Entergy

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Fred Dacimo
Site Vice President
Administration

February 03, 2005

Re: Indian Point Unit 3
Docket No. 50-286
NL-05-014

Document Control Desk
U.S. Nuclear Regulatory Commission
Mail Stop O-P1-17
Washington, DC 20555-0001

Subject: **Supporting Information for License Amendment Request Regarding Indian Point Unit 3 Stretch Power Uprate (TAC MC 3552)**

Reference.

1. Entergy letter NL-04-069 to NRC, "Proposed Change to Technical Specifications: Stretch Power Uprate (4.85%) and Adoption of TSTF-339", dated June 3, 2004.

2. Entergy letter NL-04-145 to NRC, "Supporting Information for License Amendment Request Regarding Indian Point 3 Stretch Power Uprate (TAC MC 3552)", dated November 18, 2004

Dear Sir:

Entergy Nuclear Operations, Inc (Entergy) is submitting additional information to support NRC review of the Stretch Power Uprate (SPU) license amendment (Reference 1) for Indian Point 3 (IP3). This information is being provided as discussed with the staff during teleconferences on January 14, 25 and February 1, 2005.

Attachment 1 provides the information regarding Hot Leg Switchover (HLSO) time; Attachment 2 provides the response to NRC RSB Additional RAI on LOC-4 ; and Attachment 3 provides Entergy's response to NRC Request for Description of IP3 Compliance with 10CFR50.68.

Attachment 4 provides Entergy's partial response to the NRCs request for clarifications and supporting information regarding Reactor Vessel Internals resulting from the teleconference on January 27, 2005.

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Attachments 5 and 6 contain errata pages based on revised fluence values addressed in Attachment 4 for the Stretch Power Uprate Licensing Report transmitted in the original IPEC-Unit 3 License Amendment Request dated June 3, 2004. (Reference 1). Attachment 5 pages are for the proprietary version (WCAP-16212-P) and Attachment 6 pages are for the non-proprietary version (WCAP-16212- NP). Since there is no proprietary information on any of these pages, an application for withholding is not required for these replacement pages.

Attachment 7 contains additional pages for OPDT/OTDT and Tave calculation to complete the calculation file sent in our November 18, 2004 submittal letter (Reference 2). Included in this submittal are IP3-CALC-RPC-00290 Revision 3, pages 40 to 53 of 56; and Attachment pages 11 and 13 of 13. IP3-CALC-ESS-00281, Revision 2 pages 37 to 41 of 52.

Based on the Staff's request during teleconference on February 1, 2005, Entergy is specifically requesting NRC approval of the Accident Analysis assumption pertaining to auxiliary feedwater operation for the Loss-of-Normal-Feedwater (LONF) event and the Loss of All AC Power to Station Auxilairies (LOAC) event. (See WCAP-16212-P, Section 6.3.1, 6.3.7 and 6.3.8. Attachment 8 provides Indian Point Piping Vibration (PV) Plan Logic Diagrams with Examples.

The additional supporting information provided in this letter does not alter the conclusions of the no significant hazards evaluation that supports the subject license amendment requests. There are no new commitments being made in this submittal. If you have any questions or require additional information, please contact Mr. Patric Conroy at (914) 734-6668.

I declare under penalty of perjury that the foregoing is true and correct. Executed on 02/03/05.

Sincerely,

Fred R. Dacimo
Site Vice President
Indian Point Energy Center

Attachment 1: Response to NRC Question regarding Hot Leg Switchover (HLSO) time from January 14, 2005 Teleconference

Attachment 2: Response to NRC RSB Additional RAI on LOC-4 from January 14, 2005 Teleconference

Attachment 3: Response to NRC Request for Description of IP3 Compliance with 10CFR50.68

Attachment 4: Partial Response to NRC request for clarifications and supporting information regarding Reactor Vessel Internals resulting from teleconference on January 27, 2005.

Attachment 5: Errata Pages for WCAP-16212-P Indian Point Nuclear Generating Unit 3 Stretch Power Uprate NSSS and BOP Licensing Report, June 3, 2004 Submittal. (Proprietary version)

Attachment 6: Errata Pages for WCAP-16212-NP Indian Point Nuclear Generating Unit 3 Stretch Power Uprate NSSS and BOP Licensing Report, June 3, 2004 Submittal (Non-proprietary version)

Attachment 7: OPDT/OTDT and TAve Calculation Pages

Attachment 8: Indian Point Piping Vibration (PV) Plan Logic Diagrams with Examples

cc: next page

cc: Mr. Patrick D. Milano, Senior Project Manager
Project Directorate I
Division of Licensing Project Management
U.S. Nuclear Regulatory Commission

Mr. Samuel J. Collins
Regional Administrator, Region 1
U.S. Nuclear Regulatory Commission

Resident Inspector's Office
Indian Point Unit 3
U.S. Nuclear Regulatory Commission

Mr. Peter R. Smith, President
New York State Energy, Research
and Development Authority

Mr. Paul Eddy
New York State Dept. of Public Service

ATTACHMENT 1 TO NL-05-014

Response to NRC Question regarding Hot Leg Switchover (HLSO) time from January 14, 2005 Teleconference

(1 Page)

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

Hot Leg Switchover (HLSO) Time

NRC Request:
Confirm that ECCS flows are sufficient to match core boil off rates for the earliest time at which Hot Leg Switchover (HLSO) will be initiated.

Entergy Response for IP3:
Nuclear Safety Advisory Letter NSAL-04-1 addressed concerns related to the time at which HLSO should be initiated relative to the calculated HLSO time and also addressed the need to evaluate the adequacy of core injection flow if earlier HLSO times are implemented in EOPs.

The maximum HLSO time in post-LOCA calculations is based on boric acid precipitation potential and is then checked to ensure that adequate flow is available at that HLSO time. The EOPs are written to instruct operators to initiate HLSO at the specified HLSO time, and it is recognized that the HLSO realignment process requires a finite amount of time. The acceptability of this approach is based on the nature of the HLSO calculations and the conservatism in the methodology used to calculate HLSO time. Most significant is the 4% uncertainty margin applied to the boric acid saturation limit of 27.53 weight percent (at atmospheric pressure). This 4% reduction in the boric acid saturation limit typically translates to a margin of more than 2 hours between the recommended HLSO time and the time at which boric acid precipitation may potentially occur.

The EOP-designated HLSO times are interpreted as the beginning of the hot leg recirculation realignment process. This is consistent with the definition of ERG footnote V.01 (Time for transferring to hot leg recirculation). For the reasons described above, there is sufficient margin in the HLSO calculations such that the realignment can be completed before the potential for boric acid precipitation exists.

Entergy has evaluated the earliest time at which preparations for HLSO actions after a postulated LOCA can start. This early time of 4 hours is based on radiological dose considerations. IP3 procedures will allow activities to prepare for HLSO to start at 4 hours, but specifically state that HLSO is to "commence" at 6.5 hours.

Nevertheless Entergy evaluated an early 4 hour switchover to hot leg recirculation for Indian Point Unit 3. Breaks in both the cold leg and hot leg were considered. For ECCS injection lines on the leg with the assumed break (e. g., hot leg or cold leg), ECCS spillage was conservatively calculated and considered. Decay heat was based on the Appendix K required decay heat standard (1971 ANS, infinite operation, with 20% uncertainty). No SI subcooling was assumed. Both active and passive failures were considered.

The calculated core boil-off at 4.0 hours after the postulated LOCA is 285 gpm. For a cold leg break and the limiting single active failure, the available ECCS flow after realignment to hot leg recirculation is 477.6 gpm. For a hot leg break and the limiting single active failure, the available ECCS flow is 345.5 gpm. For the limiting single passive failure, the evaluation credited LHSI consistent with the actions specified in the EOPs. The available low head ECCS flow for the limiting single passive failure is 751 gpm with one line spilling. Thus, for either hot leg or cold leg breaks, the available ECCS flow is well in excess of the calculated core boil-off at 4.0 hours after the postulated LOCA.

In summary, a HLSO "window" of 4.0 - 6.5 hours is confirmed acceptable for Indian Point Unit 3.

ATTACHMENT 2 TO NL-05-014

Response to NRC RSB Additional RAI on LOC-4 from January 14, 2005 Teleconference

(1 Page)

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

Response to NRC RSB Additional RAI on LOC-4

NRC Request:
For the IP3 Response to LOC-4, the equivalent analysis for IP2 goes out to 1600 seconds. The plots for IP3 only go to 600 seconds. Please provide explanation / justification to conclude that IP3 performance beyond 600 seconds would be consistent with IP2.

Entergy Response:
It is reasonable to conclude the IP3 performance beyond 600 seconds will be consistent with that of IP2 because at 600 seconds both plants exhibit the following trends:

- Rod cladding surface temperature is stable, decreasing and approaching the saturation level.
- Downcomer collapsed level is stable and the effects of downcomer boiling have clearly been mitigated.
- Core collapsed liquid levels are steady.
- Liquid pool is established and maintained in the upper plenum above the core plate and below the hot leg bottom.
- Loss of inventory through the break is replenished by a steady safety injection flow as evidenced by the increasing reactor vessel mass.

For IP2 these trends are sustained beyond 600 seconds, as demonstrated by the reported extended transient.

With respect to long-term core quench behavior, IP2 and IP3 are plants with very similar features. They are both 4-loop Westinghouse designed PWRs with the same number of fuel assemblies, same power level, and similar peaking factors. Their ECCS systems and containments are sufficiently similar that it is reasonable to conclude that the long term performance will be consistent for the two plants. It is further noted that there are no safety system related differences between the two units that would significantly affect their expected long term performance.

