Beaver Valley Power Station

Radiation Protection Technical Position/Evaluation/Calculation

Subject	No.	PAGE 1 OF
Process Safety Limits, Alarm Setpoints and EAL Indicator Value for 2CHS-RQ101A/B	**ERS-SFL-88-027**	**13**

Reference
HPP________ EPP ________ T/S ________ CR ________ DCP________

Category

☐ Technical Position ☒ Technical Evaluation ☐ Calculation

Unit 1 ☐ Unit 2 ☒

Purpose

The purpose of this technical evaluation is to document the derivation of alarm setpoints for Unit 2 DRMS monitor 2CHS-RQ101A/B. Alarm setpoints were previously documented by SWEC 12241-UR(B)-410, Rev. 1. Also provided are revised database engineering unit conversion factors. Also the monitor indication (without consideration for instrument error) associated with an RCS activity concentration of 21 uCi/g is calculated.

☐ **ORIGINAL ISSUE**

☒ **REVISION # 3**

Revision description:

This revision adds the letdown radiation monitor indications that correspond to an RCS concentration equivalent to 21 uCi/g dose equivalent iodine-131 (DE I-131). This value is proposed for use as part of the NEI EAL (Emergency Action Level) upgrade project for EAL SU9. Updated references. Updated the source term/basis to use 12241-UR(B)-484 data.

by	checker/reviewer	independent review (calculation only)
John T. Lebda (signature) 8-10-11 date	Michael Unfried (signature) 8-10-2011 date	N/A - Not a Calculation date

Checklist		Attachments
☒ Purpose	☒ Results	☒ Data Sheets
☒ Methodology	☒ References	☐ Illustrations
☒ Input Data		☐ Printouts
		☐ Code Listings

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		☐ ________

PURPOSE

The purpose of this calculation is to determine the alarm setpoints (alert and high) for the Unit 2 letdown radiation monitor, CHS-RQ101A/B high range and low range channels. This revision incorporates changes necessary to reflect implementation of Unit 2 Technical Specification Amendment 101[1]. This Amendment lowers the reactor coolant system Technical Specification allowed activity limit which forms the basis for the monitor alarm setpoints. Also the monitor indication (without consideration for instrument error) associated with an RCS activity concentration of 21 uCi/g is calculated.

DISCUSSION

The basis for the CHS-101A/B alarm setpoints is discussed in the Unit 2 NRC SER section 4.2.4.2[2] which states "The reactor coolant letdown monitors – which include high- and low- range offline liquid monitors in the reactor coolant letdown line that can detect conditions that indicate fuel rod failure…". Further the Unit 2 UFSAR[3] Section 4.2.3.3 states "Provisions for detection of fuel rod failure include high- and low-range off-line liquid monitors in the reactor coolant letdown line as discussed in Section 11.5.2.5.10". UFSAR[4] Section 11.5.2.5.10 provides a general description of monitor configuration and function, but does not mention the alarm setpoints. These documents establish the licensing basis for the monitor and monitor alarm function. Note that the extent of fuel failure or any other specifics regarding the alarm setpoints is not mentioned.

Calculation History:

SWEC 12241 UR(B)-410-1 (1986)[5]

This calculation package initially provided high range monitor alarm safety limit values based on 1% failed fuel (high setpoint) and the Technical Specification RCS concentration limits (alert setpoint), and low range monitor alarm safety limit values based on expected RCS activity (high setpoint) and 0.05% failed fuel RCS concentration (alert setpoint). Revision 1 was made after it was discovered that, although there are two monitors, they feed a common alarm channel. Therefore, only one each of a high and an alert setpoint are possible. The revision 1 setpoints were based on the Technical Specification RCS concentration limits (48 hour action limit of 1.0 μCi/g DEI-131) for the high setpoint, and the alert setpoint was set at 75% of this value.

ERS-SFL-88-027-1 (1989)[6]

This calculation revised the monitor setpoints using updated monitor isotopic efficiencies. The previous SWEC calculations were performed using preliminary vendor calibration data. This calculation maintained the setpoint bases established in 12241-UR(B)-410, Rev. 1[5].

ERS-SFL-88-027-2 (1999)[21]

This revision was made to address source term changes resulting from Unit 2 Technical Specification Amendment 101[1]. This Amendment lowers the Technical Specification reactor coolant system (RCS) activity concentration limit from 1.0 μCi/g dose equivalent iodine 131 (DEI-131) to 0.35 μCi/g. Additionally, the basis for defining DEI-131 is changed to use dose conversion factors based on ICRP 26/30[7,8] and taken from Federal Guidance Report 11[9]. (These changes had been previously implemented at Unit 1[10].) Additionally, this calculation incorporates a recent update made to the design RCS activity concentrations[11,12].

This information is used to derive the revised Technical Specification reactor coolant system (RCS) activity concentration limit for each radioisotope. Also, this change has a significant impact on the calculated alarm setpoint and monitor conversion factor (CF11). The impacts are further discussed in the RESULTS section of this calculation package.

ERS-SFL-88-027, Rev. 3 (2011)
Added the letdown radiation monitor indications that correspond to an RCS concentration equivalent to 21 uCi/g dose equivalent iodine-131 (DE I-131). This value is proposed for use as part of the NEI EAL upgrade project for EAL SU9. Updated references. Updated the source term/basis to use 12241-UR(B)-484[19] data.

Comparison to Unit 1:
The Unit 1 letdown radiation monitors setpoints are based on an RCS activity concentration with 1% failed fuel[13]. The high-high alarm is set to actuate at an RCS concentration while operating with 1% failed fuel and the high alarm is set to actuate at an RCS concentration while operating with 0.5% failed fuel. These concentrations are much higher than the Technical Specification activity concentration limits. The difference between the two Units is apparently due to the SWEC analyst's decision to select the Technical Specification activity concentration limits as the setpoint basis (rather than the originally used 1% failed fuel) when revision 1 of 12241-UR(B)-410 was performed. Using this as the setpoint basis will cause the Unit 2 monitor to alarm with a lower amount of failed fuel as compared to that for Unit 1.

Because of the difference discussed above, a different methodology must be used to determine the activity concentrations between the Units. At Unit 1, with the setpoint based on activity concentration with 1% failed fuel, it was necessary to make adjustments in the source term to consider that additional RCS clean-up will occur when the letdown system is operated at a flow rate higher than 60 gpm, the value at which the design activity concentrations were calculated. A higher flow rate, normally approximately 105 gpm, is routine and this is taken into consideration in the alarm setpoint calculation. At Unit 2, using the Technical Specification activity concentration limit at the setpoint basis, any need to adjust for variation in activity removal is eliminated.

With regard to the proposed EAL monitor indication of 21 uCi/g, the only difference between Unit 1 (cpm) and Unit 2 (uCi/cc) is that the calculations are done to provide indication in the appropriate units.

METHODOLOGY

The methodology of this calculation is identical to that used in the previous revision. This RCS isotopic mix is assumed to be that calculated for the Technical Specification concentration limit. These values are then multiplied by the monitor efficiency specific to each radioisotope and the resulting count rates are summed to produce the monitor response. Because Technical Specification concentration is expressed in units of μCi/g and efficiency is expressed as cpm-cc/μCi this calculation corrects for density at the monitor. Finally, because the isotopic mix is updated, the monitor engineering unit conversion factors (CF11) are recalculated. All of the mathematical operations are provided in further detail on the Attachment 2 spreadsheets.

Instrument error is considered when determining the alarm trip setpoint. BVPS Unit 2 is committed to Regulatory Guide 1.105[14]. This document provides the basis for instrument setpoints for safety related systems, and is implemented through Radiological Engineering Administrative Manual procedure BVBP-RP-0002[15]. Therein, the Total Loop Uncertainty is defined as:

$$TLU = (EA^2 + PA^2 + CA^2 + SA^2 + DA^2 + +LA^2 + TA)^{0.5} \qquad \text{[eq. 1]}$$

And the Trip Setpoint as:

$$TSP = AL / [1 + (\%TLU / 100 + (\%DEADBAND) / 100] \qquad \text{[eq. 2]}$$

The TLU has previously been determined to equal 21%[16]. Because this value is derived elsewhere, the reader is referred to the source, and BVBP-RP-0002, for explanation of the variables in the error analysis equation.

The TSP is:

$$TSP = \frac{\text{Activity conc (AL) } (\mu Ci/cc)}{1 + (21\% / 100) + (10\% / 100)} = \frac{\text{Activity conc (AL) } (\mu Ci/cc)}{1.31} \qquad \text{[eq. 3]}$$

INPUT DATA AND ASSUMPTIONS

1. Reactor Coolant Technical Specification activity concentrations [19, Table 9.2]
2. Basis for Technical Specification activity = 0.35 μCi/g DEI-131 (48 hour limit) [1]
3. Proposed EAL monitor indication = 21 μCi/g DEI-131 (Technical Specification instantaneous limit) [1]
4. CHS-RQ-101A/B nuclide efficiencies (Nuclide efficiencies are listed in Attachments 1 & 2) [17]
5. Fluid temperature at CHS-101A/B = 130 °F [5]
6. Fluid density at CHS-101A/B = 61.6 lbm/ft^3 [5]
7. Fluid density – Standard = 62.43 lbm/ft^3 [Calculated]

   7.481 gal/ft^3 * 3785.3 cm^3/gal * 1 g/cm^3 / 453.592 g/lbm [18]
8. Instrument Error = ±21% [16]

RESULTS

For the high range monitor and the low range monitor (Attachment 2), the monitor response in cpm is calculated using activity concentrations at the (48 hour) Technical Specification limits. Because the RCS activities are given in μCi/g, only a slight density correction is necessary to determine the concentration in μCi/cc at the monitor. Consistent with the current analysis of record (and with Unit 1), the monitor response is calculated in terms of gross activity. That is, those isotopes that cause no monitor response are included. By employing this method, the monitor reading will represent total activity, even though some isotopes cannot be detected. Also, it is important to note that the monitor reading in μCi/cc represents the concentration at the monitor, and not in the RCS. Because of density differences, this difference is approximately 40%, with the actual concentration in the RCS being lower. The setpoint calculation is based on mass concentration rather than volume concentration, and is not affected by this fact.

From Attachment 2:
Note: The spreadsheet carries higher precision than shown below.

Technical Specification activity concentration = 4.97E+01 μCi/cc at the monitor. This is the analytical limit (AL), or process safety limit. Applying equation 3 to determine the high alarm trip set point (TSP):

4.11E+01 μCi/cc = the high alarm trip setpoint with instrument error adjustment (4.97E+01 μCi/cc / 1.31). This should be set with the background subtract feature active, or with the corresponding background added to the alarm setpoint.

and taking 75% of the high setpoint to calculated the alert alarm setpoint:

3.08E+01 μCi/cc = the alert alarm trip setpoint. This should be set with the background subtract feature active, or with the corresponding background added to the alarm setpoint.

Note: Although there are two monitors (high range and low range) they both provide input to a single set of alarms (high alarm and alert alarm).

The corresponding high range monitor response = 1.38E+03 cpm / 4.97E+01 μCi/cc

The corresponding low range monitor response = 3.49E+05 cpm / 4.97E+01 μCi/cc

3.60E-02 μCi/cc-cpm = the high range monitor engineering unit conversion factor (CF11) (4.97E+01 μCi/cc / 1.38E+03 cpm)

1.43E-04 μCi/cc-cpm = the low range monitor engineering unit conversion factor (CF11) (4.97E+01 μCi/cc / 3.49E+05 cpm)

As compared to the current alarm setpoints, the values calculated herein are slightly higher. This is attributed to use of the revised term used in this revision. The influence of the revised source term was previously evaluated in 10080-UR(B)-508[20], and was judged to not be significant. Therefore no setpoint revision was made at that time. This technical evaluation does use the revised source term to calculate alarm setpoints, and the change is not significant as was assumed in 10080-UR(B)-508. This change will be communicated to Radiological Operations, however the current alarm setpoints appear appropriate with not obvious change needed. If the revised alarm setpoints are used, then the revised CF11 values will also need to be used.

Predicted monitor cpm at maximum Technical Specification activity concentrations:

	Current cpm	Rev. 3 cpm
High range	1.35E+03	1.38E+03
Low range	3.45E+05	3.49E+05

The monitor engineering unit conversion factors (CF11):

	Current µCi/cc-cpm	Rev, 3 µCi/cc-cpm
High range	3.68E-02	3.60E-02
Low range	1.44E-04	1.43E-04

The monitor alarm setpoint values:

	Current µCi/cc	Rev. 3 µCi/cc
High	38.0	41.1
Alert	28.5	30.8

The calculated monitor indication that corresponds to an RCS activity concentration of 21 uCi/g is 2.98E+03 uCi/cc for the high range channel. Note that this is a proposed EAL value and does not include instrument error consideration. This value is "offscale" with the low range monitor (range of 1.43E-3 to 1.43E+3 uCi/cc), so no EAL value is applicable to the low range monitor.

REFERENCES

1. Unit 2 Technical Specification Amendment 101, Docket No. 50-412, 1999
2. Unit 2 NRC SER Chapter 4, Section 4.2.4.2, Online Fuel System Monitoring
3. Unit 2 UFSAR Chapter 4, Section 4.2.3.3, Fuel Rod Performance
4. Unit 2 UFSAR Chapter 11, Section 11.5.2.5.10, Reactor Coolant Letdown Monitor (High and Low Range)
5. SWEC Calculation 12241 UR(B)-410-1, Determine the Safety Limits for the Reactor Coolant Letdown High Range and Low Range Monitor 2CHS-RQI-101A & B, 1987
6. Calculation ERS-SFL-88-027 Rev. 1, Process Safety Limits and Alarm Setpoints for 2CHS-RQ101 A/B, 1989
7. ICRP Publication 26, Recommendations of the International Commission on Radiological Protection, Pergamon Press, New York, Reprinted 1981
8. ICRP Publication 30, Limits for Intakes of Radionuclides by Workers, Pergamon Press, New York, 1978
9. Federal Guidance Report 11. Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, US EPA 521/1-88-020, 1988
10. Unit 1 Technical Specification Amendment 205, Docket No. 50-334, 1997
11. SWEC Calculation 12241 UR(B)-478, Design Reactor Core Inventory (3.96% Initial Enrichment) and Associated Equilibrium Primary and Secondary Coolant Activities for BVPS, 1999
12. SWEC Calculation 12241 UR(B)-479, Radiological Source Term for Accident Analyses – Composite Equilibrium Reactor Core Inventory (3.6% - 7% Initial Enrichment) and Associated Design Primary and Secondary Coolant Activities for BVPS, 1999
13. Calculation ERS-JTL-99-005, Unit 1 Letdown Radiation Monitor (RM-1CH-101) Alarm Setpoint Calculation, 1999
14. US NRC Regulatory Guide 1.105, Instrument Setpoints, Revision 1, 1976
15. BVBP-RP-0002, Radiation Monitor Alarm Setpoint Determination
16. SWEC Calculation 12241 UR(B)-432-2, Trip Setpoint Calculation for 8 Radiation Monitors Associated with DRMS Communication Loop #1, 1987
17. Calculation ERS-SFL-86-026, r9, Unit 2 DRMS Isotopic Efficiencies, 1995
18. The Health Physics and Radiological Health Handbook, Shleien, B., Scinta, Inc, Silver Spring, Revised Edition, 1992
19. SWEC Calculation 10080-UR(B)-484, Primary and Secondary Design/Technical Specification Activity Concentrations Including Pre-Accident Iodine Spike Concentrations and Equilibrium Iodine Appearance Rates Following Power Uprate, 200299
20. SWEC Calculation 10080-UR(B)-508, Impact of Atmospheric Containment Conversion, Power Uprate, and Alternative Source Terms on the Alarm Setpoints for the Radiation Monitors at BVPS2
21. Calculation ERS-SFL-88-027 Rev. 2, Process Safety Limits and Alarm Setpoints for 2CHS-RQ101 A/B, 1999

Alarm Setpoint Methodology

DISCUSSION

This appendix describes the bases for the alarm setpoint methodology. Only increasing value alarm setpoints are addressed. A similar methodology could be described for decreasing value alarm setpoints, but these are not applicable to radiation monitoring.

USNRC Regulatory Guide 1.105, Instrument Setpoints [1], provides a regulatory position on setpoints on systems important to safety. The guide provides the following definition of "systems important to safety":

> *"...those systems that are necessary to ensure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shutdown the reactor and maintain it in a safe condition, or (3) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR Part 100, Reactor Site Criteria...."*

The BVPS Unit 2 UFSAR [2] contains a commitment to this regulatory guide, but the referenced discussion in section 7 of the UFSAR does not specifically address radiation monitors. SWEC addressed RG 1.105 in the development of Unit 2 category 1 radiation monitor setpoints. This issue was addressed by the Radiation Safety Committee in meeting 25-87[3] and a position paper was prepared on this issue [4]. While recognizing the need to consider instrument errors in determining alarm setpoints, this position paper concluded that the regulatory guide was (1) applicable to a subset of the Unit 2 monitors, (2) applicable to only those Unit 1 monitors installed in response to a Unit 2 licensing commitment, and (3) not applicable to effluent monitors (ODCM). This position paper was accepted by the RSC (BV-RSC-27-87) and approved by the OSC (BV-OSC-48-87).

Regulatory Guide 1.105 provides, in part:

> *"...The setpoints should be established with sufficient margin between the technical specification limits for the process variable and the nominal trip setpoint to allow for (a) the inaccuracy of the instrument; (b) uncertainties in the calibration, and (c) the instrument drift that could occur during the interval between calibrations...."*

The methodology employed by SWEC was, as was this appendix, based on ANSI/ISA-S67.04-1988, Setpoints for Nuclear Safety-Related Instrumentation [5], which provides a means to accomplish the above.

DEFINITIONS

Safety Limit [SL] — A limit on an important process variable that is necessary to reasonably protect the integrity of the physical barriers that guard against uncontrolled release of radioactivity [5]. Safety limits are documented in the UFSAR, in technical specification bases, and in other design basis documentation.

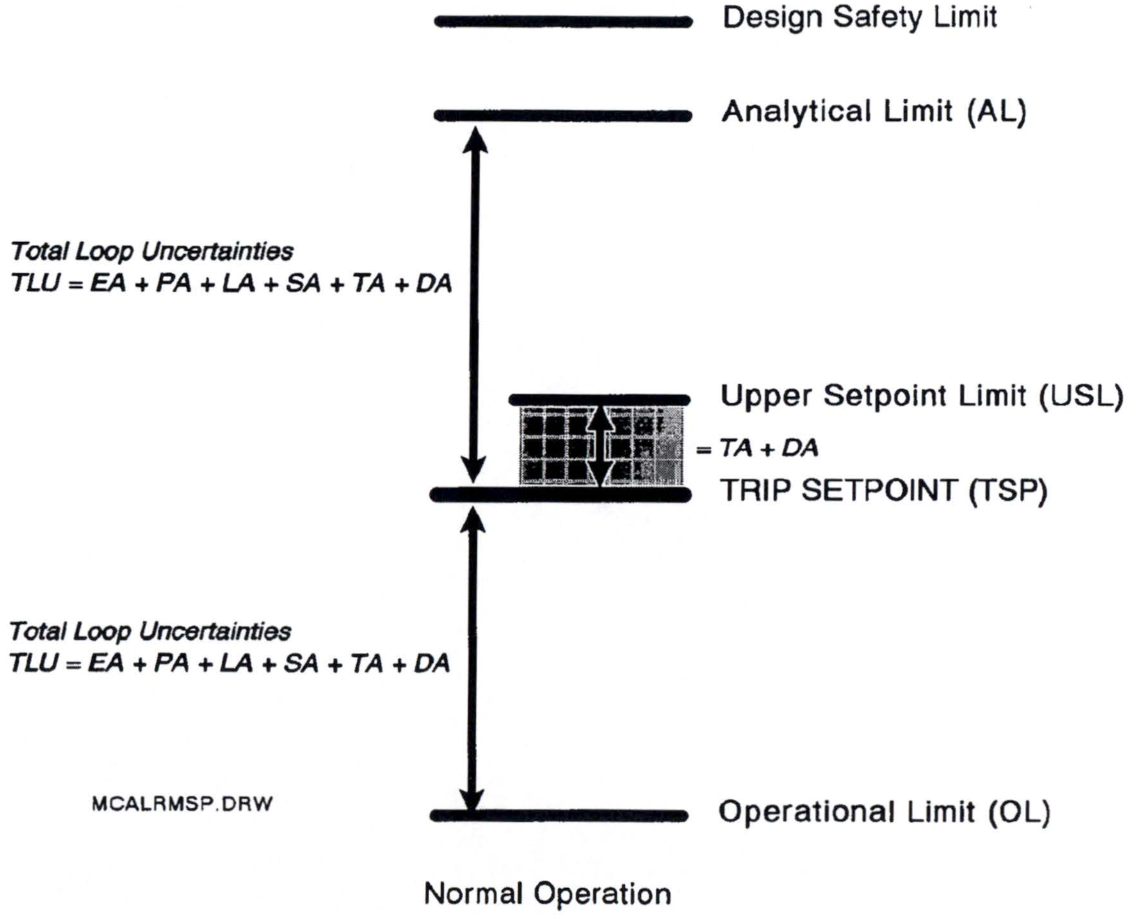
Analytical Limit [AL] — Limit of a measured or calculated variable established by safety analyses to ensure that a safety limit is not exceeded [5]. The difference between a safety limit and an analytical limit provides margin to account for process dependent effects such as (but not limited to) process delays, emergency diesel generator sequencing, valve or damper closure times, and instrument response times.

Trip Setpoint [TSP] — A predetermined value [of the monitored parameter] at which a bistable device changes state to indicate that the quantity under surveillance has reached the selected value [5]. The difference between a trip setpoint and an analytical limit is the allowance provided to account for instrument uncertainty, instrument calibration uncertainty (and, if not addressed in the determination of analytical limit, process dependent effects).

Upper Setpoint Limit [USL] A predetermined value of the monitored parameter above the trip setpoint that, if exceeded during periodic surveillance testing, indicates unsatisfactory instrument performance. The band defined between the trip setpoint and the upper setpoint limit is the allowance provided to account for instrument uncertainties such as setpoint drift, power supply drift, random response variation, deadband, etc.

Operational Limit [OL] The maximum value that the monitored parameter may attain during normal operations, based on administrative controls, that will not result in the occurrence of an alarm.

These quantities are illustrated on the figure below.



DETERMINATION OF ALLOWANCES

Environmental Allowance [EA] Includes the effects of radiation, temperature, pressure, humidity, chemical sprays on the instrumentation. EA should be determined for all safety related monitors expected to operate under accident conditions if the instrument vendor has indicated an accuracy under these conditions that differs from the accuracy expressed for operation under normal conditions. Applies only to QA Category 1 monitors.

Leakage Allowance [LA] Includes instrument signal losses due to cable or penetration leakage or impedence. Applies only to QA Category 1 monitors.

Process Allowance [PA] Includes effects associated with the measurement of the process parameter (e.g., sample line plateout, isokinetic sampling), errors associated with calculation of the process parameter by indirect measurements (e.g., determining flow from Dp measurements).

Calibration Allowance [CA] Includes errors associated with calibrations of the sensor and the readout rack, such as those related to the calibration standard, equipment, and method.

Sensor Allowance [SA] Includes errors associated with the sensor and readout accuracy. Considerations include: linearity; deadtime; energy response linearity; repeatability; power supply stability; temperature, pressure, and humidity changes; ADC/DAC errors, etc.

Drift Allowance [DA] Includes errors due to undesired changes in instrument response, over a period of time, that are independent of the instrument input or use environment. The period of time is normalized to the period between instrument calibrations or surveillance testing.

Tolerance Allowance [TA] Includes administrative tolerances allowed for calibration and/or setpoint adjustment (e.g., adjust to within ± xx% of xxxx cpm).

The errors addressed by these allowances may be dependent or independent. Dependent errors are summed algebraically. Independent errors are summed using the root-of-squared-sums method. Prior to summing, all errors are normalized to a common base (e.g., percent of span, percent of full scale). Unit 1 calibration MSPs provide a tolerance of ±10%. Unit 2 calibration MSPs provide a tolerance of ±15%.

Not all of these allowances are applicable to a particular monitor -- only those applicable are considered. Dependent errors (e.g., LA, CP), are not addressed explicitly if it is reasonable to conclude that sensor-to-readout (end-to-end) calibrations adequately compensate for these effects. In cases where one allowance envelopes a related allowance, only the most restrictive allowance is summed. For example, an instrument setpoint accuracy (i.e., SA) of ±1% is considered enveloped by a tolerance allowance (TA) of ±10%.

The total instrument loop uncertainty (TLU) is the sum of the individual allowances. Assuming LA, to be dependent, and the remainder to be independent:

TLU = LA ± SQRT(EA2 + PA2 + CA2 + SA2 + DA 2+ TA 2)

The trip setpoint equals:

NOTE: In the following, %+TLU refers to the total loop uncertainty in the under-response direction expressed in percent. %-TLU refers to the total loop uncertainty in the over-response direction expressed in percent.

TSP = AL - (TLU x TSP)

TSP = AL / [1 + (%-TLU) /100]

The upper setpoint limit (USL) (NOTE: See definition above.):

USL = TSP + (TSPxDA) + (TSPxTA)

USL = TSP[1 + SQRT(DA2 + TA2)]

The operational limit (OL):

OL = TSP - (TLUxTSP)

OL = TSP[1- (%-TLU/100)]

1. USNRC, Instrument Setpoints, Regulatory Guide 1.105, USGPO ,11/76
2. BVPS Unit 2 Updated Safety Analysis Report, 1990
3. Minutes of Radiation Safety Committee Meeting 25-87
4. Applicability of RG1.105 to BVPS Radiation Monitors, ERS-SFL-87-036, 1987
5. ISA, Setpoints for Nuclear Safety-Related Instrumentation, ANSI/ISA-S67.04-1988
6. Ficke, R, Instrument Setpoint Calculations, presentation at Sorrento Electronics DRMS User's Group Meeting, Fall, 1990

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	A	B	C	D	E	F	G	H	I	J	K	L	M
1	CHS-101A/B Low Range Configuration High Alarm Setpoint and CF11.												
2		T. S. Max.	*Density Corr	T. S. Max.	Efficiency				T. S. Max.	*Density Corr	T. S. Max.	Efficiency	
3		(uCi/g)	(g/cc)	(uCi/cc)	(cpm-cc/uCi)	(cpm)			(uCi/g)	(g/cc)	(uCi/cc)	(cpm-cc/uCi)	(cpm)
4	Kr-83m	3.89E-02	0.9867	3.84E-02	0.000E+00	0.00E+00		Sr-92	9.79E-05	0.9867	9.66E-05	7.921E+04	7.65E+00
5	Kr-85	1.18E+01	0.9867	1.16E+01	0.000E+00	0.00E+00		Y-90	5.64E-06	0.9867	5.56E-06	0.000E+00	0.00E+00
6	Kr-85m	1.35E-01	0.9867	1.33E-01	0.000E+00	0.00E+00		Y-90m	0.00E+00	0.9867	0.00E+00	3.535E+02	0.00E+00
7	Kr-87	9.00E-02	0.9867	8.88E-02	2.718E+04	2.41E+03		Y-91	4.54E-05	0.9867	4.48E-05	2.515E+02	1.13E-02
8	Kr-88	2.52E-01	0.9867	2.49E-01	8.093E+04	2.01E+04		Y-91m	7.51E-05	0.9867	7.41E-05	0.000E+00	0.00E+00
9	Kr-89	7.25E-03	0.9867	7.15E-03	8.275E+04	5.92E+02		Y-92	8.40E-05	0.9867	8.29E-05	1.916E+04	1.59E+00
10	Kr-90	0.00E+00	0.9867	0.00E+00	6.292E+04	0.00E+00		Zr-95	6.00E-05	0.9867	5.92E-05	1.043E+05	6.17E+00
11	Xe-131m	4.84E-01	0.9867	4.78E-01	0.000E+00	0.00E+00		Nb-95	6.09E-05	0.9867	6.01E-05	1.032E+05	6.20E+00
12	Xe-133	2.95E+01	0.9867	2.91E+01	0.000E+00	0.00E+00		Mo-99	7.24E-02	0.9867	7.14E-02	1.852E+04	1.32E+03
13	Xe-133m	3.99E-01	0.9867	3.94E-01	0.000E+00	0.00E+00		Tc-99	0.00E+00	0.9867	0.00E+00	0.000E+00	0.00E+00
14	Xe-135	9.16E-01	0.9867	9.04E-01	3.686E+03	3.33E+03		Tc-99m	3.88E-02	0.9867	3.83E-02	0.000E+00	0.00E+00
15	Xe-135m	9.09E-02	0.9867	8.97E-02	0.000E+00	0.00E+00		Ru-103	5.67E-05	0.9867	5.59E-05	6.669E+03	3.73E-01
16	Xe-137	1.88E-02	0.9867	1.85E-02	2.734E+03	5.07E+01		Ru-106	2.10E-05	0.9867	2.07E-05	0.000E+00	0.00E+00
17	Xe-138	6.36E-02	0.9867	6.28E-02	3.957E+04	2.48E+03		Rh-106	2.33E-05	0.9867	2.30E-05	1.522E+04	3.50E-01
18	I-131	2.74E-01	0.9867	2.70E-01	1.060E+04	2.87E+03		Ag-110m	0.00E+00	0.9867	0.00E+00	3.188E+05	0.00E+00
19	I-132	1.08E-01	0.9867	1.07E-01	2.831E+05	3.02E+04		Sb-124	0.00E+00	0.9867	0.00E+00	1.966E+05	0.00E+00
20	I-133	4.10E-01	0.9867	4.05E-01	1.316E+04	5.32E+03		Te-125m	4.20E-05	0.9867	4.14E-05	0.000E+00	0.00E+00
21	I-134	6.00E-02	0.9867	5.92E-02	2.461E+05	1.46E+04		Te-127	1.11E-03	0.9867	1.10E-03	0.000E+00	0.00E+00
22	I-135	2.36E-01	0.9867	2.33E-01	9.640E+04	2.24E+04		Te-129	1.35E-03	0.9867	1.33E-03	1.154E+03	1.54E+00
23	H-3	3.50E+00	0.9867	3.45E+00	0.000E+00	0.00E+00		Te-129m	1.37E-03	0.9867	1.35E-03	4.723E+03	6.38E+00
24	C-14	0.00E+00	0.9867	0.00E+00	0.000E+00	0.00E+00		Te-131	1.23E-03	0.9867	1.21E-03	2.143E+04	2.60E+01
25	Ar-41	0.00E+00	0.9867	0.00E+00	8.154E+04	0.00E+00		Te-131m	3.42E-03	0.9867	3.37E-03	1.365E+05	4.61E+02
26	Cr-51	9.30E-03	0.9867	9.18E-03	0.000E+00	0.00E+00		Te-132	2.85E-02	0.9867	2.81E-02	0.000E+00	0.00E+00
27	Mn-54	4.80E-03	0.9867	4.74E-03	9.833E+04	4.66E+02		Te-133	8.32E-04	0.9867	8.21E-04	4.605E+04	3.78E+01
28	Mn-56	0.00E+00	0.9867	0.00E+00	1.301E+05	0.00E+00		Te-133m	1.85E-03	0.9867	1.83E-03	2.037E+05	3.72E+02
29	Fe-55	3.60E-03	0.9867	3.55E-03	0.000E+00	0.00E+00		Te-134	2.84E-03	0.9867	2.80E-03	5.890E+04	1.65E+02
30	Fe-59	9.00E-04	0.9867	8.88E-04	8.444E+04	7.50E+01		Cs-134	5.74E-01	0.9867	5.66E-01	2.169E+05	1.23E+05
31	Co-57	0.00E+00	0.9867	0.00E+00	1.759E+02	0.00E+00		Cs-134m	4.19E-03	0.9867	4.13E-03	0.000E+00	0.00E+00
32	Co-58	1.38E-02	0.9867	1.36E-02	1.006E+05	1.37E+03		Cs-135	0.00E+00	0.9867	0.00E+00	0.000E+00	0.00E+00
33	Co-58m	0.00E+00	0.9867	0.00E+00	0.000E+00	0.00E+00		Cs-136	1.42E-01	0.9867	1.40E-01	1.860E+05	2.61E+04
34	Co-60	1.59E-03	0.9867	1.57E-03	1.662E+05	2.61E+02		Cs-137	3.60E-01	0.9867	3.55E-01	9.631E+04	3.42E+04
35	Co-60m	0.00E+00	0.9867	0.00E+00	2.039E+02	0.00E+00		Ba-137m	3.41E-01	0.9867	3.36E-01	1.018E+05	3.43E+04
36	Ni-65	0.00E+00	0.9867	0.00E+00	3.254E+04	0.00E+00		Ba-139	7.57E-03	0.9867	7.47E-03	3.124E+02	2.33E+00
37	Cu-64	0.00E+00	0.9867	0.00E+00	3.988E+02	0.00E+00		Ba-140	3.89E-04	0.9867	3.84E-04	0.000E+00	0.00E+00
38	Zn-65	1.53E-03	0.9867	1.51E-03	4.364E+04	6.59E+01		La-140	1.34E-04	0.9867	1.32E-04	1.221E+05	1.61E+01
39	Br-83	7.17E-03	0.9867	7.07E-03	0.000E+00	0.00E+00		Ce-141	5.87E-05	0.9867	5.79E-05	0.000E+00	0.00E+00
40	Br-84	3.55E-03	0.9867	3.50E-03	9.626E+04	3.37E+02		Ce-143	4.33E-05	0.9867	4.27E-05	1.367E+04	5.84E-01
41	Br-85	3.75E-04	0.9867	3.70E-04	6.924E+03	2.56E+00		Ce-144	4.45E-05	0.9867	4.39E-05	0.000E+00	0.00E+00
42	Rb-88	2.62E-01	0.9867	2.59E-01	3.352E+04	8.67E+03		Pr-143	5.46E-05	0.9867	5.39E-05	1.264E-03	6.81E-08
43	Rb-89	1.49E-02	0.9867	1.47E-02	1.322E+05	1.94E+03		Pr-144	4.48E-05	0.9867	4.42E-05	2.461E+03	1.09E-01
44	Rb-90	1.16E-03	0.9867	1.14E-03	7.616E+04	8.72E+01		Np-239	6.60E-03	0.9867	6.51E-03	0.000E+00	0.00E+00
45	Sr-89	3.31E-04	0.9867	3.27E-04	1.410E+01	4.61E-03		Cs-138	9.76E-02	0.9867	9.63E-02	1.177E+05	1.13E+04
46	Sr-91	1.37E-04	0.9867	1.35E-04	7.623E+04	1.03E+01		Te-127m	3.20E-04	0.9867	3.16E-04	1.291E+01	4.08E-03
47		4.87E+01		4.81E+01		1.18E+05			1.69E+00		1.67E+00		2.31E+05
48									5.04E+01	- TOTALS -	4.97E+01	- TOTALS -	3.49E+05
49									uCi/g RCS		uCi/cc @ 130 degF		cpm

50 *Density correction = 0.9867 g/cc (based on letdown temperature of 130 degrees F)

52 Col B & I values from 12241-UR(B)-484 Table 9.2 — Col D = Col B * Col C ; Col K = Col I * Col J

53 Col C & J = 61.6 lbm/ft³ @130 degF / 62.43 lbm/ft³ standard = 0.9867 — Col E & L values from ERS-SFL-86-026 r3

54 Col F = Col D * Col E ; Col M = Col K * Col L

57 CF11 calculation: CF11 = at-monitor activity at T.S. limit (uCi/cc) / monitor count rate with RCS at T.S. limit (cpm)

58 CF11 = 4.97E+01 / 3.49E+05 = 1.43E-04 uCi/cc-cpm

59 uCi/cc @ 130 degF — cpm

61 cpm — uCi/cc-cpm — uCi/cc

62 Monitor indication @0.35 uCi/g DE I-131 = 3.49E+05 x 1.43E-04 = 4.97E+01

63 High alarm trip setpoint (indication with 21% instrument error included) = 4.11E+01

64 Alert alarm trip setpoint (75% of the High setpoint with 21% instrument error included) = 3.08E+01

65 Monitor indication @21 uCi/g DE I-131 (4.66E+01 * (21 / 0.35) = 2.98E+03

67 Note: Higher precision than shown is carried through the calculation.

Note: The isotopes used are consistent with the original calculation and not all of the isotopes in UR(B)-484 are included.

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Process Safety Limits, Alarm Setpoints and EAL Indicator Value for 2CHS-RQ101A/B | ERS-SFL-88-027 **Attachment 2** | 13

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	CHS-101A/B High Range Configuration High Alarm Setpoint and CF11.												
2		T. S. Max.	*Density Corr	T. S. Max.	Efficiency				T. S. Max.	*Density Corr	T. S. Max.	Efficiency	
3		(uCi/g)	(g/cc)	(uCi/cc)	(cpm-cc/uCi)	(cpm)			(uCi/g)	(g/cc)	(uCi/cc)	(cpm-cc/uCi)	(cpm)
4	Kr-83m	3.89E-02	0.9867	3.84E-02	0.000E+00	0.00E+00		Sr-92	9.79E-05	0.9867	9.66E-05	4.578E+02	4.42E-02
5	Kr-85	1.18E+01	0.9867	1.16E+01	0.000E+00	0.00E+00		Y-90	5.64E-06	0.9867	5.56E-06	0.000E+00	0.00E+00
6	Kr-85m	1.35E-01	0.9867	1.33E-01	0.000E+00	0.00E+00		Y-90m	0.00E+00	0.9867	0.00E+00	1.125E+00	0.00E+00
7	Kr-87	9.00E-02	0.9867	8.88E-02	1.496E+02	1.33E+01		Y-91	4.54E-05	0.9867	4.48E-05	1.481E+00	6.63E-05
8	Kr-88	2.52E-01	0.9867	2.49E-01	4.722E+02	1.17E+02		Y-91m	7.51E-05	0.9867	7.41E-05	0.000E+00	0.00E+00
9	Kr-89	7.25E-03	0.9867	7.15E-03	4.471E+02	3.20E+00		Y-92	8.40E-05	0.9867	8.29E-05	9.876E+01	8.19E-03
10	Kr-90	0.00E+00	0.9867	0.00E+00	3.538E+02	0.00E+00		Zr-95	6.00E-05	0.9867	5.92E-05	3.826E+02	2.27E-02
11	Xe-131m	4.84E-01	0.9867	4.78E-01	0.000E+00	0.00E+00		Nb-95	6.09E-05	0.9867	6.01E-05	3.977E+02	2.39E-02
12	Xe-133	2.95E+01	0.9867	2.91E+01	0.000E+00	0.00E+00		Mo-99	7.24E-02	0.9867	7.14E-02	6.889E+01	4.92E+00
13	Xe-133m	3.99E-01	0.9867	3.94E-01	0.000E+00	0.00E+00		Tc-99	0.00E+00	0.9867	0.00E+00	0.000E+00	0.00E+00
14	Xe-135	9.16E-01	0.9867	9.04E-01	9.664E+00	8.73E+00		Tc-99m	3.88E-02	0.9867	3.83E-02	0.000E+00	0.00E+00
15	Xe-135m	9.09E-02	0.9867	8.97E-02	0.000E+00	0.00E+00		Ru-103	5.67E-05	0.9867	5.59E-05	1.734E+01	9.70E-04
16	Xe-137	1.88E-02	0.9867	1.85E-02	1.525E+01	2.83E-01		Ru-106	2.10E-05	0.9867	2.07E-05	0.000E+00	0.00E+00
17	Xe-138	6.36E-02	0.9867	6.28E-02	2.359E+02	1.48E+01		Rh-106	2.33E-05	0.9867	2.30E-05	4.900E+01	1.13E-03
18	I-131	2.74E-01	0.9867	2.70E-01	3.120E+01	8.44E+00		Ag-110m	0.00E+00	0.9867	0.00E+00	1.276E+03	0.00E+00
19	I-132	1.08E-01	0.9867	1.07E-01	1.046E+03	1.11E+02		Sb-124	0.00E+00	0.9867	0.00E+00	7.016E+02	0.00E+00
20	I-133	4.10E-01	0.9867	4.05E-01	6.093E+01	2.46E+01		Te-125m	4.20E-05	0.9867	4.14E-05	0.000E+00	0.00E+00
21	I-134	6.00E-02	0.9867	5.92E-02	1.129E+03	6.68E+01		Te-127	1.11E-03	0.9867	1.10E-03	0.000E+00	0.00E+00
22	I-135	2.36E-01	0.9867	2.33E-01	5.492E+02	1.28E+02		Te-129	1.35E-03	0.9867	1.33E-03	5.112E+00	6.81E-03
23	H-3	3.50E+00	0.9867	3.45E+00	0.000E+00	0.00E+00		Te-129m	1.37E-03	0.9867	1.35E-03	1.591E+01	2.15E-02
24	C-14	0.00E+00	0.9867	0.00E+00	0.000E+00	0.00E+00		Te-131	1.23E-03	0.9867	1.21E-03	9.294E+01	1.13E-01
25	Ar-41	0.00E+00	0.9867	0.00E+00	4.824E+02	0.00E+00		Te-131m	3.42E-03	0.9867	3.37E-03	5.995E+02	2.02E+00
26	Cr-51	9.30E-03	0.9867	9.18E-03	0.000E+00	0.00E+00		Te-132	2.85E-02	0.9867	2.81E-02	0.000E+00	0.00E+00
27	Mn-54	4.80E-03	0.9867	4.74E-03	4.294E+02	2.03E+00		Te-133	8.32E-04	0.9867	8.21E-04	2.301E+02	1.89E-01
28	Mn-56	0.00E+00	0.9867	0.00E+00	6.348E+02	0.00E+00		Te-133m	1.85E-03	0.9867	1.83E-03	9.227E+02	1.68E+00
29	Fe-55	3.60E-03	0.9867	3.55E-03	0.000E+00	0.00E+00		Te-134	2.84E-03	0.9867	2.80E-03	2.219E+02	6.22E-01
30	Fe-59	9.00E-04	0.9867	8.88E-04	4.887E+02	4.34E-01		Cs-134	5.74E-01	0.9867	5.66E-01	7.155E+02	4.05E+02
31	Co-57	0.00E+00	0.9867	0.00E+00	5.743E-01	0.00E+00		Cs-134m	4.19E-03	0.9867	4.13E-03	0.000E+00	0.00E+00
32	Co-58	1.38E-02	0.9867	1.36E-02	4.227E+02	5.76E+00		Cs-135	0.00E+00	0.9867	0.00E+00	0.000E+00	0.00E+00
33	Co-58m	0.00E+00	0.9867	0.00E+00	0.000E+00	0.00E+00		Cs-136	1.42E-01	0.9867	1.40E-01	9.073E+02	1.27E+02
34	Co-60	1.59E-03	0.9867	1.57E-03	9.753E+02	1.53E+00		Cs-137	3.60E-01	0.9867	3.55E-01	2.906E+02	1.03E+02
35	Co-60m	0.00E+00	0.9867	0.00E+00	1.195E+00	0.00E+00		Ba-137m	3.41E-01	0.9867	3.36E-01	3.072E+02	1.03E+02
36	Ni-65	0.00E+00	0.9867	0.00E+00	1.885E+02	0.00E+00		Ba-139	7.57E-03	0.9867	7.47E-03	1.828E+00	1.37E-02
37	Cu-64	0.00E+00	0.9867	0.00E+00	2.345E+00	0.00E+00		Ba-140	3.89E-04	0.9867	3.84E-04	0.000E+00	0.00E+00
38	Zn-65	1.53E-03	0.9867	1.51E-03	2.503E+02	3.78E-01		La-140	1.34E-04	0.9867	1.32E-04	6.601E+02	8.73E-02
39	Br-83	7.17E-03	0.9867	7.07E-03	0.000E+00	0.00E+00		Ce-141	5.87E-05	0.9867	5.79E-05	0.000E+00	0.00E+00
40	Br-84	3.55E-03	0.9867	3.50E-03	5.077E+02	1.78E+00		Ce-143	4.33E-05	0.9867	4.27E-05	4.596E+01	1.96E-03
41	Br-85	3.75E-04	0.9867	3.70E-04	3.137E+01	1.16E-02		Ce-144	4.45E-05	0.9867	4.39E-05	0.000E+00	0.00E+00
42	Rb-88	2.62E-01	0.9867	2.59E-01	1.870E+02	4.83E+01		Pr-143	5.46E-05	0.9867	5.39E-05	4.637E-06	2.50E-10
43	Rb-89	1.49E-02	0.9867	1.47E-02	7.277E+02	1.07E+01		Pr-144	4.48E-05	0.9867	4.42E-05	1.049E+01	4.64E-04
44	Rb-90	1.16E-03	0.9867	1.14E-03	4.161E+02	4.76E-01		Np-239	6.60E-03	0.9867	6.51E-03	0.000E+00	0.00E+00
45	Sr-89	3.31E-04	0.9867	3.27E-04	6.843E-02	2.23E-05		Cs-138	9.76E-02	0.9867	9.63E-02	6.765E+02	6.51E+01
46	Sr-91	1.37E-04	0.9867	1.35E-04	3.306E+02	4.47E-02		Te-127m	3.20E-04	0.9867	3.16E-04	3.758E-02	1.19E-05
47		4.87E+01		4.81E+01		5.68E+02			1.69E+00		1.67E+00		8.14E+02
48									5.04E+01	- TOTALS -	4.97E+01	- TOTALS -	1.38E+03
49									uCi/g RCS		uCi/cc @ 130 degF		cpm

50 *Density correction = 0.9867 g/cc (based on letdown temperature of 130 degrees F)

52 Col B & I values from 12241-UR(B)-484 Table 9.2

53 Col C & J = 61.6 lbm/ft³ @130 degF / 62.43 lbm/ft³ standard = 0.9867

Col D = Col B * Col C ; Col K = Col I * Col J

Col E & L values from ERS-SFL-86-026 r3

Col F = Col D * Col E ; Col M = Col K * Col L

57 CF11 calculation: CF11 = at-monitor activity at T.S. limit (uCi/cc) / monitor count rate with RCS at T.S. limit (cpm)

58 CF11 = 4.97E+01 / 1.38E+03 = 3.60E-02 uCi/cc-cpm

59 uCi/cc @ 130 degF cpm

61 cpm uCi/cc-cpm uCi/cc

62 **Monitor indication @0.35 uCi/g DE I-131 = 1.38E+03 x 3.60E-02 = 4.97E+01**

63 **High alarm trip setpoint (indication with 21% instrument error included) = 4.11E+01**

64 **Alert alarm trip setpoint (75% of the High setpoint with 21% instrument error included) = 3.08E+01**

65 **Monitor indication @21 uCi/g DE I-131 (4.66E+01 * (21 / 0.35) = 2.98E+03**

67 Note: Higher precision than shown is carried through the calculation.

Note: The isotopes used are consistent with the original calculation and not all of the isotopes in UR(B)-484 are included.