
EXPLOSIVE DESTRUCTION SYSTEM

AND

HIGH THROUGHPUT EXPLOSIVE DESTRUCTION SYSTEM

AUGUST 15, 2008

Brent Haroldsen

Sandia National Laboratories

MS 9291, PO Box 969, Livermore, CA, USA 94551-0969
925-294-2590, FAX: 925-294-3282, blharol@sandia.gov



EDS Mission

A transportable system that:

- Destroys fused and armed chemical munitions
- Contains all blast, fragments, and gases
- Chemically treats the munition fill
- Confirms destruction by sampling
- Recontainerizes the waste into commercial containers





The Original EDS Mission Included 3 Scenarios

- At chemical munition recovery locations when a chemical munition is deemed unsafe to transport by vehicle or to store by routine means at the time of recovery.
- At chemical munition storage locations when a previously recovered chemical munition is determined not to be safe for continued storage.
- At locations that have a limited number of chemical munitions, (with or without explosive components), that can be treated in the EDS when the quantities do not justify the use of other destruction systems.





The EDS Design Reflects the Mission Scenarios

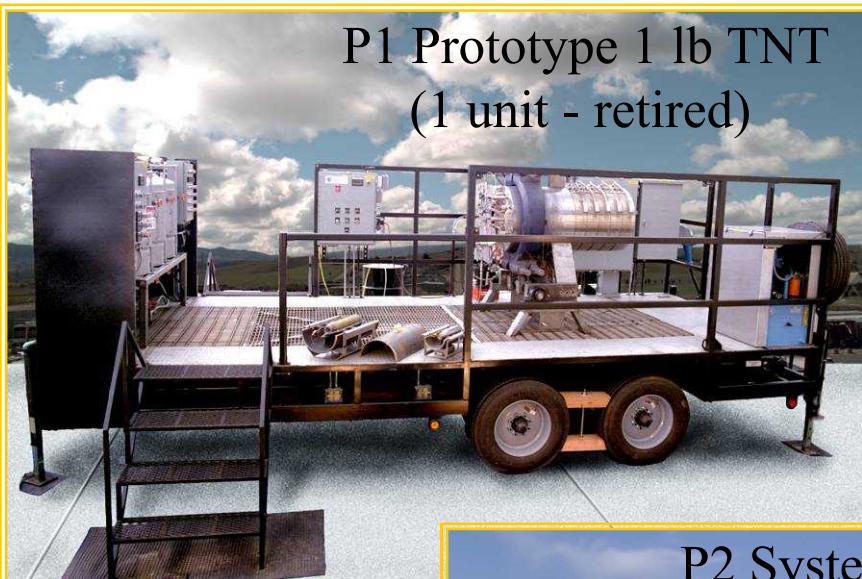
- Easy to transport
- Self contained and rapidly deployed
- Low temperature chemical treatment for wide public acceptance (non-incineration)
- Batch operation with confirmed destruction
- Conservative operating parameters
- Simple and reliable (manual operation, redundancy)
- Safe, robust, flexible, and versatile
- Process time not a major concern





EDS has three system designs

P1 Prototype 1 lb TNT
(1 unit - retired)



P1 System 1½ lbs TNT
2 units in service



P2 System 4.8 lbs TNT
2 units in service, 1 in fabrication





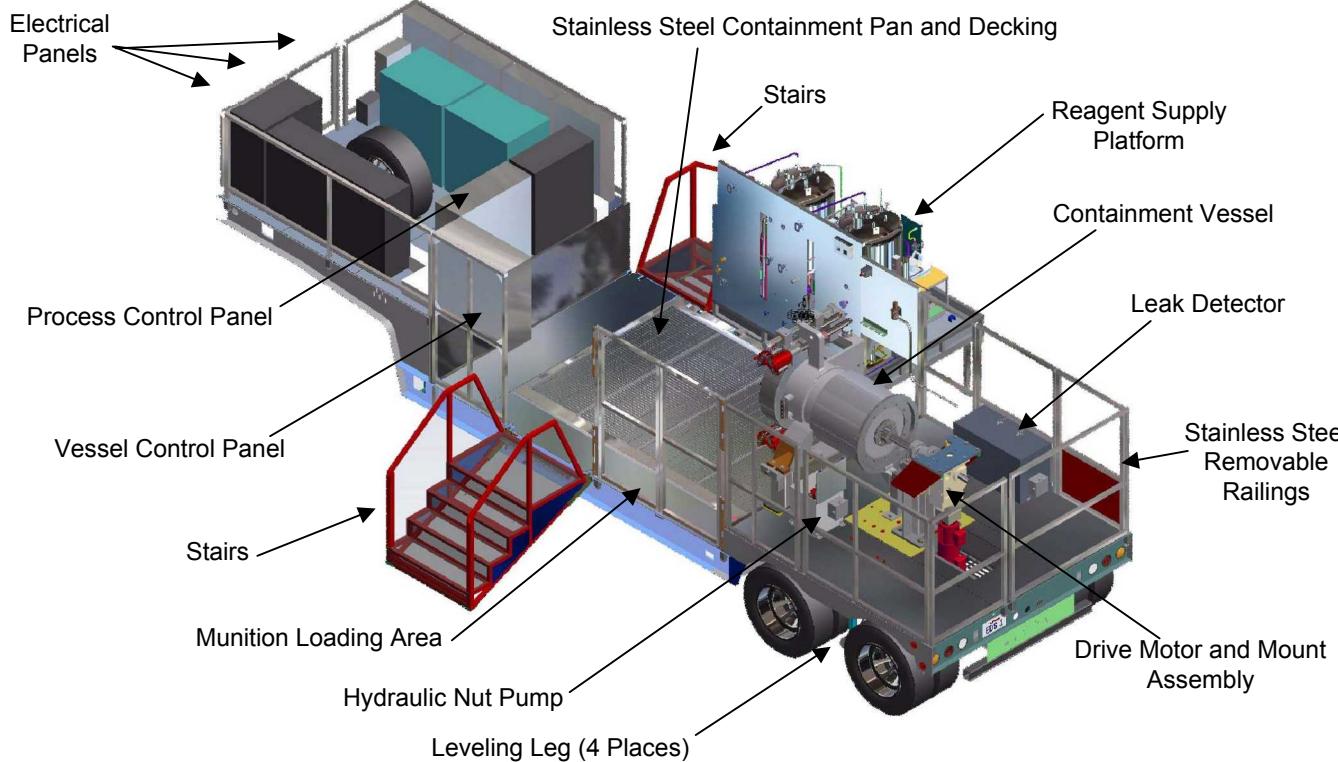
Operational Scenario

- X-ray and PINS locate the fuze and identify the chemical fill
- Munition is placed into the fragment suppression system (FSS)
- FSS is loaded into the vessel
- Shaped charges open the munition and detonate burster
- Treatment chemicals are added
- Vessel is rotated and heated
- Samples are taken
- Effluent is drained into 55 gallon drum and disposed of at a hazard waste facility
- Hot water is used to destroy solid heel
- Door is opened and metal scraps are removed





EDS P1 System Layout



Compressor/Dryer

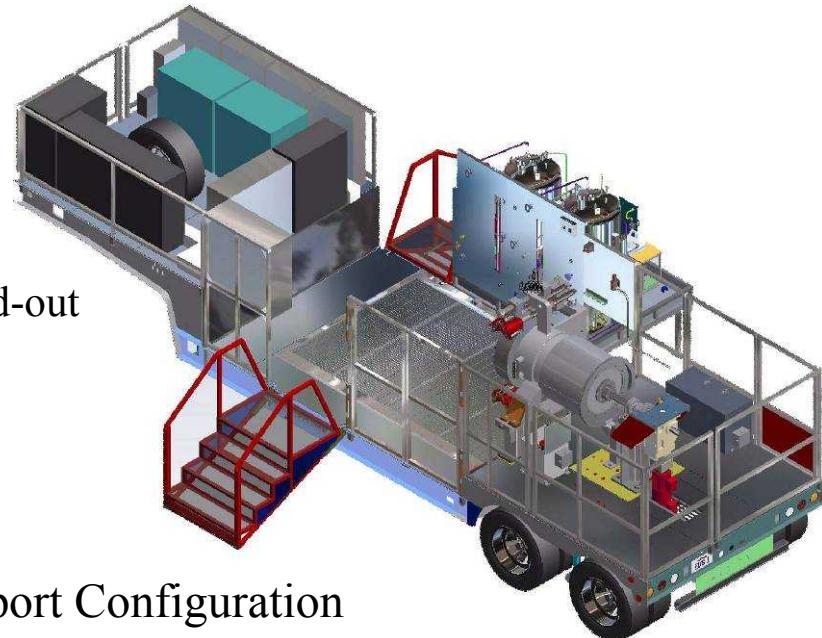
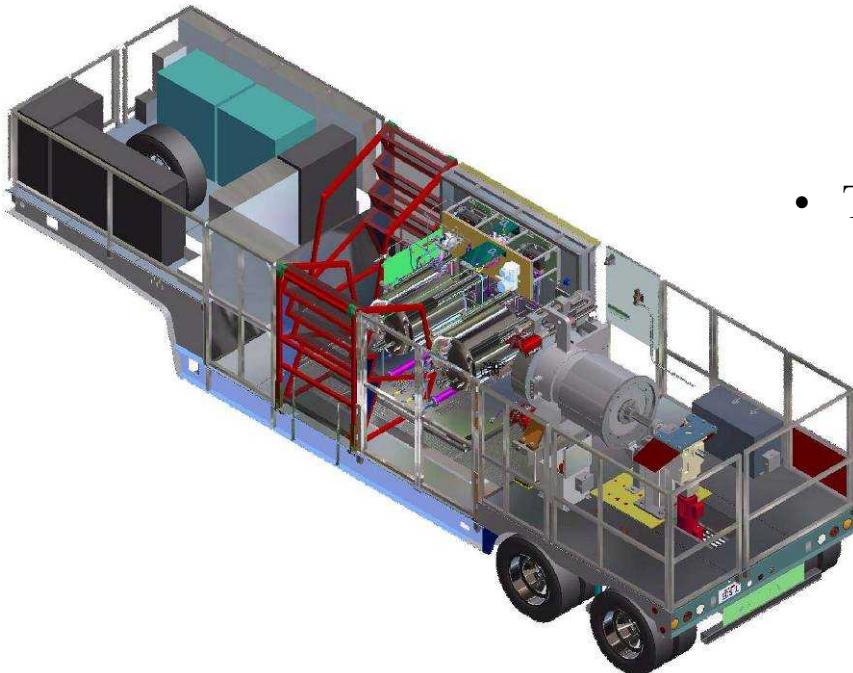


