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HIGH THROUGHPUT EXPLOSIVE DESTRUCTION SYSTEM

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Introduction – In the decade since The Explosive Destruction System (EDS) was developed, its role in the non-stockpile chemical materiel program has expanded substantially. It was originally intended for emergency use to treat one or two munitions a year. For comparison, two systems are currently in continuous use at Pine Bluff Arsenal treating approximately 1200 munitions. With the expanded mission has come a desire to increase the throughput of the systems. With potential future missions, such as remediation of large burial sites, this desire will be even greater. A significant improvement in throughput was achieved by configuring the EDS fragment suppression system and shaped charges to process multiple munitions. However, an even greater increase can be achieved by improving the design or operating procedures to decrease the process time. It is important to recognize that the limited process rate of EDS, as now configured, is not inherent in the technology, but grew out of the original mission requirements. In this paper we describe a High Throughput Explosive Destruction System (HTEDS) capable of processing up to 60 munitions per day. The HTEDS can achieve a 20-fold increase in capacity by optimizing the proven EDS technology to reduce the process time and increase the number of munitions in each batch. These improvements will also decrease the effluent stream and reduce the workload on the operators.

Original EDS Mission – The EDS was originally developed by Sandia National Laboratories for the Product Manager for Non-Stockpile Chemical Materiel to treat small volumes of recovered munitions at the recovery site in the limited circumstances where the munition was deemed unsafe to transport or to store. As such, EDS was to fill a critical, but limited role with just a few uses each year. Consistent with that mission, the EDS design emphasized transportability, flexibility, redundancy, surety of destruction, self contained operation, and the simplicity of manual operation. There was no emphasis on process time or throughput since the actual destruction process was just a fraction of the overall deployment time.

The EDS has now proven to be a flexible, capable, and effective system that has achieved a significant degree of acceptance with the public and within the regulatory community. Several factors have contributed to its success:

- It uses the Army's proven, low-temperature neutralization protocol to treat the CWM. It does not use incineration nor rely on the uncontrolled fireball from the explosives to destroy the agents.
- The use of explosives to access the munition provides the flexibility to safely process many different types of munitions regardless of their condition. The use of explosive devices is very reliable.
- The batch operation ensures that the process is entirely contained from the time the munition enters the system until there is positive confirmation, by sample analysis, of agent destruction. Consequently, unusual conditions and equipment problems can be handled calmly and methodically.
- The system is small and self-contained so it is easily transported.
- The system has redundancy and flexibility that have allowed it to handle munitions and agents well beyond the original scope.

The EDS operation has not changed appreciably from the original prototype. The process takes about 20 hours over two days. Up to six munitions, depending on size and explosive content, are placed in the fragment suppression system with the shaped charges. The assembly is loaded into the vessel, the door is sealed, and the seal is leak tested. The shaped charges simultaneously open the munitions and destroy their bursters. Treatment or "neutralization" chemicals are then pumped into the vessel and the vessel is heated to 60ºC with external resistance heaters. Liquid samples are collected and analyzed to confirm destruction of the agent after which the effluent is drained to waste drums and the vessel is filled again, this time with water. The water is heated to 100ºC to destroy any remaining heel. Since the heat is applied externally, the structure must be heated to substantially greater than 100ºC. During both heating steps, the vessel is continuously rotated on its axis to mix the contents and speed the reaction. After the vessel cools over night, a gas sample is collected and analyzed, the water is drained, the vessel is flushed with helium, and the vessel is opened. Solid debris is removed and the vessel is prepared for the next operation.

High Throughput Explosive Destruction System –The proposed HTEDS achieves greater throughput in four ways. First, a larger detonation containment vessel, with twice the volume of the EDS P2 vessel, will allow processing of more munitions or larger munitions in each batch. The current vessels consist of a deep cylindrical cup with a flat door. The increased volume for HTEDS is achieved by using two cups placed end to end with the seal and clamp in the middle as shown in figure 4. Instead of a hinged door, one end of the vessel will roll on rails to spread apart axially.

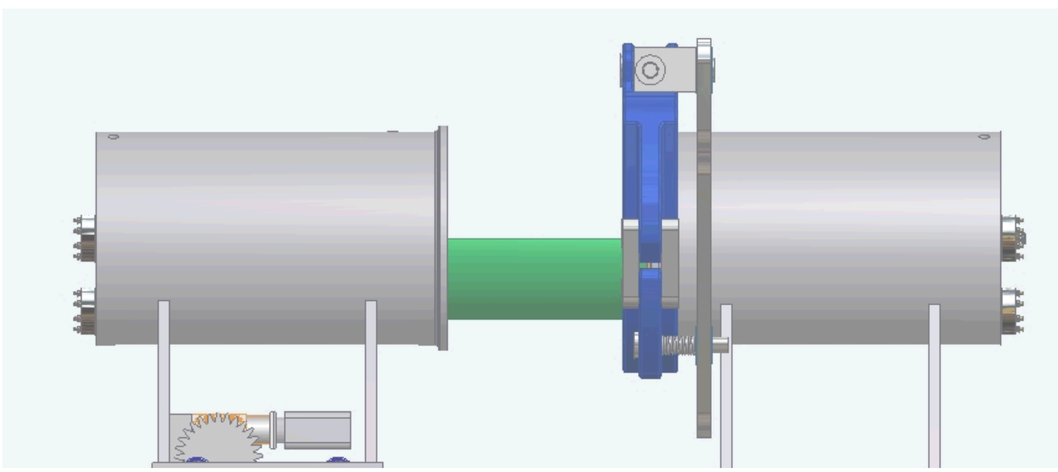

Figure 4. Dual Cylindrical Cup Design for EDS/M55 Detonation Containment Vessel

Second, the system will use two detonation containment vessels in an alternating sequence so that a single operating crew can support both vessels.

Third, instead of using the same vessel for detonation and treatment, the system will have a separate treatment vessel operated in a semi-continuous batch mode. A semi-continuous batch operation refers to two or more batch operations which are run sequentially in separate vessels. This approach maintains the advantages of batch operation, but allows the second batch to start before the first one is completed. Following the detonation of the shaped charges to open the munitions and destroy the bursters, the chemical agents will be washed to the treatment vessel for neutralization. This frees up the detonation vessel for the next lot of munitions, it speeds up the treatment process, and it allows many munitions to be neutralized together. Each detonation vessel will be able to process two or three batches of munitions each day, instead of one every two days. The contents from all of these munitions will be added to the 500-gallon treatment vessel throughout the day. The treatment vessel will be sampled the following morning at the start of the operation to confirm destruction of the agent and then it will be drained and refilled with fresh reagent. This provides plenty of time to destroy the agent so neutralization will not be the rate limiting step.

The key to using semi-continuous batch operation for EDS is the ability to transfer the contents of the detonation vessel into the treatment vessel. This will be done by circulating heated liquid from the treatment vessel through the detonation vessel and back. A closed loop recirculation path with a canned-motor pump ensures total containment at all times. Canned motor pumps are used routinely for pumping hazardous fluids. They handle slurries and particulate laden fluids at temperatures, pressures, and volumes appropriate for this application. The fluid will be introduced into the detonation containment vessel through a series of spray nozzles to knock down vapors and scrub the surfaces of the vessel and fragments. After an appropriate soak time, the fluid will be drained back to the treatment vessel.

The fourth way that HTEDS will achieve greater throughput is by eliminating various steps in the process and completing others more quickly through a combination of process automation and hardware improvements. Only a few of these changes are described here.

In the current process hot water is used to destroy polymerized agent heel and decontaminate the detonation vessel. The process is unnecessarily slow because the water is heated in the vessel using external band heaters. In HTEDS the time for this step will be drastically shortened by injecting preheated steam into the vessels instead. We anticipate that this operation will be required only at the end of each day and not after each detonation.

Since the agent will not be treated in the detonation vessels, the vessels do not need to rotate. This greatly simplifies the design and operation of the system. There will be no need to repeatedly connect and disconnect supply hoses. More importantly, the vessels can use Grayloc's standard remote clamping system instead of the custom-designed sliding clamps and hydraulic nuts. This eliminates the manual processes of sliding the two clamps together, tightening the hex nuts, actuating the hydraulic nuts, and securing the hex nuts, as well as the reverse processes at the end of the operation. This saves almost an hour and reduces the level of effort for the operators.

Another significant improvement will be a reduction in the time spent assembling the munitions in the fragment suppression system and loading them into the vessel. We are currently testing a semi-permanent fragment barrier to replace the current disposable fragment suppression system. The new design uses a series of rods around the circumference of the vessel, as shown in figure 5, to protect the walls, while still allowing fluids to flow freely around all parts of the vessel. The rods are reusable, but are inexpensive and can be easily replaced if damaged. This design not only simplifies the assembly, it also substantially reduces the amount of metal scrap that is produced by the process.

Figure 5. Advanced Fragment Suppression System

In the HTEDS, the munitions and shaped charges will be assembled on a platform or tray between the two ends of the vessel. When the vessel ends come together, the tray will slide into the vessel. Similarly, during vessel opening, the tray will pull the fragments out.

Pumps, heaters, valves, and numerous other components will be actuated and controlled remotely from the control room and routine sequences of events such as vessel closure or transfer of reagents between vessels will be automated to be completed with a single command. This speeds the operation, reduces the workload on the operators, reduces the inherent hazards, and minimizes the potential for operator error. Manual operation is always a backup option.

The system layout for HTEDS is shown in figure 6. It consists of two detonation containment vessels that feed into a single agent treatment vessel. Everything is mounted on three skids. The skids eliminate the cost and complexity of the specialized trailer used on EDS with its fold out wings and stairs. They can be easily transported on flat bed trucks so they have little impact on transportability. Connections between the skids are minimal so there is little impact on setup time. Everything is located close to the ground, making it easily accessible to the operators and eliminating much of the lifting of munitions and heavy hardware. Since the vessel does not have to rotate, there is no rotation motor, no drive train, no electrical slip ring, no trolley wheels, and no paddle inside the vessel. Fluid connections are hard plumbed to the vessel in place of quick-connect fittings. The various interlocks and safety features associated with the rotation are no longer needed. The vessel is fastened directly to the skid instead of resting on castors so there is no need to secure it for transportation.

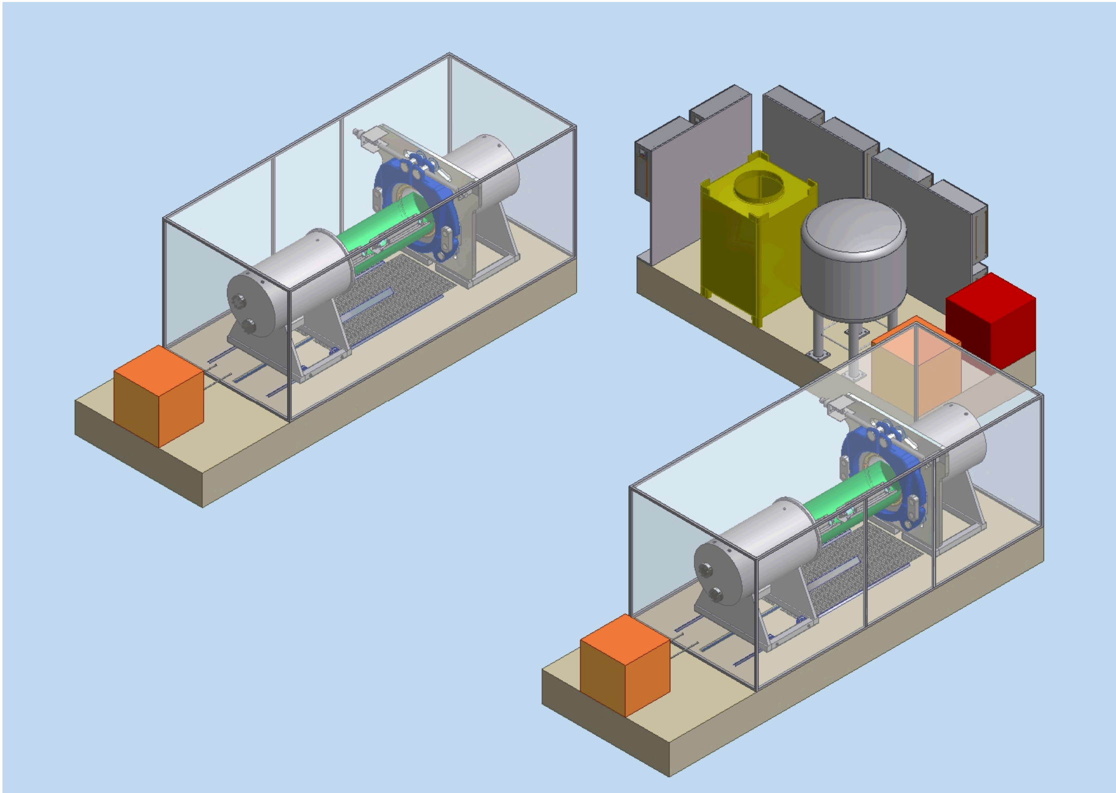

Figure 6. Conceptual Drawing of High Throughput Explosive Destruction System

HTEDS Process time – The top half of Figure 7 shows a simplified timeline for the current EDS. Heating and agitating the containment vessel during the agent treatment step and again during the water rinse step consume the most time. The required time in both steps is driven by how long it takes to heat a vessel massive enough to contain the initial explosion. Other time consuming steps are closing and opening the vessel door, collecting samples, and preparing the vessel for the next run. Overall, it takes two days with a very long first day (~13 hour) to process a single group of six 4.2-inch mortar rounds or similar munitions.

By comparison, the timeline for the HTEDS is illustrated in the bottom half of Figure 7. We expect the HTEDS to complete five batches in one 10-hour day with the system ready to resume operation the next day at the same rate. Furthermore, the detonation containment vessel will handle twice as many munitions in one batch as the EDS P2. Altogether, the HTEDS will be able to process sixty 4.2 inch mortars in one day compared to six in two days in the EDS P2. A single crew can handle the operation of the entire system including both detonation containment vessels. Their primary task will be preparing and loading the munitions into the vessels. Much of the remainder of the process will be handled remotely from the control room.

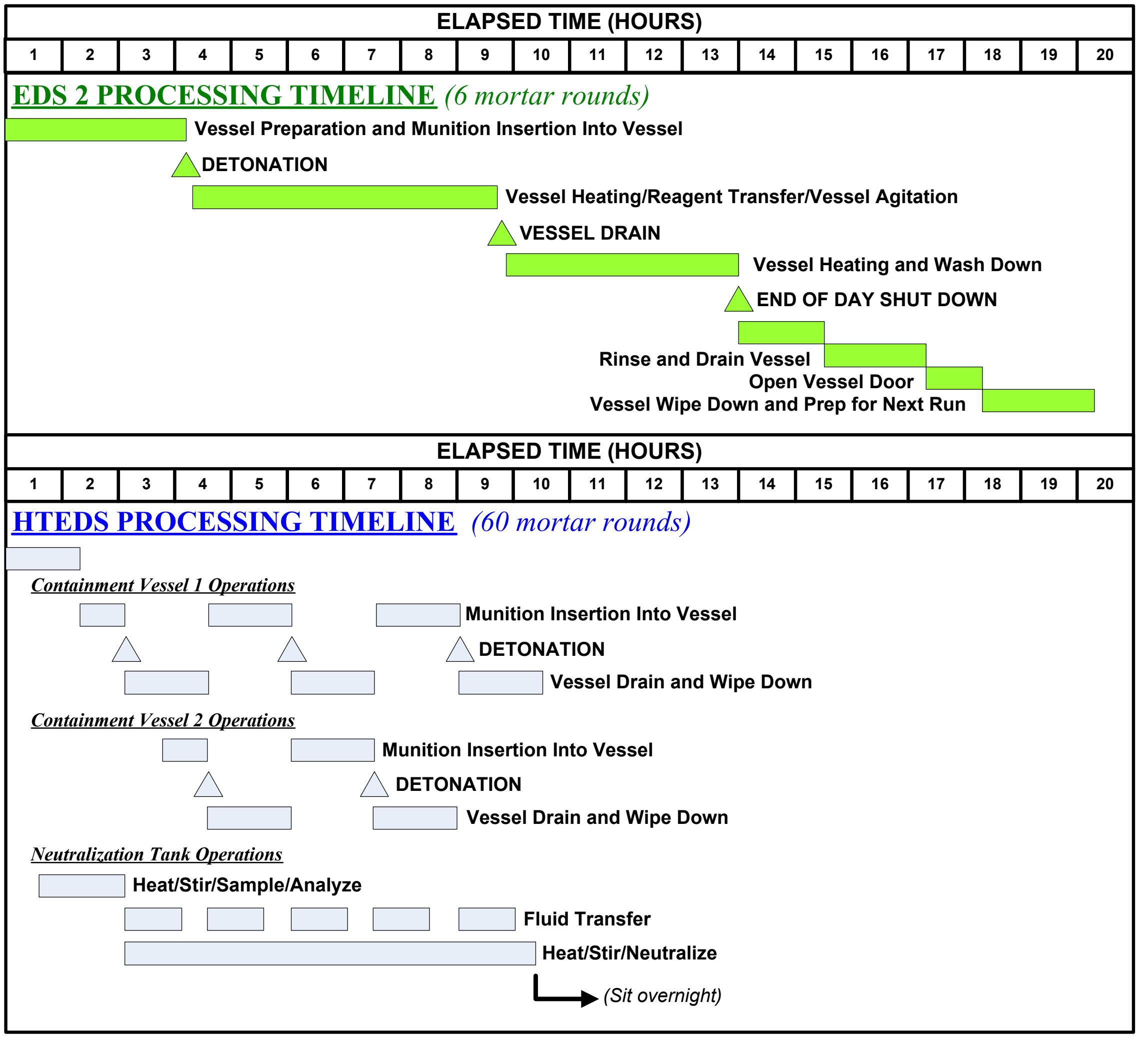

Figure 7. Comparison of process times for EDS P2 and HTEDS

Conclusions – The EDS has proven to be a flexible, capable, and effective system. As a result, its mission has grown drastically from the original concept. To meet the increased demand, the Army has begun processing multiple munitions in each operation. However, significant further increases in capacity can be achieved by optimizing the design and process. The proposed HTEDS will be able to process up to sixty munitions in a day while maintaining the key attributes that have made EDS successful. These include the use of the Army's proven, low temperature neutralization protocol; use of explosives to safely and effectively access munitions regardless of their condition; and use of a batch process for complete containment until there is positive confirmation of agent destruction. More information with greater detail about the HTEDS design is available in a white paper from Sandia National Laboratories.