U.S. DEPARTMENT OF ENERGY
CARLSBAD FIELD OFFICE

BASIS OF KNOWLEDGE FOR EVALUATING OXIDIZING CHEMICALS IN TRU WASTE

DOE/WIPP-17-3589
Revision 2

Effective: May 26, 2026

This document implements the WIPP DSA.

This document supersedes DOE/WIPP-17-3589, Revision 1.

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Effective: May 26, 2026

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CHANGE HISTORY SUMMARY

Revision Number	Date Issued	Description of Changes
0	July 2017	Initial issue.
1	December 2018	Streamlined report to be less general and focus criteria to more accurately apply to specific types and sources of waste. Revised throughout to be consistent with removal of chapter 4 and attachment 1. Provided an exemption for LANL RNS and UNS waste with treatment plans approved before BoK, Rev. 0, was issued. Removed note regarding use of BoK for TRU waste remaining in WIPP Waste Handling Building and Waste Control Specialists. Removed Chapter 4, “Basis of Knowledge Test Methods,” and renumbered remainder of the document. Changed title of section 4.1 to “Evaluation and Review” and direct TRU waste sites to options in section 2 for waste containing oxidizing chemicals that fail to meet a BoK criterion. Changed the title of section 4.4 to “pH Adjustment of Oxidizing Acids, Bases and Solutions;” revised language for pH adjustment; added bullet for elimination of potential incompatibilities between 74 reactivity groups; and removed bullet on LANL-CO formal testing. Listed examples of polyols in section 4.5 and introduced polysaccharides as a subcategory of polyols. Removed historical testing discussion on rags and wipes from section 4.5.2. Changed the title of section 4.5.3 to “Ion Exchange Resins” and removed examples of glycerin and organic solvents from this section. Reorganized subsections in section 4.6 and included “Inorganic Sludges with Oxidizing Chemicals not Mixed with Sorbents” and “Oxidizing Chemicals Solidified in a Cement or Grout Matrix” in this section. Inserted Floor-Dry sorbent into Table 4-4.

Revision Number	Date Issued	Description of Changes
		Added an example of a calculation for mixtures of organic and inorganic sorbing materials with oxidizing chemicals. Revised section 4.10 to allow 30 wt. % oxidizing chemicals regardless of matrix inorganic or organic composition (excluding organic liquids). Deleted section 5.12.1. Added new section 4.11, “Oxidizing Chemicals in Waste Retrieved from Earthen Disposal Pits.” Added references in section 7.0, “Records,” pointing to the section 2.0 options that would generate the document, and deleted paragraph regarding BoK Review Board’s documented decision. Inserted WIPP Certified Programs before AK records to distinguish between CBFO records. Replaced Attachment 1 Form 3589-1 with a description of RNS and UNS treatment and a list of drums treated at LANL that are exempt from BoK requirements. Revision 1 involves extensive rewriting of the document; therefore, no change bars are present.
2	April 2026	Revised the document to provide more direction in evaluations, clarify language, reformat tables to add and remove information, remake equations for clarity and uniform formatting, and include a new attachment. Added text to section 4.1 to provide direction on reporting evaluated containers that do not meet BoK criteria. Added text to section 4.2 clarifying that AKEs evaluate waste to identify the type and physical state of oxidizing chemicals that persist in the final waste form. Removed nitric acid from Table 4-1 because it was not tested. Section 4.4 now includes requirement to pH adjust acids and bases prior to sorbing. (Change was made to ensure consistency with Appendix C1 of the WIPP Hazardous Waste Facility Part B Permit Application [DOE, 1997a].) Clarified polysaccharides and polyols descriptions in section 4.5. Edited Tables 4-2 and 4-3 to include a new column with the manufacturer of the sorbents listed in the tables. Added sorbents granted equivalency from the CBFO to

Revision Number	Date Issued	Description of Changes
		Tables 4-2 and 4-3. Removed Portland cement from and added vermiculite to Table 4-3. Revised equation in sections 4.5.1 and 4.6.1 to include wt. of waters of hydration in the numerator (oxidizing chemical wt.). Section 4.6.1 was edited to allow WIPP Certified Programs to grant inorganic sorbent equivalency as they meet the criteria outlined in the text. Eliminated the particle size requirements for cemented or grouted waste in section 4.6.3. Edited section 5.1 to allow treatment of waste containing oxidizing chemical with zeolites and other inorganic sorbents. Deleted Attachment I which listed Los Alamos National Laboratory (LANL) KMI Zeolite treatment of TRU Waste Components during the Period of May 18, 2017, through March 14, 2018, including Table I-1, UNS and RNS Zeolite Treatment, and Table I-2, List of 55-gallon drums generated from RNS and UNS Treatment. All but four containers have shipped to WIPP. Two will ship to WIPP (container identification numbers added to the text in section 2.0) and two require additional treatment to remove prohibited items. In Table 4-2, the 40 wt. % of oxidizing chemicals allowed in Nochar N960 and A660 reduced to 32 wt. % to show only result of testing with the bounding oxidizing chemical (i.e., potassium nitrite). Added new Attachment I to provide bulk density information on inorganic sorbents for calculations. Added text describing when to use Attachment I following Tables 4-2 and 4-3. The extensive revisions constitute a complete rewrite of the document; therefore, change bars are not applied.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

AK	Acceptable Knowledge
Al	aluminum
BoK	Basis of Knowledge
°C	degrees Celsius
CBFO	Carlsbad Field Office
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DQO	Data Quality Objective
DSA	Documented Safety Analysis
EOPS	engineered organic polymer sorbent(s)
EPA	U.S. Environmental Protection Agency
HCl	hydrochloric acid
HF	hydrofluoric acid
HNO_3	nitric acid
H_2SO_4	sulfuric acid
INL	Idaho National Laboratory
LANL	Los Alamos National Laboratory
LANL-CO	LANL-Carlsbad Operations
$NaNO_3$	sodium nitrate
NaOH	sodium hydroxide
RNS	remediated nitrate salt
SBAA	Safety Basis Approval Authority
SDS	Safety Data Sheet(s)
Si	silicon
TDS	Technical Data Sheet
TRU	transuranic
UNS	unremediated nitrate salt
WAC	Waste Acceptance Criteria
WIPP	Waste Isolation Pilot Plant
WM-STA	Waste Management Senior Technical Advisor
wt. %	weight percent

Units of Measurement

Å	angstrom
cm^3	cubic centimeter
g	gram
g/cm^3	grams per cubic centimeter
g/mL	grams per milliliter
J/g	joules per gram
lbs/ft^3	pounds per cubic foot
mL	milliliter
mL/g	milliliter per gram
mm	millimeter

EXECUTIVE SUMMARY

The airborne radioactive material release on February 14, 2014, in room 7 of the Waste Isolation Pilot Plant (WIPP) underground disposal unit 7 was caused by an exothermic chemical reaction of nitrate oxidizing chemicals and organic materials in a single 55-gallon container. Following this event, a new WIPP Documented Safety Analysis (DSA), Revision 5b, was developed that addressed potential hazards related to the airborne radioactive material release and evaluated and addressed new fire hazard scenarios. The revised hazards analysis within the WIPP DSA specifically included potential chemical exothermic reactions in waste containers and propagating fires.

Compliance with WIPP Waste Acceptance Criteria (WAC) (DOE/WIPP-02-3122) was credited as initial conditions to the hazards analysis and Chapter 18 was added, making the WIPP WAC compliance program a safety management program within the WIPP DSA. The WIPP DSA, Chapter 18, and the WIPP WAC require the use of this document when performing the enhanced Acceptable Knowledge (AK) process on transuranic (TRU) waste determined to contain oxidizing chemicals.

The WIPP WAC was revised to address the conditions and requirements of the WIPP DSA. The use of this Basis of Knowledge for Evaluating Oxidizing Chemicals in TRU Waste (BoK) by the WIPP Certified Programs is specified in the WIPP WAC, Appendix H, Enhanced Acceptable Knowledge.

This document establishes criteria that must be used by the WIPP Certified Programs to evaluate TRU waste containing one or more oxidizing chemicals to determine acceptability at the WIPP as-is, with respect to the oxidizing chemicals, and to identify when additional evaluation, compensatory measures, or treatment is required. This BoK also includes options and requirements to be used by TRU waste sites when further evaluation, testing, and/or treatment are required.

The U.S. Department of Energy Carlsbad Field Office will review requests, plans, and technical justifications and provide written decisions prior to implementation by the TRU waste sites.

1.0 PURPOSE

This Basis of Knowledge (BoK) provides criteria to be used in conjunction with Acceptable Knowledge (AK) procedures of the Waste Isolation Pilot Plant (WIPP) Certified Programs for evaluating transuranic (TRU) waste (hereafter referred to as "TRU waste" or "waste") with one or more oxidizing chemicals to determine acceptability at WIPP as-is, identify when additional evaluation, compensatory measures, or treatment is required, and evaluate waste for acceptability post-treatment. This BoK also includes options and requirements to be used by TRU waste sites when further evaluation, testing, and/or treatment are required.

2.0 APPLICATION AND SCOPE

WIPP Certified Programs' AK personnel performing the enhanced AK process shall evaluate TRU waste that contains one or more oxidizing chemicals using the criteria contained in this BoK. The application of these criteria is not dependent on a TRU waste site's determination that the waste does or does not exhibit the hazardous waste characteristics of ignitability or reactivity due to oxidizer properties. WIPP Certified Programs shall submit BoK evaluations to sitedocuments@cbfo.doe.gov for U.S. Department of Energy (DOE) Carlsbad Field Office (CBFO) Waste Management Senior Technical Advisor (WM-STA) review until notified by the CBFO Manager that continued review by the WM-STA is no longer required.