Generator



EDS P1 Transport and Operational Configurations

- Operational configuration
 - Wing platform folded down using trailer hydraulic system
 - Leveling legs hydraulically lowered
 - Stairs manually folded out with air assist
 - Electrical connections and plumbing to the fold-out wing



- Transport Configuration
 - Standard 5th wheel towing
 - System specs
 - Height = 8 feet
 - Length = 30 feet
 - Width = 8.5 feet
 - Weight = 34,000 pounds
 - Ground clearance = 18 inches



Phase 2 Systems



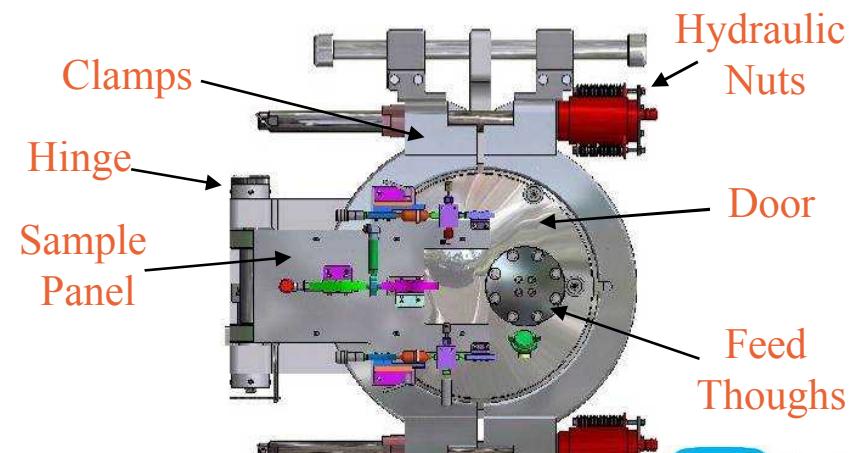
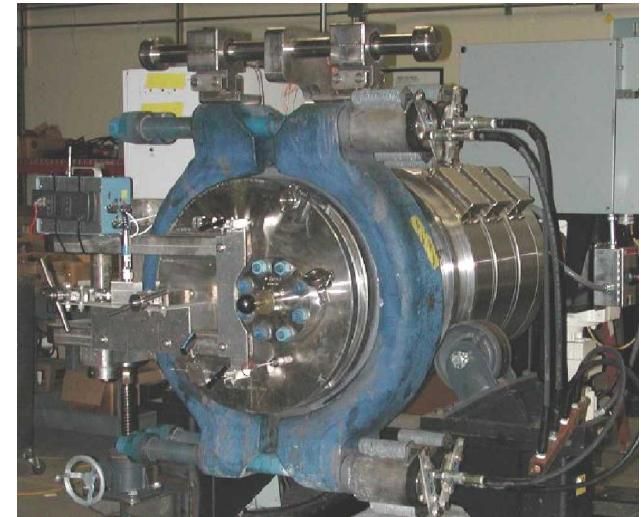
- 40-foot single drop trailer
- 3-times larger
- 4.8 lb vessel rating
- 55,000 pounds total





Vessel Design

- Manufactured by Grayloc Products
- 316 stainless steel
- Hinged door
- Clamped door closure
 - Metal seal ring
 - Hydraulic nuts
- Consolidated high-voltage electrical feed throughs
- Sampling, fill, and drain ports
- Internal paddle for mixing





Containment vessel comparison

P1 Vessel

Dimensions:

19 $\frac{3}{4}$ " I.D.
38" deep
2" wall
4 $\frac{1}{2}$ " rear wall
7" door

Volume:

50 gallons

Capacity:

1.5 lbs TNT

Ordnance:

4.2 inch mortar
Livens projectile
75 mm
etc.



P2 Vessel

Dimensions:

29 $\frac{1}{4}$ " I.D.
56" deep
3 $\frac{1}{2}$ " wall
6 $\frac{1}{4}$ " rear wall
9" door

Volume:

160 gallons

Capacity:

4.8 lbs TNT

Ordnance :

8 inch artillery
155 mm artillery
Multiple
munitions
etc.



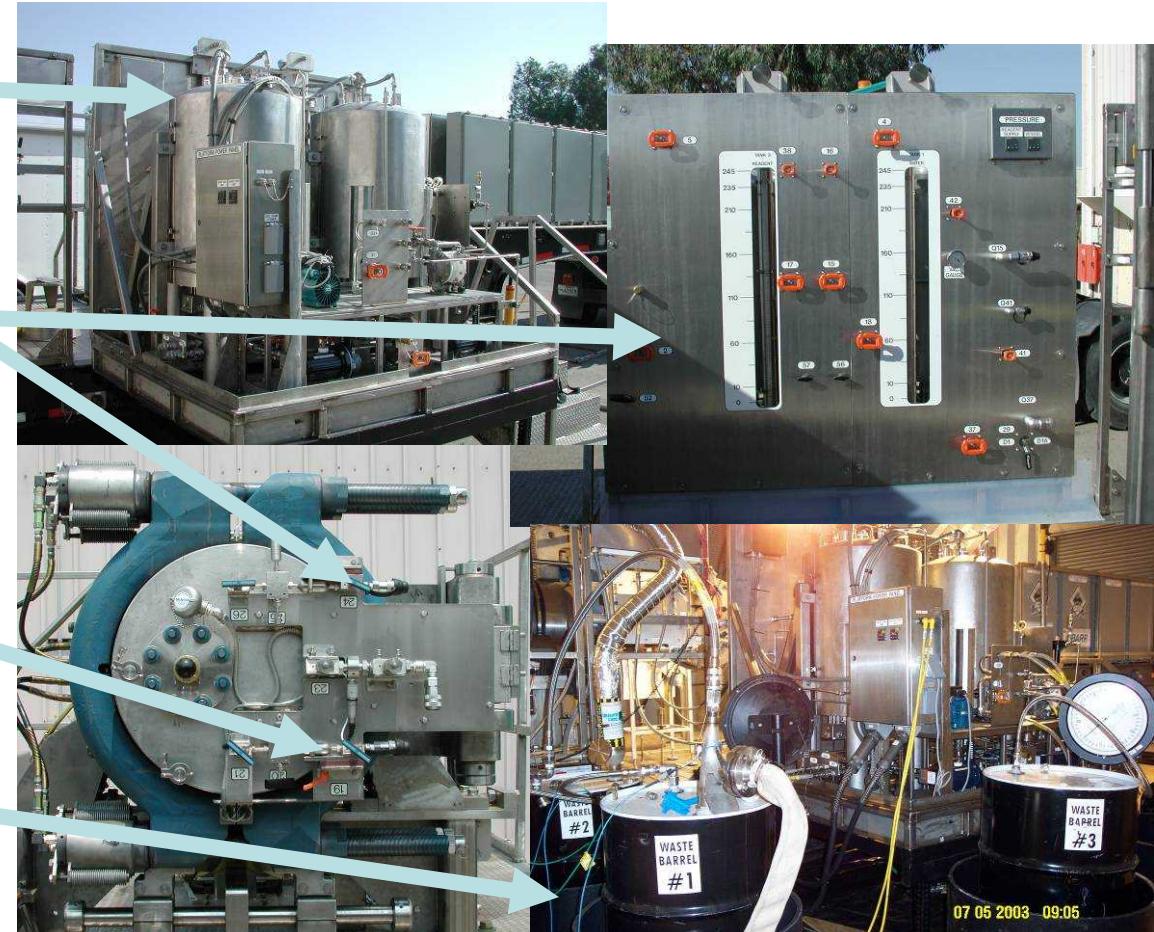
Chemical Transfer System

Two 65-gallon tanks for water and reagent

Pumps and valves allow for transfer of reagents, (MEA, NaOH, or NaMnO₄) and water into the vessel