Therefore, the post-600 seconds stable quench behavior predicted for IP2 will also apply to this IP3 analysis.

ATTACHMENT 3 TO NL-05-014

Response to NRC Request for Description of IP3 Compliance with 10CFR50.68

(3 Pages)

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

NRC Request:
Need description of how IP3 meets 10CFR50.68

Entergy Response:
Compliance with each of the requirements of 10CFR50.68 is discussed below.

10CFR50.68(b)(1) Requirement:
Plant procedures shall prohibit the handling and storage at any one time of more fuel assemblies than have been determined to be safely subcritical under the most adverse moderation conditions feasible by unborated water.

Compliance:
All fresh fuel assemblies must meet the Fresh Fuel Storage Rack criticality requirement that all fresh fuel above 4.5 w/0 must contain a minimum number of Integral Fuel Burnable Absorber's (IFBAs). Standard Operating Procedure SOP-RP-6, New Fuel Removal from Shipping Container and Inspection, currently permits only one new fuel assembly to be in transit between the associated shipping cask and dry storage rack. This is stated in the Precautions and Limitations section of the procedure.

10CFR50.68(b)(2) Requirement:
The estimated ratio of neutron production to neutron absorption and leakage (k-effective) of the fresh fuel in the fresh fuel storage racks shall be calculated assuming the racks are loaded with fuel of the maximum fuel assembly reactivity and flooded with unborated water and must not exceed 0.95, at a 95 percent probability, 95 percent confidence level. This evaluation need not be performed if administrative controls and/or design features prevent such flooding or if fresh fuel storage racks are not used.

Compliance:
The new fuel storage facility is used to receive and store new fuel in a dry condition upon arrival on site and prior to loading in the reactor. The new fuel storage racks are designed to store new fuel in a geometric array that precludes criticality. A criticality analysis was done to demonstrate that k-effective is maintained less than or equal to 0.95 when the new fuel racks are fully loaded and dry or flooded with moderator in the event of a design basis fuel handling accident. This analysis was reviewed and approved by the NRC (NRC letter to NYPA, "Issuance of Amendment for Indian Point Nuclear Generating Unit No. 3 (TAC NO. M96474)", dated April 15, 1997).

10CFR50.68(b)(3) Requirement:
If optimum moderation of fresh fuel in the fresh fuel storage racks occurs when the racks are assumed to be loaded with fuel of the maximum fuel assembly reactivity and filled with low-density hydrogenous fluid, the k-effective corresponding to this optimum moderation must not exceed 0.98, at a 95 percent probability, 95 percent confidence level. This evaluation need not be performed if administrative controls and/or design features prevent such moderation or if fresh fuel storage racks are not used.

Compliance:
Technical Specification 4.3.1.2.b assures compliance with the requirement of 10CFR50.68(b)(3): "The new fuel storage racks are designed and shall be maintained with: k-effective </= 0.95 under all possible moderation conditions (Credit may be taken for burnable integral neutron absorbers)."

10CFR50.68(b)(4) Requirement:
If no credit for soluble boron is taken, the k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with unborated water. If credit is taken for soluble boron, the k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with borated water, and the k-effective must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated water.

Compliance:
Technical Specification 4.3.1.1.b assures compliance with the requirement of 10CFR50.68(b)(4): "The spent fuel storage racks are designed and shall be maintained with: k-effective </= 0.95 if assemblies are inserted in accordance with Technical Specification 3.7.16, Spent Fuel Assembly Storage."

10CFR50.68(b)(5) Requirement:
The quantity of SNM, other than nuclear fuel stored onsite, is less than the quantity necessary for a critical mass.

Compliance:
The total amount of non-fuel SNM on site is such that it meets the "forms not sufficient to form a critical mass" guidance in Section 1.1 of Regulatory Guide (RG) 10.3 and the total amount of non-fuel SNM is significantly less than the quantities delineated in 10 CFR 70.24(a).

10CFR50.68(b)(6) Requirement:
Radiation monitors are provided in storage and associated handling areas when fuel is present to detect excessive radiation levels and to initiate appropriate safety actions.

Compliance:
Area radiation monitor channel R-5 monitors radiation levels in the Fuel Storage Building. This provides warning that water in the spent fuel pool is highly contaminated, that fuel is being improperly handled, or that the pool level is dangerously low for prevailing conditions. High radiation alarms are displayed on the main annunciator, the radiation monitoring cabinets, and at the detector location. In the alarm condition, the supply air tempering units trip if running, the exhaust fan operates to maintain negative pressure in Fuel Storage Building, the face dampers to the charcoal filter will open if closed, the Fuel Storage Building rolling door closes and the air is applied to the door seals. The bypass dampers around the charcoal filters must be manually closed if open.

10CFR50.68(b)(7) Requirement:
The maximum nominal U-235 enrichment of the fresh fuel assemblies is limited to five (5.0) percent by weight.

Compliance:
Technical Specification 4.2.1 restricts the enrichment of reload fuel to no more than 5.0 weight percent U-235.

10CFR50.68(b)(8) Requirement:
The FSAR is amended no later than the next update which §50.71(e) of this part requires, indicating that the licensee has chosen to comply with §50.68(b).

Compliance:
The UFSAR Section 9.5 will be updated following the next refueling outage to state that IP3 has chosen to comply with 10CFR50.68(b).

ATTACHMENT 4 TO NL-05-014

Partial Response to NRC RAI Regarding Reactor Vessel Internals from January 27, 2005 Teleconference

(1 Pages)

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

Partial Response to NRC RAI Regarding Reactor Vessel Internals from January 27, 2005 Teleconference

<u>NRC RAI Request #1</u> (Ref; NL-04-156 dated 12/15/04)
Validate fluence values provided in Table 5.1-3, specifically fluence value should be 0.922 x 10^{19} n/cm2) Additionally confirm if other data relies on the fluence data in table 5.1-3

<u>Response to Request #1:</u>
Westinghouse provided, during the teleconference on 1/27/05, assurance that the fluence value was not used in other tables. The revised Table 5.1-3 and page 5.1-5 are provided in Attachments 5 and 6 to this response.

ATTACHMENT 6 TO NL-05-014

ERRATA PAGES FOR WCAP-16212-NP
INDIAN POINT NUCLEAR GENERATING UNIT 3
STRETCH POWER UPRATE NSSS AND BOP LICENSING REPORT

(Non-proprietary version)

Revised Table 5.1-3 and page 5.1-5

(2 Pages)

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

Table 5.1-3

RT_{PTS} Calculations for IP3 Beltline Region Materials at 27.1 EFPY with (3216 MWt) SPU Fluences

Material	Fluence (10^{19} n/cm^2, E>1.0 MeV)	FF	CF (°F)	ΔRT_{PTS} (1) (°F)	Margin (°F)	$RT_{NDT(U)}$ (2) (°F)	RT_{PTS} (3) (°F)
Intermediate Shell Plate B2802-1	0.922	0.977	137	133.8	34	5	173
Intermediate Shell Plate B2802-2	0.922	0.977	152	148.5	34	-4	179
Intermediate Shell Plate B2802-3	0.922	0.977	136	132.9	34	17	184
Lower Shell Plate B2803-1	0.922	0.977	128	125.1	34	49	208
Lower Shell Plate B2803-2	0.922	0.977	150	146.6	34	-5	176
Lower Shell Plate B2803-3	0.922	0.977	160	156.3	34	74	264
→ Using S/C Data	0.922	0.977	170.9	167.0	17 (4)	74	**258**
Intermediate and Lower Shell Weld Longitudinal Weld Seams (heat 34B009)	0.922	0.977	**224**	218.8	65.5	-56	228
Intermediate to Lower Shell Circumferential weld Seams (heat 13253)	0.922	0.977	**189**	184.7	56	-54	187

Notes:

1. ΔRT_{PTS} = CF * FF
2. Initial RT_{NDT} values are measured values except for the intermediate and lower longitudinal welds.
3. $RT_{PTS} = RT_{NDT(U)} + \Delta RT_{PTS}$ + Margin (°F)
4. Using credible surveillance data.

power level of 3216 MW through 27.1 EFPYs (EOL) for IP3 as shown in Table 5.1-3. The change in RT_{PTS} due to the SPU, as compared to the MUR Program to 3068 MWt, is 1°F. This evaluation also determined that the limiting material is relatively close to the PTS screening criteria of 270°F and is expected to exceed this screening criteria at ~36 EFPY.

5.1.2.5 Upper Shelf Energy

All beltline materials have a USE greater than 50 ft-lb through 27.1 EFPY (EOL) as required by the Code of Federal Regulations (CFR) 10CFR50, Appendix G (Reference 6). The 27.1 EFPY (EOL) USE was predicted using the EOL 1/4 thickness (1/4t) SPU fluence projections that correspond to a SPU power level of 3216 MWt. Despite the fact that the vessel fluence projections have increase due to the SPU, as compared to the MUR Program to 3068 MWt, the change in USE decrease is zero. The USE values are presented in Table 5.1-5.

5.1.2.6 Inlet Temperature

RG 1.99, Revision 2 (Reference 7), which is also the basis for 10CFR50.61 (Reference 5), states that "The procedures are valid for a nominal irradiation temperature of 550°F. Irradiation below 525°F should be considered to produce greater embrittlement, and irradiation above 590°F may be considered to produce less embrittlement." The temperature range of 525°F to 590°F serves as the basis of the equations and tables that are used in all the RV internal analyses described herein. Therefore, the inlet temperature, which is the temperature to which the reactor vessel is subjected, must be maintained within this range to uphold all existing analyses.

