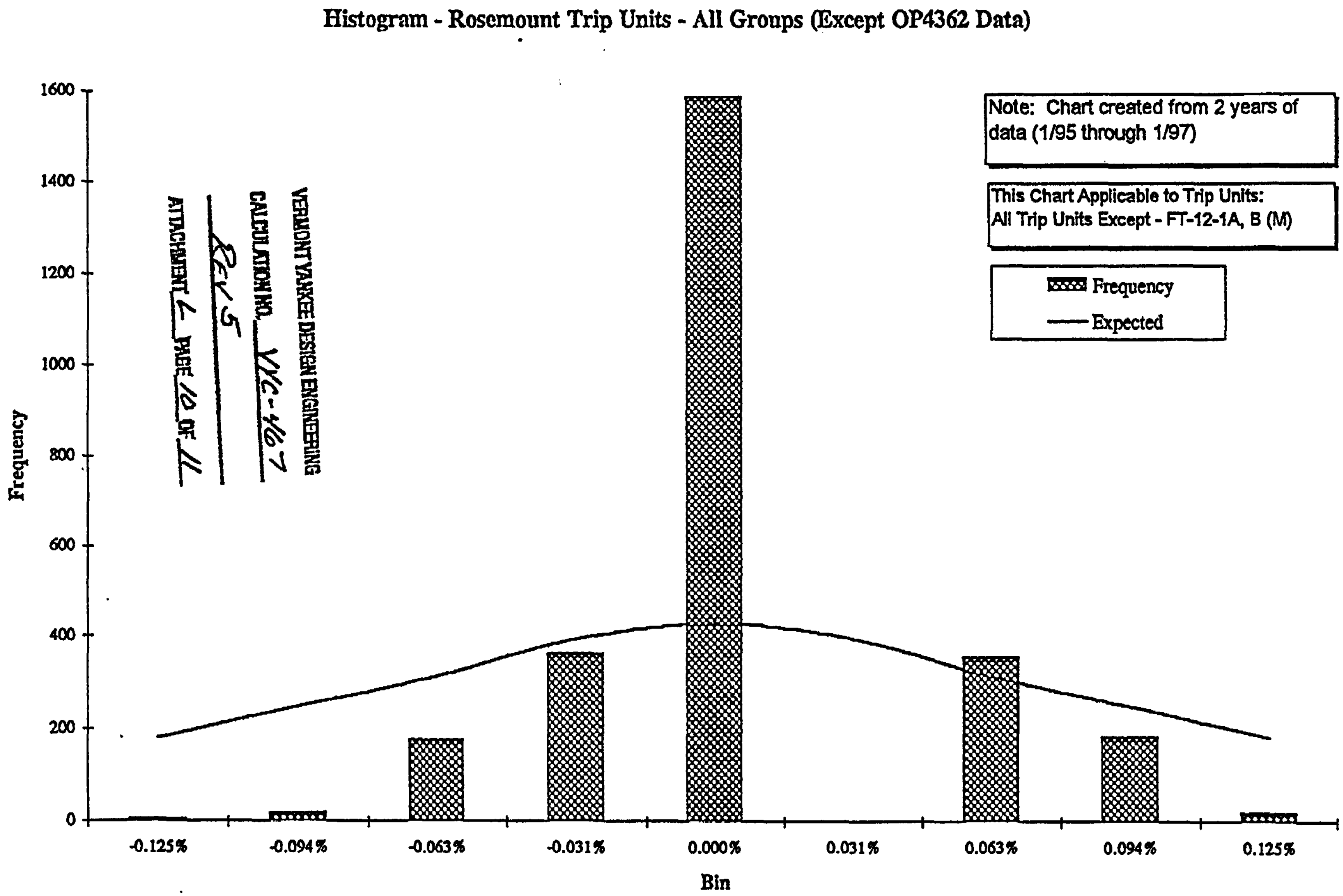
Cumulative Probability Plot - Rosemount Trip Units - All Groups (Except OP-4362 Data)




