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From:
Alexander Marion

TACs:
MC5537

To:
James Lyons

*** YELLOW ***

For Signature of:

Routing:
Dyer
Borchardt
Sheron
Carpenter
NRR Mailroom

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

Assigned To:
DLPM

Contact:
MARSH, LEDYARD (TAD) B

Special Instructions:

NUCLEAR ENERGY INSTITUTE

Alexander Marion
SENIOR DIRECTOR, ENGINEERING
NUCLEAR GENERATION DIVISION

December 17, 2004

Mr. James E. Lyons
Deputy Director, Division of Licensing Project Management
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

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

REFERENCE: NRC Letter to NEI (L. Marsh to A. Marion), June 17, 2004

Dear Mr. Lyons:

The reference letter contains an enclosure entitled "Problem Statement on the Use of Instrumentation, Systems, and Automation Society (ISA) Standard 67.04, Part II, 'Methodology for the Determination of Setpoints for Nuclear Safety-Related Instrumentation,' Method 3." The problem statement describes NRC staff concerns that Method 3 allowable values, which represent surveillance test limits, could lead to a situation "where an instrument channel is believed to be operable following a periodic surveillance (e.g., CFT, COT) even though the channel may not meet the definition of operability because the process parameter being measured may exceed the AL assumed in the plant's safety analysis should an accident occur without initiating the required actuation."

The NEI Setpoint Methods Task Force (SMTF) has evaluated the concerns described in the problem statement and concluded that allowable values determined using Method 3 establish a conservative limit for safety-related instrument channel surveillance testing. Method 3 allowable values provide high assurance that drifted instrument channel setpoints that could challenge plant safety limits will be identified by surveillance testing.

The bases for these conclusions are contained in an NEI technical white paper submitted to NRC in December 2003 and in a recent letter to NEI from MPR Associates, Inc. Through contract with EPRI, MPR was asked to perform an independent review of both the NEI white paper and the NRC problem statement. The independent review (enclosed) concludes that ISA Method 3 provides adequate protection. The SMTF is prepared to meet with the NRC staff to discuss the enclosed report.

1776 I STREET, NW SUITE 400 WASHINGTON, DC 20006-3708 PHONE 202.739.8000 FAX 202.785.4019 www.nei.org

NEI's objection to the process that NRC has been using to pursue resolution of the Method 3 issue is contained in my letter to you dated November 29, 2004. Based on the NEI white paper, the MPR independent review and the reasons in the November letter, we request that NRC promptly complete the review of pending license amendment requests (LARs) using ISA Method 3. In addition, we request that NRC withdraw any request for additional information (RAI) that implies the staff will not review a LAR based on Method 3 unless the method is modified to alleviate staff concerns. We consider a RAI conditioned on a change to the licensing basis to be a backfit under 10 CFR 50.109.

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

Sincerely,

Alex Marion

Alexander Marion

Attachments

c: Brian W. Sheron, NRC
Richard J. Barrett, NRC
Ledyard B. Marsh, NRC
Edwin M. Hackett, NRC
Thomas H. Boyce, NRC
Sher Bahadur, NRC CRGR
Christopher Gratton, NRC
NEI Administrative Points of Contact
NEI Licensing Contacts List

Attachment to the
Enclosure to
MPR Letter Dated
December 14, 2004

Monte Carlo Simulation of Instrument Channel Surveillance Testing

Calculation No. 0140-0403-PJR-01

MPR	MPR Associates, Inc. 320 King Street Alexandria, VA 22314

CALCULATION TITLE PAGE

Client: Nuclear Energy Institute	Page 1 of 13 plus Appendices A and B
Project: Instrumentation Channel Setpoint Review	Task No. 0140-0403-0244-00
Title: Monte Carlo Simulation of Instrument Channel Surveillance Testing	Calculation No. 0140-0403-PJR-01

Preparer / Date	Checker / Date	Reviewer & Approver / Date	Rev. No.
Phil Rush 10/28/04	Ling-Yu Song 10/28/04	Jim Nestell 10/29/04	0
Phil Rush 11/30/04	Scott Kiffer 11/30/04	Jim Nestell 11/30/04	1
Phil Rush [signature] 12/8/04	Scott Kiffer [signature] 12/8/04	Jim Nestell [signature] 12/8/04	2

MPR

MPR Associates, Inc.
320 King Street
Alexandria, VA 22314

RECORD OF REVISIONS

Calculation No.	Prepared By	Checked By	Page: 2
0140-0403-PJR-01	P. R[illegible]	[illegible]	

Revision	Affected Pages	Description
0	All	Initial Issue
1	All	Developed a new Monte Carlo model to complete the analysis that includes random uncertainties in the observed (as-found) trip setpoint. Instrument channel uncertainties were used in the revised model that are similar to those described in ISA-RP67.04, Part II (Recommended Practice).
2	4, 6, 10	Corrected minor typographical errors and clarified text.

Note: The revision number found on each individual page of the calculation carries the revision level of the calculation in effect at the time that page was last revised.

Table of Contents

PURPOSE

This calculation describes a Monte Carlo model that is used to simulate surveillance testing of safety-related instrument channels. The analysis revises a previous calculation and assumes that instrument channel surveillance testing determines an as-found trip setpoint based on a single datum that is subject to drift and other uncertainties included in the test. The simulation model is used to demonstrate the effects of using ISA Methods 2 and 3 (Reference 1) for calculating instrument channel Allowable Values. Analyses using the model calculate the percentage of instances where an instrument channel appears operable based on simulated surveillance testing when the actual trip setpoint would be above the analytical limit if the channel were called upon to actuate. In addition, the percentage of iterations where a channel is identified as inoperable when the channel would have actuated before the analytical limit (i.e., false call rate) is calculated.

SUMMARY OF RESULTS

The results from 11 different simulations are summarized in Table 1. The two columns on the right side of the table indicate the percentage of iterations where a channel was declared operable and the actual trip setpoint was greater than the Analytical Limit. The results indicate that Allowable Values established using ISA Methods 2 or 3 will ensure that there is a high probability of identifying an inoperable instrument channel that would not actuate a response below the Analytical Limit.

Table 2 lists the false call rates for the eleven simulation cases analyzed in this calculation. The results indicate that Method 2 Allowable Values are an inefficient indicator of overall channel operability when the ratio of the uncertainties that are evaluated in the surveillance test (COT) to the uncertainties that are not included in the surveillance test (nCOT) is low. The simulation results indicate that the use of Method 2 would lead to an instrument channel being called inoperable over 50% of the time when the ratio of COT to nCOT is equal to 0.1. In this analysis, Method 2, on average, provides a level of conservatism approximately one order in magnitude greater than Method 3.

The use of the Allowable Value as the inoperability criterion is most effective when most of the instrument channel uncertainties are evaluated in surveillance testing (i.e., COT » nCOT). The criterion established using either ISA Method 2 or 3 ensures a high probability of detecting a truly inoperable condition.

Table 1. Summary of Simulation Results

Analysis Case No.	COT/nCOT	Trip Setpoint (psi)	Allowable Value (psi)		TSP Offset (psi)	Exceedances of AL with Observed TSP < AV	
			Method 2	Method 3		Method 2	Method 3
1	0.1	1911.2	1919.2	1953.9	4.5	1.1%	2.5%
2					9	0.7%	2.4%
3					22.5	0.3%	2.4%
4					43	0.1%	1.6%
5	1.0	2208.9	2267.6	2337.3	48	0.3%	3.4%
6					96	0.3%	4.7%
7					115	0.2%	4.7%
8	10	2062.9	2364.0	2382.8	90	0.0%	0.2%
9					180	0.0%	0.6%
10					270	0.0%	0.7%
11					300	0.0%	0.8%

Table 2. Comparison of False Call Rates[1]

Analysis Case No.	COT/nCOT	False Call Rate	
		Method 2	Method 3
1	0.1	51.3%	3.3%
2		59.9%	5.1%
3		78.8%	16.4%
4		93.1%	48.7%
5	1.0	39.5%	6.2%
6		58.6%	17.9%
7		60.9%	24.2%
8	10	1.8%	0.4%
9		4.0%	0.3%
10		5.3%	1.0%
11		5.3%	1.1%

[1] False Call Rate is percentage of iterations where the as-found trip setpoint (TSP Observed) is greater than the Allowable Value and the actual trip point (Actual TSP) is below the Analytical Limit.

Background

During a surveillance test, a portion of instrument channel components are tested to determine the as-found trip setpoint (Reference 2). The testing may include only a portion of the channel and is typically conducted under conditions that are not representative of design basis accident conditions. Consequently, testing may not include all of the uncertainties that can affect the instrument channel trip setpoint. A criterion is established for the test to determine whether the entire instrument channel is operable or inoperable. The current criterion used by the industry for this purpose is the Allowable Value (AV). If the margin between the as-found trip setpoint recorded in the surveillance test and the Analytical Limit (AL) is less than the margin between AV and AL, then the instrument channel is declared inoperable and corrective actions must be taken. This calculation examines the impact of calculating AV using two methods included in ISA-RP67.04, Part II, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation" (Reference 1).

Analysis Assumptions

1. The terms used in the calculation are consistent with the definitions used in ISA-S67.04-Part I, "Setpoints for Nuclear Safety-Related Instrumentation," (Reference 2). In addition, the Analytical Limit (AL), Allowable Value (AV), and Trip Setpoint (TSP) are defined consistent with the Figure 1 in Reference 2. That is, the process variable increases toward AL, so the value of the AL is greater than AV which is larger than the TSP.

2. Only a portion of the instrument channel is tested during surveillance testing, and the test environment is not representative of limiting conditions for instrument channel uncertainties.

3. The instrument channel random uncertainties are normally distributed.

4. The TSP and AVs are calculated assuming uncertainties at a 0.95 probability.

5. The simulation model parameter that represents an as-found trip setpoint (Observed TSP; see p. 10) is determined from a single test of the instrument channel. Therefore, both random and bias uncertainties are included in the as-found trip setpoint.

6. The AV is the inoperability criterion for surveillance testing. Corrective actions are taken when it is determined that an instrument channel has an as-found trip setpoint above AV.

7. The optional margin term to increase the conservatism of the trip setpoint (see equation 7.1 of Reference 1) is zero.

APPROACH

A Monte Carlo model is constructed in Microsoft Excel (2002). The model simulates surveillance testing of an instrument channel with an AV calculated using ISA-RP67.04 (Reference 1). An input parameter to the model specifies whether AV is calculated using Method 2 or 3 of the ISA standard. For each iteration, the model calculates an "Observed TSP" and an "Actual TSP." The as-found trip setpoint, as it is defined in Reference 2, is the Observed TSP in the simulation model. The inoperability criterion in this calculation is AV. Therefore, an instrument channel should be declared inoperable when the Observed TSP exceeds AV. A second term is calculated in each iteration that corresponds to a trip setpoint that could be observed if the entire system were called upon to actuate. This value is called the Actual TSP. If the Actual TSP exceeds the AL, then the safety limit is not protected.

The spreadsheet model simulates an instrument channel surveillance test with the operability criterion established using either ISA Method 2 and 3. The user specifies a nonconservative drift in the instrument channel that essentially moves the nominal trip setpoint closer to AL. The model compares the Actual TSP to AL and the Observed TSP to AV in 10,000 iterations. The model calculates the percentage of iterations where the instrument channel appears to be operable (Observed TSP < AV) but would cause an actuation when the process parameter exceeds AL (Actual TSP > AL). If the operability criterion for the surveillance test is established appropriately, then this condition should occur infrequently.

The simulation is designed to be independent of time and the changes that would occur to the instrument channel between the time when a surveillance test is completed and actuation of a channel at some time in the future. The results provide a snapshot of the instrument channel at one instance in time and indicate the likelihood that a nonconservative change in the trip setpoint would be identified at that moment. This is achieved by calculating the Observed TSP and the Actual TSP using the same random uncertainties for COT terms and drift.

A feature is included in the model to quantify the percentage of iterations when a channel is declared inoperable (Observed TSP > AV) when the Actual TSP is less than AL. This is called the false call rate.

Model Inputs

The fictitious instrument channel modeled in this calculation senses pressure in a system and initiates a protective action before the pressure exceeds 2396 psi (i.e., AL). The channel consists of several distinct and independent components that influence the setpoint by either random uncertainties that will change with each actuation of the system or a fixed bias value that does not change within the time scale of each test. The bias term, however, does include a small random component to account for uncertainty in the bias term. Table 3 lists the random uncertainties for the four modules used in one of the simulation cases. The bias terms are discussed later in this calculation.

Table 3. Sample Component Uncertainties in Simulation Model (Analysis Case No. 1)

	Component Random Uncertainties (% of Span)			
	EE	M&TE	DR	RA
e1	3	0.7	0.3	1
e2	4.5	1.2	0.1	0.5
e3	3.75	1	0.15	0.5
e4	13.8498	0.2	0.2	0.75
PE	0.05			

Note: Shaded cells indicate random uncertainties that are included in COT.

