UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

October 26, 2018

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Request for license amendment and adjustment of tritium effluent values for new D_2 cold source under 10 CFR 20.1302(2)(c)

Ref: Docket 50-184, TR-5 Facility License

Sirs/Madams:

The NIST Center for Neutron Research (NCNR) Test Reactor (NBSR) is in the process of designing and building a liquid deuterium cold source to replace the current liquid hydrogen source. NRC reviewed the original liquid hydrogen cold source and concluded in a letter of May 17, 1993, that no unreviewed safety question existed and that it could be implemented under 10CFR50.59. A preliminary analysis of the proposed liquid deuterium cold source shows that there is no credible scenario that could affect the reactor, and, with one exception, all changes fall within the criteria of 10 CFR 50.59(c)(2). This one exception is that the potential for a new type of accident will exist due to long term use of liquid deuterium resulting in a build-up of tritium in the deuterium.

In 10 CFR 20, Appendix B, a licensee is instructed to treat effluent concentrations of HT or T_2 (and, by inference, DT) gas as equivalent to tritiated water. Appendix B incorrectly states that "... HT and T_2 oxidizes in air and in the body to HTO." The International Committee on Radiation Protection, in ICRP-66 states that, without combustion, only about 0.01% of the HT is absorbed and converted to HTO. Thus, in accordance with 10 CFR 20.1302(2)(c), the NCNR is requesting the commission approve the use of actual chemical characteristics of gaseous DT in using the ICRP-30 gaseous tritium dose conversion factor in lieu of the 10 CFR 20 Appendix B instruction to treat as tritiated water. As the attached accident analysis shows, proper use of ICRP values for uncombusted DT will result in public doses well below 10 CFR 20 limits and is easily bounded by the maximum hypothetical accident calculated doses. However, as this is an accident of a different type as defined by 10 CFR 50.59(c)(2)(v), the NCNR is also requesting a license amendment to use this analysis.

A020
NRR

NIST

As is the case for the current cold source, there appear to be no potential adverse effects on the reactor, so no technical specifications need to be changed.

Respectfully,

Robert Dimeo, Director
NIST Center for Neutron Research
100 Bureau Drive, MS 6100
Bldg. 235, Room K107
Gaithersburg, MD 20899

I declare under penalty of perjury that the foregoing is true and correct.

Executed on October 26, 2018

By: ______________

Enclosure(s)

cc: Xiaosong Yin, BRR/DPR/PRLB

NBSR SAR CHAPTER 13 REVISON FOR DEUTERIUM COLD SOURCE – TABLE OF CONTENTS

List of Figures

13 ACCIDENT ANALYSES

13.1.1 Tritium Gas Release

This scenario considers an accidental release of tritiated deuterium (DT) gas from the Cold Source Deuterium Storage Tanks. Unrelated, the annual tritium vapor (DTO) release from primary coolant evaporation is discussed in Chapter 11. DT gas is produced by irradiation of liquid deuterium (LD_2), which can be used as a moderator in cold neutron source. The equilibrium activity for the Unit 3 LD_2 cold source is 2,838 Ci; it will take about 60 years, at full power, to reach saturation, however. Hydrogen cold sources also produce small quantities of tritiated hydrogen gas through a D(n,γ)T reaction, but the equilibrium tritium activity is much lower (0.5 Ci in 16 years).

The deuterium distribution system spans indoor locations, 2 m^3 both inside and outside confinement, and one designated exterior storage site, a 16 m^3 ballast tank adjacent to the guide hall. A ground-level release from the tank presents the greatest threat to public safety. The analyzed release point was 100 m from the stack, which corresponds to a system failure at the southwest corner of the guide hall. This point clearly bounds all conceivable releases paths to the 400 m boundary.

Three release modes have been analyzed: a gaseous DT puff release; a slow DTO vapor release resulting from a deflagration (standing flame); and an instantaneous DTO release from a detonation (explosion). All cases were analyzed in HotSpot 3.0.3 (Lawrence Livermore National Laboratory, 2015), using default settings unless otherwise noted. Class F (moderately stable) meteorological conditions and a wind speed of 1 m/s were found to be conservative in all cases except the deflagration.

13.1.1.1 Deuterium Leak Resulting in Gaseous DT Puff

A tritium gas leak could result from inadvertent venting of the deuterium system, perhaps through gross mismanagement during a charging operation. In the analyzed scenario, the entire deuterium inventory is immediately discharged at ground level as DT gas. There is very little uptake of tritium gas in the body compared to tritium in the form of water vapor:

Per 10 CFR 20, dose calculations should treat gaseous DT as DTO. This simplification is unrealistic because the conversion is exothermic and any significant quantity of DTO that forms from DT gas implies the presence of a heat source, which dramatically increases airborne dispersion and dilutes the dose to the public. Furthermore, DTO is readily absorbed in the lungs, while DT gas is not. Per ICRP 30 (ICRP, 1979) and later, the dose conversion factor for DT is ~10^4 times smaller than for DTO for this reason.

The ECN 1078 revisions to Chapter 13 of the SAR (September 2018) present the basis for a License Amendment Request to be submitted to NRC to use the ICRP 30 dose conversion factor for the case of an accidental release of tritium gas from the deuterium ballast tanks.

13.1.1.2 Deuterium Deflagration Resulting in DTO Plume

Hydrogen gasses are flammable in atmosphere in concentrations between 4-75 %. In this bounding scenario a standing flame, or deflagration, converts the entire DT inventory to DTO as it escapes a guillotine break in the pipe over a calculated duration. The HotSpot model for "general fire" was used with the "fuel and burn duration" input options.