Histogram - Rosemount Trip Units - All Groups (Except OP4362 Data)
Note: Chart created from 2 years of data (1/95 through 1/97)
This Chart Applicable to Trip Units:
All Trip Units Except - FT-12-1A, B (M)
Frequency
Expected
1600
1400
1200
1000
800
600
400
200
0
Frequency
-0.125%
-0.094%
-0.063%
-0.031%
0.000%
0.031%
0.063%
0.094%
0.125%
Bin
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SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.030389046		ANOVA					
R Square	0.000923494			df	SS	MS	F	Significance F
Adjusted R Square	0.000553054		Regression	1	4.44781E-07	4.44781E-07	2.492965837	0.114473315
Standard Error	0.000422392		Residual	2697	0.000481184	1.78415E-07		
Observations	2699		Total	2698	0.000481629			
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-2.29394E-05	1.55104E-05	-1.478969909	0.13926514	-5.33528E-05	7.47404E-06	-5.33528E-05	7.47404E-06
Interval	5.9812E-07	3.78817E-07	1.578912866	0.114473315	-1.44682E-07	1.34092E-06	-1.44682E-07	1.34092E-06
RESIDUAL OUTPUT								
Observation	% Drift	Residuals	Observation	% Drift	Residuals	Observation	% Drift	Residuals
1	-4.99581E-06	-0.001245004	901	-6.79017E-06	6.79017E-06	1801	-2.00521E-06	2.00521E-06
2	-2.00521E-06	-0.001247995	902	-6.79017E-06	6.79017E-06	1802	-2.00521E-06	2.00521E-06
3	-5.59393E-06	-0.001244406	903	-6.79017E-06	6.79017E-06	1803	-2.00521E-06	2.00521E-06
4	-8.58453E-06	-0.001241415	904	-6.79017E-06	6.79017E-06	1804	-2.00521E-06	2.00521E-06
5	-6.79017E-06	-0.00124321	905	-6.79017E-06	6.79017E-06	1805	-2.00521E-06	2.00521E-06
6	-1.03789E-05	-0.001239621	906	-6.79017E-06	6.79017E-06	1806	-2.00521E-06	2.00521E-06
7	-7.38829E-06	-0.001242612	907	-6.79017E-06	6.79017E-06	1807	-2.00521E-06	2.00521E-06
8	-6.79017E-06	-0.00124321	908	-6.79017E-06	6.79017E-06	1808	-2.00521E-06	2.00521E-06
9	-6.79017E-06	-0.00124321	909	-6.79017E-06	6.79017E-06	1809	-2.00521E-06	2.00521E-06
10	-6.19205E-06	-0.001243808	910	-6.79017E-06	6.79017E-06	1810	-2.00521E-06	2.00521E-06
11	-6.19205E-06	-0.001243808	911	-6.79017E-06	6.79017E-06	1811	-2.00521E-06	2.00521E-06
12	-6.19205E-06	-0.001243808	912	-6.79017E-06	6.79017E-06	1812	-2.00521E-06	2.00521E-06
13	-5.59393E-06	-0.001244406	913	-6.19205E-06	6.19205E-06	1813	-2.00521E-06	2.00521E-06
14	-5.59393E-06	-0.001244406	914	-6.19205E-06	6.19205E-06	1814	-2.00521E-06	2.00521E-06
15	-5.59393E-06	-0.001244406	915	-6.19205E-06	6.19205E-06	1815	-2.00521E-06	2.00521E-06
16	-5.59393E-06	-0.001244406	916	-6.19205E-06	6.19205E-06	1816	-2.00521E-06	2.00521E-06
17	-5.59393E-06	-0.001244406	917	-6.19205E-06	6.19205E-06	1817	-2.00521E-06	2.00521E-06
18	-3.79957E-06	-0.0012462	918	-6.19205E-06	6.19205E-06	1818	-2.00521E-06	2.00521E-06
19	-2.60333E-06	-0.001247397	919	-6.19205E-06	6.19205E-06	1819	-2.00521E-06	2.00521E-06
20	-2.00521E-06	-0.001247995	920	-6.19205E-06	6.19205E-06	1820	-2.00521E-06	2.00521E-06
21	-2.00521E-06	-0.001247995	921	-6.19205E-06	6.19205E-06	1821	-2.00521E-06	2.00521E-06
22	3.14895E-05	-0.001281489	922	-6.19205E-06	6.19205E-06	1822	-2.00521E-06	2.00521E-06
23	-2.17432E-05	-0.000603257	923	-6.19205E-06	6.19205E-06	1823	-2.00521E-06	2.00521E-06
24	-1.03789E-05	-0.000614621	924	-6.19205E-06	6.19205E-06	1824	-2.00521E-06	2.00521E-06
25	-9.18265E-06	-0.000615817	925	-6.19205E-06	6.19205E-06	1825	-2.00521E-06	2.00521E-06
26	-7.98641E-06	-0.000617014	926	-6.19205E-06	6.19205E-06	1826	-2.00521E-06	2.00521E-06
27	-7.98641E-06	-0.000617014	927	-6.19205E-06	6.19205E-06	1827	-2.00521E-06	2.00521E-06
28	-7.98641E-06	-0.000617014	928	-6.19205E-06	6.19205E-06	1828	-2.00521E-06	2.00521E-06
29	-7.98641E-06	-0.000617014	929	-6.19205E-06	6.19205E-06	1829	-2.00521E-06	2.00521E-06
30	-7.38829E-06	-0.000617612	930	-6.19205E-06	6.19205E-06	1830	-2.00521E-06	2.00521E-06
31	-7.38829E-06	-0.000617612	931	-6.19205E-06	6.19205E-06	1831	-2.00521E-06	2.00521E-06
32	-7.38829E-06	-0.000617612	932	-6.19205E-06	6.19205E-06	1832	-2.00521E-06	2.00521E-06
33	-7.38829E-06	-0.000617612	933	-6.19205E-06	6.19205E-06	1833	-2.00521E-06	2.00521E-06
34	-6.79017E-06	-0.00061821	934	-6.19205E-06	6.19205E-06	1834	-2.00521E-06	2.00521E-06
35	-6.79017E-06	-0.00061821	935	-6.19205E-06	6.19205E-06	1835	-2.00521E-06	2.00521E-06
36	-6.79017E-06	-0.00061821	936	-6.19205E-06	6.19205E-06	1836	-2.00521E-06	2.00521E-06
37	-6.79017E-06	-0.00061821	937	-6.19205E-06	6.19205E-06	1837	-2.00521E-06	2.00521E-06
38	-6.79017E-06	-0.00061821	938	-6.19205E-06	6.19205E-06	1838	-2.00521E-06	2.00521E-06
39	-6.79017E-06	-0.00061821	939	-6.19205E-06	6.19205E-06	1839	-2.00521E-06	2.00521E-06
40	-6.79017E-06	-0.00061821	940	-6.19205E-06	6.19205E-06	1840	-2.00521E-06	2.00521E-06
41	-6.79017E-06	-0.00061821	941	-6.19205E-06	6.19205E-06	1841	-2.00521E-06	2.00521E-06
42	-6.79017E-06	-0.00061821	942	-6.19205E-06	6.19205E-06	1842	-2.00521E-06	2.00521E-06
43	-6.79017E-06	-0.00061821	943	-6.19205E-06	6.19205E-06	1843	-2.00521E-06	2.00521E-06
44	-6.79017E-06	-0.00061821	944	-6.19205E-06	6.19205E-06	1844	-2.00521E-06	2.00521E-06
45	-6.79017E-06	-0.00061821	945	-6.19205E-06	6.19205E-06	1845	-2.00521E-06	2.00521E-06
46	-6.79017E-06	-0.00061821	946	-6.19205E-06	6.19205E-06	1846	-2.00521E-06	2.00521E-06
47	-6.79017E-06	-0.00061821	947	-6.19205E-06	6.19205E-06	1847	-2.00521E-06	2.00521E-06
48	-6.79017E-06	-0.00061821	948	-6.19205E-06	6.19205E-06	1848	-2.00521E-06	2.00521E-06
49	-6.79017E-06	-0.00061821	949	-6.19205E-06	6.19205E-06			
50	-6.19205E-06	-0.000618808	950	-6.19205E-06	6.19205E-06			
51	-6.19205E-06	-0.000618808	951	-6.19205E-06	6.19205E-06			
52	-6.19205E-06	-0.000618808	952	-6.19205E-06	6.19205E-06			
53	-6.19205E-06	-0.000618808	953	-6.19205E-06	6.19205E-06			
54	-6.19205E-06	-0.000618808	954	-6.19205E-06	6.19205E-06			
55	-6.19205E-06	-0.000618808	955	-6.19205E-06	6.19205E-06			
56	-6.19205E-06	-0.000618808	956	-6.19205E-06	6.19205E-06			