5.1.2.7 Conclusions

The fluence projections used for the SPU, while considering actual power distributions incorporated to date, have increased versus the fluence projections developed for the MUR Program (to 3068 MWt). However, this increase has had minimal affect on the analyses of record for reactor vessel integrity since the PTS and USE remain within the acceptance criteria, the PTS curves had less than I EFPY decrease, the ERG category remains unchanged, and there were only minor withdrawal time changes to the withdrawal schedule. The regulatory criteria continue to be met for the SPU conditions. Therefore, there is no significant effect on RV integrity related to the SPU.

ATTACHMENT 7 TO NL-05-014

OPDT/OTDT and Tave Calculation Pages

(21 Pages)

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

10.0 DETERMINE ALLOWABLE VALUE (AV)

The Allowable Value (AV) can be calculated from the following equation; (Refs. 3.1.3 & 3.2.1)

$$AV = TS \pm CU_{CAL}$$

Where,

TS = Trip Setpoint

CU_{CAL} = Channel Uncertainty (CU) as seen during calibration. Therefore, uncertainties due to a harsh environment, process measurement, or primary element are not considered. For conservatism, only RA, DR and ALT uncertainties are considered. The following use AFT and $e_{n\,CAL}$ interchangeably. CU_{CAL} is based on;

$$CU_{CAL} = \pm\sqrt{e_1 CAL^2 + e_2 CAL^2 \ldots}$$

Where;

$$e_{nCAL} = \pm\sqrt{RA_1^2 + DR_1^2 + ALT_1^2}$$

The AV will be calculated using the SRSS method consistent with the method used for the determination of the trip setpoint. Therefore, a check calculation is not required. (Ref. 3.1.3)

10.1 Determine e_{cal}

10.1.1 Determine AFT_1 (Ref. 3.2.17)

As defined above CU_{CAL} only considers the normal uncertainties as seen during calibration, therefore, the module uncertainty equation e_1 reduces to;

$$AFT_1 = \pm\sqrt{RA_1^2 + DR_1^2 + ALT_1^2 + SH_1^2}$$

The e_1 effects for RA, DR and ALT are substituted in the above equation.

$$AFT_1 = \pm\sqrt{0.03^2 + 0.045^2 + 0.07^2 + 0.0015^2}$$

$$AFT_1 = \pm 0.089\ \%\ of\ Span$$

The calibrated span for e_1 is 30-700°F, therefore;

$$AFT_1 = (\pm 0.089\ \%) * (670°F)$$

$$AFT_1 = \pm 0.592\ °F$$

Converting "°F" to "% of ΔT Span", given ΔT = 75°F;

$$AFT_1 = \pm\frac{0.592}{75} * (100) = \pm 0.790\ \%\ of\ \Delta T\ Span$$

Similarly for modules e_2, e_3, e_4, e_5 and e_6, the uncertainty associated with the module calibration is;

10.1.2 Determine AFT_2,

$$AFT_2 = \pm\sqrt{0.5^2 + 0.41^2 + 0.5^2}$$ (Ref. 3.2.17)

$$AFT_2 = \pm 0.817\ \%\ of\ Span$$

e_2 Calibration Span = 120°F

$$AFT_2 = (\pm 0.817\,\%) * (120\,°F)$$

$$AFT_2 = \pm 0.980°F$$

Converting "°F" to "% of ΔT Span", given ΔT = 75°F;

$$AFT_2 = \pm \frac{0.980}{75} * (100) = \pm 1.307\%\ of\ \Delta T\ Span$$

10.1.3 Determine AFT_3 (Refs. 3.2.17 & 3.5.13)

The only microprocessor test requirements are for a software check. Therefore there is no As-Found Tolerance.

Therefore,

$AFT_3 = 0$

10.1.4 Determine AFT_4,

$$AFT_4 = \pm\sqrt{0.5^2 + 0.25^2 + 0.5^2}$$ (Ref. 3.2.17)

$$AFT_4 = \pm 0.75\,\%\ of\ Span$$

e_4 Calibration Span = 120°F

$$AFT_4 = (\pm 0.75\,\%) * (120\,°F)$$

$$AFT_4 = \pm 0.90\,°F$$

Converting "°F" to "% of ΔT Span", given ΔT = 75°F;

$$AFT_4 = \pm \frac{0.90}{75} * (100) = \pm 1.20\,\%\ of\ \Delta T\ Span$$

10.1.5 Determine AFT_5

$$AFT_5 = \pm\sqrt{0.2^2 + 0.65^2 + 0.5^2}\ (8/5)$$ (Sect. 7.7)

$$AFT_5 = 1.350\,\%\ of\ Span$$

e_5 Calibration Span = 75°F

$$AFT_5 = (1.350\,\%) * (75\,°F)$$

$$AFT_5 = \pm 1.013\,°F$$

Converting "°F" to "% of ΔT Span" given ΔT = 75°F,

$$AFT_5 = \pm \frac{01.013}{75} * (100) = \pm 1.350\%\ of\ \Delta T\ Span$$

10.1.6 Determine AFT_6

$$AFT_6 = \pm\sqrt{0.2^2 + 0.65^2 + 0.63^2}\ (8/5)$$ (Sect. 7.7)

$$AFT_6 = \pm 1.483\,\%$$

e_6 Calibration Span = 75°F

$$AFT_6 = (\pm 1.483\,\%) * (75\,°F)$$

$$AFT_6 = \pm 1.112\,°F$$

Converting "°F" to "% of ΔT Span", given ΔT = 75°F;

$$AFT_6 = \pm \frac{1.112}{75} * (100) = \pm 1.483\% \text{ of } \Delta T \text{ Span}$$

10.1.7 Determine AFT_P

$$AFT_P = \pm\sqrt{1.6^2 + 0.5^2} + 0.3 \text{ (Drift Bias)} \qquad \text{(Sect. 7.8)}$$

$$AFT_P = \pm 1.676\,\%, +0.3 \text{ of Span}$$

e_p Process Span = 800 PSI

$$AFT_P = \pm (1.676\,\%) * (800) + (0.3\%) * (800)$$

$$AFT_P = \pm 13.408 \text{ P.S.I.}, +2.4 \text{ P.S.I.}$$

10.1.8 Determine AFT_7

The uncertainty for e_7 is a "lumped" term given as 1.5% Power. For purposes of determining an AFT value, we will consider only 1.0% as sensible during calibration. Therefore, AFT will be taken as the following:

AFT = [1.5*54/75]*4.0*1.2

$$AFT_7 = \pm 5.184\,\% \text{ of } \Delta T \text{ Span} \qquad \text{(Sect. 7.9)}$$

10.1.9 Determine AFT_8

$$AFT_8 = \pm\sqrt{0.5^2 + 0.5^2} \qquad \text{(Sect. 7.10)}$$

$$AFT_8 = \pm 0.707\,\% \text{ Power}$$

$$AFT_8 = [0.707 * 54/75] * 4.0 * 1.2$$

$$AFT_8 = \pm 2.443\% \text{ of } \Delta T \text{ Span}$$

10.1.10 Determine AFT_9

$$AFT_9 = \pm\sqrt{0.8^2 + 0.8^2} \qquad \text{(Sect. 7.11)}$$

$$AFT_9 = \pm 1.131\,\% \text{ Power}$$

$$AFT_9 = [1.131 * 54/75] * 4.0 * 1.2$$

$AFT_9 = \pm$ 3.910% of ΔT Span

10.1.11 Determine AFT_{10}

$$AFT_{10} = \pm\sqrt{0.866^2 + 0.5^2} \qquad \text{(Sect. 7.12)}$$

$$AFT_{10} = \pm 1.0\,\% \text{ of } \Delta T \text{ Span}$$

10.1.12 Determine AFT_{11}

$$AFT_{11}=\pm\sqrt{0.866^2+0.5^2} \quad \text{(Sect. 7.13)}$$

$$AFT_{11}=\pm 1.0\,\%\ of\ \Delta\ T\ \ Span$$

10.1.13 Determine AFT_{12}

$$AFT_{12}=\pm\sqrt{0.5^2+0.2^2+0.5^2} \quad \text{(Sect. 7.14)}$$

$$AFT_{12}=\pm 0.735\,\%\ of\ \Delta\ T\ Span$$

10.1.14 Determine AFT_{13}

$$AFT_{13}=\pm\sqrt{0.5^2+0.2^2+0.5^2} \quad \text{(Sect. 7.14)}$$

$$AFT_{13}=\pm 0.735\%\ of\ \Delta\ T\ \ Span$$

10.2 Determine CU_{CAL} for OPΔT

Given the above CU_{CAL} definition, the channel uncertainty equation for OPΔT from Section 7.17 reduces to;

$$CU_{CAL}=\pm\sqrt{AFT_1^2+AFT_2^2+AFT_3^2+AFT_4^2+AFT_5^2+AFT_6^2+AFT_{10}^2+AFT_{12}^2}\ \ (OP\Delta T)$$

