# ATTACHMENT 2

# WASTE CHARACTERIZATION PLAN

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# WASTE CHARACTERIZATION PLAN

## 1.0 Introduction

This attachment describes the hazardous wastes treated at the Utah Test and Training Range-North (UTTR-North) Thermal Treatment Unit (TTU) and discusses the procedures to be followed to ensure proper waste identification.

Reactive wastes have been treated at the UTTR-North TTU for over 30 years, under both interim status and, since 2003, as a permitted treatment facility. Because of the wide variety of potential wastes that can be treated at the facility and the inherent nature of excess military munitions, a knowledge-based waste characterization approach has been utilized.

During permit development, while the facility was operating under interim status, an effort was made to categorize munitions that could potentially be treated and to develop a database that could be used to provide munition specific characterization data for items treated at the TTU. A “Waste Characterization Technical Memorandum” and associated addenda from Radian International described these efforts and were included in the 2003 Hazardous Waste Operating Permit as “Attachment 2, Technical Memorandum, UTTR: Waste Characterization Evaluation for the TTU.”

This revised attachment, entitled “Waste Characterization Plan,” contains the same knowledge-based approach as the original version, but excludes discussion regarding the development of a separate munitions database specifically for the UTTR. Instead, it describes the knowledge-based characterization process and discusses the wastes that have been historically treated at the UTTR.

## 2.0 Physical and Chemical Characterization [UAC R315-264-13 and R315-270-14(b)(2)]

## 2.1 Definition of Reactive Hazardous Waste [UAC R315-261-23(a)]

Wastes treated at the UTTR-North TTU are hazardous by virtue of their characteristic reactivity and are classified with the primary EPA Hazardous Waste Number of D003. These wastes meet the definition of reactivity found in the UAC R315-261-23(a)(6)(8); specifically, they are:

- Capable of detonation or explosive reaction if subjected to a strong initiating source or if heated under confinement and/or
- A "forbidden explosive" as defined in 49 CFR 173.54 or a "Class 1 explosive" as defined in 49 CFR 173.50(b)(1), (2), or (3).

## 2.2 Knowledge-Based Waste Characterization

Unlike traditional hazardous wastes generated during manufacturing or maintenance processes, the reactive wastes treated at the TTU are most commonly contained in obsolete items such as munitions or rocket motors. These items have been manufactured to exacting tolerances and specifications and their physical characteristics and chemical constituents have been well documented. This information may be obtained from manufacturers and from the Department of Defense (DoD) and used for a knowledge-based waste determination. The following data sources may be used to characterize reactive wastes treated at the TTU:

- Manufacturer and DoD technical information documents
- Manufacturer material safety data sheets (MSDS)
- The DoD Munitions Items Disposition Action System (MIDAS) database
- Department of Transportation explosive classification [49 CFR 173.50]

Specific waste identification, characterization, and acceptance procedures are described in Attachment 3.

## 2.3 Physical Characterization

The wastes treated at the TTU are generally physically intact unserviceable or obsolete missile motors, munitions, or scrap propellant. Although it is possible that some off-specification ordnance and propellant items may be treated at the TTU, their physical components would be consistent with data presented in this section.

Waste munitions treated by OB/OD processes generally consist of an assortment of explosive fill materials wholly contained in metal casings (brass, aluminum, or steel). Propellants (e.g., rocket motors) may be housed in non-metallic casings. The metal casing constitutes the majority of the gross weight of a munition item, while the explosive filler is typically 20% to 40% of the gross weight. For example, the explosive component of a MK-82 500-lb general purpose bomb is approximately 192 lb. This explosive filler weight is known as the net explosive weight (NEW). In the case of missile motors, the most commonly treated items at the TTU, the NEW of the propellant comprises the majority of the total weight of the item.

## 2.4 Waste Sources

Waste munitions treated at the TTU are generated either locally from storage facilities at the UTTR, from Hill AFB, or received from other DoD installations or contractors under pre-arrangement or under contract. Waste munitions include:

- Rejected munitions and components that do not meet military specifications (MILSPEC);
- Items that have exceeded their maximum intended “shelf-life”;
- Items that appear damaged or show evidence of deterioration and corrosion;
- Items declared surplus; and
- Waste material from propellant or munitions testing operations.

## 2.5 Chemical Characterization

Many types of fundamental chemical compounds are used in explosives formations: nitrates, amines, aromatics, azides, and perchlorates. In addition, other chemical materials are used as oxidizers and fuels (e.g., metals), binders, plasticizers, or processing aids. Although all these materials are constituents of explosives, many of these compounds are not explosive, such as sodium and potassium nitrate.

Table 1 provides a summary of explosive compositions that may be treated at the UTTR-North TTU and their chemical formulas. Also shown are their EPA hazardous waste numbers. Because the TTU treats military munitions for their reactivity, the primary hazardous waste number is D003. As such, reactive constituents are present in all materials being thermally treated. Ancillary hazardous waste numbers may also be applied to military munitions items due to constituents such as lead (D008) that may be part of the explosive material formulation. These compounds are subjected to the same TTU thermal treatment process as the military munitions.