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INPUT ASSUMPTIONS SOURCE DOCUMENT

Vermont Yankee Nuclear Power Station

Cycle 20

Revision 1

May 1998

VERMONT YANKEE DESIGN ENGINEERING

CALCULATION NO. VYC-467

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ATTACHMENT M PAGE 1 OF 3

GE OPL-3 FORM
(Continued)

Parameter Description	Units	Cycle (19) Resolved Value	GE Proposed Value	Customer Proposed Value	Cycle (20) Resolved Value	Ref
1.0 PARAMETERS USED IN RELOAD LICENSING ANALYSES (RLA)						
1.2 SCRAM Parameters						
A. APRM Neutron Flux Scram Setpoint (At Rated Drive Flow)						
1. RLA Value TSL ( ) AL (X)	% Rated		120.00	125.40	120.00	
2. NTSP	% Rated			120.00	120.00	
B. APRM Thermal Power Scram (TPS) Setpoint (At Rated Drive Flow)						
1. RLA Value TSL ( ) AL (X)	% Rated					
2. NTSP	% Rated					
C. TPS Time Constant (Maximum Value)	Sec					
D. Vessel Dome Pressure Scram Setpoint						
1. RLA Value TSL ( ) AL (X)	psig		1055.00	1070.00	1085.00	
2. NTSP	psig			1055.00	1055.00	
E. Response Time of Pressure Scram Sensor	Sec		0.50	1.80	1.80	3
F. MSIV Position Switch Setpoint						
1. RLA Value TSL (X) AL ( )	% Open		90.00		90.00	
G. Turbine Stop Valve (TSV) Position Switch Setpoint						
1. RLA Value TSL (X) AL ( )	% Open		90.00		90.00	
H. Response Time of TCV Fast Closure Sensor (Maximum)	Sec		0.03		0.03	
I. Additional RPS Delay for BPV Inquiry (TCV Fast Closure/Full Bypass Plants Only)	Sec					
J. Response Time (Delay) of RPS Logic (Maximum)	Sec		0.05		0.05	
K. Response Time of CRD During SCRAM	Table		67B		67B	11

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GE OPL-3 FORM
(Continued)