10.2.1 Since CU_{CAL} is a function of the T_{HOT} and T_{COLD} parameters of ΔT, the T, CU_{THOT}, CU_{TCOLD} and CU_{Tavg} equations must be calculated for the calibration portion of the loop. Therefore, solving for T_{CAL};

$$T_{CAL}=\pm\frac{\sqrt{3(AFT_1^2+AFT_2^2)}}{3}$$

$$T_{CAL}=\ \pm\frac{\sqrt{3(0.790^2+1.307^2)}}{3}$$

$$T_{CAL}=\pm 0.881\,\%\ of\ \Delta\ T\ \ Span$$

10.2.2 Solving for CU_{THOT} calibration;

$$CU_{THOT}(CAL)=\pm\sqrt{T_{CAL}^2+AFT_3^2+AFT_4^2}$$

$$CU_{THOT}(CAL)=\pm\sqrt{0.881^2+0.0^2+1.20^2}$$

$$CU_{THOT}(CAL)=\pm 1.488\,\%\ of\ \Delta\ T\ \ Span$$

10.2.3 Solving for CU_{TCOLD} calibration;

$$CU_{TCOLD}(CAL)=\pm\sqrt{T_{CAL}^2\ +AFT_2^2+AFT_4^2}$$

$$CU_{TCOLD}(CAL)=\pm\sqrt{0.881^2+1.307^2+1.20^2}$$

$$CU_{TCOLD}(CAL)=\pm 1.981\%\ of\ \Delta\ T\ \ Span$$

10.2.4 Solving for CU_{Tavg} calibration;

$$CU_{TAVG}(CAL)=\pm\frac{\sqrt{CU^2_{THOT}(CAL)+CU^2_{TCOLD}(CAL)}}{2}$$

$$CU_{TAVG}(CAL)=\pm\frac{\sqrt{1.488^2+1.981^2}}{2}$$

$$CU_{TAVG}(CAL)=\pm 1.238\ \%\ of\ \Delta\ T\ \ Span$$

10.2.5 Solving for CU ΔT calibration ($CU_{\Delta TCAL}$);

$$CU\ \Delta T\,(CAL)\pm\sqrt{CU^2_{THOT}(CAL)+CU^2_{TCOLD}(CAL)}$$

$$CU_{\Delta T(CAL)}=\pm\sqrt{1.488^2+1.981^2}$$

$$CU_{\Delta T(CAL)}=\pm 2.477\ \%\ of\ \Delta\ T\ \ Span$$

10.2.6 The term above $[\,AFT_1^2+AFT_2^2+AFT_3^2+AFT_4^2\,]$ represents the total Calibration Uncertainties of T_{avg} and ΔT circuits. Therefore, this term can be replaced with; $[\,CU^2_{TAVG}(CAL)+CU^2_{\Delta T}(CAL)\,]$.

$CU_{CAL(OP\Delta T)}$ = +/- $\{[CU_{tavg}(Cal)*K_6]^2 + CU^2_{\Delta T}(CAL) + AFT^2_5 + AFT^2_{10} + AFT^2_{12}\}^{1/2}$

$CU_{CAL\ (OP\Delta T)}$ = +/-$\{[1.238*0.0015]^2 + 2.477^2 + 1.350^2 + 1.483^2 + 1.0^2 + 0.735^2\}^{1/2}$

$CU_{CAL\ (OP\Delta T)}$ = $\pm\sqrt{(1.238*0.0015)+2.477^2+1.350^2+1.483^2+1.00^2+0.735^2}$

CU cal $_{(OP\Delta T)}$ = +/- 3.348% of ΔT Span

10.3 Determine CU_{CAL} for OTΔT

Given the above CU_{CAL} definition, the Channel Uncertainty equation for OTΔT from Section 7.18 reduces to;

$$CU_{CAL}=\pm\sqrt{AFT_1^2+AFT_2^2+AFT_3^2+AFT_4^2+AFT_5^2+AFT_6^2+(\,AFT_P*K_3\,)^2+AFT_7^2+AFT_8^2+AFT_9^2+AFT_{11}^2+AFT_{13}^2}\,(OT\Delta T)$$

Since $|\,AFT^2_1 + AFT^2_2 + AFT^2_3 + AFT^2_4| = |CU^2_{tavg}(CAL) + CU^2_{DELTAT}(CAL)|$

$$CU\ CAL(OT\ddot{A}T)=\pm\sqrt{[CU_{tavg}(CAL)*K_1]^2+CU^2_{\Delta T}(CAL)+AFT_5^2+AFT_6^2+(\,AFT_P*K_3\,)^2+AFT_7^2+AFT_8^2+AFT_9^2+AFT_{11}^2+AFT_{13}^2}$$

CU CAL (OTDT) = $\pm$ $[(1.238*0.022) + 2.477^2 + 1.350^2 + 1.483^2 + (13.408*0.0007)^2 + 5.184^2 + 2.443^2 + 3.910^2 + 1.0^2 + 0.735^2]^{1/2}$ + 2.4*0.0007

$CU_{CAL(OT\Delta T)} = \pm\ 7.736\ \%\ of\ \Delta T\ Span$

10.4 OPΔT Allowable Value (AV) Calculation

Calculating for OPΔT (K_4) Allowable Value (AV)

Given,

TS	=	1.0807	(Sect. 9.1)
$CU_{CAL\ (OP\Delta T)}$	=	±3.348% of ΔT Span	

Using the conversion 1.3888, from Section 7.9.1

$CU_{CAL\,(OP\Delta T)}$ = (±3.348%) * (1.3888)

$CU_{CAL\,(OP\Delta T)}$ = ±4.649% Power

The magnitude of CU_{CAL} is combined with the Trip Setpoint in an appropriate direction to determine AV for an increasing signal.

Therefore,

AV = TS - CU_{CAL}

AV = 1.0807 + 0.04649

AV = 1.127 (OPΔT)

Therefore the allowance for uncertainties between AL and AV is:

1.164 – 1.127 = 0.037 (OPΔT)

10.5 OTΔT Allowable Value (AV) Calculation

Calculating for OTΔT (K_1) Allowable Value (AV)

Given, TS = 1.42 - 0.1795

TS = 1.241 (Sect. 9.2)

$CU_{CAL\,(OT\Delta T)}$ = ±7.736% of ΔT Span

Converting "% of ΔT Span" to a value based on 138.88% full power

$CU_{CAL\,(OT\Delta T)}$ = (±7.736%) * (1.3888)

$CU_{CAL\,(OT\Delta T)}$ = ±10.74% Power

The magnitude of CU_{CAL} is combined with the Trip Setpoint in an appropriate direction to determine AV for an increasing signal. Therefore,

AV = 1.241 + 0.1074

AV = 1.348 (OTΔT)

Therefore the allowance for uncertainties between AL and AV is:

1.42 – 1.35 = 0.07 (OTΔT)

Note: The NRC Staff position regarding AV is currently uncertain. The Staff has generalized that the application of ISA Method 3 may not be a conservative approach for determining AV. Therefore, the following evaluation is included to document an ultra conservative ISA Method 2 AV.

This evaluation will combine all uncertainties except RA, DR and ALT (shown bolded) to determine a channel uncertainty value U_{total} which will be added or subtracted, as appropriate, from the AL to determine an AV which will be closer to the Trip Setpoint as shown below.

10.6 AV Evaluation using method 2 variation for U_n

The Allowable value will be calculated by the following;

10.6.1 **Determine U_1, for module e_1:**

Where: Bias = 0

$e_1 = \pm(0.03^2 + 0.045^2 + 0.0 + 0.0 + 0.0 + 0.03^2 + 0.07^2 + 0.0015^2)^{½}$

$U_1 = \pm0.03\%$ for the RTD (Cold Leg and Hot Leg) calibrated span is 30 – 700°F

$U_1 = \pm[(0.03\%)(670°F) = 0.20°F$ for the RTD (Cold Leg and Hot Leg) calibrated span

Converting "°F" to "% of ΔT Span", given ΔT = 75°F;

$U_1 = \pm (0.20°F / 75°F) * (100)$

$U_1 = \pm$ 0.268% of ΔT Span

10.6.2 **Determine U_2 for module e_2:**

Where: Bias = 0

$e_2 = \pm(0.5^2 + 0.41^2 + 0.27^2 + 0.25^2 + 0.11^2 + 0.50^2)^{½} \pm 0$

$U_2 = \pm0.38\%$ of span

Given the R/E calibrated span is bounded by 520°F to 640°F (or 120°F) U_2 effect in terms of "°F " is,

$U_2 = \pm(0.38\%)(120°F) = 0.177°F$

Converting "°F" to "% of ΔT Span", given ΔT = 75°F;

$U_2 = \pm(0.177°F / 75°F) *(100)$

$U_2 = \pm$ 0.236% of ΔT Span

10.6.3 **Determine U_3, for module e_3:**

Where: Bias = 0

$e_3 = \pm(0.10^2 + 0.50^2)^{½} \pm 0$

$U_3 = \pm0.50\%$ of span

Given that the R/E calibrated span is 520°F to 640°F (or 120°F), U_3 effect in terms of "°F" is,
$U_3 = (120°F)\ (0.50\%) = \pm0.600°F$

Converting "°F" to "% of ΔT Span", given ΔT = 75°F;

$U_3 = \pm(0.600°F / 75°F) *(100)$

$U_3 = \pm$ 0.800% of ΔT Span

10.6.4 **Determine U_4 for the module e_4:**

Where: Bias = 0

$e_4 = \pm(0.5^2 + 0.25 + 0.243^2 + 0.50^2 + 0.11^2 + 0.50^2)^{½} \pm 0$

$U_4 = \pm 0.57\%$ of span

Given that the E/I calibrated span is 520°F to 640°F (or 120°F), U_4 effect in terms of "°F" is,
$U_4 = \pm(0.57\%)(120°F)$

$U_4 = \pm 0.68°F$

Converting "°F" to "% of ΔT Span", given ΔT = 75°F;