The BoK does not cover chemical incompatibility. TRU waste sites and WIPP Certified Programs' AK personnel must ensure potential chemical incompatibilities are documented, evaluated, and safely managed to ensure the waste does not pose a risk for an adverse reaction consequence. Basis of Knowledge evaluations shall only be performed after a waste stream chemical compatibility evaluation has been approved by the CBFO. Chemical compatibility evaluations and BoK evaluations are an essential part of the WIPP Documented Safety Analysis (DSA, DOE/WIPP-07-3372, current revision).

> The unremediated nitrate salt (UNS) and remediated nitrate salt (RNS) TRU wastes at Los Alamos National Laboratory (LANL) were treated with KMI zeolite to remove the oxidizer properties. These waste populations, post KMI zeolite treatment, were packaged into a total of 274 55-gallon drums. The CBFO reviewed LANL test data, treatment plans, and procedures concurrent with the development of Revision 0 of this BoK and agreed that the planned and implemented processes would result in the successful treatment of the oxidizing properties of the oxidizing chemicals contained in the wastes. There are two containers remaining to ship from LANL: 55-gallon drum LA00000072726 and 55-gallon drum LA00000072735 overpacked into 85-gallon drum LA00000072783. Two KMI zeolite-treated drums remain onsite at LANL due to other WIPP WAC prohibited conditions: 55-gallon drums LA00000071916 and LA00000071964. All other LANL TRU wastes with one or more oxidizing chemicals are subject to evaluation using the criteria contained in this BoK.

The criteria used in this document are based on bounding conditions developed in part to account for the potential drying of the waste from environmental conditions it can be subjected to inside the transportation packaging and after emplacement in the desiccating salt environment of the WIPP disposal units. Accounting for changes in the waste that can occur due to environmental conditions that can exist during active waste management minimizes the possibility of a radioactive particulate airborne release in the Category 2 nuclear facility until the waste is isolated from the WIPP underground ventilation air flow. If a TRU waste site's waste is outside the criteria established in this BoK, the TRU waste site or WIPP Certified Program has the options of:

a) requesting the DOE CBFO WM-STA evaluate information provided by the TRU waste site or WIPP Certified Program that the unlisted oxidizing chemical is bounded by at least one of the listed oxidizing chemicals; or

b) requesting an inorganic sorbent equivalency evaluation by the CBFO WM-STA to determine if the unlisted sorbent is compositionally equivalent to a tested inorganic sorbent, or a TRU waste site or WIPP Certified Program grants inorganic sorbent equivalency and provides justification documentation to the DOE CBFO WM-STA per section 4.6.1 of this BoK; or

c) performing tests (when appropriate) using a method approved by the CBFO Manager and/or proposing a treatment method when necessary; or

d) performing tests using the modified U.S. Environmental Protection Agency (EPA) method 1040 as specified in section 6.0 of this document, and treating the waste with an acceptable inorganic sorbent; or

e) treating the waste with an acceptable inorganic sorbent as described in section 5.0 of this document when an unlisted inorganic sorbent is not compositionally equivalent; or

f) treating waste with oxidizing chemical that was previously sorbed with organic sorbent using zeolites as specified in section 5.0; or

g) treating the waste with zeolites or other inorganic sorbent, as specified in section 5.0, when listed oxidizing chemical concentrations in engineered organic polymer sorbent (EOPS) or inorganic sorbent cannot be bounded or when an oxidizing chemical listed in Table 4-1 of this BoK is the sole component of the waste; or

h) providing a written technical justification to the CBFO WM-STA that each container with the current waste form is sufficiently characterized to enable compliant shipment and receipt at WIPP with respect to the oxidizing chemicals in the waste, and justification that the waste would not develop an unacceptable risk of a release until isolated from the WIPP underground ventilation air flow.

Based on the merits of the written technical justification and the recommendation of the CBFO WM-STA, the CBFO Manager, with concurrence of the CBFO Safety Basis Approval Authority (SBAA) (if a different person), may determine that the waste is acceptable as-is, compliant with WIPP program and facility requirements with respect to the oxidizing chemical in the waste, and presents no additional hazard to the facility that has not been considered and mitigated in the WIPP DSA.

3.0 DEFINITIONS

Organic Materials – Carbon-containing compounds, which include not only hydrocarbons but also compounds with other elements, including hydrogen (most compounds contain at least one carbon-hydrogen bond), nitrogen, oxygen, halogens, phosphorus, silicon, and sulfur. Organic materials are not limited to compounds produced by living organisms but include human-made substances such as plastics and polymers. Carbon-containing compounds that are simple salts, such as carbonates, oxides, and carbides, are inorganic materials.

Oxidizing Chemical – A chemical that, while alone is not necessarily combustible, readily yields oxygen to cause or enhance the combustion of organic materials.

For the purposes of this BoK, an oxidizing chemical is:

- A chemical identified in this document as an oxidizing chemical; or
- A chemical or chemical mixture identified as hazard class 5.1 or 5.2 in the Hazard class or Division, or Label Codes columns of the Hazardous Materials Table in Title 49 Code of Federal Regulations (CFR) 172.101. However, a chemical with a numeric provision listed in the Special provisions (§172.102) column of the Hazardous Materials Table, that excludes it from the 49 CFR Subchapter C – Hazardous Materials Regulations, is not an oxidizing chemical subject to evaluation using this BoK.

NOTE: Safety Data Sheets (SDS) obtained from chemical manufacturers or distributors may or may not identify the subject chemical is a class 5.1 or 5.2 hazardous material oxidizer. SDS have not proven to be reliable sources of information in this regard. Other sources of information must be used to determine if the chemical in question is or is not an oxidizer.

Waste Component – Discrete waste component that contains one or more oxidizing chemicals.

4.0 CRITERIA FOR EVALUATING TRU WASTE WITH OXIDIZING CHEMICALS

4.1 Evaluation and Review

The WIPP Certified Program's AK personnel must evaluate waste containing one or more oxidizing chemicals to the criteria in this section. Evaluations are typically performed on a discrete population of waste from a single waste stream where each container is evaluated against the BoK criteria.

The TRU waste site or WIPP Certified Program shall select appropriate option(s) a) through h) from section 2.0 when the AK personnel's pre-evaluation determines that the waste will fail to meet any of the BoK criteria and when containers fail to meet BoK criteria through formal evaluation. Each WIPP Certified Program shall provide formal BoK evaluations for CBFO Office of the Manager review until such time the CBFO Manager notifies them that CBFO reviews are no longer required.

4.2 Oxidizing Chemical Verification

The oxidizing chemicals identified in Table 4-1 are bounded by potassium nitrite. Formal testing performed by LANL-Carlsbad Operations (LANL-CO) (hereafter referred to as "formal testing") identified the allowed weight percent (wt. %) of oxidizing chemical[1] in EOPS (Table 4-2), inorganic sorbents (Table 4-3), and when remediating previously sorbed oxidizing chemicals (Table 5-1). Waste streams with oxidizing chemicals, whether listed in Table 4-1 or not, must be reevaluated by the AK personnel to determine if oxidizing chemicals persist in the waste. This reevaluation must focus on the process chemistry where the waste originated and what the chemical constituents are in the waste. Actions that could change the oxidizing chemicals during or after the process include reducing, neutralizing, rinsing, solidifying, drying, calcining, pyrolyzing, and others. If the waste has been repackaged, actions that would have affected the waste chemistry must be identified and evaluated, and additions to the waste must be accounted for. The final description of the waste should be representative of the constituents and overall composition of the waste as it persists in the final waste form.

If the AK reevaluation determines an oxidizing chemical is present in the TRU waste stream and not listed in Table 4-1, the TRU waste site or WIPP Certified Program may implement section 2.0, option a), to provide information to the CBFO Office of the Manager that the oxidizing chemical is bounded by at least one oxidizing chemical listed in Table 4-1. The CBFO Office of the Manager will evaluate the documented position and provide a written decision for the AK record. If the CBFO determines the oxidizing chemical is not bound by at least one of the oxidizing chemicals listed in Table 4-1, then the TRU waste site must select from options c), d), or h) from section 2.0.

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[1] LANL-CO, "Results from Preparation and Testing of Sorbents Mixed with Potassium Nitrite," DWT-RPT-003, January 19, 2017, LA-UR-16-27276.