CRD Control Fraction	SCRAM Time, Sec (1)						
				BWR6			
	67A	67B	OPTB	SS(2)	AOPT	OPPT	TSIP
0	0.200	0.200	0.200	0.100	0.100	0.100	0.200
1				0.138	0.138	0.153	
5	0.375	0.375	0.324	0.218	0.219	0.252	0.490
10				0.317	0.321	0.376	
20	0.900	0.900	0.694	0.503	0.516	0.644	0.900
40				0.874	0.907	1.179	
50	2.000	2.000	1.459	1.087	1.175	1.540	2.000
75				1.620	1.844	2.444	
90	5.000	3.500	2.535	1.940	2.246	2.986	3.500
100	5.750	3.875	2.804	2.153	2.690	3.380	3.875

Notes:

(1) Time from de-energization of SCRAM solenoid to specified CRD insertion.

(2) Technical Specification (surveillance requirements) values.

TSL = Technical Specification Limit
AL = Analytical Limit
NTSP = Nominal Trip Setpoint
AV = Allowable Value (Minimum)
SS = Steady-State Operation
AOPT = Abnormal Operating Pressurization Transient
OPPT = Overpressure Protection Transients

VERMONT YANKEE DESIGN ENGINEERING
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APPENDIX B
WE-103 REVIEW CHECKLIST

Preparer		Reviewer	
Name (please print)	TIMOTHY BINDER	Name (please print)	Michael Anderson
Organization	VY DESIGN ENG.	Organization	VYDE
Signature	Timothy J. Binder	Signature	Michael W. Anderson
Date	03/31/99	Date	4/20/99

Requirement	Preparer	Reviewer
Ensure the title page is appropriately filled out. • Correct number of pages. • QA Record filled out. • ~~IMS number filled out.~~* TJB 1* T.J. Binder 3/29/99 • Record number filled out (13.C09.001 included if microfiche or hard copy of computer runs are attached to the calculation). • Descriptive title. • Plant, cycle number and calculation number included. "N/A" can be used for plant and cycle number. • Signatures and dates are included, and are in correct chronological order. Print the name and individuals' organization (if other than YAEC) below the signature. The title page reviewer and approver dates do not pre-date any date in the calculation except for changes containing that individual's initials and date. • All WE-108 computer codes and other keywords not in the title which can be used to retrieve the calculation are listed in the keyword field.	TJB	MWA
Ensure the Form WE-103-2 is included and properly completed when a computer code is used.	N/A	—
Ensure Form WE-103-3 is included, and has signatures/dates from both the preparer and the reviewer and that all comments have been addressed. If no comments, use the following statement: "Reviewed in accordance with WE-103 with no comments."	TJB	MWA
Ensure review of the calculation can be done without recourse to the originator.	TJB	N/A
Ensure computer codes are used in accordance with WE-103 Steps 4.1.4.4 through 4.1.4.6.	TJB	MWA
Ensure the calculation includes a title page, objective, method, inputs, assumptions, calculations, results, conclusions and references.	TJB	MWA
Ensure the inputs are referenced to formal documents, e.g., WE-103. The reference cannot be a YAEC report unless formal QA records are checked and also referenced. INPUTS REFERENCED TO FORMAL DOCS INCLUDING VENDOR MANUALS.	TJB	N/A
Ensure design input internal and external correspondence is prepared and reviewed, and is, therefore, a QA record. If there is only one signature on the correspondence, verify that it is a QA record. ALL DOCUMENTS EXCLUDING VENDOR DATA, ARE DOUBLE SIGNATURE CORRESPONDENCES	TJB	N/A

VERMONT YANKEE DESIGN ENGINEERING
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APPENDIX B
WE-103 REVIEW CHECKLIST
(Continued)

Requirement	Preparer	Reviewer
Ensure that if design specifications were used as input to the calculation, the performance characteristics are verified in writing by the provider of the component/product or by cognizant YAEC/plant personnel.	YB	N/A
Ensure that input and modeling uncertainties are explicitly addressed in the calculation.	N/A	N/A
Ensure that the applicable input considerations from WE-100, Table 1 have been incorporated and are explicitly addressed within the calculation.	YB	N/A
Ensure individuals responsible for each portion of the calculation are identified when multiple preparers and/or reviewers are utilized. Page initialing is optional, even in the cases where initial boxes are provided on the pages.	N/A	—
Ensure each page has a page number and the calculation number and revision number, if applicable. Dates on each page are optional.	YB	[initials]
Ensure that every page of every attachment (or Appendix) contains its attachment (or Appendix) number.	YB	[initials]
Ensure corrections are addressed in one of the following approaches: • Retyped and identified by a vertical line with revision number, if applicable, in the right margin; OR • Lined out, initialed and dated by preparer; OR • Photocopy of original to eliminate any previous correction tape, whiteout, or erasures.	YB	[initials]
Ensure enhancements and clouding are initialed and dated.	N/A	—
Confirm legibility meets WE-103, Appendix A. Specific pages can be exempt if they are: (1) documents received from another organization who is the original QA custodian, or (2) supplemental pages included for information only. In these two cases, make sure a memo was issued to RMS per WE-002, Section 3.4.3.	YB	[initials]
Review of 10CFR50.46 reporting requirements has been documented for analyses which assess conformance with 10CFR50.46. NOT CHANGING CORE COOLING DESIGN BASES OR PARAMETER	N/A	N/A
Ensure computer codes are validated for the computing environment.	N/A	N/A
Ensure script files are included in the calculation or referenced to another calculation. Also, ensure the preparer identifies how the code/script was run.	N/A	N/A
Ensure applicable outstanding ~~Condition~~ EVENT + Reports (ER/CRs) have been reviewed for influence on the calculation and note review in calculation.	YB	N/A
Ensure relevant conditions/limitations have been reviewed for their effect on this calculation and the review is noted in the calculation.	YB	[initials]