$U_4 = \pm(0.680°F / 75°F) *(100)$

$U_4 = \pm$ 0.907% of ΔT Span

10.6.5 **Determine U_5, for the module e_5:**

Where: Bias = 0

$e_5 = \pm(0.20^2 + 0.65^2 + 0.30^2 + 0.50^2 + 0.12^2 + 0.50^2)^{½} \pm 0$

$U_5 = \pm 0.595\%$

Because of the input to output relationship discussed above, we will also multiply this uncertainty by 8/5 to account for the gain effect. Therefore:

$U_5 = \pm.95\%$ of span

Given the dynamic compensator (Cold Leg and Hot Leg) calibrated span is 540 to 615°F or 75°F, U_5 effect in terms of "°F" is, (ref. 3.5.4)

$U_5 = \pm(0.95\%)(75°F)$

$U_5 = \pm.714°F$

10.6.6 **Determine U_6, for the module e_6:**

Where: Bias = 0

$e_6 = \pm(0.20^2 + 0.65^2 + 0.302^2 + 0.50^2 + 0.122^2 + 0.63^2)^{½} \pm 0$

$U_6 = \pm.597\%$ of span

Because of the input to output relationship discussed above, we will also multiply this uncertainty by 8/5 to account for the gain effect. Therefore:

$U_6 = \pm.95\%$ of span

Given the bistable (Cold Leg and Hot Leg) calibrated span is 540°F to 615°F or 75°F, U_6 effect in terms of "°F" is, (ref.3.5.4)
$U_6 = \pm(0.95\%)(75°F)$

$U_6 = \pm.716°F$

10.6.7 **Determine U_7, for the module e_7:**

Where: Bias = 0

$e_7 = \pm 5.184\%$ of ΔT span

For this module it is considered conservative to use a value of 100% of e_7 to determine U_7.

$U_7 = \pm 5.184\%$ of ΔT span

10.6.8 **Determine U_8, for the module e_8:**

Where: Bias = 0

$e_8 = \pm(0.50^2 + 0.04^2 + 0.50^2)^{½} \pm 0$

$U_8 = \pm 0.04\%$ of full span power

Using the full power range span, f (ΔI) penalty and conversion for full power ΔT

$U_8 = \pm (0.04 * 54/75) * 4.00 * 1.2$

$U_8 = \pm 0.138\%$ of ΔT Span

10.6.9 **Determine U_9, for the module e_9:**

Where: Bias = 0

$e_9 = \pm(0.80^2 + 0.04^2 + 0.80^2)^{½} \pm 0$

$U_9 = \pm 0.04\%$ of full span power

Using the full power range span, and conversion for full power ΔT

$U_9 = \pm (0.04 * 54/75) * 1.2$

$U_9 = \pm 0.035\%$ of ΔT Span

10.6.10 **Determine U_{10}, for the module e_{10}:**

Where: Bias = 0

$e_{10} = \pm(0.80^2 + 0.80^2)^{½} \pm 0$

U_{10} is considered to be negligible for this module, therefore,

$U_{10} = \pm 0.0$ of ΔT Span

10.6.11 **Determine U_{11}, for the module e_{11}:**

Where: Bias = 0

$e_{11} = \pm(0.866 + 0.50^2)^{½} \pm 0$

U_{11} is considered to be negligible for this module, therefore,

$U_{11} = \pm 0.0$ of ΔT Span

10.6.12 **Determine U_{12} for the module e_{12}:**

Where: Bias = 0

$e_{12} = \pm(0.5^2 + 0.20 + 0.243^2 + 0.50^2 + 0.191^2 + 0.50^2)^{1/2} \pm 0$

$U_{12} = \pm 0.588\%$ of ΔT Span (OP ΔT)

10.6.13 **Determine U_{13} for the module e_{13}:**

Where:Bias = 0

$e_{13} = \pm(0.5^2 + 0.20 + 0.243^2 + 0.50^2 + 0.241^2 + 0.50^2)^{1/2} \pm 0$

$U_{13} = \pm 0.606\%$ of ΔT Span (OT ΔT)

10.6.14 **Determine U_P for the module e_P:**

Where: Bias = +0.30

$e_P = \pm(1.60^2 + 1.28^2 + 0.31^2 + 0.10^2 + 0.95^2 + 0.50^2)^{1/2} + 0.3$

$U_p = \pm 1.627\%, +0.30\%$

Converting this uncertainty to process units (2500 – 1700 = 800psi) the following equation is used;

$U_p = (\pm 1.627\%, +0.30\%) * 800$ psi

$U_p = \pm 13.02$ psi, +2.4 psi

10.6.15 **Determine U_{PMI}**

The PM_i total uncertainty is identified as ±3.744% of ΔT Span. It is considered conservative to assume that 20% of the uncertainty is comprised of random accuracy and drift. However, since the incore instrumentation system components are not directly evaluated for uncertainties, we will conservatively include the full PM_i value. Therefore:.

$U_{PMI} = \pm 3.744\%$

10.6.16 Determine $U_{PMi/e}$

The $PM_{i/e}$ total uncertainty is identified as ±8.645% of ΔT Span. It is considered conservative to assume that 10% of the uncertainty is comprised of random accuracy and drift in excore system components evaluated for uncertainties in this calculation. Therefore, a value of ±7.7805% of ΔT Span (±8.645 *90%) will be as $U_{PMi/e}$

$U_{PMi/e} = \pm 7.7805\%$ rounded to 7.781% of ΔT Span

10.7 **Determine U_{TOTAL} for OPΔT and OTΔT**

In order to solve for total U for both OPΔT and OTΔT; T_U must be determined. T_{COLD} will include the cold leg streaming effect of -1.0% of ΔT span. A T_{HOT} streaming PM random effect of ±1.0°F or 1.33% of ΔT span will be included. U_{TOTAL} is a function of the T_{HOT} and T_{COLD} parameters of ΔT, the T, U_{THOT}, U_{TCOLD} and U_{TAVG} equations must be calculated for the U portion of the loop. Therefore, solving for T_U,

10.7.1 **Determine T_U**

$T_U = \pm [3(U_1^2 + U_2^2)]^{1/2} / 3$

$T_U = \pm [3(0.268\%^2 + 0.236\%^2)]^{½} / 3$

$\mathbf{T_U = \pm 0.206\%}$

10.7.2 **Solving for U_{THOT},**

$U_{THOT} = \pm (U_{PM}^2 + T_U^2 + U_3^2 + U_4^2)^{½} \quad \pm Bias$

$U_{THOT} = \pm (1.33\%^2 + 0.206\%^2 + 0.800\%^2 + 0.907\%^2)^{½} \pm 0.0$ of ΔT span

$U_{THOT} = \pm 1.807\%$ of ΔT span

10.7.3 **Solving for U_{TCOLD},**

$U_{TCOLD} = \pm (U_1^2 + U_2^2 + U_4^2)^{½}$ -Bias

$U_{TCOLD} = \pm (0.268\%^2 + 0.236\%^2 + 0.907\%^2)^{½}$ -1.0% of ΔT span

$U_{TCOLD} = \pm 1.034\%$ -1.0% of ΔT span

10.7.4 Solving for U_{TAVG}, (This represents the total U_{TAVG} uncertainty at the input to module e_5)

$U_{TAVG} = \pm (U^2_{THOT} + U^2_{TCOLD})^{½} /2$- Bias/2 (Sec. 7.10.3)

$U_{TAVG} = \pm [(1.807^2 + 1.034^2)]^{½} /2 - 1.0\% /2$

$U_{TAVG} = \pm 1.041\%$ with -0.5 Bias of T_{AVG} span

10.7.5 **Solving for $U_{\Delta T}$,** (This represents the total $U_{\Delta T}$ uncertainty at the input to module e_6)

$U_{\Delta T} = \pm (U^2_{TCOLD} + U^2_{THOT})^{½}$ (Sec. 7.10.3)

$U_{\Delta T} = \pm [(1.807^2 + 1.034^2)^{½}]$ -1.0% of ΔT span

$U_{\Delta T} = \pm 2.082\%$, -1.0% of ΔT span

10.7.6 **Calculate total OPΔT channel U value ($U_{OP\Delta T}$)**

$U_{OP\Delta T}$ is determined from the following;

$U_{OP\Delta T} = \pm (U_{PM}^2 + U_1^2 + U_2^2 \_u_3^2 + U_4^2 + U_5^2 + U_6^2 + PM_{cal}^2 + e10^2 + e12^2)^{1/2} \pm B$

In the above combination of terms, ($U_{PM}^2 + U_1^2 + U_2^2 \_u_3^2 + U_4^2$) represents the total U of both the tAVG and the ΔT portions of the hot and cold let temperature circuits. Using U_{TAVG} and $U_{\Delta T}$, $U_{OP\Delta T}$ becomes;

$U_{OP\Delta T} = \pm [(U_{TAVG} {}^*K_6)^2 + U_{\Delta T}^2 + U_5^2 + U_6^2 + PM_{cal}^2 + U_{10}^2 + U_{12}^2]^{1/2} \pm B$ of ($T_{AVG} {}^*K_6$, ΔT, $IRE_{TAVG} {}^*K_6$, IREΔT)

Where,	U_{TAVG} = ± 1.041% with -0.5% Bias of T_{AVG} span
$U_{\Delta T}$	= ± 2.082%, -1.0% Bias of ΔT span
U_5	= ± 0.95% ΔT span
U_6	= ± 0.95% ΔT span
PM_{cal}	= ± 0.907% ΔT span
U_{10}	= ± 0.0%of ΔT Span

U_{12} = ±0.588% of ΔT Span (OPΔT)