## Table 1
## Chemical Composition of Explosives

| Explosive | Chemical Formula | Primary Hazardous Waste No. | Ancillary Hazardous Waste No.[a] |
|---|---|---|---|
| Primary Explosives: | | | |
| Diazodinitrophenol (DDNP) | $C_6H_2N_4O_5$ | D003 | - |
| Lead azide | $N_6Pb$ (71% Pb) | D003 | D008 |
| Lead mononitroresorcinate (LMNR) | $C_6H_3O_2Pb$ (57.5% Pb) | D003 | D008 |
| Lead stephynate | $C_6HN_3O_8Pb$ | D003 | D008 |
| Mercury fulminate[b] | $C_2HgN_2O_2$ | D003 | P065[c], D009 |
| Potassium dinitrofuroxane (KDNBF) | $C_6H_2N_4O_6K$ | D003 | - |
| Tetracene | $C_{18}H_{12}$ | D003 | - |
| Fuels: | | | |
| Antimony sulfide | $Sb_2S_5$ | D003 | |
| Calcium silicide | $CaSi_2$ | D003 | D001 |
| Lead thiocynate | $Pb(SCN)_2$(64% Pb) | D003 | D008 |
| Oxidizers: | | | |
| Ammonium perchlorate | $NH_4ClO_4$ | D003 | - |
| Barium nitrate | $BaN_2O_6$ | D003 | D005 |
| Potassium chlorate | $KClO_3$ | D003 | - |
| Aliphatic Nitrate Esters: | | | |
| 1,1,1-Trimethylolethane trinitrate (TMETN) | $C_5H_9O_9N_3$ | D003 | - |
| 1,2,4-Butanetriol trinitrate (BTN) | $C_4H_7N_3O_9$ | D003 | |
| Diethyleneglycol dinitrate (DEGN) | $C_4H_8N_2O_7$ | D003 | - |
| Nitrocellulose | $C_{12}H_{16}(ONO_2)_4O_6$ | D003 | - |
| Nitroglycerin | $C_3H_5N_3O_9$ | D003 | P081[c] |
| Nitrostarch | $C_6H_1O_5NO_2$ | D003 | - |
| Pentaerythritol tetranitrate (PETN) | $C_5H_8N_4O_{12}$ | D003 | - |
| Triethylene glycodinitrate (TEGN) | $C_6H_{12}O_4N_2O_4$ | D003 | - |
| Nitramines: | | | |
| 2,4,6-Trinitrophenylmethylnitramine (tetryl) | $C_7H_5N_5O_5$ | D003 | - |
| Cyclotetramethylenetetranitramine (HMX) | $C_4H_8N_8O_2$ | D003 | - |
| Cyclotrimethylenetrinitramine (RDX) | $C_3H_6N_6O_6$ | D003 | - |
| Ethylenediamine dinitrate (EDDN Haleite) | $C_2H_6N_4O_4$ | D003 | - |
| Nitroguanidine | $CH_4N_4O_2$ | D003 | - |
| Nitroaromatics: | | | |
| 1,3 Diamine-2,4,6-trinitrobenzene (DATB) | $C_6H_4N_6O_6$ | D003 | - |
| 1,3,5-Triamino-2,4,5-trinitrobenzene (TATB) | $C_6H_6N_6O_6$ | D003 | - |
| 2,2′4,4′6,6′-Hexanitroazobenzene (HNAB) | $C_{12}N_8O_{12}$ | D003 | - |
| 2,4,6-Trinitrotoluene (TNT) | $C_7H_5N_3O_6$ | D003 | - |
| Hexanitrostilbenzene (HNS) | $C_{12}H_2N_6O_{12}$ | D003 | - |
| Ammonium nitrate | $NH_4NO_3$ | D003 | - |
| Black powder | $K(Na)NO_3$ | D003 | - |

**Table 1**
**(Continued)**

| Explosive | Chemical Formula | Primary Hazardous Waste No. | Ancillary Hazardous Waste No.[a] |
|---|---|---|---|
| Various compositions, including compositions A, B, and C; ednatols; octols; tertylols; pentolite; tritonal; picratol; amatol; ammonal; plastic bonded explosives (PBX); minol; torpex; high blast explosive (HBX); and dynamite (military) | Mixtures of the above chemicals | D003 | P081[c] |
| **Propellants** | | | |
| Mixtures of nitrocellulose, nitroglycerin, and nitroguanidine (designated as M-series propellants—single, double, and triple base) May also include significant quantities of ammonium perchlorate, HMX, and aluminum powder. | Varies | D003 | P081[c], D008 |
| **Pyrotechnics** | | | |
| Combinations of oxidizers, fuels, and binding agents. Typical components:<br>• Oxidizers are peroxides and perchlorates;<br>• Fuels are aluminum and magnesium; and<br>• Binding agents are resins, waxes, plastics, oils, retardants, waterproofing agents, and color intensifiers. | Varies | D003 | - |

[a]Additional EPA hazardous waste numbers may be applied if technical data indicates the munition (explosive and non-explosive components) contains hazardous constituents not listed here.
[b]Mercury is no longer used to formulate military munitions.
[c]The "P" listing is only applied if the material being treated is a pure "commercial chemical product or manufacturing chemical intermediate." It is not applied to finished munitions or propellants that contain mercury fulminate or nitroglycerin. See 40CFR 261.33 for more information.

