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NUCLEAR GENERATION GROUP

RNP-I/INST-1135

Nuclear Instrumentation Intermediate Range Error Analysis

☐ BNP UNIT ____ ☐ CR3 ☐ HNP ☒ RNP ☐ NES ☐ ALL

APPROVAL

REV	PREPARED BY	REVIEWED BY	SUPERVISOR
0	Signature Signature on File Name Date	Signature Signature on File Name Date	Signature Signature on File Name Date
1	Signature Name James Snelson Date 2/11/03	Signature Name C.B. Holland Date 2/11/03	Signature Name T.L. Sherwood Date 02/11/03

(For Vendor Calculations)

Vendor ____________________ Vendor Document No. ____________

Owner's Review By ____________________ Date ____________

List of Effective Pages

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Revision Summary

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REVISION 1

Rev. #	Revision Summary (list ECs incorporated)
0	Original issue of calculation.
1	Correct minor errors in calculation and place in standard format

1.0 PURPOSE

The objective of this calculation is to determine the instrument loop uncertainties for the Intermediate Range Nuclear Instrumentation System (NIS) High Neutron Flux Trip and Permissive P6. This calculation will provide assurance that the trip settings occur within the limits established by Technical Specifications.

The following instruments are within the scope of this calculation:

Channel N-35

Detector Assembly	NE-35
Excore NIS Intermediate Range Drawer 35	N-35
Reactor Turbine Generator Board (RTGB) Indication	NI-35B
Reactor Turbine Generator Board (RTGB) Recorder	NR-45

Channel N-36

Detector Assembly	NE-36
Excore NIS Intermediate Range Drawer 36	N-36
Reactor Turbine Generator Board (RTGB) Indication	NI-36B
Reactor Turbine Generator Board (RTGB) Recorder	NR-45

2.0 FUNCTIONAL DESCRIPTION

The Intermediate Range NIS channels consist of two independently operating channels designated as N-35 and N-36. Each channel receives a signal from a compensated ion gas chamber detector. The detector is compensated to remove the effects of gamma radiation and provide a clean neutron signal. The detector's output signal is a current in the range of 10^{-11} to 10^{-3} amperes. The detector signal is then processed by the electronic modules within the Intermediate Range Drawer, which provides indication and bistable trip outputs.

2.1 NORMAL FUNCTION

The primary function of the Intermediate Range NIS channels are to monitor the neutron flux and provide protection for the reactor by generating appropriate trips and alarms. These channels overlap with both the Source Range and Power Range channels. The Intermediate Range Reactor Trip serves as a backup for the Power Range Low Power Trip at lower power levels (≤ 25%). At power, the Intermediate Range can serve as a backup to Power Range for indication purposes only. These channels also provide a Permissive (P6) for de-energization of the source range detectors and block of the Source Range Trip. The channels also provide a control function input to the Rod Control System (Rod Stop).

2.2 ACCIDENT MITIGATING FUNCTION

The Intermediate Range NIS channels are not required for any Design Basis Accident scenario. Therefore, only normal conditions will be considered by this calculation.

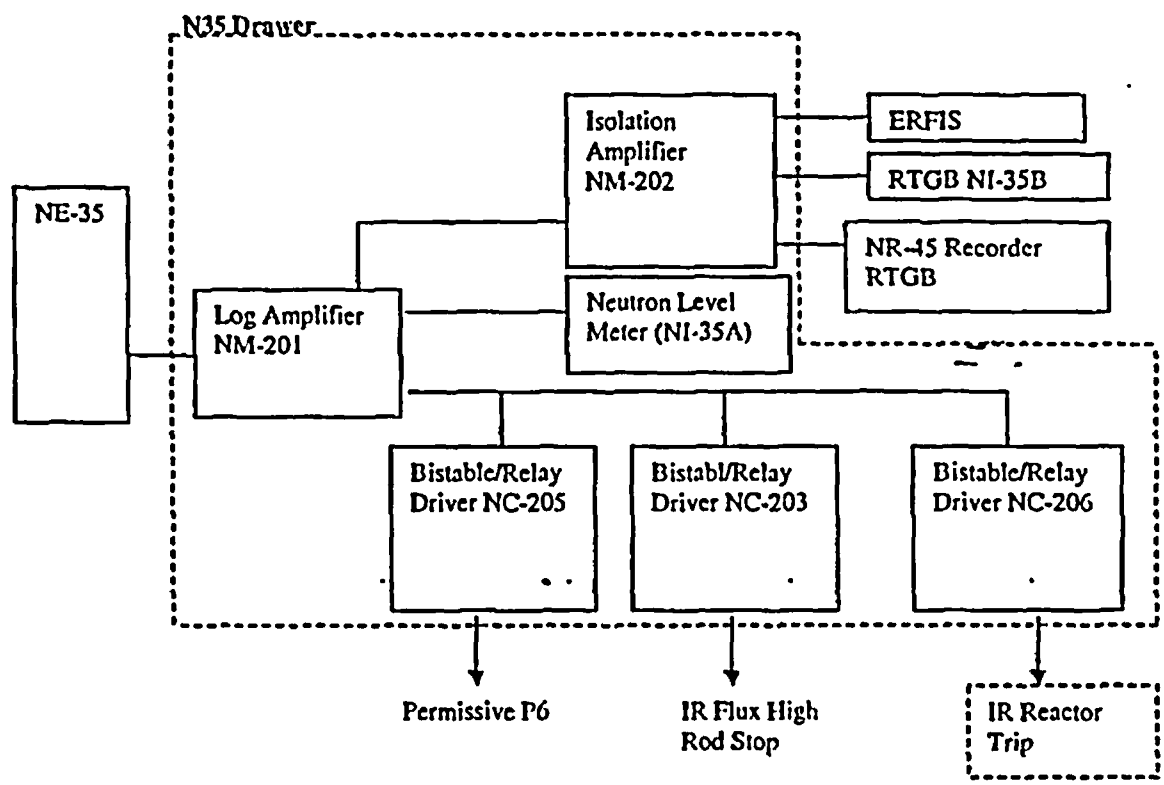
2.3 POST ACCIDENT MONITORING

The Intermediate Range NIS channels are not required for post accident monitoring. There are two separate channels, N51 and N52, that perform this function for neutron flux indication.

2.4 POST SEISMIC

The only components of the NIS that are required to function after a Design Basis Earthquake (DBE) are the post accident monitoring channels N51 and N52. The Intermediate Range channels do not fall under this category. Seismic qualification testing was performed on the NIS process racks and detectors, which includes the Intermediate Range channels.. Per Reference 4.2.2, the effect on the process racks (drawers) was negligible. Per Reference 4.2.2, the Seismic Effect (SE) on the detectors was insignificant compared to the large accuracy value given for the detector uncertainty. Since the effect on the equipment as the result of an Operating Basis Earthquake (OBE) are insignificant, and the fact that the equipment is not required following a DBE, seismic considerations will not be included in this analysis.

3.0 LOOP DIAGRAM



Note: Diagram applies to N36 Drawer also.

Tag number	Function	Make and Model	Location	Reference
NE-35 NE-36	Primary Element	Westinghouse WL-23707	Containment	4.1.2, 4.5.1
N-35 N-36	Intermediate Range Drawer	Westinghouse 6051D46G01	Control Room	4.1.2, 4.5.1
NI-35A NI-36A	Neutron Level Meter	Westinghouse EIL-A-10356	Control Room	4.1.2, 4.2.1
NM-201	Log Amplifier	Philbrick/Nexus Model 2502	Control Room	4.1.2, 4.2.1
NM-202	Isolation Amplifier	Hybrid Systems N200-3	Control Room	4.1.2, 4.2.1
NC-203 NC-205 NC-206	Bistable/Relay Driver	Westinghouse 3359C39GO1	Control Room	4.1.2, 4.2.1
NI-35B NI-36B	Indicator	International Instruments 2520VB	RTGB	4.1.2, 4.5.1
NR-45	Recorder	Westronics D11E-10-10-11- X1-000 001	RTGB	4.1.2, 4.5.1

Instrument Identification

4.0 REFERENCES

4.1 DRAWINGS

4.1.1 Not used

4.1.2 5379-04570, Nuclear Instrumentation System-Intermediate Range N-35 Functional Block Diagram, Revision 4

4.2 VENDOR MANUALS AND INFORMATION

4.2.1 728-790-18, Nuclear Instrumentation System, Revision 8

4.2.2 Seismic Testing of Electrical and Control Equipment, WCAP-7937-L

4.3 CALIBRATION AND MAINTENANCE PROCEDURES

4.3.1 MMM-006, Calibration Program, Revision 22

4.3.2 Not used

4.3.3 LP-704, Nuclear Instrumentation System Intermediate Range Channels N35 and N36, Revision 9

4.3.4 OST-001, Nuclear Instrumentation Source Range, Intermediate Range, & Power Range, Revision 58

4.3.5 OST-006, Nuclear Instrumentation Source Range and Intermediate Range, Revision 48

4.3.6 EST-067, Intermediate Range Detector Setpoint Determination , Revision 6

4.3.7 EGR-NGGC-0153, Engineering Instrument Setpoints , Revision 9

4.4 CALCULATIONS

4.4.1 RNP-I/INST-1049, Nuclear Instrumentation Power Range Error Analysis, Revision 3

4.4.2 RNP-I/INST-1138, Nuclear Instrumentation Power Range Error Analysis using LEFM Based Secondary Calorimetric, Revision 1

4.4.3 RNP-E-1.005, 120 Vac Instrument Bus Voltage Evaluation, Revision 2

4.5 OTHER REFERENCES

4.5.1 Equipment Data Base (EDB)

4.5.2 UFSAR Sections 7 and 15

4.5.3 HB Robinson Improved Technical Specifications

4.5.4 Westinghouse Setpoint Methodology for Shearon Harris, 1364-53067, Revision 2

5.0 INPUTS AND ASSUMPTIONS

5.1 INPUTS

5.1.1 The environmental conditions are:

Location	Normal [illegible]	Reference [illegible]
Control Room	70°-77° F	4.5.2

5.1.2 Bistable outputs are digital and do not add any uncertainty value, therefore this will not be considered by this calculation.

5.1.3 Total Loop Uncertainty for the Power Range indication is taken from Reference 4.4.1. This input is used for the Intermediate Range High Trip Bistable because the setpoint, as it corresponds to percent full power, is derived from the Power Range reading. The Total Loop Uncertainty for the Power Range indication is ± 5.86% Span.

5.2 ASSUMPTIONS

5.2.1 The values used for Process Measurement Effect (PME) were obtained from Reference 4.5.4. These values are assumed to be conservative for Robinson Nuclear Plant, given that the core geometry for HNP is larger than that of RNP. The uncertainty is assumed to include all effects concerned with the detectors. This is considered to be a random uncertainty, as it was treated that way in Reference 4.5.4.

5.2.2 Reference Accuracy (RA) for analog devices consists of linearity, hysteresis, and repeatability. When these components are not called out specifically, it will be assumed that they are random, independent, normally distributed, and equal.

5.2.3 The indication scales for the Intermediate Range Channels are logarithmic and the final uncertainties are expressed in terms of percent span. The percent span uncertainties are constant across the scale, but the engineering units vary across the scale. The allowable values calculated are converted to engineering units since the uncertainty is to be applied at a single point on the scale.

For a logarithmic scale the following formula is used to express the percent span error at a specific point. The span of the Intermediate Range covers 8 decades, 10^{-11} to 10^{-3} amps

$$E = P * \log^{-1}\left[\frac{Espan * D}{100\%}\right]$$

Where:

E = Error in Eng. Units
P = Point of interest
Espan = Error in % Span
D = number of decades = 8

Conversely, the following formula will be used to express error at a specific point on a logarithmic scale to percent span error. The error in engineering units is a limit. So expressing this as a percent of ideal value, the following is used.

$$Limit = 100\left(\frac{lim}{setpt}\right)$$

The limit is then converted to percent span by the following equation.

$$Error = 100 * \frac{LOG\left[\frac{Limit}{100}\right]}{8}$$

5.2.4 Reference 4.5.4 is a Harris Plant Document. It is also valid for H.B. Robinson since the excore instrumentation is essentially identical.

6.0 CALCULATION OF UNCERTAINTY CONTRIBUTORS

6.1 ACCIDENT EFFECTS (AE)

Intermediate Range channels N35 and N36 are not required during or after any postulated accident. Therefore, only normal conditions will be considered by this calculation.

6.2 SEISMIC EFFECT (SE)

Seismic considerations will not be included in this calculation, as described in Section 2.4.

6.3 INSULATION RESISTANCE ERROR (IR)

Intermediate Range channels N35 and N36 are not required to function during or after any Design Basis Accident. Therefore, Insulation Resistance Error will not be considered by this calculation.

6.4 PROCESS MEASUREMENT ERROR (PME)

As stated in Assumption 5.2.1, an all inclusive value for effects associated with the Intermediate Range.detectors was obtained from the Reference 4.5.4. This value is given in percent span, which is conservatively assumed to be 0-120% rated thermal power. Therefore,

PME = ± 8.40% Span

6.5 PRIMARY ELEMENT ERROR (PE)

Primary Element Errors are not applicable to this calculation.

6.6 LOG AMPLIFIER

6.6.1 Log Amplifier's Unverified Attributes of Reference Accuracy (RA_{amp})

The accuracy value for the amplifier is given by Reference 4.2.1 as ± 0.50% Span between 10^{-11} and 10^{-10} amps and ± 1.00% Span between 10^{-10} and 10^{-3} amps. For conservatism, this calculation will use ± 1.00% as the accuracy value. It is assumed that this value includes the effects of linearity, hysteresis, and repeatability.

RA_{amp} = ± 1.00% Span

Per Reference 4.3.3, the Log Amplifier is calibrated at 9 cardinal points, 5 up and 4 down. Therefor, it verifies hysteresis and linearity but not repeatability. Per Reference 4.3.7, the following equation is utilized to compute the repeatability portion of the Log Amplifier Reference Aaccuracy.

$$\text{Repeatability} = \pm\frac{RA}{\sqrt{3}} = \pm\frac{1.00}{\sqrt{3}} = \pm 0.58\%\ \text{Span}$$

Therefore,

RA_{amp} = ± 0.58% Span

6.6.2 Log Amplifier Calibration Tolerance (CAL_{amp})

Per Reference 4.3.3 the amplifier is calibrated using external test equipment and the panel meter. The tolerance on the calibration is ± 0.1 Volts on a 10 Volt span. This equates to a calibration tolerance of ± 1.00 % Span.

CAL_{amp} = ± 1.00% Span

6.6.3 Log Amplifier Drift (DR_{amp})

Per Reference 4.3.7, when a drift value is not provided a default value of ± 1.00% Span shall be used.

$$DR_{amp} = \pm 1.00\% \text{ Span}$$

6.6.4 Log Amplifier M&TE Effect (MTE_{amp})

Per Reference 4.3.3, a Picoamp Source and DMM are used as the M&TE for calibration of the Log Amplifier. The Picoamp Source supplies the current input and the DMM measures the voltage output. The Picoamp Source used at RNP has an accuracy of ± 0.50% of setting + 2pA on the lowest setting and ± 0.50% of setting + 1pA on the highest setting to be used. In the range from 10^{-6} to 10^{-4}, the accuracy is ± 0.50% of setting + 100pA. Per Reference 4.3.3, a setting of 10^{-5} is used in this area. The MTE is then ± 0.501% span or ±0.50 % span. The DMM accuracy as stated in Reference 4.3.3 is ± 0.10% Reading. Per Reference 4.3.3, the calibration is from 0 to 50 mVdc. Using a reading at 50mVdc with a span of 50mVdc, the MTE associated with the DMM is ± 0.50% span. Therefore, the total M&TE Effect for the Log Amplifier is given as follows.

$$MTE_{amp} = \sqrt{0.50^2 + 0.10^2}$$

$$MTE_{amp} = \pm 0.51\% \text{ Span}$$

6.6.5 Log Amplilfier Temperature Effect (TE_{amp})

Per Reference 4.2.1, the Temperature vs Stability is within the accuracy requirements. The accuracy requirements are ± 1.00% Span in the area of concern. Therefore

$$TE_{amp} = \pm 1.00 \% \text{ Span}$$

6.6.6 Log Amplifier Power Supply Effect (PSE_{amp})

The power supply for the Log Amlifier is a DC power supply located within the Intermediate Range drawer. Per reference 4.2.1, the power supply has a high level of regulation and is well within the power requirements for the amplifier.

$$PSE_{amp} = N/A$$

6.6.7 Log Amplifier Total Device Uncertainty (TDU_{amp})

Total Device Uncertainty is computed using the following equation:

$$TDU_{amp} = \sqrt{(CAL_{amp} + MTE_{amp})^2 + RA_{amp}{}^2 + DR_{amp}{}^2 + TE_{amp}{}^2}$$

$$TDU_{amp} = \sqrt{(1.00 + 0.51)^2 + 0.58^2 + 1.00^2 + 1.00^2}$$

$$TDU_{amp} = \pm 2.15\% \text{ Span}$$

The Intermediate Range High-Level Trip setpoint is given in the Technical Specifications (Reference 4.5.3) as a percent of Reactor Thermal Power (RTP). This setpoint is based on the current level of the Intermediate Range channel that corresponds to 25% RTP. This value is obtained via Reference 4.3.6 by performing a "best fit" curve of the current signal by comparing the current level equivalent to percent RTP reading on the Power Range Channels at various increments. Therefore, an additional error is encountered by using the Power Range indication to determine the setpoint value. The Power Range indication, in effect, becomes an M&TE error. The error incurred is conservative since the Power Range indication is over a 0-120% RTP range, and the Intermediate Range goes beyond this range. The Power Range indication uncertainty is ± 5.86% Span per Section 5.1.3 and will be called MTE_{pwr}.

The M&TE error for this application will be noted as MTE_{amp1} and is determined as follows:

$$MTE_{amp1} = \sqrt{MTE_{amp}^2 + MTE_{pwr}^2}$$

$$MTE_{amp1} = \sqrt{0.51^2 + 5.86^2}$$

$$MTE_{amp1} = \pm 5.88\% \text{ Span}$$

Therefore, the Total Device Uncertainty for the Log Amplifier for the IR High Level Trip application will be called TDU_{amp1}, and is determined as follows.

$$TDU_{amp1} = \sqrt{(CAL_{amp} + MTE_{amp1})^2 + RA_{amp}^2 + DR_{amp}^2 + TE_{amp}^2}$$

$$TDU_{amp1} = \sqrt{(1.00 + 5.88)^2 + 0.58^2 + 1.00^2 + 1.00^2}$$

$$TDU_{amp1} = \pm 7.05\% \text{ Span}$$

6.6.8 Log Amplifier As-Found Tolerance (AFT_{amp})

The As-Found Tolerance(AFT) is computed using the following equation:

$$AFT_{amp} = \sqrt{CAL_{amp}^2 + MTE_{amp}^2 + DR_{amp}^2}$$

$$AFT_{amp} = \sqrt{1.00^2 + 0.51^2 + 1.00^2}$$

$$AFT_{amp} = \pm 1.50\% \text{ Span}$$

6.6.9 Log Ampfier As-Left Tolerance (ALT_{amp})

$$ALT_{amp} = CAL_{amp}$$

$$ALT_{amp} = \pm 1.00\% \text{ Span}$$

Error Contributor	Value	Type	Section
RA	± 0.58% Span	Random	6.6.1
CAL	± 1.00% Span	Random	6.6.2
DR	± 1.00% Span	Random	6.6.3
MTE	± 0.51% Span	Random	6.6.4
MTE_{ampl}	± 5.88% Span	Random	6.6.4
TE	± 1.00% Span	Random	6.6.5
PSE	N/A	N/A	6.6.6
As Left Tolerance (ALT)	± 1.00% Span	Random	6.6.9
As Found Tolerance (AFT)	± 1.50% Span	Random	6.6.8
Total Device Uncertainty (non accident)	± 2.15% Span	Random	6.6.7
Total Device Uncertainty (non-accident TDU_{ampl})	± 7.05% Span	Random	6.6.7

Log Amplifier Uncertainty Summary

6.7 BISTABLE/RELAY DRIVER

The Bistable/Relay Drivers are solid state bistable modules that are located within the Intermediate Range drawers. There are two separate modules that provide the IR High Level Trip signal and the P6 Permissive. These two modules are identical and both will be considered under this section.

6.7.1 Bistable/Relay Driver's Unverified Attributes of Reference Accuracy (RA_{bis})

Vendor data contained in Reference 4.2.1 specifies a ± 5.0 mV accuracy given in terms of repeatability. Since this device is a bistable, repeatability is the only term that will be considered for Reference Accuracy. The input range of the device is 0-10 Vdc, so the Reference Accuracy term is given as follows:

RA_{bis} = (0.005 Vdc/10 Vdc) * 100

RA_{bis} = ± 0.05% Span

6.7.2 Bistable/Relay Driver Calibration Tolerance (CAL_{bis})

Per Reference 4.3.3 the As Found/As Left calibration tolerance for the Bistable/Relay Driver is given as ± 0.25% Span (0.025 Vdc tolerance from a 0-10 Vdc span).

CAL_{bis} = ± 0.25% Span

6.7.3 Bistable/Relay Driver Drift (DR_{bis})

Vendor data given in Reference 4.2.1 states that the drift, or stability, of the Bistable/Relay Driver is ± 0.25% Full Scale. This value is given as a limit of error, with no time dependency. The bistables are checked on a bi-weekly frequency, so this value is conservative for the Drift term.

DR_{bis} = ± 0.25% Span

6.7.4 Bistable/Relay Driver M&TE Effect (MTE_{bis})

A DMM with an accuracy of ± 0.10% of reading is called for by calibration procedure to measure the input to the bistable. Since the span of the voltage to be adjusted is 0 to 5 Vdc or 0 to 10 Vdc, this is also % Span. Since this is a bistable output, the only M&TE required will be for the input signal.

MTE_{bis} = ± 0.10% Span

6.7.5 Bistable/Relay Driver Temperature Effect (TE_{bis})

Vendor data per Reference 4.2.1 gives no value for Temperature Effect on the Bistable Relay Driver. So for conservatism, the default value of ± 0.50% Span will be used per Reference 4.3.7. Therefore,

TE_{bis} = ± 0.50% Span

6.7.6 Bistable/Relay Driver Power Supply Effect (PSE_{bis}):

The power supply for the Bistable Relay Driver is a DC power supply located within the Intermediate Range drawer. Per reference 4.2.1, the power supply has a high level of regulation and is well within the power requirements for the bistable.

PSE_{bis} = N/A

6.7.7 Bistable/Relay Driver Total Device Uncertainty (TDU_{bis})

Per Reference 4.1.2 and Section 3.0 of this calculation the Total Device Uncertainty of the Bistable/Relay driver is used in an instrument loop with the Log Amplifier to provide the IR High Level Trip, IR Flux High Rod Stop, and Permissive P6. The value for Drift for the Log Amplifier was an assumed value. Per Reference 4.3.7, if a value for drift is assumed, it is assumed to be for that instrument loop. This bounds the bistable drift. Therefore, the Bistable/Relay drive drft is excluded from the calculation of TDU_{bis}. Therefore, Total Device Uncertainty is computed excluding a value for the Bistable/Relay Driver drift.:

$$TDU_{bis} = \sqrt{(CAL_{bis} + MTE_{bis})^2 + RA_{bis}{}^2 + TE_{bis}{}^2}$$

$$TDU_{bis} = \sqrt{(0.25 + 0.10)^2 + 0.05^2 + 0.50^2}$$

$$TDU_{bis} = \pm 0.61\% \text{ Span}$$

6.7.8 Bistable/Relay Driver As-Found Tolerance (AFT_{bis})

The As Found Tolerance is computed using the following equation:

$$AFT_{bis} = \sqrt{CAL_{bis}{}^2 + DR_{bis}{}^2 + MTE_{bis}{}^2}$$

$$AFT_{bis} = \sqrt{0.25^2 + 0.25^2 + 0.10^2}$$

$$AFT_{bis} = \pm 0.37\% \text{ Span}$$

6.7.9 Bistable/Relay Driver As-Left Tolerance (ALT_{bis})

$$ALT_{bis} = CAL_{bis}$$

$$ALT_{bis} = \pm 0.25\% \text{ Span}$$

Error Contributor	Value	Type	Section
RA	±0.05% Span	Random	6.7.1
CAL	±0.25% Span	Random	6.7.2
DR	±0.25% Span	Random	6.7.3
MTE	±0.10% Span	Random	6.7.4
TE	±0.50% Span	Random	6.7.5
PSE	N/A	N/A	6.7.6
As Left Tolerance (ALT)	±0.25% Span	Random	6.7.9
As Found Tolerance (AFT)	±0.37% Span	Random	6.7.8
Total Device Uncertainty (non-accident)	±0.61% Span	Random	6.7.7

Bistable/Relay Driver Uncertainty Summary

6.8 NEUTRON LEVEL METER

The Neutron Level Meter is located on the front of the Intermediate Range drawers. This uncertainty will only be considered for the allowable value for the High Level Trip setpoint, since it is used as M&TE by the Channel Operability Test.

6.8.1 Neutron Level Meter's Unverified Attributes of Reference Accuracy (RA_{ind})

Vendor data contained in Reference 4.2.1 specifies a ± 0.25% accuracy, which includes the effects of linearity, hysteresis, and repeatability. Calibration procedure (Reference 4.3.3) gives a calibration tolerance of ± 1.00% Span. The only unverified attribute of the Reference Accuracy in the calibration process is the repeatability of the meter. Calculation of the repeatability portion of the Reference Accuracy yields a 0.144% error. Therefore,

$RA_{ind} = \pm 0.14\%$ Span

6.8.2 Neutron Level Meter Calibration Tolerance (CAL_{ind})

The calibration procedure, Reference 4.3.3, gives a calibration tolerance for the meter as ± 1.00% Span.

$CAL_{ind} = \pm 1.00\%$ Span

6.8.3 Neutron Level Meter Drift (DR_{ind})

Vendor data per Reference 4.2.1 does not give a value for drift. Per Reference 4.3.7, if a value for drift is not provided a default value may be used.

$DR_{ind} = \pm 1.00\%$ Span

6.8.4 Neutron Level Meter M&TE Effect (MTE_{ind})

A DMM with an accuracy of ± 0.10% is called for by calibration procedure to measure the input to the meter. Since the output is indication, the only M&TE required will be for the input signal.

$MTE_{ind} = \pm 0.10\%$ Span

6.8.5 Neutron Level Meter Temperature Effect (TE_{ind})

Vendor data per Reference 4.2.1 gives no value for Temperature Effect on the meter. Per Reference 4.3.7, if a value for the Temperature Effect is not provided, a default value may be used. The default value is ± 0.50% Span. Therefore,

$TE_{ind} = \pm 0.50\%$ Span

6.8.6 Neutron Level Meter Readability Effect (RE_{ind})

Readability Effect (RE) is defined as one-half the smallest division on the indicator scale. The Neutron Level Meter is a logarithmic scale that does not have symmetrical divisions on the scale, but the divisions are equal in value. The Readability Effect will then be given in percent span. This input was obtained via plant walkdown. The readability of the scale relates to one-tenth of a decade over an eight decade span. Therefore, per Reference 4.3.7 the readability is,

$RE_{ind} = \pm 1.25\%$ Span

6.8.7 Neutron Level Meter Total Device Uncertainty (TDU_{ind})

Total Device Uncertainty is computed using the following equation:

$$TDU_{ind} = \sqrt{(CAL_{ind} + MTE_{ind})^2 + RA_{ind}^2 + DR_{ind}^2 + TE_{ind}^2 + RE_{ind}^2}$$

$$TDU_{ind} = \sqrt{(1.00 + 0.10)^2 + 0.14^2 + 1.00^2 + 0.50^2 + 1.25^2}$$

$$TDU_{ind} = \pm 2.01\% \text{ Span}$$

6.8.8 Neutron Level Meter As-Found Tolerance (AFT_{ind})

The As Found Tolerance is computed using the following equation:

$$AFT_{ind} = \sqrt{CAL_{ind}^2 + DR_{ind}^2 + MTE_{ind}^2}$$

$$AFT_{ind} = \sqrt{1.00^2 + 1.00^2 + 0.10^2}$$

$$AFT_{ind} = \pm 1.42\% \text{ Span}$$

6.8.9 Neutron Level Meter As-Left Tolerance (ALT_{ind})

$$ALT_{ind} = CAL_{ind}$$

$$ALT_{ind} = \pm 1.00\% \text{ Span}$$

Error Contributor	Value	Type	Section
RA	± 0.14% Span	Random	6.8.1
CAL	± 1.00% Span	Random	6.8.2
DR	± 1.00% Span	Random	6.8.3
MTE	± 0.10% Span	Random	6.8.4
TE	± 0.50% Span	Random	6.8.5
RE	± 1.25% Span	Random	6.8.6
As Left Tolerance (ALT)	± 1.00% Span	Random	6.8.9
As Found Tolerance (AFT)	± 1.42% Span	Random	6.8.8
Total Device Uncertainty (non-accident)	± 2.01% Span	Random	6.8.7

Neutron Level Meter Uncertainty Summary

7.0 TOTAL LOOP UNCERTAINTY (TLU)

7.1 Total Loop Uncertainty - Plant normal

No bias errors were found during analysis of this uncertainty. Therefore, all uncertainties used in this section will be random errors.

7.1.1 Power Above Permissive P6 Total Loop Uncertainty

The Permissive P6 setpoint is derived from within the Intermediate Range Channel as an amperes neutron level and not a percentage of full power. Therefore, the only uncertainties that apply to this setpoint are associated with the Intermediate Range Channel.

The Total Loop Uncertainty of the Permissive P6 setpoint will consider the following equipment/signals.

The Detector, which measures neutron level and outputs a current representing the neutron level.

The Log Amplifier, which amplifies the detector current input and outputs a voltage to be used for bistables and indication.

The Bistable/Relay Drivers which receive the voltage signal from the Log Amplifier and trip at a preset value.

The Total Loop Uncertainty for the Permissive P6 bistable is given as:

$$TLU_{P6} = \sqrt{PME^2 + TDU_{amp}{}^2 + TDU_{bis}{}^2}$$

$$TLU_{P6} = \sqrt{8.40^2 + 2.15^2 + 0.61^2}$$

$$TLU_{P6} = \pm 8.69\%\ \text{Span}$$

7.1.2 Permissive P6 Allowable Value

The Allowable Value of a setpoint is defined as an allowance provided to account for expected drift in the testable portion of the loop. For this setpoint, the testable portion is the Bistable/Relay Driver. This is the As Found Tolerance as determined in Section 6.7.8.

$$\text{Allowable Value} = \pm 0.37\%\ \text{Span}$$

The following formula from assumption 5.2.3 is used to convert the Allowable Value to Engineering Units,

$$AV_{eng\text{-}units} = (SP)LOG^{-1}\left(\frac{(Error)(Decades)}{100}\right)$$

$$AV_{eng\text{-}units} = \left(10^{-10}\right)LOG^{-1}\left(\frac{(\pm 0.37)(8)}{100}\right)$$

This is an increasing setpoint. The negative value for the uncertainty shall be used. Therefore, the allowable value is,

$$AV = 9.34 \times 10^{-11} \text{ amps}$$

7.1.3 Intermediate Range High Level Trip Total Loop Uncertainty

The Total Loop Uncertainty of the IR High Level Trip setpoint will consider the following equipment/signals.

The Detector, which measures neutron level and outputs a current representing the neutron level.

The Log Amplifier, which amplifies the detector current input and outputs a voltage to be used for bistables and indication. As discussed in Section 6.6.7, the Log Amplifier will have an additional error from the Power Range indication. This error will be applied to the M&TE of the Log Amplifier, since that is the setpoint value representing 25% RTP is read at the Log Amplifier output.

The Bistable/Relay Drivers which receive the voltage signal from the Log Amplifier and trip at a preset value.

The Total Loop Uncertainty for the High Level Trip bistable is given as:

$$TLU_{HLT} = \sqrt{PME^2 + TDU_{ampl}^2 + TDU_{bis}^2}$$

$$TLU_{HLT} = \sqrt{8.40^2 + 7.05^2 + 0.61^2}$$

$$TLU_{HLT} = \pm 10.98\% \text{ Span}$$

7.1.4 Intermediate Range High Level Trip Allowable Value

The Allowable Value of a setpoint is defined as an allowance provided to account for expected drift in the testable portion of the loop. For this setpoint, the testable portion is the Bistable/Relay Driver. The setpoint is tested by Reference 4.3.5, which uses the test circuit within the Intermediate Range Drawer to trip the bistable and verifies the trip point with the Neutron Level Meter. This method of testing will make the meter on the front of the drawer an MTE Effect. The Allowable Value for this setpoint will be calculated the same as the As Found Tolerance, except that the meter Total Device Uncertainty (TDU_{ind}) from Section 6.8.7 will be substituted as the M&TE (MTE_{HLT}):

$$AV = \sqrt{CAL_{bis}^2 + MTE_{HLT}^2 + DR_{bis}^2}$$

$$AV = \sqrt{0.25^2 + 2.01^2 + 0.25^2}$$

$$AV = \pm 2.04\% \text{ Span}$$

In order to discuss this in percent RTP, an assumption will have to be made. The actual IR High Level Trip setpoint is determined in Intermediate Range current via Reference 4.3.6, and the value changes. For the discussion of this setpoint a simulated value of current will be used to represent 25% RTP. This will have no effect on the uncertainty, as the error is applied at each reading on a logarithmic scale and is the same percent error at each current reading. It should be noted that the conversion technique for %RTP to IR current is not exact, but as long as the same conversion is used to determine the current setpoint as is used in changing the allowable value back to %RTP, then the allowable value shown below will be correct. The assumption will be made that 0-120% RTP = 1×10^{-3} amps.

Converting the Allowable Value to Engineering Units (formula in 5.2.3), where the setpoint is 2.083×10^{-4} amps,

$$AV_{eng\text{-}units} = (SP)LOG^{-1}\left(\frac{(Error)(Decades)}{100}\right)$$

$$AV_{eng\text{-}units} = \left(2.083 \times 10^{-4}\right)LOG^{-1}\left(\frac{(\pm 2.04)(8)}{100}\right)$$

$$AV = 3.033 \times 10^{-4} \text{ amps}$$

This error is converted to percent RTP, Allowable Value (%RTP) utilizing the following relationship:

$$\frac{120\%}{1\text{x}10^{-3}} = \frac{AV_{\%RTP}}{AV_{engunits}} = \frac{120\%}{1\text{x}10^{-3}} = \frac{AV_{\%RTP}}{3.033\text{x}10^{-4}}$$

$$AV_{\%RTP} = 36.40\% \text{ RTP}$$

AV in % RTP = 36.40% RTP. TS is ≤ 37.02% RTP. The TS value can be met and be outside the calculated value.

8.0 DISCUSSION OF RESULTS

As shown in Section 7.1, the Total Loop Uncertainty (TLU) and Allowable Value (AV) were calculated for both the Intermediate Range High Level Trip and the Permissive P6.

The Permissive P6 calculated Total Loop Uncertainty was determined to be ± 8.69% Span. The Allowable Value for this setpoint was calculated to be ± 0.37% Span, which relates to 9.34×10^{-11} amps for a setpoint of 1×10^{-10} amps. The Allowable Value given in the Improved Technical Specifications is 7.28×10^{-11} amps. The existing value for Technical Specification is conservative.

The IR High Level Trip calculated Total Loop Uncertainty was determined to be ± 10.98% Span. The Allowable Value for this setpoint was calculated to be ± 2.04% Span, which relates to 36.40% RTP for a setpoint of 25% RTP. The Allowable Value given in the Improved Technical Specifications is 37.02% RTP. The existing value for Technical Specifications is non-conservative.

8.1 Impact on Improved Technical Specifications

As discussed above in Section 8.0, the Allowable Values provided by Technical Specifications are non-conservative with respect to the calculated values. A Technical Specification change should be submitted to adjust the Allowable Values to those determined by this calculation.

8.2 Impact on UFSAR

There is no impact from this calculation on the UFSAR, since the setpoints did not change and no credit is taken in the UFSAR for Intermediate Range Channels.

8.3 Impact on Design Basis Documents

There is no impact on any Design Basis Documents by this calculation, since nothing concerning the function or trip settings change with these channels.

8.4 Impact on Other Calculations

There is no impact on other calculations because these values are not used in any other calculations.

8.5 Impact on Plant Procedures

Plant calibration procedure, LP-704, for the Intermediate Range High Level Trip calibration and channel operability test will require revision to include the As Found Tolerances determined by this calculation.

Document Indexing Table

Document Type (e.g. CALC, DWG, TAG, PROCEDURE, SOFTWARE)	ID Number (e.g., Calc No., Dwg. No., Equip. Tag No., Procedure No., Software name and version)	Function (i.e. IN for design inputs or references; OUT for affected documents)	Relationship to Calc. (e.g. design input, assumption basis, reference, document affected by results)
DWG	5379-04570	IN	Provides block of system
TM	728-790-18	IN	Provides system function information
PROCEDURE	MMM-006	IN	Provides calibration tolerances
PROCEDURE	LP-704	IN	Provides calibration procedures & test equipment requirements
PROCEDURE	OST-001	IN	Provides periodic testing methods
PROCEDURE	OST-006	IN	Provides testing procedures
PROCEDURE	EST-067	IN	Determines setpoint values
PROCEDURE	EGR-NGGC-0153	IN	Provides procedure for setpoint determination
CALCULATION	RNP-I/INST-1049	IN	Provides Power Range setpoint data
CALCULATION	RNP-I/INST-1138	IN	Provides Power Range Error using LEFM
CALCULATION	RNP-E-1.005	IN	Provides power supply specifications
EDB	NE-35, NE-36	IN	Detector data
EDB	N-35,N-36	IN	IR drawer data
EDB	NI-35B, NI-36B	IN	RTGB indicator data
EDB	NR-45	IN	RTGB recorder data
VENDOR INPUT	WESTINGHOUSE 1364-53067	IN	Provides detector data

(For the purpose of creating cross references to documents in the Document Management System and equipment in the Equipment Data Base)

ATTACHMENT 2
Sheet 1 of 1
Record of Lead Review

Design RNP-I/INST-1135 Revision 1

The signature below of the Lead Reviewer records that:

- the review indicated below has been performed by the Lead Reviewer;
- appropriate reviews were performed and errors/deficiencies (for all reviews performed) have been resolved and these records are included in the design package;
- the review was performed in accordance with EGR-NGGC-0003.

☒ **Design Verification Review** ☐ **Engineering Review** ☐ **Owner's Review**

☒ Design Review
☐ Alternate Calculation
☐ Qualification Testing

☐ **Special Engineering Review**

☐YES ☐N/A **Other Records are attached.**

C.B. HOLLAND *C.B. Holland* I&C 2/6/03
Lead Reviewer **(print/sign)** **Discipline** **Date**

Item No.	Deficiency	Resolution
1	ADD ASSUMPTION THAT REF. 4.5.4 IS VALID FOR RNP BECAUSE	ADDED
	HNP IS ALSO (W) PLANT AND EXCORE INSTRUMENTATION IS EFFECTIVELY IDENTICAL.	
2.	6.7.7 ADD TO NEXT TO LAST SENTENCE, "THIS BOUNDS THE BISTABLE DRIFT AND THEREFORE	ADDED
	BISTABLE/RELAY DRIVER DRIFT IS EXCLUDED FROM CALCULATING TDU_{BU} FOR THIS DEVICE.	

FORM EGR-NGGC-0003-2-5
This form is a QA Record when completed and included with a completed design package. Owner's Reviews may be processed as stand alone QA records when Owner's Review is completed.