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AUG 30 1994 35 Station 21					ENGINEERING DATA TRANSMITTAL					Page 1 of <u>1</u> 1. EDT 605963	
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1	1	Cog.Eng. JC VAN KEUREN	<i>JC Van Keuren</i>	8/25/94	H4-64	BR BOWMAN	<i>BR Bowman</i>	8/26/94	N2-56	1	1
1	1	Cog. Mgr. JW DAUGHTRY	<i>JW Daughtry</i>	8-25-94	H4-64	PR PREVO			P7-56	3	
1	1	QA JE PARKER	<i>J.E. Parker</i>	8/26/94	N1-71	S GUTTENBERG			N2-53	3	
1	1	Safety EJ KREJCI	<i>E.J. Krejci</i>	8/26/94	N1-72	DJ NIELSEN			N2-53	3	
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1	1	CG MCCARGAR	<i>CG McCargar</i>	8/26/94	N2-56	DL POLZIN			N2-56	3	
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18. JC VAN KEUREN <i>JC Van Keuren</i> Signature of EDT Originator Date 8/25/94	19. _____ Authorized Representative Date for Receiving Organization	20. JW DAUGHTRY <i>JW Daughtry</i> Cognizant Manager Date 8-25-94	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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RELEASE AUTHORIZATION

Document Number: WHC-SD-AF-HC-002, REV. 0

Document Title: Hazard Categorization and Classification for the Sodium Storage Facility

Release Date: 8/30/94

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SUPPORTING DOCUMENT		1. Total Pages 21 25
2. Title HAZARD CATEGORIZATION AND CLASSIFICATION FOR THE SODIUM STORAGE FACILITY	3. Number WHC-SD-FF-HC-002	4. Rev No. 0
5. Key Words HAZARD CATEGORIZATION, FFTF, SODIUM STORAGE FACILITY APPROVED FOR PUBLIC RELEASE	6. Author Name: J. C. VAN KEUREN <i>J C Van Keuren</i> Signature Organization/Charge Code 8D150/E01138	
7. Abstract <i>8/30/94 W. J. Jole</i> Hazard Categorization and Hazard Classification evaluations have been performed for the Sodium Storage Facility. The Hazard Categorization based on the inventory of radioactive materials is "Radiological Facility," i.e below Category 3 limits. The Hazard Classification based on the evaluation of the chemical hazards is "moderate."		
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9. Impact Level SQ		

HAZARD CATEGORIZATION AND CLASSIFICATION OF THE SODIUM STORAGE FACILITY

1. INTRODUCTION

The Sodium Storage Facility is planned to be constructed in the 400 area for long term storage of sodium from the Fast Flux Test Facility (FFTF). A Hazard Categorization has been performed according to DOE Standard 1027-92 (Reference 1) as required by DOE Order 5480.23. A Hazard Classification has been performed in order to evaluate the potential toxic consequences of a sodium fire according to the provisions of DOE Order 5481.1B. The conclusion of these evaluations is that the Sodium Storage Facility meets the requirements of the lowest Hazard Category, i.e., "radiological facility," and the Hazard Classification is recommended to be "moderate."

2. FACILITY DESCRIPTION

The Sodium Storage Facility will be a building constructed in the 400 area and will contain four large sodium storage tanks. Three of the tanks have a capacity of 80,000 gallons of sodium each, and the fourth will hold 52,500 gallons. The three larger tanks are mounted vertically and the smaller is mounted horizontally. The tanks are carbon steel and were designed for use in the Clinch River Breeder Reactor Plant. The tanks are built to the ASME Section III Code. The tanks will be connected by piping with each other and to the FFTF. Sodium from the Fast Flux Test Facility (FFTF) primary and secondary Heat Transport Systems (HTS), Interim Decay Storage (IDS), and the Fuel Storage Facility (FSF) will be transferred to the facility, and stored there in a frozen state pending final disposition.

The building will be equipped with features to mitigate a sodium spill. It is anticipated that these features will include smoke detectors, steel drip pans, and/or steel liners on the floor. Nuclear radiation shielding calculations will be performed to assure that appropriate radiation limits are met.

The maximum amount of sodium that will be stored in the facility is 260,000 gallons (984,000 L). The sources of the sodium are as follows:

Primary HTS	=	140,000 gallons (530,000 L)
Secondary HTS	=	66,000 gallons (250,000 L)
FSF	=	31,000 gallons (117,000 L)
IDS	=	23,000 gallons (87,000 L)

The sodium will be pumped into the facility as a liquid but will be allowed to freeze in the tanks after the transfer is complete. This solidification can take up to several months due to the insulation on the tanks and the high heat capacity of the large quantities of sodium. The sodium contains some radioactive isotopes as discussed in Section 3.