ZA Y.B. 3/29/99

VERMONT YANKEE DESIGN ENGINEERING

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VYNPS

TABLE 7.2.1

REACTOR PROTECTION SYSTEM

INSTRUMENTATION SPECIFICATIONS

Scram Function	Instrument	Required Accuracy	CTS Trip Setting	ITS Allowable Value
Neutron Monitoring System Scram	See Section 7.5, "Neutron Monitoring System"			
Nuclear System High Pressure	Pressure Transmitter/ Bistable	± 3.75psig/±3psig ~~±12 psig~~ 3/29/99	≤1055 psig	1082 psig
Reactor Vessel Low Water Level	Level Transmitter/ Bistable	±3.3 inches	≥127 inches above top of enriched fuel	
Turbine Stop Valve Closure	Position Switch	---	≤10% valve closure	
Turbine Control Valve Fast Closure	*	---	Start of control valve fast closure	
Main Steam Line Isolation Valve Closure	Position Switch	---	≤10% valve closure	
Scram Discharge Volume High Water Level	Level Transmitter Electronic Trip Unit	Repeatable within trip setting tolerance	≤21 gal.	
Primary Containment High Pressure	Pressure Transmitter/ Electronic Trip Unit	±0.05 psig	≤2.5 psig	
Main Steam Line High Radiation	Gamma Monitor	---	3 times normal background level at rated power	

* This signal is derived from the same event or events which cause fast closure of the control valves.

3.2.2.2 Accident 1 - HELB (RWCU-21)

$TE_{a1xmtr} = 19.8 \cdot psi$

$$e_{a1R1xmtr} := \sqrt{CE_{xmtr}^2 + DB_{xmtr}^2 + DA_{xmtr}^2 + TE_{a1xmtr}^2}$$

$e_{a1R1xmtr} = 25.14 \cdot psi$

3.2.2.3 Accident 2 - Seismic Event

$SE_{xmtr} = 7.5 \cdot psi$

$$e_{a2R1xmtr} := \sqrt{CE_{xmtr}^2 + DB_{xmtr}^2 + DA_{xmtr}^2 + SE_{xmtr}^2 + TE_{nxmtr}^2}$$

$e_{a2R1xmtr} = 18.04 \cdot psi$

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3.3.0 MASTER TRIP UNITS PT-2-3-55A(M), 55B(M), 55C(M), 55D(M)

3.3.1. Uncertainty Elements

3.3.1.1 Reference Accuracy (A)

$A = (AX^2 + h^2 + l^2 + r^2)^{1/2}$

Where:

A = Reference accuracy of instrument
AX = vendor's stated basic accuracy expression
h = hysteresis
l = linearity
r = repeatability

FOR PURPOSE OF TS AND IN ACCORDANCE WITH VYI 41/97, THE MASTER TRIP UNIT ACCURACY OF ±0.13% IS INCREASED TO ±0.2% to INCLUDE THE CALIBRATOR, OR:
0.2% x 1500 PSIG = ±3 PSIG
[signature] 3-24-97

$AX_{mtu} := 0 \cdot \% \cdot CS_{mtu}$

$h_{mtu} := 0 \cdot \% \cdot CS_{mtu}$

$l_{mtu} := 0 \cdot \% \cdot CS_{mtu}$

$r_{mtu} := 0.13 \cdot \% \cdot CS_{mtu}$

$$A_{mtu} := \sqrt{AX_{mtu}^2 + h_{mtu}^2 + l_{mtu}^2 + r_{mtu}^2} \cdot \left(\frac{CS_{xmtr}}{CS_{mtu}}\right)$$

$A_{mtu} = 1.95 \cdot psi$ Master Trip Unit Accuracy

MEMORANDUM

YANKEE ATOMIC - BOLTON

To:	File	Date:	April 23, 1997
		Group #:	VYI 41/97
From:	G.J. Hengerle	WO #:	4894
Subject:	Improved Setpoint Program/FSAR Table Revisions and M&TE Accuracy	IMS #:	
		File #:	SETPOINTMEMO-11.489

References:

a. Vermont Yankee Setpoint Design Guide (Draft)

Background:

The Vermont Yankee Setpoint Design Guide (reference a) addresses the manner in which M&TE should be used. Reference a) does not address the manner in which the Vermont Yankee FSAR should be modified to reflect changes to accuracy. The manner in which these two issues should be addressed is discussed below.