13.1.1.3 Deuterium Detonation Resulting in DTO Puff

Hydrogen gasses are explosive in atmosphere at concentrations in the range of 18-59 %. In this scenario, a DT detonation instantly converts 100 % of the DT to a DTO puff. The HotSpot model for "general explosion" was used with the entire deuterium inventory used as the explosive.

13.1 Accident Analysis and Determination of Consequences

13.1.1 Tritium Gas Release

Limiting Assumptions

The equilibrium tritium activity from indefinite continuous operation at 20 MW was calculated to be 2,838 Ci, contained as a gas in the 18 m^3 volume at 5 bar. An outdoor release point 100 m from the stack was used to bound all credible deuterium release scenarios. This radius is just beyond the southwest corner of the guide hall. All release scenarios were evaluated using HotSpot 3.0.3. The HotSpot atmospheric dispersion models are designed for near-surface releases, short-range (less than 10 km) dispersion, and short-term (less than 24 hours) release durations in unobstructed terrain and simple, standard meteorological conditions.

Technical Specifications

Because a tritium gas release has no effect on reactor safety, there are no Technical Specifications associated with it.

Discussion

The deuterium cold source is located in a reactor vessel thimble, which is physically contiguous with bulk air in the C-100 wing. Deuterium is supplied to the cold source through a floor trench and liquified by a helium heat exchanger, also located in room C-100. The deuterium gas supply line penetrates confinement from room D-100, which shares air with the guide hall. A 2 m^3 deuterium gas ballast tank is located in D-200, and this in turn is supplied by piping that traverses the guide hall and exits through a penetration in the west wall. A 16 m^3 ballast tank is located in a designated outdoor handling space just outside the guide hall.

All deuterium system components in C-100 are surrounded or covered by shielding that makes the system completely inaccessible during normal operations. Procedures are in place to evacuate the hydrogen or deuterium lines before removing this shielding. The facility crane has been retrofitted with an electronic no-fly zone in the vicinity of the deuterium condenser for additional safety. Outside C-100, exposed portions of the deuterium system are protected by steel barricades and concrete trenches to eliminate the possibility of accidental damage. The designated outdoor handling space is a concrete pad surrounded by protective bollards. The entire deuterium system also has a protective helium jacket. Thus, no single failure could result in leakage of deuterium to atmosphere.

In the analyzed scenarios, a catastrophic failure releases tritiated deuterium (DT) gas directly to atmosphere. The deuterium system for Unit 3 is at 5 bar when warm, so the deuterium inventory to be released in a rupture is:

$$m_D = \Delta\rho * V = (0.813 - 0.163)\, kg/m^3 * 18\, m^3 = 11.7\, kg$$

For the LD_2 cold source, the equilibrium tritium inventory is:

$$\frac{\partial N_T}{dt} = RR_{LD_2\,abs} - N_T(t)\,\lambda_T$$

$$RR_{LD_2\,abs} = N_D(t) \int \sigma(E)\,\phi(E)\,\partial E$$

The specific integral neutron absorption reaction rate for cold deuterium in the cryostat, or tritium production rate, is most readily determined using MCNP6 via an F4 tally and an FM multiplier card to integrate the continuous energy reaction rate. The equilibrium tritium activity is then:

$$A_T(\infty) = RR_{MCNP} * V_{exposed} * \frac{t_{operating}}{t_{operating} + t_{shutdown}}$$

Using the facility MCNP model, the specific tritium production rate in Unit 3 at 20 MW was calculated to be 3.0×10^9 atoms/cc-s. This is a fair approximation of the specific tritium production rate for the deuterium cold source in the CT thimble. For the Unit 3 (a 35 L cold source), the total equilibrium tritium activity from continuous operation at 20 MW is 2,838 Ci. If periodic 38.5 day cycles with 10 day shutdowns are considered, this value is only 2,253 Ci. In either case equilibrium will occur after about 60 years, as shown in Figure 13.8.

The highly conservative 2,838 Ci estimate is analyzed to provide room for future operational flexibility, such as an operating pressure increase.

13.1.1.1 Gaseous DT Release

Since the DT will be stored well below its auto-ignition temperature of 560 C, it does not react with oxygen in the air. Furthermore, DT is buoyant in air and disperses quickly, resulting in a low dose rate at any ground location. HotSpot provides an appropriate tritium release model with an option to specify the release height and fraction of DTO; a value of 0 was used for both parameters. As stated in Section 13.1.9.1, for this case only the elemental dose conversion factor for tritium was used rather than tritiated water (ICRP, 1979).

Figure 13.9 plots the results for a 2,838 Ci source for the 6 standard classes of meteorological conditions. The plots show that the maximum TEDE (Total Effective Dose Equivalent – external and internal) for an individual at the 400 m boundary (300 m from the release point) would be 0.05 mrem. The maximum TEDE to an occupational worker at any distance is shown to be 0.6 mrem, observed within 20 m of the release point.