The uncertainties are specified in terms of a percentage of a 3000 psi span for the instrument channel. The values represent the upper 95th percentile value of the random uncertainty. The uncertainties for four channel modules, e1 through e4, are divided into four groups that represent the uncertainties defined in Reference 1. Only M&TE (measurement and test equipment), DR (drift), and RA (reference accuracy) for modules e3 and e4 are evaluated in the simulated surveillance test (shaded cells in Table 3). The remaining random uncertainties of Table 3 such as EE (combined environmental effects) and PE (process element) are included in nCOT, the instrument channel uncertainties that are not evaluated in the surveillance test. One other random uncertainty term that is included in nCOT accounts for process measurement uncertainty (PM). As described in Reference 1, this uncertainty term does not apply to a component, but PM uncertainty is included in the simulation model for completeness.

There are two bias terms included in the simulation model, Bias1 and Bias2. These bias terms establish the fixed change in the instrument channel trip setpoint that occurs in the interval between when the trip setpoint was set to the licensing basis TSP and the surveillance test. A small random component is included to account for the uncertainty in the bias term. Bias1 is included in nCOT, while Bias2 is included in COT (the instrument channel uncertainties that affect the surveillance test).

Table 4. Bias Uncertainties in Simulation Model

	Magnitude of Bias (psi)	Random Uncertainty in Bias, r_{bias} (psi)
Bias1	12	0.6
Bias2	5	1.2

Since all of the random uncertainties are specified at a 95% probability level and have a mean of zero, the standard deviation of each uncertainty distribution is calculated by dividing the value by a standardized normal variable. For a normal distribution, the value of this variable is equal to 1.96 (see Table A3 in Reference 3).

Calculation of Trip Setpoint and Allowable Values

The simulation model calculates the TSP and AV by combining the uncertainty terms in accordance with the methods described in the ISA recommended practices document (Reference 1). The instrument channel TSP is calculated using the equation below.

$$TSP = AL - \left(\sqrt{r_1^2 + r_2^2 + r_3^2 + \ldots + r_n^2 + nr_1^2 + nr_2^2 + nr_3^2 + \ldots + nr_m^2} + Bias1 + Bias2\right)$$

where,

AL	=	Analytical limit, psi
r_i	=	Random uncertainties that affect the surveillance test outcome, psi
nr_i	=	Random uncertainties that are not tested, psi
$Bias1, Bias2$	=	Non-random instrument channel uncertainties (including random component at 0.95 probability level), psi

The ISA Recommend Practices includes an additional margin term in the expression for the TSP. Margin can be included to increase the conservatism in the trip setpoint. This analysis assumes a margin of zero.

A comparison of the uncertainties that are evaluated in the surveillance test (COT) and the uncertainties that are not included in the surveillance test (nCOT) can provide an indication as to how much of the instrument channel is evaluated in the test. COT and nCOT are calculated as shown below.

$$COT = \sqrt{r_1^2 + r_2^2 + r_3^2 + \ldots + r_n^2} + Bias2$$

$$nCOT = \sqrt{nr_1^2 + nr_2^2 + nr_3^2 + \ldots + nr_m^2} + Bias1$$

The terms COT and nCOT are used to calculate the instrument channel AV. The approach used to calculate AV by Method 2 (AV_2) and Method 3 (AV_3) is given below. AV is fixed prior to the simulation and is constant for all iterations.

$$AV_2 = AL - nCOT$$

$$AV_3 = TSP + COT$$

Simulation Model

The simulation model is created in Excel (see Appendix A). Twenty uniform random numbers are used to calculate random normal deviates ($Z_1 ... Z_{20}$) using the method of Box and Muller (see Section 11.3.3 of Reference 3). The uniform deviates are generated in Excel using the RAND() function. The following expression calculates two random normal deviates (Z_1, Z_2) from two uniform deviates (R_1 and R_2).

$$Z_1 = \sqrt{2\ln(1/R_1)} \cdot \cos(2\pi R_2)$$

$$Z_2 = \sqrt{2\ln(1/R_1)} \cdot \sin(2\pi R_2)$$

The deviates, Z_1 and Z_2, are independent and normally distributed with a mean of 0 and a standard deviation of 1.

For a single observation of the trip setpoint, the as-found value is equal to nominal trip setpoint plus the random and bias uncertainties that can affect the test (i.e., COT). For this analysis, the drift uncertainty for module e3 is replaced with a fixed value that is input by the user (TSP Offset). This offset in the trip setpoint simulates a nonconservative drift in the instrument channel setpoint. By assuming that one of the drift terms is fixed, a bias is imposed on the TSP that was not accounted for in the trip setpoint calculation. The as-found trip setpoint is called the Observed TSP in the spreadsheet model. The Observed TSP is calculated as follows:

$$\text{Observed TSP} = \text{Trip Setpoint} + \sum_{i=1}^{5} \frac{r_i}{1.96} \cdot Z_i + \left(Bias2 + \frac{r_{bias}}{1.96} \cdot Z_{bias} \right) + \text{TSP Offset}$$

The *Bias2* term in the equation corresponds to only the constant portion of the instrument channel bias in COT. The random component of *Bias2* comes from the term r_{bias} and varies with each iteration.

The user specifies a value for the TSP Offset at the beginning of the simulation, and this value remains unchanged for all iterations.

The Actual TSP is a trip setpoint that could be observed if the system were called upon to actuate. This value includes all the uncertainty terms that make up both COT and nCOT with the exception of the drift term for module e3, which is replaced by TSP Offset.

Each simulation iteration compares the Actual TSP and Observed TSP to AL and AV, respectively. If the Observed TSP is less than AV, then the simulation assumes that the instrument channel is operable. If the Actual TSP is greater than AL the safety limit is not protected. When both of these conditions occur simultaneously, this implies that the instrument channel was perceived as operable when in fact, it would not have actuated below the analytical limit. The number of times that both of these conditions is true (i.e., the Observed TSP < AV and the Actual TSP > AL) is recorded ("Number of exceedances") and divided by the total number of iterations. The result is given as the percentage of simulations where an incorrect operability determination is made for the instrument channel.

A second number is calculated in the simulation that indicates how many times the instrument channel would have been declared inoperable on the basis of the surveillance test result (Observed TSP > AV) when the actuation point for the entire channel is below AL (Actual TSP < AL). This condition represents a conservative, but false, operability determination. The final result for a simulation is the number of times this occurs divided by the total number of iterations, given as a percent.

SIMULATION RESULTS

Twenty-two simulations were completed using 11 sets of input values to the model. Results were compared for each set of results obtained when AV was set using the two methods of the ISA recommended practices (i.e., Method 2 and 3). The uncertainty values were varied to quantify the percentage of AL exceedances at COT to nCOT ratios of 0.1, 1, and 10. Several TSP Offset values are used in the analyses for each COT to nCOT ratio. The values selected for the analyses span the margin between the trip setpoint and the Method 3 AV. The first TSP Offset value for a fixed COT to nCOT ratio is equal the uncertainty for the e3 drift term at a 95% probability (i.e., value used in establishing the TSP). The second value is twice the offset used in the first case. The third and fourth TSP Offset values (for COT/nCOT = 0.1 and 10) span up to the Method 3 AV.

Results for each simulation are included in Appendix A. Table 5, below, summarizes one of the key results for the 11 analysis cases.

Table 5. Summary of Simulation Analysis Results

Analysis Case No.	COT/nCOT	Trip Setpoint (psi)	Allowable Value (psi) Method 2	Allowable Value (psi) Method 3	TSP Offset (psi)	Exceedances of AL with Observed TSP < AV Method 2	Exceedances of AL with Observed TSP < AV Method 3
1	0.1	1911.2	1919.2	1958.9	4.5	1.1%	2.5%
2					9	0.7%	2.4%
3					22.5	0.3%	2.4%
4					43	0.1%	1.6%
5	1.0	2208.9	2267.6	2337.3	48	0.3%	3.4%
6					96	0.3%	4.7%
7					115	0.2%	4.7%
8	10	2062.9	2364.0	2382.8	90	0.0%	0.2%
9					180	0.0%	0.6%
10					270	0.0%	0.7%
11					300	0.0%	0.8%

The results indicate that a nonconservative operability call is unlikely to occur when AV is established using either Method 2 or Method 3. The percentage of iterations where an as-found trip setpoint indicates an operable channel but the actual trip point occurs beyond AV was low for all simulations. Attempts to increase the AL exceedance percentage above those in Table 5 using alternate input values did not yield substantially different results. Thus, the results presented herein are robust.

The level of conservatism provided by an AV determined with Method 2 is approximately one order in magnitude higher than for Method 3 AVs. However, as indicated in Table 6, the frequency of false calls is considerably higher for Method 2 than Method 3. The simulated inputs used in this calculation indicated a false call rate of 50% for Method 2 when the drift imposed on the instrument channel was relatively low and COT/nCOT is equal to 0.1. Method 3 false call rates for the same simulation inputs were over 15 times lower (3.3%). The trend evident from all the results suggests that as the drift imposed on the instrument channel increases, the false call rate increased regardless of which method is used to establish AV.

Table 6. Incorrect Operability Calls for Operable Instrument Channels

Analysis Case No.	COT/nCOT	False Call Rate[1] Method 2	False Call Rate[1] Method 3
1	0.1	51.3%	3.3%
2		59.9%	5.1%
3		78.8%	16.4%
4		93.1%	48.7%
5	1.0	39.5%	6.2%
6		58.6%	17.9%
7		60.9%	24.2%
8	10	1.8%	0.4%
9		4.0%	0.9%
10		5.3%	1.0%
11		5.3%	1.1%

1 False Call Rate is percentage of iterations where the as-found trip setpoint is greater than the Allowable Value and the actual trip point is below the Analytical Limit.

Referring back to Table 5, the likelihood of not identifying an inoperable instrument channel via testing appears to be dependent on the ratio of COT to nCOT. When using Method 2 to establish instrument channel AVs, interrogating more of the instrument channel uncertainties in the surveillance test resulted in fewer nonconservative operability conclusions. The trend apparent in the Method 3 simulation results suggests a similar, but nonlinear, relationship between the ratio of COT to nCOT and incorrect operability calls.

REFERENCES

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

2. ANSI/ISA Standard ANSI/ISA-S67.04-Part I, "Setpoints for Nuclear Safety-Related Instrumentation," Instrument Society of America, 1995.

3. W. M. Bowen and C. A. Bennet, eds., Statistical Methods for Nuclear Material Management, NUREG/CR-4604, U. S. Nuclear Regulatory Commission, December 1988.

A

Detailed Simulation Results

Details of the input variables and results are included on a single worksheet in the Excel simulation model. The model is capable of analyzing the instrument channel using either Method 2 or Method 3 in a single simulation run. The user specifies which calculation method is used to determine AV. The only variable not explicitly identified on the input/output worksheet is the standardized normal variable used to calculate the standard deviation of instrument channel uncertainties (i.e., 1.96 – see p. 9 of calculation).

The two primary output parameters from the simulation are the "Number of exceedances" and "Number of false calls." At the end of all simulation iterations, both of these values are divided by the total number of iterations to yield the percentage values that are given in Table 5 and Table 6. The number of exceedances and false calls is recorded using a Visual Basic macro in Excel, which also recalculates all the uniform random deviates at each iteration. A printout of the simulation macro is given in Appendix B.

Before each simulation and after all channel uncertainties have been set, the user specifies the TSP Offset near the top of the input/output worksheet. In addition, the user specifies whether AV is calculated by ISA Method 2 or 3 by entering the method number in a cell adjacent to the label, "AV Calculation Method:." The simulation is started by executing the macro, "MonteCarlo."

Eleven pairs of simulations were completed to support this calculation (11 simulations for each of Methods 2 and 3). Details of the input and output from each of these simulations is given on the following pages.