## 2.6 Description and Classification of Military Explosives

Various approaches are employed to categorize the thousands of explosives that may potentially be treated at the TTU. Explosive compounds used in military munitions can be put into four general categories: primary explosives, booster and secondary explosives, propellants, and pyrotechnics. These categories are summarized as follows:

**Primary Explosives:** Primary explosives are used to initiate larger, less sensitive energetic components. The rate of burn for these explosives is controlled to ensure excessive pressure does not develop and that desired ballistic effects are achieved. Primary explosives are mixtures that are very sensitive to shock or friction and are a mixture of fuel, oxidizer, and explosive compounds. Typical fuels are antimony sulfide and lead thiocyanate; oxidizers include barium nitrate and potassium nitrate. The primary initiators are lead azide and lead styphnate.

**Booster and Secondary Explosives:** Booster and secondary explosives evolve large volumes of hot gas in a short time after initiation. These non-initiating explosives are too insensitive to be initiated by means of impact, friction, or brief application of heat. These explosives are primarily nitrates, nitro compounds, and nitramines. The most common high explosives are cyclotrimethylenetrinitramine (RDX), trinitrotoluene (TNT), trinitrophenylmethylnitramine (tetryl), cyclotetramethylenetetranitramine (HMX), and various combinations of these compounds. High explosive ordnance may have waxes or aluminum powder as additives.

**Propellants:** Propellants are low detonation rate explosives that generate large volumes of hot gas over a longer period of time, creating a sustained pressure used to propel objects. The propellant mixtures are typically classified as single- or double-based. Single-based propellants are composed mainly of nitrocellulose, while double-based propellants are mixtures of nitrocellulose and nitroglycerin. The primary components of propellants treated at the UTTR include ammonium perchlorate, HMX, and aluminum powder. A number of miscellaneous chemical compounds are also added to the propellant charge to control deflagration characteristics or to promote stability during storage. These additives include various nitrated organic compounds, metals, and metal salts. All components of military propellants are in solid form and contain no free liquids.

**Pyrotechnics:** Pyrotechnics generate large amounts of heat but much less gas than propellants or explosives. Pyrotechnic compositions are generally finely divided fuels such as metals, alloys, and hydrocarbons mixed with an oxidizer. Typical oxidizers consist of metal nitrates, ammonium, or metal perchlorates, chlorates, and peroxides. Secondary constituents also present in pyrotechnic mixtures are binders, ignition agents, retardants, and colorants. Typical minor components include black powder, chlorinated organics, waxes, sugar, asphalt, polyvinyl chloride, and vegetable oils.

Table 2 was developed based on these four general categories of military explosives. It summarizes the major types of explosives and lists specific explosives for each type. Also included in Table 2 are the designations used in the Munitions Items Disposition Action System (MIDAS) database known as "MIDAS families." These family designations are used to categorize munitions by usage and constituent type in the MIDAS database, one of the potential information sources for characterization of items treated at the TTU. The 34 MIDAS families are defined in Table 3. Items that are included in the IN (inert) or TA (chemical munitions) MIDAS families are not treated at the TTU.

In addition to the MIDAS family designations, the last column of Table 2 presents the constituent subfamily names developed to summarize and consolidate similar explosive compounds. These subfamilies are based primarily on their main chemical constituents and on the expected method of constituent breakdown during deflagration or detonation. For example, since Composition A and Composition C explosives are blends of nitramines (i.e., RDX) and various binders and plasticizers, they are consolidated into the constituent subfamily Nitramine Blends. In cases where primary chemical types (e.g., nitramines and nitroaromatics) are blended to create boosters or explosives, a subfamily was created to represent this binary or ternary composition. In the case of military pyrotechnics, energetics high in particulate loading were divided into two constituent families, one representing energetics that typically burn due to oxidation, and a second representing energetics that typically detonate after initiation by an initiating charge (primary explosive) or that demonstrate almost instantaneous deflagration followed by detonation (e.g., photoflash cartridges).

Based on this type of consolidation, 18 subfamilies were created to describe all munitions used by the military and potentially treated at the TTU. A list of constituent subfamilies and their descriptions is found in Table 4.

Finally, munitions may be categorized by their Department of Transportation explosive hazard division (49 CFR 173.50). These divisions are listed in Table 5. This classification is the primary indicator of whether an item will be treated by open detonation or open burning at the TTU.

By utilizing the various categorization strategies that have been described, in conjunction with manufacturer and DoD information sources, TTU operators can make decisions about item safety and treatment methodologies. This information is also used to understand potential chemical emissions and make decisions about what analytes should be included in environmental sampling and analysis plans including the Waste Analysis Plan for Residue and Ash (Attachment 3) and the Surface Water, Soil, and Groundwater Sampling and Analysis Plans (Attachments 9A, 9B, and 15 respectively).