Sampling manifold enables sampling of liquid and vapor

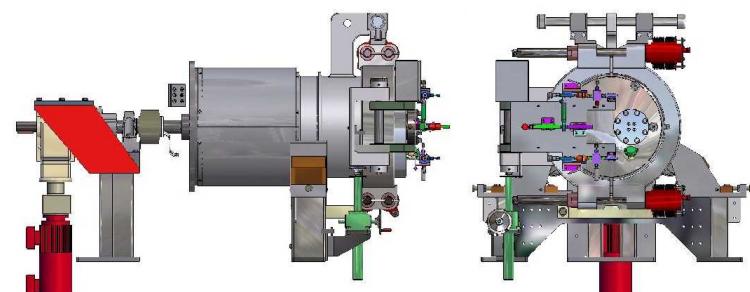
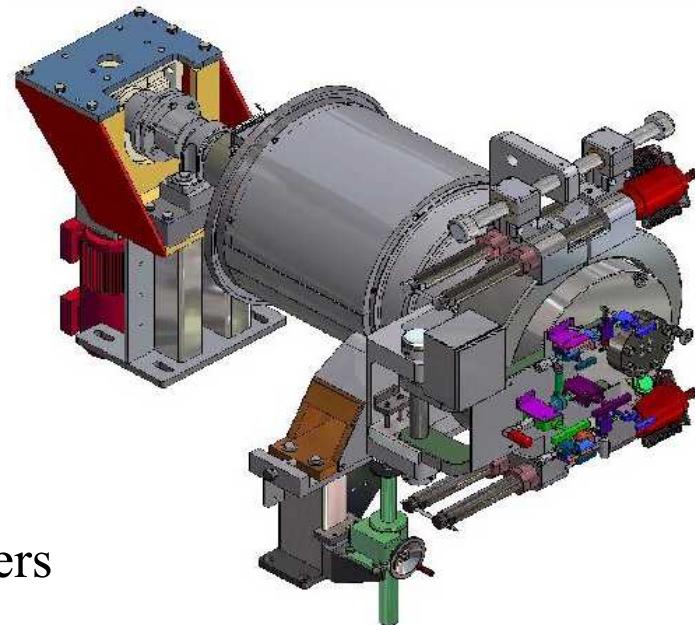
Effluent is drained to 55-gallon drums





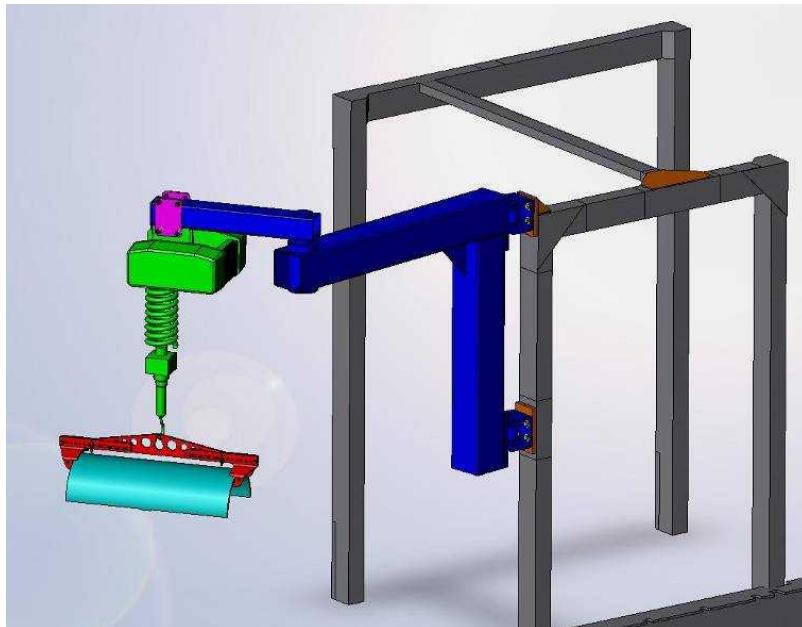
Rotary Agitation for Improved Mixing and Uniform Heating

- Electric motor drive
- Caster wheels
 - 17,000 lb capacity EDS P1
 - 20,000 lb capacity EDS P2
- 360° continuous rotation
 - Slip ring to transfer power to band heaters
 - RF signal for pressure and temperature
 - Interlocks for safe operation