Discussion:

Vermont Yankee FSAR:

The Vermont Yankee FSAR contains tables in Section 7 which identify the instrument functions, setpoint, and accuracy.

Issue:

- Historically, the "accuracy" was the reference accuracy of the sensor. This was easy to comprehend when the trip channel was composed of a single bistable switch. The analog upgrades added components which made the table more complicated. Later, the "accuracy" was selectively revised to reflect the total loop uncertainty (which included variables in addition to reference accuracy). The Improved Setpoint Program (ISP) will be developing new error analysis which will again impact this section of the FSAR.

- Historically, the "trip setting" was the value found in the Vermont Yankee Technical Specification. This value will not be affected in the Custom Technical Specifications (CTS). However, the Improved Technical Specifications (ITS) will specify an Allowable Value (to be determined in the setpoint calculation).

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Resolution:

The FSAR tables affected by the new/revised calculations could result in changes to the Vermont Yankee FSAR. The following guidance shall be applied when identifying the FSAR changes:

1. The "accuracy" component is to be the reference accuracy of the sensor (RA_{Sensor}) and, if part of an analog loop, the reference accuracy of the trip unit bistable ($RA_{Trip\ Unit}$). Each component and its required accuracy should be identified as shown on the attached.

   In some cases, the RA_{Device} is very small such that the available M&TE accuracy ($RA_{M\&TE}$) is larger than the RA_{Device} value. In these cases, the RA_{Device} is de-rated to be equal to the $RA_{M\&TE}$. In these cases, the de-rated value should be applied as the RA_{Device}, as determined in the setpoint calculation.

2. The CTS trip setting will not be changed as a result of the ISP. However, the ISP includes an evaluation to determine the new ITS Allowable Value. To address the new ITS value, the FSAR tables will be revised, as necessary, to identify the new ITS value next to the existing CTS value as shown on the attached.

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M&TE:

Issue:

Reference a) provides guidance as to how M&TE should be addressed. The ISA RP67.04 Draft 10 implies the use of 0.5% (of span) is acceptable. For consistency, what approach should be applied to specifying M&TE?

Resolution:

This is in agreement with the Yankee Operational Quality Assurance Manual (YOQAP-1-A Revision 27), Sections II & XI and ANSI N45.2.4-1972. Specifically:

> "When characteristics, efficiencies, capabilities, or other properties are measured to appraise compliance with specifications, the [M&TE] instrument must have adequate accuracy to determine the measured quantity to the precision required by the stated specifications."

The guidance provided in reference a) is consistent with YOQAP-1-A. To achieve the requirement, the M&TE accuracy must be at least equal to (or better than) the Reference Accuracy of the instrument being calibrated. For consistency, the limiting M&TE error contribution (and the M&TE criteria to be required in future calibrations) will equal the Reference Accuracy.

Conclusion:

The above discussion provides general guidance for proposed FSAR revisions and M&TE. Other methods are acceptable. It is at the discretion of the Preparer to determine if the methods discussed above, or another approach (with bases), should be applied for their specific application. Acceptability of the method(s) applied shall be determined by concurrence with the independent reviewer.

The guidance provided in this memorandum will be incorporated into a future revision of the Vermont Yankee Setpoint Design Guide (as appropriate). Until then, this memorandum is an interim change to the design guide.

George J. Hengerle
Senior I&C Engineer
Vermont Yankee Design Engineering

Interim Design Guide References

1. Memo VYI 31/97, "Improved Setpoint Program/Application of Analyzed Drift Values in Setpoint Determination", April 2, 1997.
2. Memo VYI 32/97, "Improved Setpoint Program/Relationship of HELB Environments to RPS Setpoints", DRAFT
3. Memo VYI 41/97, "Improved Setpoint Program/FSAR Table Revisions and M&TE Accuracy", April 23, 1997.

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C:

Design Engineering	Setpoint Team
R.G. January	M. Anderson (Bolton)
R.T. Vibert	J. Lewis (Vernon)
D.E. Yasi	M. Mustafa (Bolton)
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*for distribution to EXCEL setpoint support engineers

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CALCULATION/ANALYSIS REVIEW

CALCULATION NO. VYC-467 REVISION NO. 5

COMMENTS	RESOLUTION
1. Update the following:	
A. On Cover Page, YNSD should be YAEC.	UPDATED TO REFLECT YAEC
B. TS is at Amendment 169, or review for impact. 4/18/99	T.S. AMENDMENT 169 ADDRESSES SERVICE WATER. THEREFORE, THERE IS NO IMPACT
2. In Sect. 2.2.7 clarify the minor discrepancy between calculated hc and implemented hc, to wit:	SECT 2.2.7 WAS REVISED TO CLARIFY HC DISCREPANCY
A. The worst-case hc discrepancy is negligible.	
B. The implemented hc is "conservative" relative to trip pressure.	
3. In Table 12, consider showing AL in the OTS column as well.	TABLE 12 REVISED TO ADDRESS AL FOR OTS
4. In Table 11 consider if it would be more appropriate to use rounded values.	PREFER TO KEEP INITIAL TLU VALUES AS CALCULATED. SUBSEQUENT ROUNDING PERFORMED TO SUPPORT SETPOINT DEVELOPMENT