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	4.5 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	3	0.7	0.3	1	90	21	9	30	97.58	*Not tested*
e2	4.5	1.2	0.1	0.5	135	36	3	15	140.55	*Not tested*
e3	3.75	1	0.15	0.5	112.5	30	4.5	15	117.48	*Tested*
e4	13.8498	0.2	0.2	0.75	415.494	6	6	22.5	416.19	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

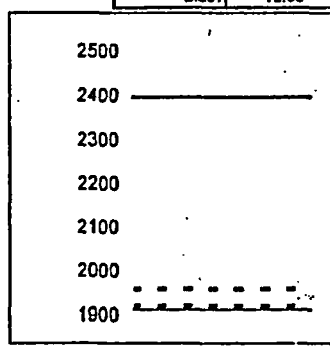
	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	33.84
e4	24.05
Bias2	6.20

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	NTU (psi)
e1	97.58
e2	140.55
e3	112.50
e4	415.49
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi		
Channel Uncertainty =	484.8 psi		
Margin =	0 psi		
Trip Setpoint =	1911.2 psi		
COT =	47.7 psi		
nCOT =	476.8 psi		
COT/nCOT =	0.10		
Method 2 AV:	AL - (nCOT + Margin) =	1919.2 psi	[Ref. 7.3 of RP]
Method 3 AV:	TSP + COT =	1958.9 psi	[Ref. 7.3 of RP]



Number of iterations:	*10000*
AV Calculation Method:	2
Simulation AV =	1919.2
Number of exceedances =	111
Percentage of exceedances =	1.11%
Number of false calls =	*5128*
Percentage of false calls =	51.28%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.318	-1.513	-69.5		-75.6	1930.7	2102.8	1	0
e1 (M&TE)	0.493	0.066	0.7						
e1 (DR)	0.911	-0.197	-0.9						
e1 (RA)	0.675	-0.385	-5.9						
e2 (EE)	0.564	0.015	1.0		-16.3				
e2 (M&TE)	0.752	-1.070	-19.7						
c2 (DR)	0.795	-0.538	-0.8						
e2 (RA)	0.396	0.411	3.1						
e3 (EE)	0.937	0.168	9.6	8.2	9.6				
e3 (M&TE)	0.173	0.319	4.9						
e3 (DR)	0.891	-0.212	-0.5						
e3 (RA)	0.323	0.430	3.3						
e4 (EE)	0.257	1.122	237.9	0.8	237.9				
e4 (M&TE)	0.131	1.207	3.7						
e4 (DR)	0.729	-0.793	-2.4						
e4 (RA)	0.508	-0.040	-0.5						
PM	0.796	0.327	5.0		5.0				
PE	0.830	-0.591	-0.5		-0.5				
Bias1	0.213	-0.528	11.8		11.8				
Bias2	0.299	1.678	6.0	6.0					
Channel offset				4.5					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	4.5 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	3	0.7	0.3	1	90	21	9	30	97.58	*Not tested*
e2	4.5	1.2	0.1	0.5	135	36	3	15	140.55	*Not tested*
e3	3.75	1	0.15	0.5	112.5	30	4.5	15	117.48	*Tested*
e4	13.6498	0.2	0.2	0.75	415.494	6	6	22.5	416.19	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	33.84
e4	24.05
Bias2	6.20

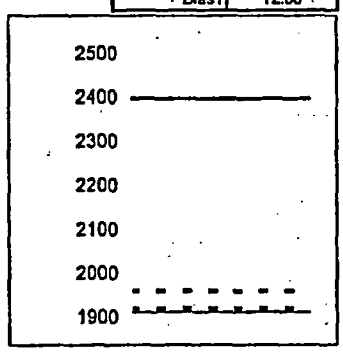
Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	6 psi

	NTU (psi)
e1	97.58
e2	140.55
e3	112.50
e4	415.49
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	484.8 psi
Margin =	0 psi
Trip Setpoint =	1911.2 psi
COT =	47.7 psi
nCOT =	476.8 psi
COT/nCOT =	0.10

Method 2 AV: AL - (nCOT + Margin) = 1919.2 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 1958.9 psi [Ref. 7.3 of RP]



Number of Iterations:	10000
AV Calculation Method:	3
Simulation AV =	1958.9
Number of exceedances =	249
Percentage of exceedances =	2.49%
Number of false calls =	334
Percentage of false calls =	3.34%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.137	0.185	8.5		42.0	1887.9	2247.5	0	0
e1 (M&TE)	0.235	1.986	21.3						
e1 (DR)	0.152	-1.492	-6.8						
e1 (RA)	0.389	1.244	19.0						
e2 (EE)	0.234	-1.699	-117.0		-122.0				
e2 (M&TE)	0.512	-0.126	-2.3						
e2 (DR)	0.657	-0.902	-1.4						
e2 (RA)	0.529	-0.165	-1.3						
e3 (EE)	0.192	0.275	15.8	-27.4	15.8				
e3 (M&TE)	0.774	-1.797	-27.5						
e3 (DR)	0.995	-0.101	-0.2						
e3 (RA)	0.480	0.013	0.1						
e4 (EE)	0.092	2.071	439.0	-6.3	439.0				
e4 (M&TE)	0.948	-0.700	-2.1						
e4 (DR)	0.469	1.049	3.2						
e4 (RA)	0.912	-0.644	-7.4						
PM	0.060	-1.694	-25.9		-25.9				
PE	0.623	-1.661	-1.3		-1.3				
Bias1	0.265	0.058	12.0		12.0				
Bias2	0.244	1.628	6.0	6.0					
Channel offset				4.5					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: P. Rush

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2398 psi		
TSP Offset:	9 psi		
Margin:	0 psi		
Span:	3000 psi	(Uncertainties are % of total span.)	

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	3	0.7	0.3	1	90	21	9	30	97.58	*Not tested*
e2	4.5	1.2	0.1	0.5	135	36	3	15	140.55	*Not tested*
e3	3.75	1	0.15	0.5	112.5	30	4.5	15	117.48	*Tested*
e4	13.8498	0.2	0.2	0.75	415.494	6	6	22.5	416.19	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	33.84
e4	24.05
Bias2	6.20

	NTU (psi)
e1	97.58
e2	140.55
e3	112.50
e4	415.49
PM	30.00
PE	1.50
Bias1	12.60

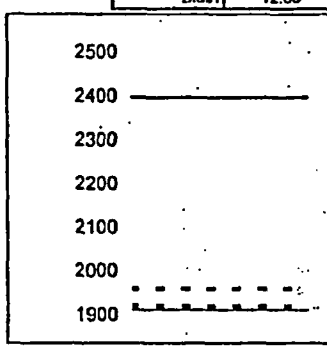
Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

Analytical Limit =	2398 psi
Channel Uncertainty =	484.8 psi
Margin =	0 psi
Trip Setpoint =	1911.2 psi
COT =	47.7 psi
nCOT =	476.8 psi
COT/nCOT =	0.10

Method 2 AV: AL - (nCOT + Margin) = 1919.2 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 1958.9 psi [Ref. 7.3 of RP]

Number of iterations:	10000
AV Calculation Method:	2
Simulation AV =	1919.2
Number of exceedances =	67
Percentage of exceedances =	0.67%
Number of false calls =	5990
Percentage of false calls =	59.90%



Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.645	-0.166	-7.8		-24.7	1922.7	1640.3	1	0
e1 (M&TE)	0.278	0.921	9.9						
e1 (DR)	0.133	0.563	2.6						
e1 (RA)	0.795	-1.927	-29.5						
e2 (EE)	0.406	0.737	50.8		79.2				
e2 (M&TE)	0.156	1.122	20.6						
e2 (DR)	0.346	1.233	1.9						
e2 (RA)	0.089	0.775	5.9						
e3 (EE)	0.839	-0.256	-14.7	-1.7	-14.7				
e3 (M&TE)	0.679	-0.534	-8.2						
e3 (DR)	0.589	-0.579	-1.3						
e3 (RA)	0.345	0.849	6.5						
e4 (EE)	0.213	-1.592	-337.5	-0.4	-337.5				
e4 (M&TE)	0.430	0.747	2.3						
e4 (DR)	0.924	-0.373	-1.1						
e4 (RA)	0.557	-0.139	-1.6						
PM	0.836	0.169	2.6		2.6				
PE	0.205	0.574	0.4		0.4				
Bias1	0.537	0.923	12.3		12.3				
Bias2	0.905	-0.625	4.6	4.6					
Channel offset				9					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: *P. Rue*

Checked By: *[signature]*

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	9 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	3	0.7	0.3	1	90	21	9	30	97.58	*Not tested*
e2	4.5	1.2	0.1	0.5	135	36	3	15	140.55	*Not tested*
e3	3.75	1	0.15	0.5	112.5	30	4.5	15	117.48	*Tested*
e4	13.8498	0.2	0.2	0.75	415.494	6	6	22.5	416.19	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

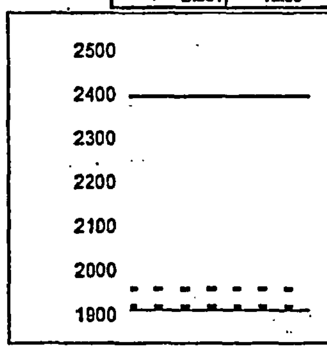
	TU (psi)
e3	33.84
e4	24.05
Bias2	6.20

	NTU (psi)
e1	97.58
e2	140.55
e3	112.50
e4	415.49
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	484.8 psi
Margin =	0 psi
Trip Setpoint =	1911.2 psi
COT =	47.7 psi
nCOT =	476.8 psi
COT/nCOT =	0.10

Method 2 AV: AL - (nCOT + Margin) = 1919.2 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 1958.9 psi [Ref. 7.3 of RP]



Number of Iterations:	10000
AV Calculation Method:	3
Simulation AV =	1958.9
Number of exceedances =	235
Percentage of exceedances =	2.35%
Number of false calls =	513
Percentage of false calls =	5.13%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.979	0.206	9.6		-10.1	1933.3	1816.2	0	0
e1 (M&TE)	0.003	0.004	0.0						
e1 (DR)	0.338	0.417	1.9						
e1 (RA)	0.796	-1.413	-21.6						
e2 (EE)	0.677	-0.193	-13.3		-0.8				
e2 (M&TE)	0.285	0.862	15.6						
e2 (DR)	0.579	0.855	1.3						
e2 (RA)	0.902	-0.603	-4.6						
e3 (EE)	0.516	0.210	12.1	16.9	12.1				
e3 (M&TE)	0.221	1.130	17.3						
e3 (DR)	0.973	0.229	0.5						
e3 (RA)	0.957	-0.049	-0.4						
e4 (EE)	0.008	-0.703	-149.1	-8.9	-149.1				
e4 (M&TE)	0.713	-3.011	-9.2						
e4 (DR)	0.266	-1.564	-4.8						
e4 (RA)	0.456	0.447	5.1						
PM	0.444	1.245	19.1		19.1				
PE	0.034	0.271	0.2		0.2				
Bias1	0.310	-1.523	11.5		11.5				
Bias2	0.483	0.162	5.1	5.1					
Channel offset				9					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi	
TSP Offset:	22.5 psi	
Margin:	0 psi	
Span:	3000 psi	(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	3	0.7	0.3	1	90	21	9	30	97.58	*Not tested*
e2	4.5	1.2	0.1	0.5	135	36	3	15	140.55	*Not tested*
e3	3.75	1	0.15	0.5	112.5	30	4.5	15	117.48	*Tested*
e4	13.8498	0.2	0.2	0.75	415.494	6	6	22.5	416.19	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

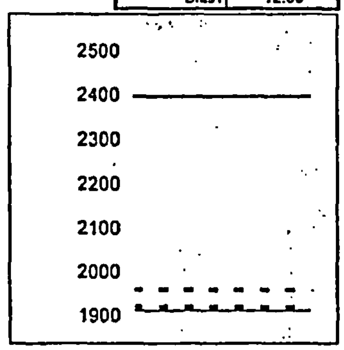
	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	33.84
e4	24.05
Bias2	1.20

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	NTU (psi)
e1	97.58
e2	140.55
e3	112.50
e4	415.49
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi		
Channel Uncertainty =	484.8 psi		
Margin =	0 psi		
Trip Setpoint =	1911.2 psi		
COT =	47.7 psi		
nCOT =	476.8 psi		
COT/nCOT =	0.10		
Method 2 AV:	AL - (nCOT + Margin) =	1919.2 psi	[Ref. 7.3 of RP]
Method 3 AV:	TSP + COT =	1958.9 psi	[Ref. 7.3 of RP]
Number of iterations:	10000		
AV Calculation Method:	2		
Simulation AV =	1919.2		
Number of exceedances =	32		
Percentage of exceedances =	0.32%		
Number of false calls =	7878		
Percentage of false calls =	78.78%		



Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.261	-1.518	-69.7		-70.0	1902.3	1651.5	0	0
e1 (M&TE)	0.438	0.622	6.7						
e1 (DR)	0.139	-1.981	-9.1						
e1 (RA)	0.489	0.137	2.1						
e2 (EE)	0.563	1.005	69.2		73.3				
e2 (M&TE)	0.057	0.373	6.9						
e2 (DR)	0.863	0.327	0.5						
e2 (RA)	0.853	-0.434	-3.3						
e3 (EE)	0.286	-0.457	-26.2	-27.1	-23.2				
e3 (M&TE)	0.703	-1.514	-23.2						
e3 (DR)	0.601	0.868	2.0						
e3 (RA)	0.915	-0.514	-3.9						
e4 (EE)	0.069	-1.070	-226.9	-9.4	-226.9				
e4 (M&TE)	0.673	-2.051	-6.3						
e4 (DR)	0.392	-1.366	-4.2						
e4 (RA)	0.490	0.089	1.0						
PM	0.499	-0.814	-12.5		-12.5				
PE	0.629	-0.853	-0.7		-0.7				
Bias1	0.798	0.620	12.2		12.2				
Bias2	0.064	0.262	5.2	5.2					
Channel offset				22.5					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	22.5 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	3	0.7	0.3	1	90	21	9	30	97.58	*Not tested*
e2	4.5	1.2	0.1	0.5	135	36	3	15	140.55	*Not tested*
e3	3.75	1	0.15	0.5	112.5	30	4.5	15	117.48	*Tested*
e4	13.8498	0.2	0.2	0.75	415.494	6	6	22.5	416.19	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	33.84
e4	24.05
Bias2	6.20

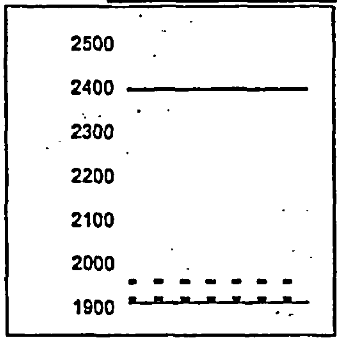
Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	6 psi

	NTU (psi)
e1	97.58
e2	140.55
e3	112.50
e4	415.49
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	484.8 psi
Margin =	0 psi
Trip Setpoint =	1911.2 psi
COT =	47.7 psi
nCOT =	476.8 psi
COT/nCOT =	0.10

