Effect of DEI-131 Weighting Factors on NRC Performance Indicator

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Why be Concerned?

- Dose-Equivalent I-131 (DEI-131) was intended to provide a 'standardized' approach to assess coolant iodines based on dose impact
- Differences in weighting factors 'defeat' standardized approach
- DEI-131 is being tracked by the NRC as a performance indicator under the barrier integrity cornerstone… will INPO follow suit?

Iodine Calculation Methods

- There are two common methods for calculating the amount of iodine released from the reactor core:
  - Total Iodine
  - Dose Equivalent Iodine (DEI)

Total Iodine

- 'Old' methodology… pre-dates DEI
- Pilgrim Technical Specifications state that total iodine in reactor coolant must be than 20 uCi/mL
- This makes it difficult to compare PNPS to other plants using DEI… implications to NRC cornerstone comparisons

Dose Equivalent I-131 (DEI)

- Standard Technical Specification (STS) adopted a more 'uniform' approach of reporting iodine - Dose Equivalent Iodine (DEI)
- The STS state "The specific activity of the reactor coolant shall be limited to DOSE EQUIVALENT I-131 specific activity $\leq$ 0.2 uCi/gm."

Dose Equivalent Iodine

- DEI is based on thyroid dose received from inhalation and is defined in STS as:

  DOSE EQUIVALENT I-131 - *DOSE EQUIVALENT I-131 shall be that concentration of I-131 (microcuries/gram) that alone would produce the same thyroid dose as the quantity and isotopic mixture of I-131, I-132, I-133, I-134, and I-135 actually present.*

TID-14844

- TID-14844, "Calculation of Distance Factors for Power and Test Reactor Sites"
- Written to provide guidance for calculating doses in an *EMERGENCY*
- Based on DBA LOCA assumptions
- Issued by the AEC in 1962

TID-14844

Nuclide	rad/Ci	DEI Factor
I-131	1.48E+06	1.00E+00
I-132	5.35E+04	3.61E-02
I-133	4.00E+05	2.70E-01
I-134	2.50E+04	1.69E-02
I-135	1.24E+05	8.38E-02

RegGuide 1.109

- Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Radioactive Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I"
- Intended for calculating doses to the *PUBLIC FROM ROUTINE EFFLUENT RELEASES*
- Issued by NRC in 1977, but based on ICRP-2 (~1950's)

RegGuide 1.109

Nuclide	mrem/pCi	DEI Factor
I-131	1.49E-03	1.00E+00
I-132	1.43E-05	9.60E-03
I-133	2.69E-04	1.81E-01
I-134	3.73E-06	2.50E-03
I-135	5.60E-05	3.76E-02

ICRP-30

- ICRP-30, "Limits for Intakes of Radionuclides by Workers"
- Developed as international guidance for calculating *DOSE IMPACT TO RADIATION WORKERS*
- Based on "Standard Man" approach; ICRP-26 & 23
- More sophisticated metabolic models than previous approaches

ICRP-30

Nuclide	Sv/Bq	DEI Factor
I-131	2.92E-07	1.00E+00
I-132	1.74E-09	5.96E-03
I-133	4.86E-08	1.66E-01
I-134	2.88E-10	9.86E-04
I-135	8.46E-09	2.90E-02

ICRP-68

- ***NOT RECOGNIZED BY THE NRC!*** However, adopted by IAEA, may be used outside USA
- ICRP-68, "Dose Coefficients for Intakes of Radionuclides by Workers"
- Updated international guidance for calculating *DOSE IMPACT TO RADIATION WORKERS*
- Based on updated "Standard Man" approach; ICRP-61/60 vs. ICRP-26/23
- Updated metabolic models from ICRP-30

ICRP-68

Nuclide	Sv/Bq	DEI Factor
I-131	3.90E-07	1.00E+00
I-132	3.60E-09	9.23E-03
I-133	7.60E-08	1.95E-01
I-134	7.70E-10	1.97E-03
I-135	1.50E-08	3.85E-02

Pilgrim Station Typical Mix

Nuclide	uCi/mL	ICRP-30	RG-1.109	TID-14844	ICRP-68
I-131	1.05E-05	1.05E-05	1.05E-05	1.05E-05	1.05E-05
I-132	5.04E-04	3.01E-06	4.84E-06	1.82E-05	4.66E-06
I-133	1.47E-04	2.45E-05	2.66E-05	3.98E-05	2.87E-05
I-134	1.61E-03	1.59E-06	4.04E-06	2.73E-05	3.19E-06
I-135	4.24E-04	1.23E-05	1.60E-05	3.56E-05	1.63E-05
Total	**2.70E-03**	**5.19E-05**	**6.20E-05**	**1.31E-04**	**6.34E-05**
% Limit	0.01%	0.03%	0.03%	0.07%	0.03%
ICRP-30 Ratio	--	1.00	1.19	2.53	1.22

Pre-failure Iodines

Nuclide	uCi/mL	ICRP-30	RG-1.109	TID-14844	ICRP-68
I-131	6.29E-06	6.29E-06	6.29E-06	6.29E-06	6.29E-06
I-132	1.89E-04	1.13E-06	1.82E-06	6.84E-06	1.75E-06
I-133	9.71E-05	1.62E-05	1.75E-05	2.62E-05	1.89E-05
I-134	4.30E-04	4.24E-07	1.08E-06	7.26E-06	8.48E-07
I-135	2.08E-04	6.04E-06	7.84E-06	1.75E-05	8.02E-06
Total	**9.31E-04**	**3.00E-05**	**3.45E-05**	**6.41E-05**	**3.58E-05**
% Limit	0.00%	0.02%	0.02%	0.03%	0.02%
ICRP-30 Ratio	--	1.00	1.15	2.13	1.19

Post-failure Iodines

Nuclide	uCi/mL	ICRP-30	RG-1.109	TID-14844	ICRP-68
I-131	3.46E-03	3.46E-03	3.46E-03	3.46E-03	3.46E-03
I-132	2.65E-03	1.58E-05	2.54E-05	9.58E-05	2.45E-05
I-133	7.00E-03	1.17E-03	1.26E-03	1.89E-03	1.36E-03
I-134	1.40E-03	1.38E-06	3.51E-06	2.37E-05	2.77E-06
I-135	4.81E-03	1.39E-04	1.81E-04	4.03E-04	1.85E-04
Total	**1.93E-02**	**4.78E-03**	**4.94E-03**	**5.88E-03**	**5.04E-03**
% Limit	0.10%	2.39%	2.47%	2.94%	2.52%
ICRP-30 Ratio	--	1.00	1.03	1.23	1.05
Post:Pre Ratio	21	159	143	92	141

Summary

- TID-14844 dose factors yield the highest calculated DEI
  - 'Old' science; overly conservative?
- ICRP-30 dose factors yield the lowest calculated DEI
  - 'New' science = better?; aligns with 10CFR20
- ICRP-30 dose factors appear to be the most 'sensitive' to fuel failure, yielding the largest change in DEI values

Summary (continued)

- Differences in dose conversion factors between TID-14844, Reg.Guide 1.109, and ICRP-30 yield different weighting factors that can affect DEI:
  - Normal iodine values: 2.5x variation
  - Failure iodine values: 1.25x variation
- 'Defeats' standardized approach, making comparisons between different plants difficult to perform

Summary (continued)

- NRC is using DEI as performance indicator… will INPO/WANO be far behind to apply (misuse?) DEI as an indicator to rank plants' performance? *Think about…*
  - Liquid Curies Discharged: *zero release*
  - Liquid Volume Discharged: *zero release*
  - Fuel Reliability Indicator: *FRI has to be 1 uCi/sec to be top quartile*