Identify method(s) of review:

- ■ Calculation/analysis review
- ☐ Alternative calculational method
- ☐ Qualification testing

Resolution By: [signature] 04/20/99
Preparer/Date

Comments Continued on Page: 2

Concurrence with Resolution Michael W. Anderson 4/21/99
Reviewer/Date

VERMONT YANKEE DESIGN ENGINEERING
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CALCULATION/ANALYSIS REVIEW

CALCULATION NO. VYC-467 REVISION NO. 5

COMMENTS	RESOLUTION
5. Re-Consider the need to change MTU AFT from 0.04 mA to 0.05 MA. Within this context: A. Review memo VYI 92/97, Rev 1. B. For convenience and inherent "conservatism" you may want to retain CE=CT+A for the purposes of e_u and e_u/e_s; using CE=CT for e_t.	CE VALUE REVISED PER VYI 92/97. CE=CT IS THE ESTABLISHED RELATIONSHIP. CE=CT USED FOR ALL MTU UNCERTAINTY FOR EASE OF CALIBRATION VICE DEVELOPING TWO VALUES FOR CE. AS A RESULT OF CHANGING CE AFT WAS RECALCULATED.
6. In B-5.1.2, typically it is preferred to restrictively round test-related determinants.	6. Rounding up of +0.17 psi to whole pound units is acceptable for A. Human factors B. @ +0.01% CS, the rounding value is too small to be discerned by the calibration process. [initials] 4/21/99

Identify method(s) of review:

- ■ Calculation/analysis review
- ☐ Alternative calculational method
- ☐ Qualification testing

Resolution By: [signature] 4/20/99
Preparer/Date

Comments Continued on Page: 3 ~~NA~~ [initials] 4/21/99

Concurrence with Resolution [signature: Michael W. Anderson] 4/21/99
Reviewer/Date

FORM WE-103-3
Revision 5

CALCULATION/ANALYSIS REVIEW

CALCULATION NO. VYC-467 REVISION NO. 5

COMMENTS	RESOLUTION
7. In Attach B, Sect. 1 the surv. interval for xmitter & MTU is incorrectly calculated as a function of time without being related to the Ref. 6.36 definitions.	7. Comment for record only. The term TC_N is not used, but rather surv. intervals as per Ref. 6.36 are correctly incorporated in the Sect. 2 DA evaluations. [initials] 4/26/99
8. In Attach B, Sect. 3.3.1.5 the MTU Expected Performance to which Actual plant performance is compared is ±3.6685 psig.	8. None required. PP & EP. [initials] 4/26/99

Identify method(s) of review:

- ■ Calculation/analysis review
- ☐ Alternative calculational method
- ☐ Qualification testing

Resolution By: None Required [initials] 4/26/99
Preparer/Date

Comments Continued on Page: N/A

Concurrence with Resolution ____________________
Reviewer/Date

VERMONT YANKEE SETPOINT CONTROL PROGRAM
INTERDEPARTMENTAL REVIEW OF CALCULATION:

VYC- 467 Revision 5 has been prepared and independently reviewed. The Departments impacted by this calculation are requested to review the results of this calculation, concur with the results and/or recommendations, and document the department's acceptance prior to the calculation being approved.

1. Summary: This calculation evaluates the uncertainty & setpoints for Reactor System High Pressure Trip Loop

2. Calculation Open Items: AP-0028 to be Assigned

   Not Applicable — N/A P.W. Allen 3/2/00

3. Department Review - contact the Setpoint Program Manager (G. Hengerle) if not in agreement with the conclusions/statements.

   3.1. Vermont Yankee E&C

   3.1.a. Procedure; OP4312 "Reactor Vessel High Pressure Scram Function Test/Calibration" will require the following :

		From	To	Disagree	Agree
1.	Calibration Tolerances:				
	PT-2-3-55A/B/C/D				
	a. As Found values:	+/- 0.17 mA	+/- 0.16 mA	☐	☑
	b. As Left values:	+/- 0.04 mA	+/- 0.04 mA	☐	☑
	PT-2-3-55A/B/C/D (M)				
	a. As Found values:	+/- 0.04 mA	+/- 0.03 mA	☐	☑
	b. As Left values:	+/- 0.03 mA	+/- 0.03 mA	☐	☑
2.	Nominal Setpoint	1038 psig	1038 psig	☐	☑
		15.07 mA	15.07 mA	☐	☑
3.	Limiting Setpoint	1068 psig	1066 psig	☐	☑
4.	Head Correction	12 psig	12 psig	☐	☑

5. Insert the following M&TE requirements:

M&TE	Ranges	Resolution
Heise Gage 901B	0-2000	0.1 psig
Heise CM & CMM	0-2000	2 psig (Minor Div)
HP 34401A Digital Multimeter	0-100	0.0001 mA
Rosemount Readout Assembly	0-28	0.01 mA