K_6 = 0.0015 ΔT Span/°F T_{AVG},

EA_{IRE} = IRE_{TAVG} = - 0.477% Bias of ΔT Span

= $IRE_{\Delta T}$ = -0.613% Bias of ΔT Span

$U_{OP\Delta T} = \pm [(1.041 * 0.0015)^2 + 2.082^2 + 0.95^2 + 0.95^2 + 0.907_i^2 + 0.0^2 + 0.588^2]^{1/2} \pm B$ of (-0.5*0.0015, -1.0, -0.477 *0.0015, -0.613)

$U_{OP\Delta T} = \pm (0.0015615^2 + 2.082^2 + 0.95^2 + 0.95^2 + 0.907^2 + 0.0^2 + 0.588^2)^{1/2} \pm B$ of (-0.00075, -1.0, 0.0007155, -0.613)

$U_{OP\Delta T}$ = ± 2.703, -1.614% ΔT Span

$U_{OP\Delta T}$ = + 2.703, -4.317% ΔT Span

10.7.7 Calculate total OTΔT channel U value ($U_{OT\Delta T}$)

$U_{OT\Delta T}$ is determined from the following;

$U_{OT\Delta T} = \pm (U_{PM}^2 + U_1^2 + U_2^2 + U_3^2 + U_4^2 + U_5^2 + U_6^2 + PM_{cal}^2 + U_P^2 + PM_i^2 + PM_{i/e}^2 + U_7^2 + U_8^2 + U_9^2 + U_{11}^2 + U_{13}^2)^{1/2} \pm B$

In the above combination of terms, $(U_{PM}^2 + U_1^2 + U_2^2 \_u_3^2 + U_4^2)$ represents the total U of both the T_{AVG} and the ΔT portions of the hot and cold let temperature circuits. Using U_{TAVG} and $U_{\Delta T}$, $U_{OP\Delta T}$ becomes;

$U_{OT\Delta T} = \pm [(U_{TAVG} * K_2)^2 + U_{\Delta T}^2 + U_5^2 + U_6^2 + PM_{cal}^2 + (U_P * K_3)^2 + U_{PMI}^2 + U_{PMi/e}^2 + U_7^2 + U_8^2 + U_9^2 + U_{11}^2 + U_{13}^2]^{1/2} \pm$ Biases of ($T_{AVG} * K_2$, ΔT, $U_P * K_3$)

Where, U_{TAVG} = ± 1.041% with -0.5% Bias of T_{AVG} span

$U_{\Delta T}$ = ± 2.082%, -1.0% Bias of ΔT span

U_5 = ± 0.95% ΔT span

U_6 = ± 0.95% ΔT span

PM_{cal} = ± 0.907% ΔT span

U_P = ± 13.02 psi, +2.4 psi Bias

U_{PMI} = ±3.744% ΔT span

$U_{PMi/e}$ = ±7.781% ΔT span

U_7 = ± 5.184% ΔT span

U_8 = ± 0.138% ΔT span

U_9 = ± 0.035%of ΔT Span

U_{11} = ±0.00% of ΔT Span (OPΔT)

U_{13} = ± 0.606% ΔT span

K_2 = ± 0.022% ΔT span/°F T_{AVG}

K_3 = ± 0.0007 ΔT Span/psi

$U_{OT\Delta T} = \pm [(1.041 * 0.022)_i^2 + 2.082^2 + 0.95^2 + 0.95^2 + 0.907_i^2 + (13.02 * 0.0007)^2 + 3.744^2 + 7.781^2 + 5.184^2 + 0.138^2 + 0.035^2 + 0.00^2 + 0.606^2]^{1/2} \pm$ Biases of (-0.50 *0.022, -1.00, +2.4 *0.0007)

$U_{OT\Delta T} = \pm[0.023^2 + 2.082^2 + 0.95^2 + 0.95^2 + 0.907_i^2 + .009^2 + 3.744^2 + 7.781^2 + 5.184^2 + 0.138^2 + 0.035^2 + 0.00^2 + 0.606^2]^{1/2} \pm$ Biases of (-0.011, -1.00, +0.0017)

$U_{OT\Delta T} = \pm$ 10.3845, +0.0017, -1.011% ΔT Span

$U_{OT\Delta T}$ = + 10.3862, -11.396% ΔT Span

10.8 Determine Nominal AVs

The nominal AVs can be calculated from the following equation;

$$AV = AL \pm U$$

10.8.1 OPΔT (K_4) Allowable Value

For OPΔT, the relationship of the Analytical Limit ($K_{4\,(MAX)}$), Allowable Value ($K_{4\,(AV)}$) and Uncertainty ($U_{OP\Delta T}$) is as follows;

$$K_{4\,(max)}\,\Delta T_o - K_{4(AV)}\,\Delta T_o = U_{OP\Delta T}$$

$$K_{4\,(max)} - K_{4\,(AV)} = \frac{U_{OP\Delta T}}{\Delta T_o}$$

Solving for the Allowable Value ($K_{4(AV)}$)

$$AV = K_{4(AV)} = K_{4\,(max)} - \frac{U_{OP\Delta T}}{\Delta T_o}$$

From above, $U_{OP\Delta T} = -4.317\ \%\ of\ \Delta T\ Span$

The above OPΔT uncertainty $U_{OP\Delta T}$ is the uncertainty at a condition of measured Full Power ΔT (equaling 75°F, or 100% of Span). However, IP3's full power ΔT will be assumed to be 54°F, which is a bounding lowest loop measured ΔT compared to a ΔT calibrated Span of 75°F. The following may be determined for; (Ref. 3.5.12)

$\frac{U_{OP\Delta T}}{\Delta T_o}$ (Refs. 3.2.22 & 3.2.23)

Given, ΔT_o = ΔT at 100% Full Power

ΔT Span = (75/54) * 100 ΔT_o = 138.888% of ΔT_o

$$\frac{U_{OP\Delta T}}{\Delta T_o} = -\frac{(4.317\%\ of\ \Delta T\ Span)*(138.888\%\ Full\ Power)}{(100\%\ Full\ Power)*(100\%\ \Delta T\ Span)}$$

$$\frac{U_{OP\Delta T}}{\Delta T_o} = -0.0599$$

The negative value of $\frac{U_{OP\Delta T}}{\Delta T_o}$ is used to determine AV since the process is increasing towards the analytical limit. Therefore, calculating the Allowable Value for OPΔT; (Ref. 3.1.3)

$$AV_{(OP\Delta T)} = AL - \frac{U_{OP\Delta T}}{\Delta T_o}$$

$AV_{(OP\Delta T)}$ = 1.164 - 0.0599 (Refs. 3.2.13 & 3.2.26)

$AV_{(OP\Delta T)}$ = 1.1041 (OPΔT)

10.8.2 OTΔT (K_1) Allowable Value

For OTΔT, the relationship of Analytical Limit (K_{1max}), Allowable Value (K_{1AV}) and the uncertainty ($U_{OT\Delta T}$) are as follows;

$$K_{1(max)}\,\Delta T_o - K_{1AV}\,\Delta T_o = U_{OT\Delta T}$$

$$K_{1(max)} - K_{1AV} = \frac{U_{OT\Delta T}}{\Delta T_o}$$

Solving for the Trip Setpoint ($K_{1(TS)}$),

$$TS = K_{1AV} = K_{1(max)} - \frac{U_{OT\Delta T}}{\Delta T_o}$$

From above,

$$U_{OT\Delta T} = -11.396\%\ of\ \Delta T\ Span$$

The above OTΔT uncertainty is the uncertainty for at a condition of a measured Full Power ΔT equaling 75°F. Similarly to OPΔT, OTΔT is also based on a Full Power Rating of 138.888% for 54°F, which is the lowest loop measured ΔT compared to a ΔT calibrated Span of 75°F.

The following may be determined for; $\frac{U_{OT\Delta T}}{\Delta T_o}$ (Ref. 3.2.22)

Given, ΔT_o = ΔT at 100% Full Power

ΔT Span = (75/54) * 100 ΔT_o = 138.888% of ΔT_o

$$\frac{U_{OT\Delta T}}{\Delta T_o} = -\frac{(11.396\%\ of\ \Delta T\ Span)*(138.888\%\ Full\ Power)}{(100\%\ Full\ Power)*(100\%\ \Delta T\ Span)}$$

$$\frac{U_{OT\Delta T}}{\Delta T_o} = -0.1583$$

Therefore, calculating the AV for OTΔT;

AV = 1.42 - 0.1583 (Refs. 3.2.13 & 3.2.26)

AV = 1.2617 (OTΔT)

$U_{OP\Delta T}$ = + 1.610%, - 3.224% ΔT Span (The process is increasing toward the AL, therefore, the negative uncertainty value will be subtracted from the AL to determine the OPΔT AV)

Determine Allowable Value for OPΔT

Given: OPΔT (K_4) AL = 1.164 OPΔT

$U_{OP\Delta T}$ = + 1.610%, - 3.224% ΔT Span

For OPΔT, the relationship of the AL ($K_{4(MAX)}$), AV ($K_{4(AV)}$), and the AV/AL Channel Uncertainty ($U_{OP\Delta T}$) are as follows;

$K_{4(MAX)}\,\Delta T_O - K_{4(AV)}\,\Delta T_O = U_{OP\Delta T}$

$K_{4(MAX)} - K_{4(AV)} = U_{OP\Delta T} / \Delta T_O$

Solving for the Allowable Value ($K_{4(AV)}$

AV = $K_{4(AV)}$ = $K_{4(MAX)} - (U_{OP\Delta T} / \Delta T_O)$

The above AV/AL OPΔT uncertainty is the instrumentation uncertainty at a condition of measured Full Power ΔT (equaling 75°F, or 100% of Span). However, IP3's full power ΔT will be assumed to be 54°F, which is a bounding lowest loop measured ΔT compared to a ΔT calibrated Span of 75°F. The following may be determined for;

