Design Analysis

Ginna Station

Instrument Loop Performance Evaluation and Setpoint Verification

Instrument Loop Number (SG F464)

Rochester Gas and Electric Corporation
89 East Avenue
Rochester, New York 14649

DA EE-92-089-21

Revision 1

(September 15, 1997)

EWR 5126

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Design Engineer Date

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Independent Reviewer Date

TECHNICAL INPUT FORM				
EIN	FE-464, FT-464, FQ-464, FC-464A, FM-464A, FM-464B, FM-464C, FI-464, FE-465, FT-465, FQ-465, FC-4645, FM-465A, FM-465B, FM-465C, FI-465, FE-474, FT-474, FQ-474, FC-474A, FM-474A, FM-474B, FM-474C, FI-474, FE-475, FT-475, FQ-475, FC-475A, FM-475A, FM-475B, FM-475C, FI-475			
KEYWORDS	Instrument, Setpoint, Uncertainty, Main Steam Flow			
CROSS REF	CPI-FLO-464, CPI-FT-464, CPI-FLO-465, CPI-FT-465, CPI-FLO-474, CPI-FT-474, CPI-FLO-475, CPI-FT-475, AR 97-1174			
PSSL 05	EWR/ OTHER 5126	PROPRIETARY	YES	NO X
COMMENT				
SUPERSEDES				

REVISION STATUS SHEET

Revision Number	Affected Sections	Description of Revision
0	N/A	Original
1	1.1, 1.2, 5.1.1, 2.0, 9.9, 10.1, 11.0, Attachment 1	Resolution of PCAQs 94-67, 94-068 and ACTION Report 97-1174; Delete Attachments A, B, C, and D

INSTRUMENT PERFORMANCE EVALUATION AND
SETPOINT VERIFICATION

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INSTRUMENT PERFORMANCE EVALUATION AND SETPOINT VERIFICATION

Instrument Loop Identification

Calibration Procedure No. CPI-FT-464 and CPI-FLO-464

Description: Calibration of Steam Generator A Steam Flow Transmitter FT-464 and Calibration of Steam Generator A Steam Flow Loop 464 Rack Instrumentation.

The Instrument Performance Evaluation and Setpoint Verification of the following equipment will be performed by this document:

1. FE-464
2. FT-464
3. FQ-464
4. FC-464A
5. FM-464A
6. FM-464B
7. FM-464C
8. FI-464
9. PT-468

1.0 Purpose

1.1 The purpose of this calculation is to determine the overall loop uncertainty associated with main steamline A flow measurement channel F-464. This loop provides safety-related main steam flow indication at the main control board for both normal and post-accident conditions, inputs to the ESF actuation circuitry for steamline isolation, and provides non-safety related input to the advanced digital feedwater control system, PPCS, and flow recorder FR-464. The safety-related portion of this loop is comprised of the venturi flow element, differential pressure transmitter, power supply, alarm bistable, multiplier/divider (which also receives an input from steam generator A pressure loop P468), square root extractor, current repeater, and the control room indicator. This portion of the process loop is the subject of this analysis.

1.2 Revision 1 of this analysis is for resolution of PCAQs 94-067 and 94-068. This revision does not affect original Attachments A, B, and C, therefore, they are not reproduced in this revision. See Revision 0 for Attachments A, B, and C. Main Steam flow instrument loops F465, F474 and F475 are equivalent to loop F464 therefore, this analysis is applicable to loops F465, F474 and F475 as well.

2.0 References

1. UFSAR Table 7.5-1, "Regulatory Guide 1.97 Revision 3/NUREG-0737 Comparison Table".

2. Regulatory Guide 1.97, "Instrumentation for Light Water-Cooled Nuclear Plants to Assess Plant and Environs Conditions During and Following an Accident", (Rev. 3, Dated May, 1983).

3. Improved Technical Specifications, R.E. Ginna Nuclear Power Plant

   Table 3.3.1-1 Reactor Trip System Instrumentation
   Table 3.3.2-1 ESFAS Instrumentation
   Table 3.3.3-1 Accident Monitoring Instrumentation

4. Calibration Procedure CPI-FT-464, "Calibration of Steam Generator A Steam Flow Transmitter FT-464".

5. Calibration Procedure CPI-FLO-464, "Calibration of Steam Generator A Steam Flow Loop 464 Rack Instrumentation".

6. Steam Generator A Steam Flow Loop FT-464 Instrument loop Wiring Diagram, Drawing No. 11302-0364, Sheet 1.

7. 65P Panel-Mounted Indicating Milliammeters and Voltmeters, Product Specifications, PSS 2A-3B1 A, The Foxboro Co., Dated 1982.

8. Test Report of Seismic Vibration Testing of Specific Foxboro

Instruments, Dept. 383, Test Report No. TI-1070A, Dated 6/25/74.

9. TICP-3, Category II Pneumatic Calibrators, Rev. 11.

10. Guidelines for Instrument Loop Performance Evaluation and Setpoint Verification, Rev. 1.

11. Main Steam F464 Block Diagram.

12. Precalculation Instrument Review Checklist for Instrument Loop MS F464, Dated 7/05/94.

13. RG&E Drawing No. 03023-018, "Environmental Qualification of Class 1E Equipment FT 464".

14. Memo from Gary A. Cain to Mr. Baker, "Request for letter stating calibration accuracies of Digital Multifunction Meters", Dated March 29, 1990.

15. TICP-4, Category II, Digital Multifunction Meter, Rev. 11.

16. RG&E UFSAR Tables:

3.11-1	Environmental Service Conditions for Equipment Designed to Mitigate Design Basis Events.
7.2-1	List for Reactor Trip, ESF Actuation, and Containment Isolation.
7.4-2	Safe Shutdown Instruments.

17. EOP Setpoint Database.

18. RG&E Dwg. No. 33013-1363, Sheet 6, "Logic Diagram Safeguarads Actuation Signals."

19. Foxboro Drawing No. CD-11, Interconnection Wiring Diagram Rack SD, Reactor Protection System, Sheet 2 of 3.

20. Main Steam P&ID, Drawing No. 33013-1231.

21. Foxboro Drawing No. CD-3, Interconnection Wiring Diagram Rack R-2, Reactor Protection System, Sheet 1 of 3.

22. Special Instruction G-3645, "Model 63S Rack Mounted Alarms - Style A", The Foxboro Co., Dated 4/68.

23. Model 66A Square Root Converter, The Foxboro Co., Dated 3/67.

24. General Specifications, 66B Series Electronic Consotrol Current Repeater, GS 2A-2D1 A, The Foxboro Co., Dated 5/81.

25. Seismic Vibration Test of Specific "H" Line Instrumentation, The Foxboro Co., Dated 8/26/75.

26. Product Specifications "N-E11 and N-E13 Series d/p Nuclear

Electronic Pressure Transmitters", PSS 9-1B1 A, The Foxboro Co., Dated 87.

27. Foxboro Report QOAAC10, Rev. A, "Test Plan and Test Procedures for Class 1E Qualification of N-E10 Series Transmitters".

28. Steam Generator A Pressure Loop PT-468 Instrument loop Wiring Diagram, Drawing No. 11302-0368, Sheet 1 and Sheet 2.

29. Deleted

30. Precalculation Instrument Review Checklist for Instrument Loop SG P468, Dated 4/4/94.

31. Calibration Procedure CPI-PT-468, "Calibration of Steam Generator A Steam Pressure Transmitter PT-468".

32. Calibration Procedure CPI-PRESS-468, "Calibration of Steam Generator A Steam Pressure Loop 468 Rack Instrumentation".

33. Integrated System Performance Analysis SG 1A, Steam Flow FT-464, Dated 10/24/90.

34. Foxboro General Specification, GS2A-5E2 A for Model 66D Series Electronic Consotrol Multiplier/Divider, Faxed information from Matt Griffin of the Foxboro Co., Dated 2/20/94.

36. Performance Test Code, ANSI/ASME PTC Interim Supplement 19.5 on Instrument and Apparatus, Application, Part II of Fluid Meters, Sixth Edition-1971.

37. Hydraulic Institute Standards Centrifugal, Rotary and Reciprocating Pumps, 13th ed. Centrifugal Pump Test Code.

38. Telecon with Fred Buse (Ingersol Rand-Dresser, Allentown N.J.) Chairman, Hydraulic Institute Test Standard Committee by George Daniels, Dated 11/10/92.

39. Westinghouse Letter, To R. Baker, ADFCS Steam Flow Compensation, Dated 1/08/91.

40. Main Steam Inside Containment (EWR - 2512), Drawing No. C-381-350, Sheet 1.

41. ITT Controls, Drawing No. T3B4DC2DD184910, Flow Venturi, Change No. 2.

42. Controlled Vender Manual, V1.01-002, Book No. 1893, Type 66D Multiplier-Divider, The Foxboro Co.

43. Westinghouse Nuclear Energy Systems, Manual No. W-1001-s, FE-464 and FE-474, Received 2/24/70.

44. Foxboro Product Specification PSS 2A-1C1 H for E13-DH, Foxboro Co., dated 1981.

45. Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation, ISA-RP67.04, Part II.

46. Error analysis by George Daniels concerning density compensation, Dated 7/05/94.

47. Westinghouse correspondence NSD-SAE-ESI-97-513 from R.H.Owoc to R.Eliasz, dated 9/11/97.

3.0 Assumptions

1. The following inaccuracies for each component were assumed:

   Transmitter FT-464 drift .25% for 12 months was specified in Ref. 26; 0.5% will be used for an 18 month interval.

   Indicator FI-464
   readability = 1/2 subdivision (Reference 10 Section 10.5.2.3)
   = 1/2 ($.1X10^6$ MPPH) or
   = 1.32% Full Scale

   Rack equipment temperature effect is negligible

   Combined Rack drift 1.0% (F.S.) for 18 months

   Test Points TP/464, TP/464A and TP/468 resistor tolerances are ±1.0%

   Basis:
   FT-464: The drift term of .5% for 18 months is conservative based on industry experience and the fact drift is not a linear function, accumulating most of the term in the first few weeks following calibration.