Lift assist reduces operator strain





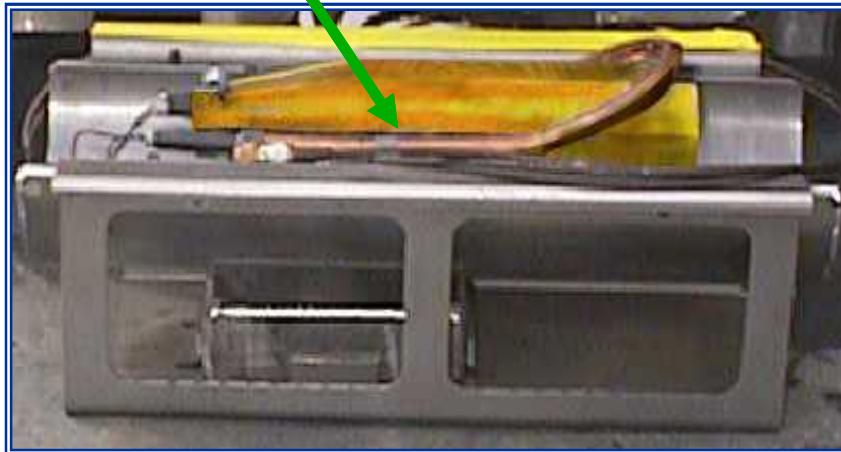
Special hardware for Lewisite



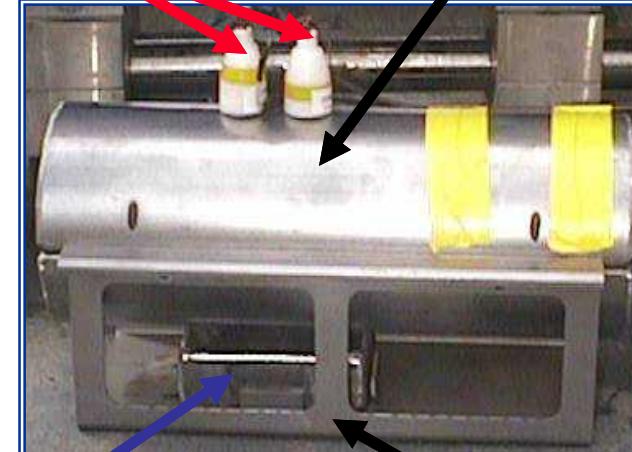


Explosive Shaped Charges and Fragment Suppression System

Linear Shaped Charge



Conical Shaped Charges



End Plates Not Shown

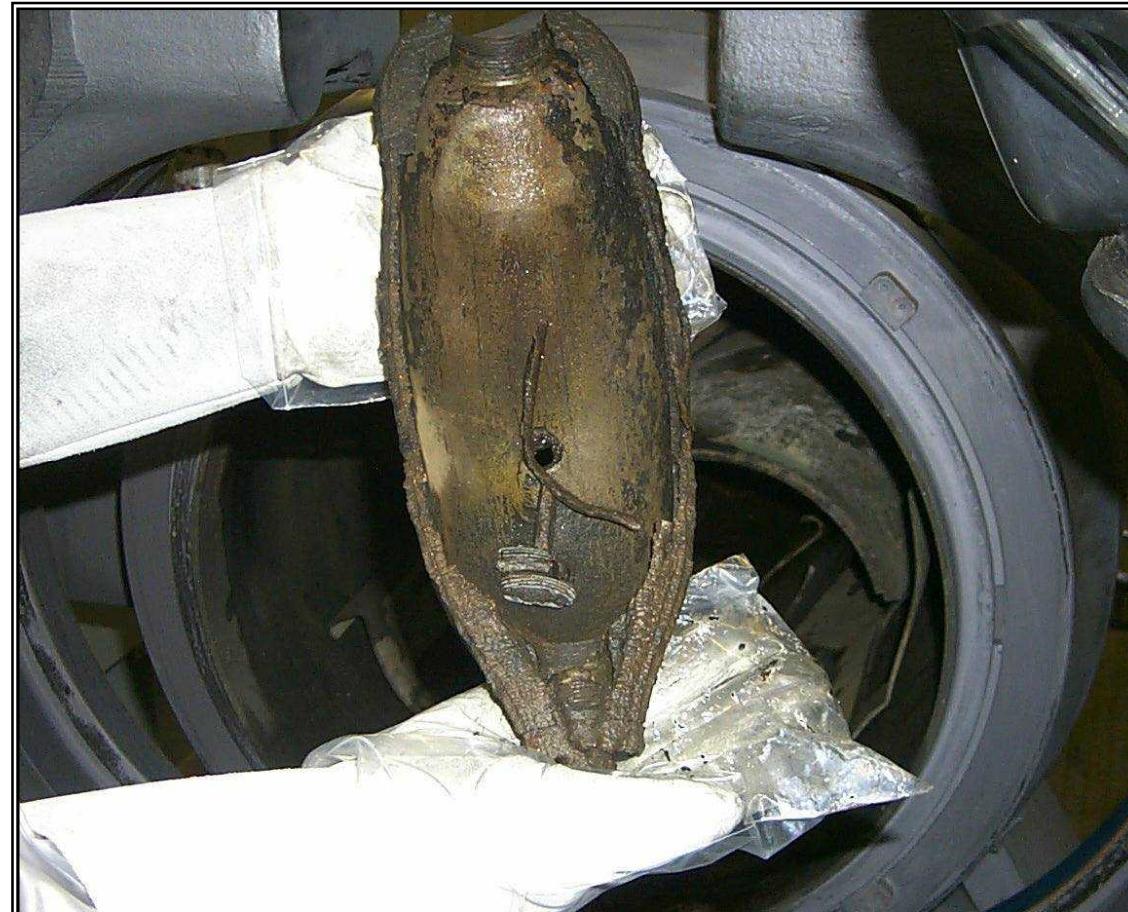
Stop Block

Cradle

- Steel shell construction
- Designed to transfer energy from small, high velocity fragments to large low velocity fragments (less than 170 ft /second)
- Also, used to align munition and shaped charges
- Disposed of as solid waste



Munition Cut with Shaped Charge





Munition processing of 4-inch CG Stokes mortar



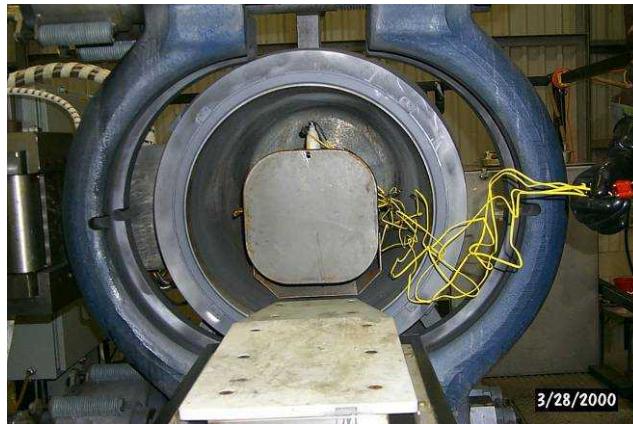
Munition in Cradle



Linear Shaped Charge



FSS and conical shaped charge



Assembly in vessel



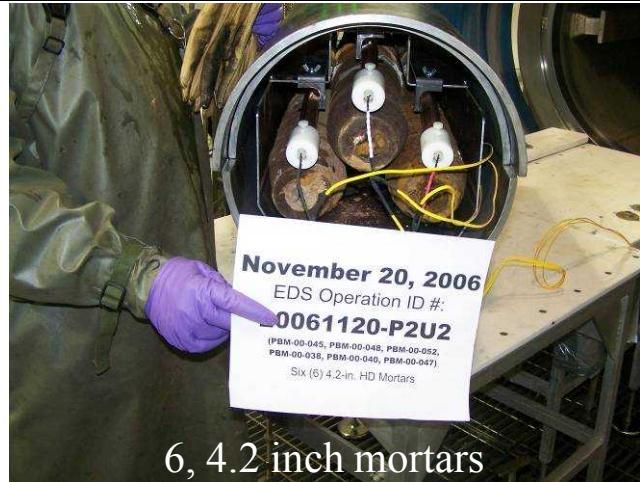
Debris after treatment



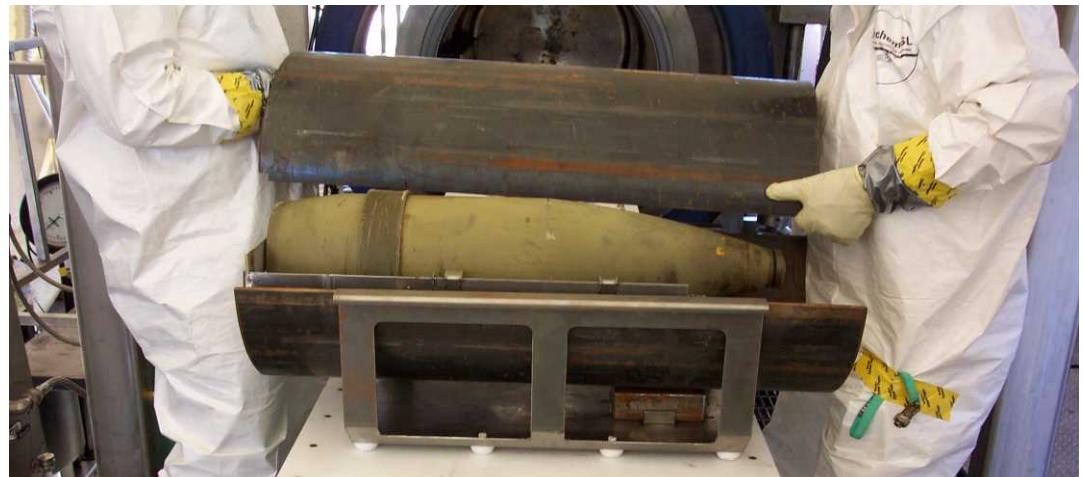
Munition fragments



EDS P2 can handle large munitions or multiple smaller munitions



155 mm artillery



8 inch artillery



EDS has destroyed over 1300 items of many types

- 75 mm projectile
- 4.2 inch mortar
- Liven projectile
- 4 inch Stokes mortar
- 4.5 inch projectile
- M139 bomblet
- 4 inch mortar
- E123 bomblet
- M60 105 mm projectile
- M125 bomblet
- 8 inch artillery
- 155 mm artillery
- 25 pounder
- German Traktor Rocket
- M70 bomb





EDS uses proven low-temperature chemistry to treat a variety of agents

Agent

H, HD – Mustard
HN-3 – Nitrogen mustard
GB – Sarin
CG – Phosgene
VX
L – Lewisite
AC – Hydrogen Cyanide
PS – Chloropicrin
DA – Dichlorophenylarsine
PD – phenyldichloroarsine
TPA – Triphenylarsine
CK – Cyanogen Chloride
CB – Chlorobenzene
Sn – Tin
RP – Red Phosphorus
FS smoke

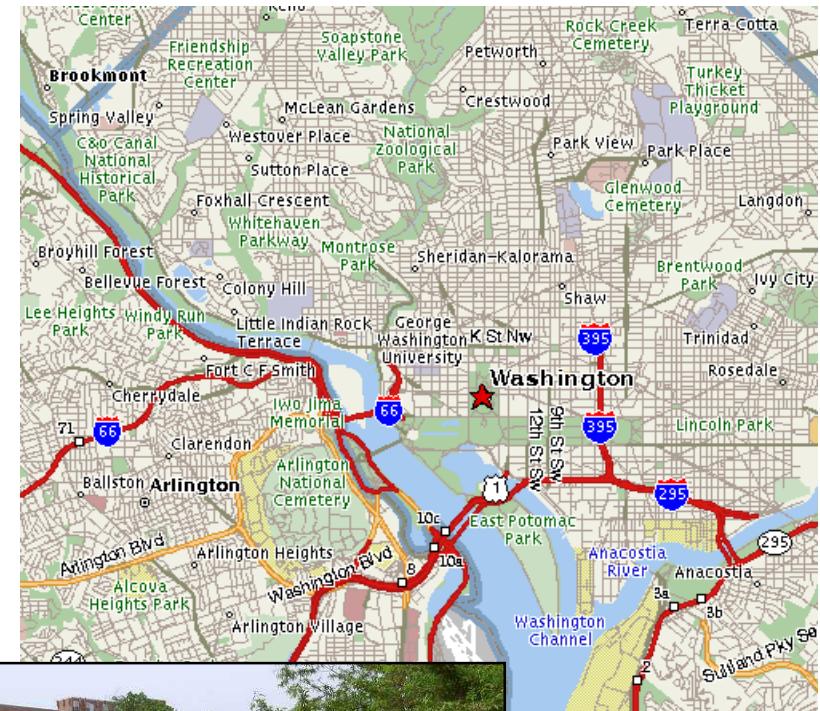
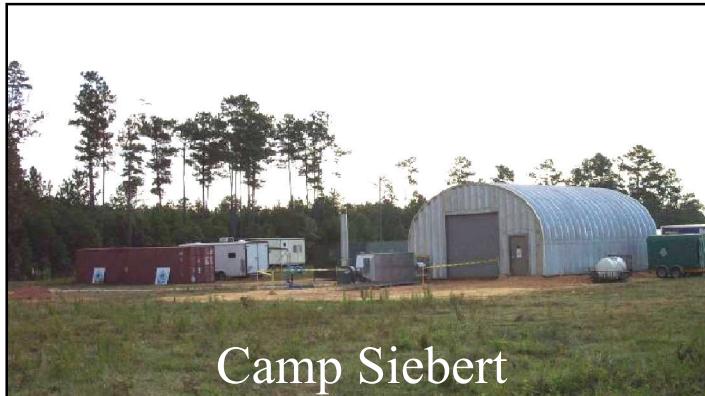
Treatment chemical

Monoethanolamine
Monoethanolamine
Monoethanolamine
Sodium hydroxide
MEA/NaOH
Sodium permanganate
Sodium hydroxide
Sodium hydroxide
Sodium permanganate
Sodium permanganate
Sodium permanganate
Sodium hydroxide
Monoethanolamine
Sodium hydroxide
Sodium persulfate
Sodium hydroxide



EDS Deployments

- Porton Down, UK
- Rocky Mountain Arsenal, CO
- Aberdeen Proving Grounds, MD
- Camp Siebert, AL
- Spring Valley, DC
- Dugway Proving Ground, UT
- Dover Air Force Base
- Pine Bluff Arsenal, AR





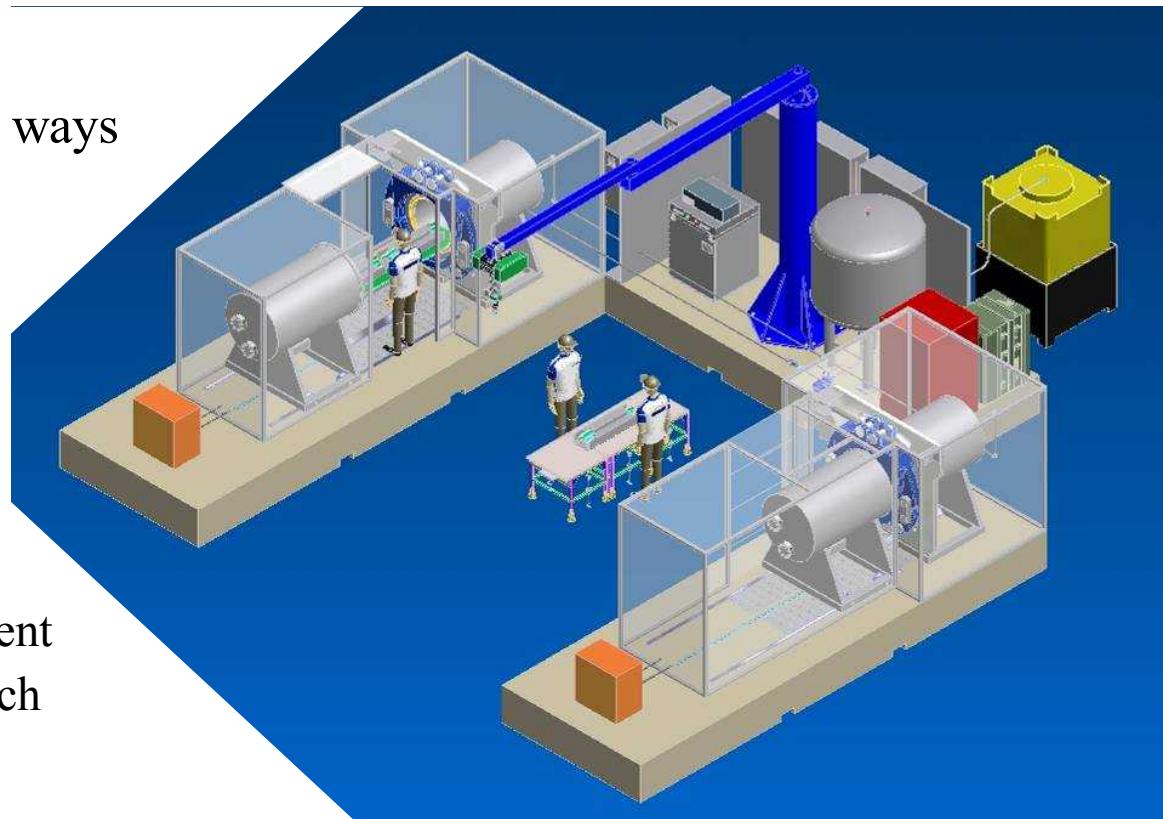
The EDS Mission has Grown

- EDS was intended to treat small numbers of munitions at the recovery sites.
- Original expectation was 1 or 2 munitions per year.
- Two EDS systems are now in continuous use at Pine Bluff to destroy ~1200 munitions.
- Future applications could require higher process rates.
- Our proposed high-throughput EDS is intended to satisfy this need



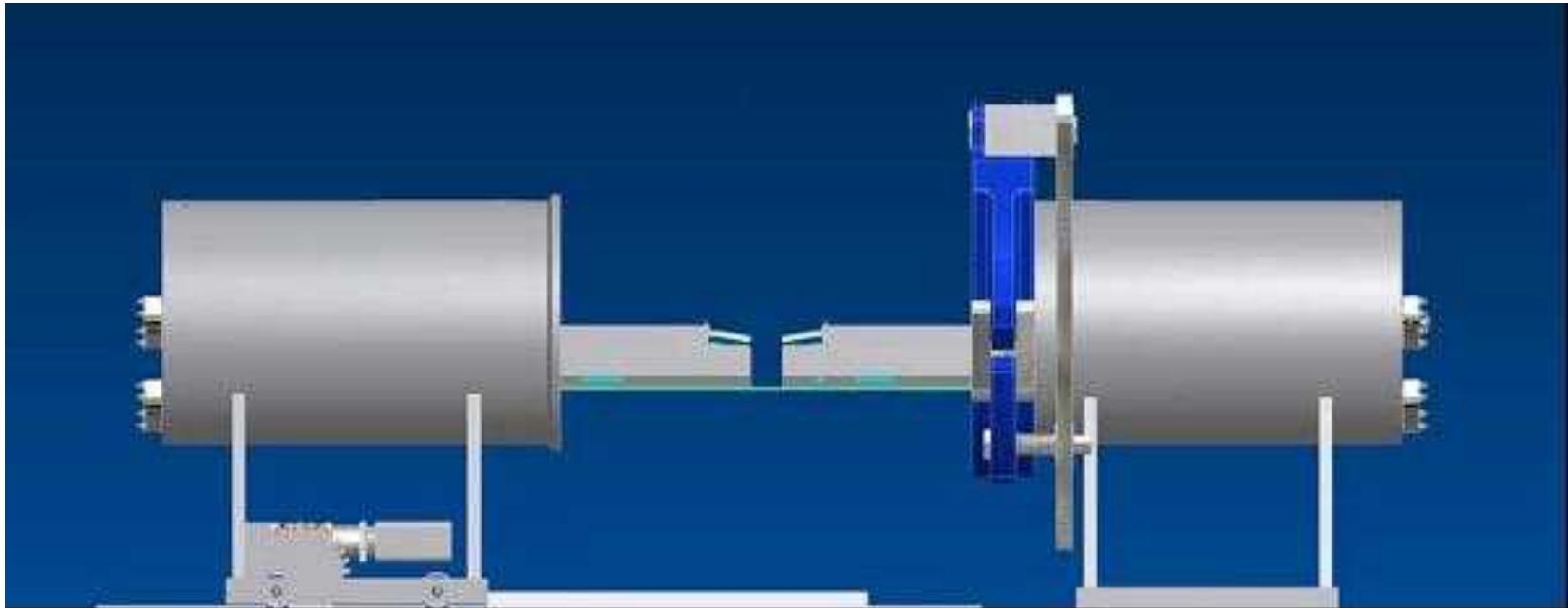
HTEDS optimizes the proven EDS technology

- Improves throughput in four ways
 - Larger batch size
 - Parallel processing
 - Semi-batch operation
 - Optimization of processes
- Maintains proven features
 - Low-temperature chemical treatment process
 - Shape charges to access agent
 - Total containment with batch operation
 - Transportability





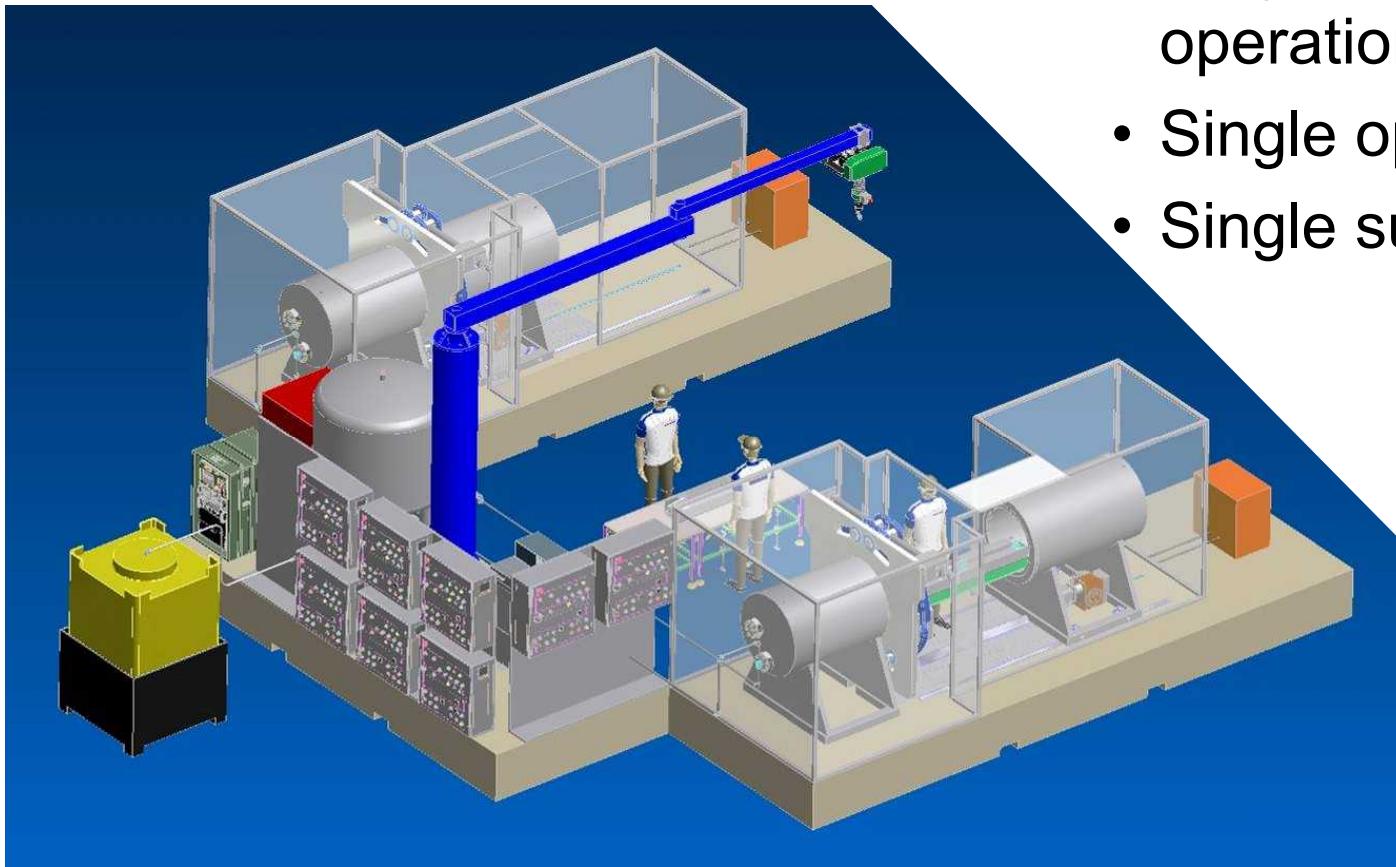
Larger vessel accommodates more munitions or larger munitions



- Twice the length of the EDS P2 vessel
- One end slides axially on rails
- Clamp and seal are in the center of the vessel



Two vessels allow parallel processing

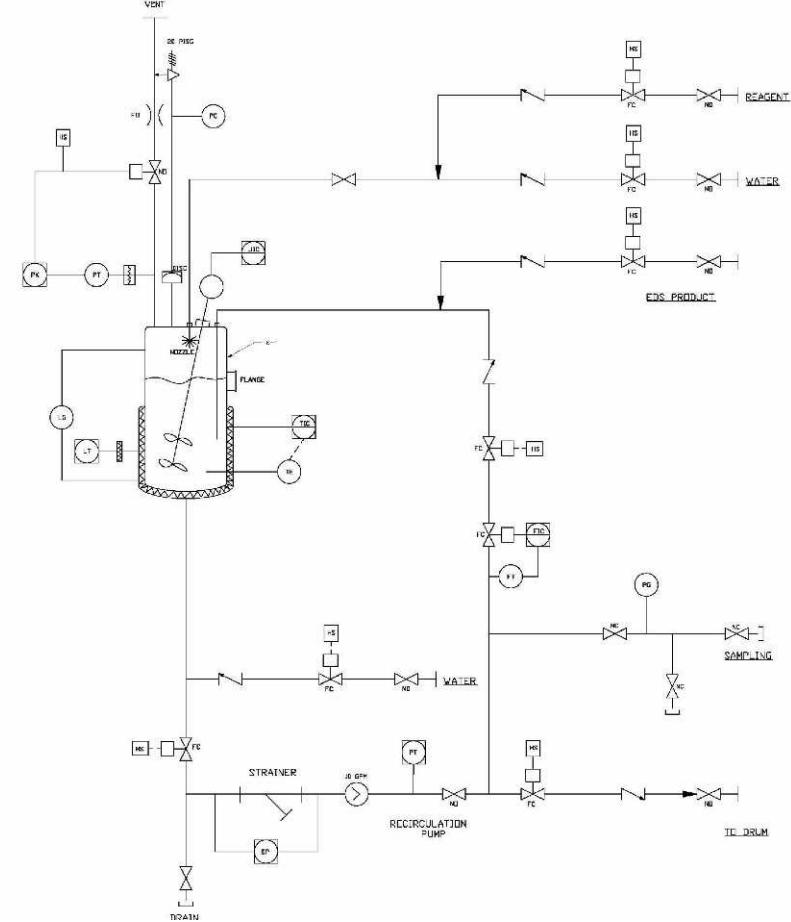


- Staggered operation
- Only one critical operation at a time
- Single operating crew
- Single support skid



Separate treatment tank for semi-batch operation

- Heated, stirred treatment tank
 - Handles entire day's operation
- Closed circulation system to wash agent from vessel
 - Canned motor pumps
 - Vapor knockdown nozzles
- Steam injection
 - Rapidly destroy heel





Process improvements

- No vessel rotation
 - Simplifies system design (no motor, slip ring, castors, etc)
 - Simplifies processing (no hoses to connect and disconnect)
 - Allows use of standard closure clamps
- Improve clamp design
 - Faster operation with less effort
 - More reliable
 - Remotely actuated
- Increase automation and remote actuate of pumps and valves
 - Frees the crew to handle the munitions
 - Decreases time in PPE
 - Decreases the chance of worker error
 - Manual operation is always a backup option



Process improvements

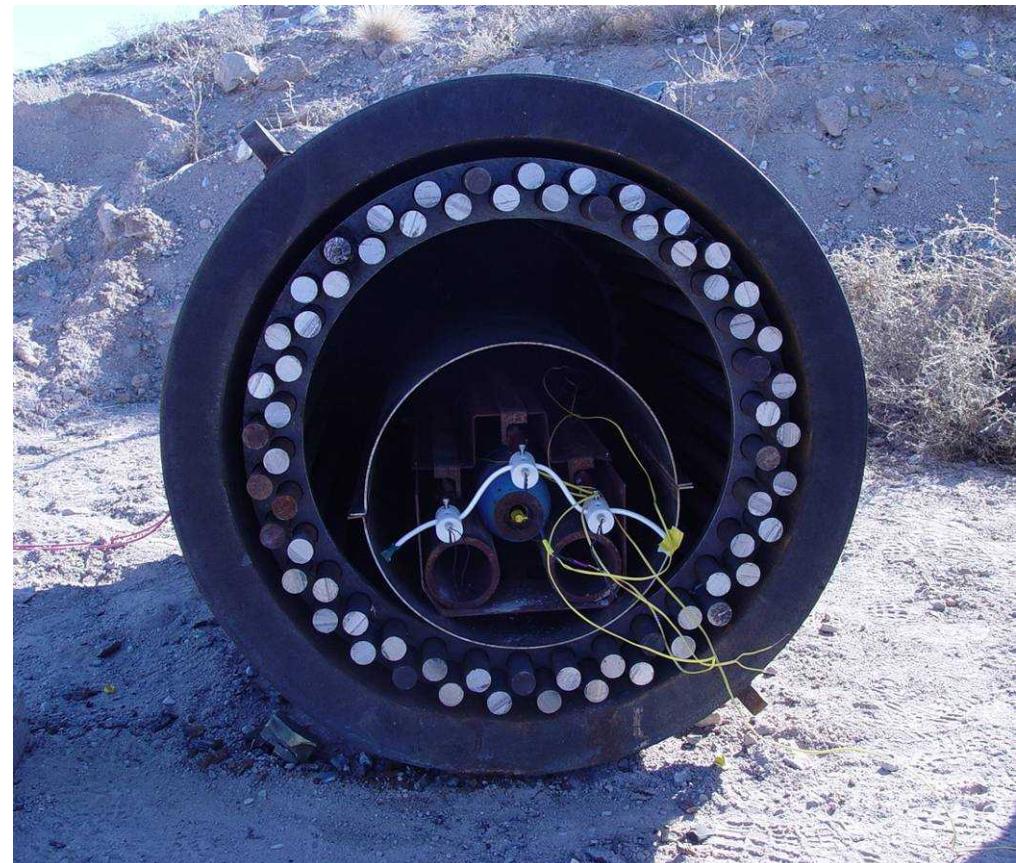
- Replace hot water rinse with steam injection
 - Faster heating
 - Eliminate long cooldown
 - May only be required at the end of the day
- Place vessels in fume hoods
 - Eliminate leak test
 - Eliminate helium flush
 - Eliminate delays for air monitoring
- No carbon filter and burst disk on drums
 - Part of treatment vessel design
- Replace wastes drums with Intermediate Bulk Container
- Improve fragment suppression system