Table 4-1 – Oxidizing Chemicals Bounded by Formal Testing

Oxidizing Chemicals Bounded by Formal Testing	
Aluminum (III) nitrate nonahydrate	Potassium iodate
Ammonium cerium (IV) nitrate	Potassium nitrate
Ammonium persulfate	Potassium nitrite
Barium nitrate	Potassium periodate
Bismuth (III) nitrate pentahydrate	Potassium permanganate
Cadmium nitrate	Potassium persulfate
Calcium hypochlorite	Praseodymium (III) nitrate hexahydrate
Calcium nitrate tetrahydrate	Rhenium nitrate hexahydrate
Cerium (III) nitrate hexahydrate	Rubidium nitrate
Cesium nitrate	Samarium (III) nitrate hexahydrate
Chromium (III) nitrate nonahydrate	Silver (I) nitrate
Cobalt (II) nitrate hexahydrate	Silver (I) nitrite
Copper (II) nitrate trihydrate	Silver (I) oxide
Erbium (III) nitrate pentahydrate	Silver (II) oxide
Europium (III) nitrate pentahydrate	Sodium bromate
Gadolinium (III) nitrate hexahydrate	Sodium chromate
Indium (III) nitrate tetrahydrate	Sodium dichromate dihydrate
Iron (III) nitrate nonahydrate	Sodium nitrate
Lanthanum (III) nitrate hexahydrate	Sodium nitrite
Lead (II) nitrate	Strontium (II) nitrate
Lead (IV) peroxide	Terbium (III) nitrate pentahydrate or hexahydrate
Lithium hypochlorite	Tetrabutylammonium nitrate
Lithium nitrate	Tetrapropylammonium nitrate
Magnesium nitrate*	Thallium (I) nitrate trihydrate
Mercury (II) nitrate monohydrate	Thallium (III) nitrate trihydrate
Neodymium (III) nitrate hexahydrate	Thorium nitrate hexahydrate
Nickel (II) nitrate hexahydrate	Uranyl nitrate hexahydrate
Plutonium nitrate pentahydrate	Yttrium (III) nitrate hexahydrate
Potassium bromate	Zinc nitrate hexahydrate
Potassium chromate	Zirconium (IV) nitrate pentahydrate
Potassium dichromate	Zirconium oxynitrate

*Magnesium nitrate is hygroscopic and deliquescent, readily converting to magnesium nitrate hexahydrate when exposed to moisture. Magnesium nitrate hexahydrate is the most stable form of magnesium nitrate salt.[2] Magnesium nitrate hexahydrate is not regulated as a U.S. Department of Transportation hazardous material per Special Provision 332 in 49 CFR §172.102. Testing performed by LANL-CO during oxidizing chemical scoping studies further supports that magnesium nitrate hexahydrate does not enhance the combustion of organic matter.

4.3 Distribution of Oxidizing Chemicals within Waste Components

Transuranic waste with oxidizing chemicals may consist of a single waste component or multiple waste components (e.g., sorbent used for wet or liquid oxidizing chemicals, evaporator salts, filter media containing oxidizing chemicals). Only the waste components with oxidizing chemicals require evaluation using the criteria in the BoK. Personnel performing the AK characterization must determine how well the oxidizing

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[2] Wheeler, R. C., Frost, G. B., "A Comparative Study of the Dehydration Kinetics of Several Hydrated Salts," Can. J. Chem., **33** (1955), 546-561.

chemicals are distributed as well as the concentration of oxidizing chemicals within each waste component that contains oxidizing chemicals.

4.4 pH Adjustment of Oxidizing Acids, Bases, and Solutions

Oxidizing acids and aqueous solutions with oxidizing chemicals must be pH adjusted prior to, or during, sorbing or solidifying. **This requirement applies to wastes packaged after the effective date of this document revision.** When sorbing, adjustment to a pH of $\geq$ 4 to $\leq$ 10 is the minimum required but, in all cases, the pH of the oxidizing liquid must meet the sorbent manufacturer's technical specifications for use of the sorbent product. Measurements for pH can be taken with calibrated pH meters and electrodes, test strips, or pH papers used and maintained within the manufacturer's specifications.

Waste must remain in a safe and compliant state during extended storage periods. When it is known that waste with liquid requiring treatment with sorbent will remain onsite for an extended amount of time after undergoing characterization using real-time-radiography or visual examination, the pH adjusted waste will be less likely to corrode the waste container into which it is placed. This requirement will make sure the waste remains compliant and ensure continued safety of the waste through emplacement and isolation from the underground air flow within WIPP.

pH adjustment of strong acids and bases is required for the following reasons:

- Significantly limits acid-catalyzed or base-catalyzed reactions of the pH adjusted acid or base.
- Strong acids and bases can change the mineral structure of zeolites and other inorganic sorbents, especially in terms of surface area, pore size, and chemical surface composition.[3] They can degrade the organic "backbone" of some EOPS. Certain strong acids and bases can increase hydrophobicity, thus affecting the capacity of the sorbent and possibly rendering the oxidizing chemical treatment ineffective.
- Compatibility of the waste with other waste, packaging materials, and the payload container is substantially increased because potential incompatibilities between 74 reactivity groups are eliminated pursuant to the 1980 EPA document EPA-600/2-80-076.[4]

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[3] G. Jozefaciuk and G. Bowanko, "Effect of Acid and Alkali Treatments on Surface Areas and Adsorption Energies of Selected Minerals," *Clays and Clay Minerals,* Vol. 50, No. 6, 771-783, 2002.

[4] Hatayama, H. K., Chen, J. J., de Vera, E. R., Stephens, R. D., Storm, D. L. (1980, April). *A Method for Determining the Compatibility of Hazardous Wastes (EPA-600/2-80-076)*, United States Environmental Protection Agency https://www.epa.gov/sites/default/files/2016-03/documents/compat-haz-waste.pdf

Potentially explosive compounds can form when organic neutralizing or buffering agents are used with oxidizing chemicals. Acceptable Knowledge personnel shall identify and evaluate the use of organic neutralizing or buffering agents with oxidizing acids and bases, and acidic and basic solutions. This evaluation applies prior to sorbing and when the organic neutralizing or buffering agents were ingredients in inorganic sorbents and EOPS products. When either case exists, testing must be performed that demonstrates the sorbed waste does not pose a hazard when exposed to mechanical impact, spark, friction, and/or heat. Testing results shall be provided to the CBFO Office of the Manager. When testing determines the waste poses a hazard, the TRU waste site must identify a method of treatment that will eliminate the hazard. Concurrence on the proposed method of treatment must be obtained from the CBFO Manager to ensure acceptability at WIPP.

4.5 Organic Sorbents

Organic sorbents used in TRU waste can be divided into the following groups:

- Polysaccharides - organic molecules containing multiple synthetic or naturally occurring monosaccharides such as cellulose and starch. Polysaccharides include polyols such as polyvinyl alcohol, rayon, glycerin [glycerol], etc. Polysaccharides also include some EOPS.
- EOPS, also known as hydrogels and super-absorbing polymers (polyacrylates, polyacrylamides, etc.).
- Condensation polymers such as polyesters.
- Hydrocarbons (polypropylene, polystyrene resins, etc.).

Mixtures of certain polysaccharide materials and oxidizing chemicals can be incompatible and mixing them may result in adverse reaction consequences. Oxidizing chemicals sorbed with incompatible polysaccharide sorbents are not acceptable at WIPP without additional treatment.

4.5.1 Engineered Organic Polymer Sorbents with Oxidizing Chemicals

Table 4-2 lists the maximum wt. % of oxidizing chemicals allowed when well-mixed with EOPS. An oxidizing chemical is well-mixed in the EOPS when at least one of the following criteria is met:

- A known liquid is added in a volume approaching the sorbing capacity of the EOPS for that liquid; or
- Liquid is stirred or mixed with EOPS.

Table 4-2 – Wt. % of Oxidizing Chemicals Allowed in EOPS (Previously Sorbed)

EOPS	Manufacturer	Composition listed in the Safety Data Sheet	Wt. % of oxidizing chemicals allowed
AQUASORB™	SNF, Inc.	Cross-linked copolymer of acrylamide and potassium acrylate	≤ 31
Aquasorb High Performance* (23-0036)	Advanced Poly-Zone, Inc.	Sodium polyacrylate (lightly cross-linked)	≤ 33
AquaSorbe-GP Superabsorbent Polymer* (23-0035)	Aquadox	Sodium polyacrylate (lightly cross-linked)	≤ 33
Nochar N910 and A610	Nochar, Inc.	Thermoplastic elastomer (Copolymer of styrene, butadiene, and possibly acrylates and phthalates)	≤ 30
Nochar N960 and A660	Nochar, Inc.	Copolymer of acrylamide	≤ 32
Nochar N965	Nochar, Inc.	Mixture containing 60% N910 and 40% N960	≤ 31
Quik-Solid®	The ARK Enterprises, Inc. CETCO a Minerals Technologies Inc. company	Sodium polyacrylate (lightly cross-linked)	≤ 33
RADSORB* (22-0011)	Environmental Scientific, Inc.	Sodium polyacrylate, cross-linked	≤ 31
Universal Polypropylene (Allwik Universal Pillow contents)	Brady SPC	Polypropylene	≤ 30
Waste Lock® 770	M² Polymer Technologies, Inc.	Sodium polyacrylate, cross-linked	≤ 31
WaterWorks SP-400	WaterWorks™ America, Inc.	Acrylic acrylate resin	≤ 32

* These sorbents were not part of the initial testing; rather, they were determined to be equivalent to listed sorbents.

Waste shall be evaluated to determine if the oxidizing chemical concentration is below the wt. % in Table 4-2. Sum the weight of each of the oxidizing chemicals (include the weight of the waters of hydration) and divide by the cumulative sum of the weight of the sorbents and oxidizing chemicals (including the weight of the waters of hydration) to yield the concentration of oxidizing chemicals in the waste. When oxidizing chemical concentrations are not known and cannot be bounded, the TRU waste site must consider the mixture as 100 wt. % oxidizing chemical(s) and perform treatment as specified in section 2.0, option g).