$U_{OP\Delta T} / \Delta T_O$ = ΔT at 100% Full Power

ΔT Span = (75 / 54) X 100 ΔT_O = 138.888% of ΔT_O

$U_{OP\Delta T} / \Delta T_O$ = -[(3.224% of ΔT Span X 138.888% Full Power) / (100% Full Power X 100% ΔT Span)]

$U_{OP\Delta T} / \Delta T_O$ = -0.0448

The negative value of $U_{OP\Delta T} / \Delta T_O$ is used to determine AV since the process is increasing towards the AL. Therefore, calculation the AV for OPΔT;

$AV_{OP\Delta T}$ = AL - ($U_{OP\Delta T} / \Delta T_O$)

$AV_{OP\Delta T}$ = 1.164 – 0.0448

$AV_{OP\Delta T}$ = **1.1192 OPΔT**

NOTE: AL = 1.164 (OPΔT K4)
METHOD 3 AV = 1.127
METHOD 2 AV = 1.119 (1.104 using the more conservative Method 2 approach in Section 10.8.1)
Tech Spec AV = 1.100
TS (calculated) = 1.0807
TS (implementing) = 1.074

Therefore, Method 2, being the more conservative AV determination methodology, will be the basis for establishing the SPU AV for the OPDT function.

Calculation No. IP3-CALC-RPC-00290	Revision 3	Project: ER No. 04-3-027
Title: Instrument Loop Accuracy / Setpoint Calculation, Overpower Delta-T (OPDT) and Overtemperature Delta-T (OTDT), Reactor Trip		

The following may be determined for; $U_{OT\Delta T} / \Delta T_O$

ΔT_O = ΔT at 100% Full Power

ΔT Span = $(75 / 54) \times 100\ \Delta T_O = 138.888\%$ of ΔT_O

$U_{OT\Delta T} / \Delta T_O$ = -[(5.320% of ΔT Span X 138.888% Full Power) / (100% Full Power X 100% ΔT Span)]

$U_{OT\Delta T} / \Delta T_O$ = -0.0739

The negative value of $U_{OT\Delta T} / \Delta T_O$ is used to determine AV since the process is increasing towards the AL. Therefore, calculation the AV for OTΔT;

$AV_{OT\Delta T}$ = AL - $(U_{OP\Delta T} / \Delta T_O)$

$AV_{OT\Delta T}$ = 1.420 – 0.0739

$AV_{OT\Delta T}$ = **1.346 OTΔT**

NOTE: AL = 1.420 (OTΔT K1)
METHOD 3 AV = 1.348
METHOD 2 AV = 1.346 (1.2617 using the more conservative Method 2 approach in Section 10.8.2)
Tech Spec AV = 1.260
TS (calculated) = 1.241
TS (implementing) = 1.22

Therefore, Method 2, being the more conservative AV determination methodology, will be the basis for establishing the SPU AV for the OTDT function.

The random and independent errors include:

ACCICENT	NORMAL	
$PM_{hot} = \pm 1.00°F$	$PM_{hot} = \pm 1.00°F$	(sec. 7.1)
$PM_{cold} = -0.75°F$	Bias $PM_{cold} = -0.75°F$ Bias	(sec. 7.1)
PE = 0.0	PE = 0.0	(sec. 7.2)
$e_1 = \pm 0.64 °F$	$e_1 = \pm 0.63 °F$	(sec. 7.3.12)
$e_2 = \pm 1.25 °F$	$e_2 = \pm 1.08 °F$	(sec. 7.4.11)
$e_3 = \pm 0.612 °F$	$e_3 = \pm 0.612 °F$	(sec. 7.5.11)
$e_4 = \pm 1.26 °F$	$e_4 = \pm 1.13 °F$	(sec. 7.6.11)
$e_5 = \pm 1.42 °F$	$e_5 = \pm 1.24 °F$	(sec. 7.7.11)
$e_6 = \pm 0.78 °F$	$e_6 = \pm 0.70 °F$	(sec. 7.8.11)

The channel uncertainty (CU) is determined by calculating the propagation of the individual error components through the Lo T_{avg} circuit.

Lo T_{avg} *is determined by the following:*

$T_{HOT} = (T_1 + T_2 + T_3) / 3$, $T_{Avg} (T_{HOT} + T_{COLD}) / 2$

Where, $T_1 + T_2 + T_3$ = Hot Leg RTD/Transmitter Output

T_{HOT} = Hot Leg Average Temperature

T_{COLD} = Cold Teg Temperature

T_{Avg} = T_{HOT} and T_{COLD} Average Temperature

7.10.1 Calculate Total T_{HOT} Channel Uncertainty (CU_{THOT})

To calculate the total T_{HOT} channel uncertainty (CU_{THOT}), first, the average T_{HOT} uncertainty (T) must be determined with individual random uncertainties of modules e_1 and e_2 propagated through the T_{HOT} circuit using the Square Root Sum of Squares (SRSS), as follows:

$$T = \pm[(e^2_1 + e^2_2) + (e^2_1 + e^2_2) + (e^2_1 + e^2_2)]^{½} / 3$$

Where,

T = Average Uncertainty of the three Hot Leg measurements.

$$T = \pm[3(e^2_1 + e^2_2)]^{½} / 3$$

$$T\ (ACCIDENT) = \pm[3(0.64^2 + 1.25^2)]^{½} / 3$$

$$T\ (ACCIDENT) = \pm 0.811°F$$

$$T\ (NORMAL) = \pm[3(0.63^2 + 1.08^2)]^{½} / 3$$

$$T\ (NORMAL) = \pm 0.722°F$$

Please note that the Hot and Cold Leg IRE effects are included in the overall CU uncertainty *determination of Section 7.10.4.*

The total T_{HOT} Channel Uncertainty (CU_{THOT}) is calculated by including PM, e_3 and e_4 module uncertainties in SRSS as follows:

$$CU_{THOT} = \pm(PM^2 + T^2 + e_3^2 + e_4^2)^{½} \pm B$$

Where bias = 0

ACCIDENT $CU_{THOT} = \pm(1.00^2 + 0.811^2 + 0.612^2 + 1.26^2)^{½}$

ACCIDENT $CU_{THOT} = \pm 1.90°F$

NORMAL $CU_{THOT} = \pm(1.00^2 + 0.722^2 + 0.612^2 + 1.13^2)^{½}$

NORMAL $CU_{THOT} = \pm 1.78°F$

➽ NORMAL CU_{THOT} not including PM = ±1.474°F

7.10.2 Calculate T_{COLD} Uncertainty (CU_{TCOLD})

To calculate CU_{TCOLD}, the random uncertainties of modules e_1, e_2 and e_4 are combined using SRSS:

$CU_{TCOLD} = \pm (Pm^2 + e^2{}_1 + e^2{}_2 + e^2{}_4)^{½} + Bias$

ACCIDENT $CU_{TCOLD} = \pm (0.64^2 + 1.25^2 + 1.26^2)^{½} - 0.75$

ACCIDENT $CU_{TCOLD} = \pm 1.89°F - 0.75°F$

NORMAL $CU_{TCOLD} = \pm (0.63^2 + 1.08^2 + 1.13^2)^{½} - 0.75$

➽ NORMAL $CU_{TCOLD} = \pm 1.69°F - 0.75°F$

7.10.3 Calculate T_{avg} Uncertainty (CU_{Tavg})

To calculate CU_{TAVG} the CU_{THOT} and CU_{TCOLD} random uncertainties must be propagated through the T_{avg} circuit using SRSS as follows:

$CU_{TAVG} = \pm(CU^2{}_{THOT} + CU^2{}_{TCOLD})^{½} / 2$

ACCIDENT $CU_{TAVG} = [\pm(1.90^2 + 1.89^2)^{½} - 0.75] / 2$

ACCIDENT $CU_{TAVG} = [\pm 2.68°F - 0.75°F] / 2$

ACCIDENT $CU_{TAVG} = \pm 1.34°F, - 0.375°F$

NORMAL $CU_{TAVG} = [\pm(1.78^2 + 1.69^2)^{½} - 0.75] / 2$

NORMAL $CU_{TAVG} = [\pm 2.45°F - 0.75°F] / 2$

NORMAL $CU_{Tavg} = \pm 1.23°F \; -0.375°F$

7.10.4 Calculate the Total Channel Uncertainty (CU)

To calculate Total CU, modules e_5, e_6 and IRE (IRE for ACCIDENT only) are combined with CU_{Tavg} using SRSS.

