Camp Minden M6 and CBI Potential Technology Screening Information

Decineration™ **Leidos** **Paritosh Dave** **Sr. Program Mngr** **356 Ninth Ave** **Suite 106** **Picatinny Arsenal, NJ 07806** **973-366-3200** **paritosh.r.dave@leidos.com** **U.S. Demil, LLC** **David J. Kautz, PE** **140 Irwin Place** **Amherst, NY 14228** **716-983-3856** **dkautz@usdemil.com**	Please describe how your technology or process works and the equipment involved. **Please see attachment #1** Is this existing equipment or does it need to be fabricated? **One unit exists, more can be fabricated.** Is a donor explosive required? **No**	Has your technology/ process been tested or used with M6, CBI, propellants, or similar materials? **Not bulk M6 / CBI but an array of military munitions containing propellants and explosives** What permits or approvals do you have in hand? **At the team's physical location, all required Federal and State permits for the demilitarization of explosives / propellants. In LA, none.** Describe actual uses, volumes treated, and results of tests or applications for M6 like materials. **Federal Contracts for the demilitarization of munitions, PADs / CADs, SAA, bulk explosives and landmines.**	Can your technology/ process be implemented on-site at Camp Minden? **Yes** How long would it take to mobilize, install and be ready to treat material? **6 -7 months, depending on permits from State & Federal agencies** Would it require any extra handling or preparation of the M6 and CBI? **No** What are the key space and logistical requirements for your installation on-site including storage of residues/wastes? **A 40'x100' work area with proper barriers and a 480V, 400amp power feed**	What is the Destruction Efficiency of your process? **100%** What is the nature of the residues/wastes that will remain, and what processes/ disposal/recycling will be used for this residue/ waste? **There will be no residue / waste** What percent volume reduction (or addition) is achieved? **100%**	What is the nature and composition of any emissions? **TOVs – hydrocarbons / broken nitroamines / nitroesters** How are emissions monitored, captured, tested, treated and ultimately disposed? **Please see attachment #2** What potential hazards to workers, other on-base personnel and nearby residents should be considered and how are they managed? **All standard hazard potentials when dealing with propellants but nothing from the nature of the technology.**	What is the highest throughout you have achieved through your process? **500 pounds per hour of RDX (limited by permit cap)** What is the reasonable maximum daily capacity/ throughput you believe you could achieve at Camp Minden? **1,000 pounds per hour per machine on a 24/7 continuous basis** What is the reliability and maintenance requirements of your equipment? **The equipment is standard industrial components with proven reliability and 24hr repair response if required.** Is it subject to weather? **No**

ATTACHMENT 1

Science

The science behind the USD Decineration™ technology has been proven and accepted for decades in both the petroleum industry and in the R&D community. In the petroleum industry, it is the basis for "cracking" long chain hydrocarbons into lighter distillates. In the R&D community, it is the subject of much research into the decomposition of nitramines and nitrate esters; e.g., G.T. Long, Department of Chemistry, University of Utah (Thermal Analysis of High Explosives: Liquid State Decomposition of RDX) and LT K.K. Miles, Naval Postgraduate School (The Thermal Decomposition of RDX).

The application of the science to the carbon-carbon (C-C) bond of hydrocarbons is a mature industrial technology and needs no further explanation in this report.

The application of the science to an industrial "cracking" process of nitramines and nitrate esters is new to the DoD energetics community, and the unique nature of these energetic compounds warrants additional discussion.

The industrial embodiment of the Decineration™ process is the use of an externally heated, rotating horizontal tube which essentially duplicates the laboratory model known as "a horizontal flat plate in atmosphere". When the energetic is applied to the surface of the hot plate, it begins to decompose via the breaking of various molecular bonds. When a decomposition compound is formed that is in a gaseous state at the tube interior operating temperature (approximately 450°F), the molecule (known as a VOC for EPA regulatory purposes) evolves from the plate and the process terminates. In practical application this provides a set of self-limiting decomposition reactions that do not drive to total decomposition / oxidation as does a combustion process.

For organic-based explosives, the science directs us to look at the, Nitrogen-Nitrogen (N-N), the Carbon-Nitrogen (C-N) and the Nitrogen-Oxygen (N-O) bonds.

The C-N bond dissociation energy is lower than the C-C bond energy (See Table XX below); e.g. the C-N bond will "crack" at a lower energy input (external heat) than the C-C bond. The N-N and N-O bond energies are also lower than the C-C bond energy, and will also break before the C-C bond. The physical consequence of these lower dissociation energies is that when conditions are established under which hydrocarbon "cracking" is achieved, total nitramine bond cracking will occur, and all but the double C=C bond of the nitrate esters will be "cracked". As shown in Table XX below, the double C=C bond in the nitrate ester has a higher dissociation energy than the single C-C bond previously discussed. These C=C bonds typically will not break under the operating temperatures of the Decinerator™. The consequence of this is that VOCs are formed, and upon analysis are reported as "broken aniline analogs" and similar compounds.

From a thermochemical perspective, it is possible that some portion of the released nitrogen from the "cracking" process is recombining to form gaseous Nitrogen (N_2), and analysis of the process gases generated by the Decinerator™ reveal the formation of various NO_X compounds.

Table XX – Pertinent Molecules (Bond Dissociation Energy)

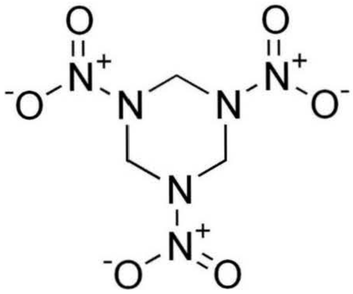
Average Bond Dissociation Energies (kj/mol)			
Single Bond		**Multiple Bond**	
C-C	347	C=C	614
C-N	305	C=N	615
C-O	358	C=O	745
N-O	201	N=O	607
N-N	160	N=N	418
O-O	146	O=O	495
C-H	414	C≡C	839

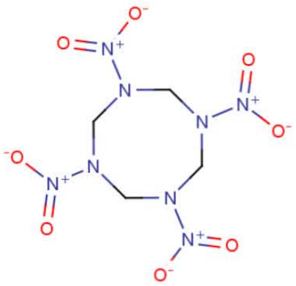
The final atomic bonding pair we must review is the Carbon-Oxygen (C-O) molecule, which is common in the nitrate ester compounds. The C-O molecule has a higher bond dissociation energy than the C-C bond and will be broken only if the thermal energy reaches a sufficient level to energize the bond. The thermal conditions under which the Decineration™ furnace operates will result in some percentage of the total carbon contained in nitrate esters being emitted as CO and CO_2 (broken molecules recombined or evolved into "combustion gases"), although combustion (oxidation) has not occurred. The likely pathway for this evolution of carbon oxides is that the thermal environment is sufficient to break the C-C and C-N bonds adjacent to either side of the C-O bonds, but that not all of the C-O bonds will be broken. This would result in evolution of CO (carbon monoxide), and a likely recombination of CO and “free” oxygen that would be generated by the catalytic converter or thermal oxidizer as CO_2.

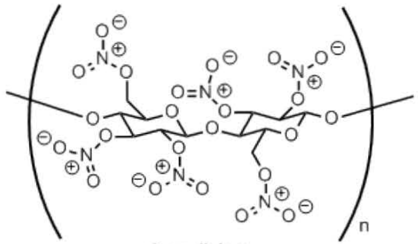
Also of interest is the energy released during the decomposition of RDX. It was observed that the decomposition of RDX occurs as a two stage process. The first stage appears to be endothermic while the second is exothermic. The exothermic reaction is not combustion (oxidation) but rather an energy release without oxidation. In this case, the energy is released into the interior of the Decinerator™ tube. This presents itself physically as an energy source inside the tube causing the furnace zone controllers to reduce heat output. The phenomena can continue past zero controller output at which time the tube temperature will rise. These conditions were noted in the field testing when DODICs containing RDX were processed.

The science of thermal decomposition without oxidation was proven with the Decinerator™ furnace in two (2) DoD contracts as well as USD privately funded testing.

Images of the molecular arrangement for RDX, HMX and nitrocellulose are shown below, illustrating the bonding pairs discussed above.







nitrocellulose

ATTACHMENT 2

USD Emissions Abatement System (EAS) – Functional Description

The USD EAS is specifically designed to be an integral part of the Decinerator™'s control system. It is sized to match the Decineration™ operating conditions and emissions profile, and functions as part of the temperature and "feed forward" logic loops. The feed-forward control philosophy was developed in the 1960s by the iron and steel industry to allow real time stack exhaust data to be utilized to ramp down feed automatically prior to an alarm state. The concept automates the overall Decineration™ process in that alarms are avoided before they trigger permit condition excursions i.e. eliminating "rolling average" shut downs and or fines.

The EAS is built from individual subsystems that are selected on the basis of the Best Available Technology (BAT) for each of the functional requirements. Every technology chosen is mature, is commercial off-the-shelf (COTS), has been accepted by, and is currently installed and operational in the State of Utah. As the subsystems are COTS, their integration into a complete EAS is simple and more a function of size selection than true engineering. Each subsystem has its own control logic and the entire system is controlled by a PLC which is integrated with the Decinerator™ control.

The following functional component descriptions are listed in order of the process feed route from the Decinerator™ to the emission point.

Component: Wet Scrubber
Function: Particulate Control / SVM collection & Recovery / Chlorine Removal / SO_X removal
Design Operating Temperature: 250°F
Operational Efficiency: minimum rating - 99.9%
The wet scrubber utilizes a packed tower with recirculating water to remove particulates. Moreover, by adding chemicals to the recirculating solution, materials of concern such as Chlorine and SO_X can be removed from the gas stream. The captured particulate matter is removed from the wet scrubber by a side stream filter press which allows for the possible reclamation and recycling of metals such as lead and mercury when they are included in the emissions gases.

Component: Draft Fan
Function: Move air through the system (i.e. induce draft through the Decinerator™)
Design Operating Temperature: 212°F
The fan is powered by an A/C motor under the control of a variable frequency drive (VFD) controller. It is sized to allow a minimum 10:1 turn down ratio for airflow without the need for control vanes. The VFD is multi-looped in that it not only maintains air flow, it is part of the furnace temperature control.

Component: Catalytic Converter
Function: Removal of SVOCs, VOCs and NO_X
Design Operating Temperature: 700°F
Operational Efficiency: minimum rating - 99.9%
The converter utilizes a series of catalyst beds selected to break down the incoming organics and NO_X into carbon dioxide, water and nitrogen gas. The catalyst metals are selected both for their intended function / performance and for their economic availability and operational life-cycle costs. The unit is electrically preheated to 700°F. Once the Decinerator™ begins to produce organic vapors and or NO_X, the energy released by the decomposition of the organics and or NO_X is self-sustaining and the preheater shuts off. This latter feature is characteristic of emission gas catalytic converters, and it represents significant operational cost savings compared to thermal oxidizers or other thermal gas treatment units that require constant energy input to maintain operating temperatures.

Component: Continuous Emissions Monitoring System (CEMS)
Function: Monitor / Data Log Emissions
Design Operating Temperature: 700°F
The CEMS utilizes current state-of-the-art, COTS sampling and analysis equipment. The PLC software data logs (monitor and store) all information required by the Authority of Jurisdiction. Further, the data can be utilized by the Decinerator™ controller to modify the feed rate (i.e. "feed forward" as discussed above).

Component: Stack
Function: Direct treated gas exiting the catalytic converter vertically for compliant discharge
Design Operating Temperature: 700°F
The stack is a vertical, nominal 26" diameter, COR-TEN™ (non-stainless) steel assembly that mounts at the discharge of the catalytic converter body. The final height would be calculated once an actual physical location is selected but is typically 20 feet in length (30 feet above local grade).