13.2 Accident Analysis and Determination of Consequences

13.2.9.2 TEDE from DT Deflagration Resulting in DTO

A deflagration is most likely to occur if a section of pipe is ruptured or the tank is punctured with a small hole. The effluent DT gas is then ignited, forming a standing flame as it escapes. Bernoulli's equation is employed to calculate the release rate:

$$v = \sqrt{2\,\Delta P/\rho}$$

Thus, for a 404 kPa differential pressure and STP helium density of 0.163 kg/m^3, the ab initio escape velocity would be 2,226 m/s, or about Mach 2.4. Above approximately Mach 0.3, however, the gas mass flow rate will be choked due to the physical limit of the speed of sound, which is 933 m/s for deuterium at 5 bar. The following equation for choked flow can be used to predict the tank depletion time in this pressure regime:

$$\dot{m} = C_d A \sqrt{k \rho_0 P_0 \left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

where C_d is a discharge coefficient for the roughness of the hole (conservatively assumed here to be 1), A is the area of the hole, and k is the heat capacity ratio (c_p / c_v). The choked flow condition associated with this equation is defined above the critical pressure, P*, of the system, which is based on k. For deuterium, k is 1.3991, and P* is approximately 0.528*P_0. Below the P* threshold, Bernoulli's equation may be applied instead. A finite element Matlab script was written to predict the gas mass flow rate and tank pressure as a function of time with the discontinuous function at P* described above. The results of this calculation are shown in Figure 13.10.

A hole radius of 2.04 cm corresponds to the 1-1/2" schedule 40 pipe that is proposed to connect the ballast tank to the remainder of the system, and smaller and larger hole radii are offered for illustrative purposes. For failure modes that produce a leak path larger than a pipe sheer, it is assumed that the initiating event would cause an explosion, not a standing flame.

The HotSpot model, "General Fire," was used to model the 2.04 cm pipe break with the Fuel and Burn duration input option. The Burn Duration was set to 1.22 min as determined using Matlab above. The H_2+O reaction energy of 241.8 kJ/mol was used to find the heat of combustion:

$$\frac{241.8\,kJ/mol}{4\,g/mol} = 1.44e4\;cal/g$$

and the liquid-equivalent fuel volume (for energy release) was calculated to be:

$$\frac{11.7\;kg\;D_2}{0.81\;\;kg/l} = 3.80\;gal$$

A "Physical Height of the Fire" parameter of 0 m was conservatively selected to model a downward facing penetration at the exit of the tank. Unique to this scenario, the most conservative meteorological condition was found to be Class E instead of Class F. These parameters were used to produce Figure 13.11, which shows that the maximum TEDE is 0.26 mrem at a public location 4.2 km from the release point. The dose to occupational workers is negligible.

13.2.9.3 TEDE from Detonation Resulting in a DTO Puff

The postulated deuterium gas explosion could conceivably be caused by a shockwave, perhaps due to a major crane failure, a vehicular collision, or a high velocity impact like a bullet. Various protective measures are in place to mitigate each of these possibilities, but they were not considered for the analysis. The HotSpot model, "General Explosion" was selected with a High Explosive parameter (energy release in lbs TNT equivalent) of the deuterium inventory calculated by:

$$241.8\;kJ/mol * \frac{11.7\;kg}{4\;g/mol}\;/\;4.184\;\;MJ/kg\;TNT = 373\;lbs\;TNT$$

This method was used to generate Figure 13.12, which shows the TEDE at the 400 m boundary (300 m from the release point) would be 1.5 mrem. The peak dose of 9 mrem would be inflicted on an occupational worker in the immediate vicinity of the tank. These results are extremely conservative because for unconfined vapor clouds, the fraction of vapor involved is typically less than 10% (Baker, 1983). The physical damage to personnel at this distance is beyond the scope of this Chapter 13 analysis.

13.3 References

Baker, W. E., Cox, P. A., Westine, P. S., Kulesz, J. J. and Strehlow, R. A. (1983) *Explosion Hazards and Evaluation* Elsevier Scientific Publishing Company, Amsterdam, The Netherlands.

Breimeister, J. F. (March 1997). *MCNP – A General Monte Carlo N-Particle Transport Code, Version 4b*. LA-12625, Los Alamos National Laboratory: Albuquerque, New Mexico.

Carew, J., Cheng ,L., Hanson, A., Xu, J., Rorer, D. and Diamond, D. (March, 2004). *Physics and Safety Analysis for the NIST Research Reactor*, BNL-NIST-0803, Rev. 1. Brookhaven National Laboratory: Upton, NY.

Croff, A. G. (July 1980). *A User's Manual for the ORIGEN2 Computer Code*. ORNL/TM-7175, Oak Ridge National Laboratory: Oak Ridge, Tennessee.

DiNunno, J. J., Baker, R. E., Anderson, F. D., and Waterfield, R. L. (March 1962) *Calculation of Distance Factors for Power and Test Reactors*. U.S. Atomic Energy Commission.

Eckerman, K. F. and Ryan, J. C. (1993). *Federal Guidance Report No. 12: External Exposures to Radionuclides in Air; Water; and Soil*. EPA-402-R-93-081, Environmental Protection Agency.

Eckerman, K. F., Wolbarst, A. B. and Richardson, A. C. B. (1988). *Federal Guidance Report No. 11: Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*. EPA-5201/1-88-020, Environmental Protection Agency.

Environmental Protection Agency (2004). *CAP-88*. <http://www.epa.gov/radiation/assessment/CAP88/index.html>.

International Commission on Radiological Protection, ICRP Publication 30, "Limits for Intakes of Radionuclides by Workers", Annals of the ICRP, 3 (1979).

Lawrence Livermore National Laboratory (2004). *HotSpot* <http://www.llnl.gov/nai/technologies/hotspot/>.

Lawrence Livermore National Laboratory (2015). *HotSpot* <http://www.llnl.gov/nai/technologies/hotspot/>.S. Mirshak, W. D. Durant and R. H. Towell, "Heat Flux at Burnout", DP-355, DuPont (1959).

National Bureau of Standards (November, 1980). *Addendum 1, Final Safety Analysis Report,* NBS Research Reactor Radiation Division.

National Bureau of Standards, (1966a). *FSAR on the National Bureau of Standards Reactor,* NBSR-9, U.S. Department of Commerce.