   FI-464: Refer to Reference 10, Section 10.5.2.3; readability has been selected from the guidance provided in this section.

   Temperature effect is considered negligible since rack components are located in the main control room and relay room which are controlled environments.

   Combined Rack drift effect is based on similar equipment specifications and on sound engineering judgement.

   Test resistor tolerance of ±1.0% is based on sound engineering judgement and previous experience.

2. Normal ambient temperature in the Containment Building is 90°F.

   Basis:
   This basis represents the mid-point of the design temperature of the Containment Building, 60°F - 120°F (90°F ± 30°F).

3. Assume the power supply effect is negligible.

   Basis:
   Refer to Reference 26. The transmitter operates within stated limits of performance specifications for the variations in voltage supply. Based on similar equipment specifications and on sound engineering judgement, the power supply effect is considered negligible. For the same reason, resistive elements

in modules, and conductors have negligible effect on loop accuracy as long as the load is within the range specified for the transmitter and power supply.

4. The temperature effect on the test point resistors is negligible.

Basis
The test point resistors are located in the Relay Room which is a controlled environment. The normal temperature in the relay room is 70°F to 78°F; therefore, any change in resistance due to temperature is insignificant.

4.0 Block Diagram and Scope of Analysis

Ref; Precalculation Instrument Review Checklist Block Diagram for Steam Generator Instrument Loop F464.

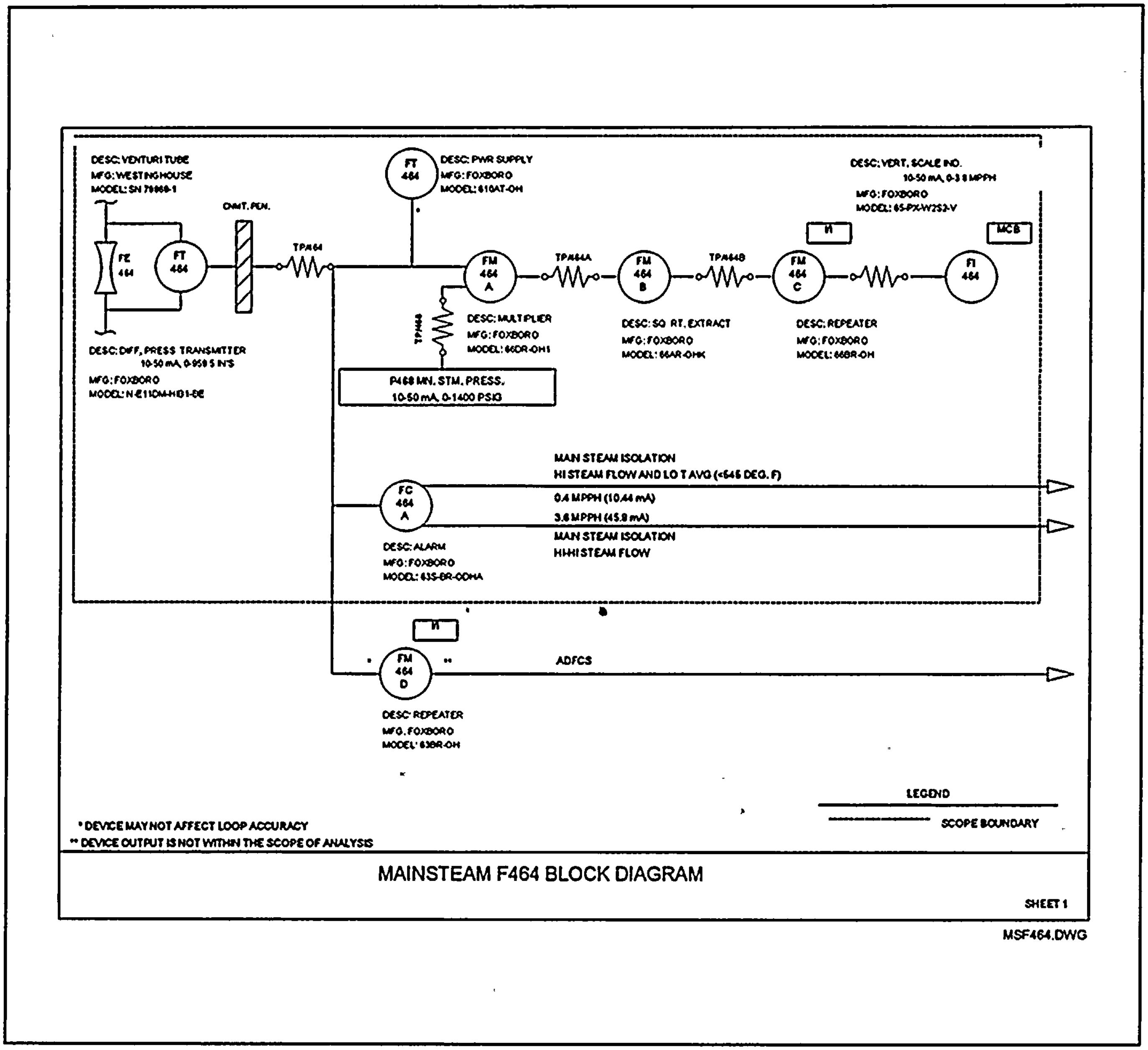


Figure 1

4.1 Description of Functions

Making reference to the Block Diagram, describe the instrument loop functions that are within the scope of the analysis using the format below.

4.1.1 Protection

This loop provides input to the ESF steam line isolation logic as follows:

Upon dual alarm bistable FC-464A sensing current corresponding to a steam flow of 0.4 X 10^6 pph @ 755 psig (approximately 12.1% of rated power) a high steam flow signal is generated. This signal satisfies a two input "OR" gate, and along with a signal from the low T_{avg} interlock, provides the two inputs to a two input "AND" gate. With a high steam flow input and the T_{avg} interlock enabled (two-out-of-four T_{avg} ≤545), a signal is generated through the "AND" gate. This signal will satisfy a two input "OR" gate, and serves as one of the two inputs to a two input "AND" gate. The other input to the "AND" gate is provided by the safeguards sequence actuation signal. With the safeguard sequence signal enabled and FC-464A sensing a high flow condition, a signal is generated through the "AND" gate and subsequent "OR" gate initiating a signal to cause a steamline isolation of loop A.

If steam flow increases above 3.6 X 10^6 pph @ 755 psig (approximately 109.1% of rated power), the second setpoint of dual alarm bistable FC-464A will be reached causing a High-High steam flow signal to be generated. This logic is similar to the above logic with the exception that a low T_{avg} condition is not necessary to satisfy the above logic. However, the safeguards sequence signal is still required to generate an initiation signal that will cause a steamline isolation of loop A.

4.1.2 Control

This loop does not perform any safety-related control functions. However, this loop provides an input to the advanced feedwater control system which automatically maintains steam generator level within a programmed band during power operations.

4.1.3 Indication

Instrument loop F464 provides control room indication (FI-464) of main steam flow (loop A) during both normal and post-accident conditions to control room operating personnel. This function of the instrument loop is safety-related, and hence, included in this analysis.

Non safety-related alarms and status lights associated with this instrument loop are as follow:

- S/G A Hi Steam Flow (Upon activation of either setpoint of FC-464A)
- Hi Steam Flow Line A FC-464A (.4 X 10^6 pph @ 755 psig)
- Hi-Hi Steam Flow Line A FC-464A (3.6 X 10^6 pph @ 755 psig)

5.0 Instrument Loop Performance Requirements

5.1 Documenting the Design Requirements for Monitoring the Process Parameter

5.1.1 Identify Performance Related Design Bases Associated With the Instrument Loop:

__SR__ Safety Classification (SR/SS/NS) as documented in the Ginna Q-list.

__Yes__ NUREG 0737/RG 1.97 as documented in Table 7.5-1, of the Ginna UFSAR.

UFSAR Table 7.5-1 lists the Main Steam flow loop FT-464 as an NRC Category 2, Type D variable. Type D variables are those variables that provide information to indicate the operation of individual safety systems and other systems important to safety. These variables are to help the operators make appropriate decisions in using the individual systems important to safety in mitigating the consequences of an accident. Category 2 variables require reliable power, seismic and nuclear qualification (if required), as stated in Table 1 "Design and Qualification Criteria for Instrumentation" of Regulatory Guide 1.97.

__Yes__ EQ (per the 10 CFR 50.49 list)

Pressure transmitter FT-464 is identified as requiring environmental qualification in the EQ Master List found in Appendix E of the Quality Assurance Manual. The pressure transmitter has been environmentally qualified through a Foxboro Qualification test program (Reference 27).

__SC-1__ Seismic Category (Seismic Class I/ Structural Integrity Only / NS)

The seismic requirements for a R.G. 1.97, Category 2, Type D Variable are specified to be in accordance with R.G. 1.100 (IEEE-344). The instrumentation for this loop are Foxboro nuclear grade components and have been seismically qualified (Reference 8, 25, 27).

__Yes__ Technical Specifications

As identified by a review of Tables 3.3.1-1, 3.3.2-1, and 3.3.3-1, of the Technical Specifications, this instrument channel is Tech. Spec. related. This flow channel is identified in Table 3.3.2-1 as ESF Actuation Instrumentation, and as such, is required to be operable whenever reactor coolant temperature is ≥350°F

with the main steam isolation valves open. Also, this table identifies operator actions to be implemented during limited operability of required instrument channels.

Table 3.3.2-1 identifies the setpoints and allowable values of the following safety functions:

Steam Line Isolation	Trip Setpoint	Allowable Values
High Steam Flow, coincident with Low	dp corresponding to ≤0.4 X 10^6 pph	dp corresponding to ≤0.55 X 10^6 pph (Changed to .66x10^6 pph; see Ref. 47 and Attachment 1)
T_{avg} and SI	@755 psig;T_{avg} ≥ 545°F	@755 psig;T_{avg} ≥ 543°F (Changed to 1005 psig; see Ref. 47 and Attachment 1)
High-High Flow, coincident with SI	dp corresponding to ≤3.6 X 10^6 pph @755 psig	dp corresponding to ≤3.7 X 10^6 pph @ 755 psig

__YES__ **UFSAR**

Per a review of Tables 7.2-1 and 7.4-2 of the UFSAR, Table 7.2-1 identifies this loop as having input to ESF actuation for steamline isolation (See Section 4.1.1 for a logic discussion).

__Yes__ **EOP**

Per a Review of the Emergency Operating Procedures Setpoint Database, the EOP setpoints associated with main steam flow rate are listed below:

EOP No.	Setpoint (lbm/hr)	Basis
L.7	3.6 X 10^6	High-High steam flow for automatic steam line isolation. This setpoint is used to identify that steam line isolation conditions have occurred.
L.8	0.4 X 10^6	The high steam line flow setpoint for main steam line isolation. This setpoint is used in coincidence with low T_{avg} to determine if steamline conditions have occurred.

5.1.2 Description of Process Parameter:
Under normal conditions: Reference 16, Table 5.4-2

Temperature:	556°F(T_{sat} @ 1085psig), 514°F (Full Load)
Pressure:	1085psig (Design), 781 psig (Normal)
Flow:	3.29 X 10^6pph @ 770 psig (Full load)

Under test conditions:

Same as normal conditions.

Under accident conditions, including which accidents: Main Steam Rupture.

Temperature:	≤561°F *
Pressure:	≤1140 psi *
Flow:	Dependent on rupture size and steam pressure

* Maximum lift setpoint of the main steam safety valves and corresponding saturation temperature.

5.1.3 Description of Limits

The limits of process control associated with this measured parameter are discussed and evaluated in Section 10.2.

5.2 Documenting the Environmental Conditions Associated With the Process Parameter

5.2.1 Identification of the Sensor Location:

Containment Building, Upper Level, near elevator.

5.2.2 Description of Environmental Service Conditions for the Sensor:

5.2.2.1 Normal

5.2.2.1.1 Normal Operation, Inside Containment
Reference #16 UFSAR Table 3.11-1.

Temperature:	60°F to 120°F
Pressure:	Atmospheric
Humidity:	60% Nominal
Radiation:	Less than 1 rad/hr general. Can be higher or lower near specific components.

5.2.2.1.2 During Calibration

Same as Normal Operation above.

5.2.2.2 Accident, (LOCA) Inside Containment
Reference #16 UFSAR Table 3.11-1.

Temperature:	Figure 6.1-2 (286°F maximum)
Pressure:	Figure 6.1-1 (60 psig maximum)
Humidity:	100%
Radiation:	Tables 3.11-2 and 3.11-3; $1.43X10^7$ rads gamma $2.07X10^8$ rads beta
Flooding:	7-ft (approximately) maximum submergence elevation is 242 ft 8 in.

5.2.3 Identification of Other Components Locations:
Reference Procedure No. CPI-FLO-464

Instrument	Location
FC-464A Alarm Bistable	Control Room, Reactor Protection Channel 1, Rack R2.
FM-464A Multiplier/ Divider	Control Room, Reactor Protection Channel 1, Rack R2.
FM-464B Sqrt Extractor	Control Room, Reactor Protection Channel 1, Rack R2.
FM-464C Current Repeater	Control Room, Reactor Protection Channel 1, Rack R2.
FI-464 Indicator	Control Room, MCB, Front Center Section.

5.2.4 Description of Environmental Service Conditions for Other Components:

5.2.4.1 Normal

5.2.4.1.1 Normal Operation, Main Control Room, Relay Room
Reference #16 UFSAR Table 3.11-1.

Temperature:	50°F to 104°F
Pressure:	Atmospheric
Humidity:	60% Nominal
Radiation:	Negligible

5.2.4.1.2 During Calibration

Same as Normal Operation Above.

5.2.4.2 Accident, Main Control Room
Reference #16 UFSAR Table 3.11-1.

Temperature:	Less than 104°F
Pressure:	Atmospheric
Humidity:	60% Nominal
Radiation:	Negligible
Flooding	N/A

6.0 Description of the Existing Instrument Loop Configuration

6.1 Summary of Process Measurement

6.1.1 Primary Element Information: Venturi Flow Element

Manufacturer/Model No.: SN 79870-1

Size: 30"

Specifications: Beta 0.586

Ref. # 43 Section N/A

Piping Configuration/Element Description

The venturi flow measurement device is located in the containment building, installed horizontally inline with the 30" main steam piping leaving the steam generator at elevation 314.651'.

Ref. # 40 Section N/A

6.1.2 Sensor Information - Tag No. FT-464

6.1.2.1 Manufacturer/Model No.: Foxboro/N-E11DM-HIB1-BE

Ref. # 12 Section N/A

6.1.2.2 Sensor Range (-180 to 350) psid
Ref. 26 Sec. N/A
Sensor Span (20 to 200) psid
Ref. 26 Sec. N/A

6.1.3 Sensor Environmental Limits:
Description of Limits:

Press.	85 psi	Ref.	26	Sec.	N/A
Temp.	0 to 420°F	Ref.	26	Sec.	N/A
Radiation	$2x10^8$ R TID	Ref.	26	Sec.	N/A
Humidity	No Limit	Ref.	26	Sec.	N/A

6.1.4 Associated Equipment Environmental Limits:
Reference the Appropriate EQ Block Diagram
EQ Block Diagram: Reference 13 and 29

6.2 Summary of Signal Conditioning and Output Devices:

6.2.1 Signal Conditioning/Output Device Information:

6.2.1.1

Tag #/Type	Manuf./ Model	Ref.
FC-464A	Foxboro/M63S-BR-ODHA	12
FM-464A	Foxboro/M6DR-OH1	12
FM-464B	Foxboro/M66AR-OHK	12
FM-464C	Foxboro/M66BR-OH	12
FI-464	Foxboro/65-PX-W252-V	12

6.2.1.2

Tag #	Input/Output	Ref.
FC-464A	10-50mA/ON-OFF (Digital)	5
FM-464A	(2) 10-50mA/10-50mA	5
FM-464B	10-50mA/10-50mA	5
FM-464C	10-50mA/10-50mA	5
FI-464	10-50mA/0 - 3.8 X 10^6 pph	5

6.3 Scaling

6.3.1 Performing the Conversions:

FT-464 converts 0-959.5 inches of differential water pressure on the sensing diaphragm of the flow transmitter into a 10-50mA output signal. Since the flow rate and density of the process fluid (steam) both affect the differential pressure created across the venturi flow element, the transmitter's output (to indicator FI-464) is density compensated using an input from steam generator pressure loop P468. FM-464A performs this compensation using a straight line approximation of the relationship between steam pressure and fluid density (the error associated with this approximation is discussed in section 8.5). FM-464A receives input from flow transmitter FT-464 and pressure transmitter PT-468 to produce a density compensated current output as follows:

$$I_{out} = \%H*(1.876*\%P-.0133)*40 + 10$$

where:
- I_{out} = Current out of FM-464A.
- %H = Percent full Scale Current Input from FT-464 to FM-464A.
- %P = Percent full Scale Current Input from P468 to FM-464A.

Since flow is proportional to the square root of differential pressure, FM-464B converts the 10-50 mA input signal from the multiplier/divider, FM-464A, into an output signal which is a square root function of the input signal. FM-464C serves as an isolator for the output of the square root converter and as input to flow indicator FI-464. FI-464 converts the 10-50 mA signal from current

repeater/isolator FM-464C into a flow indication of $0 - 3.8 \times 10^6$ pph.

Dual Alarm bistable FC-464A senses the 10-50 mA output of flow transmitter FT-464 and actuates at a current of ≥10.44 mA (corresponding to the differential pressure created by a steam flow of ≥ 0.4×10^6pph @ 755 psig) for High Flow Steam Line Isolation, and at ≥45.90 mA (corresponding to the differential pressure created by a steam flow of 3.6×10^6pph @755 psig) for a High-High Flow Steam Line Isolation. See Section 4.1.1 for a detailed explanation of these logic signals.

7.0 Evaluation of Existing Instrument Loop Configuration Against Documented Performance Requirements

7.1 Evaluating the Loop Configuration

7.1.1 Conformance with Design Basis Performance Requirements:

Does the existing design conform to the design basis performance requirements identified in Section 5.1.1 of the checklist?

Explain: The range, location of readout, and classification of the loop are consistent with the design basis requirements for providing both normal and post-accident indication of loop A main steam flow and, to provide safety-related input to the ESF actuation circuitry for steam line A isolation. The power for this loop is supplied by MQ-400A which is powered by class 1E bus #14 and is backed by 125V Vital Battery A this meets Regulatory Guide 1.97 requirements.

Safety Classification	- SR
Reg. 1.97	- Yes
EQ	- Yes
Seismic	- Yes
Tech. Spec.	- Yes
UFSAR	- Yes
EOP	- Yes

7.1.2 Performance of Safety Related or Safety Significant Functions:

Can the existing loop adequately perform each of its Safety Related functions (protection, control, and/or indication)?

Explain: The design of this instrument loop is adequate to provide a 0 - 3.8 X 10^6 pph flow indication of main steam line A to control room operators during both normal and post-accident conditions. Additionally, this loop will satisfactorily provide safety-related input to the ESF initiation circuitry.

7.1.3 Evaluating the Consistency of Instrument Loop Documentation

Is the loop configuration shown in the calibration procedure(s) consistent with the applicable design drawing(s)? Are component manufacturers and model numbers documented in the calibration procedure consistent with those shown on applicable design drawings? If significant inconsistencies exist, has reasonable assurance of the actual configuration been established? Have appropriate notifications been made regarding drawing changes?

Explain: The loop configuration shown in the calibration

procedure is consistent with the applicable design drawings. Model numbers have been provided on the Precalculation Instrument Checklist.

7.2 Evaluating the Loop's Measurement Capability

7.2.1 Evaluating the Range/Span:

- Is the calibrated span of the sensor and any indication devices (indicators, recorders, computer output points) broad enough to envelope all of the limits in Section 5.1.3 of the checklist?

Explain: The calibrated span of the flow transmitter and indicator is broad enough to envelope the limits and setpoints associated with this instrument loop.

7.2.2 Evaluating the Setpoint and Indicated Values vs. the Span:

Explain: The setpoint evaluation is included with the evaluation of the span/range provided in paragraph 7.2.1 above.

7.2.3 Reviewing the Units of Measure:

Are the units for the indicated values shown within the calibration procedures consistent with the EOPs?

Explain: The operator action points stated in the EOPs are in pounds mass per hour which corresponds with the scale of the control room indicator.

7.3 Evaluating the Calibration

7.3.1 Reviewing the Calibrated Components:

Is every applicable component and output calibrated?

Explain: Procedure CPI-FT-464 and CPI-FLO-464 ensures the calibration of the applicable safety-related components.

7.3.2 Reviewing the Primary Element:

Does the calibration of the sensor properly reflect the sizing of the primary element?

Explain: The sensors calibrated span (0 - 959.5" of H_2O) properly reflects the differential pressure created by main steam flow rates through venturi tube FE-464.

7.3.3 Reviewing the Direction of Interest:

Does the calibration procedure exercise the components in the direction of interest?

Explain: The transmitter and indicator are calibrated both upscale and downscale. The alarm bistable is calibrated upscale for setting and downscale for resetting.

7.3.4 Evaluating the Scaling:

Are the scaling equations and constants described in Section 6.3 and 8.3.1 of this checklist consistent with the existing system performance requirements.

Explain: The scaling equations and factors are consistent with the system performance requirements. See Section 6.3 and 8.3.1 for a more detailed discussion.

7.3.5 Evaluating Calibration Correction Factors:

Describe any calibration corrections used to account for process, environmental, installation effects or for any special design features employed by the instrument. These include corrections within the calibration process for elevation, static head, density, calibration temperatures, etc. Ensure any effect not accounted for by the calibration process is included within the determination of the total loop uncertainty (See Section 9.9).

Explain: See Section 8.3

8.0 Documentation of Loop Uncertainties

8.1 Documenting the Components of Sensor Accident Uncertainty (AEUp and AEUs)

8.1.1 Pipe Breaks

Transmitter Accident Performance - FT-464

Analysis of environmental qualification test report data on Foxboro transmitters shows significant negative bias during the simulated LOCA exposure. These effects are described and tabulated in Reference 33. Two combination of bias and random error are observed. The effects occurring during the first two hours of LOCA testing at 340°F (Ginna peak is 286°F) are tabulated below as AB_1 (bias) and $Crae_1$ (random error). These errors are considered "worst case" and are used to evaluate the appropriate setpoints. The effects occurring after this, when test temperature is 240°F, are tabulated as AB_2 (bias) and $Crae_2$ (random error). These errors can be considered applicable (and conservative) for post accident setpoints not required during the initial (first two hours) accident recovery. Worst case errors are used unless otherwise noted.

Note: The environmental limits for a LOCA envelope the environmental conditions associated with a main steam line rupture, therefore the following uncertainties are conservative.

Accident Effect	Uncertainty	Reference/Section
Temperature Effect(Te)	See $Crae_1$	N/A
Pressure Effect(Pe)	See $Crae_1$	N/A
Radiation Effect(Re)	See $Crae_1$	N/A
Steam/Chem Spray(S/Ce)	See $Crae_1$	N/A
Accident Bias(AB_1)	-11.56% Full Scale	Reference 33
Combined Random Accident Effect($Crae_1$) (per IEEE 323 tests)	±0.82% Full Scale	Reference 33
Accident Bias(AB_2)	-2.26% Full Scale	Reference 33
Combined Random Accident Effect($Crae_2$) (per IEEE 323 tests)	±1.49% Full Scale	Reference 33

8.1.2 Seismic Event

Seismic Effect	Uncertainty	Reference/Section
Pressure Transmitter FT-464 (Se_{sensor})	±1.00% Full Scale	Reference 27
Alarm Bistable FC-464A (Se_1)	±1.00% Full Scale	Reference 25
Multiplier/Divider FM-464A (Se_2)	±0.45% Full Scale	Reference 8
SQRT Extractor FM-464B (Se_3)	±1.00% Full Scale	Reference 25
Current Repeater FM-464C (Se_4)	±0.20% Full Scale	Reference 25
Flow Indicator FI-464 (Se_5)	±1.70% Full Scale	Reference 8

8.2 Documenting the Components of the Accident Current Leakage Effect (CLU)

Associated Equipment Accident Effects	Uncertainty	Reference/Section
Cable Leakage(Cl)	See Total	N/A
Splice Leakage(Sl)	See Total	N/A
Penetration Leakage(Pl)	See Total	N/A
Term Block Leakage(TBl)	See Total	N/A
Conduit Seal Leakage(CSl)	See Total	N/A
Total	Negligible	Reference 33

8.3 Determining the Components of Process Measurement Uncertainty (PMU):

8.3.1 Documenting the Components of Process Measurement Uncertainty (PMU)

Primary element accuracy and conversion of flow error to head error

Process measurement uncertainty (PMU) in differential pressure flow measurement arises from several sources; manufacturing tolerances (e.g. dimensional, finish) of the flow element, the installation tolerances (e.g. centering, bore conformity to flow axis), the uncertainty of fluid reference data related to flow

(e.g. flow coefficients, viscosity), dimensional tolerances in piping, and uncertainty in flowing fluid state variables (e.g. temperature, pressure, chemical composition). All of these effects result in flow measurement uncertainties that uniformly increase with flow rate (and differential head) and diminish as the flow rate goes to zero. This contrasts with the uncertainties associated with electronic components in the instrument loop which do not vary with flow rate or go to zero at no flow conditions. However, the net effect on total loop uncertainty is an amplification of the electronic errors at low flow rates due to error propagation through the non linear signal conditioning module (square root extractor). Certain error data is available as it applies to flow rate, while other data is published in a form directly related to head. The flow measurement uncertainty related to primary element (venturi tube) fabrication and installation tolerances is -0.2 ± 0.5 percent of indicated full flow, as specified in Reference 43.

It is desirable to directly relate flow errors to head errors. This is useful for converting errors to a common base so they can be combined. Reference 43 states that an installed error of -0.2 ± 0.5 percent of the "true" discharge coefficient is guaranteed. This is equivalent to a flow error at full flow. To convert the venturi flow error to a head error, the relationship between flow and head is used (Attachment D - refer to Section 1.2):

$$\delta Q=100*[\sqrt{(\%head+\delta he)/100}-\sqrt{\%head/100}]$$

Where:

δQ	=	Flow Error in percent
%head	=	Percent head developed (ie. at 100% flow, 100% head is developed)
δhe	=	Head Error in percent

To obtain random "primary element accuracy (Pea_R)", in terms of head error, the equation above is solved as follows[1];

$$0.5\%=100*[\sqrt{(100+\delta he)/100}-\sqrt{100/100}]$$

$$\sqrt{100+\delta he}-\sqrt{100}=0.05$$

$$\delta he=1.0\%\ Full\ Scale$$

Based on elementary fluid mechanics[2], the head error due to the various uncertainties in orifice fabrication and installation is given by:

$$\delta he = constant \times Q^2$$

so that;

$$Pea_R = 1.0 \times 10^{-4} \times Q^2$$

where the flow (Q) is in percent span.

The bias uncertainty is obtained in the same way.

$$Pea_B = -.40 \ percent\ span$$

at full flow;

$$Pea_{1B} = -0.40 \times 10^{-4} \times Q^2$$

at other flow rates.

The primary element accuracy can now be expressed in terms of the uncertainty related to head or flow. Other process measurement uncertainties are handled similarly.

(1) For more insight into this equation see Equation 2a of Attachment D, Part I, (see Section 1.2).

(2) See Equation 3 of Attachment D, Part II, (see Section 1.2).

<u>Uncertainty and bias related to primary element calibration</u>

The existing Ginna flow element calibration data is based on a single flow-differential pressure point for each orifice. For FE-464, this point is 3.8 MPPH @ 959.5 "standard"[1] inches of water. Flowing fluid temperature effects are discussed below. Calibration data was then generated using the formula:

$$Q = C\sqrt{h_w * \gamma}$$

where:

- Q = Volumetric flow rate (MPPH)
- C = Constant determined by a single point specification (3.8 MPPH, 959.5" @ 755psig)
- h_w = Differential pressure in "standard" inches of water
- γ = Flowing fluid (water) specific weight (lbm/ft³)

This calibration methodology is appropriate to the analog instrument loops used at Ginna Station, which provide flow

indication based on a single constant multiple of the square root of differential pressure. Since the discharge coefficient is essentially constant over the range of Reynolds numbers which corresponds to flow rates down to about 2 percent, this relation is an accurate model for (venturi tube) flow measurements at constant temperature.

There are certain random and systematic (bias) errors which are directly related to the Ginna calibration data and methodology (and related instrument design). These errors are described below:

(1) The calibration instrument indicates differential pressure in inches of water at 68°F.

Calibration Error

Calibration of the flow transmitter is based on a two point calibration equation (0MPPH, 0"H_2O; 3.8 MPPH, 959.5" of H_2O @ 755psig). The full flow calibration point differs from the flow element data provided by Westinghouse, Reference 43 (3.8 MPPH, 945.5" of H_2O @ 755psig). This results in a measurement bias of -14" of H_2O. Therefore:

$$Pma_{2B} = -1.48*10^{-4}*(Q)^2$$

8.3.1 Documenting the Components of Process Measurement Uncertainty (PMU)

Effect	Head Uncertainty	Ref/Section
Primary Accuracy Bias (Pma_{1B})	$-1.48*10^{-4}*(Q)^2$	Section 8.3.
Calibration Bias (Pma_{2B})	$-0.40*10^{-4}*(Q)^2$	Section 8.3
Primary Element Accuracy, Random, (Pea_R)	$\pm1.00*10^{-4}*(Q)^2$	Section 8.3

8.4 Documenting Measurement and Test Equipment Uncertainty (M&TEU)

8.4.1 Determining Measurement and Test Equipment Uncertainty (M&TEU)

8.4.1.1 Determining the Calibration Uncertainties (M&TEU):

For each component, identify the type of M&TE used for the calibration, the uncertainty attributed to the M&TE, and the associated reference/section numbers that provided the M&TE information.

Tag No	Test Equipment/Model No.
FT-464	1) One Hewlett-Packard/3466A Multimeter

Calibration of digital voltmeters per the requirements of TICP-4 (Reference 15) is ±0.1% of input (full scale) plus 1 count (insignificant)

Accuracy = ± .1% Full Scale
Sce_1 = ± .1% Full Scale

FT-464 2) Pneumatic Calibrator, Ametek Model RK1100WC or equivalent, Category II

Calibration by the Ametek pneumatic calibrator per the requirements of TICP-3 provides for a tolerance of 2 inches of water for a range up to 1000 inches of water. (Reference 9)

Accuracy = ± 2.0" of H_2O
Sce_2 = ± (2.0/959.5)*100% Full Scale
Sce_2 = ± 0.21% Full Scale

FC-464A 1) One Hewlett-Packard/3466A Multimeter

Calibration of digital voltmeters per the requirements of TICP-4 (Reference 15) is ±0.1% of input (full scale) plus 1 count (insignificant)

Accuracy = ± .1% Full Scale
Rce_1 = ± .1% Full Scale

FM-464A 1) Two Hewlett-Packard/3466A Multimeters

Calibration of digital voltmeters per the requirements of TICP-4 (Reference 15) is ±0.1% of input (full scale) plus 1 count (insignificant)

Accuracy = ± .1% Full Scale
Rce_2 = ± .2% Full Scale

FM-464B 1) Two Hewlett-Packard/3466A Multimeters

Calibration of digital voltmeters per the requirements of TICP-4 (Reference 15) is ±0.1% of input (full scale) plus 1 count (insignificant)

Accuracy = ± .1% Full Scale
Rce_3 = ± .2% Full Scale

Tag No	Test Equipment/Model No.
FM-464C	1) Two Hewlett-Packard/3466A Multimeters Calibration of digital voltmeters per the requirements of TICP-4 (Reference 15) is ±0.1% of input (full scale) plus 1 count (insignificant) Accuracy = ± .1% Full Scale Rce_4 = ± .2% Full Scale
FI-464	1) One Hewlett-Packard/3466A Multimeter Calibration of digital voltmeters per the requirements of TICP-4 (Reference 15) is ±0.1% of input (full scale) plus 1 count (insignificant) Accuracy = ± .1% Full Scale Rce_5 = ± .1% Full Scale
TP/464	1) 10Ω Test Resistor TP/464 is used as a calibration point to convert the 10 - 50 mADC signal from the current generator into a 100 - 500 mVDC test point for monitoring. Rce_6 =±1.0% Full Scale; Assumption 1
TP/464A	1) 10Ω Test Resistor TP/464A is used as a calibration point to convert the 10 - 50 mADC signal from the current generator into a 100 - 500 mVDC test point for monitoring. Rce_7 =±1.0% Full Scale; Assumption 1
TP/464B	1) 10Ω Test Resistor TP/464B is used as a calibration point to convert the 10 - 50 mADC signal from the current generator into a 100 - 500 mVDC test point for monitoring. Rce_8 =±1.0% Full Scale; Assumption 1
TP/464C	1) 10Ω Test Resistor TP/464C is used as a calibration point to convert the 10 - 50 mADC signal from the current generator into a 100 - 500 mVDC test point for monitoring. Rce_9 =±1.0% Full Scale; Assumption 1

Tag No	Test Equipment/Model No.
TP/468	1) 10Ω Test Resistor TP/468 is used as a calibration point to convert the 10 - 50 mADC signal from the current generator into a 100 - 500 mVDC test point for monitoring.

Rce_{10} =±1.0% Full Scale; Assumption 1

M&TEU	Uncertainty	Reference/Section
Sensor Calibration Effect FT-464 (Sce_1)	±0.10% Full Scale	This Calc/Sec 8.4
Sensor Calibration Effect FT-464 (Sce_2)	±0.21% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect FC-464A (Rce_1)	±0.10% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect FM-464A (Rce_2)	±0.20% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect FM-464B (Rce_3)	±0.20% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect FM-464C (Rce_4)	±0.10% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect FI-464 (Rce_5)	±0.10% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect TP/464 (Rce_6)	±1.00% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect TP/464A (Rce_7)	±1.00% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect TP/464B (Rce_8)	±1.00% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect TP/464C (Rce_9)	±1.00% Full Scale	This Calc/Sec 8.4
Rack Equipment Calibration Effect TP/468 (Rce_{10})	±1.00% Full Scale	This Calc/Sec 8.4

8.5 Documenting Rack Equipment Uncertainty (REU)

REU	Uncertainty	Reference/Section
Rack Equipment Accuracy FC-464A (Rea_1)	±0.50% Full Scale	Reference 22
Rack Equipment Accuracy FM-464A (Rea_2)	±0.50% Full Scale	Reference 34
Rack Equipment Accuracy FM-464B (Rea_3)	±0.50% Full Scale	Reference 23
Rack Equipment Accuracy FM-464C (Rea_4)	±0.50% Full Scale	Reference 24
Rack Equipment Accuracy FI-464 (Rea_5)	±1.50% Full Scale	Reference 7
Rack Temperature Effect (Rte)	Negligible	Assumption 1
Rack Power Supply Effect (Rpse)	Negligible	Assumption 3
Readability (Rme_1)	±1.32% Full Scale	Reference 46

8.6 Documenting Sensor Uncertainty (SU)

Sensor Temperature Effect

Ste = ±1% (ΔT Design Temp. of Bldg. / 110° F [Ref. 27, Assumption 2])
Ste = ±.01 (30°F / 110°F)
Ste = ±.27% Full Scale

SU	Uncertainty	Reference/Section
Sensor Accuracy (Sa)	±0.65% Full Scale *	Reference 26
Sensor Static Pressure Effect (Sspe)	±0.27% Full Scale **	Reference 44
Sensor Temperature Effect (Ste)	±0.27% Full Scale	This Calc/Sec 8.6
Sensor Power Supply Effect (Spse)	Negligible	Assumption 3
Sensor Miscellaneous Effect (Sme)	N/A	N/A

* Includes the effects of reproducibility ±.15% and accuracy of ±.5%. Note reproducibility includes hysteresis, repeatability, deadband and drift over a one hour period.

** Based on a design SG pressure of 1085 psig and a 1.5% pressure effect corresponding with a pressure variation of 6000 pounds (Ref. 44).

8.7 Documenting Drift Uncertainty (DU)

DU	Uncertainty	Reference/Section
Sensor Drift(Sd)	±0.50% Full Scale	Assumption 1
Rack Equipment Drift (Red_1) Path 1	±1.00% Full Scale	Assumption 1
Rack Equipment Drift (Red_2) Path 2	±0.25% Full Scale	Assumption 1
Rack Equipment Drift (Red_3) Path 2	±0.75% Full Scale	Assumption 1

8.8 Documenting Tolerance Uncertainty (TU)

TU	Uncertainty	Reference/Section
Sensor Tolerance Effect FT-464 (St)	±1.00% Full Scale	Reference 4
Rack Equipment Tolerance FC-464A (Ret_1)	±1.00% Full Scale	Reference 5
Rack Equipment Tolerance FM-464A (Ret_2)	±1.00% Full Scale	Reference 5
Rack Equipment Tolerance FM-464B (Ret_3)	±1.00% Full Scale	Reference 5
Rack Equipment Tolerance PM-464C (Ret_4)	±1.00% Full Scale	Reference 5
Rack Equipment Tolerance FI-464 (Ret_5)	±2.00% Full Scale	Reference 5

9.0 Loop Uncertainty Evaluation

Note: The following loop evaluation is performed using uncertainties measured in percent full scale.

Density Compensation Error Analysis

In evaluating the loop uncertainty for the density compensated main steam line A flow rate indication, it is necessary to evaluate the signal conditioning performed by FM-464A (multiplier/divider) to determine its affect on loop uncertainty. The signal conditioning performed by this device, as discussed in section 6.3, is shown below:

$$\%I_{out} = \%H*(1.876*\%P-.0133)$$

where:
- $\%I_{out}$ = Current out of FM-464A.
- $\%H$ = Percent full scale head input from FT-464 to FM-464A.
- $\%P$ = Percent full scale pressure input from P468 to FM-464A.

The output uncertainty associated with the above signal conditioning device can be derived using a simplified signal conditioning modeling equation. This is shown below:

$$C = A(K_1*B + K_2)$$

where:
- $K_{1 \text{ and } 2}$ = constants
- A,B = Variables
- C = Output as a function of A and B

The derivation of the resultant full scale error "c" with input uncertainties "a" and "b" is performed below:

$$C + c = (A+a)*(K_1*(B + b) + K_2)$$

$$C + c = A*((K_1B + K_1b) + K_2) + a*((K_1B +K_1b) + K_2)$$

Combining terms:

$$C + c = (AK_1B + AK_2) + (AK_1b + aK_1B + aK_1b + aK_2)$$

Substituting C for $(AK_1B + AK_2)$:

$$C + c = C + (AK_1b + aK_1B + aK_1b + aK_2)$$

Therefore:

$$c = (AK_1b + aK_1B + aK_1b + aK_2)$$

Note: aK_1b is the product of two errors; this term is negligible. The above equation represents the uncertainty associated with the output of the simplified signal conditioning equation. The

uncertainty associated with the output of density compensation module FM-464A is obtained by performing the following substitutions:

$A = \%H \quad a = \%H_e$
$B = \%P \quad b = \%P_e$
c = Output uncertainty

Therefore:

$$c = K_1(\%H * \%P_e) + \%H_e[(K_1*\%P + K_2)]$$

where: $\%P_e$ = Multiplier input uncertainty from SG pressure loop P468
$\%H_e$ = Multiplier input uncertainty from SG flow loop F464

Using the SRSS methodology this error equation can be written as:

$$c = [(K_1 * \%H * \%P_e)^2 + \%H_e^2(K_1 * \%P + K_2)^2]^{(1/2)}$$

By accumulating the errors prior to the multiplier/divider and processing them through the above equation, the corrected uncertainty out of the multiplier/divider is obtained.

Flow Measurement Error Analysis

The sources of uncertainty in flow rate measurement fall into two categories, with respect to flow rate itself. As discussed in Section 8.3, errors due to primary element fabrication and installation tolerances, and uncertainty in the flowing fluid parameters (Process Measurement Uncertainties) are functions of flow rate. These process measurement errors (PMUs) tend to be significant (and may dominate) the total loop uncertainty at high flows, and become less significant, and finally drive toward zero at very low flows. This contrasts with the uncertainties associated with electronic components in the instrument loop which do not vary with flow rate or go to zero at no flow conditions. The net effect on total loop uncertainty associated with electronic components is an amplification of the electronic errors at low flow rates due to error propagation through the non linear signal conditioning module (square root extractor).

In addition, differential pressure flow measurement instrument loops contain a non-linear signal processing element (the square root extractor) due to the relation between flow rate and differential pressure. This presents a problem in combining errors from different sources because uncertainties that are approximately normally distributed in the input signal to a non-linear device, are not normally distributed in the output signal. The validity of combining uncertainty estimates using the square root of the sum of the squares (sometimes called the SRSS "method"), depends fundamentally on linear processing. This problem is sometimes avoided by approximating the characteristic

curve of non-linear devices by truncating the Taylor expansion at the first derivative (linearizing). For flow loops, this method can only be used with accuracy for errors at flow rates that are high relative to the instrument span. It is appropriately used in some process measurement calculations when the concern is only for errors near specific setpoints in the high flow region of the instrument span.

In these analyses, uncertainties are processed through the square root extractor using the general relation below which is documented in Reference 45 (Table 1 of Section 6.3.2 of draft report ISA-RP67.04, Part II).

$$\%F_e = 100 * [\sqrt{(\%h + h_e)/100} - \sqrt{\%h/100}]$$

where:
- F_e = Flow error in percent span
- h = Head in percent span
- h_e = Head error in percent span

All uncertainties that affect the measurement signal prior to the input of the square root extractor are treated as head errors (converted from flow error, if necessary). Errors that affect the output signal of the square root extractor, including the accuracy of the square root module itself, are processed linearly and can normally be combined using SRSS.

Data Processing

In order to accommodate the variability of uncertainties over the flow span, perform the non-linear transformations, and avoid a large volume of manual arithmetic, a computer program using the advanced spreadsheet environment (QUATTRO PRO) is used to process data. Data for the stated percent flow are listed in the following sections for reference and verification purposes. Graphical representation of flow indication uncertainty over the entire flow span is shown in Figure 2. Computer program documentation is provided in Attachment C.

Instrument Error Analysis Paths

Instrument loop flow paths to be evaluated.

Path 1 Uncertainties affecting the output of FC-464A
Flow 94.7% Full Scale

Path 2 Uncertainties affecting the output of FI-464.
Flow 87% Full Scale

9.1 Process Measurement Uncertainty (PMU)

Path 1

Biases will be accounted for in Section 9.9.

$$PMU = (Pea)$$

$$PMU = \pm 0.90\%$$

Path 2

Biases for path 2 require insertion into error equations defined in Section 9.0 for both the multiplier/divider and the square root extractor. The calculated values of biases associated with this uncertainty path are stated in section 9.9.

$$PMU = (Pea)$$

$$PMU = \pm 0.76\%$$

9.2 Measurement and Test Equipment Uncertainty (M&TEU)

Path 1

$$M\&TEU = \pm[(Sce_1)^2 + (Sce_2)^2 + (Rce_1)^2 + (Rce_6)2]^{1/2}$$

$$M\&TEU = \pm[(0.10)^2 + (0.21)^2 + (0.10)^2 + (1.00)^2]^{1/2}$$

$$M\&TEU = \pm 1.03\%$$

Path 2

Input side of multiplier/divider

$$M\&TEUmi = \pm[(Sce_1)^2 + (Sce_2)^2 + (Rce_6)^2 + (Rce_{10})^2]^{1/2}$$

$$M\&TEUmi = \pm[(0.10)^2 + (0.21)^2 + (1.00)^2 + (1.00)^2]^{1/2}$$

$$M\&TEUmi = \pm 1.43$$

Output of multiplier/divider input side of square root extractor

$$M\&TEUi = \pm[(Rce_2)^2 + 2*(Rce_7)^2]^{1/2}$$

$$M\&TEUi = \pm[(0.20)^2 + 2*(1.00)^2]^{1/2}$$

$$M\&TEUi = \pm 1.43$$

Output side of square root extractor

$$M\&TEUo = \pm[(Rce_3)^2 + (Rce_4)^2 + (Rce_5)^2 + 2*(Rce_8)^2 + 2*(Rce_9)^2]^{1/2}$$

$$M\&TEUo = \pm[(0.20)^2 + (0.10)^2 + (0.10)^2 + 2*(1.00)^2 + 2*(1.00)^2]^{1/2}$$

$$M\&TEUo = \pm 2.01$$

9.3 Determining the Accident Environmental Uncertainties (AEU)

For Pipe Breaks:

$$AEUp = \pm[(Crae_1)^2]^{1/2} + AB$$

$$AEUp = \pm[(0.82)^2]^{1/2} + (-11.56)$$

$$AEUp = \pm 0.82\% + (-11.56)\%$$

For Seismic Events:

Path 1

$$AEUs = \pm[(Se_{sensor})^2 + (Se_1)^2]^{1/2}$$

$$AEUs = \pm[(1.00)^2 + (1.00)^2]^{1/2}$$

$$AEUs = \pm 1.41\%$$

Path 2

Input side of multiplier/divider

$$AEUsmi = \pm[(Se_{sensor})^2]^{1/2}$$

$$AEUsmi = \pm[(1.00)^2]^{1/2}$$

$$AEUsmi = \pm 1.00$$

Output of multiplier/divider input side of square root extractor

$$AEUsi = \pm[(Se_2)^2]^{1/2}$$

$$AEUsi = \pm[(0.45)^2]^{1/2}$$

$$AEUsi = \pm 0.45$$

Output of square root extractor

$AEUso = \pm[(Se_3)^2 + (Se_4)^2 + (Se_5)^2]^{1/2}$

$AEUso = \pm[(1.00)^2 + (0.20)^2 + (1.70)^2]^{1/2}$

$AEUso = \pm1.98$

9.4 Accident Current Leakage Effect (CLU)

Path 1-2

CLU = Negligible (Reference 33)

9.5 Rack Equipment Uncertainty (REU)

Path 1

$REU = \pm[(Rea_1)^2]^{1/2}$

$REU = \pm[(0.50)^2]^{1/2}$

$REU = \pm\ 0.50\%$

Path 2

Input side of multiplier/divider

There are no rack components prior to the multiplier/divider module FM-464A.

Output of multiplier/divider input side of square root extractor

$REUi = \pm[(Rea_2)^2 + (Rme_1)^2]^{1/2}$

$REUi = \pm[(0.50)^2 + (1.32)^2]^{1/2}$

$REUi = \pm\ 0.50$

Output of square root extractor

$REUo = \pm[(Rea_3)^2 + (Rea_4)^2 + (Rea_5)^2 + (Rme_2)^2]^{1/2}$

$REUo = \pm[(0.50)^2 + (0.50)^2 + (1.50)^2 + (1.32)^2]^{1/2}$

$REUo = \pm\ 2.12$

9.6 Sensor Uncertainty (SU)

Path 1-2

$SU = \pm[(Sa)^2 + (Sspe)^2 + (Ste)^2]^{1/2}$

$SU = \pm[(0.65)^2 + (0.27)^2 + (0.27)^2]^{1/2}$

$SU = \pm 0.76\%$

9.7 Drift Uncertainty (DU)

Path 1

$DU = \pm[(Sd)^2 + (Red_1)^2]^{1/2}$

$DU = \pm[(0.50)^2 + (1.00)^2]^{1/2}$

$DU = \pm 1.12\%$

Path 2

Input side of multiplier/divider

$DUmi = \pm[(Sd)^2]^{1/2}$

$DUmi = \pm[(0.50)^2]^{1/2}$

Output of multiplier/divider input side of square root extractor

$DUi = \pm[(Red_2)^2]^{1/2}$

$DUi = \pm[(0.25)^2]^{1/2}$

$DUi = \pm 0.25$

Output of square root extractor

$DUo = \pm[(Red_3)^2]^{1/2}$

$DUo = \pm[(0.75)^2]^{1/2}$

$DUo = \pm 0.75$

9.8 Tolerance Uncertainty (TU)

Path 1

$TU = \pm[(St_1)^2 + (Ret_1)^2]^{1/2}$

$TU = \pm[(1.00)^2 + (1.00)^2]^{1/2}$

$TU = \pm 1.41\%$

Path 2

Input side of multiplier/divider

$TUmi = \pm[(St_1)^2]^{1/2}$

$TUmi = \pm[(1.00)^2]^{1/2}$

$TUmi = \pm 1.00\%$

Output of multiplier/divider input side of square root extractor

$TUi = \pm[(Ret_2)^2]^{1/2}$

$TUi = \pm[(1.00)^2]^{1/2}$

$TUi = \pm 1.00$

Output of square root extractor

$TUo = \pm[(Ret_3)^2 + (Ret_4)^2 + (Ret_5)^2]^{1/2}$

$TUo = \pm[(1.00)^2 + (1.00)^2 + (2.00)^2]^{1/2}$

$TUo = \pm 2.45$

9.9 Calculating the Total Loop Uncertainties

Provide the total loop uncertainty (TLU) for each end device for normal, seismic and accident conditions, as applicable.