## Table 2

## Military Explosive Compositions and Classifications

| Explosive Types | Description | Example Compounds | MIDAS Family | Constituent Subfamily |
|---|---|---|---|---|
| **Primary Explosives** | | | | |
| Lead azide | Salt of hydrazoic acid (initiator) | Lead azide | HZ, SC, SF | Primary explosives compounds:<br>• Mercury fulminate<br>• Lead azide<br>• DDNP<br>• Lead stephynate<br>• Tetracene<br>• Lead thiocynate |
| Mercury fulminate | Salt of a fulminic or paracyanic acid, used as initiator | | | |
| DDNP | DADNP, used as initiator | DDNP | | |
| Lead stephynate | Anhydrous salt, used as primer | Lead stephynate | HA, HZ, SC, SF | |
| Tetracene | Intermediate booster and primer (rare) | Tetracene | HA | |
| Primary compositions | Initiators for HE, propellants, and pyrotechnics | Consists of combinations of:<br>• Lead stephynate<br>• Tetracene<br>• Barium nitrate<br>• Antimony sulfide<br>• Aluminum<br>• Lead thiocynate<br>• Potassium chlorate | HA, SC, SF | |
| **Booster and Secondary Explosives** | | | | |
| Nitramines | N-type nitration where nitrogroup is attached to a nitrogen atom being nitrated | HMX, RDX, EDDN (Haleite), tetryl (pyrolite, tetralite) | HA, HC, HE, HI, HP, HR, HT, HX, HZ, LR, SA, SF | Nitramines |
| Nitroaromatics | C-types nitration where nitrogroup is attached to a carbon atom being nitrated | TATB, TNT | HB, HC, HE, HG, HR, HT, HX, HZ, LR | Nitroaromatics |
| Aliphatic nitrate esters | O-type nitration where nitrogroup is attached to an oxygen atom being nitrated | BTN, nitrocellulose (NC), nitroglycerin (NG), PETN, TEGN, TMETN, and DEGN | HR, HX, PB, PD, SC, SF | Aliphatic nitrate esters |
| Binary compositions | Composition C | RDX/plasticizer | HE, HX | Nitramine blend |
| | Composition A | RDX/desensitizer | HE, HI | |
| | Composition B | RDX/TNT (60/40)<br>Others called Cyclotols | HE, HG, HP, HR, HX, HZ, LR, SA, SF | Nitroaromatic and nitramines blend |
| | Ednatols | Haleite/TNT | | |
| | Octols | HMX/TNT | HR, LR | |

## Table 2

## (Continued)

| Explosive Types | Description | Example Compounds | MIDAS Family | Constituent Subfamily |
|---|---|---|---|---|
| **Booster and Secondary Explosives (cont.)** | | | | |
| Binary compositions (cont.) | Tetrytols | TNT/Tetryl | HX | Nitroaromatic and nitramines blend |
| | Pentolite | PETN/TNT | PD | Aliphatic nitrate ester and Nitroaromatic blend |
| | Tritonal | TNT/flaked aluminum | HB | Nitroaromatic blends |
| | Picratol | Ammonium pictrate/TNT | HD | |
| | Amatol | Ammonium nitrate/TNT | | Ammonium nitrate blend |
| | Ammonal | Ammonium nitrate/aluminum with TNT/DNT/RDX mixture | | |
| Plastic bonded explosives | Water gel/slurry explosives | Water gel/slurry explosives | | |
| Ternary compositions | Minol | Ammonium nitrate/TNT/aluminum | | |
| | Anatex | Ammonium nitrate/TNT/RDX | | |
| | DBX (depth charges) | Ammonium nitrate/TNT/RDX | HH | |
| | High Blast Explosive (HBX) | RDX/TNT/Aluminum | HB, HD | Nitroaromatic and nitramines blend |
| | Torpex | RDX/TNT/Aluminum powder | | |
| | PBX | >% RDX/HMX/PETN with polymeric binder | HE, HR, HT, LR | Aliphatic nitrate ester and nitramine blends |
| Quaternary compositions | Dynamite | Dynamite | | |
| Industrial explosives | Mixtures of NC/NG/NQ to achieve ballistic requirements | M-series, including:<br>• single-base<br>• double-base<br>• triple-base<br>• composite<br>• ball (modified double-base) | Not applicable | Single base, double base, triple base propellants |

**Table 2**

**(Continued)**

| Explosive Types | Description | Example Compounds | MIDAS Family | Constituent Subfamily |
|---|---|---|---|---|
| **Propellants** | | | | |
| Propellants | Mixtures of NC/NG/NQ to achieve ballistic requirements. May also include significant quantities of ammonium perchlorate, HMX, and aluminum powder. | M-series, including:<br>• single-base<br>• double-base<br>• triple-base<br>• composite<br>• ball (modified double base) | Single base<br>HI, PB, PC, SA<br>Double base<br>PB, PC, PD, SA<br>Triple base<br>PB, PC, SA, SC | Single base, double base, triple base propellants |
| **Pyrotechnics** | | | | |
| Delays and fuzes | Delays and fuzes | Mixtures of oxidants and powered metals | SF | High particulate loading (explosive) or high particulate loading (burning) |
| Incendiaries | Incendiaries | Thermite (aluminum and rust), Phosphorous, Napalm, Bombs with magnesium casing | SF | |
| Photoflash | Photoflash compositions | Mixture containing:<br>• Aluminum or magnesium (fuel)<br>• Barium nitrate or potassium perchlorate (oxidizer) | FP | High particulate loading (explosive) |
| Colored and white smoke | Explosive dissemination type (dispersed with bursting charge to create hydrolysis) | Mixtures of sulfur trioxide, chlorosulfonic acid | CS | |
| | Venturi thermal generator (slow burning smoke) | Ammonium nitrate or ammonium chloride mixed with fuel | FI, FP | Ammonium nitrate blend |
| | Burning type | White phosphorous<br>Red phosphorous (signal) | CP, CS | High particulate loading (burning) |
| Tracers and fumers | Tracers and fumers | Contain mixtures of:<br>• Strontium peroxide<br>• Magnesium<br>• Potassium perchlorate (oxidizer), etc. | SA | High particulate loading (burning) |