Method 2 AV: AL - (nCOT + Margin) = 1919.2 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 1958.9 psi [Ref. 7.3 of RP]



Number of iterations:	10000
AV Calculation Method:	3
Simulation AV =	1958.9
Number of exceedances =	242
Percentage of exceedances =	2.42%
Number of false calls =	1636
Percentage of false calls =	16.36%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.271	-1.613	-74.1		-65.8	1952.5	2234.0	0	0
e1 (M&TE)	0.489	0.109	1.2						
e1 (DR)	0.887	-0.076	-0.3						
e1 (RA)	0.275	0.483	7.4						
e2 (EE)	0.019	1.348	92.8		138.6				
e2 (M&TE)	0.171	2.482	45.6						
e2 (DR)	0.809	0.642	1.0						
e2 (RA)	0.972	-0.112	-0.9						
e3 (EE)	0.606	0.955	54.8	7.2	54.8				
e3 (M&TE)	0.047	0.289	4.4						
e3 (DR)	0.837	-0.474	-1.1						
e3 (RA)	0.396	0.364	2.8						
e4 (EE)	0.609	0.625	132.4	7.1	132.4				
e4 (M&TE)	0.858	-0.775	-2.4						
e4 (DR)	0.420	1.220	3.7						
e4 (RA)	0.062	0.498	5.7						
PM	0.405	0.671	10.3		10.3				
PE	0.833	-1.164	-0.9		-0.9				
Bias1	0.626	0.671	12.2		12.2				
Bias2	0.872	-0.898	4.6	4.6					
Channel offset				22.5					

Analytical Limit:	2398 psi	
TSP Offset:	43 psi	
Margin:	0 psi	
Span:	3000 psi	(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)				Total (psi)	
	EE	M&TE	DR	RA	EE	M&TE	DR	RA		
e1	3	0.7	0.3	1	90	21	9	30	97.58	*Not tested*
e2	4.5	1.2	0.1	0.5	135	36	3	15	140.55	*Not tested*
e3	3.75	1	0.16	0.5	112.5	30	4.5	15	117.48	*Tested*
e4	13.8498	0.2	0.2	0.75	415.494	6	6	22.5	416.19	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

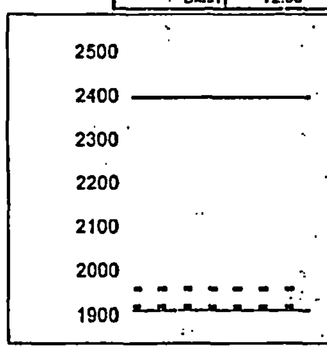
	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	33.84
e4	24.05
Bias2	6.20

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	NTU (psi)
e1	97.58
e2	140.55
e3	112.50
e4	415.46
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2398 psi			
Channel Uncertainty =	484.8 psi			
Margin =	0 psi			
Trip Setpoint =	1911.2 psi			
COT =	47.7 psi			
nCOT =	476.8 psi			
COT/nCOT =	0.10			
Method 2 AV:	AL - (nCOT + Margin) =	1919.2 psi	[Ref. 7.3 of RP]	
Method 3 AV:	TSP + COT =	1958.9 psi	[Ref. 7.3 of RP]	



Number of iterations:	10000
AV Calculation Method:	2
Simulation AV =	1919.2
Number of exceedances =	11
Percentage of exceedances =	0.11%
Number of false calls =	9312
Percentage of false calls =	93.12%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.436	1.012	46.5		38.9	1950.5	1591.7	1	0
e1 (M&TE)	0.694	-0.795	-8.5						
e1 (DR)	0.237	-1.643	-7.5						
e1 (RA)	0.460	0.426	6.5						
e2 (EE)	0.309	1.503	103.5		101.1				
e2 (M&TE)	0.969	-0.298	-5.4						
e2 (DR)	0.842	0.507	0.8						
e2 (RA)	0.084	0.295	2.3						
e3 (EE)	0.464	-1.178	-67.6	13.1	-67.6				
e3 (M&TE)	0.449	0.387	5.9						
e3 (DR)	0.633	0.205	0.5						
e3 (RA)	0.216	0.934	7.2						
e4 (EE)	0.108	-2.108	-446.4	-20.6	-440.4				
e4 (M&TE)	0.509	-0.118	-0.4						
e4 (DR)	0.194	0.147	0.5						
e4 (RA)	0.763	-1.804	-20.7						
PM	0.463	0.398	6.1		6.1				
PE	0.802	-1.177	-0.9		-0.9				
Bias1	0.198	-0.102	12.0		12.0				
Bias2	0.741	-1.798	3.9	3.9					
Channel offset				43					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: P. Rue

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	43 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	3	0.7	0.3	1	90	21	9	30	97.58	*Not tested*
e2	4.5	1.2	0.1	0.5	135	36	3	15	140.55	*Not tested*
e3	3.75	1	0.15	0.5	112.5	30	4.5	15	117.48	*Tested*
e4	13.8498	0.2	0.2	0.75	415.494	6	6	22.5	416.19	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	33.84
e4	24.05
Bias2	6.20

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

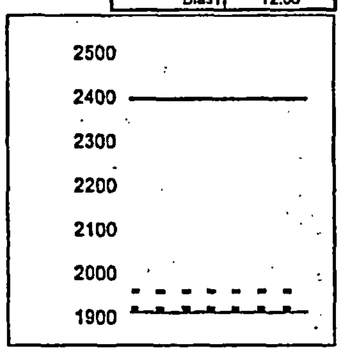
	NTU (psi)
e1	97.58
e2	140.55
e3	112.50
e4	415.49
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	484.8 psi
Margin =	0 psi
Trip Setpoint =	1911.2 psi
COT =	47.7 psi
nCOT =	476.8 psi
COT/nCOT =	0.10

Method 2 AV: AL - (nCOT + Margin) = 1919.2 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 1958.9 psi [Ref. 7.3 of RP]

Number of iterations:	10000
AV Calculation Method:	3
Simulation AV =	1958.9
Number of exceedances =	162
Percentage of exceedances =	1.62%
Number of false calls =	4869
Percentage of false calls =	48.69%



Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.992	0.126	5.8		-4.6	1934.0	2147.1	0	0
e1 (M&TE)	0.963	-0.029	-0.3						
e1 (DR)	0.742	0.246	1.1						
e1 (RA)	0.802	-0.733	-11.2						
e2 (EE)	0.206	-1.582	-109.0		-130.2				
e2 (M&TE)	0.576	-0.813	-14.9						
e2 (DR)	0.213	-1.891	-2.6						
e2 (RA)	0.544	-0.479	-3.7						
e3 (EE)	0.294	-0.837	-48.0	-31.5	-48.0				
e3 (M&TE)	0.660	-1.322	-20.2						
e3 (DR)	0.026	-2.259	-5.2						
e3 (RA)	0.592	-1.471	-11.3						
e4 (EE)	0.083	1.881	398.8	5.9	398.8				
e4 (M&TE)	0.909	-1.203	-3.7						
e4 (DR)	0.721	0.255	0.8						
e4 (RA)	0.199	0.767	8.8						
PM	0.439	-1.016	-15.6		-15.6				
PE	0.396	0.782	0.6		0.6				
Bias1	0.714	0.465	12.1		12.1				
Bias2	0.154	0.677	5.4	5.4					
Channel offset				43					

Prepared By:

Checked By:

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	96 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	1	0.7	0.3	0.2	30	21	9	6	38.16	*Not tested*
e2	2	0.1	0.1	0.5	60	3	3	15	61.99	*Not tested*
e3	2	1.945757066	1.6	1.6	60	58.372712	48	48	107.77	*Tested*
e4	2	1.6	1.6	1.6	60	48	48	48	102.53	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	89.53
e4	83.14
Bias2	6.20

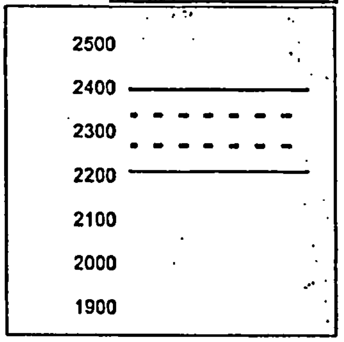
Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	NTU (psi)
e1	38.18
e2	61.99
e3	60.00
e4	60.00
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	187.1 psi
Margin =	0 psi
Trip Setpoint =	2208.9 psi
COT =	128.4 psi
nCOT =	128.4 psi
COT/nCOT =	1.00

Method 2 AV: AL - (nCOT + Margin) = 2267.6 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 2337.3 psi [Ref. 7.3 of RP]



Number of iterations:	10000
AV Calculation Method:	2
Simulation AV =	2267.6
Number of exceedances =	26
Percentage of exceedances =	0.26%
Number of false calls =	5862
Percentage of false calls =	58.62%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.586	0.936	14.3		32.0	2294.4	2288.9	1	0
e1 (M&TE)	0.070	0.440	4.7						
e1 (DR)	0.015	1.235	5.7						
e1 (RA)	0.180	2.631	8.1						
e2 (EE)	0.479	-0.165	-5.0		-2.0				
e2 (M&TE)	0.272	1.202	1.8						
e2 (DR)	0.340	-1.401	-2.1						
e2 (RA)	0.452	0.440	3.4						
e3 (EE)	0.070	-2.304	-70.5	-14.2	-70.5				
e3 (M&TE)	0.500	-0.001	0.0						
e3 (DR)	0.694	-0.630	-15.4						
e3 (RA)	0.618	-0.577	-14.1						
e4 (EE)	0.655	0.895	27.4	-1.1	27.4				
e4 (M&TE)	0.963	-0.214	-5.2						
e4 (DR)	0.732	0.637	15.6						
e4 (RA)	0.899	-0.467	-11.4						
PM	0.797	-0.380	-5.8		-5.8				
PE	0.345	0.557	0.4		0.4				
Bias1	0.603	0.929	12.3		12.3				
Bias2	0.938	-0.384	4.8	4.8					
Channel offset				96					

Calculation 0140-0403-PJR-01 Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	96 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)				Total (psi)	
	EE	M&TE	DR	RA	EE	M&TE	DR	RA		
e1	1	0.7	0.3	0.2	30	21	9	6	38.18	*Not tested*
e2	2	0.1	0.1	0.5	60	3	3	15	61.99	*Not tested*
e3	2	1.945757066	1.6	1.6	60	58.372712	48	48	107.77	*Tested*
e4	2	1.6	1.6	1.6	60	48	48	48	102.53	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

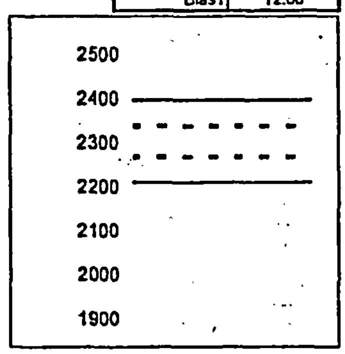
	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	89.53
e4	83.14
Bias2	6.20

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	NTU (psi)
e1	38.18
e2	61.99
e3	60.00
e4	60.00
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	187.1 psi
Margin =	0 psi
Trip Setpoint =	2208.9 psi
COT =	128.4 psi
nCOT =	128.4 psi
COT/nCOT =	1.00



Method 2 AV: AL - (nCOT + Margin) = 2267.6 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 2337.3 psi [Ref. 7.3 of RP]

Number of Iterations:	10000
AV Calculation Method:	3
Simulation AV =	2337.3
Number of exceedances =	474
Percentage of exceedances =	4.74%
Number of false calls =	1788
Percentage of false calls =	17.88%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.044	2.210	33.8		16.8	2295.9	2298.8	0	0
e1 (M&TE)	0.922	-1.177	-12.6						
e1 (DR)	0.434	-1.228	-5.6						
e1 (RA)	0.450	0.401	1.2						
e2 (EE)	0.225	-0.284	-6.7		-3.0				
e2 (M&TE)	0.724	-1.703	-2.6						
e2 (DR)	0.564	0.090	0.1						
e2 (RA)	0.237	1.068	8.2						
e3 (EE)	0.828	0.443	13.6	16.9	13.6				
e3 (M&TE)	0.122	0.425	12.7						
e3 (DR)	0.985	-0.013	-0.3						
e3 (RA)	0.262	0.174	4.3						
e4 (EE)	0.227	-0.385	-11.8	-29.9	-11.8				
e4 (M&TE)	0.714	-1.679	-41.1						
e4 (DR)	0.836	-0.125	-3.1						
e4 (RA)	0.283	0.585	14.3						
PM	0.104	-1.684	-25.8		-25.8				
PE	0.395	1.300	1.0		1.0				
Bias1	0.238	0.201	12.1		12.1				
Bias2	0.769	-1.662	4.0	4.0					
Channel offset				96					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi	
TSP Offset:	115 psi	
Margin:	0 psi	
Span:	3000 psi	(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	1	0.7	0.3	0.2	30	21	9	6	38.18	*Not tested*
e2	2	0.1	0.1	0.5	60	3	3	15	61.99	*Not tested*
e3	2	1.945757066	1.6	1.6	60	58.372712	48	48	107.77	*Tested*
e4	2	1.6	1.6	1.6	60	48	48	48	102.53	*Tested*
	Environ. Effects	Measure and Test	Drift	Reference Accuracy	*Not Tested*	*Tested*	*Tested*	*Tested*		

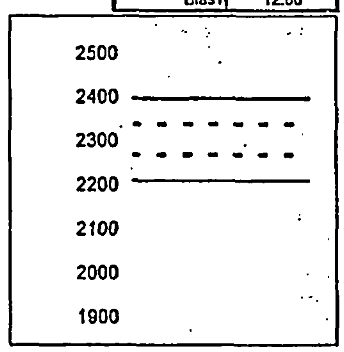
	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	89.53
e4	83.14
Bias2	6.20

	NTU (psi)
e1	38.18
e2	61.99
e3	60.00
e4	60.00
PM	30.00
PE	1.50
Bias1	12.60

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

Analytical Limit =	2396 psi
Channel Uncertainty =	187.1 psi
Margin =	0 psi
Trip Setpoint =	2208.9 psi
COT =	128.4 psi
nCOT =	128.4 psi
COT/nCOT =	1.00



Method 2 AV: AL - (nCOT + Margin) = 2267.6 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 2337.3 psi [Ref. 7.3 of RP]

Number of iterations:	10000
AV Calculation Method:	2
Simulation AV =	2267.6
Number of exceedances =	16
Percentage of exceedances =	0.16%
Number of false calls =	6090
Percentage of false calls =	60.90%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.966	-0.213	-3.3		2.5	2387.9	2462.0	0	0
e1 (M&TE)	0.401	0.153	1.6						
e1 (DR)	0.619	0.973	4.5						
e1 (RA)	0.982	-0.109	-0.3						
e2 (EE)	0.891	0.479	14.7		32.6				
e2 (M&TE)	0.012	0.037	0.1						
e2 (DR)	0.064	0.934	1.4						
e2 (RA)	0.185	2.148	16.4						
e3 (EE)	0.399	1.118	34.2	41.1	34.2				
e3 (M&TE)	0.096	0.768	22.8						
e3 (DR)	0.576	0.740	18.1						
e3 (RA)	0.126	0.745	18.2						
e4 (EE)	0.902	0.225	6.9	17.4	6.9				
e4 (M&TE)	0.832	-0.396	-9.7						
e4 (DR)	0.729	0.654	16.0						
e4 (RA)	0.096	0.452	11.1						
PM	0.593	-0.926	-14.2		-14.2				
PE	0.570	-0.435	-0.3		-0.3				
Bias1	0.349	1.139	12.3		12.3				
Bias2	0.106	0.898	5.6	5.6					
Channel offset				115					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi	
TSP Offset:	115 psi	
Margin:	0 psi	
Span:	3000 psi	(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	1	0.7	0.3	0.2	30	21	9	6	38.18	*Not tested*
e2	2	0.1	0.1	0.5	60	3	3	15	61.99	*Not tested*
e3	2	1.945757066	1.6	1.6	60	58.372712	48	48	107.77	*Tested*
e4	2	1.6	1.6	1.6	60	48	48	48	102.53	*Tested*
	Environ. Effects	Measure and Test	Drift	Reference Accuracy	Not Tested	Tested	Tested	Tested		

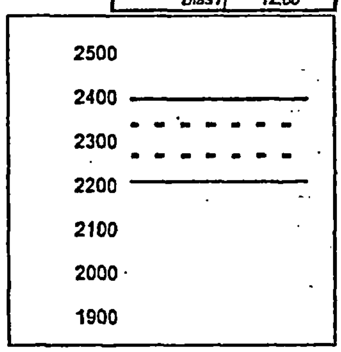
	(%)	(psi)	
PM	1	30	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	89.53
e4	83.14
Bias2	6.20

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	NTU (psi)
e1	38.18
e2	61.99
e3	60.00
e4	60.00
PM	30.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	187.1 psi
Margin =	0 psi
Trip Setpoint =	2208.9 psi
COT =	128.4 psi
nCOT =	128.4 psi
COT/nCOT =	1.00



Method 2 AV: AL - (nCOT + Margin) = 2267.6 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 2337.3 psi [Ref. 7.3 of RP]

Number of Iterations:	10000
AV Calculation Method:	3
Simulation AV =	2337.3
Number of exceedances =	468
Percentage of exceedances =	4.68%
Number of false calls =	2421
Percentage of false calls =	24.21%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.088	-0.159	-2.4		-39.7	2302.7	2293.8	0	0
e1 (M&TE)	0.739	-2.201	-23.6						
e1 (DR)	0.045	-2.189	-10.1						
e1 (RA)	0.579	-1.185	-3.6						
e2 (EE)	0.069	-0.719	-22.0		-16.9				
e2 (M&TE)	0.700	-2.197	-3.4						
e2 (DR)	0.558	0.247	0.4						
e2 (RA)	0.213	1.052	8.1						
e3 (EE)	0.125	0.709	21.7	-73.2	21.7				
e3 (M&TE)	0.507	-1.911	-56.9						
e3 (DR)	0.051	-2.346	-57.5						
e3 (RA)	0.544	-0.665	-16.3						
e4 (EE)	0.584	0.731	22.4	46.3	22.4				
e4 (M&TE)	0.125	0.736	18.0						
e4 (DR)	0.667	0.311	7.6						
e4 (RA)	0.194	0.845	20.7						
PM	0.613	-0.600	-9.2		-9.2				
PE	0.354	0.788	0.6		0.6				
Bias1	0.416	0.753	12.2		12.2				
Bias2	0.154	1.088	5.7	5.7					
Channel offset				115					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: P. R

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	90 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	0.05	0.05	0.3	0.2	1.5	1.5	9	6	11.02	*Not tested*
e2	0.02	0.1	0.1	0.5	0.6	3	3	15	15.60	*Not tested*
e3	0	1.7	3	2.2	0	51	90	66	122.71	*Tested*
e4	0	1.8	9.118463954	2.5	0	54	273.5539186	75	288.74	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	0.1	3	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	122.71
e4	288.74
Bias2	6.20

	NTU (psi)
e1	11.02
e2	15.60
e3	0.00
e4	0.00
PM	3.00
PE	1.50
Bias1	12.60

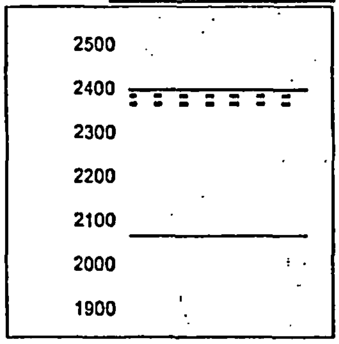
Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

Analytical Limit =	2396 psi
Channel Uncertainty =	333.1 psi
Margin =	0 psi
Trip Setpoint =	2062.9 psi
COT =	319.9 psi
nCOT =	32.0 psi
COT/nCOT =	10.00

Method 2 AV: AL - (nCOT + Margin) = 2364.0 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 2382.8 psi [Ref. 7.3 of RP]

Number of iterations:	10000
AV Calculation Method:	2
Simulation AV =	2364.0
Number of exceedances =	
Percentage of exceedances =	0.00%
Number of false calls =	182
Percentage of false calls =	1.82%



Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.334	0.133	0.1		-5.7	1744.1	1746.9	0	0
e1 (M&TE)	0.236	1.475	1.1						
e1 (DR)	0.368	-1.408	-6.5						
e1 (RA)	0.518	-0.157	-0.5						
e2 (EE)	0.322	-1.403	-0.4		-5.4				
e2 (M&TE)	0.441	0.545	0.8						
e2 (DR)	0.558	-0.911	-1.4						
e2 (RA)	0.590	-0.580	-4.4						
e3 (EE)	0.165	-1.178	0.0	-75.2	0.0				
e3 (M&TE)	0.643	-1.489	-38.7						
e3 (DR)	0.495	0.481	22.1						
e3 (RA)	0.816	-1.084	-36.5						
e4 (EE)	0.014	-0.168	0.0	-338.9	0.0				
e4 (M&TE)	0.741	-2.912	-80.2						
e4 (DR)	0.017	-2.314	-323.0						
e4 (RA)	0.400	1.681	84.3						
PM	0.378	1.320	2.0		2.0				
PE	0.947	-0.453	-0.3		-0.3				
Bias1	0.592	0.861	12.3		12.3				
Bias2	0.091	0.554	5.3	5.3					
Channel offset				90					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: P. R[signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi	
TSP Offset:	90 psi	
Margin:	0 psi	
Span:	3000 psi	(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	0.05	0.05	0.3	0.2	1.5	1.5	9	6	11.02	*Not tested*
e2	0.02	0.1	0.1	0.5	0.6	3	3	15	15.60	*Not tested*
e3	0	1.7	3	2.2	0	51	90	66	122.71	*Tested*
e4	0	1.8	9.118463954	2.5	0	54	273.5539186	75	288.74	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

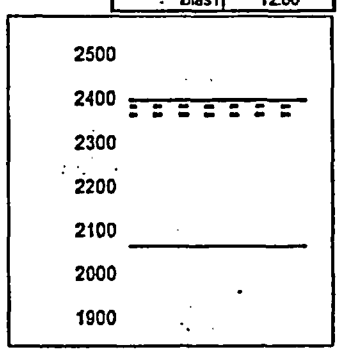
	(%)	(psi)	
PM	0.1	3	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	122.71
e4	288.74
Bias2	6.20

	NTU (psi)
e1	11.02
e2	15.60
e3	0.00
e4	0.00
PM	3.00
PE	1.50
Bias1	12.60

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

Analytical Limit =	2396 psi		
Channel Uncertainty =	333.1 psi		
Margin =	0 psi		
Trip Setpoint =	2062.9 psi		
COT =	319.9 psi		
nCOT =	32.0 psi		
COT/nCOT =	10.00		
Method 2 AV:	AL - (nCOT + Margin) =	2364.0 psi	[Ref. 7.3 of RP]
Method 3 AV:	TSP + COT =	2382.8 psi	[Ref. 7.3 of RP]
Number of Iterations:	10000		
AV Calculation Method:	3		
Simulation AV =	2382.8		
Number of exceedances =	25		
Percentage of exceedances =	0.25%		
Number of false calls =	42		
Percentage of false calls =	0.42%		



Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.261	0.747	0.6		2.9	2089.0	2103.4	0	0
e1 (M&TE)	0.175	1.460	1.1						
e1 (DR)	0.665	0.674	3.1						
e1 (RA)	0.884	-0.601	-1.8						
e2 (EE)	0.018	0.391	0.1		-0.2				
e2 (M&TE)	0.772	-2.816	-4.3						
e2 (DR)	0.864	-0.080	-0.1						
e2 (RA)	0.274	0.534	4.1						
e3 (EE)	0.817	-0.574	0.0	3.2	0.0				
e3 (M&TE)	0.571	-0.275	-7.2						
e3 (DR)	0.560	-1.031	-47.3						
e3 (RA)	0.454	0.309	10.4						
e4 (EE)	0.893	0.263	0.0	-72.2	0.0				
e4 (M&TE)	0.843	-0.397	-11.0						
e4 (DR)	0.906	-0.372	-51.9						
e4 (RA)	0.592	-0.244	-9.3						
PM	0.425	-0.853	-1.3		-1.3				
PE	0.363	0.991	0.8		0.8				
Bias1	0.852	0.516	12.2		12.2				
Bias2	0.067	0.230	5.1	5.1					
Channel offset				90					

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2398 psi	
TSP Offset:	180 psi	
Margin:	0 psi	
Span:	3000 psi	(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	0.05	0.05	0.3	0.2	1.5	1.5	9	6	11.02	*Not tested*
e2	0.02	0.1	0.1	0.5	0.6	3	3	15	15.60	*Not tested*
e3	0	1.7	3	2.2	0	51	90	66	122.71	*Tested*
e4	0	1.8	9.118463954	2.5	0	54	273.5539186	75	288.74	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

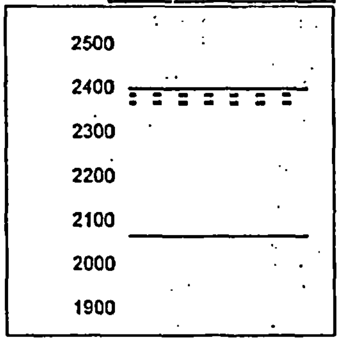
	(%)	(psi)	
PM	0.1	3	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	122.71
e4	288.74
Bias2	6.20

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	NTU (psi)
e1	11.02
e2	15.60
e3	0.00
e4	0.00
PM	3.00
PE	1.50
Bias1	12.60

Analytical Limit =	2398 psi		
Channel Uncertainty =	333.1 psi		
Margin =	0 psi		
Trip Setpoint =	2062.9 psi		
COT =	319.9 psi		
nCOT =	32.0 psi		
COT/nCOT =	10.00		
Method 2 AV:	AL - (nCOT + Margin) =	2364.0 psi	[Ref. 7.3 of RP]
Method 3 AV:	TSP + COT =	2382.8 psi	[Ref. 7.3 of RP]