<u>TLU Normal</u>

Path 1

$TLU = \pm (M\&TEU^2 + REU^2 + SU^2 + DU^2 + TU^2 + PMU^2)^{1/2} + PMU_{biases}$

$TLU = \pm (1.03^2 + 0.50^2 + 0.76^2 + 1.12^2 + 1.41^2 + 0.90^2)^{1/2} + PMU_{biases}$

| $TLU(+) = (2.437) + Pma_{1B} + Pma_{2B}$

| $TLU(-) = -(2.437) + Pma_{1B} + Pma_{2B}$

$TLU(+) = (2.437) + (-1.33) + (-0.36)$

$TLU(-) = -(2.437) + (-1.33) + (-0.36)$

$TLU(+) = 0.74\%$

$TLU(-) = -4.13\%$

Path 2

Input side of multiplier/divider

$MDIU = \pm (M\&TEUmi^2 + REUmi^2 + SU^2 + DUmi^2 + TUmi^2 + PMU^2)^{1/2}$

$MDIU = \pm (1.43^2 + NA^2 + 0.76^2 + 0.50^2 + 1.00^2 + 0.76^2)^{1/2}$

$MDIU = \pm 2.11$

Output side of multiplier/divider

$MDOU = \pm 3.40$ (See Section 9.0)

Input side of square root extractor

$SRIU = \pm (M\&TEUi^2 + REUi^2 + DUi^2 + TUi^2 + MDOU^2)^{1/2}$

$SRIU = \pm (1.43^2 + 0.50^2 + 0.25^2 + 1.00^2 + 3.40^2)^{1/2}$

$SRIU = \pm 3.86$

Output of square root extractor

$SROU = 2.19$ (See Section 9.0)

Output side of square root extractor

$SRSS = \pm (M\&TEUo^2 + REUo^2 + DUo^2 + TUo^2)^{1/2}$

$SRSS = \pm (2.01^2 + 2.12^2 + 0.75^2 + 2.45^2)^{1/2}$

$SRSS = \pm 3.89$

Total Loop Uncertainty

$TLU(-) = \pm(SROU^2 + SRSS^2)^{1/2} + TLU_B$

$TLU(+) = \pm(SROU^2 + SRSS^2)^{1/2} + TLU_B$

$TLU(-) = -(2.19^2 + 3.89^2)^{1/2} + (-1.03)$

$TLU(+) = (2.19^2 + 3.89^2)^{1/2} + (-1.03)$

$TLU(-) = -5.50$

$TLU(+) = 3.43$

TLUa Accident

Path 1

$$TLUa = CLU \pm (AEUp^2 + M\&TEU^2 + REU^2 + SU^2 + DU^2 + TU^2 + PMU^2)^{1/2} + PMU_{biases} + AB$$

$$TLUa = 0.00 \pm (0.82^2 + 0.50^2 + 0.76^2 + 1.12^2 + 1.41^2 + 1.19^2)^{1/2} + PMU_{biases} + AB$$

TLUa(+) = 0.45%

TLUa(-) = -16.48%

Path 2

Input side of multiplier/divider

$$MDIU = \pm (AEUP^2 + M\&TEUmi^2 + REUmi^2 + SU^2 + DUmi^2 + TUmi^2 + PMU^2)^{1/2}$$

$$MDIU = \pm (1.49^2 + 1.43^2 + NA^2 + 0.76^2 + 0.50^2 + 1.00^2 + 0.76^2)^{1/2}$$

MDIU = ± 2.26

Output side of multiplier/divider

MDOU = ±3.51 (See Section 9.0)

Input side of square root extractor

$$SRIU = \pm (M\&TEUi^2 + REUi^2 + DUi^2 + TUi^2 + MDOU^2)^{1/2}$$

$$SRIU = \pm (1.43^2 + 0.50^2 + 0.25^2 + 1.00^2 + 3.51^2)^{1/2}$$

SRIU = ± 3.96

Output of square root extractor

SROU = 2.25 (See Section 9.0)

Output side of square root extractor

$SRSS = \pm (M\&TEUo^2 + REUo^2 + DUo^2 + TUo^2)^{1/2}$

$SRSS = \pm (2.01^2 + 2.12^2 + 0.75^2 + 2.45^2)^{1/2}$

$SRSS = \pm 3.89$

Total Loop Uncertainty

$TLU(-) = \pm(SROU^2 + SRSS^2)^{1/2} + TLU_B + AB$

$TLU(+) = \pm(SROU^2 + SRSS^2)^{1/2} + TLU_B$

$TLU(-) = -(2.25^2 + 3.89^2)^{1/2} + (-1.03) + (-18.60)$

$TLU(+) = (2.25^2 + 3.89^2)^{1/2} + (-1.03)$

$TLU(-) = -24.12$

$TLU(+) = 3.46$

TLUs Seismic

Path 1

$TLUs = \pm (AEUs^2 + M\&TEU^2 + REU^2 + SU^2 + DU^2 + TU^2 + PMU^2)^{1/2} + PMU_{biases}$

$TLUs = \pm (1.41^2 + 1.03^2 + 0.50^2 + 0.76^2 + 1.12^2 + 1.41^2 + 1.19^2)^{1/2} + PMU_{biases}$

$TLUs(+) = (2.92) + PMU_B$

$TLUs(-) = -(2.92) + PMU_B$

$TLUs(+) = 0.69\%$

$TLUs(-) = -5.16\%$

Path 2

Input side of multiplier/divider

$MDIU = \pm (AEUs^2 + M\&TEUmi^2 + REUmi^2 + SU^2 + DUmi^2 + TUmi^2 + PMU^2)^{1/2}$

$MDIU = \pm (1.00^2 + 1.43^2 + NA^2 + 0.76^2 + 0.50^2 + 1.00^2 + 0.76^2)^{1/2}$

$MDIU = \pm 2.33$

Output side of multiplier/divider

MDOU = ±3.56 (See Section 9.0)

Input side of square root extractor

$$SRIU = \pm(AEUsi^2 + M\&TEUi^2 + REUi^2 + DUi^2 + TUi^2 + MDOU^2)^{1/2}$$

$$SRIU = \pm\ (0.45^2 + 1.43^2 + 0.50^2 + 0.25^2 + 1.00^2 + 3.51^2)^{1/2}$$

$$SRIU = \pm\ 4.00$$

Output of square root extractor

SROU = 2.27 (See Section 9.0)

Output side of square root extractor

$$SRSS = \pm\ (AEUs^2 + M\&TEUo^2 + REUo^2 + DUo^2 + TUo^2)^{1/2}$$

$$SRSS = \pm\ (1.98^2 + 2.01^2 + 2.12^2 + 0.75^2 + 2.45^2)^{1/2}$$

$$SRSS = \pm\ 3.89$$

Total Loop Uncertainty

$$TLU(-) = \pm(SROU^2 + SRSS^2)^{1/2} + TLU_B$$

$$TLU(+) = \pm(SROU^2 + SRSS^2)^{1/2} + TLU_B$$

$$TLU(-) = -(2.27^2 + 3.89^2)^{1/2} + (-1.03)$$

$$TLU(+) = (2.27^2 + 3.89^2)^{1/2} + (-1.03)$$

$$TLU(-) = -5.54$$

$$TLU(+) = 3.47$$

Where:
- TLUs = The Total Loop Uncertainty Seismic
- TLUa = The Total Loop Uncertainty Accident
- CLU = Current Leakage Uncertainty
- AEUs = Accident Environmental Uncertainty (Seismic)
- AEUp = Accident Environmental Uncertainty (Pipe Break)
- PMU = Process Measurement Uncertainty
- REU = Rack Equipment Uncertainty
- SU = Sensor Uncertainty
- DU = Drift Uncertainty
- TU = Tolerance Uncertainty
- M&TEU= Measurement and Test Equipment Uncertainty

MDIU = Uncertainty in equipment prior to the multiplier/divider
MDOU = Uncertainty out of the multiplier/divider
SRIU = Uncertainty in equipment prior to the square root converter (Head Error)
SROU = Uncertainty in equipment prior to the square root converter (Flow Error)
SRSS = Uncertainty in equipment including and after the square root converter (Flow Error)

End Device	Normal	Seismic TLU	Acc. TLU
Path 1 - 12.1% Full Flow			
FC-464A	-2.29% (low)	-14.00% (low)	-2.70% (low)
	+2.24% (high)	+2.38% (high)	+2.64% (high)
Path 1 - 94.7% Full Flow			
FC-464A	-4.13% (low)	-5.16% (low)	-16.48% (low)
	+0.747% (high)	+0.69% (high)	+0.45% (high)
Path 2			
FI-464	-5.50% (low)	-5.54% (low)	-24.12% (low)
	+3.43% (high)	+3.47% (high)	+3.46% (high)

9.10 Comparing the Reference Accuracy vs. the Calibration Tolerance

From the calibration procedure(s), identify the calibration tolerance associated with each component. Next, obtain the reference accuracy associated with each component. Translate both effects into the equivalent units. Ensure that the calibration tolerance is greater than or equal to the reference accuracy for each component.

Tag No.	Reference Accuracy	Calibration Tolerance
FT-464	0.65%	1.00%
FC-464A	0.50%	1.00%
FM-464A	0.50%	1.00%
FM-464B	0.50%	1.00%
FM-464C	0.50%	1.00%
FI-464	1.50%	2.00%

Therefore, the calibration is acceptable.

10.0 Setpoint Evaluations

10.1 Assigning the Limits

For each instrument function, identify the associated limits and limit type.

Output Device	Limit Value	Type of Limit
FI-464 (L.7)	3.6×10^6 pph (Inc)	Operational
FI-464 (L.8)	0.4×10^6 pph (Inc)	Operational
FC-464A	3.7×10^6 pph (Inc)	Analytical
FC-464A	0.55×10^6 pph (Inc)	Analytical

EOP Setpoints L.7 and L. 8 are operational setpoints with no basis that need verification. Additionally, normal instrument channel uncertainties, shown in Figure 1.0 (Conclusion; Section 11.0) of this evaluation, will cause no operational concerns.

High High Steam Flow Isolation

dp corresponding to 3.7×10^6 pph at 755 psig = 910" of H_2O:

Maximum Acceptable Setpoint = Limit - TLU

= 910" of H_2O - (0.0413*959.5)" ofH_2O

= 870" of H_2O

The actual setpoint of FC-464A for the High-High steam flow trip is 45.9 mA which corresponds to a differential pressure of 861.5" of H_2O. This setpoint is below the maximum allowable setpoint and is therefore acceptable.

High Steam Flow Isolation with Low T_{avg}

dp corresponding to 0.55×10^6 pph at 755 psig = 20.1" of H_2O:

Maximum Acceptable Setpoint = Limit - TLU

= 20.1" of H_2O - (0.0229*959.5)" of H_2O

= -1.87" of H_2O

The actual setpoint of FC-464A for the High steam flow trip is 10.44 mA which corresponds to a differential pressure of 10.55" of H_2O. This is above the maximum setpoint calculated above, and therefore this setpoint is not acceptable. PCAQ 94-067 was issued to address this concern. Per Reference 47, the maximum allowable limit will be changed to $.66 \times 10^6$ ppm @ 1005 psig. PCAQ 94-067 is resolved in Attachment 1.

Temperature Allowable Value

Tech Spec Table 3.3.2-1 identifies the setpoint for the High Steam Flow with low T_{avg} as having a setpoint of 545°F with an allowable temperature of ≥543°F. The uncertainty in T_{avg} (TC-401A) is ±1.77°F (DA EE-92-091-21), therefore, this setpoint is acceptable. PCAQ 94-068 was originally initiated due to low existing margin, however, subsequent instrument drift studies have shown that uncertainty values are conservative. PCAQ 94-068 is therefore considered resolved.

10.2 Evaluating the Setpoint(s):

Compare the existing setpoint, reset point or indicated value within the calibration procedure with the maximum or minimum acceptable setpoint.

Output Device	Setpoint (INC/DEC)	Acceptable Setpoint
FC-464A	861.5 " of H_2O (Inc)	863.9" of H_2O (Inc)
FC-464A	10.55" of H_2O (Inc)	0" of H_2O

11.0 Conclusion

A review of the instrument loop performance requirements against the existing loop configuration for F464 was conducted by this evaluation. The results of this review determined the safety related instrument channel F464 will provide satisfactory main steam flow indication, however the setpoint associated with ESF input for high steam line isolation required further review.

A review of the adequacy of the calibration activities and calibration procedure CPI-FT-464, "Calibration of Steam Generator A Steam Flow Pressure Transmitter FT-464" and calibration procedure CPI-FLO-464, "Calibration of Steam Generator A Steam Flow Loop 464 Rack Instrumentation", was also conducted under this Instrument Loop Performance Evaluation. All applicable safety related components are adequately calibrated up and downscale using correct calibration techniques.

The normal and accident total loop uncertainties for the steam generator flow indicator is graphically shown in Figure 1. These uncertainties are considered acceptable causing no operational concerns.

The high flow and high-high flow steam line isolation inputs were evaluated in Section 10.1 of this calculation. The High-High steam flow isolation setpoint was found to be acceptable. The High steam flow with low T_{avg} isolation setpoints required further review. Per Reference 47 and Attachment 1, a new maximum allowable limit for this setpoint has been specified, and the existing setpoint has been shown to be acceptable.

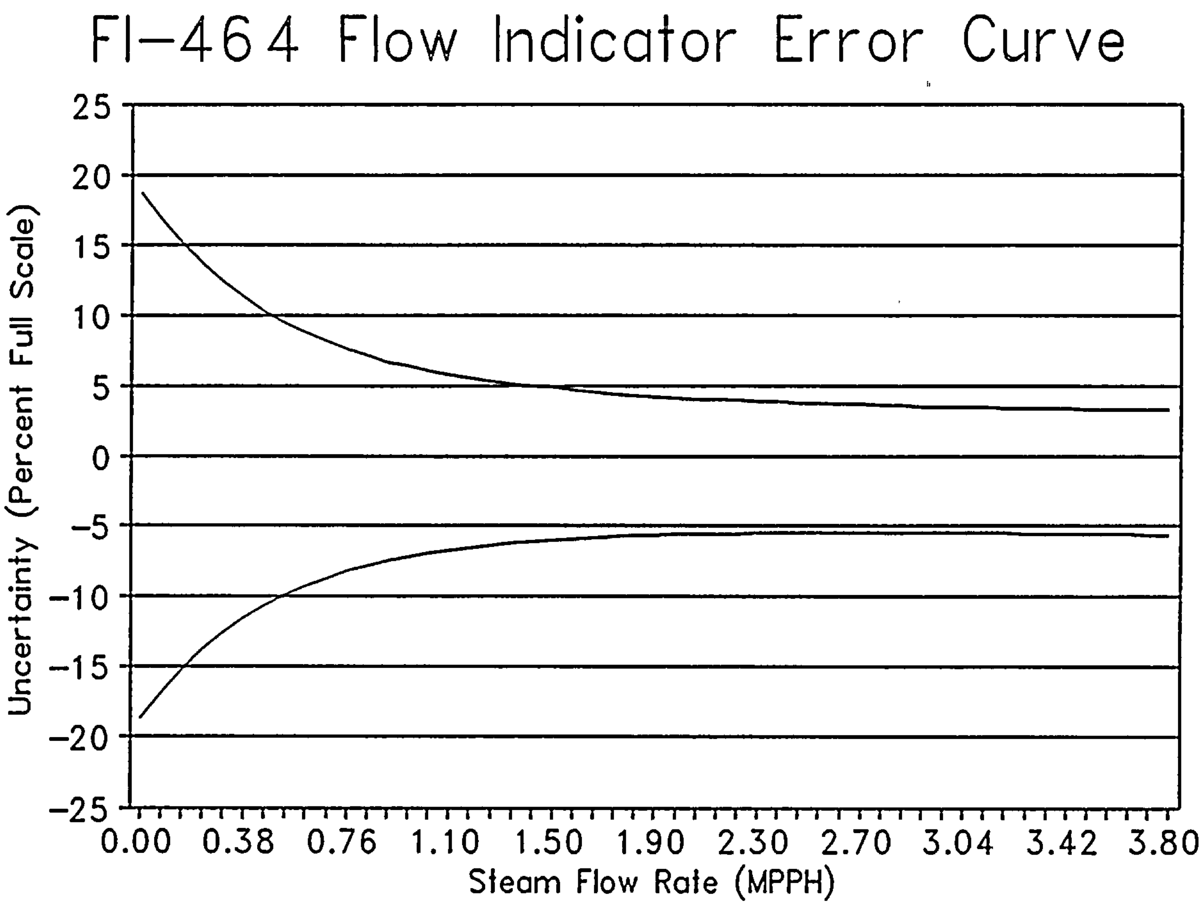

FI-464 Flow Indicator Error Curve
Uncertainty (Percent Full Scale)
25
20
15
10
5
0
-5
-10
-15
-20
-25
0.00
0.38
0.76
1.10
1.50
1.90
2.30
2.70
3.04
3.42
3.80
Steam Flow Rate (MPPH)

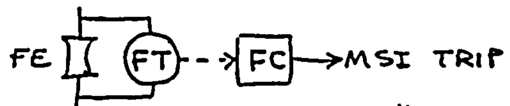
Figure 2.0

RESOLUTION OF PCAQ 94-067; MSI on HIGH STEAM FLOW WITH LOW TAVG

Using historical calibration data documented in DA EE-95-109, the individual uncertainty terms for FT-464 and FC-464A/B can be replaced with a single total uncertainty value:

FT-464 = ±.95% and FC-464A/B = ±.51%

The total uncertainty of the High Steam Flow setpoint for MSI is:



(FE = ±0.9%)

$TLU = \pm(FE^2 + FT^2 + FC^2)^{1/2}$ + Process Biases

$TLU = \pm(.9^2 + .95^2 + .51^2)^{1/2}$ + Process Biases

$TLU = \pm 1.40$ + Process Biases

Process Biases = $P_{MA1B} + P_{MA2B} = [-1.48E^{-4} \times (\%\ \text{full flow})^2] + [-.4E^{-4} \times (\%\ \text{full flow})^2]$

EVALUATE FOR A SF SETPOINT OF 0.4 MPPH (12.1% full flow)

$TLU = \pm 1.40 + (-1.48E^{-4} \times 12.1^2) + (-.4E^{-4} \times 12.1^2) = \pm 1.40 + (-.0022)$

$TLU = +1.396\%$

-1.402%) Total Uncertainty in direction of interest

0.4 MPPH CONVERT TO DP: $DP = 66.45(SF\ pph)^2 = 66.45(.4)^2 =$ 10.63 INWC

TLU = 1.402% of DP span = $\frac{959.5\ \text{INWC}}{100\ \%} \times 1.402\% =$ 13.45 INWC

NEW MAX. ALLOWABLE VALUE FROM REFERENCE 47 = .66 mpph = 28.95 INWC

Setpoint + TLU = 10.63 + 13.45 INWC = 24.08 INWC

24.08 INWC IS LESS THAN 28.95 INWC LIMIT, THEREFORE, ACCEPTABLE.