**Table 2**

**(Continued)**

| Explosive Types | Description | Example Compounds | MIDAS Family | Constituent Subfamily |
|---|---|---|---|---|
| **(Pyrotechnics (cont.)** | | | | |
| Flares and signals | Thermal radiation from the product oxide particles and the spectral emission from excited metals | Consist of:<br>• Sodium nitrate (oxidant)<br>• Magnesium<br>• Aluminum (fuel at times)<br>• Binder | CP, CR, CS, FP | High particulate loading (burning) |
| Ignitors and initiators | Ignitors and initiators (between primary ignitor and main charge) | Black powder<br>Ignition mixtures containing:<br>• Aluminum<br>• Barium chromate<br>• Laminac<br>• Magnesium<br>• Others | Black Powder<br>FP, I, PD, SC<br><br>Ignition mixtures<br>PD, SC, SF | Black powder<br>Ignition mixtures |

**Table 3**
**MIDAS Families**

| Family | Description |
|---|---|
| AT | Armor Tile (Reactive) |
| CD | Munitions Containing Dyes |
| CH | Munitions Containing Hexachloroethane (Smoke) |
| CP | White Phosphorous Containing Ammunition |
| CR | Riot Control Munitions |
| CS | Smoke-Producing Munitions (not including those that contain white or red phosphorous or hexachloroethane) |
| DU | Ammunition Items Using Depleted Uranium |
| FI | Incendiary/Thermite |
| FP | Pyrotechnics/Illumination/Nonfrag/Tracers |
| HA | HE Components (detonators, boosters, or bursting charges) |
| HB | HE Bombs |
| HC | HE Cartridges |
| HD | High Explosive "D" (ammonium picrate) |
| HE | Bulk High Explosives (TNT, Compostion A, Composition B, Composition C-4, PBX, RDX) |
| HG | HE Grenades HE |
| HH | HE Depth Charges and Underwater Munitions |
| HI | HE ICM/CBU & Submunitions |
| HM | Missiles |
| HP | HE Projectiles and Warheads |
| HR | HE Rockets |
| HT | Torpedoes |
| HX | Demolition Material |
| HZ | HE Land Mines |
| IN | Inert Items |
| LR | Large Rocket Motors (solid propellant ICBM, SLBM, or space launch booster motors) not including tactical rocket or missile motors or anti-ballistic missile systems |
| NN | No Family (ammunition and components that cannot be identified) |
| PB | Bulk Propellant |
| PC | Propellant Charges & Increments |
| PD | Propellant Munitions/Components |
| SA | Small Caliber Ammunition |
| SB | Sonobouys |
| SC | Incinerable Munitions and Components (items typically assigned to hazard classes 1.3 and 1.4 that do not fit into any other family) |
| SF | Fuzes |
| TA | Chemical Muntions (containing GB, VX, Mustard etc.) |

**Table 4**

**Constituent Subfamilies**

| Constituent Subfamily | Constituent Subfamily Description | Typical Energetics within the Constituent Subfamily | Applicable MIDAS Family |
|---|---|---|---|
| Primary explosives compounds | Low detonation rate explosives based on lead, mercury, and similar heavy metals. Power is generated by the release of electrons from crystal imperfections during ignition. The rate of burn is controlled to ensure that excessive pressure does not develop. Crystal imperfections serve as shallow electron traps and release electrons during conduction both at elevated temperature (thermal excitation) and through intense flame reaction (photoexcitation). | Mercury fulminate<br>Lead azide<br>DDNP<br>Lead stephynate<br>Tetracene<br>Lead thiocynate | HA, HZ, SC, SF |
| Nitramines | Compounds prepared by N-type nitration where a nitrogroup is attached to a nitrogen atom of the compound being nitrated. These cyclic nitramines are used in explosives and propellants as an energetic source of gases. | HMX<br>RDX<br>EDDN (Haleite)<br>Tetryl (pryolite, tetralite) | HA, HC, HE, HI, HP, HR, HT, HX, HZ, LR, SA, SF |
| Nitroaromatics | Nitroaromatics are compounds prepared by C-type nitration in which a nitrogroup is attached to a nitrogen atom of the compound being nitrated. | TATB<br>TNT | HB, HC, HE, HG, HR, HT, HX, HZ, LR |
| Aliphatic nitrate esters | Compounds prepared by O-type nitration where nitrogroup is attached to a nitrogen atom of the compound being nitrated. These organic-based explosives are fast burning and generate large amounts of gas by-products. | BTN<br>Nitrocellulose (NC)<br>Nitroglycerin (NG)<br>PETN<br>TEGN<br>TMETN<br>DEGN | HR, HX, PB, PD, SC, SF |
| Nitramine blends | Nitramine blends consist of the nitramine mixed with plasticizers (Composition C) or desensitizers (Composition A) to create explosives that are less sensitive, demonstrate better workability, and detonate at a lower rate than a pure nitramine. | Composition A<br>Composition C | HE, HX, HI |
| Nitroaromatic and nitramine blends | Nitroaromatic/nitramine blends create a nitrogen-rich atmosphere and generate very large blast effects. They have readily available supplies of oxygen and nitrogen and are capable of producing a higher presence than a pure version of either compound. The blends are generally less sensitive than either a pure nitroaromatic or nitramine and are used primarily in fuzes and high explosive cartridges. | Composition B<br>Ednatols<br>Octols<br>Tetrytols<br>HBX<br>Torpex<br>Minol | HB, HD |

**Table 4**

**(Continued)**

| Constituent Subfamily | Constituent Subfamily Description | Typical Energetics within the Constituent Subfamily | Applicable MIDAS Family |
|---|---|---|---|
| Aliphatic nitrate ester and nitroaromatic blends | Blends of the aliphatic nitrate ester (e.g., PETN) with the nitroaromatic (e.g., TNT) create a high explosive with an increased blast strength, fragmentation strength, and heat of combustion and provide more charge weight per volume than pure TNT. These blends are primarily used in detonators and boosters requiring high detonation rates and are melt-loaded. | Pentolite | PD |
| Aliphatic nitrate ester and nitramine blends | Aliphatic nitrate ester/nitramine blends consist of a thermosetting plastic binder (e.g., polyurethane) filled with powered explosives, oxidants, and nitramine fuels (e.g., RDX or ammonium perchlorate). Oxidant fuels, (e.g. powered aluminum) are not commonly added since the inherent properties of the nitramine usually meet the requirements for the explosives. They are primarily used in fuzes and HE cartridges. | PBX | HE, HR, HT, LR |
| Nitroaromatic blends | Nitroaromatic blends consist of the nitroaromatic used with aluminum flakes or aluminum pictrate to create explosives that are less sensitive than TNT, capable of being cast, and detonate at approximately the same rate as a pure nitroaromatic. The optimum percentage of aluminum is between 18% and 20%. | Picratol<br>Tritonal | HB, HD |
| Ammonium nitrate (AN) blends | Ammonium nitrate, the primary inorganic high explosive, reacts with the TNT creating a larger exothermic reaction and resulting in higher heat generation, greater expansion of gases, and greater blast effect.<br><br>Incorporation of aluminum to ammonium nitrate/TNT mixtures causes:<br>• Increased sensitivity to impact, friction, and rifle bullet impact.<br>• Increased temperatures of detonation (1700°C to 3900°C).<br>• Increased power up to 20%.<br>• Increased total volume of gas evolved during detonation (sometimes).<br>• Decreased detonation velocity and brisance.<br><br>In fuel-air bombs, the ammonium nitrate increases the heat of detonation by almost three-fold. | Amatol (TNT/AN)<br>Ammonal (TNT/AN/aluminum)<br>Water gel/slurry explosives<br>Minol (TNT/AN/aluminum)<br>Anatex (TNT/RDX/AN)<br>DBX (TNT/AN/aluminum)<br>Fuel-air bombs (AN/fuel oil) | HH |

**Table 4**

**(Continued)**

| Constituent Subfamily | Constituent Subfamily Description | Typical Energetics within the Constituent Subfamily | Applicable MIDAS Family |
|---|---|---|---|
| Single-base propellant | Nitrocellulose is the principle energetic in single-base propellants. The propellants are characterized by a low flame temperature and low energy content. Except in rare cases, nitroglycerin and other explosives are not found in these propellants. | M-series propellants (M1, M6, M10, and IMR) | HI, PB, PC, SA |
| Double-base propellant | Nitrocellulose is gelantized by nitroglycerin in double-base propellants. This results in higher energetic strength and increased ballistic potential and flame temperature. Other aliphatic nitrate esters may be used (e.g., DEGN); however, this is uncommon. In double-base propellants, the nitroglycerin acts as a strong oxygen source.<br><br>Ball propellants have a deterrent coating (e.g., dibutylphthalate) to reduce the burn rate of the propellant. | Ball propellants<br>M-series propellants (M2, M5, M8, and M18) | PB, PC, PD, SA |
| Triple-base propellant | Nitroguanidine, as a nitrogen source, is added to the nitroglycerin and nitrocellulose in triple-base propellants. This result is increased energy content without raised flame temperature and substantially reduced concentrations of combustibles (hydrogen and carbon monoxide) in the product gas. | M-series propellants (M30 and M31) | PB, PC, SA, SC |
| Composite propellant | Composite propellants are suspensions of crystalline oxidizers (e.g., ammonium or potassium perchlorate) and metallic fuels in a resin binder. The oxidizers are a dense oxygen source and contribute the most to the burning characteristics of composite propellants. Numerous cross-linking chemicals are used as binders, catalysts, and as processing aids. | Rocket motors | |
| High particulate loading (burning) | Incendiaries are characterized by high heats of oxidation, components metals in the sodium spectrum, and the ratio of oxide to metal volume greater than one. Illumination and signal devices are a result of thermal radiation generated by oxidation of excited metals. Sodium nitrate is usually used as the oxidant due to its sensitivity to the human eye. The only exception is in infrared devices, which use constituents that peak in the infrared spectrum rather than the sodium spectrum. | Tracers and fumers<br>Smokes with phosphorous compounds, zinc chloride, or metallic phosphides<br>Smokes with ammonium nitrate/chloride and oil<br>Incendiaries, flares, and signals<br>Napalm<br>Delays | CP, CR, CS, FP, SA |