Vermont Yankee Setpoint Control Program
Interdepartmental Review of Calculation VYC- 467 Revision 5

3.1.b. The following comments/recommendations apply:

	Concur	Comments
1. None	☐	

[signature] / 1/24/00 Sign & Date
Vermont Yankee E&C Representative

3.2. Vermont Yankee Reactor Engineering

	Concur	Comments
3.2.a. This revision does not impact Vermont Yankee Reactor Engineering	☒	Figure 2 (p.17) Normal Operating Pressure should be 1010 psig. See 010105. ED 1/26/2000

[signature] / 11-26-2000
Ed Duda 1/26/2000 Sign & Date
Vermont Yankee RE Representative

3.3. Vermont Yankee Operations

	Concur	Comments
3.3.a. This revision did not change the existing setpoint or existing margins of operation to the Analytical Limit. Therefore, there is no impact to Vermont Yankee Operations	☒	

[signature] / 1-30-00 Sign & Date
Vermont Yankee Operations Representative

3.4. Vermont Yankee Systems Manager

	Concur	Comments
3.4.a. This revision did not change the existing setpoint or associated Analytical Limits. Therefore, there is no impact to Vermont Yankee System Engineering.	☒	

[signature] / 02/24/00 Sign & Date
Vermont Yankee System Engineering Representative

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F.W. Allen 3/2/00

Vermont Yankee Setpoint Control Program
Interdepartmental Review of Calculation VYC-467 Revision 5

3.5. YNSD Nuclear Engineering

			Concur	
Comments				
3.5.a.	Custom Technical Specifications			
1.	Analytical Limit used in setpoint determination:	1085	☑	(1)
2.	Potential accident trip (LOCA):	N/A	☐	(1)
3.	Potential accident trip (HELB):	N/A	☐	(1)
3.5.b.	Improved Technical Specifications			
1.	Analytical Limit used in setpoint determination:	1085	☑	(1)
2.	Potential accident trip (LOCA):	N/A	☐	(1)
3.	Potential accident trip (HELB):	N/A	☐	(1)

(1) No change to Analytical Limits identified in VYC-467 Revision 5.

Mark P. DeFrancisco / 12/22/99 — Sign & Date

YNSD NED Representative

* Used in GE reload analysis (VY provides setpoint via OPL-5 form). Used in non-limiting FSAR transient analysis (VYC-1705)

3.6. Vermont Yankee DBD Manager

		Yes	No
3.6.a.	The DBD is complete (an AP-0028 to follow) The results of this calculation does not change any values in the associated DBD.	☒	☐

James W. Allen / 3/2/00 — Sign & Date

ISP Program Manager

3.7. Vermont Yankee Licensing

		Impact	Yes	No
3.7.a.	FSAR Changes (AP-0028 to follow)	None	☐	☒
3.7.b.	Other impact on licensing basis:	None	☐	☒

James W. Allen / 3/2/00 — Sign & Date

ISP Program Manager

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J.W. Allen 3/2/00

Vermont Yankee Setpoint Control Program
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3.8. Vermont Yankee ITS Manager

		Yes	No
3.8.a.	This analysis does not provide an input to the ITS. Therefore, An Allowable Value does not apply.	☐	☒
3.8.b.	This analysis does not provide an input to Technical Requirements Manual.	☐	☒

James W. Allen / 3/2/00
Sign & Date
ISP Program Manager

3.9. Other Department(s)/Program(s) None

3.9.a. Impact assessment/recommendations: NA — Concur ☒

James W. Allen / 3/2/00
Sign & Date
ISP Program Manager

4. Setpoint Program Manager

	Completed
4.1. Concurs with above.	☑
4.2. Interdepartmental Review form (copy/steps 1 through 3) incorporated into calculation.	☑
4.3. Calculation has been approved.	☑ Approved on 3/2/00
4.4. AP-0028 commitments have been assigned and forwarded for incorporation into the Commitment Tracking System.	☑

James W. Allen / 3/2/00
Sign & Date
ISP Program Manager

VERMONT YANKEE DESIGN ENGINEERING
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J.W. Allen
3/2/00

5. Post-Approval Requirements

a. E&C (perform as appropriate):
   - Initiate AP0022 Setpoint Change Request — AP0028 VYCϕ467R5_ϕ1
   - Update MPAC
   - Revise calibration/functional/logic test procedure
   - Inform the following after changes are implemented:
     - Setpoint Coordinator
     - Setpoint Program Manager
     - Training (notified via AP-0022 if initiated)
     - Operations (notified via AP-0022 if initiated)
     - Design Engineering

b. Setpoint Program Manager: Update Program Manual (after step 5.a). — AP0028 VYCϕ467R5_ϕ2

c. Setpoint Coordinator: Update Setpoint Data Base (after step 5.a) — AP0028 VYCϕ467R5_ϕ3

d. Design Engineering: Initiate FSAR/DBD changes, as appropriate (if DBD has been completed) — AP0028 NA

Comments: