

# DETONATION GROUND SOILS, & EXPLOSIVE-CONTAMINATED METAL HAVE NO REACTIVITY CHARACTERISTIC UNDER RCRA HAZARDOUS WASTE REGULATIONS

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## ABSTRACT

Explosive reactivity tests conducted on soils prove that the soils are unreactive even with up to 20% explosives added, and do not exhibit the "reactivity characteristic" as defined by the Environmental Protection Agency (EPA), for regulated hazardous wastes.<sup>6,7,8</sup> Behaviour of various types of soil is discussed. The official EPA approved method for determining explosive reactivity is described, of more than twenty methods commonly used to measure explosive sensitivity.

It is also important to know whether metal pieces, such as downloaded projectile casings, shrapnel, and equipment have acquired the "reactivity characteristic" from small amounts of contaminating explosives attached to them. Metal pieces coated with up to 2.2 grams of high explosive per pound of metal tested unreactive.<sup>6</sup>

Downloaded casings, shrapnel, and soil from detonation grounds, which have slight explosive contamination, and which are set to be discarded are thus not to be classed as hazardous waste by virtue of explosive reactivity under EPA regulations.

## CATEGORIES OF HAZARDOUS WASTE

A material is not a hazardous waste if it is not a waste to begin with. The Resource Conservation and Recovery Act (RCRA) defines the general category of "waste" as "solid waste," even if it is other than solid, 40 CFR<sup>1</sup> Part 261.2. "Hazardous waste" is then defined as a solid waste which also has any of certain types of defined hazardous features, 40 CFR 261.3.

### LISTED HAZARDOUS WASTES

**Wastes with non-specific sources** make up the F-List of hazardous wastes, 40 CFR 261.31. Spent solvents and waste waters are included, which originate from the manufacture and assembly of munitions.

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26th DOD Explosives Safety Seminar, 16-18 Aug 1994, Doral Resort, Miami, Florida.

**Wastes with specific sources** make up the K-List of hazardous wastes, 40 CFR 261.32. These include K044 sludges from explosive manufacturing, K045 carbon from treatment of wastewater containing explosives, K046 sludges from lead-based explosive initiating compounds, and K047 pink water and red water from TNT operations. The main hazard from K044, K045 and K047 is explosive reactivity, whereas the main hazard from K046 is toxicity.

**Discarded commercial products** make up the P-List of acute hazardous wastes and the U-List of non-acute hazardous wastes, 40 CFR 261.33. A few of these are reactive explosives, but most are listed because of toxicity. They include many chemicals used in munitions, such as P009 ammonium picrate (Explosive D), P033 cyanogen chloride, P065 mercury fulminate, P081 nitroglycerin, P095 phosgene, P105 sodium azide, U002 acetone, U234 trinitrobenzene, U044 chloroform, U069 dibutyl phthalate, U088 diethyl phthalate, U226 & 227 trichloroethanes, U098 1,1-dimethylhydrazine, several other hydrazines, U105 2,4-dinitrotoluene, U106 2,6-dinitrotoluene, U154 methanol, U159 methyl ethyl ketone (MEK), U161 methyl isobutyl ketone (MIBK), pentachlorophenol (part of F027 polychlorophenols). The P- and U-Lists include many other chemicals used in munitions or in the manufacturing of munitions.

#### CHARACTERISTIC HAZARDOUS WASTES

**Any ignitability, corrosivity, reactivity or toxicity characteristic** of a waste automatically classifies it as a hazardous waste. Definitions and test procedures are given for most characteristic hazardous wastes in Subpart C, 40 CFR 261.20 to 261.24. The Toxic Characteristic Leaching Procedure (TCLP) test is one of the most important tests for munition wastes, as heavy metals present often increase disposal costs.

If toxic components leach out in the TCLP test at greater than certain allowed concentrations the item is defined as a hazardous waste by virtue of toxicity. Munition components often contain lead, barium, chromium, cadmium, silver, and 2,4-dinitrotoluene, which are in the TCLP list. Munitions have cadmium in brazing welds brazing flux, silver solder, paints, and anti-rust coatings, usually with no mention in the military records that cadmium is present. Cadmium, lead and their oxides are volatile enough to be deposited in the flue ducts and baghouse during incineration. Open burning and detonation (OBOD) residues often contain toxic metals from munitions.

**APPENDIX VIII** of 40 CFR 261 lists Principal Hazardous Constituents. The regulators may declare a waste to be hazardous if the waste contains anything on this list. APPENDIX VIII lists many chemicals commonly used in munitions, most of which are listed because of toxicity, such the toxic metals, diphenylamine, dibutyl phthalate, dinitrotoluenes, nitroglycerin, sulfur mustard, and nitrogen mustards. The treatment of such hazardous wastes

by incineration has specific requirements given in 40 CFR Subpart O of Parts 264 and 265 for feedstocks which contain ingredients listed in APPENDIX VIII. The treatment must achieve a destruction and removal efficiency (DRE) of 99.99% or better for most such ingredients, and 99.9999% for dioxin types.

## **EXPLOSIVE REACTIVITY**

### **DEFINITION OF EXPLOSIVE REACTIVITY**

**Explosive reactivity characteristic** accounts for three of the eight categories of reactivity characteristic, 40 CFR 261.23(a)(6,7,8). Paragraph (6) is reactivity as a result of a strong initiating force or heating under pressure. Paragraph (7) refers to capability of explosion at standard temperature and pressure. Paragraph (8) states that a waste which is a Class A or Class B explosive is a hazardous waste. Some state regulators make a gross misinterpretation of paragraph (8), by maintaining it also means that a waste with traces of Class A or Class B explosive is a hazardous waste.<sup>2</sup> This unfortunate error and others like it have led to serious illegal hindrance of military operations by regulators. The main reason for the experiments reported here is to refute that error. Waste with traces of explosive are properly judged by paragraph (6), for which EPA has made an exact recipe available, as described in the Bureau of Mines headings below.

The RCRA reference in 40 CFR 261.23(a)(8) is outdated by several years. It refers to "Class A explosive as defined in 49 CFR 173.53," and "Class B explosive as defined in 49 CFR 173.88." Yet these paragraphs in the U.S. Transportation Code were changed several years ago to correspond to new universal designations of hazard class for explosives, and there is no such thing anymore as Class A and Class B. Class A formerly referred to detonating explosives, which are approximately represented now by hazard class 1.1. Class B explosives formerly referred to non-detonating deflagrating explosives such as propellants, which are now mostly represented by hazard class 1.3. These are not defined by Parts 173.53 and 173.88 in the current 49 CFR, but rather by Part 173.50.

**The U.S. Bureau of Mines** was asked by EPA to examine 2 dozen known explosive sensitivity tests of the railroad, military and mining industries, to choose a method for determination of explosive reactivity under RCRA. EPA made the request because no method was given in the regulations to judge explosive reactivity, whereas explicit definitions or tests were given for determination of most characteristic hazardous wastes. Methods in common use to determine explosive sensitivity include weight impact, friction, spark, detonation of a donor charge, and other methods. The Bureau of Mines chose a combination of tests using zero-gap propagation from a donor charge, and internal ignition by electric spark, to correspond to the EPA wording of 40 CFR 261.23(a) paragraph (6) for initiation by a strong force or by heat with confinement, and paragraph (7) for capability to explode at standard temperature and pressure.<sup>3</sup>

## CRITERIA FOR JUDGMENT THAT A SAMPLE HAS EXPLOSIVE REACTIVITY

There are materials that explode from a strong initiating force but not from heat with confinement, and vice versa. Therefore a sample has explosive reactivity characteristic if it is caused to explode from either a strong initiating force (zero-gap test below), or from heat with confinement (the internal ignition test below) or both.

**FIGURE 1., FIGURE 2., AND FIGURE 3.**

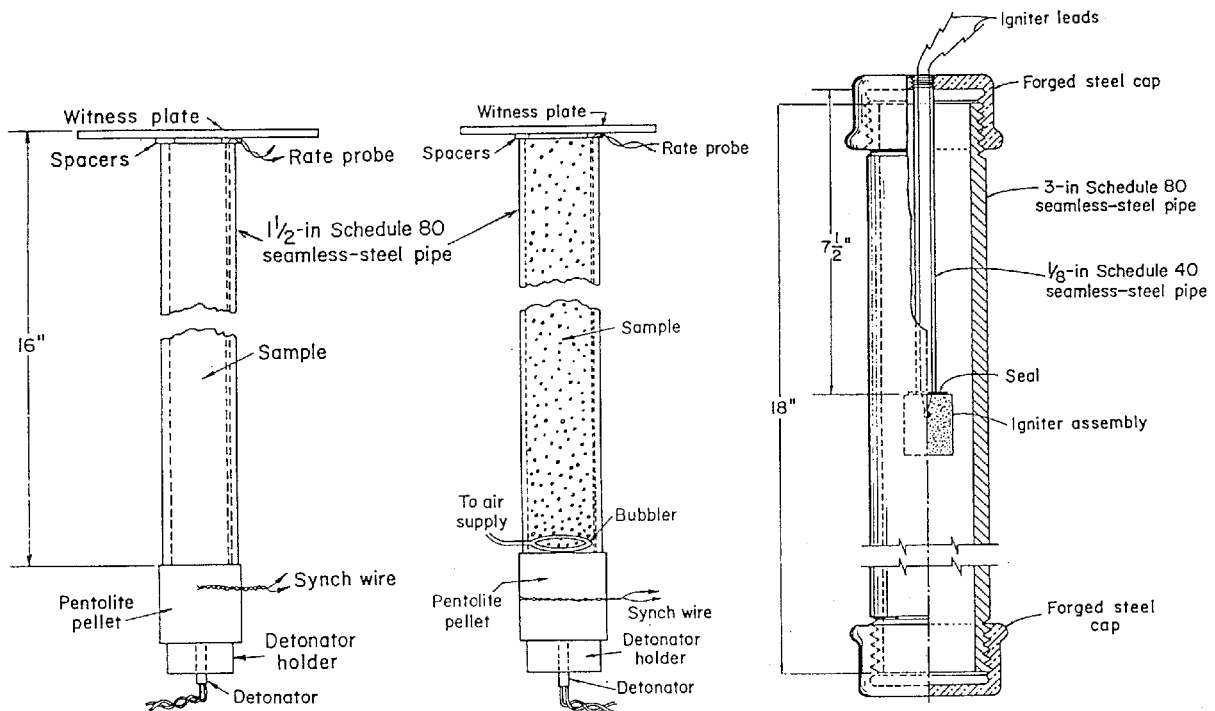


Figure 1.—Bureau of Mines' gap test for solids.

Figure 2.—Bureau of Mines' gap test for liquids.

Figure 3.—Bureau of Mines' internal ignition test.

## DETAILS OF THE BUREAU OF MINES TEST FOR EXPLOSIVE SENSITIVITY

Three vessel types (Fig. 1, 2, 3) are approved for tests,<sup>3</sup> volume 425 ml for zero-gap tests of solids and liquids, 1950 ml for internal ignition. For TEAD tests each vessel is mounted 30 cm above the soil, taped to a 2-cm diameter, 1-m tall pipe.

## ZERO-GAP TEST

**Zero-gap sample vessels** are 16-inch long, 1.5-inch diameter, schedule 80 black seamless steel pipe, with a detonation velocity probe mounted against the inner wall. A 6 x 6 x 0.125-inch mild steel witness plate is laid on top of the sample pipe, held 0.062 inch away with spacers placed at the edge of the pipe. The bottom of the pipe is closed with two layers of 0.003-inch thick polyethylene sheet held in place with rubber bands and PVC electrical tape. At TEAD the booster is made from two 82-g pentolite pellets, 2.0 inches in diameter and each 1.0 inch thick, density  $1.6 \pm 0.05 \text{ g/cm}^3$ , with a No.8 strength electric detonator between them, all taped tightly ("zero-gap") to the bottom of the sample pipe. Samples are filled to the top of the pipe. Solids are tamped by tapping the side of the pipe with wood until no further settling is noted. The pipe for liquid samples is equipped with a means to inject air bubbles at the bottom at a rate of 1.2 L/min, to increase explosive sensitivity, and match real-world industrial conditions, which often impart bubbles. See Figures 1. and 2.

**The continuous velocity of detonation probe**<sup>4</sup> mounted against the inner wall of the sample pipe is made of thin aluminum tubing, with an axial resistance wire which has 7.62 ohms/inch and is insulated with varnish. The probe tube is crimped against the inner resistance wire at the bottom end, which is imbedded in the pentolite. If the sample detonates when initiated by the pentolite booster, the velocity probe wall is crushed against the inner wire as the shock wave moves up the sample pipe, breaking the insulation to make electrical connection, and decreasing the resistance as the effective length shortens. A constant electrical current of 0.06 A is made to flow between the outer and inner conductors of the velocity probe, and the voltage between them is plotted against time on an oscilloscope. The slope of the tracing is proportional to the velocity of the shock wave.

**Explosive reactivity** is indicated by the following criteria. The test is run in triplicate. All tests must show: 1) the sample tube fragmented along its entire length, 2) a hole punched in the witness plate, and 3) a propagation velocity greater than 4900 ft/s. Absence of any one of these conditions indicates lack of reactivity.

## INTERNAL IGNITION TEST

**Sample vessels** are 18-inch long, 3-inch diameter, schedule 80 carbon-steel pipes with 2.9-inch ID, 0.30-inch wall thickness and 3000-lb forged steel threaded end caps. An igniter capsule filled with 0.7 oz (20 g) of black powder is imbedded in the center of the sample. The capsule is a 0.81-inch diameter, 2.5-inch long cylinder, made from 0.01-inch thick cellulose acetate sheet held together with two layers of nylon-filament-reinforced cellulose acetate tape. A 0.343-ohm resistance heater made of a looped 1-inch long, 0.02-inch diameter nickel-chromium wire is imbedded within the black powder. Insulated 0.026-inch diameter lead wires for the igniter are channeled out through a 0.125-inch schedule 40 seamless steel pipe attached to one of the end caps. The igniter is fired by a 15-A current from a 20-V transformer. See Figure 3.

**Explosive reactivity** is indicated by triplicate runs at  $25 \pm 3$  °C all of which result in fragmentation of the pipe or at least one end cap into two or more distinct pieces. Results are considered to be negative if the pipe is only split or laid open, or if the pipe or caps are distorted to the point that the caps are blown off.

## TEST ARRANGEMENTS

### SAMPLE PREPARATION

Soil samples were taken from the most used detonation pits at TEAD North (NA) and at TEAD South (SA), and from surface soil at TEAD SA between pits. Shrapnel from projectile casings was gathered from the surface at the SA OBOD site. Soil samples and metal pieces were assayed for presence of common explosives. Samples were tested for reactivity as found, and with various amounts of 1:1 TNT/RDX explosive added. Metal samples were coated with TNT/RDX in solution which was then allowed to dry hard. PROJECT SOP

Handling of explosives and munitions in the U.S. Military is governed by very strict regulations, which provide control of safety, health and environmental risks. TEAD offices of Safety, Industrial Health, Environmental Management, Surveillance, and Ammunition Operations all have input to the terms of the Standing Operating Procedure (SOP) for any project in which munitions or explosives are involved, and they all approve the final SOP. Stepwise descriptions of each operation are given with specifications for equipment and protective clothing, etc. In this project the transfer of black powder, TNT, RDX, pentolite pellets, and initiating caps from storage to the test area, and transfer of the unused portions back to storage is documented with official forms to account for the total amount. Handling and experimental operations are described in 6 operation steps in the SOP.<sup>5</sup>

## QUANTITATIVE ANALYSIS OF EXPLOSIVE CONTENT OF SAMPLES

### EXPLOSIVE LEVELS IN THE SOILS AND METAL AS SAMPLED

**Analytical chemical procedures** used were approved by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) at Aberdeen Proving Ground, MD (APG). That agency has since been incorporated into a new organization, the U.S. Army Environmental Center. These procedures involve such tools as high performance liquid chromatography (HPLC) with ultraviolet (UV) detector, nitrate analysis by auto analyzer, mass spectroscopy and specific colorimetry. The abbreviated explosive names are listed in Table 1. in the order 1,3-dinitrobenzene, 2,4-dinitrotoluene, 2-amino-4,6-dinitrotoluene, 2,6-dinitrotoluene, cyclotetramethylenetetranitramine, nitrobenzene, nitroglycerin, pentaerythritol tetranitrate, cyclotrimethylene-trinitramine, tetryl (2,4,6,N-tetranitro-N-methylaniline), 1,3,5-trinitrobenzene, 2,4,6-trinitrotoluene. Analyses were conducted by American West Analytical

Laboratories. The levels of contamination were within the range of a few dozen parts per million (ppm) by weight, as shown in the following chart. ND means none detected at the detection level of 0.10 ppm.

**HPLC conditions** were developed independently by both USATHAMA and TEAD: reversed phase column (non-polar stationary phase), with combinations of acetonitrile, tetrahydrofuran, methanol, and water for the mobile phase, and changes of the UV detector wavelength at certain points in the elution in order to separate peaks that would otherwise be superimposed. Most USATHAMA approved methods for quantitative explosive analysis are now incorporated into EPA method 8330.

**Cold Regions Research & Engineering Laboratory (CRREL)** Hanover, New Hampshire 03755-1290 has published results of many experiments to improve extraction and analysis of explosives, especially from soils and other matrices in which the explosives are bound up tightly. Thomas F. Jenkins and co-workers at CRREL continue to publish reports which improve the standards for explosive analysis, and any agency which has a need to stay aware of the best standards would be well advised to get on their mailing list.

**Good methods do not require total extraction of explosives from the sample** if the method is reproducible and has narrow enough variance for a correction factor to be accurate. Aromatic nitro compounds such as TNT, and aliphatic nitro compounds such as nitroguanidine and some of the organometallic explosives respond well with HPLC and GCMS. But the nitrate esters PETN, NG, and NC usually ride the solvent front unresolved. Manipulations like changing the UV detector wavelength and the mobile phase have improved resolution and accuracy for NG and PETN, but NC methodology is still in need of improvement. Nitrogen analysis alone is not sufficient for a fraction which has all but NC removed, because NC grades vary in %N from 11 to 14.14, and can also vary in degree of polymerization (DP), which is usually about 1200. Colorimetry might be used for the total nitrate esters, with subtraction of the NG and PETN determined otherwise to estimate the NC.

**Table 1. Chemical Analysis of Explosives in Soil & Metal Samples<sup>6</sup>**

Values = ppm by weight, ND = none detected at detection level of 0.10

|             | North Area<br>Pit Soil | South Area<br>Pit Soil | South Area<br>Surface Soil | South Area<br>Metal Chips |
|-------------|------------------------|------------------------|----------------------------|---------------------------|
| 13DNB       | ND                     | ND                     | ND                         | ND                        |
| 24DNT+2ADNT | <b>0.30</b>            | ND                     | ND                         | ND                        |
| 26DNT       | <b>0.16</b>            | ND                     | ND                         | ND                        |
| HMX         | <b>2.20</b>            | ND                     | ND                         | ND                        |
| NB          | ND                     | ND                     | ND                         | ND                        |
| NG          | ND                     | ND                     | ND                         | ND                        |
| PETN        | ND                     | ND                     | ND                         | ND                        |
| RDX         | <b>18.0</b>            | <b>1.20</b>            | <b>1.20</b>                | ND                        |
| Tetryl      | <b>14.0</b>            | ND                     | <b>0.15</b>                | ND                        |
| TNB         | <b>0.69</b>            | <b>0.18</b>            | <b>0.59</b>                | ND                        |
| TNT         | <b>6.10</b>            | <b>3.00</b>            | <b>11.0</b>                | <b>0.18</b>               |

#### STANDARD METHODS AND STANDARD SAMPLES

**To request copies of the USATHAMA analytical methods**for determination of explosive components in samples, POC's are:

For work with Installation Restoration samples:

Douglas Scarborough, Tel 301-671-6823; DSN-584-6823  
U.S. Army Environmental Center, ATTN: SFIM-AED-IRG  
Aberdeen, MD 21010-5401

For other samples:

Martin Stutz, Tel 301-671-2055; DSN-584-2055  
U.S. Army Environmental Center, ATTN: SFIM-AED-TSC  
Aberdeen, MD 21010-5401

**Standard analytical reference material (SARM) samples** of most explosives are also available from sources approved by the U.S. Army Environmental Center (AEC). These are very pure crystalline or liquid samples of the chemicals which compose the explosive mixtures used in military. They are used to calibrate instruments and procedures for conducting quantitative and qualitative chemical analyses.

**To request SARM samples**, contact:

Dr. Stanley Caulder, Tel 301-743-4223; DSN 354-4223  
Naval Surface Weapons Center, Bldg 600  
Indian Head, MD 20640

#### SHIPPING CONTAINERS FOR SAMPLES OF EXPLOSIVES

**Special shipping tubes are now approved** for shipping small samples of SARMs, or samples for analysis. Within the weight limits approved by DOT, usually 5 to 25g of PETN equivalent, these can be sent through ordinary mail without explosive labels or special precautions, because the containers have been tested to contain an explosion of much more energetic material than approved for shipping. They are essentially pipe nipples made from seamless schedule 80 steel, with threaded end caps. Information is available for these through DOT-E 9571 and DOT-E 8451. The approved containers were originally quite large: 6-inch diameter and 24-inch length, then 4.5-inch diameter and 14-inch length, and now smaller yet with a specially milled design of USATHAMA.

## TEAD FIELD TESTS

**Table 2. Summary of Zero-Gap & Internal Ignition Tests Conducted**

Z = Zero-Gap, I = Internal Thermal Ignition, X = Explosive added

|            | North Area<br>Pit Soil | South Area<br>Pit Soil | South Area<br>Surface Soil | South Area<br>Metal Chips |
|------------|------------------------|------------------------|----------------------------|---------------------------|
| As Sampled | Z, I                   | Z, I                   |                            | Z, I                      |
| As Sampled | Z, I                   | Z, I                   |                            | Z, I                      |
| As Sampled | Z, I                   |                        | Z, Z, I                    | Z, I                      |
| +Explosive | Z+4.8%X                | Z+4.8%X                |                            | Z +2.2gX/lb               |
| +Explosive | Z+4.8%X                | Z+4.8%X                |                            | Z +2.2gX/lb               |
| +Explosive | Z+4.8%X                |                        | Z +4.8%X                   | Z +2.2gX/lb               |
| +Explosive | Z+10%X                 | Z+10%X                 |                            | I +4.5gX/lb               |
| +Explosive | Z+10%X                 | Z+10%X                 |                            | I +4.5gX/lb               |
| +Explosive | Z,I+10%X               | Z,I+10%X               | I +10%X                    | I +4.5gX/lb               |

The above summary lists the 40 explosive tests conducted, 25 zero-gap tests and 15 internal ignition tests. Replicates of most tests were included. The zero-gap tests were all run first. The gap test pipes remained intact except at the bottom end which was flared out or blown off by the pentolite initiator. In one of the zero-gap tests the upper of two pentolite pellets did not detonate high order, as shown by the unbroken bottom end of the pipe, although the fire ball appeared to be as large as in all other zero-gap tests. This test was repeated, giving the typical distorted bottom end. The witness plates were not penetrated in any test or even bulged out. Some of them were bent slightly.

**The internal ignition tests** did not have an energetic display as visual or audible evidence that the black powder had ignited. Most but not all tests showed a slight puff of dust being emitted from the cap threads or the wire inlet to the heater element. Therefore all test pipes were opened and examined after at least 30 minutes. This confirmed that the igniter had indeed exploded the black powder which charred the surrounding sample in every test. In the samples containing 10% supplemental high explosive the charred region was the largest,

extending several inches into the sample. Some of the ignition tests originally scheduled for intermediate amounts of supplemental explosive to be added to the sample were omitted because the gap tests had shown no activity with the highest amount of supplemental explosive. Ignition tests on the soil and metal as sampled were followed directly by ignition tests with 10% additional explosive in the soil and twice the scheduled amount of explosive to be coated on the metal.

**None of the 40 tests showed explosive reactivity** of material as sampled, or with 10% supplemental explosive in the soils, with 2.2 g/lb additional explosive on the metal in gap tests, or with 4.5 g/lb additional explosive on the metal in the ignition tests.<sup>6</sup> Slight explosive content was shown in the most reused OBOD soils as sampled, totalling only from 4.38 to 41.45 ppm. Explosive contamination of the metal from the OBOD range was only 0.18 ppm as sampled.

## **OTHER REPORTED REACTIVITY TESTS ON SOIL/EXPLOSIVE MIXTURES**

### **HERCULES TESTS ON SOILS AND PROCESS WASTES**

Conclusions similar to those found at TEAD were also found by Hercules Corp on loamy sand and sandy soils from various OBOD sites, using the same Bureau of Mines tests described here. No RCRA type explosive reactivity was found in soils with up to 10% moisture and 12% explosive, or up to 21% explosive in soils with 21% moisture.<sup>7</sup> Older test methods had shown that process sludges did not have explosive reactivity. PICATINNY

### **ARSENAL TESTS ON VARIOUS SOILS**

Before the Bureau of Mines test methods were published to address RCRA reactivity categories (6) and (7), the Army did reactivity tests on soil/explosive mixtures using Army methods for testing sensitivity: friction pendulum, weight drop impact, electrostatic initiation, detonation shock from a donor explosive, and thermal ignition.<sup>8</sup> Samples of soil were taken from various military installations, including high humus soils, high clay soils, and lagoon settling pond sediment soils from 4 military installations. The most sensitivity was found with the humus soils, which were then used for the most tests. The report concluded that soil/explosive mixtures probably have no explosive hazard if the explosive content is less than 25% by weight, and if samples being incinerated remain unconfined.<sup>8</sup>

## **CONTAMINATED WASTE PROCESSORS**

The Army has used a type of chamber furnace with a car-bottom for many years to incinerate waste contaminated with small amounts of explosive. The waste is of various types: paper and cardboard dunnage, metal projectile casings and equipment, fabric, wood, plastic and glass. The car-bottom furnace is called the Contaminated Waste Processor or CWP. Eight

military locations in U.S.A. use the CWP.

CWP feedstock is considered unreactive by RCRA definition of explosive reactivity characteristic by regulators with EPA authority at 7 of the 8 locations where CWP's are used. Of the 8 locations only the Tooele Army Depot CWP is required to have a RCRA permit for CWP feedstock contaminated with small amounts of explosive, by an edict of the Utah Division of Solid and Hazardous Waste about February 1990.<sup>2</sup> Category (8) of 40 CFR 261.23(a) states that wastes that are Class A or Class B explosives are hazardous waste. This was extended incorrectly to mean that wastes with only a trace of explosive are also hazardous wastes by virtue of explosive reactivity characteristic. As a result, CWP operations at TEAD have ceased for the last four-and-a-half years. Actually the CWP was designed to handle feedstock that has up to 3 lbs of explosive distributed throughout a batch, with up to 1 lb in a pocket, although the feedstock normally has only small amounts of explosive. Downloaded projectile casings, worker clothing, and packing material account for most of the contaminated CWP feedstock.

The findings of this report further confirm that OBOD soil and projectile casings are non-hazardous waste feedstock for CWP units.

## DEFINITIONS

|                   |                                                                                                      |
|-------------------|------------------------------------------------------------------------------------------------------|
| A                 | Ampere                                                                                               |
| 2ADNT             | 2-Amino-4,6-dinitrotoluene explosive                                                                 |
| AEC               | U.S. Army Environmental Center, APG                                                                  |
| APG,MD            | Aberdeen Proving Ground, Maryland                                                                    |
| CFR               | U.S. Code of Federal Regulations                                                                     |
| cm                | Centimeter                                                                                           |
| CRRL              | Cold Regions Research and Engineering Laboratory, NH                                                 |
| CWP               | Contaminated Waste Processor                                                                         |
| 13DNB             | 1,3-Dinitrobenzene explosive                                                                         |
| 24DNT             | 2,4-Dinitrotoluene explosive                                                                         |
| 26DNT             | 2,6-Dinitrotoluene explosive                                                                         |
| DOD               | U.S. Department of Defense                                                                           |
| DOT               | U.S. Department of Transportation                                                                    |
| DP                | Degree of polymerization                                                                             |
| DSN               | Defense Switching Network, telephone system                                                          |
| EFD               | Engineering and Fabrication Division, TEAD                                                           |
| EPA               | U.S. Environmental Protection Agency                                                                 |
| f                 | Feet                                                                                                 |
| f/s               | Feet per second                                                                                      |
| g                 | Gram                                                                                                 |
| g/cm <sup>3</sup> | Gram per cubic centimeter                                                                            |
| g/lb              | Gram per pound                                                                                       |
| HMX               | Cyclotetramethylenetetranitramine explosive                                                          |
| HPLC              | High performance liquid chromatography                                                               |
| ID                | Inner diameter                                                                                       |
| lb                | Pound                                                                                                |
| L/min             | Liter per minute                                                                                     |
| m                 | Meter                                                                                                |
| MEK               | Methyl ethyl ketone                                                                                  |
| MIBK              | Methyl isobutyl ketone                                                                               |
| ml                | Milliliter                                                                                           |
| N                 | Nitrogen                                                                                             |
| NA                | North area of TEAD                                                                                   |
| NB                | Nitrobenzene explosive                                                                               |
| NC                | Nitrocellulose explosive                                                                             |
| ND                | None detected at the detection level                                                                 |
| NG                | Nitroglycerin explosive                                                                              |
| OBOD              | Open burning and open detonation                                                                     |
| oz                | Ounce avoirdupois                                                                                    |
| Pentolite         | A 50/50 mixture of PETN and TNT -- a 10/90 mixture also called pentolite is not used in this project |

## DEFINITIONS CONTINUED

|                |                                                                                                              |
|----------------|--------------------------------------------------------------------------------------------------------------|
| PETN           | Pentaerythritol tetranitrate                                                                                 |
| POC            | Point of contact                                                                                             |
| ppm            | Parts per million                                                                                            |
| PVC            | Polyvinyl chloride                                                                                           |
| RCRA           | Resource Conservation and Recovery Act                                                                       |
| RDX            | Cyclotrimethylenetrinitramine explosive                                                                      |
| SA             | South area of TEAD                                                                                           |
| SARM           | Standard analytical reference material                                                                       |
| SOP            | Standing Operating Procedure                                                                                 |
| TCLP           | Toxic Characteristic Leaching Procedure                                                                      |
| TEAD           | Tooele Army Depot, Utah 84074                                                                                |
| Tetryl         | 2,4,6,N-Tetranitro-N-methylaniline explosive                                                                 |
| TNB            | 1,3,5-Trinitrobenzene explosive                                                                              |
| TNT            | 2,4,6-Trinitrotoluene explosive                                                                              |
| ug/g           | Microgram per gram, or ppm by weight                                                                         |
| USATHAMA<br>of | U.S. Army Toxic and Hazardous Material Agency, now reorganized as part<br>the U.S. Army Environmental Center |
| UV             | Ultra violet                                                                                                 |
| V              | Volt                                                                                                         |

## REFERENCES

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