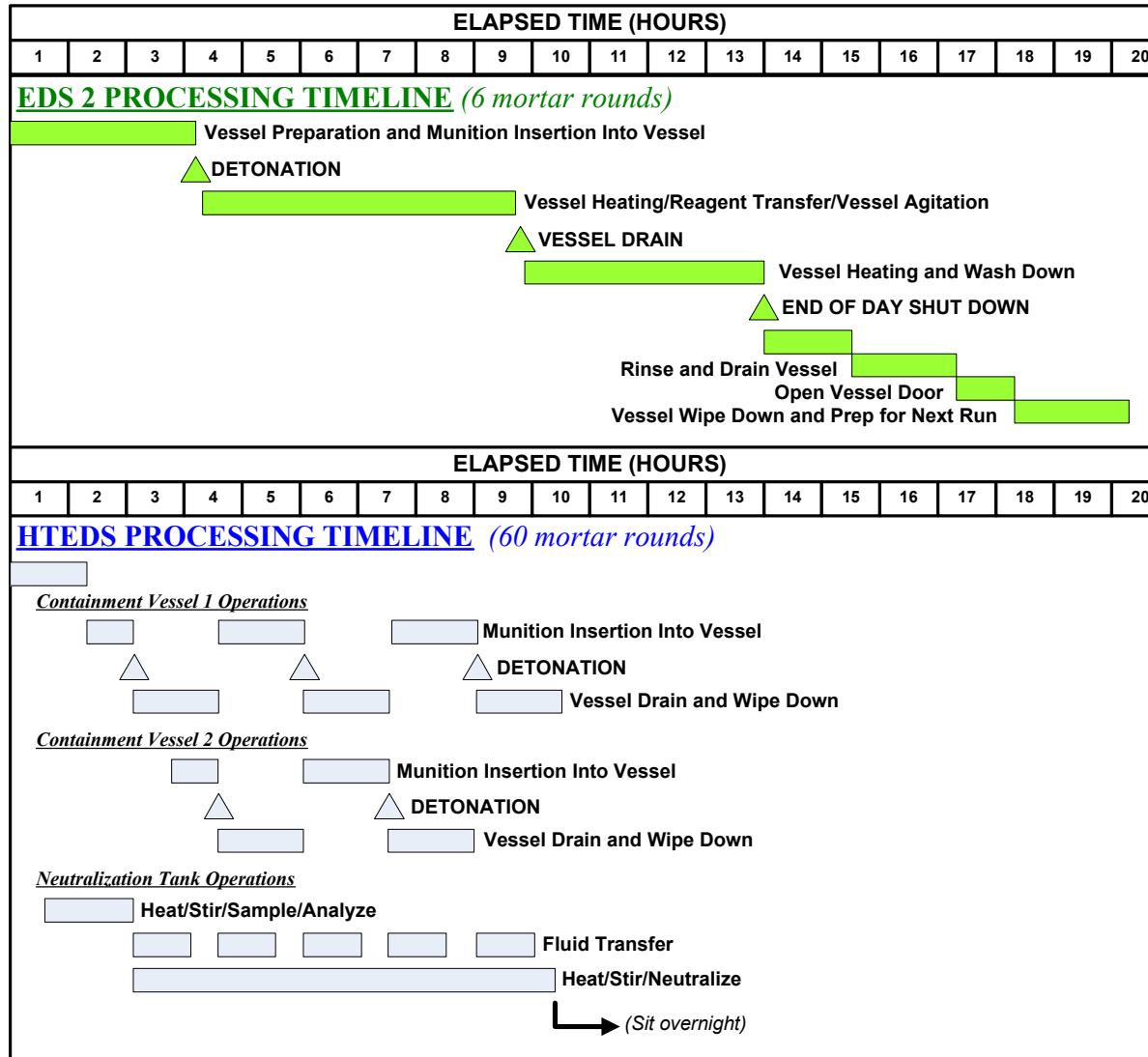
Advanced fragment suppression design

- Reduces consumable hardware and waste
- Simplifies assembly
- Provides universal design for all munitions



