Is Tritium Over-Regulated, Part 2 Should The TFG Support Higher Tritium Threshold Values? (LA-UR-14-22479)

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April, 2014

Last year I proposed that the TFG accept new Nuclear Facility Category thresholds proposed in NA-1 SD G 1027

	Category 3 threshold	Category 2 threshold
DOE-STD-027-92	**1.6 grams (tritium)**	**30 grams (tritium)**
	8.4 grams (Pu-239)	900 grams (Pu-239)
NA-1 SD-G 1027	**0.87 grams (tritium)**	**62.4 grams (tritium)**
	39 grams (Pu-239)	2600 grams (Pu-239)

The TFG voted 7 to 2 against accepting the NA-1 SD G 1027 proposal!

Based on discussions at the April 2013 meeting I concluded -

- The proposed change to the Release Fraction from 1 to 0.5 was justified. (consistent with NRC guidance)
- The changes to the dose model, 66.6 rem/Ci and Respiration Rates, were justified (latest ICRP)
- The use of an understandable model for tritium was preferred
- A vote for the increased in Category 2 threshold from 30 to 62.4 grams would likely have passed
- A vote to decrease in Category 3 threshold from 1.6 to 0.87 grams was certain to fail
- The comparison to Pu-239 helped the Cat 2 threshold increase and hurt the Cat 3 threshold decrease.
- Further work was needed, especially on the Category 3 threshold, to gain a TFG recommendation

What should the TFG recommend for the next revision of DOE-1027-92?

- **No change to the existing Category 2 and Category 3 thresholds**
  - Inconsistent with new ICRP guidelines
  - Very conservative, especially compared to other radionuclides
  - Basis for the Category 3 threshold value is not well understood
- **Adjust the model with new ICRP guidelines**
  - Change Category 2 threshold to 31.2 (adopt latest ICRP, RF @ 1.0)
  - Leave Category 3 threshold at 1.6, with unknown basis
- **Develop new model for tritium categorization or adjust existing model to be defensible and less conservative**
  - Use new ICRP guidelines
  - Use Release Fraction of 0.5
  - Incorporate physical properties of tritium

The existing DOE STD-1027-92 and NA-1 SD G 1027 calculation/model has few variables.

For Category 2 Threshold

Q (g) = 1 rem /(RF x SA x X/Q x (CEDE x RR + CDSE)

RF = Release Fraction = 1.0 or 0.5

SA = Specific Activity = 9630 Ci/g

X/Q = Dispersion Factor = 1 E-4 sec/m3

CEDE = 66.6 rem/Ci / 99.9 with skin absorption (all oxide)

RR = Respiration Rate = 3.33 E-4 m3/sec (during plume passage)

CDSE = Cloud Shine Dose Equivalent = 0 for tritium

Q = Threshold Value = 31.2 for (RF=1.0) or 62.4 for (RF= 0.5)

Note: The only variables are RF and maybe X/Q

DOE STD-1027-92 and NA-1 SD G 1027 use different Category 3 threshold models that yield the same result

For Category 3 Threshold (using NA-1 SD G 1027)

Q (g) = 10 rem /(RF x SA x X/Q x (CEDE x RR + CDSE)

RF = Release Fraction = 1.0 or 0.5

SA = Specific Activity = 9630 Ci/g

X/Q = Dispersion Factor = 7.2 E-2 sec/m3

CEDE = 66.6 rem/Ci / 99.9 with skin absorption (all oxide)

RR = Respiration Rate = 3.33 E-4 m3/sec (for 24 hours)

CDSE = Cloud Shine Dose Equivalent = 0 for tritium

Q = Threshold Value = 0.43 for (RF=1.0) or 0.87 (for FR= 0.5)

Note: The only variables are RF and maybe X/Q

Potential Release Fraction Changes

- **NA-1 SD G 1027 uses Airborne Release Fraction x Respirable Fraction**
  - Only certain size particles are respirable
  - All tritium is respirable but only the oxide fraction is retained
  - For tritium if ARF= 0.5 and RF(oxide fraction) = 0.5 then RF in the model would be 0.25 and Cat 2 would be 124.8 g and Cat 3 would be 1.74 g

- **Tritium in different forms could have different Release Fraction**
  - Tritium as gas would have a high release fraction (0.5 or 1.0)
  - Tritium oxide as liquid would have a low release fraction (10-3)
  - Tritium oxide as a solid/molecular sieve would have a low release fraction
  - Tritium as a metal hydride would have a very low release fraction
    - Different hydrides could have different ARFs and RFs
  - Could require a more complex model and/or complex inventory controls

Can the Dispersion Factor, X/Q, be adjusted for tritium?

- 1027 Uses Gaussian Plume model with receptor at 30 meters
- Ground level release, class D stability and wind at 1 m/sec
- Developed to model downwind behavior of aerosols/particulates (e.g smoke, plutonium)
- Tritium (especially elemental tritium) has physical properties, buoyancy and diffusion, that make standard dispersion models more conservative for tritium than particulates
- A small 50% decrease in X/Q (more dispersion) would raise the threshold value by a factor of 2
- Accounting for hydrogen diffusion velocity (< 2 cm/sec) and buoyancy velocity (120 – 900 cm/sec) could significantly increase dispersion

A simple Excel model Illustrates the potential diffusion contribution to the dispersion.

- Assume a 30 meter radius semi-sphere
- Assume semi-sphere is expanding at the hydrogen diffusion velocity (1 cm/sec)
- Assume uniform tritium concentration inside the sphere (conservative)
- Assume no wind and no buoyancy (100 x diffusion)
- Use threshold dose of 10 rem with 24 hour oxide exposure
- This, diffusion only model, with a release fraction of 0.5 yields a Category 3 threshold of about 2.5 grams

A tritium specific model is very likely to yield thresholds greater than either the Gaussian plume or simple diffusion model !

- **A comprehensive and conservative tritium model should include all forms of dispersion (Gaussian, diffusion and buoyancy)**
- **Receptor breathing elemental or oxide**
- **Tritium physical properties vs hydrogen**
- **Tritium oxide dispersion model would not yield thresholds as high as elemental (hydrogen) model for the same Release Fraction**
- **Elemental vs oxide release considerations**
  - Elemental with slow oxidation (< 1% per day) is typical for most large tritium releases
  - Elemental with fast oxidation (fire) provides extra dispersion energy
  - Liquid oxide release would have a lower release fraction
  - Gaseous oxide (steam) release would have thermal buoyancy
  - Oxide stored on molecular sieve would have a low release fraction

Since the TFG did not adopt the NA-1 SD G 1027 methodology/ values, what next?

- **Leave existing threshold values in place. If so how to deal with the new ICRP guidelines and lack of Cat 3 threshold model?**
- **Adjust the 1027 model for tritium to be less conservative!**
- **Develop a new/different model for tritium.**
- **If we decide to adjust the existing model or develop a new model how do we proceed?**

Volunteers?

BACKUP SLIDES

Is Tritium over-regulated by DOE? Should the TFG support NA-1 SD G 1027 tritium values?

(LA-UR-13-22542)

Tritium Focus Group

Mike Rogers

April, 2013

NOT MEASUREMENT SENSITIVE

DOE-STD-1027-92
December 1992

CHANGE NOTICE NO.1
September 1997

DOE STANDARD

HAZARD CATEGORIZATION AND ACCIDENT ANALYSIS TECHNIQUES FOR COMPLIANCE WITH DOE ORDER 5480.23, NUCLEAR SAFETY ANALYSIS REPORTS

U.S. Department of Energy
Washington, D.C. 20585

AREA SAFT

DOE-STD-1027-92 defines Nuclear Facility Categories and therefore the graded regulatory approach for facilities.

- **Category 1 Potential for significant off-site consequence**
- **Category 2 Potential for significant on-site consequence**

  (1 rem @ 100 meters with very conservative meteorological conditions)
- **Category 3 Potential for only significant localized consequences**

  (10 rem @30 meters with 24 hr. exposure)
- **Radiological (less than Category 3 consequences)**

SUPPLEMENTAL GUIDANCE

NA-1 SD G 1027

Approved: 11-28-11

GUIDANCE ON USING RELEASE FRACTION AND MODERN DOSIMETRIC INFORMATION CONSISTENTLY WITH DOE STD 1027-92, *HAZARD CATEGORIZATION AND ACCIDENT ANALYSIS TECHNIQUES FOR COMPLIANCE WITH DOE ORDER 5480.23, NUCLEAR SAFETY ANALYSIS REPORTS, CHANGE NOTICE NO. 1*

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NA-1 SD G 1027 calculated, but did not change, tritium values pending Tritium Focus Group input.

"**The position of the TFG [Tritium Focus Group] is to retain the existing DOE-STD-1027 thresholds** for tritium Category 2 and 3 nuclear facilities as is. **The next meeting of the TFG** is tentatively scheduled for the spring at SRS [Savannah River Site] and signed correspondence by all participants of that meeting can be obtained at that time if desired."

"**Accordingly**, the radionuclide threshold values for tritium in Table 1 of this guidance **default to the values in DOE-STD-1027-92** (30 grams for Hazard Category 2 and 1.6 grams for Hazard Category 3)."

The most significant difference for Cat 2 threshold calculations is the assumed tritium release fraction.

	NRC	1027-92	NA-1 SD G 1027
Gases (Noble)	1.0	1.0	1.0
Highly Volatile/ Combustible	0.5	0.5	0.5
Semi Volatile	0.01	0.01	0.01
Solid/Powder/Liquid	0.001	0.001	0.001

Tritium

Is change to Tritium release fraction justified?

- **Tritium is a gas but not a Noble gas.**
- **Tritium is better described as “Highly Volatile/Combustible”.**
- **The oxide form is assumed in all dose models, which at least implies that the release was combustible.**
- **NA -1 SD G 1027 calculations are consistent with NRC and EPA models.**

NA-1 SD G 1027 used the latest ICRP dose conversion factors and breathing rates.

- ICRP 72 dose factors to the public for the Category 2 threshold
- ICRP 68 dose factors to the worker for the Category 3 threshold

- Breathing rate of 3.3 x 10-4 m3/sec (public and workers)

  (DOE-1027-92 used 3.5 x 10-4 public and 2.66 x 10-4 worker)
- Dose conversion factor of 66.7 Rem/ Ci for Tritium

- X/Q = 1x10-4 sec/m3 was used for the Category 2 calculation
- X/Q = 7.2x10-2 sec/m3 was used for the Category 3 calculation

Why did tritium category three threshold decrease from 1.6 grams to 0.87?

I propose that the TFG accept the NA-1 SD G 1027 methodology for tritium and recommend that the calculated Category 2 threshold be 62.4 grams.

- **Consistent with other isotopes and NRC/EPA models**
- **Uses latest ICRP dose model recommendations**
- **No known negative impact to existing facilities**
- **Potential reduction of requirements/controls for some existing facilities**

Should the TFG also adopt the calculated Category 3 threshold?

- **Consistent with other isotopes and NRC/EPA models**
- **Uses latest ICRP dose model recommendations**
- **Could have negative impact to existing facilities!**
- **Are there NNSA/DOE tritium facilities with greater that 0.87 grams but less than 1.6 grams of tritium?**

If not, the TFG should also adopt 0.87 as the Cat 3 threshold!

Does NA-1 SD G 1027 go far enough? Comparison to Pu-239

	H-3	Pu-239	ratio Pu/T
Cat 3	0.87g	38.6 g	44.4
Cat 2	62.4g	2610g	41.8
Rem/g	6.42 E5	1.56 E8*	240
Rem/C2	4 .0 E7	4.1 E11	1 E4
1 um particle	0.00017 Rem	0.2 Rem*	12000

*** Pu-239 Injection dose conversion factor = 2.5 E9 CEDE/Ci**

Additional Opportunities

$$ST = MAR \times DR \times ARF \times RF \times LPF$$

Consider :

- **tritium stored as a metal hydride**
- **tritium oxide stored on molecular sieve**

Category 3 non-reactor nuclear facilities require significantly less regulation.

- **No off-site or significant on-site consequences.**
- **Potential for only significant localized consequences/ worker dose.**
- **DSA requires hazard analysis but not accident analysis.**
- **No Safety Class SSCs and fewer (if any) Safety Significant SSCs.**

  (Would require significantly less "Conduct of Engineering".)
- **"TSRs may consist solely of an inventory limit to maintain Hazard Category 3 classification and provide appropriate commitments to safety programs in the administrative controls section of the TSR." (DOE-STD-3009-94)**