**Table 4**

**(Continued)**

| Constituent Subfamily | Constituent Family Description | Typical Energetics within the Constituent Family | Applicable MIDAS Family |
|---|---|---|---|
| High particulate loading (explosive) | Explosives that are pulverized/atomized and then vaporized or where a preground solid is dispersed by the explosion of a bursting charge. Photoflash and thermite munitions are included since detonation occurs almost instantaneously after initiation and deflagration. | Smokes with metallic chlorides<br>Thermite<br>Photoflash<br>Fuzes | SF, FP |
| Black powder | A low order detonation agent used primarily as an initiator for artillery propellant charges and for blank small arms ammunition. Compositions consist of three formulations using varying percentages of potassium nitrate, sodium nitrate, charcoal, coal, and sulfur. | Blanks<br>Ignitors (artillery) | FP, I, PD, SC |
| Ignition mixtures | 17 formulations consisting of an oxidizer (e.g., barium peroxide or potassium perchlorate) or heavy metal (e.g., zirconium) combined with binders (e.g., sugar and charcoal). Accelerators (e.g., powered aluminum) may be used to quicken initiation. | First fire, ignition or starters (intermediates between the primary ignitor and main charge) | PD, SC, SF |

**Table 5**

**Department of Transportation Explosive Hazard Class Divisions**

| Class 1 Explosive Division | Description (49 CFR 173.50) |
|---|---|
| **Division 1.1** | Explosives that have a mass explosion hazard, i.e. a mass explosion affects almost the entire load instantaneously. |
| **Division 1.2** | Explosives that have a projection hazard but not a mass explosion hazard. |
| **Division 1.3** | Explosives that have a fire hazard and either a minor blast hazard or minor projection hazard or both, but not a mass explosion hazard. |
| **Division 1.4** | Explosives that present minor explosion hazard. The explosive effects are largely confined to the package and no projection or fragments of appreciable size or range are expected. An external fire must not cause virtually instantaneous explosion of almost the entire contents of the package. |
| **Division 1.5** | Very insensitive explosives that have a mass explosion hazard but are so insensitive that there is little probability of initiation or of transition from burning to detonation under normal conditions of transport. |
| **Division 1.6** | Extremely insensitive articles that do not have a mass explosive hazard and that contain only extremely insensitive detonating substances and demonstrate a negligible probability of accidental initiation or propagation. |

## 2.7 Characterization of Past Waste Treatment

The TTU facility is permitted for the treatment of a wide variety of energetic materials as described in Section 2. However over the last 20 years, the primary focus at the facility has been the treatment of large solid fuel rocket motors. Treatment of large rocket motors began in the early 1990s with the Poseidon C-3 missile motors. With the completion of the C-3 treatment program, treatment activities at the TTU over the past decade have focused on the Trident C-4 and D-5, Titan, and Minuteman motors. Future treatment operations are likely to continue to focus on large rocket motors including the Trident II or D-5 motor and Minuteman III motors. Treatment statistics from 2002 to 2022 are shown in Figure 1. Figure 2 shows the annual total mass (net explosive weight) of all items treated from 2002 to 2022.

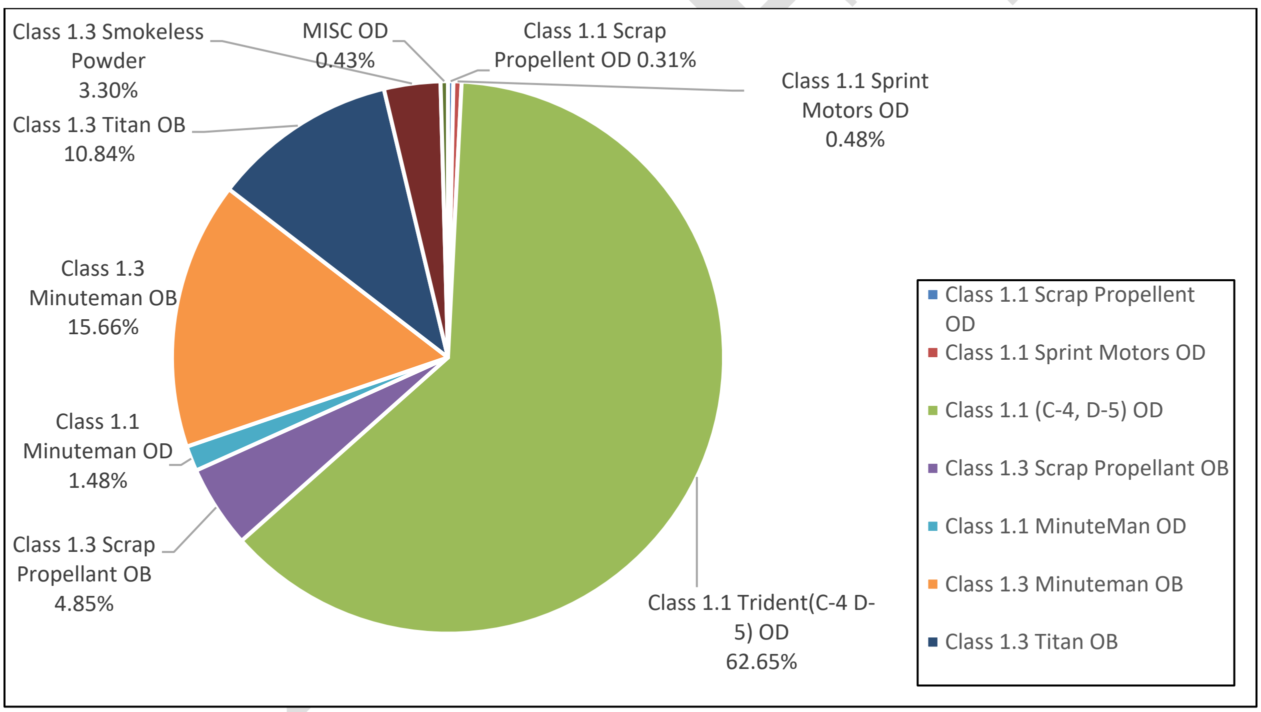


**Figure 1. Items treated at the Thermal Treatment Unit from 2002 to 2022. Total mass of items treated during this period was 28,246,121 pounds.**

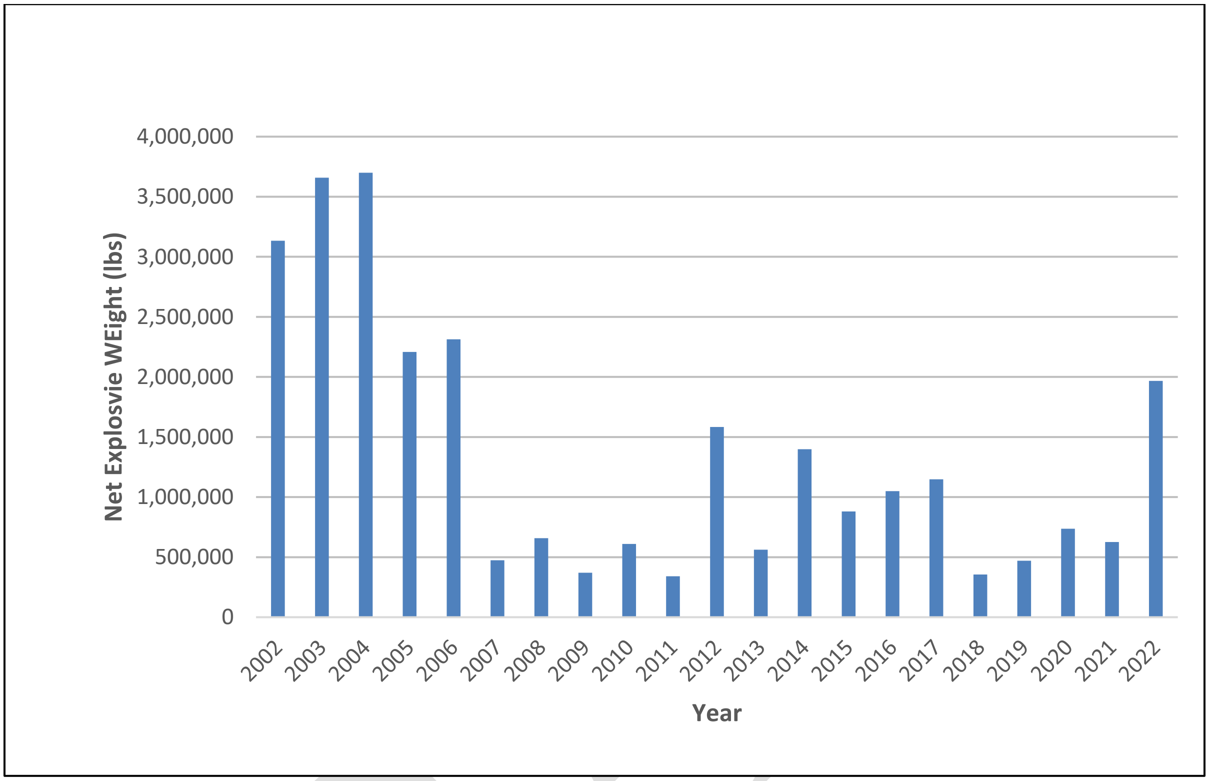


**Figure 2. Total annual net explosive weight of items treated at the Thermal Treatment Unit from 2002 to 2022. Total mass of items treated during this period was 28,246,121 pounds.**

## 3.0 Waste Analysis Plan [R315-264-13(b) and (c) and R315-270-14(b)(3)]

The UTTR-North TTU both treats waste and may generate waste as a result of the treatment process. The description of how these wastes are characterized before treatment, storage, or disposal activities are carried out is contained in the Waste Analysis Plan for Residue and Ash (Attachment 3).