When dried to constant mass, EOPS are fuels, and potassium nitrite (the bounding oxidizing chemical) concentrations above those listed in Table 4-2 accelerated their burn rates when tested. EOPS have been used to sorb oxidizing chemical solutions for years without a reported self-ignition event. While EOPS and carbohydrate sorbents are organic compounds, they react with oxidizing chemicals differently. The oxidizing chemical to fuel concentrations that produced non-oxidizer results in burn rate tests were approximately 20 wt. % less for the carbohydrate sorbents than for the EOPS. Color changes were observed in some EOPS during sample preparation for burn testing, indicating that some chemical changes were occurring. These potential chemical changes were represented in the samples tested and the burn rates observed for these samples were virtually the same as the burn rates for EOPS samples with no observed color changes.

Oxidizing chemical wastes sorbed in EOPS not found in Table 4-2 are not acceptable for disposal at WIPP unless section 2.0, option c) or f), is implemented.

4.5.2 Organic Rags, Wipes, Sorbent Pads, and Pillows

When the TRU waste site or WIPP Certified Program determines waste rags, wipes, sorbent pads, and pillows contaminated with oxidizing chemicals would yield oxygen readily to cause or enhance the combustion of organic materials, the following criteria shall apply:

- Rags, wipes, sorbent pads, and pillows shall be treated to the criteria contained in section 5.2 or 5.4; or
- The TRU waste site may treat the waste by a method that can be approved by the CBFO Manager.

4.6 Inorganic Materials with Oxidizing Chemicals

4.6.1 Oxidizing Chemicals Sorbed in Inorganic Sorbents

Table 4-3 provides the maximum concentration of oxidizing chemical acceptable at WIPP when it is sorbed in a listed inorganic sorbent. An oxidizing chemical can be considered well-mixed in the inorganic sorbent when at least one of the following criteria is met:

- A known liquid is added in a volume approaching the liquid holding capacity of the inorganic sorbent; or
- Liquid is stirred or mixed with the inorganic sorbent.

Table 4-3 – Inorganic Sorbents, Allowable Oxidizing Chemical Concentrations, and Liquid Holding Capacities

Sorbent Name	Manufacturer	Composition listed in the SDS	Wt. % of oxidizing chemicals allowed	Measured Liquid Holding Capacity (mL/g sorbent)
Absorb-N-Dry® (Granules)	Complete Environmental Products Inc	Fuller's Earth 90-100% or Bentonite calcined 90-100% and Quartz < 10% bulk	≤ 28	0.683
AQUASET™ (Granular)	Fluid Tech Inc	Sodium montmorillonite	≤ 27	0.263
AQUASET II™ (Powder)	Fluid Tech Inc	Sepiolite	≤ 45	1.44
AQUASET II-G™ (Granular)	Fluid Tech Inc	Sepiolite	≤ 36	1.33
Celite® S (Powder)	Imerys Minerals, Sigma-Aldrich	Kieselguhr (a diatomaceous earth)	≤ 36	3.07
ChemOil-Away (Finely divided particulate)	ChemOil-Away	Volcanic ash ≥ 98% organic material ≤ 2%	≤ 13	0.853
Dri-Rite* (Granular) (22-0031)	The Dri-Rite Company	Sodium montmorillonite	≤ 27	0.263
Drierite® (Granular)	Fisher Scientific/Acros Organics	Calcium sulfate	≤ 29	0.843
Floor-Dry™ (Granular)	EP Minerals	Kieselguhr (a diatomaceous earth)	≤ 36	3.07
GSA Absorbent Oil and Water* (Granular) (22-0004)	Excel-Mineral Company Inc	Kieselguhr (a diatomaceous earth)	≤ 36	3.07
KMI Natural Zeolite (4 to 7 Å pore size)	KMI Zeolite Inc.	Natural clinoptilolite (aluminosilicate mineral)	≤ 35	0.51
Oil Dri® Concentrated Floor Absorbent* (Granules) (22-0006)	Oil Dri Corporation of America	Fuller's Earth 80-100% Quartz 10-20%	≤ 28	0.683
Oil-Dri® Granular Absorbent* 1003000 (Granules) (22-0018)	Oil Dri Corporation of America	Bentonite 90-100% Quartz < 10% bulk	≤ 28	0.683
Oil-Dri® Granular Absorbent 1003004 (Granular)	Oil Dri Corporation of America	Fuller's Earth 100%	≤ 38	1.06
Oil-Dri® Granular Absorbent – TF* 1003005 (Granular) (24-0507)	Oil Dri Corporation of America	Kieselguhr (a diatomaceous earth)	≤ 36	3.07

Sorbent Name	Manufacturer	Composition listed in the SDS	Wt. % of oxidizing chemicals allowed	Measured Liquid Holding Capacity (mL/g sorbent)
Oil-Dri® Premium Absorbent – Granular Absorbent GA* (Granular) (23-0391)	Oil Dri Corporation of America	Fuller's Earth 90-100% Quartz 0-10%	≤ 28	0.683
Oil-Dri® Quick-Sorb* 1003000 (Granular) (24-0877)	Oil Dri Corporation of America	Silica hydrated 90-100% Fuller's Earth 90-100% Bentonite 90-100% and Quartz < 10% bulk	≤ 28	0.683
Oil Dry* (No information available) (22-0004)	Excel International Inc.	Kieselguhr (a diatomaceous earth)	≤ 36	3.07
OptiSorb* (Granules) (19-0018)	EP Minerals	Kieselguhr (a diatomaceous earth)	≤ 36	3.07
PETROSORB*(Granules) other names: HIDRI, DRIZIT, ZIPZORB, TRAKSTR, MEGADRI (23-0037)	Sud-Chemie	Fuller's Earth Hydrous Magnesium Aluminum Silicate	≤ 28	0.683
Plaster of Paris (Powder)	Fisher Scientific/Arcos Organics	Calcium sulfate hemihydrate	≤ 24	0.931
SELECTSORB* (Granules) (19-0018)	EP Minerals	Kieselguhr (a diatomaceous earth)	≤ 36	3.07
Soda Solvay Dense** (Powder) (24-0301)	Solvay Chemicals International SA	Sodium carbonate (Soda Ash)	≤ 21.5	0.559
Spill-X-A® (Powder)	Tyco Fire Protection Products/Ansul	Magnesium oxide 60-100% Attapulgite 7-13% Sodium carbonate 5-10%	≤ 33	0.605
Vermiculite** (medium)	Uline	Exfoliated vermiculite granules	≤ 20	2.00
Zeolite (10 Å pore size)	Sigma-Aldrich	Synthetic aluminosilicate mineral	≤ 44	1.12
Zeolite (4 Å pore size)	Sigma-Aldrich	Synthetic aluminosilicate mineral	≤ 35	1.15

* These sorbents were not part of the initial testing; rather, they were determined to be equivalent to listed sorbents. Liquid holding capacity was not experimentally determined for these sorbents.

** Added following testing performed at Southwest Research Institute to a CBFO-approved test plan.

Waste shall be evaluated to determine if the oxidizing chemical concentration is below the wt. % of oxidizing chemical allowed in Table 4-3. Sum the weight of each of the oxidizing chemicals (include the weight of the waters of hydration) and divide by the cumulative sum of the weight of the sorbents and oxidizing chemicals (including the weight of the waters of hydration) to yield the concentration of oxidizing chemicals in the waste. When performing calculations requiring the density of a BoK-listed inorganic sorbent, the reported loose or bulk density for the inorganic sorbent as found in the respective SDS or technical data sheet (TDS) for the product shall be used. When a density range is provided in the SDS or TDS, the midpoint of the range shall be used. If no density value is available for an inorganic sorbent, Table I-1 in Attachment I provides density values that shall be used when performing calculations that require inorganic sorbent density.

> **NOTE**: **Specific gravity values for inorganic sorbents are <u>not</u> to be used in weight percentage calculations, as those values reflect the inorganic mineral as found in nature and not the prepared product when used as a sorbent.**

If the weights of either the oxidizing chemicals or the sorbents are known, it may be possible to perform bounding calculations for the oxidizing chemical concentration using the solubility of the oxidizing chemical and the inorganic sorbent liquid holding capacity. Examples of how bounding calculations can be used are shown below.

Example 1

The oxidizing chemical (sodium nitrate [$NaNO_3$]), sorbent name (AQUASET II™), and volume of $NaNO_3$ solution sorbed (2 gallons) are known, but the concentration of $NaNO_3$ in the solution and the weight of AQUASET II™ are unknown.

Step 1

Determine the weight in grams (g) of $NaNO_3$ in the solution using $NaNO_3$ solubility of 87.6 g/100 milliliters (mL) in water at 20 °C and 2 gallons for the volume of solution sorbed.

$$\boldsymbol{NaNO_3\ solubility \times vol.\,sorbed = wt.\,of\ NaNO_3}$$

So

$$\frac{87.6g\ NaNO_3}{100\ mL} \times \frac{3785\ mL}{gallon} \times 2\ gallons\ NaNO_3\ solution\ sorbed = 6631\ g\ NaNO_3$$

Step 2

Determine the weight in grams of AQUASET II™ required to sorb 2 gallons of $NaNO_3$ solution using the measured liquid holding capacity of 1.44 milliliters per gram (mL/g) of AQUASET II™ as listed in Table 4-3.

$$\frac{\boldsymbol{volume\ of\ NaNO_3\ solution\ sorbed}}{\boldsymbol{measured\ liquid\ holding\ capacity\ of\ AQUASET\ II^{™}}} = \boldsymbol{weight\ of\ AQUASET\ II^{™}}$$

So

$$\frac{2\ gallons\ NaNO_3\ solution \times \frac{3785\ mL}{gallon}}{\frac{1.44\ mL\ NaNO_3\ solution}{g\ AQUASET\ II^{™}}} = 5257\ g\ AQUASET\ II^{™}$$

Step 3

Calculate the wt. % of $NaNO_3$ in AQUASET II™ using the weight of $NaNO_3$ from Step 1 and the weight of AQUASET II™ from Step 2.

$$\frac{\boldsymbol{g\ NaNO_3}}{\boldsymbol{g\ NaNO_3 + g\ AQUASET\ II^{™}}} \times \mathbf{100} = \boldsymbol{wt.\%\ NaNO_3}$$

So

$$\frac{6631\ g\ NaNO_3}{6631\ g\ NaNO_3 + 5257\ g\ AQUASET\ II^{™}} \times 100 = 56\ wt.\%\ NaNO_3$$

Conclusion: The $NaNO_3$ is at a concentration above the 45 wt. % allowed at WIPP in AQUASET II™ and must either be treated with additional AQUASET II™ to bring the bounded oxidizing chemical salts concentration to meet the oxidizing chemical's allowed concentration identified in Table 4-3 or have tests performed to show $NaNO_3$ at this concentration produces a non-oxidizer result.

Step 4

The TRU waste site has decided to add additional AQUASET II™ to this waste. Calculate the additional AQUASET II™ that must be added and mixed to bring the bounded oxidizer salt's concentration to ≤ 45 wt. %. Use the wt. % of oxidizing chemicals allowed value for AQUASET II™ from Table 4-3, and the weights in grams of AQUASET II™ and the bounding oxidizer salt.

$$\left(\left(\frac{\mathbf{100}}{\boldsymbol{wt.\%\ oxidizing\ chem.\ allowed}} - \mathbf{1}\right) \times \boldsymbol{g\ bounding\ oxidizer\ salt}\right) - \boldsymbol{initial\ weight\ of\ sorbent} = \boldsymbol{weight\ of\ additional\ sorbent\ needed}$$

So

$$\left(\left(\frac{100}{45\ wt.\%} - 1\right) \times 6631\ g\ NaNO_3\right) - 5257\ g\ AQUASET\ II^{\text{™}} = 2848\ g\ AQUASET\ II^{\text{™}}$$

Example 2

Multiple concentrations of $NaNO_3$ solutions were added to the inorganic sorbent Celite® S. The concentration of each individual $NaNO_3$ solution is known; however, the volume of each solution sorbed is not known. The most concentrated solution sorbed was 6 molar $NaNO_3$ so it will be used to bound the $NaNO_3$ solutions sorbed. The solutions were sorbed in 4200 g of Celite® S inorganic sorbent.

Step 1

Determine the total volume of the sorbed $NaNO_3$ solutions using the most concentrated (bounding concentration) of 6 molar $NaNO_3$ and the measured holding capacity for Celite® S.

$$\boldsymbol{wt.\ of\ sorbent \times measured\ liquid\ holding\ capacity\ of\ sorbent = volume\ of\ solution}$$

So

$$4200\ g\ Celite®\ S \times \frac{3.07\ mL\ solution}{g\ Celite®\ S} = 12{,}894\ mL\ total\ volume\ sorbed\ of\ 6\ molar\ NaNO_3$$

Step 2

Determine the weight of $NaNO_3$ solutions sorbed in Celite® S using the total volume of 6 molar $NaNO_3$ solution determined in Step 1.

$$\begin{aligned} &\boldsymbol{total\ volume\ of\ 6\ molar\ NaNO_3\ solution\ sorbed} \\ &\qquad \boldsymbol{\times\ concentration\ of\ NaNO_3\ solution} \\ &\qquad \boldsymbol{=\ bounding\ weight\ of\ NaNO_3\ salt\ in\ sorbed\ solutions} \end{aligned}$$

So

$$\begin{aligned} &12{,}894\ mL\ total\ volume\ sorbed\ of\ 6\ molar\ NaNO_3 \times \frac{6\ moles\ NaNO_3}{1{,}000\ mL} \times \frac{85\ g\ NaNO_3}{mole} \\ &\qquad = 6{,}576\ g\ bounded\ weight\ of\ NaNO_3 \end{aligned}$$

Step 3

Calculate the wt. % of $NaNO_3$ salt sorbed in the known weight of 4200 g of Celite® S using the bounded weight of $NaNO_3$ calculated in Step 2.

$$\frac{\boldsymbol{g\ NaNO_3}}{\boldsymbol{g\ NaNO_3 + g\ Celite® \ S}} \times \mathbf{100} = \boldsymbol{wt.\%\ NaNO_3}$$

So

$$\frac{6{,}576\ g\ NaNO_3}{6{,}576\ g\ NaNO_3 + 4{,}200\ g\ Celite® \ S} \times 100 = 61\ wt.\%\ NaNO_3$$

Conclusion: The sorbed oxidizing chemical is at a concentration above 36 wt. % allowed at WIPP in Celite® S and must either be treated or have tests performed to show $NaNO_3$ at this concentration in Celite® S produces a non-oxidizer result.

Step 4

The TRU waste site has decided to add additional Celite® S to this waste. Calculate the additional Celite® S that must be added and mixed to bring the bounded oxidizer salt's concentration to ≤ 36 wt. %. Use the wt. % of oxidizing chemicals allowed value for Celite® S from Table 4-3, and the weights in grams of Celite® S and the bounding oxidizer salt.

$$\left(\left(\frac{\mathbf{100}}{\boldsymbol{wt.\%\ oxidizing\ chem.allowed}} - \mathbf{1}\right) \times \boldsymbol{g\ bounding\ oxidizer\ salt}\right) - \boldsymbol{initial\ weight\ of\ sorbent} = \boldsymbol{weight\ of\ additional\ sorbent\ needed}$$

So

$$\left(\left(\frac{100}{36\ wt.\%} - 1\right) \times 6{,}576\ g\ NaNO_3\right) - 4{,}200\ g\ Celite® \ S = 7{,}491\ g\ Celite® \ S$$

<u>Example 3</u>

The concentrations of sodium nitrate, potassium nitrate, and calcium nitrate in solution are not known in an evaporator liquid waste stream. The solubility of sodium nitrate is 87.6 g/100 mL of water, the solubility of potassium nitrate is 33.0 g/100 mL of water, and the solubility of calcium nitrate is 129 g/100 mL of water. The process flow sheets identify sodium nitrate and potassium nitrate solutions as the predominant feed solutions sent to the evaporator. A way to bound the concentrations of oxidizer salts in the evaporator liquid waste stream is to identify the salt with the highest solubility between the predominant feed solutions. The liquid has been sorbed in 8 gallons of AQUASET II™. The bulk density of AQUASET II™ (sepiolite clay) is 75 pounds per cubic foot, which correlates to 1.20 grams per cubic centimeter (g/cm^3).

Step 1

Determine the weight of the AQUASET II™ using the volume of sorbent used (8 gallons) and the bulk density of the AQUASET II™ (sepiolite, 1.20 g/cm^3).

$$\boldsymbol{Volume\ of\ sorbent \times Density\ of\ sorbent = Weight\ of\ sorbent}$$

So

$$8\ gal.\, of\ AQUASET\ II^{\text{™}} \times \frac{3785\ cm^3}{1\ gal.} \times \frac{1.20\ g\ AQUASET\ II^{\text{™}}}{cm^3} = 36{,}336\ g\ AQUASET\ II^{\text{™}}$$

Step 2

Calculate the volume of solution sorbed from the liquid holding capacity of AQUASET II™ (1.44 mL/g) using the following equation:

$$\boldsymbol{Sorbent's\ Liquid\ Holding\ Capacity \times weight\ of\ sorbent = Volume\ of\ solution}$$

So

$$\frac{1.44\ mL}{g\ AQUASET\ II^{\text{™}}} \times 36{,}336\ g\ AQUASET\ II^{\text{™}} = 52{,}324\ mL\ solution$$

Step 3

Calculate the weight of the bounding weight oxidizer salts in the evaporator liquid waste stream.

$$\begin{aligned}&\boldsymbol{Solubility\ of\ the\ bounding\ salt \times Volume\ of\ solution}\\ &\boldsymbol{= Bounding\ weight\ of\ oxidizer\ salts\ in\ the\ evaporator\ liquid\ waste\ stream}\end{aligned}$$

Of the two most predominant oxidizer salts in the feed solutions, sodium nitrate has the highest solubility (87.6 g/100 mL of water); therefore, it will be the oxidizer salt used for the bounding calculation.

$$\frac{87.6\ g\ NaNO_3}{100\ mL} \times 52{,}324\ mL\ solution = 45{,}836\ g\ NaNO_3$$

Step 4

Calculate the bounding wt. % of oxidizer salts sorbed in 8 gallons of AQUASET II™.

$$\frac{\boldsymbol{g\ bounding\ oxidizer\ salt}}{\boldsymbol{g\ bounding\ oxidizer\ salt + g\ AQUASET\ II^{™}}} \times \mathbf{100}$$

$$= \boldsymbol{bounding\ wt.\%\ of\ oxidizer\ salts}$$

Or

$$\frac{45{,}836\ g\ NaNO_3}{45{,}836\ g\ NaNO_3 + 36{,}336\ g\ AQUASET\ II^{™}} \times 100 = 56\ wt.\%\ oxidizer\ salts$$

Conclusion: The sorbed oxidizer salts exceed the 45 wt. % allowed at WIPP in AQUASET II™ and must either be treated or have tests performed to show $NaNO_3$ at this concentration in AQUASET II™ produces a non-oxidizer result.

Step 5

The TRU waste site has decided to add additional AQUASET II™ to this waste. Calculate the additional AQUASET II™ that must be added and mixed to bring the bounded oxidizer salt's concentration to ≤ 45 wt. %. Use the wt. % of oxidizing chemicals allowed value for AQUASET II™ from Table 4-3, and the weights in grams of AQUASET II™ and the bounding oxidizer salt.

$$\left(\left(\frac{\mathbf{100}}{\boldsymbol{wt.\,\%\ oxidizing\ chem.\ allowed}}-\mathbf{1}\right)\times\boldsymbol{g\ bounding\ oxidizer\ salt}\right)-\boldsymbol{initial\ weight\ of\ sorbent}=\boldsymbol{weight\ of\ additional\ sorbent\ needed}$$

So

$$\left(\left(\frac{100}{45\ wt.\,\%}-1\right)\times 45{,}836\ g\ NaNO_3\right)-36{,}336\ g\ AQUASET\ II^{\text{™}}=19{,}686\ g\ AQUASET\ II^{\text{™}}$$

For components of waste with more than one inorganic sorbent, the maximum allowed concentration of oxidizing chemicals is determined by the lowest maximum concentration of any of the components. For example, for a mixture of wet Drierite® and Zeolite (10 Å pore size), the maximum concentration of oxidizing chemicals allowed is 29 wt. %.

Waste containing inorganic sorbents not listed in Table 4-3 are not acceptable for disposal at WIPP. The TRU waste site or WIPP Certified Program may request an evaluation that the sorbent is equivalent to one of the sorbents listed by name in Table 4-3 and receive a written determination from the CBFO Office of the Manager for the AK record, or the CBFO will allow the TRU waste site or WIPP Certified Program to grant equivalency for sorbents that are compositionally identical to inorganic sorbents and similar in particle size and bulk density to the equivalent sorbent found in Table 4-3. In this case, the TRU waste site will provide the CBFO Office of the Manager with the following information for the sorbent:

- Formal letter to the DOE CBFO WM-STA requesting a sorbent equivalency evaluation (inorganic sorbents only) by the CBFO WM-STA to determine if the unlisted sorbent is compositionally equivalent to a tested sorbent, or provide written notice to the CBFO WM-STA that a sorbent equivalency has been granted and include the information in the following bullet list:
    - Sorbent product name
    - Chemical composition
    - Sorbent particle size (affects liquid holding capacity)
    - Product bulk density
    - Product manufacturer
    - SDS and other product data sheets
    - Product name of the equivalent sorbent

The sorbent will then have the same wt. % of oxidizing chemical allowed and the same liquid holding capacity for the sorbent it is equivalent to.

CAUTION: The CBFO may revoke at any time the deemed equivalency if provided information is not complete, is inaccurate, or does not meet the equivalency criteria.

If determined that the inorganic sorbent is not equivalent, the TRU waste site or WIPP Certified Program must select an applicable option listed in section 2.0. If option 2.0 c) is selected, then data shall be collected using a CBFO-approved test plan that demonstrates that the concentration in wt. % of most representative metal oxidizing chemical salt found in the mixture to sorbents produces a non-oxidizer result (see section 6.0).

When there is inadequate information to quantitate the concentration of oxidizing chemical, the waste must be treated as 100 wt. % oxidizing chemical with an inorganic sorbent listed in Table 4-3 using the corresponding allowable oxidizing chemical concentration (or see section 2.0).

NOTE: The CBFO will not grant equivalency for Hydromatrix, Micro-Cel® E, or perlite. These inorganic sorbents are not effective for treating oxidizing chemicals to produce non-oxidizer results; therefore, they must be treated as 100% oxidizing chemical with zeolite or another inorganic sorbent when they contain oxidizing chemicals.

4.6.2 Inorganic Sludges with Oxidizing Chemicals Not Mixed with Sorbents

Inorganic sludges containing oxidizing chemicals that are not mixed with sorbents have been generated from plutonium purification and other processes. As an example, chemical salt sludges resulted from reactions that included neutralization, flocculation, co-precipitation, rotary diatomite filtration and evaporation. Inorganic sludges up to 30 wt. % oxidizing chemicals that have not been mixed with sorbent are acceptable at WIPP, provided liquids are not present at more than the limit specified in DOE/WIPP-02-3122, *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant.*

4.6.3 Oxidizing Chemicals Solidified in a Cement or Grout Matrix

Oxidizing chemical liquids and particulate containing oxidizing chemicals are sometimes fixed in an inorganic form of cement or grout for disposal. Cement or grout containing oxidizing chemicals shall be considered well-mixed if the process involved mixing, stirring, or other manipulation of the cement or grout paste and oxidizing chemicals prior to setting. For purposes of this BoK, wastes with inorganic oxidizing chemicals, whether listed in Table 4-1 or not, that are cemented or grouted are not oxidizers. However, some inorganic oxidizing chemicals are incompatible with Portland cement and can pose health risks to workers at the time the waste is cemented or grouted.

Inorganic cements and grouts prevent the oxidizing chemicals they contain from being activated with heat and do not require further treatment if no free liquids are present.

4.6.4 Ion Exchange Resins and Miscellaneous Organic Materials

Other organic wastes or materials containing oxidizing chemicals are known to exist at some of the TRU waste sites. Some of these are in the TRU waste inventory and others will enter the TRU waste inventory. An example of organic waste is ion exchange resins (commonly amine- or sulfonate-substituted divinylbenzene cross-linked to a polystyrene backbone) with various nitrate loadings. Ion exchange resins with oxidizing chemicals that are stabilized with Portland cement are not oxidizers when the resins are well-mixed in the cement and do not exceed 10 wt. % in the set cement monolith. When the cement monolith is intact based on visual observation, it is acceptable to conclude that the 10 wt. % limit for the ion exchange resins has been met. Ion exchange resins in excess of 10 wt. % tend to fracture the cement due to swelling.[5]

Ion exchange resins that do not meet the criteria above, organic solvents, and other miscellaneous organic materials containing oxidizing chemicals are not acceptable at WIPP without a verifiable basis that can be used to determine the waste will be safe and compliant for receipt and emplacement in WIPP. A verifiable basis may include the results of testing or other information that can be confirmed. Due to the potential to form mechanical impact, spark, friction, and/or heat sensitive compounds when some oxidizing chemicals and organics are mixed, the CBFO may require additional testing beyond the testing of oxidizing chemicals to determine acceptability.

4.7 Multiple Waste Components with Oxidizing Chemicals

When the waste has multiple components with oxidizing chemicals, each component shall be evaluated independently, using the appropriate criteria in this document. If no criteria are applicable to a waste component, then contact the CBFO WM-STA for guidance.

4.8 Oxidizing Chemicals that are the Sole Component of Waste

Oxidizing chemicals that are the sole waste component(s) (e.g., metal nitrate salts with or without free liquid) are not acceptable for disposal at WIPP without treatment (see section 2.0 g)).

4.9 Surfaces Contaminated with Oxidizing Chemicals

Waste components with low porosity and impermeable surfaces that have been exposed to liquid or solid oxidizing chemicals are surface contaminated only. These types of waste components will not exhibit oxidizing behavior regardless of the distribution of the oxidizing chemicals when there is no observable adhesion of the oxidizing chemical to the surface.

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[5] G. Veazey and R. Ames, “Cement Waste Form Development for Ion-Exchange Resins at the Rocky Flats Plant,” LA- 13226-MS, March 1997, Los Alamos National Laboratory.

4.10 Oxidizing Chemicals Spilled or Released into Soils

Soils containing up to 30 wt. % oxidizing chemicals are allowable without treatment, provided the soils are not heavily contaminated with organics released in liquid form or as finely divided solids (excluding natural organic matter content of the soil). The term "heavily contaminated" implies that a visually significant or measurable amount of organic liquid or finely divided organic solid is present in the soil.

4.11 Oxidizing Chemicals in Waste Retrieved from Earthen Disposal Pits at Idaho National Laboratory (INL)

In the case of targeted waste retrieved from the INL Radioactive Waste Management Complex burial pits, it is assumed that the soil contains up to 22 wt. % non-visible metal nitrate salts (i.e., ~60% sodium nitrate, ~30% potassium nitrate, and ~10% other salts).[6] Waste retrieved from disposal pits cannot contain more than 8% visible salts by volume (~7.6 wt. % visible salts). Historic testing indicates that 30 wt. % oxidizing chemical concentration produces a non-oxidizer result in S3000 summary category group (i.e., homogeneous solids) inorganic or organic wastes.

The dissolved salt in the soils plus the remaining visible crystals cannot exceed 30 wt. %.[7] Crystalline oxidizing chemical salts removed from the soil/waste mixture must be treated as oxidizing chemical salts.

5.0 <u>CRITERIA FOR TREATMENT OF WASTE CONTAINING OXIDIZING CHEMICALS</u>

If the waste does not pass the evaluation criteria of section 4.0 and must be treated, the following treatments are acceptable based on formal testing results.

5.1 Treatment with Inorganic Sorbent

If the concentration of oxidizing chemicals in the sorbent exceeds the maximum value listed in Table 4-3, the waste can be treated by adding more of the same inorganic sorbent to the waste. The inorganic sorbent must be well-mixed with the waste and the oxidizing chemical concentration must be below the maximum wt. % of oxidizing chemicals allowed. For this criterion, the treated mixture is considered well-mixed when the additional inorganic sorbent is distributed evenly throughout the waste.

Adding a different inorganic sorbent to previously sorbed oxidizing chemical is permitted provided the added sorbent is listed in Table 4-3 and the quantity of added sorbent to

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[6] Kimmitt, R.R., Chemical Compatibility and Inventory Evaluation for the Accelerated Retrieval Project, Engineering Design File, EDF-5307, current revision, Idaho Cleanup Project, Idaho Falls, Idaho.

[7] Kimmitt, R. R., Allowable Nitrate Salt Concentration in ARP Waste, Engineering Design File, EDF-8723, current revision, Idaho Cleanup Project, Idaho Falls, Idaho.

meet the allowable oxidizing chemical concentration is calculated based on the total mass of the original sorbent. The treated mixture is considered well mixed when the additional inorganic sorbent is distributed evenly with the original sorbent. When a powdered or finely divided particulate inorganic sorbent is to be used with a granular sorbent, the original sorbent must be wetted prior to mixing with the different inorganic sorbent to ensure the oxidizing chemical is effectively treated.

Dry oxidizing chemicals or waste components with oxidizing chemicals must be wetted before sorbing with an inorganic sorbent. The resulting sorbed mixture must be within the allowable oxidizing chemical concentration specified in Table 4-3. Wetting oxidizing chemicals before sorbing enhances the process by increasing solubility, contact area, and promoting ion exchange. Optimizing wetting conditions is vital for achieving effective sorption and not unduly increasing the final waste volume. Dry mixing does not account for differences in density and particle size and can result in oxidizing chemical separation, potentially rendering the treatment of the oxidizing chemical ineffective.

Viscous or tacky waste with oxidizing chemicals that can adhere to a sorbent can be sorbed and is not dry for the purpose of compliance with the above criterion. Sorbing is allowed even when observable liquid is not present if the waste and sorbent are well-mixed, and the final waste form meets the allowable oxidizing chemical concentration for the sorbent used as specified in Table 4-3.

5.2 Treatment of Organic Sorbents, Rags, Wipes, Pads, and Pillows with Zeolite

Table 5-1 lists the final wt. % of oxidizing chemicals and zeolites that produce a non-oxidizer result in a homogeneous treated oxidizing chemical and organic sorbent mixture.

Table 5-1 – Final wt. % of Zeolites Required to Treat Previously Sorbed Oxidizing Chemical in Organic Sorbent Mixtures and Rags, Wipes, Pads, and Pillows

Mixture to Remediate	Wt. % of 4 Å to 10 Å zeolite required in a treated homogeneous mixture
Oxidizing chemicals in EOPS	≥ 50
Oxidizing chemicals in cellulose (e.g., cheesecloth, cotton rags, wipes, etc.)	≥ 70
Oxidizing chemicals in polyester rags, pads and polyester encased cellulose sorbent pillows	≥ 70

The wt. % of 4 Å to 10 Å zeolite required is the minimum wt. % of zeolite that must be achieved in the final previously sorbed waste and zeolite treated homogeneous mixture.

The final zeolite concentration of the treated homogeneous mixture is determined from the as-received weight of the zeolite and the weight of the previously sorbed mixture's dry weight. Only the wt. % values for oxidizing chemicals and zeolites from Table 5-1 can be used when treating oxidizing chemicals previously sorbed in organic sorbents.

For the BoK, the treated mixture is considered well-mixed when the zeolite is distributed evenly throughout the waste. Rags, wipes, pads, and pillows must be size reduced to pieces of no more than one inch in all dimensions. It is the responsibility of the TRU waste site to ensure that the treatment process is demonstrated to produce thoroughly blended mixtures. Additionally, it is the responsibility of the TRU waste site to ensure that the selected treatment process is compliant with their safety and regulatory requirements.

5.3 Handling of Zeolite

Zeolites are believed to be compatible with the oxidizing chemicals listed in Table 4-1. However, there are some documented chemical incompatibilities and observed properties of zeolite that TRU waste sites should note may be problematic when handling zeolites for treatment of oxidizing chemical wastes.

Strong acids and bases can affect the surface area, pore diameter, pore volume, and crystallinity of zeolites, causing them to become less effective as a sorbent over time. Hydrochloric acid (HCl), nitric acid (HNO_3), sulfuric acid (H_2SO_4), hydrofluoric acid (HF), and other strong acids found in TRU waste can cause pitting (i.e., increase in surface area). Strong acids can increase the ratio of Si-to-Al in some zeolite varieties (e.g., Clinoptilolite), causing them to become more hydrophobic. Zeolites can also dissolve in strong alkaline hydroxides, such as sodium hydroxide (NaOH), but the hydroxide must be heated.

Transuranic waste sites handling zeolite should also be aware of its heat of immersion, which results in the zeolite heating upon being mixed with water. This was observed in the holding capacity studies as steam rising from the sample tray when the potassium nitrite solution was slowly added to the zeolite. Heats of immersion of zeolites have been reported as high as 375 J/g (joules per gram).[8]

Transuranic waste sites treating waste with zeolite are encouraged to perform small-scale tests prior to initiating waste treatment with zeolite to determine if any of these properties need to be accounted for. Transuranic waste sites should not initiate the treatment of oxidizing chemical waste unless the treatment can be performed safely and effectively.

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[8] Coughlin, B. & Carroll, W. M., "Water in Ion-Exchanged L, A, X, and Y Zeolites: A Heat Immersion and Thermogravimetric Study." Physical Chemistry Laboratories, University College, Ireland, Dec 1975.

5.4 Treatment of Organic Sorbents, Rags, Wipes, Pads, and Pillows with Inorganic Sorbents Other Than Zeolites

A TRU waste site may use an inorganic sorbent other than zeolite if the weight percent of oxidizing chemicals allowed for the listed sorbent is met for the treated waste. The treated mixture is considered well-mixed when the sorbent is distributed evenly throughout the waste. Rags, wipes, pads, and pillows must be size-reduced to pieces no more than one inch in all dimensions.

A TRU waste site may use an inorganic sorbent not found in Table 4-3 if test data are developed under the following conditions:

- Data are collected using a CBFO-approved test plan developed incorporating the criteria in section 6.0 to determine the wt. % of oxidizing chemical allowed for the initial waste mixture blended with the selected inorganic treatment sorbent. This is the wt. % concentration of oxidizing chemical in inorganic sorbent that produces a non-oxidizer result.

Test plans should be submitted to the CBFO Office of the Manager for approval. Approval will be documented, in writing, by the CBFO Manager. Data shall be provided to the CBFO WM-STA after validation by the TRU waste site. Once the data are approved by the CBFO, acceptance criteria for that sorbent will be provided, in writing, and included in a revision to this BoK.

6.0 CRITERIA FOR TESTING WASTE CONTAINING OXIDIZING CHEMICALS

Testing to determine the oxidizing chemical wt. % in sorbent, soil, or other waste that produces a non-oxidizer result shall be developed in accordance with EPA publication SW-846 entitled *Test Methods for Evaluating solid Waste: Physical/Chemical Methods, Chapter One.* The test plan must specify how the waste will be bound if representative waste sample testing cannot be performed.

If SW-846 Method 1040, *Test Method for Oxidizing Solids,* is to be used, the method modifications specified in section 6.1 must be applied. The modifications made to the SW-846 Method 1040 test were put in place to account for the environmental conditions the waste could experience during shipment in unvented Nuclear Regulatory Commission-certified Type B packages, when received and managed in the WIPP surface storage facilities, and after emplacement in the WIPP underground until the waste is isolated from the underground ventilation air flow. Data quality objectives (DQOs) will be established that are no less restrictive than those listed in section 6.2. Additional DQOs may be developed if they add to the quality of the test results.

It is the responsibility of the TRU waste site to ensure their testing can be implemented in compliance with site safety and regulatory requirements. The test plan shall be provided to the CBFO for review and approval. Copies of the following types of documents shall be provided to the CBFO Office of the Manager when testing is completed:

- Procurement procedures and records for purchases of quality affecting chemicals and equipment;
- Instrument calibration documents;
- Data validation and verification procedures and reports;
- Sample data sheets; and
- Data report or summary document.

The CBFO Manager will issue written acceptance criteria when the results of testing are accepted. The criteria issued will be incorporated in a revision to this BoK.

Oxidizing chemicals that are likely to ignite or explode during sample preparation are not amenable to testing using the modified SW-846 Method 1040. Alternate test methods and treatments will have to be identified for these oxidizing chemicals. The CBFO will cooperate with the TRU waste sites in seeking an acceptable testing and treatment path for wastes such as these.

6.1 Modified Method 1040 Testing Approach

The SW-846 Method 1040 requires testing representative samples of wastes. Non-radioactive surrogates may be used for testing if a site is unable to conduct burn rate tests on radioactive materials.

Modifications shall be made to the SW-846 Method 1040 to account for the intended use of the analytical results specific to WIPP or to account for conditions in the laboratory. The SW-846 Method 1040 modifications required or determined acceptable by the CBFO are described below.

- The SW-846 Method 1040 requires drying of a sample at 65 ± 2 degrees Celsius (°C) for 12 hours. Drying until a relatively constant mass (± 2 g) is required, regardless of total drying time.
- The SW-846 Method 1040 requires the sample to be cut, crushed, or ground so that the particle size of the sample to be tested is no larger than 0.5 millimeter (mm) (passes through a 32-mesh sieve). Materials must be size-reduced as much as possible. If a particle size reduction to no larger than 0.5 mm is not possible, then the difference in size shall be accounted for by developing an alternative reference standard that can be compared to the SW-846 Method 1040 prepared reference standard.
- The SW-846 Method 1040 requires each sample to be evaluated in 1:1 and 4:1 (by weight) waste to cellulose ratios. Since most oxidizing chemicals alone or when mixed with inorganic sorbents are not combustible, the SW-846 Method 1040 specifies the addition of cellulose as the organic fuel for testing. Some of the wastes identified in TRU waste streams are organic and are readily combustible when dried. Cellulose fuel should not be added to these

samples because it will make the sample fuel rich and oxidizing chemical lean. This condition will extend the observed burn times of the samples and it does not accurately represent the actual waste. For treatment, samples containing organic waste with oxidizing chemicals shall be tested in a 3:2 oxidizing chemical to organic ratio without the addition of cellulose fuel.

- Per SW-846 Method 1040, the burn rate test is repeated five times for each waste to cellulose ratio mixture. Method 1040 also requires mixing 100 g to 160 g of sample with cellulose to provide enough of the mixture for five tests, and 30 g aliquots are measured from this large batch for each burn test. If these prepared sample quantities are believed to pose an undue safety risk, each 30 g sample may be prepared individually. Data quality objectives addressing weighing accuracy and mixing times should be developed and implemented for consistency of the samples.
- The SW-846 Method 1040 states that all tests must be conducted under standard test conditions, which include a temperature of 20 ± 5 °C and a relative humidity of 50 ± 10%. If conditions deviate beyond these ranges, a new reference standard must be tested, and the testing for that sample repeated. Data quality objectives that cover the environmental conditions must be written and monitored during testing to show the environmental conditions are not changing beyond those written in the unmodified SW-846 Method 1040.
- The SW-846 Method 1040 states that the ignition wire should be placed on a ceramic plate before the sample is added on top of the wire in a conical pile. In this configuration, there is a gap between the ceramic plate and the funnel used to form the conical sample pile due to the ignition wire and insulator block attached to the wire. The funnel shall be inverted onto the ceramic plate with no ignition wire present, and the ignition wire shall be carefully pressed or slid into the cone of sample from the top or side to better retain the cone shape without displacing the pile base. For the samples that could not be fully size-reduced per the method, the samples shall be placed on top of the ignition wire ensuring an air gap remains between ceramic plate and the ignition wire.
- The SW-846 Method 1040 states that once the sample pile ignites, the power to the ignition wire is turned off. The SW-846 Method 1040 shall be modified to keep the ignition wire energized for 15 seconds, even if ignition occurs sooner, to reduce the subjectivity of when ignition takes place. If the sample does not ignite within 15 seconds, the wire shall remain energized until the analyst determines ignition has occurred, or for at least 3 minutes, as directed in the unmodified SW-846 Method 1040.

The SW-846 Method 1040 classifies a solid waste into one of four categories of oxidizers based on the shortest mean burning time between the 4:1 and 1:1 oxidizing chemical to cellulose samples. This allows the possibility for a non-oxidizer result to be obtained if any of the five individual burn rates used to calculate the mean burning time are shorter than the mean burning time for the 3:7 potassium bromate to cellulose reference standard. To ensure that the average burn time is in the non-oxidizer category, the following modification shall be made: A non-oxidizer result occurs when either the burn times for all samples and duplicate sample are greater than the 3:7 potassium bromate to cellulose reference standard, or the samples do not burn at all. If the first two aliquots of a sample or duplicate sample do not ignite within 3 minutes, the sample shall be labeled a non-oxidizer, and no further testing shall be required for the remaining aliquots for that sample or duplicate.

6.2 Oxidizing Chemical Testing and Data Quality Objectives

Many factors, such as particle size, reagent moisture content, room temperature, humidity, ventilation, position of the test sample in the hood, and the position of the ignition wire within the test pile, can impact the burn rates and method precision. The burn rates for individual burn rate tests performed on each sample and the mean burn rates for each series of burn rate tests shall be recorded on data sheets generated from the execution of a CBFO Manager-approved test plan. It is essential that all steps be conducted in a consistent manner under uniform experimental conditions to obtain reliable and reproducible results. Therefore, the test plan shall specify DQOs that define the acceptable level of uncertainty or variation in parameters that can affect the overall method accuracy or precision.

To ensure the environmental conditions are consistent for a set of burn rate measurements performed using the modified SW-846 Method 1040 approach, a DQO for room temperature and humidity shall be specified for the location of the test. All five aliquots for any sample must be tested within a range of 5 °C above or below the room temperature at which the same 3:7 potassium bromate to cellulose reference standard is measured.

Relative humidity of the room must remain within a range of 10% above or below the initial relative humidity at which the same 3:7 potassium bromate to cellulose reference standard is measured.

To ensure sample consistency and the proper concentrations of oxidizing chemicals and sorbents in samples, the DQO for weights of oxidizing chemicals, sorbents, and cellulose shall be ± 0.05 g. The DQO to establish dryness of the sample shall be a difference of ± 2 g between the final sample weight and the previous weight measurement. Each test sample batch shall be dried for 12 hours before the first weight measurement. Each test sample batch shall be dried for at least 4 additional hours between subsequent weight measurements. To ensure samples are dried at a consistent temperature, the DQO for drying oven temperature shall be 65 ± 2 °C. Finally, to ensure consistency between each burn rate measurement and to gauge the consistency of the procedures, a DQO for the range on the reference standard tests shall be established. For any given series of burn rates, a set of five aliquots of 3:7 potassium bromate to cellulose reference standard must be within a range of ± 60 seconds from the average result obtained, or the reference series shall be invalid and must be repeated. A DQO for thermocouple measurements shall be established to account for errors in thermocouple readings so that the temperature of the ignition wire does not exceed 1050 °C or fall below 1000 °C.

7.0 RECORDS

The following documents, under the CBFO records heading, will be generated as necessary when implementing the BoK and shall be processed and maintained as quality assurance records in accordance with established CBFO records management procedures.

CBFO records

- TRU waste site or WIPP Certified Program (section 2.0 option a)) bounded oxidizing chemical request and WM-STA's approvals with acceptance criteria
- TRU waste site or WIPP Certified Program (section 2.0 option b)) inorganic sorbent equivalency evaluation requests and WM-STA's sorbent equivalency approvals with wt. % of oxidizing chemicals allowed or WIPP Certified Program inorganic sorbent equivalency approval and justification documentation
- TRU waste site or WIPP Certified Program (section 2.0 option c)) test method approval requests, WM-STA's recommendation memo, and CBFO Manager's approvals
- TRU waste site or WIPP Certified Program test plans (section 2.0 options c) and d)), WM-STA's recommendation memo, and CBFO Manager's approvals
- TRU waste site or WIPP Certified Program test data (section 2.0 options c), d), and h)), CBFO review records, WM-STA's recommendation memo, and CBFO Manager-issued acceptance criteria (when applicable)
- TRU waste site or WIPP Certified Program treatment plans (section 2.0 options e), f), and g)), WM-STA recommendation memo, and CBFO Manager's written approvals
- TRU waste site or WIPP Certified Program technical justification submittals (section 2.0 option h)), WM-STA's recommendation memo, and CBFO Manager's written approvals

The WIPP Certified Program Acceptable Knowledge Expert and Site Project Manager shall be included on electronic distribution of CBFO responses to the above-listed TRU waste site requests and submittals. The CBFO Senior Nuclear Safety Advisor, National TRU Program Certification Division Director, Quality Assurance Division Director, SBAA, and WM-STA shall be included on electronic distribution.

TRU Waste Site and/or WIPP Certified Programs' AK records

- BoK evaluations and CBFO WM-STA's written approvals (WIPP Certified Programs only)

- TRU waste site or WIPP Certified Program (section 2.0 option a)) bounded oxidizing chemical request and CBFO WM-STA’s bounded oxidizing chemical approvals with acceptance criteria
- TRU waste site or WIPP Certified Program (section 2.0 option b)) sorbent equivalency requests and CBFO WM-STA’s sorbent equivalency approvals with wt. % of oxidizing chemicals allowed or inorganic sorbent equivalency approval and justification documentation or TRU waste site or WIPP Certified Program equivalency determination and justification documentation
- TRU waste site or WIPP Certified Program (section 2.0 option c)) test method approval requests and CBFO Manager’s approvals
- TRU waste site or WIPP Certified Program test plans (section 2.0 options c) and d)) and CBFO Manager’s approvals
- TRU waste site or WIPP Certified Program test data (section 2.0 options c), d), and h)) and CBFO Manager-issued acceptance criteria (when applicable)
- TRU waste site or WIPP Certified Program treatment plans (section 2.0 options e), f), and g)) and CBFO Manager’s written approvals
- TRU waste site or WIPP Certified Program technical justification submittals (section 2.0 option h)) and CBFO Manager’s written approvals

Attachment I: Inorganic Sorbent Density Table

Table I-1 - Bulk Densities for Approved Inorganic Sorbents

Primary Inorganic Sorbent Component	Bulk Density (lbs/ft^3)
Bentonite	55
Clinoptilolite	49
Diatomaceous Earth	12
Drierite (Calcium Sulfate)	65
Fuller's Earth	40
Kieselguhr	12
Magnesium Oxide	58
Plaster of Paris (calcium sulfate hemihydrate)	50
Sepiolite	75
Sodium Montmorillonite	55
Vermiculite	6.1
Zeolite	49

Note: If no density value is available for an inorganic sorbent, the above table provides density values that shall be used when performing calculations that require inorganic sorbent density (see BoK section 4.6.1).