Number of iterations:	10000
AV Calculation Method:	2
Simulation AV =	2364.0
Number of exceedances =	1
Percentage of exceedances =	0.01%
Number of false calls =	402
Percentage of false calls =	4.02%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.391	1.143	0.9		6.3	2125.4	2147.7	0	0
e1 (M&TE)	0.093	0.756	0.6						
e1 (DR)	0.651	0.571	2.6						
e1 (RA)	0.144	0.729	2.2						
e2 (EE)	0.244	-0.946	-0.3		5.4				
e2 (M&TE)	0.345	1.387	2.1						
e2 (DR)	0.783	-0.427	-0.7						
e2 (RA)	0.354	0.554	4.2						
e3 (EE)	0.978	0.189	0.0	5.6	0.0				
e3 (M&TE)	0.069	0.088	2.3						
e3 (DR)	0.821	-0.621	-28.5						
e3 (RA)	0.475	0.098	3.3						
e4 (EE)	0.051	0.808	0.0	-127.8	0.0				
e4 (M&TE)	0.804	-2.302	-63.4						
e4 (DR)	0.883	-0.369	-51.4						
e4 (RA)	0.618	-0.337	-12.9						
PM	0.680	-0.411	-0.6		-0.6				
PE	0.672	-0.776	-0.6		-0.6				
Bias1	0.766	-0.427	11.9		11.9				
Bias2	0.650	-0.591	4.6	4.6					
Channel offset				180					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: P. Re

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	180 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	0.05	0.05	0.3	0.2	1.5	1.5	9	6	11.02	*Not tested*
e2	0.02	0.1	0.1	0.5	0.6	3	3	15	15.60	*Not tested*
e3	0	1.7	3	2.2	0	51	90	66	122.71	*Tested*
e4	0	1.8	9.118463954	2.5	0	54	273.5539186	75	288.74	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	0.1	3	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	122.71
e4	288.74
Bias2	6.20

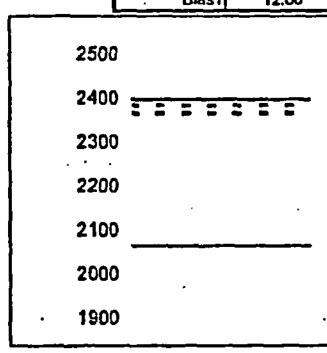
Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	6 psi

	NTU (psi)
e1	11.02
e2	15.60
e3	0.00
e4	0.00
PM	3.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	333.1 psi
Margin =	0 psi
Trip Setpoint =	2062.9 psi
COT =	319.9 psi
nCOT =	32.0 psi
COT/nCOT =	10.00

Method 2 AV: AL - (nCOT + Margin) = 2364.0 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 2382.8 psi [Ref. 7.3 of RP]



Number of Iterations:	10000
AV Calculation Method:	3
Simulation AV =	2382.8
Number of exceedances =	59
Percentage of exceedances =	0.59%
Number of false calls =	90
Percentage of false calls =	0.90%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.529	-0.082	-0.1		-4.2	2308.2	2317.8	0	0
e1 (M&TE)	0.738	-1.125	-0.9						
e1 (DR)	0.776	-0.266	-1.2						
e1 (RA)	0.689	-0.660	-2.0						
e2 (EE)	0.836	-0.098	0.0		0.2				
e2 (M&TE)	0.724	-0.590	-0.9						
e2 (DR)	0.480	-1.151	-1.8						
e2 (RA)	0.449	0.381	2.9						
e3 (EE)	0.605	0.220	0.0	-10.7	0.0				
e3 (M&TE)	0.785	-0.978	-25.5						
e3 (DR)	0.054	-2.379	-109.3						
e3 (RA)	0.471	0.438	14.7						
e4 (EE)	0.332	-1.481	0.0	70.9	0.0				
e4 (M&TE)	0.510	-0.090	-2.5						
e4 (DR)	0.195	0.030	4.1						
e4 (RA)	0.247	1.809	69.2						
PM	0.511	0.400	0.6		0.6				
PE	0.194	1.088	0.8		0.8				
Bias1	0.869	0.459	12.1		12.1				
Bias2	0.084	0.267	6.2	6.2					
Channel offset				180					

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	270 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	0.05	0.05	0.3	0.2	1.5	1.5	9	6	11.02	*Not tested*
e2	0.02	0.1	0.1	0.5	0.6	3	3	15	15.60	*Not tested*
e3	0	1.7	3	2.2	0	51	90	66	122.71	*Tested*
e4	0	1.8	9.110463954	2.5	0	54	273.5539186	75	288.74	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

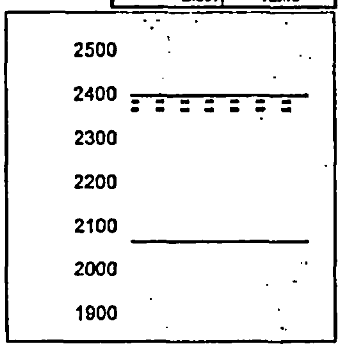
	(%)	(psi)	
PM	0.1	3	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	TU (psi)
e3	122.71
e4	288.74
Bias2	6.20

	NTU (psi)
e1	11.02
e2	15.60
e3	0.00
e4	0.00
PM	3.00
PE	1.50
Bias1	12.00

Analytical Limit =	2396 psi		
Channel Uncertainty =	333.1 psi		
Margin =	0 psi		
Trip Setpoint =	2062.9 psi		
COT =	319.9 psi		
nCOT =	32.0 psi		
COT/nCOT =	10.00		
Method 2 AV:	AL - (nCOT + Margin) =	2364.0 psi	[Ref. 7.3 of RP]
Method 3 AV:	TSP + COT =	2382.8 psi	[Ref. 7.3 of RP]
Number of iterations:	10000		
AV Calculation Method:	2		
Simulation AV =	2364.0		
Number of exceedances =			
Percentage of exceedances =	0.00%		
Number of false calls =	527		
Percentage of false calls =	5.27%		



Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.585	-0.201	-0.2		3.0	2340.7	2355.2	0	0
e1 (M&TE)	0.281	1.016	0.8						
e1 (DR)	0.084	-0.857	-3.9						
e1 (RA)	0.313	2.058	6.3						
e2 (EE)	0.776	-0.216	-0.1		-1.0				
e2 (M&TE)	0.299	0.679	1.0						
e2 (DR)	0.360	1.329	2.0						
e2 (RA)	0.940	-0.525	-4.0						
e3 (EE)	0.418	1.155	0.0	-80.6	0.0				
e3 (M&TE)	0.080	0.639	16.6						
e3 (DR)	0.012	0.693	31.8						
e3 (RA)	0.788	-2.887	-97.2						
e4 (EE)	0.284	1.395	0.0	83.4	0.0				
e4 (M&TE)	0.079	0.754	20.8						
e4 (DR)	0.732	0.242	33.8						
e4 (RA)	0.200	0.753	28.8						
PM	0.935	0.244	0.4		0.4				
PE	0.865	-0.275	-0.2		-0.2				
Bias1	0.552	1.084	12.3		12.3				
Bias2	0.017	0.115	5.1	5.1					
Channel offset				270					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	270 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	0.05	0.05	0.3	0.2	1.5	1.5	9	6	11.02	*Not tested*
e2	0.02	0.1	0.1	0.5	0.6	3	3	15	15.60	*Not tested*
e3	0	1.7	3	2.2	0	51	90	66	122.71	*Tested*
e4	0	1.8	9.118463954	2.5	0	54	273.5539186	75	288.74	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

	(%)	(psi)	
PM	0.1	3	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

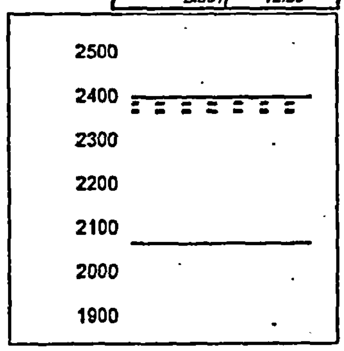
	TU (psi)
e3	122.71
e4	288.74
Bias2	6.20

	NTU (psi)
e1	11.02
e2	15.60
e3	0.00
e4	0.00
PM	3.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	333.1 psi
Margin =	0 psi
Trip Setpoint =	2062.9 psi
COT =	319.9 psi
nCOT =	32.0 psi
COT/nCOT =	10.00

Method 2 AV: AL - (nCOT + Margin) = 2364.0 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 2382.8 psi [Ref. 7.3 of RP]



Number of iterations:	10000
AV Calculation Method:	3
Simulation AV =	2382.8
Number of exceedances =	68
Percentage of exceedances =	0.68%
Number of false calls =	102
Percentage of false calls =	1.02%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.143	-0.425	-0.3		-0.8	2283.9	2286.8	0	0
e1 (M&TE)	0.285	1.927	1.5						
e1 (DR)	0.939	-0.246	-1.1						
e1 (RA)	0.629	-0.258	-0.8						
e2 (EE)	0.646	0.305	0.1		-6.8				
e2 (M&TE)	0.803	-0.884	-1.4						
e2 (DR)	0.766	0.013	0.0						
e2 (RA)	0.753	-0.730	-5.6						
e3 (EE)	0.904	-0.432	0.0	-6.7	0.0				
e3 (M&TE)	0.545	-0.126	-3.3						
e3 (DR)	0.780	-0.697	-32.0						
e3 (RA)	0.523	-0.101	-3.4						
e4 (EE)	0.325	-0.967	0.0	-47.0	0.0				
e4 (M&TE)	0.362	1.145	31.6						
e4 (DR)	0.425	-0.209	-29.1						
e4 (RA)	0.725	-1.292	-49.4						
PM	0.295	-1.273	-1.9		-1.9				
PE	0.402	0.904	0.7		0.7				
Bias1	0.674	-0.747	11.8		11.8				
Bias2	0.591	-0.482	4.7	4.7					
Channel offset				270					

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2398 psi	
TSP Offset:	300 psi	
Margin:	0 psi	
Span:	3000 psi	(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				*Module Uncertainties (psi)*					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	0.05	0.05	0.3	0.2	1.5	1.5	9	6	11.02	*Not tested*
e2	0.02	0.1	0.1	0.5	0.6	3	3	15	15.60	*Not tested*
e3	0	1.7	3	2.2	0	51	90	66	122.71	*Tested*
e4	0	1.8	9.118463954	2.5	0	54	273.5539186	75	288.74	*Tested*
	Environ. Effects	*Measure and Test*	*Drift*	*Reference Accuracy*	*Not Tested*	*Tested*	*Tested*	*Tested*		

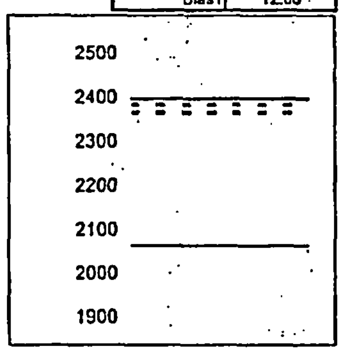
	(%)	(psi)	
PM	0.1	3	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

	TU (psi)
e3	122.71
e4	288.74
Bias2	6.20

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	NTU (psi)
e1	11.02
e2	15.60
e3	0.00
e4	0.00
PM	3.00
PE	1.50
Bias1	12.60

Analytical Limit =	2398 psi			
Channel Uncertainty =	333.1 psi			
Margin =	0 psi			
Trip Setpoint =	2062.9 psi			
COT =	319.9 psi			
nCOT =	32.0 psi			
COT/nCOT =	10.00			
Method 2 AV:	AL - (nCOT + Margin) =	2364.0 psi	[Ref. 7.3 of RP]	
Method 3 AV:	TSP + COT =	2382.8 psi	[Ref. 7.3 of RP]	
Number of iterations:	10000			
AV Calculation Method:	2			
Simulation AV =	2364.0			
Number of exceedances =	4			
Percentage of exceedances =	0.04%			
Number of false calls =	532			
Percentage of false calls =	5.32%			



Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.044	-2.406	-1.8		4.6	2403.8	2404.9	0	0
e1 (M&TE)	0.455	0.692	0.5						
e1 (DR)	0.164	1.763	8.1						
e1 (RA)	0.939	-0.711	-2.2						
e2 (EE)	0.008	1.168	0.4		-13.4				
e2 (M&TE)	0.812	-2.862	-4.4						
e2 (DR)	0.328	0.625	1.0						
e2 (RA)	0.819	-1.358	-10.4						
e3 (EE)	0.722	0.805	0.0	8.2	0.0				
e3 (M&TE)	0.010	0.049	1.3						
e3 (DR)	0.400	1.339	61.5						
e3 (RA)	0.024	0.205	6.9						
e4 (EE)	0.247	-0.606	0.0	27.5	0.0				
e4 (M&TE)	0.309	1.559	43.0						
e4 (DR)	0.880	0.028	3.9						
e4 (RA)	0.759	-0.506	-19.3						
PM	0.497	-0.694	-1.1		-1.1				
PE	0.650	-0.958	-0.7		-0.7				
Bias1	0.549	-0.983	11.7		11.7				
Bias2	0.421	0.523	5.3	5.3					
Channel offset				300					

Calculation 0140-0403-PJR-01
Revision 2

Prepared By: [signature]

Checked By: [signature]

Setpoint Simulation

Analytical Limit:	2396 psi
TSP Offset:	300 psi
Margin:	0 psi
Span:	3000 psi

(Uncertainties are % of total span.)