National Bureau of Standards,(December 1966b). *Supplement B of the FSAR on the National Bureau of Standards Reactor*, NBSR-9B, U.S. Department of Commerce.

National Institute of Standards and Technology (2004). *NIST Chemistry Web Book.* <http://webbook.nist.gov/chemistry/>.

NUREG-1537 *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors*, February 1996, U.S. Nuclear Regulatory Commission

NUREG/CR-5535/Rev1, *RELAP5/MOD3.3 Code Manual*, Information Systems Laboratories, Inc., Rockville, MD and Idaho Falls, ID, December 2001.

Shultis, J. K. and Faw, R. E. (June 1999). *Skydose: A Code for Gamma Skyshine calculations Using the Integral Line Beam Method.* Report 9902, Institute for Computational Research in Engineering and Science, Kansas State University: Manhattan, Kansas.

Stanford Linear Accelerator Center (SLAC) (2006). *ES&H Manual.* Chapter 36, (2006)

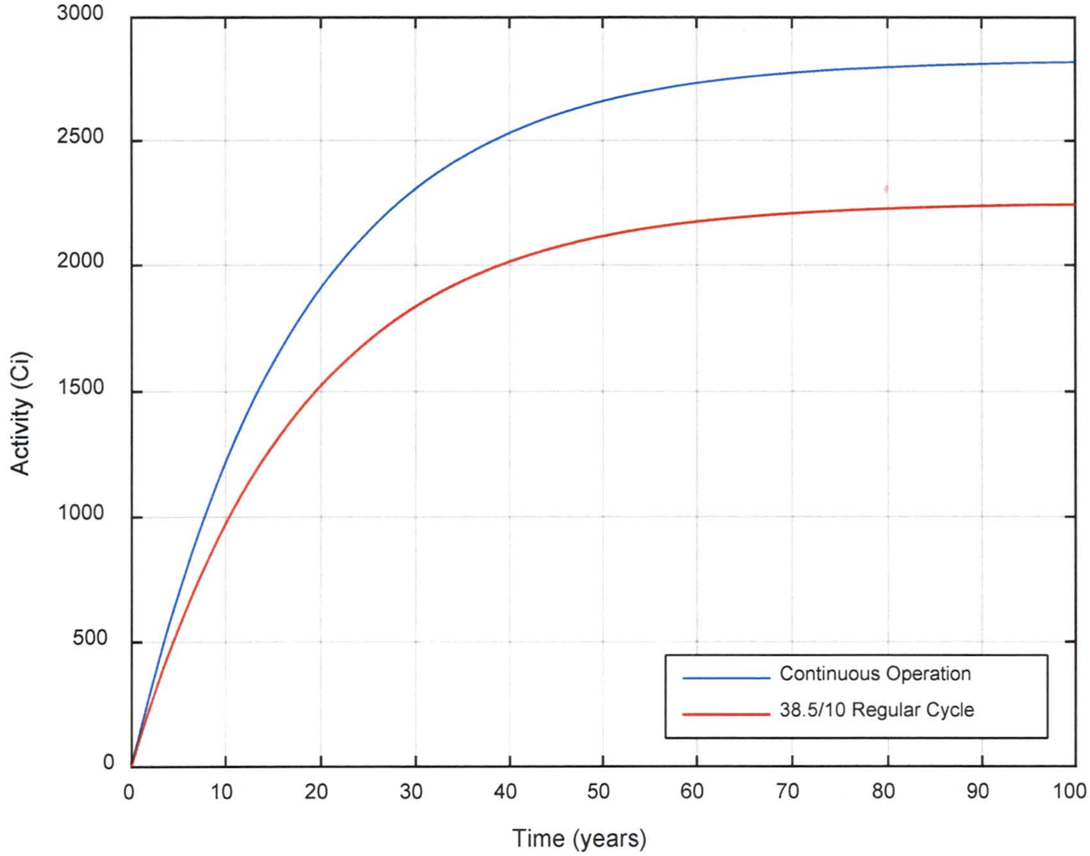

Figure 13.8: Tritium buildup for two conservative operating schedules.

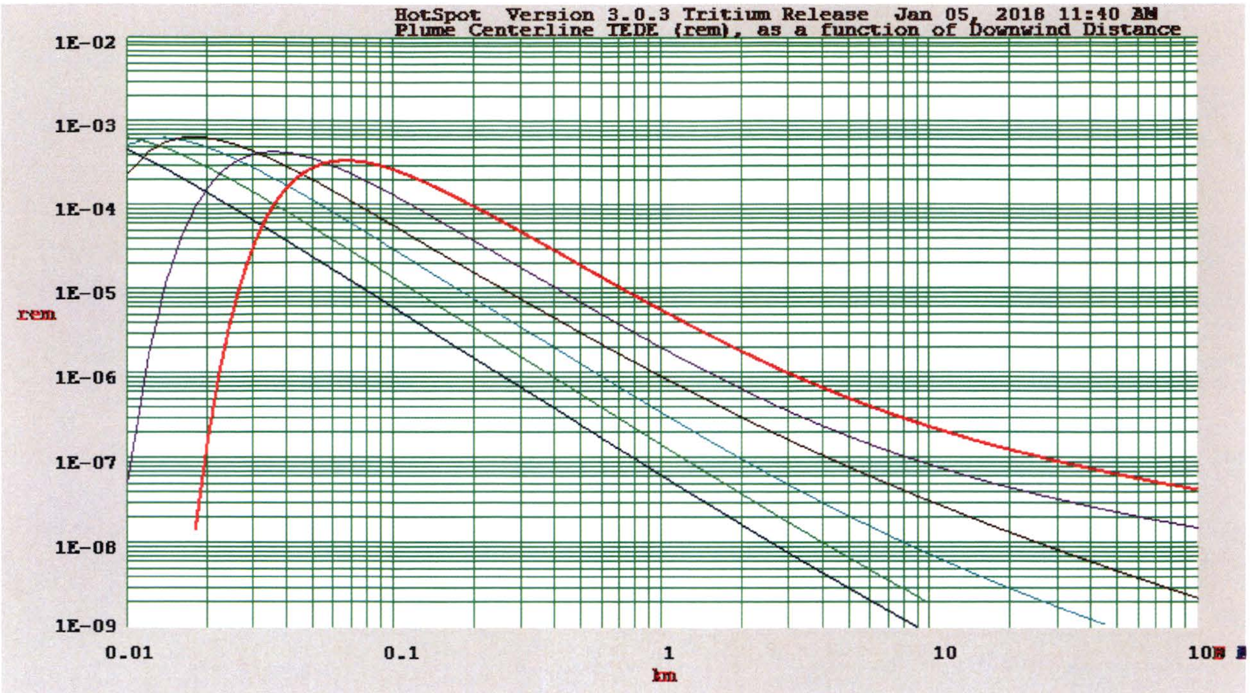

Figure 13.9: TEDE from Gaseous DT Release by Distance (HotSpot 3.0.3).

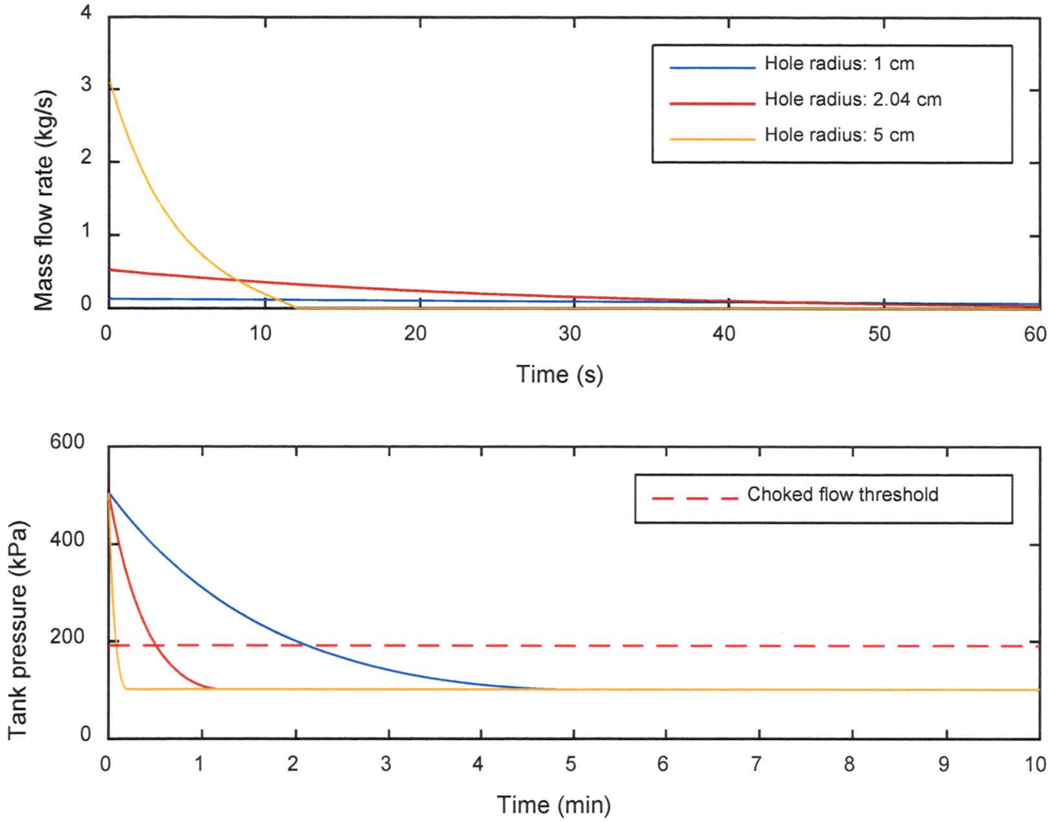

Figure 13.10: D2 ballast tank rupture profiles for select hole sizes. (Matlab script)

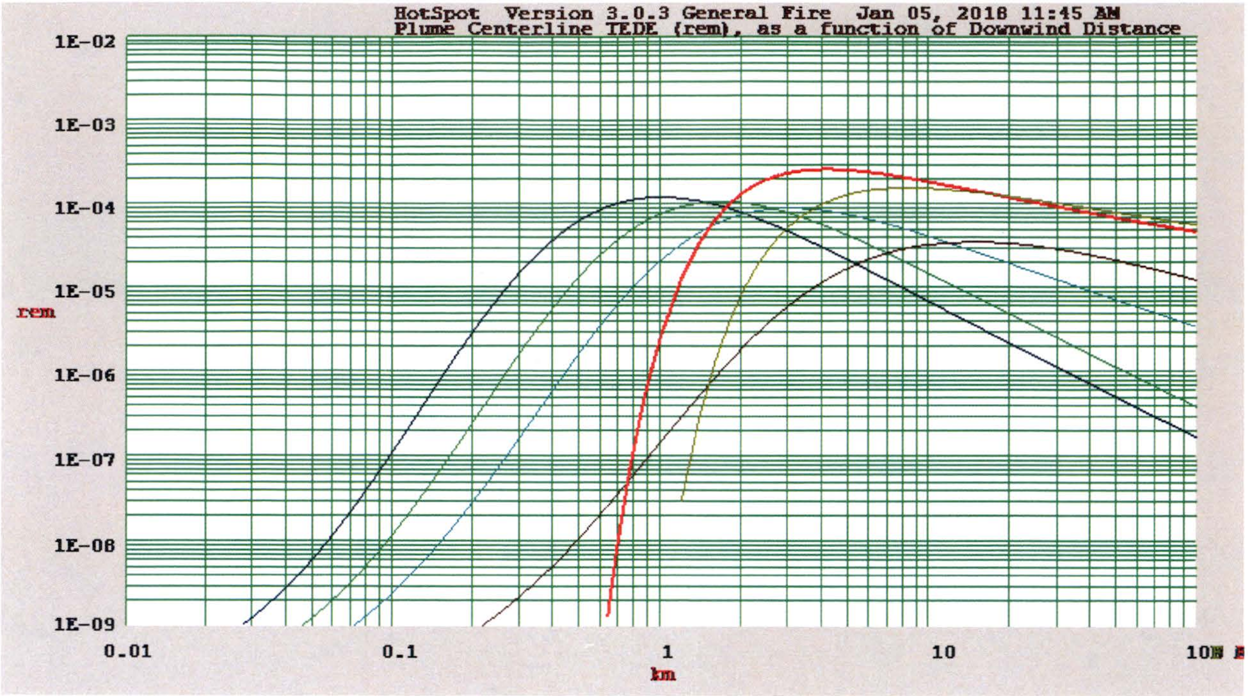

Figure 13.11: TEDE from a DT deflagration resulting in slow release of 100 % DTO. (Hotspot 3.0.3)

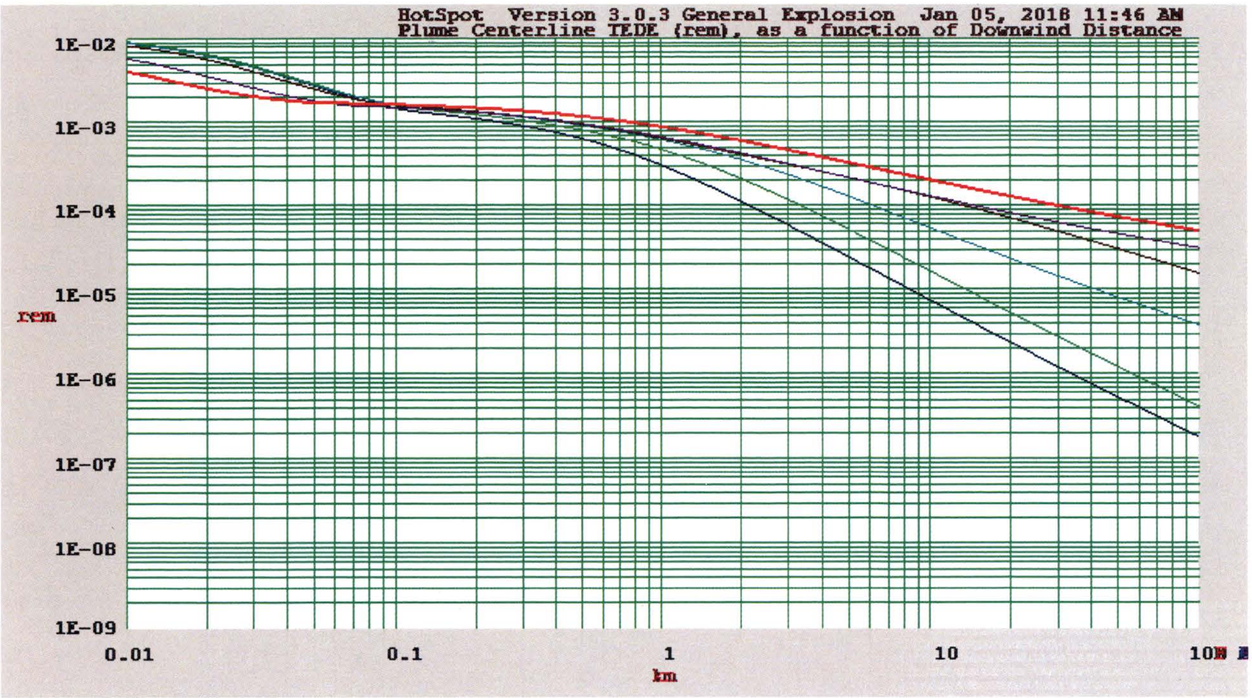

Figure 13.12: TEDE from a DT explosion resulting in 100 % DTO puff. (Hotspot 3.0.3)

ENGINEERING CHANGE NOTICE (ECN)

		[1] Approved ECR No.:	1078
[2] ECR Title:	Changes to SAR Chapter 13 for Storage of Tritium Outside Confinement		
[3] Responsible Individual(s):	Eyers, Williams		
[4] Code:	[5] Revision:	[6] Date:	

Review		☐ Level I	☑ Level II
	Name	Signature	Date
☑ Reactor Operations:	Colvard	Samuel J Colvard ☐ with comments	6/28/2018
☑ Reactor Engineering: Electrical	Main	ALW.R ☑ with comments	6/25/2018
☑ Reactor Engineering: Mechanical	Liposky	P Liposky ☐ with comments	6/26/2018
☐ Other:		☐ with comments	
☑ Health Physics:	Brown	David Brown ☐ with comments	6/28/18
☐ Hazard Review Committee (HRC):		☐ with comments	

10 CFR 50.59 Evaluation Result and Review			
10 CFR 50.59 Evaluation Result: (Attach form NCNR-0003-CM)			
	Name	Signature	Date
Safety Evaluation Committee (SEC) Review:	Mackey ~~Williams~~ 6/28/18	Elizabeth Mackey ☑ with comments	8/1/18

ECN Approvals		
	Signature	Date
Chief, Reactor Operations	Daniel E Hughes ☑ with comments	8/6/18
Chief, Reactor Engineering	☐ with comments	8/3/18
Chief, Reactor Operations and Engineering	☐ with comments	AUG 09 2018
NCNR Director	☐ with comments	AUG 09 2018

Signing to agree that amendment be submitted for approval and Changes to SAR are part of the basis of the amendment. DEH

Implementation And Close-Out								
This section is required to be updated by the responsible individual as the change is implemented.								
	Initial	Date		Initial	Date		Initial	Date
Drawings Changed			Procedures Changed			SAR Updated		
Work Completed			Test/Measurements Completed			Closed		

Distribution:	ECN File (Original) – Working, In-Process ECN R:\ Drive (Electronic copy) – Completed, Closed ECN

NCNR-0002-CM-06

ENGINEERING CHANGE NOTICE (ECN)			[1] Approved ECR No.:	1078
[2] ECR Title:	Changes to SAR Chapter 13 for Storage of Tritium Outside Confinement			
[3] Responsible Individual(s):	Eyers, Williams			
[4] Code:		[5] Revision:	[6] Date:	

[7] **Design Description**

The liquid deuterium cold neutron source installation per ECN 769, "Unit 3", will require outdoor storage of deuterium gas due to the size of the required ballast tank. The D2 gas will have a buildup of tritium primarily in the form of DT molecules. This ECN describes a license amendment to update Chapter 13 of the SAR in preparation for a new accident type (tritium gas release outside confinement) that will be introduced by the installation.

Liquid deuterium (LD_2) at 20 K is used to moderate neutrons to sub-thermal temperatures for cold neutron scattering experiments. Neutron irradiation of LD_2 produces DT, with a maximum (equilibrium) activity of 2,838 Ci for Unit 3. When the system is shut down, the LD_2 and liquid DT evaporate to the exterior ballast tanks, which total 18 m^3. The system pressure in this condition is 5 bar. As described in ECN 769, the entire system is thoroughly protected by double walled piping, concrete barriers, and a no-fly zone. However, as a precaution an unspecified catastrophic mechanical failure was evaluated in which the entire DT inventory would be released to atmosphere.

Per 10 CFR 20, dose calculations should treat gaseous DT as DTO vapor. This simplification is unrealistic because the conversion is exothermic and any significant quantity of DTO that forms from DT gas implies the presence of a heat source, which dramatically increases airborne dispersion and dilutes the dose to the public. Furthermore, DTO vapor is readily absorbed in the lungs, while DT gas is not. Per ICRP 30 and later, the dose conversion factor for DT is $\sim 10^4$ times smaller than for DTO for this reason.

The ECN and the revisions to Chapter 13 of the SAR present the basis for a License Amendment Request to be submitted to NRC to use the ICRP 30 dose conversion factor for the case of an accidental release of tritium gas from the deuterium ballast tanks.

[8] **Safety Considerations, Identification, and/or Analysis**

Three possible release modes were identified:

1. a D_2 gas leak to atmosphere, which results in a gaseous DT puff;
2. a D_2 deflagration (standing flame) that produces a DTO vapor plume; and
3. a D_2 detonation (explosion) that produces a DTO vapor puff.

Each case was evaluated using Hotspot 3.0.3, a Gaussian plume dispersion modeling code that was developed from experimental measurements by LLNL and is widely used by DOE, NNSA, and various emergency responders. Hotspot is already used throughout NBSR-14 to evaluate other dispersion scenarios, including the MHA. For a gas leak, Hotspot allows the user to specify whether DT or DTO is released.

A short discussion of tritium uptake is warranted. The dose limit table for tritium in 10 CFR 20.1302, Appendix B has the following note:

```
Gas (HT or T2) Submersion: Use above values as HT and T2 oxidize in
air and in the body to HTO
```

(We assume that the same rule applies for DT and DTO, which are not discussed elsewhere in 10 CFR 20.)

ENGINEERING CHANGE NOTICE (ECN)			[1] Approved ECR No.:	1078
[2] ECR Title:	Changes to SAR Chapter 13 for Storage of Tritium Outside Confinement			
[3] Responsible Individual(s):	Eyers, Williams			
[4] Code:		[5] Revision:		[6] Date:

However, ICRP 71 provides the following updated guidance for dose calculations of tritium gas:

> (87) Tritium gas. As noted in ICRP Publication 66 (ICRP, 1994a), a recent study in which human volunteers inhaled HT (Peterman et al., 1985) indicates that about 0.01 % of the HT inhaled is absorbed and converted to HTO.

The same advice was recommended by ORNL in FGR-12, which was adopted by the EPA in 1993 and has been implemented in Hotspot. Nevertheless, the analogous requirement of 10 CFR 20 has never been re-evaluated. Therefore, with this license amendment, the NCNR is effectively seeking the approval described in 20.1302(c):

> Upon approval from the Commission, the licensee may adjust the effluent concentration values in appendix B to part 20, table 2, for members of the public, to take into account the actual physical and chemical characteristics of the effluents (e.g., aerosol size distribution, solubility, density, radioactive decay equilibrium, chemical form).

Of the three analyzed scenarios, a D2 detonation that produces a DTO vapor puff was found to result in the highest public exposure. This scenario, in which the entire tank combusts with 100 % efficiency due to an undefined accident, is conservative because the partial confinement of the tank shell and the stoichiometric lack of oxygen within the D2 gas cloud are ignored. (Typically, only about 10% of the explosive gas is consumed in an unconfined release.) Also, all standard meteorological conditions were analyzed and the most conservative case was applied without regard for local weather history. The maximum conceivable dose to the public in this scenario was found to be 1.4 mrem at a point ~~4 km~~ 400 m from the explosion. The calculations are presented in the attached revision of Chapter 13.

RZ 8/7/18

[9] Required Tests, Retests, Surveillances, or Measurements

The deuterium inventory will be continuously monitored by an automated system to detect leaks and allow the area to be evacuated, since the explosive hazard would be far more dangerous than the radiological hazard. The reactor safety impact of and emergency response to failures of deuterium systems enabled by this license amendment must be discussed in the respective ECN. For the Unit 3 cold source, this is ECN 769.

ENGINEERING CHANGE NOTICE (ECN)

1 Approved ECR No.:	1078
2 ECR Title:	Changes to SAR Chapter 13 for Storage of Tritium Outside Confinement
3 Responsible Individual(s):	Eyers, Williams
4 Code:	
5 Revision:	
6 Date:	

10 **Engineering Document Impact Matrix**

Document Type	Superseded (From) Document Number	Rev	Superseding (To) Document Number	Rev	Approved Date
SAR	Ch. 13				

ENGINEERING CHANGE NOTICE (ECN)				1 Approved ECR No.:	1078
2 ECR Title:	Changes to SAR Chapter 13 for Storage of Tritium Outside Confinement				
3 Responsible Individual(s):	Eyers, Williams				
4 Code:		5 Revision:		6 Date:	

11 Safety Evaluation and Conclusion

Permission to use the alternate calculation methodology is backed by peer reviewed studies and mimics the approach taken by other organizations, including: DoE, DoD, NNSA, and EPA. (In particular, the DoE has extensive experience with gaseous tritium experiments that is directly relevant.) Furthermore, great care was taken throughout all three studies to ensure maximum conservatism. The highest conceivable dose to the public, 1.4 mrem, is an order of magnitude smaller than the average annual dose from cosmic radiation (33 mrem/year). For all these reasons, the NCNR has high confidence that the licensing change does not impact public safety.

10 CFR 50.59 EVALUATION

10 CFR 50.59 EVALUATION	Approved ECR/Experiment No.:	1078
ECR/Experiment Title:	Changes to SAR Chapter 13 for Storage of Tritium Outside Confinement	
Responsible Individual(s):	Eyers, Williams	
Number of pages attached:	1	**Date:** 6/20/2018

Does the proposed ECN:	YES	NO	Justification
A. **Require** a change to the Technical Specifications.	☐	X	The experiment requirements of TS 3.8 are unaffected. No existing TS are related to deuterium gas. The system volume is limited to ensure the public dose limit of 10 CFR 20 cannot be exceeded.
B. Result in more than a minimal increase in the ***frequency*** of occurrence of an accident previously evaluated in the updated FSAR.	☐	X	The change does not affect any accidents previously evaluated in the UFSAR.
C. Result in more than a minimal increase in the ***likelihood*** of occurrence of a malfunction of a structure, system, or component important to safety previously evaluated in the updated FSAR.	☐	X	The change does not affect any accidents previously evaluated in the UFSAR.
D. Result in more than a minimal increase in the ***consequences*** of an accident previously evaluated in the updated FSAR.	☐	X	The change does not affect any accidents previously evaluated in the UFSAR.
E. Result in more than a minimal increase in the ***consequences*** of a malfunction of a structure, system, or component important to safety previously evaluated in the updated FSAR.	☐	X	The change does not have a new effect on any components previously evaluated in the UFSAR.
F. Create a possibility for an accident of a different type than any previously evaluated in the updated FSAR.	X	☐	The license amendment will describe a new type of accident (tritium gas release outside containment).
G. Create a possibility for a malfunction of a structure, system, or component important to safety with a different result than any previously evaluated in the updated FSAR.	☐	X	The change does not affect any previously evaluated systems.
H. Result in ***exceeding or altering*** a design basis limit for a fission product barrier as described in the updated FSAR.	☐	X	The design basis accident is unaffected by the change. The tritium gas is not a fission product and is located outside confinement.
I. Result in a departure from a method of evaluation described in the updated FSAR used in establishing the design bases or in the safety analysis.	☐	X	The existing evaluations are unaffected, and the new evaluation uses an existing method (HotSpot 3.0.3).

Conclusion (Check one)	
☐	Based on the evaluation conducted in the above table, it is concluded that the proposed action ***does not meet*** any of the 10 CFR 50.59 criteria; therefore, the activity **does not require** a license amendment or prior NRC approval to perform the proposed action.
X	Based on the evaluation conducted on the above table, it is concluded that the proposed action ***does meet one or more*** of the 10 CFR 50.59 criteria; therefore, the activity **does require** a license amendment to be obtained from the NRC under 10 CFR 50.90 to perform the proposed action.

	Name	Signature	Date
Evaluator:	**Bryan Eyers**	[signature]	**6/20/2018**

NOTE

Consistent with the intent of 10 CFR 50.59, the justifications should be complete in the sense that another knowledgeable reviewer could draw the same conclusion. Restatement of the criteria in a negative sense or making simple statements of conclusion is **NOT** sufficient and should be avoided. The basis and logic used for engineering judgment and the determination should be documented to the extent practicable and to a degree commensurate with the safety significance and complexity of the activity.

NCNR-0003-CM-06