Selection of Alternative Particle Filtration Designs to Reduce RDX Losses in Dewatering Operations

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Holston Army Ammunition Plant (AAP) Description

- Falls under the Joint Munitions Command and is a government-owned, contractor-operated (GOCO) facility
- Manufactures a wide range of secondary detonating explosives including Research & Development eXplosive (RDX), High Melting point eXplosive (HMX), Triaminotrinitrobenzene (TATB), Nitro Triazolone (NTO), and related formulations
- U.S. Army Production Plant for Energetic Explosive Materials
Background

- Morristown 50 miles downstream of Holston Army Ammunition Plant (AAP) uses Holston River as their drinking water source
  - Center for Health Promotion and Preventive Medicine (CHPPM) determined in 2005-2006, RDX level at Morristown meets standards of <2 parts per billion (ppb)

- New municipal drinking water intake proposed for Church Hill, 5 miles downstream of Holston AAP must meet same <2 ppb RDX limit
Problem Statement

- Motivated by the newly proposed Church Hill drinking water plant, the State of Tennessee has proposed a <12.2 pounds (lbs) RDX per day discharge permit limit for Holston AAP with a 5-year implementation schedule.
- The current RDX manufacturing process sends up to 90 lbs of unrecovered (sparingly soluble) RDX per day through wastewater treatment.
- **The RDX in wastewater is lost product!**
Integrated Process Team Approach

• Apply system approach to identify problem in each phase of RDX manufacturing, including final treatment:
  – Manufacturing and Handling Operation
  – Recovery (Pollution Prevention)
  – Treatment (New Technology)
  – Integration of total operation
• Identify specific nature of the problem
• Evaluate current IWTP operations to determine efficiency of dilute, dissolved RDX removal
• Evaluate manufacturing process to determine minimization of RDX entering wastewater stream
• Evaluate additional treatment options for concentrated RDX (prior to mixing with other waste streams at IWTP)
Project Focus Area: RDX Manufacturing

Multi-pronged Approach of IPT (in GREEN)

Hexamine/Acetic Acid; Nitric Acid/Ammonia Solutions

Nitrolysis

Filter & Wash

Recover RDX?

Sewer System

Acid Recovery Concentration & Anhydride Mfg

60% Acid

Wastewater

Re-
Crystallization
(Recover Solvent)

Rede-
Watering

Product Formation

Water

Solvents

De-Watering

Reduce RDX loss

Transfer

Treat RDX

Wastewater

Discharge to River

Industrial Wastewater Treatment Plant

Transfer

Wastewater

Wastewater

Wastewater

Wastewater

Wastewater
Focus of This Presentation: Reduce RDX Loss

- **Hexamine/Acetic Acid; Nitric Acid/Ammonia Solutions**
  - Nitrolysis
  - Filter & Wash
  - Recover RDX?
  - Acid Recovery Concentration & Anhydride Mfg

- **Solvents**
  - Re-Crystallization (Recover Solvent)
  - De-Watering
  - Transfer
  - Treat RDX

- **Wastewater**
  - 60% Acid
  - Wastewater
  - Sewer System
  - Discharge to River

- **Product Formation**

**Multi-pronged Approach of IPT (in GREEN)**

- Industrial Wastewater Treatment Plant
Identify Specific Nature of the Problem

- Study to determine sources of RDX in wastewater

Solids dropping from sock probes were being washed into wastewater stream

Consensus to eliminate solids dropping onto floor

BAE Systems OSI had previously designed a modified nutsche without the problematic sock probes and tested it on a small scale with good results. They then designed two updated versions.
Dewatering Process Overview

- **Sock Filter Assembly**
- **Vacuum pump** pulling water from **Nutsche** (typically 6 in parallel)
- **Settling Tank**
- **Vacuum receiving tank**
- **Catchment Basin**
- **Flow of Filtered Water**

Floor drain system where RDX solids from floor are washed.
Design Alternatives

• 4 different alternatives are evaluated in this demonstration/validation (dem/val) project
• 2 have already been used in the RDX manufacturing process at Holston AAP
  – Design #1: Status Quo
  – Design #4: Grid Bottom with Gooseneck
• 2 prototypes were designed by BAE Systems OSI and constructed for this dem/val
  – Design #2: False Bottom Nutsche
  – Design #3: Grid Bottom Nutsche
Design #1: Status Quo

- Noted Problems
  - Non-uniform drying of RDX
  - Water heel in nutsche bottom
  - RDX solids falling to floor

- Noted Advantages
  - Familiarity with it in production
Design #2: False Bottom Nutsche

Perforated plate (filter cloth will lay on top of plate and be affixed to outside plate flange)

Bottom drain valve
Design #2: False Bottom Nutsche

- **Noted Problems**
  - Mechanics are needed to change filter media
  - Additional care needed to not damage filter when removing cake residue
  - Fines migrate to bottom

- **Advantages**
  - Larger vacuum line, and does not lift over nutsche
  - Positive seal similar to other equipment in AAP
Design #3: Grid Bottom Nutsche

Grid insert (filter cloth will lay on top of grid and be affixed to outside edge of the insert)

Bottom drain valve
Design #3: Grid Bottom Nutsche

- Noted Problems
  - Filter media seal may leak around grid insert perimeter
  - Additional care needed to not damage filter when removing cake residue
  - Fines migrate to bottom

- Advantages
  - Larger vacuum line, and does not lift over nutsche
  - Filter media change-out by operations, not mechanics
Design #4: Grid Bottom with Gooseneck
Design #4: Grid Bottom with Gooseneck

- Noted Problems
  - Additional care needed to not damage filter when removing cake residue
  - Fines migrate to bottom

- Advantages
  - Gooseneck insert will fit all existing nutsches (large cost savings driver)
  - Filter media change-out by operations, not mechanics
Designs #3 or #4: Grid Hold-down Sketch

- Clamps hold brace for securing the grid to the base of the nutsche
- Materials are all plastic
- Can be used for either Designs #3 or #4
- Allows these designs to be mechanically emptied
Design #4: Gooseneck Hold-down Sketch

- Teflon 1/8” Dia. Rope
- Kynar or Teflon Channel Assembly
- Threaded Hold Down Knob
- Kynar Tap Block 3/4-10
- (4) 1/4-20 Nylon Cap Screws
- Machined Kynar Handle 3/4-10 (stock Teflon threaded rod may be used in place of machined Kynar handle)
Qualifying Test Run

- Designs #1 & #4 already used on-site at Holston AAP
- Designs #2 & #3 prototypes manufactured and delivered
- For Designs #2 & #3, safety evaluation procedures had to be followed to allow for use of new equipment in process
  - Prototype validation and familiarization
  - Safety Team review
  - Static test run
  - Transport test run
## Qualifying Test Run in Agile Building

<table>
<thead>
<tr>
<th></th>
<th>Status quo</th>
<th>False bottom</th>
<th>Grid bottom</th>
<th>Gooseneck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Time</td>
<td>1X</td>
<td>~1X</td>
<td>~1X</td>
<td>~1x</td>
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<tr>
<td>Dewater Time #1</td>
<td>1X</td>
<td>0.9 X</td>
<td>&gt;1X</td>
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<td>Dewater Time #2</td>
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<td>0.6 X</td>
<td>&gt;1X</td>
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<tr>
<td>Dewater Time #3</td>
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<td>0.8 X</td>
<td>&gt;1X</td>
<td>---</td>
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<tr>
<td>Dewater Time #4</td>
<td>1X</td>
<td>0.6 X</td>
<td>&gt;1X</td>
<td>---</td>
</tr>
<tr>
<td>Time (Averaged)</td>
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<td>0.7 X</td>
<td>&gt;1X</td>
<td>0.5 X</td>
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<td>Determination</td>
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<td>Second Best</td>
<td>Fix Design</td>
<td>Best to Date</td>
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</table>
Qualifying Test Run Lessons Learned

- Sealing corners was difficult on Design #3 (Grid Bottom)
- O-ring vs. Gore-Tex® only seal
More Lessons Learned

- Torque requirements need to be established for flanges where top and bottom pieces are secured for Design #2 (False Bottom)

- Filter fabric restricting flow thru bottom drain; new method to secure fabric required for Design #3 (Grid Bottom)
Dem/Val Testing

- Phase I: Evaluate RDX Dewatering Efficiency
  - Evaluate moisture removal
  - Evaluate processing time to dewater RDX batch
  - Evaluate RDX concentration reduction in water (yield)
  - Evaluate quantity of RDX solids falling to floor/ending up in wastewater
  - Evaluate additional dewatering after transport
  - Evaluate time to dewater RDX per pound of material
  - Evaluate uniformity of dewatering within locations in the cake (corners vs. middle, and top vs. bottom)
Dewatering Test Setup
Dewatering Test Setup
## Dewatering Results

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
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<tbody>
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<td>Feed Time</td>
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<tr>
<td>Feed Weight</td>
<td>Insert data…</td>
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<td></td>
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<tr>
<td>Vacuum Pressure</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Solids Lost</td>
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<tr>
<td>Dewatering Time</td>
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<tr>
<td>Product Weight</td>
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<td>Insert data…</td>
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<tr>
<td>Product Moisture</td>
<td></td>
<td>Insert data…</td>
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<td>Insert data…</td>
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</tbody>
</table>
Dem/Val Testing (continued)

- Phase II: Assess Operations and Maintenance Impacts
  - Estimate quantity of water used in floor cleanup
  - Estimate quantity of water used in sock probe hydraulics
  - Determine optimal dewatering time
  - Determine impacts to next process steps (drying time)
  - Determine time to filter fouling
  - Determine filter’s useful life
  - Assess impacts to vacuum pump
  - Other Operations and Maintenance (O&M) impacts (as determined during testing)
## Pugh Matrix for Nutsche Study

<table>
<thead>
<tr>
<th></th>
<th>Status Quo</th>
<th>Gooseneck</th>
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<th>Grid bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moisture Level</strong></td>
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<tr>
<td><strong>Time-to-Dry</strong></td>
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<tr>
<td><strong>Pound of RDX</strong></td>
<td>Insert data…</td>
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<td></td>
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<tr>
<td><strong>RDX on Floor</strong></td>
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<tr>
<td><strong>Downtime for Maintenance</strong></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Filter Cleaning Time</strong></td>
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<td></td>
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<tr>
<td><strong>Shoveling Time</strong></td>
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<tr>
<td><strong>Normalized Cost</strong></td>
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<td>Insert data…</td>
<td></td>
<td>Insert data…</td>
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</table>
Outcomes

• Due to testing, Designs #X, #Y, and #Z will provide a more uniform dewatering of RDX and possibly reduce the time required for dewatering and drying

• If one of the new nutsche designs is implemented:
  – Water savings will be realized by eliminating the hydraulic lifts for the sock probes (estimated at 6,000 gallons per day per building) and also in housekeeping operations to clean up RDX from the floor
  – Lower wastewater volume, which should have an additional cost savings to Holston AAP
  – Lower concentration of RDX in wastewater stream

• Selected Design ---
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