Uncertainties for Instrument Channel Modules (at 95% probability)

	Module Uncertainties (%)				Module Uncertainties (psi)					
	EE	M&TE	DR	RA	EE	M&TE	DR	RA	Total (psi)	
e1	0.05	0.05	0.3	0.2	1.5	1.5	9	6	11.02	*Not tested*
e2	0.02	0.1	0.1	0.5	0.6	3	3	15	15.60	*Not tested*
e3	0	1.7	3	2.2	0	51	90	66	122.71	*Tested*
e4	0	1.8	9.118463954	2.5	0	54	273.5539188	75	288.74	*Tested*
	Environ. Effects	Measure and Test	Drift	Reference Accuracy	*Not Tested*	*Tested*	*Tested*	*Tested*		

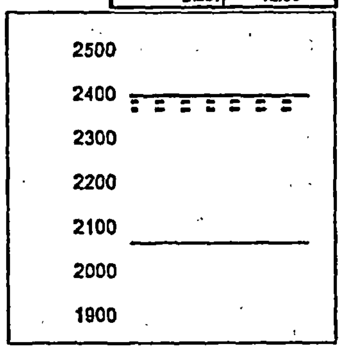
	(%)	(psi)	
PM	0.1	3	*Process measurement - Not tested*
PE	0.05	1.5	*Primary element - Not tested*
Bias1	0.02	0.6	*Positive bias of instrument channel - Not tested*
Bias2	0.04	1.2	*Positive bias of instrument channel - Tested*

Magnitude of Instrument Channel Bias	
Bias1	12 psi
Bias2 (offset)	5 psi

	TU (psi)
e3	122.71
e4	288.74
Bias2	6.20

	NTU (psi)
e1	11.02
e2	15.60
e3	0.00
e4	0.00
PM	3.00
PE	1.50
Bias1	12.60

Analytical Limit =	2396 psi
Channel Uncertainty =	333.1 psi
Margin =	0 psi
Trip Setpoint =	2062.9 psi
COT =	319.9 psi
nCOT =	32.0 psi
COT/nCOT =	10.00



Method 2 AV: AL - (nCOT + Margin) = 2364.0 psi [Ref. 7.3 of RP]

Method 3 AV: TSP + COT = 2382.8 psi [Ref. 7.3 of RP]

Number of Iterations:	10000
AV Calculation Method:	3
Simulation AV =	2382.8
Number of exceedances =	82
Percentage of exceedances =	0.82%
Number of false calls =	110
Percentage of false calls =	1.10%

Uncertainty Term	Random Number	Normal Deviate, Z	Uncertainties (psi)	Observed Error (psi)	nCOT Error (psi)	Observed TSP (psi)	Actual TSP (psi)	Criterion 1 (false call)	Criterion 2 (exceed)
e1 (EE)	0.924	0.363	0.3		8.0	2321.6	2341.2	0	0
e1 (M&TE)	0.067	0.163	0.1						
e1 (DR)	0.275	1.091	5.0						
e1 (RA)	0.131	1.180	3.6						
e2 (EE)	0.159	-1.865	-0.6		-1.9				
e2 (M&TE)	0.462	0.450	0.7						
e2 (DR)	0.440	-1.281	-2.0						
e2 (RA)	0.501	-0.009	-0.1						
e3 (EE)	0.647	-0.424	0.0	45.4	0.0				
e3 (M&TE)	0.325	0.832	21.6						
e3 (DR)	0.756	-0.247	-11.3						
e3 (RA)	0.304	0.706	23.6						
e4 (EE)	0.772	0.656	0.0	-92.0	0.0				
e4 (M&TE)	0.067	0.293	8.1						
e4 (DR)	0.776	-0.711	-99.3						
e4 (RA)	0.505	-0.021	-0.8						
PM	0.881	0.412	0.6		0.6				
PE	0.903	-0.290	-0.2		-0.2				
Bias1	0.793	0.463	12.1		12.1				
Bias2	0.131	0.500	6.3	5.3					
Channel offset				300					

MPR

MPR Associates, Inc.
320 King Street
Alexandria, VA 22314

Calculation No.	Prepared By	Checked By	Page: B-1
0140-0403-PJR-01			Revision: 2

B
Simulation Macro

File name: Setpoint simulation – Revision 1 final.xls
File date: November 28, 2004
Software: Microsoft Excel 2002
Macro name: MonteCarlo

```
Sub MonteCarlo()
'
' MonteCarlo Macro
' Macro recorded 11/15/2004 by Phil Rush
'
  Dim Icount, Crit1, Crit2, K, c1, c2, Method As Long
  Dim Result As Single
'
  Crit1 = Crit2 = 0
  Icount = Worksheets("Uncertainties").Cells(42, 3)
  For K = 1 To Icount
    Calculate
    c1 = Worksheets("Uncertainties").Cells(51, 9)
    c2 = Worksheets("Uncertainties").Cells(51, 10)
    If c1 = 1 Then Crit1 = Crit1 + 1
    If c2 = 1 Then Crit2 = Crit2 + 1
  Next K
  Worksheets("Uncertainties").Cells(45, 3) = Crit2
  Worksheets("Uncertainties").Cells(47, 3) = Crit1
  Calculate
  Result = Worksheets("Uncertainties").Cells(46, 3)
  Method = Worksheets("Uncertainties").Cells(43, 3)
  If Method = 2 Then
    Worksheets("Summary").Cells(17, 6).Value = Result
  Else
    Worksheets("Summary").Cells(19, 6).Value = Result
  End If
End Sub
```

MPR
ASSOCIATES INC.
ENGINEERS

December 14, 2004

Mr. Mike Schoppman
Nuclear Energy Institute
1776 I Street, N.W.
Suite 400
Washington, D.C. 20006-3708

Subject: Review of ISA Instrument Channel Setpoint Methods

Dear Mr. Schoppman:

At the request of NEI and EPRI, MPR independently reviewed ISA-RP67.04 Instrument Setpoint Methods to address NRC concerns with one of the methods (Method 3) currently used by many nuclear utilities. The NRC position is that Method 3 of the ISA Recommended Practices does not ensure that Plant Safely Limits are protected at a high level of assurance. Based on reviews of both the NRC and Industry positions in this matter and on independent calculations we performed, we conclude that ISA Method 3 provides adequate protection. The bases of our conclusion are provided in the enclosure.

Please call Phil Rush or me at (703) 519-0200 if you have any questions or comments.

Sincerely,

J. E. Nestell, Ph.D.

Enclosure:

"Instrument Channel Setpoint Determination Methods"

cc: G. Vine (EPRI)

MPR
ASSOCIATES INC.
ENGINEERS

Enclosure 1 to
MPR Letter Dated
December 14, 2004

Instrument Channel Setpoint Determination Methods

Introduction

Methods for establishing and monitoring instrument channel trip setpoints in nuclear power plants are specified in the Instrumentation, Systems and Automation Society of America (ISA) Standard ISA-S67.04, Reference 1. The Recommended Practice for the Standard, Reference 2, identifies three methods for establishing channel trip setpoints and the Allowable Value or limiting value for tests. In June 2004, the U.S. Nuclear Regulatory Commission (NRC) formally raised concerns with one of the ISA setpoint methods, Reference 3. The concerns focused on the Method 3 procedure for establishing the surveillance test Allowable Value. A mathematical evaluation of the methodology by the NRC appears to indicate that there are cases when an instrument channel could be tested and declared operable (test result does not exceed the Allowable Value), when, in fact, the channel is not operable. This case applies to plants following Standard Technical Specifications which assign the limiting safety system setpoint (LSSS) to the Allowable Value, thus making the Allowable Value the defacto operability limit for the instrument channel.

At the request of NEI and EPRI, MPR reviewed applicable correspondence and presentations by NRC and NEI regarding the ISA Method 3 issues. The results of that review, along with independent analysis work are summarized in this white paper.

Conclusions

Our independent analysis of the setpoint determination methods specified in the ISA Recommended Practices was pursued through a review of recent NEI and NRC positions on the subject, a review of the ISA Standard and Recommended Practices, and a review of several Standard Technical Specifications and their bases. We have also completed a Monte Carlo simulation to compare ISA Method 2 and Method 3 setpoint methods and the ability of surveillance tests to detect abnormal channel behavior before operability is impacted. Our conclusions are as follows:

1. Allowable Values determined using ISA Method 3 establish a conservative limit for safety-related instrument channel surveillance testing. The use of Method 3 provides high assurance that drifted instrument channel setpoints that could challenge plant safety limits will be identified in testing. Our assessment did not substantiate the NRC's position that Method 3 Allowable Values are nonconservative for surveillance test operability

determinations. The basis for the disagreement between the industry and the NRC appears to be an assumption in the NRC's analysis (see next paragraph).

2. An instrument channel trip setpoint measured during a surveillance test is a single measurement recorded on the first pass to the setpoint. Therefore, the difference between the measured setpoint and the nominal trip setpoint cannot be treated entirely as bias since it contains random errors that will change with each test. The NRC assumes that this difference is a bias. The bias in the system could be determined by recording multiple trip setpoint measurements to calculate the true setpoint. However, this practice is prohibited in surveillance testing to preclude channel "preconditioning."

3. A Monte Carlo simulation of a channel undergoing a single measured point surveillance test was developed and exercised by MPR. The model results support our conclusion that both Method 2 and Method 3 establish a conservative operability limit and that this conclusion holds under widely varying conditions regarding the breakdown of uncertainties evaluated during surveillance tests (COT to nCOT ratio). The conclusion is therefore robust.

4. The Monte Carlo evaluation indicates that the Method 2 Allowable Value approach is significantly more conservative than the Method 3 Allowable Value approach.

5. Although both Methods provide a high level of assurance that the Analytical Limit will be protected, the results indicate that the number of false calls (channel declared inoperable when it is operable) is larger when using Method 2 relative to Method 3.

6. The simulation results indicate that surveillance test conservatism is increased and the number of false calls is decreased when the number of instrument channel uncertainties addressed in testing is increased. This applies to both ISA methods discussed herein.

7. Most plant operators/technicians take action to recalibrate channel trip setpoints well before the Allowable Value is reached. This is because channel recalibration tolerance bands are often very tight compared to the Allowable Value computed from ISA RP67.04. This adds a further degree of conservatism for Method 3 plants, since recalibration prevents the actual trip setpoint from encroaching on the Allowable Value in the first place.

Overall, we consider ISA RP67.04 Method 3 to be an acceptable method for establishing channel Trip Setpoints and Allowable Values. The Method is conservative because it protects the Analytical Limit at a high assurance level. It also avoids some of the excessively conservative false calls associated with using Method 2.

We note that the number of instrument channel components evaluated in quarterly surveillance testing varies throughout the industry. We recommend that the NEI Setpoints Methods Task Force review industry practices with regard to the extent of the channel components tested in measurement surveillance tests and develop guidance to improve uniformity in test practices, both in the extent and frequency of testing. Our evaluation suggests that the usefulness of the testing is enhanced by testing more of the channel components, rather than less.

Finally, our review indicated an inconsistency in the requirements of ISA Standard ISA-S67.04. The issue involves an apparent requirement in the standard to obtain several readings during testing to determine the as found setpoint. As noted in 2 above, this is not permitted in surveillance testing to avoid preconditioning. The Setpoint Methods Task Force should revise the standard to appropriately reflect current industry practices.

Discussion

We have reviewed the NRC concerns regarding the use of ISA-RP67.04 Method 3 for establishing channel Trip Setpoints (TSPs) and Allowable Values (AVs), as well as the industry response (References 3, 4, and 5). It is apparent from the correspondence that the core issue centers on the level of protection provided by using the Method 3 procedure for determining the pass/fail criterion (i.e., AV) for instrument channel surveillance tests. Further, there appear to be differences between the NRC and industry positions regarding the safety significance of the AV, independent of how it is determined (Method 1, 2 or 3). For this discussion, the AV is defined as the limiting value that a trip setpoint may have when tested, beyond which actions must be taken.

As indicated by the NRC, a primary safety criterion for the operation of a nuclear power plant is that each channel trip setpoint must be set to protect the safety limits for the plant design (e.g., fuel clad temperature). Since the physical safety limit is never specifically determined in safety analyses, the Analytical Limit (AL) serves as a proxy for the safety limit. Thus, the TSP must be set far enough from the AL so that the uncertainties that affect the instrument channel will not result in a failure to actuate beyond the AL under any anticipated plant transient. If all channel uncertainties (calibration errors, instrument noise, biases, etc.) are known, then it is necessary by calculation to establish the TSP far enough from the AL to accommodate all of the uncertainties at some high assurance level (e.g., 0.95 probability at high confidence). This applies to both Method 2 and Method 3 in the ISA Standard, and is not in dispute. (Method 1 is more conservative than both of these methods.)

In Methods 2 and 3, the nominal TSP is determined from a calculation that considers all of the uncertainties associated with instrument channel components and processes. The variances for these uncertainties are combined to calculate the total channel uncertainty. Statistical factors are applied to the standard deviation of the uncertainty (i.e., square root of the variance) to calculate the total allowance between AL and the TSP at the appropriate level of assurance.

Differences between the NRC and industry positions regarding Method 3 emerge when considering the role of surveillance tests for verifying that the actual trip point will not differ unacceptably from the TSP. Tests are designed to test a portion of the uncertainties that affect channel components. The difference between ISA Methods 2 and 3 procedures for calculating the surveillance test pass/fail criterion (AV) involve how uncertainties that affect the surveillance test results (COT) and the uncertainties that are <u>not</u> interrogated (nCOT) are addressed.