The FFTF also contains about 600 gallons (2270 L) of non-radioactive sodium-potassium eutectic (NaK). The proposed disposal approach for the NaK is to mix it with the sodium. The sodium volume is so much larger than the NaK that the NaK will essentially become an impurity in the sodium and will have no effect on the facility.

3. RADIOACTIVE INVENTORY

The primary heat transport system sodium contains radioactive sodium isotopes from neutron activation of the sodium during its passage through the reactor core. The sodium also contains some fission and activation products as well as corrosion products which have leaked from the fuel or the absorber assemblies. Samples of both primary and secondary sodium have been analyzed to determine the quantity of radioactive elements contained in the sodium. The FSF and IDS sodium has not been directly exposed to the reactor neutron flux but contains some radioactive elements from sodium transferred with the fuel assemblies that were in the reactor, or from the leakage of activation or fission products during storage of the fuel or absorber assemblies. The radionuclide concentrations in the FSF and IDS sodium are much less than the primary sodium. Primary sodium radionuclide concentrations are conservatively assumed for this analysis for all the sodium except the secondary HTS sodium. The secondary HTS sodium contains no activation products but some tritium has diffused into the system. Secondary HTS tritium content is based on the measured concentration of tritium.

The most recent sodium analyses were made in February 1993. The analysis sheets are shown in Appendix A. The Sodium Storage Facility is scheduled for operation in late 1997. The reactor has not been operated since these samples were taken, so no additional radioactive isotopes have been produced. The Sodium Storage Facility inventory will be computed based on these measured radionuclide concentrations which have assumed to decay for 4 years. The radionuclide inventory is shown in Table 1.

The radionuclide concentration as a function of time is given by:

$$C = C_0 \exp(-0.693 * t / T_{1/2}) \quad (1)$$

where:

- C = Concentration for isotope of interest at time t (Ci/gm)
- C₀ = Initial measured concentration (Ci/gm)
- t = Elapsed time (4 years)
- T_{1/2} = Half life of the isotope of interest.

The inventory of each isotope is given by

$$I = C(s) V(s) \rho + C(p) V(p) \rho \quad (2)$$

where

I = Inventory of isotope

C(s) = Concentration of isotopes in the secondary HTS sodium

V(s) = Volume of secondary HTS sodium (66,000 gallons, 250,000 L)

C(p) = Concentration of isotopes in the primary HTS sodium

V(p) = Volume of primary HTS + FSF + IDS sodium (194,000 gallons, 734,000 L)

ρ = Sodium density (0.91 gm/cm³)

The inventories are shown in Table 1.

Table 1 Radionuclide Inventories in the Sodium Storage Facility

Primary HTS, FSF and IDS Sodium (194,000 gallons - 6.7 x 10 ⁸ gms)				
	Specific Activity on 3/93	Isotope Half Lives	Specific Activity on 3/97	Total Activity on 3/97
Isotope	(Ci/gm)	(Years)	(Ci/gm)	(Ci)
Na-22	5.2E-07	2.6	1.8E-07	120
Cs-137	1.0E-10	30.2	9.1E-11	0.06
Pu-239	1.2E-12	24131	1.2E-12	8E-04
H-3	1.6E-7	12.3	1.3E-07	85
Secondary HTS Sodium Inventory (66,000 gallons - 2.3 x 10 ⁸ gms)				
H-3	6.4E-08	12.3	4.8E-08	11
Total Primary + Secondary HTS H-3				96

4. HAZARD CATEGORIZATION

Hazard categorization is based on the radioactive isotope inventories as prescribed in DOE Standard 1027-92 (Reference 1). A nuclear facility may be categorized as either a Category 1, 2, 3, or a radiological facility. Category 1 is the highest category and radiological facility the lowest. To determine the category, the activity for each isotope in the facility is divided by a limit prescribed in the standard and the resulting numbers summed. If the sum exceeds 1 for the Category 3 limits, the facility is at least a Category 3 facility (a comparison to Category 2 limits would then need to be made). If the sum of the comparison to Category 3 limits does not exceed one, then the facility is designated as a "radiological" facility. The Sodium Storage Facility radionuclide inventories listed in Table 1 are compared to the Category 3 limits in Table 2.

Table 2 Hazard Categorization for Sodium Storage Limits

Isotope	Total Activity	DOE 1027-92 Category 3 Limits	Activity Divided by the Category 3 Limits
	Ci	Ci	
Na-22	120	240	0.50
Cs-137	0.06	60	0.001
Pu-239	8E-04	0.52	0.002
H-3	96	1000	0.096
Total			0.60

The sum of the ratios is less than 1. The facility therefore qualifies as a "radiological facility" and the safety analysis will be performed in accordance with DOE 5481.1B.

5. HAZARD CLASSIFICATION

Hazard Classification is required by DOE Order 5481.1B for non-nuclear facilities. The Sodium Storage Facility contains radioactive materials but the nonradiological hazard due to the large amount of sodium present is expected to be the dominant issue in the safety analysis of this facility. A Hazard Classification was therefore performed. The procedures described in Chapter 4, Rev 2 of WHC-CM-4-46 (Reference 2) were used. A simplified checklist is provided. The checklist is shown in Appendix B. The classification is clearly low based on energy source hazards, ionizing radiation hazards, and nuclear criticality hazards. The environmental hazard is also judged to be low. The hazardous material hazard classification is not obvious. The procedures used to evaluate the hazardous material hazard are based on the refined analysis methodology which requires identification of an accident scenario. Note that the purpose of the evaluation is to determine the inherent hazards of the facility to determine review level. No credit is allowed for safety systems or mitigating features in this determination.

The sodium is assumed to leak and cover the floor area of the facility. The sodium inventory of up to two tanks would be contained within in the facility floor area. There will be at most two tanks that contain liquid sodium at any one time. The area of the burn is assumed to be 8268 ft², which is the maximum internal floor area of the building. The sodium is assumed to be contained within the confines of the building cross section. This assumption is believed to be conservative since the sodium would be confined by the foundations of the building in any conceivable accident. No credit is taken for cover plates or the building walls or roof. It should, however, be noted that if design changes occur that increase the internal floor area of the building, an update to this Hazard Classification will be required.

5.1 Hazard Classification Assumptions

The following seven requirements for Hazard Classification are taken from WHC-CM-4-46, Rev 2. The requirement is given followed by a discussion of how the requirement is met.

- 1 Dispersal or release mechanisms of low probability must be considered, however they must be possible based on physical and chemical form of the material. Credit may be taken for cladding and encapsulation when it can be shown the material will remain intact for all possible operating conditions.

The accident scenario assumes that the maximum quantity of sodium in the facility which is molten at any one time is released from the tanks and burns. The burn rate calculation is based on the assumption that the sodium remains within the boundaries of the facility, as discussed above.

2. The toxic material is assumed to be present in the chemical form that provides the worst case consequences.

The sodium will be assumed to burn and form sodium oxide. The sodium oxide will then form sodium hydroxide (NaOH) due to the reaction with moisture in the air. All the sodium aerosol released from the facility is assumed to be NaOH which produces worst case toxic consequences.

3. Conservative release fractions will be used.

The sodium will be assumed to burn at a rate of 8 lbs/ft²/hr (10.8 g/m²/s). The aerosol fraction is assumed to be 0.35, i.e., 35% of the sodium burned is assumed to form an aerosol. These are conservative assumptions that have been used extensively in FFTF sodium fire analysis (Reference 3).

4. Credit may be taken for depletion by natural mechanisms.

The Chamberlain plume depletion model has been used to estimate fall out of the sodium from the plume. Justification for this model is presented in Appendix C.

5. Meteorology parameters assumed in accordance with DOE 6430.1A.

The atmospheric dispersion coefficients (X/Qs) used in the analysis are based on a ground level release using the highest X/Q for each sector (99.5 percentile) and for all 16 sectors (95 percentile) meteorology. These conditions are in accordance with DOE Order 6430.1A. Calculation for the onsite and offsite receptor X/Qs are shown in Appendix C.

6. The maximum offsite individual is assumed to remain at the specified location for 12 hours.

The acceptance criteria are based on peak concentrations. Time spent at the location is not a relevant parameter.

7. The maximum onsite individual is assumed to remain at the specified location for 12 hours.

The acceptance criteria are based on peak concentrations. Time spent at the location is not a relevant parameter.

5.2 Peak Aerosol Concentration Assumptions

The peak concentration of the aerosol from the sodium fire is given by the following:

$$C = Q_r \times A \times (X/Q) \times RF \times M \quad (3)$$

where

- C = Concentration of NaOH in air (gm/m^3)
- Q_r = Sodium burn rate/area ($8 \text{ lb}/\text{ft}^2/\text{hr}$, $10.8 \text{ gm}/\text{m}^2/\text{s}$)
- A = Cross sectional area of the building (8268 ft^2 , 768.6 m^2)
- X/Q = Atmospheric dispersion coefficient (s/m^3)
- RF = Release fraction (0.35 - see item 3 above)
- M = Ratio of mass of NaOH to Na (1.74 - $\text{NaOH}/\text{Na} = (23+16+1)/23$)
- X/Q onsite = $9.21\text{E}-03 \text{ s}/\text{m}^3$ at 100 meters from Appendix C
- X/Q offsite = $1.22\text{E}-06 \text{ s}/\text{m}^3$ at the site boundary from Appendix C

Equation 3 results are:

Maximum onsite (100 m) concentration = $46,750 \text{ mg}/\text{m}^3$
 Maximum offsite concentration = $6.2 \text{ mg}/\text{m}^3$

The onsite concentration calculation is conservative in that the maximum concentration of sodium aerosol the air will support is around $5000 \text{ mg}/\text{m}^3$. The above calculated value will conservatively be used for comparisons to the limits.

5.3 Comparison to Hazard Classification Limits

The hazard classification criteria for toxic material release are based on Emergency Response Planning Guides (ERPG). The ERPGs are defined as follows:

The ERPG-1 value is the maximum airborne concentration which it is believed that nearly all individuals could be exposed to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.

The ERPG-2 value is the maximum airborne concentration which it is believed that nearly all individuals could be exposed to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

The ERPG-3 value is the maximum airborne concentration which it is believed that nearly all individuals could be exposed to 1 hr without experiencing or developing life threatening health effects.

The ERPG values for sodium hydroxide are:

ERPG-1 2 mg/m³
 ERPG-2 40 mg/m³
 ERPG-3 100 mg/m³

The requirements for Hazard Classification as given in WHC-CM-4-46 are given in Table 3.

Table 3 Hazard Classification Criteria

<u>CLASSIFICATION</u>	<u>ONSITE</u>	<u>OFFSITE</u>
LOW	< ERPG-2 (40 mg/m ³)	< ERPG-1 (2 mg/m ³)
MODERATE	> ERPG-2 (40 mg/m ³) and < ERPG-3 (100 mg/m ³)	> ERPG-1 (2 mg/m ³) and < ERPG-2 (40 mg/m ³)
HIGH	> ERPG-3 (100 mg/m ³)	> ERPG-2 (40 mg/m ³)

The ERPG values for sodium hydroxide are shown in Table 3. The peak onsite concentration was calculated in Section 5.2 as 46,750 mg/m³ and the offsite concentration was 6.2 mg/m³. The onsite concentration exceeds ERPG-3. The offsite exceeds ERPG-1, but is less than ERPG-2. The Sodium Storage Facility meets the criteria for a moderate hazard facility based on offsite criteria, and a high hazard facility based on onsite criteria.

The following qualifying statement is given in WHC-CM-4-46. "A high hazard facility with respect to release of non-radiological material is assigned only after consideration of the actual health effects, which would result from the release, and a determination is made that this classification meets the intent of the DOE order."

The facility meets the moderate hazard off-site criteria but the concentrations onsite are quite high and could pose a threat to the onsite worker. However, the possibility of a sodium fire at FFTF causing high onsite sodium aerosol concentrations has always been recognized. The risk is considered acceptable due to the low probability of the accident, the presence of emergency response procedures that will result in prompt evacuation, and the fact that sodium fires create a visible, irritating plume that would be avoided by onsite workers. The actual onsite health effects would therefore

be limited and it does not appear a high hazard classification is warranted based on the statement in the preceding paragraph. The hazard classification for the sodium storage facility is therefore recommended to be "moderate."

6.0 References

1. DOE Standard Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, DOE-STD-1027-92, December 1992.
2. WHC-CM-4-46, Nonreactor Facility Safety Analysis Manual, September 1988.
3. Internal Memo, D. D. Stepnewski to J. B. Waldo, "Report on Containment Integrity Requirements During Plant Standby - Revision 1," March 30, 1994.

Appendix A Sodium Radioactive Isotope Concentrations

FAX

PRIMARY/SECONDARY SODIUM
SAMPLE (TRITIUM)

①②

From RF Keough
Battelle Northwest
P7-22
Richland WA 99352
(509) 376-3564
FAX (509) 372-2156

To RA BURK
376-4920

ONE

total pages.....

comments

I think these are the latest tritiums but I can't be sure. We have a new, bigger, better computerized record system which is functionally similar to a toilet.

If you have any idea that there may be newer data, I'll go to the Wizzard and see if any can be found. I know it's been a long time since the last samples.

<u>aprox date</u>	<u>loop</u>	<u>sample#</u>	<u>Ci/gm</u>
11/90	2	2-89	6.1 E-8
11/90	3	3-82	7.4 E-8
3/91	3	3-83	3.3 E-8
7/91	2	2-90	6.7 E-8
7/91	3	3-84	3.4 E-8
8/91	(pri) p-163		2.1 E-7
9/91	1	1-95	6.4 E-8
2-93	(pri) p-?		1.6 E-7

SAMPLE IDENTIFICATION	Number <u>C-PR1-64</u>	ALKALI METAL ANALYSIS	Lab Serial No. <u>93-04987</u>
	Source <u>FFTF</u>		Date Received <u>2/93</u>
	Time		
	Date <u>2/93</u>		
Sample Submitter <u>Tom Thoecke</u>	MSIN <u>N2-04</u>	Phone <u>6-4336</u>	Na ☒ NaK ☐ Li ☐ Work Order

Special Instructions

PRIMARY Sodium

ANALYSIS	RESULT*	ANALYSIS	RESULT*
☐ Oxygen		☒ Lead	<u>0.06</u>
☐ Hydrogen		☐ Lithium	<u>0.1</u>
☐ Carbon		☒ Magnesium	<u>0.7</u>
☐ Nitrogen		☒ Manganese	<u>0.4</u>
☐ Sodium		☐ Molybdenum	<u>< .04</u>
☒ Plutonium	<u>Included with total Alpha</u>	☒ Nickel	<u>0.25</u>
☐ Particulates		☐ Phosphorus	
☒ Aluminum	<u>0.2</u>	☐ Potassium	
☐ Barium	<u>< .02</u>	☐ Rubidium	
☐ Bismuth	<u>< .2</u>	☒ Silicon	<u>0.1</u>
☐ Boron	<u>< .04</u>	☐ Silver	<u>< .02</u>
☐ Cadmium	<u>< .01</u>	☐ Strontium	<u>< .01</u>
☒ Calcium	<u>0.3</u>	☐ Sulfur	
☐ Cesium		☐ Tin	<u>5.</u>
☐ Chlorine	<u>0.2 RFK</u>	☐ Titanium	<u>0.04</u>
☒ Chromium	<u>0.4</u>	☐ Uranium	<u>< 2.</u>
☐ Cobalt	<u>< .02</u>	☐ Vanadium	<u>< .02</u>
☒ Copper	<u>0.03</u>	☐ Zinc	
☐ Fluorine		☒ Tritium	<u>1.6×10^{-7} Ci/gm</u>
☐ Gold		☐ Gamma Spectrometry	<u>Na-22 = 5.2×10^{-7} Ci/gm</u>
☒ Iron	<u>2.9</u>	☐	<u>Cs-137 = $< 1 \times 10^{-10}$ Ci/gm</u>
		☒ Total Alpha	<u>1.2×10^{-12} Ci/gm</u>

Analyst's Remarks

Pu too low to isolate from other possible alpha emittersNo other Gamma Emitters DetectedSample Cups were only ~ 60% filled.

Reported By

R. Keough

Date Completed

SJ Box 3/25/933/23/93

*Unless otherwise indicated, all results are expressed in P PM.

Distribution: White - Final Report
Canary - Laboratory Logbook
Pink - Originator

BC-7340-032 (01/89)

WHC-SD-FF-HC-002 Rev 0

Appendix B Hazard Classification Work Sheets

**NONREACTOR FACILITY SAFETY
ANALYSIS MANUAL**
**Manual
Chapter
Page
Effective Date**
**WHC-CM-4-46
4.0, REV 2
17 of 18
July 31, 1992**
HAZARD CLASSIFICATION

Figure 4-5. Worksheet 4. (sheet 1 of 2)

Worksheet 4
Hazard Classification
NUCLEAR or NONNUCLEAR
☐ NONNUCLEAR ☒ NUCLEAR

STEP 1
Energy Source Hazards
L M N

If not controlled, energy source(s) are capable of:

- severely injuring several facility occupants and/or causing minor injuries outside the facility ☒
- severely injuring individual outside the facility and/or causing minor injuries offsite ☐
- severely injuring individuals offsite ☐

STEP 2
Hazardous Materials Hazards

- serious overexposure to several facility occupants and/or exposures = limits outside the facility ☐
- serious overexposures outside the facility and/or exposures = limits offsite ☒
- serious overexposures offsite ☐

 SEE
Detailed
Analysis

STEP 3
Ionizing Radiation Hazards

Unit Release Dose Equivalent (URDE) Table

RG	Column A Inventory	Column B URDE (rem/Ci)	A x B
1	8×10^{-4}	1.0×10^{-2}	8×10^{-2}
2	0	5.0×10^{-2}	0
3	0.06	5.0×10^{-3}	3×10^{-4}
4	0	2.0×10^{-7}	0
5	216	7.0×10^{-4}	1.5×10^{-1}
Total A x B =			0.23

 Radiological Hazard Class Value = $C = (\text{Total A x B}) \times (\text{Release Fraction}) \times (\text{Remoteness Factor})$

$$C = 0.23 \times 0.1 \times 0.1 = 2.3 \times 10^{-4}$$

Radiological Hazard Classification

C	Hazard Class
$C \leq 0.01$	Low
$0.01 < C \leq 100$	Moderate
$C > 100$	High

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HAZARD CLASSIFICATION

Figure 4-5. Worksheet 4. (sheet 2 of 2)

Worksheet 4 (cont)

Hazard Classification			
	L	M	H
<ul style="list-style-type: none"> • radiological hazard class value ≤ 0.01 • radiological hazard class value $0.01 < x \leq 100$ • radiological hazard class value > 100 	☒	☐	☐
or			
Only nondispersible operating conditions exist, that is, (1) nondestructive operations with radioactive materials in solid, grouted, or vitrified form, or (2) storage of radioactive materials in DOT approved shipping containers, metal pipe nipples, or fire-resistant safes.	☐		
STEP 4			
<u>Nuclear Criticality Hazard</u>	L	M	H
> 45% minimum critical mass of fissionable material		☐	
STEP 5			
<u>Environmental Hazard</u>	L	M	H
The type, form, and quantity of hazardous/radioactive material is such that, if released to the environment could cause:			
<ul style="list-style-type: none"> • moderate onsite environmental damage requiring remedial action, but negligible damage offsite • major onsite environmental damage, possibly irreparable or non-containable • moderate contamination spread offsite requiring site response • an uncontained contamination spread offsite, potentially resulting in loss of public resources 	☒	☐	☐

Summary of Results

Facility Title Sodium Storage Facility

Facility Designation ☒ Nuclear ☐ Nonnuclear

Facility Classification ☐ Low ☒ Moderate ☐ High

☐ General Use

Appendix C Atmospheric Dispersion Coefficients

The atmospheric dispersion coefficients (X/Q) were calculated using the GXQ code (Reference C.1). Calculations are based on Hanford Site 400 Area specific joint frequency data. The X/Qs are determined by taking the largest of 1) the acute 99.5 percentile dispersion factors for each sector, or 2) the acute 95% meteorology for all sectors. This is a standard approach based on NRC Regulatory Guide 1.145. A ground level release was assumed.

There are a number of potential models offered by the GXQ code to adjust X/Qs for effects that may be appropriate for specific problems. Use of these models must be demonstrated as technically justified. The Chamberlain plume depletion model was selected for this calculation. This model assumes the plume concentration decreases as it moves downwind due to dry deposition. Use of a deposition model appeared appropriate since the concentrations near the release point are very high, and fallout would be expected. Further justification was based on another sodium fire calculation which used the Chamberlain model (Reference C.2). Reference C.2 referenced supporting experimental data (Reference C.3).

The magnitude of the plume depletion is a function of a parameter called the deposition velocity. The deposition velocity was selected based on experimental data. Reference C.3 indicated good agreement between experiments and calculations for deposition velocities of 2 to 10 cm/s.

In order to validate the model and the selected deposition velocity, the reference C.3 measured ground contamination data were compared against a calculation using GXQ. The ground contamination at any location is given by:

$$G = M \times (X/Q) \times v_d \times RF$$

where

G = Ground contamination (g/m²)

M = Mass of sodium burned (g)

X/Q = Atmospheric dispersion coefficient which includes plume depletion correction (s/m³)

v_d = Deposition velocity (m/s)

RF = Fraction of sodium released as an aerosol

Reference C.3 reported measured wind velocity and stability class for each of the tests. The X/Q for the comparison with the Reference C.3 data were calculated using these parameters. Reference C.3 also indicated that plume meander caused the ground contamination to spread over a 90 degree segment. The ground contamination was calculate based on sector average X/Q divided by 4 to give a 90 degree spread. These calculated values were compared with tabular data given in Reference C.3 with an adjustment for the background value given in the report.

Comparisons of the calculations to two tests are shown in Figures C.1 and C.2. Data were calculated for 2 cm/s and 10 cm/s deposition velocity. The calculation for the 2 cm/s deposition velocity under predicted deposition close to the release and over predicted it farther away. One would intuitively expect this behavior for a model that does not include particle size distribution effects. The agreement between test and measured data looks quite good considering the uncertainties in the measurement and the relative crudeness of the model. Use of a 2 cm/s deposition velocity appears conservative for this calculation.

X/Q for the analysis of a fire in the sodium storage facility were generated with the GXQ code using the Chamberlain plume depletion model with a deposition velocity of 2 cm/s. The results are summarized in Tables C.1 and C.2. The asterisks in the tables identify the worst case locations. A sample GXQ run is attached.

400 Area joint frequency data - 10 m Pasquill A-G (1983 -1991 Average)

Table C.1 Acute Centerline 99.5 Percentile X/Q Onsite Values at 100 m.

Sector	X/Q s/m ³	
S	8.34E-03	
SSW	6.14E-03	
SW	4.06E-03	
WSW	2.96E-03	
W	3.24E-03	
WNW	3.01E-03	
NW	4.77E-03	
NNW	8.58E-03	
N	9.21E-03	*
NNE	6.38E-03	
NE	5.23E-03	
ENE	3.74E-03	
E	4.20E-03	
ESE	5.18E-03	
SE	8.25E-03	
SSE	7.14E-03	
All (95%)	7.14E-03	

* Worst Case Direction

Table C.2 Acute Centerline 99.5 Percentile X/Q Values at the Site Boundary

Sector	Distance (m)	X/Q s/m^3
S	8700	8.14E-07
SSW	7000	1.16E-06
SW	7000	8.89E-07
WSW	13100	2.01E-07
W	22200	6.90E-08
WNW	36400	2.17E-08
NW	41900	2.52E-08
NNW	41900	3.71E-08
N	16200	3.48E-07
NNE	13100	5.50E-07
NE	9000	8.02E-07
ENE	7600	8.83E-07
E	7200	1.07E-06
ESE	7500	1.22E-06 *
SE	8700	1.06E-06
SSE	8800	9.44E-07
ALL (95%)		1.00E-06

* Worst Case Direction

References

- C.1 B. E. Hey, "GXQ Program Users' Guide," WHC-SD-GN-SWD-30002, October 1993.
- C.2 Memo, M. Medsker to A. L. Bonner, "Hazard Classification and Preliminary Hazard Category for the Hallam Sodium," June 27, 1993.
- C.3 R. P. Johnson, et al, "Atmospheric Fallout of Sodium Combustion Aerosols," Proceedings of the International Meeting on Fast Reactor Safety Technology, Volume II, pp. 814-822 (1979).

Figure C.1 Comparison to INEL Data

Test 1

Figure C.2 Comparison to INEL Data

Test 2

GXQ Version 3.1 C
June 8, 1993

General Purpose Atmospheric Dispersion Code
Produced by Radiological & Toxicological Analysis
Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-3002 Rev. 0.
Validation documented in WHC-SD-GN-SWD-3003 Rev. 0.
Code Custodian is Brit E. Hey, WHC, ext. 6-2921.

Run Date = 8/15/1994
Run Time = 15:46 50.86

INPUT ECHO:

Sodium Storage Facility onsite x/q w plume depl v=0.02m/s

c GXQ Ver. 3.1 Input File

c

c MODE CHOICE:

c mode

1

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c FOR MODE make RECEPTOR DEPENDENT DATA

c 1 (site specific) sector distance z-height

c 2 (by class & wind speed) class wind speed distance offset z-height

c 3 (create plot file) class wind speed xmax imax ymax jmax xqmin power

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop icon

T F F F T F F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

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c icon = t then X/Q is air concentration
 c = f then X/Q is integrated exposure

c MODEL CHOICES:

c idep iwake ipm irise igrav iwash iflow iwind
 c 1 0 0 0 0 0 0 0
 c idep = 1 then plume depletion model turned on (Chamberlain model)
 c iwake = 1 then NRC RG 1.145 building wake model turned on
 c = 2 then MACCS virtual distance building wake model turned on
 c ipm = 1 then NRC RG 1.145 plume meander model turned on
 c = 2 then 5th Power Law plume meander model turned on
 c = 3 then sector average model turned on
 c irise = 1 then momentum/buoyancy plume rise model turned on, buoyancy
 c rise based on sensible heat emission
 c = 2 then momentum/buoyancy plume rise model turned on, buoyancy
 c rise based on initial plume density
 c igrav = 1 then gravitational settling model turned on
 c iwash = 1 then stack downwash model turned on
 c iflow = 1 then sigmas adjusted for volume flow rate
 c iwind = 1 then wind speed corrected for plume height
 c = 0 to turn any of the above models off

c PARAMETER INPUT:

c stack	wind		frequency	
c release	speed	mixing	to	scaling
c height	height	height	exceed	factor
c (m)	(m)	(m)	(%)	(?)
0.00000E+00	1.00000E+01	1.00000E+03	5.00000E+00	1.00000E+00
c				
c building	building	release	deposition	gravitational
c width	height	duration	velocity	settling
c (m)	(m)	(hr)	(m/s)	velocity
0.00000E+00	0.00000E+00	1.00000E+00	2.00000E-02	1.00000E-03
c				
c initial	initial		sensible	
c plume	plume		heat	
c density	flow	stack	emission	
c (g/cc)	rate	diameter	rate	
	(m3/s)	(m)	(cal/s)	
5.00000E+00	1.67400E+03	1.00000E+00	4.18000E+05	

c RECEPTOR PARAMETER DESCRIPTION:

c sector = 0, 1, 2... (all, S, SSW, etc.)
 c distance = meters
 c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
 c windspeed = m/s
 c offset = meters offset from plume centerline
 c xmax = maximum distance to plot or calculate to (m)

c imax = distance intervals
 c ymax = maximum offset to plot (m)
 c jmax = offset intervals
 c xqmin = minimum scaled X/Q to calculate
 c power = exponent in power function step size

c
 c RECEPTOR DEPENDENT DATA:
 c Sector Distance Height

MODE:
 Site specific X/Q calculated

LOGICAL CHOICES:
 Joint frequency used to calculate X/Q based on
 frequency of exceedance.
 No normalization of joint frequency.
 X/Q calculated for overall site.
 Output is atmospheric dispersion coefficient.

MODELS SELECTED:
 Chamberlain plume depletion

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:
 400 AREA (FFTF) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

Sodium Storage Facility onsite x/q w plume depl v=0.02m/s

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
ALL	100	0	99.98	1	7.14E-03	7.14E-03	G	7.15

Execution Time = 0 hr 1 min 4.59 sec
 Stop - Program terminated.

CHECKLIST FOR PEER REVIEW

Document Reviewed: Sodium Storage Hazard Categorization and Classification,
J. C. Van Keuren, August 17, 1994 ~~WSD~~ WHC-SD-FF-HC-002

Scope of Review: entire document

Yes	No	NA	
☐	☐	☒	* Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☒	☐	☐	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐	Software input correct and consistent with document reviewed.
☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☐	☐	☒	* Format consistent with appropriate NRC Regulatory Guide or other standards
☐	☐	☒	* Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved.

D.A. Himes 8/19/94
Reviewer (Printed Name and Signature) Date

* Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.

☐ ☐ ☐ Analysis entered into analysis database

(Printed Name and Signature) Date

HEDOP REVIEW CHECKLIST
for
Radiological and Nonradiological Release Calculations

Document reviewed (include title or description of calculation, document number, author, and date, as applicable):

Sodium Storage Hazard Categorization and Classification, J. C. Van Keuren,
~~August 17, 1994~~ WHC-SD-FF-HC-002

Submitted by: J.C. Van Keuren

Date Submitted: 8/17/94

Scope of Review: entire document

YES NO* N/A

☒	☐	☐	1.	A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.
☒	☐	☐	2.	Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.
☐	☐	☒	3.	HEDOP-approved code(s) were used.
☐	☐	☒	4.	Receptor locations were selected according to HEDOP recommendations.
☒	☐	☐	5.	All applicable environmental pathways and code options were included and are appropriate for the calculations.
☒	☐	☐	6.	Hanford site data were used.
☒	☐	☐	7.	Model adjustments external to the computer program were justified and performed correctly.
☒	☐	☐	8.	The analysis is consistent with HEDOP recommendations.
☐	☐	☒	9.	Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)
☒	☐		10.	Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.

* All "NO" responses must be explained and use of nonstandard methods justified.

D.A. Himes 8/19/94
HEDOP-Approved Reviewer (Printed Name and Signature) Date

COMMENTS (add additional signed and dated pages if necessary):

**DATE
FILMED**

10/17/94

END