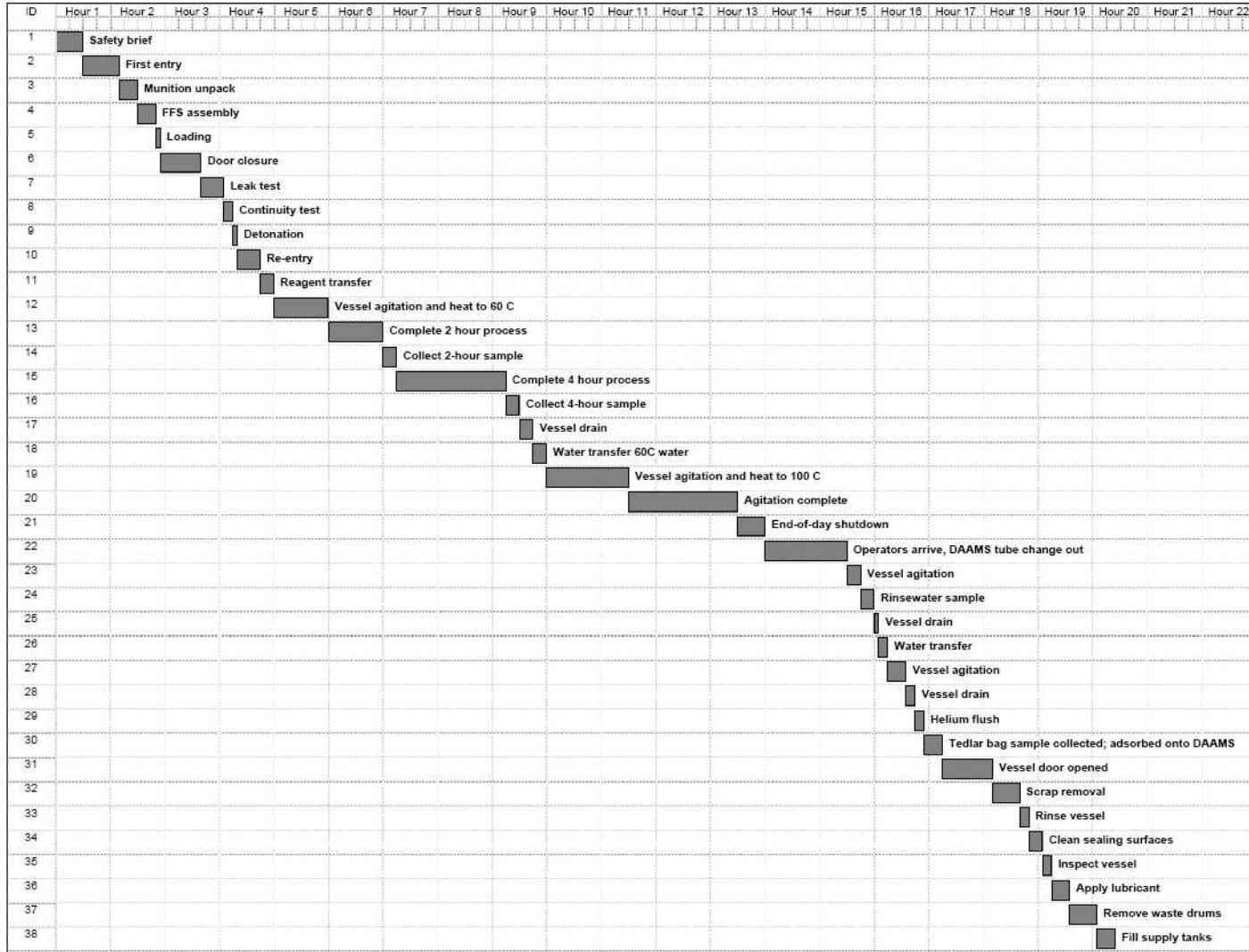


HTEDS Process Time Comparison



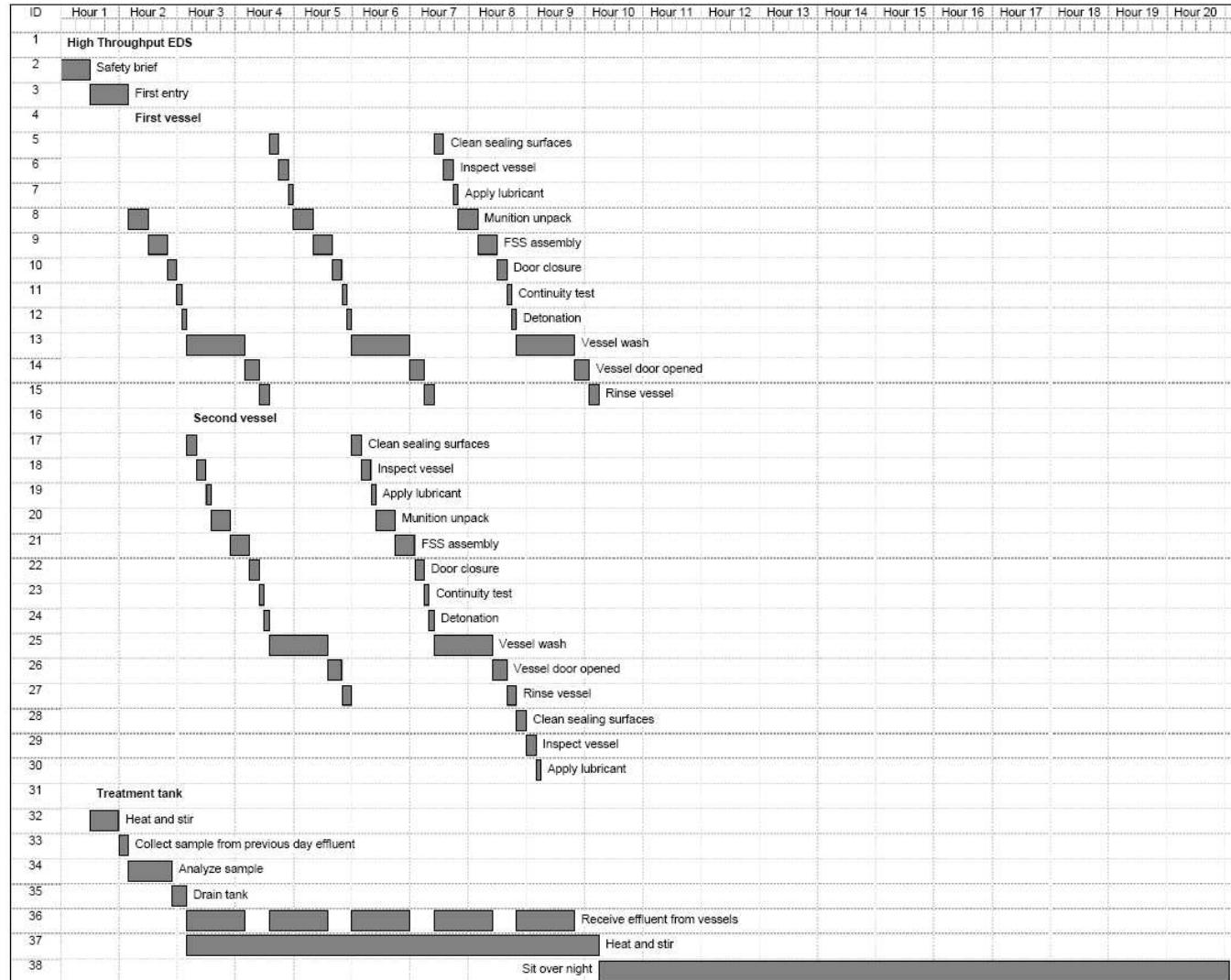


Process Time EDS





Process Time for HTEDS





Conclusions

- EDS has proven to be reliable, safe, and flexible
- The mission space has expanded dramatically
- The current limited capacity is the result of the original mission requirements
- A high throughput EDS could process up to 60 munitions per day
 - 20 fold increase in throughput;
 - Handle larger munitions;
 - Better instrumentation and increased automation;
 - Maintain transportability and ease of set-up/tear-down operations;
 - Maintain the proven explosive access and chemical treatment process that has achieved public and regulatory acceptance.





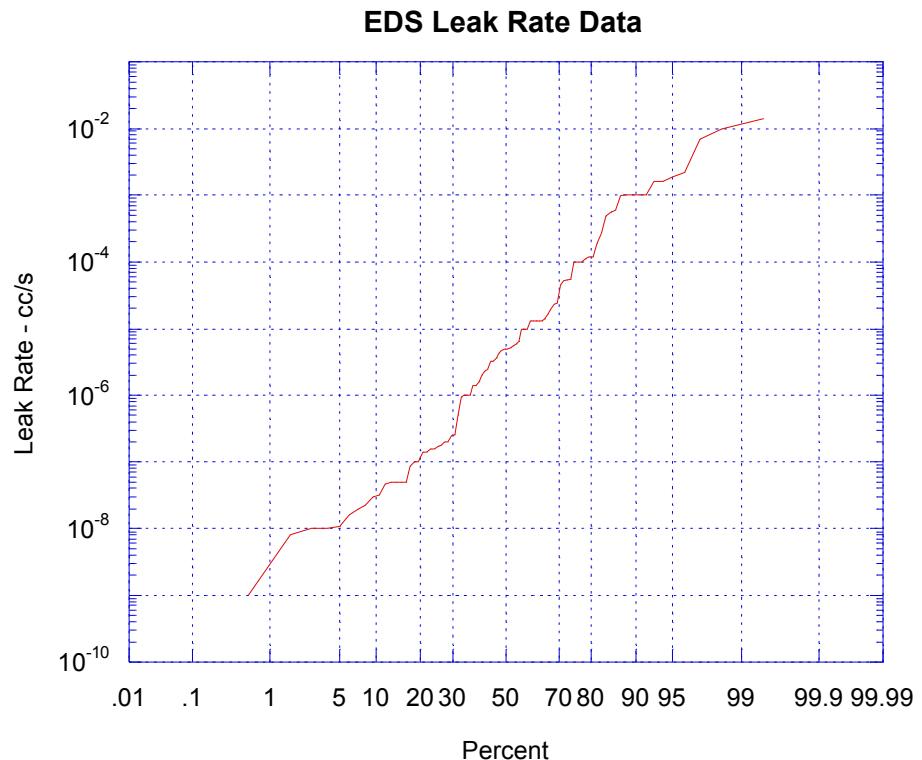
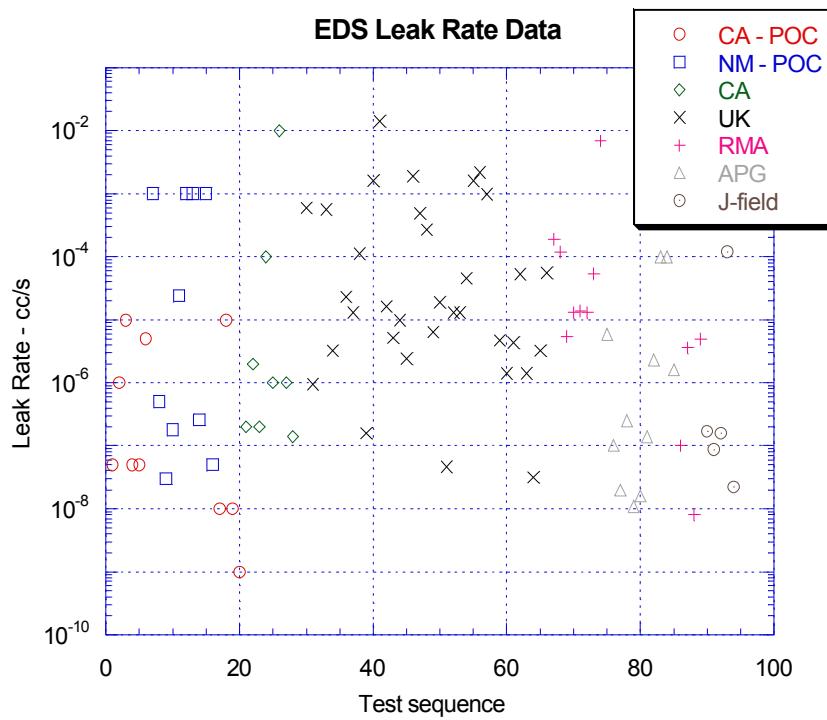
Fragment Suppression System

- Used Gurney equation to estimate average fragment velocity of ~700 ft/sec
- This is conservative because it neglects energy losses
- Used conservation of momentum to calculate velocity of fragment suppression shell
- Used a Hugoniot analysis to relate velocity to shock pressure (350 ft/sec → 30,000 psi)
- Increased the weight to provide margin of two on velocity
- Confirmed analysis with open air tests





Leak Rate Data Show Log-Normal Distribution





Detonation Improves Leak Rate

Vessel	Test	Pre-detonation	Post-detonation
P1-01	3-12-98	5×10^{-7}	3.5×10^{-7}
	3-17-98	3×10^{-8}	3×10^{-8}
	3-18-98	1.8×10^{-7}	5×10^{-8}
	3-19-98	2.4×10^{-5}	3.2×10^{-6}
P1-02	7-14-98	1.2×10^{-6}	2.6×10^{-6}
	200 gm	1.9×10^{-4}	1.8×10^{-4}
	flange	4.2×10^{-7}	3.4×10^{-7}
	1 lb	1.1×10^{-2}	2.1×10^{-3}
	flange	3.5×10^{-7}	1.5×10^{-7}
	1.25 lb	5×10^{-3}	7×10^{-4}
	flange	1.5×10^{-7}	6×10^{-9}