To see the differences, we first define "COT" to mean the total uncertainty in the channel components and conditions on test determined at a high assurance level. In other words, changes in these uncertainties would directly affect the outcome of the test. Similarly, we define "nCOT" as the uncertainty estimate for the channel components and conditions not on test. This includes untested conditions such as seismic and accident conditions. Since the total channel uncertainty is simply the combination of all instrument channel uncertainties, it is easy to show that the total allowance between the TSP and AL is equal to the SRSS of COT and nCOT (assuming there are no bias terms in the system and no margin is added):

$$| AL-TSP |=\sqrt{COT^2+nCOT^2}$$

This is shown in Figure 1, and it applies to Method 2 and Method 3 procedures for calculating the nominal TSP.

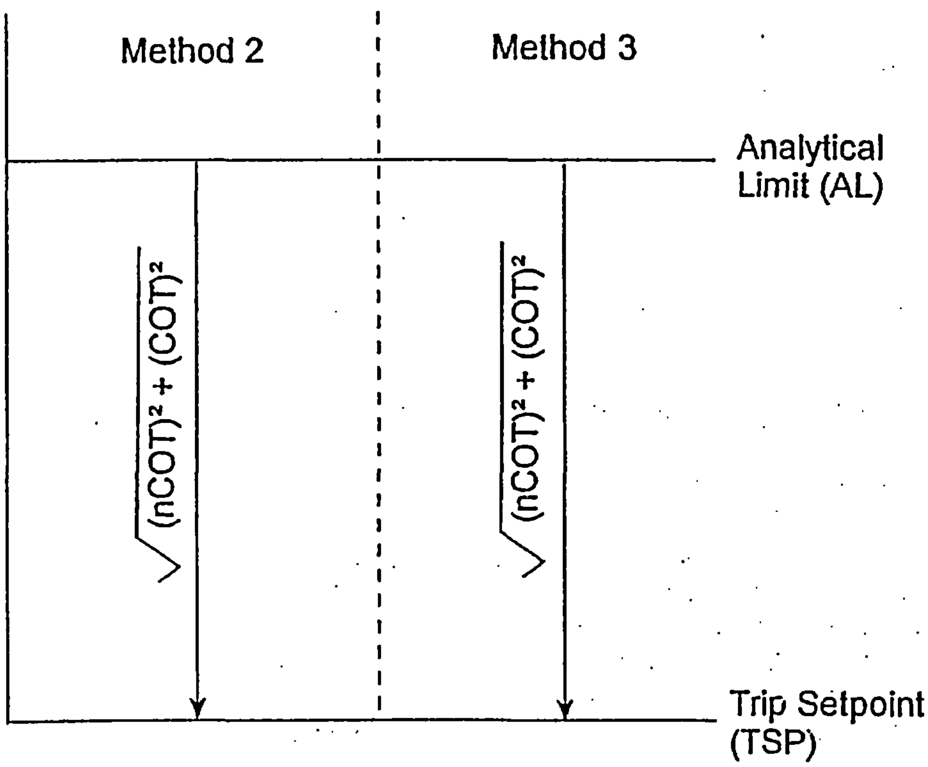


Figure 1. TSP for ISA Methods 2 and 3 Based on Total Allowance.

The departure between Methods 2 and 3 arises in how AV is calculated. In Method 2, which is not being disputed by the NRC, the AV is calculated by subtracting nCOT from AL. In Method 3, the AV is calculated by <u>adding</u> COT to the TSP. This is shown in Figure 2. Note that the Method 3 AV exceeds (or is closer to the AL than) the Method 2 AV. This is generally true, since, by the triangle inequality,

$$\sqrt{COT^2+nCOT^2} \leq COT+nCOT.$$

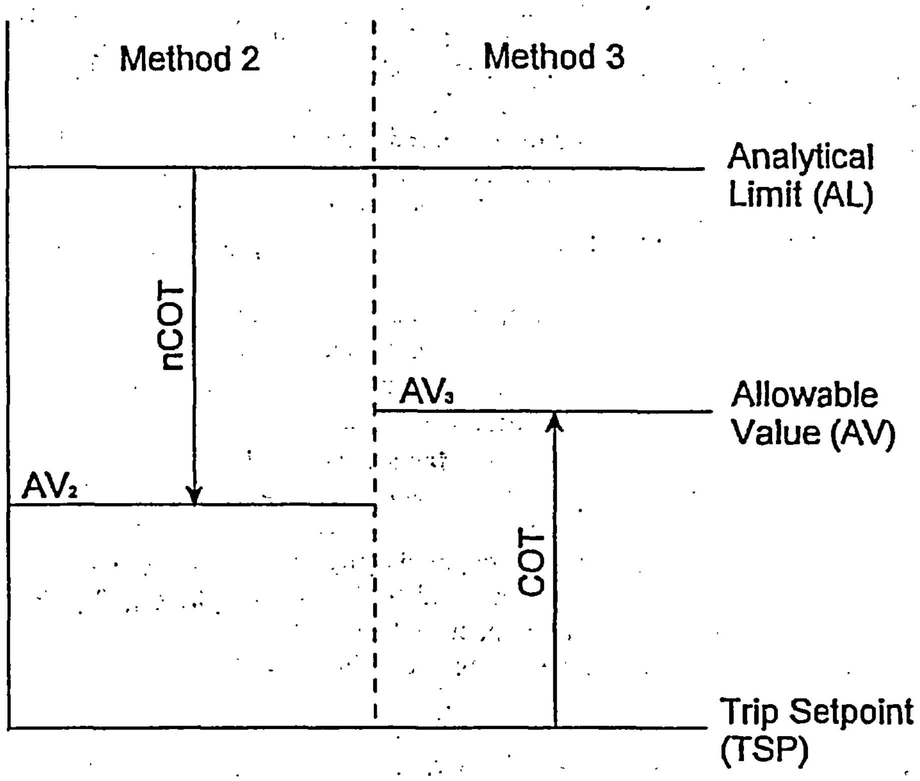


Figure 2. Position of Allowable Value Relative to Trip Setpoint and Analytical Limit

From Figure 2, it is apparent that Method 2 seems to protect the AL by establishing an exclusion boundary for the setpoint. The margin between the (drifted) setpoint and the AL is not permitted to decrease to a value that is less than that needed to compensate for the calculated uncertainties of the components and conditions that are not tested. A channel that has a trip setpoint that has drifted above the Method 2 AV level is effectively inoperable since it will no longer ensure that the AL is protected at a high level of assurance. This is true if the location of the setpoint (without nCOT) were known with a high degree of certainty. In addition, it would be possible to quantify the likelihood of exceeding AL since all COT terms are known.

The Method 3 Allowable Value is determined from the total uncertainty in the tested components and conditions which is added to the TSP. Since the COT uncertainty is a conservative estimate of the uncertainties that affect the test, exceedance of AV_3 would strongly indicate that the tested components and conditions are not behaving within the assumptions of the TSP calculation. This is consistent with the definition of Allowable Value in ISA-S67.04, and is a valid method for determining the <u>inoperability</u> of the components on test.

At first glance, it would appear that the Method 3 AV might be a poor indicator of the operability of the channel as a whole, since it does not account for the uncertainties and biases in the components and conditions <u>not</u> on test. A channel trip setpoint that has drifted to a value above AV_2 in Figure 2 is potentially inoperable, but how might surveillance testing detect this?

If the surveillance test measures the trip setpoint with little or no uncertainty, then the Method 3 AV is too close to AL; drifted setpoints between AV_2 and AV_3 would be called operable with Method 3 when they are potentially inoperable. The NRC position regarding Method 3 is based on the assumption that the trip setpoint is determined precisely through surveillance testing and the difference between the nominal TSP and the observed trip setpoint can be treated as a bias. The NRC staff is concerned that Method 3 is nonconservative for determining channel operability when the setpoint drifts above AV_2. If the assumption were valid, we would agree with the NRC's mathematical argument.

The ISA Standard defines the "as found" condition of the instrument channel as the measured trip setpoint during the first pass through the setpoint in the surveillance test. This requirement prevents preconditioning of the channel during the test, and averaging cannot be performed for determining the test result. The as found condition is compared to the Allowable Value and other administrative limits, such as recalibration tolerance bands. It is a single measurement and contains random uncertainties associated with the measurement and test equipment, components and conditions on test. It cannot be treated entirely as a bias, and it is not clear how this uncertainty might affect operability calls for the channel using Method 2 and Method 3 Allowable Values. It might be suspected that the number of inoperability calls (as found condition exceeds Allowable Value) might go up, since random uncertainties would sometimes push the measured setpoint value beyond the Allowable Value when the magnitude of the setpoint drift is low.

To investigate the effect of setpoint measurement precision on channel operability calls during measurement surveillance tests, a Monte Carlo model was developed and exercised for an instrument channel similar to an example included in ISA RP67.04. A calculation documenting this simulation analysis is attached, and it was used to demonstrate the effect of using ISA Methods 2 and 3 Allowable Values as the instrument channel operability limit. The analyses calculate the percentage of instances where an instrument channel appears to be operable based on surveillance testing when the actual trip setpoint would be above the Analytical Limit if the channel were called upon to actuate. The model is built on the assumption that the surveillance test is a single point measurement that contains COT uncertainties. The model considers a wide range of components on test (COT/nCOT ratio) from 0.1 (limited testing) to 10 (extensive testing). Setpoint drift associated with the tested components was allowed to range from the value used for calculating the TSP up to values that shifted the setpoint near AV_3.

The results from 11 different simulations are summarized in Table 1. The two columns on the right side of the table indicate the percentage of iterations where a channel was declared operable and the actual trip setpoint was greater than the Analytical Limit. The results indicate that Allowable Values established using either ISA Method 2 or 3 will ensure that there is a high probability of identifying an inoperable instrument channel that would fail to actuate below the Analytical Limit.

Table 1. Summary of Simulation Results

Analysis Case No.	COT/nCOT	Trip Setpoint (psi)	Allowable Value (psi)		TSP Offset (psi)	Exceedances of AL with Observed TSP < AV	
			Method 2	Method 3		Method 2	Method 3
1	0.1	1911.2	1919.2	1958.9	4.5	1.1%	2.5%
2					9	0.7%	2.4%
3					22.5	0.3%	2.4%
4					43	0.1%	1.6%
5	1.0	2208.9	2267.6	2337.3	48	0.3%	3.4%
6					96	0.3%	4.7%
7					115	0.2%	4.7%
8	10	2062.9	2364.0	2382.8	90	0.0%	0.2%
9					180	0.0%	0.6%
10					270	0.0%	0.7%
11					300	0.0%	0.8%

Table 2 lists the false call rates for the eleven simulation cases. The results indicate that Method 2 Allowable Values are an inefficient indicator of overall channel operability when the ratio of the uncertainties that are evaluated in the surveillance test (COT) to the uncertainties that are not included in the surveillance test (nCOT) is low. The simulation results indicate that the use of Method 2 would lead to an instrument channel being falsely called inoperable over 50% of the time when the ratio of COT to nCOT is equal to 0.1.

Table 2. Comparison of False Call Rates

Analysis Case No.	COT/nCOT	False Call Rate	
		Method 2	Method 3
1	0.1	51.3%	3.3%
2		59.9%	5.1%
3		78.8%	16.4%
4		93.1%	48.7%
5	1.0	39.5%	6.2%
6		58.6%	17.9%
7		60.9%	24.2%
8	10	1.8%	0.4%
9		4.0%	0.9%
10		5.3%	1.0%
11		5.3%	1.1%

The simulation results demonstrate that the use of either Method 2 or 3 will adequately protect the AL. The conservatism afforded in using ISA Method 2 to establish the AV is approximately one order of magnitude higher than using Method 3, but the tradeoff for this benefit is an increase in the number of incorrect inoperability calls. In addition, we note that the use of the Allowable Value as the operability criterion is most effective when most of the instrument channel uncertainties are evaluated in surveillance testing.

Safety channel operability is monitored and maintained both through periodic, measurement-based surveillance testing and recalibration. The Analytical Limit is protected by the trip setpoint, not the Allowable Value, and the setpoint drift is, in practice, kept small by a tight recalibration tolerance band. Because of this and our Monte Carlo simulation results, we have no concern that the use of ISA Method 3 for establishing the Allowable Value for surveillance tests leads to a generic safety concern.

References

1. ANSI/ISA-S67.04-Part I-1994, "Setpoints for Nuclear Safety-Related Instrumentation," Instrument Society of America, August 24, 1995.

2. ISA-S67.04, Part II, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation," International Society for Measurement and Control, September 1994.

3. Enclosure to letter from L. Marsh (NRC) to A. Marion dated June 17, 2004, "Problem Statement on the Use of Instrumentation, Systems, and Automation Society (ISA) Standard ISA 67.04 Part II, 'Methodology for the Determination of Setpoints for Nuclear Safety-Related Instrumentation,' Method 3."

4. Presentation by P. Rebstock (NRC) from June 23, 2004, meeting between NRC and NEI, "Setpoint Allowable Values for Instrument Channels in Safety-Related Service."

5. NEI White Paper, "ISA S67.04 Methods for Determining Trip Setpoints and Allowable Values for Safety-Related Instrumentation," December 2003.