$CU_{TOTAL} = \pm (CU^2_{TAVG} + e^2_5 + e^2_6)^{½} \pm B$

ACCIDENT $CU_{TOTAL} = \pm (1.34^2 + 1.42^2 + 0.78^2)^{½} +0,-1.2,-0.375$

ACCIDENT $CU_{TOTAL} = \pm 2.10°F +0, -1.575$

ACCIDENT $CU_{TOTAL} = +2.10°F, -3.675°F$

NORMAL $CU_{TOTAL} = \pm (1.23^2 + 1.24^2 + 0.70^2)^{½} -0.375$

NORMAL $CU_{TOTAL} = \pm 1.88°F, -0.375°F$

NORMAL $CU_{TOTAL} = +1.88°F, -2.25°F$

8.0 OBTAIN ANALYTICAL LIMIT (AL)

8.1 The modeled/credited value used in the Safety Analyses for Steamline Break Lo T_{avg} coincidence is 535°F.

Therefore,

LO T_{avg} AL = 535°F (see Attachment 4)

8.2 The alarm limit used as an NPL for the Hi T_{avg} setpoint for operator convenience is the COLR DNB limit for Tavg of 574.8°F (Ref 3.2.24). This is not a modeled or credited function in the Unit 3 safety analyses. However, Westinghouse correspondence supporting critical parameter values for power uprate identifies a value or 572°F

Therefore,

HI T_{avg} NPL = 574.8°F (see Attachment 6)

9.0 DETERMINE SETPOINTS(TS)AND RTD CONVERTER CALIBRATIONS

The nominal trip setpoint can be calculated from the following equation:

TS = AL ± (CU + Margin) (ref. 3.1.2)

If Margin = 0.0

Channel Uncertainty is:

ACCIDENT CU = +2.10°F, -3.675°F (Section 7.10.4)

NORMAL CU = +1.88°F, -2.25°F

9.1 LO T_{avg} TS calculation:

The negative value of CU is not used to determine TS since the process is decreasing towards the analytical limit. Accident conditions are possible during a LO T_{avg} event. Therefore,

TS = 535°F +2.10°F

TS= 537.10°F (DEC),or when scaled for 400mV and 75°F span, the decreasing mV signal is [400 mV(537.10-540) / 75]+100 = 84.5mV(DEC)which is below scale. NOTE: The existing setpoint is conservatively set at 542°F or 110.67 mV decreasing (Ref. 3.5.7).

9.2 HI T_{avg} TS calculation:

The positive value of CU is not used to determine HI T_{avg} TS since the process increases towards the alarm limit. Also, harsh environment accident conditions are not considered present during a HI Tavg event. Therefore:

TS = 574.8°F – 2.25°F

TS = 572.55°F (INC), or when scaled for a 400mV and 75°F span the increasing mV signal is [400 mV(572.55-540) / 75]+100 = 273.6 mV (INC). NOTE: The existing setpoint is conservatively set at 569.89°F or 259.46 mV increasing. (Ref. 3.5.7).

The above setpoint at 569.89 °F adequately supports the current operating Full Load Tavg of 567°Fas well as the Hi Tavg alarm NPL of 574.8°F. However, it may be necessary to increase Full Load Tavg as much as 3 degs to achieve adequate Main Stem Pressure for acceptable turbine first stage performance. Potential changes will be considered in 1 deg increments, specifically at 568, 569 and 570 °F. We will therefore configure the following setpoint changes if and at what value the full load condition is actually changed to:

FL Tavg (°F)	Hi Tavg Setpoint (°F)	Hi Tavg Setpoint (mV)
568	570.90	264.80
569	571.90	270.13
570	572.55	273.60

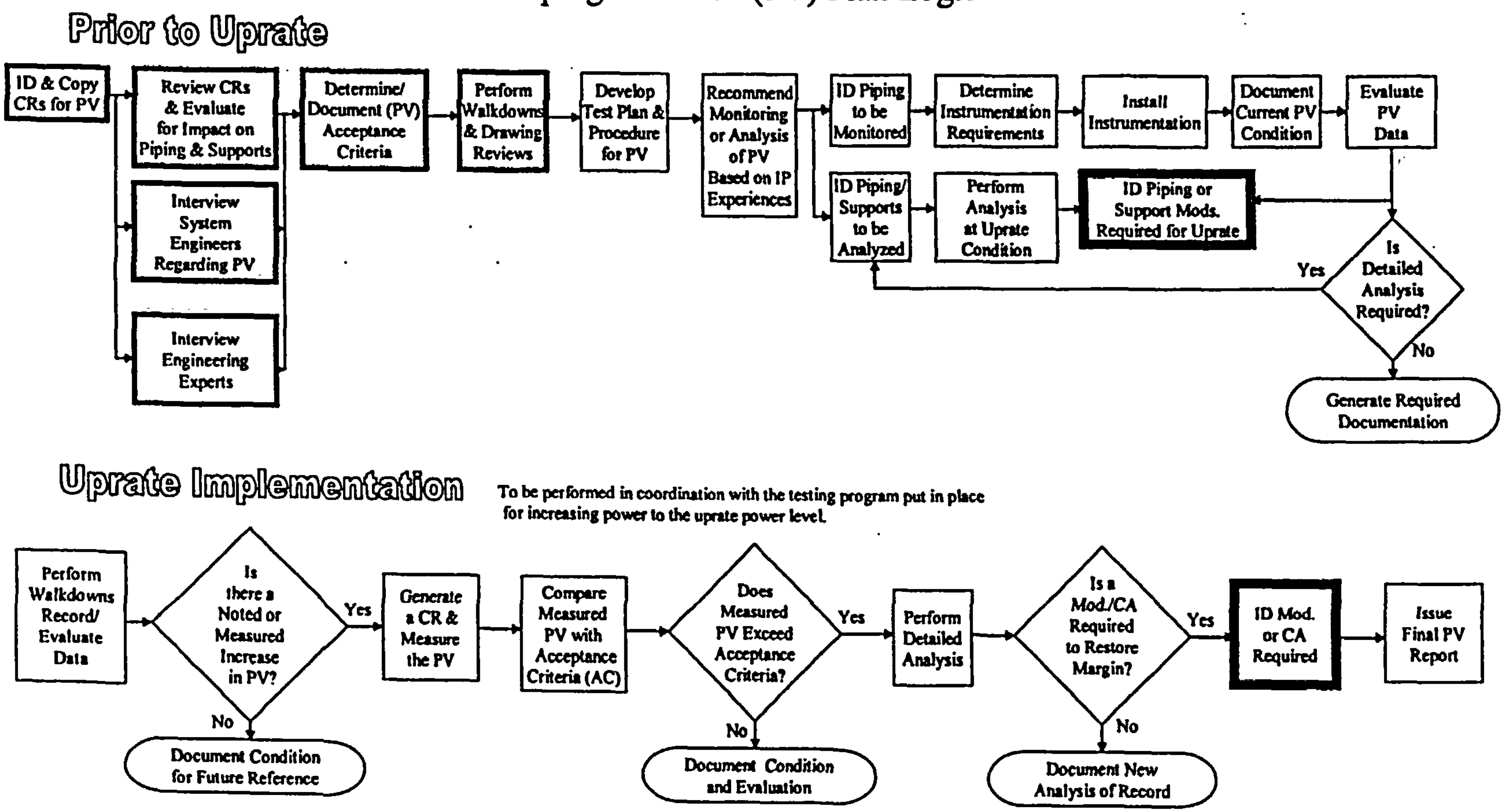
ATTACHMENT 8 TO NL-05-014

Indian Point Piping Vibration (PV) Plan Logic Diagrams with Examples

(3 Pages)

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

Indian Point
Piping Vibration (PV) Plan Logic



Indian Point Unit 3
Piping Vibration Collection Data

<table>
<tr><th colspan="3">Test Attribute</th><th>Baseline Prior to Uprate (100% RX Pwr)</th><th>Power Ascension to Uprate (96.5% RX Pwr)</th><th>Power Ascension to Uprate (100% RX Pwr)</th><th>Power Uprate + 7 Days (100% RX Pwr)</th></tr>
<tr><td colspan="3">Monitor Point ID</td><td colspan="4">P1</td></tr>
<tr><td colspan="3">Pipe Location Description</td><td colspan="4">1" vent line containing MS-63-1 (TB, El. 53', E side)</td></tr>
<tr><td colspan="3">P&ID or Piping Drawing</td><td colspan="4">9321-F-20173 (Main Steam)</td></tr>
<tr><td colspan="3">Nominal Pipe Diameter (in)</td><td colspan="4">1"</td></tr>
<tr><td colspan="3">Photo Number(s)</td><td colspan="4">12</td></tr>
<tr><td colspan="3">Test Date / Time</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Percent Reactor Power</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="9">Test Data (Max Value of Velocity and Displacement at Given Frequency)</td><td rowspan="3">X-Axis</td><td>Velocity (in/sec)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Displ (mils)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Freq (Hz)</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Y-Axis</td><td>Velocity (in/sec)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Displ (mils)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Freq (Hz)</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">In-Line Z-Axis</td><td>Velocity (in/sec)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Displ (mils)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Freq (Hz)</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Data Collected By:</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Remarks:</td></tr>
</table>

Indian Point Unit 3
Piping Vibration Collection Data

Test Attribute			Baseline Prior to Uprate (100% RX Pwr)	Power Ascension to Uprate (96.5% RX Pwr)	Power Ascension to Uprate (100% RX Pwr)	Power Uprate + 7 Days (100% RX Pwr)
Monitor Point ID			P2			
Pipe Location Description			Instrument line containing PI-7006 (TB, El 53', W side) MSR 33B			
P&ID or Piping Drawing			9321-F-20173			
Nominal Pipe Diameter (in)			3/4"			
Photo Number(s)			13			
Test Date / Time						
Percent Reactor Power						
Test Data (Max Value of Velocity and Displacement at Given Frequency)	X-Axis	Velocity (in/sec)				
		Displ (mils)				
		Freq (Hz)				
	Y-Axis	Velocity (in/sec)				
		Displ (mils)				
		Freq (Hz)				
	In-Line Z-Axis	Velocity (in/sec)				
		Displ (mils)				
		Freq (Hz)				
Data Collected By:						

Remarks: