Twin Screw Extruder Processing of MTV Based IR Decoy Compositions

14th Continuous Mixer and Extruder Users Group Meeting
11-12 October 2006

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Distribution Statement A:

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Background

- **Magnesium/Teflon/Viton (MTV) Flares**
  - **Proven Countermeasures Against Heat Seeking Missiles**
  - **Utilized by Helicopters and Fixed Wing Aircraft**

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Impetus for Change

- **High Solvent Usage Relative to Product**
  - **100 pound Coacervation Coating Mix**
    - **210 pounds n-Hexane**
    - **40 pounds of Acetone**
- **Environmental HAP Requirement**
  - **Law Signed by EPA in 2003**
  - **By May of 2008**
    - **Pollution abatement to reduce emissions by 95%**
    - **Or Reduce emissions to less than 5 tons per year**
- **Production Incidents**
  - **20 Since 1989, 8 Fatalities, 19 Injuries**
  - **Most Recent-February 2003**

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Approach

- **Demonstrate MTV Continuous Mixing process Utilizing a Twin Screw Extruder**
- **Acquire & Install TSE Capability at NSWC Crane**
- **Define and Implement Process Improvements**

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Demonstration

- **Contract with ATK Thiokol**
  - **58-mm Twin Screw Extruder**
  - **Produced 300 pounds of MTV**
    - **3 burn rates**
  - **Over 90% Solvent Reduction**
    - **Eliminated n-Hexane**
    - **Reduced acetone by 50%**
  - **Similar Sensitivity**
  - **Decoy Flares Passed Normal Qualification Testing**

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NSWC Crane Capability

- **B&P 40-mm TSE**
  - **Co-rotating**
  - **Vertically Split Barrel**
  - **Segmented Elements**
- **Brabender Loss in Weight Feeders**
- **In Line Granulator**
- **PLC/Wonderware Controlled**
- **Site Approved for 150 lbs of 1.3**

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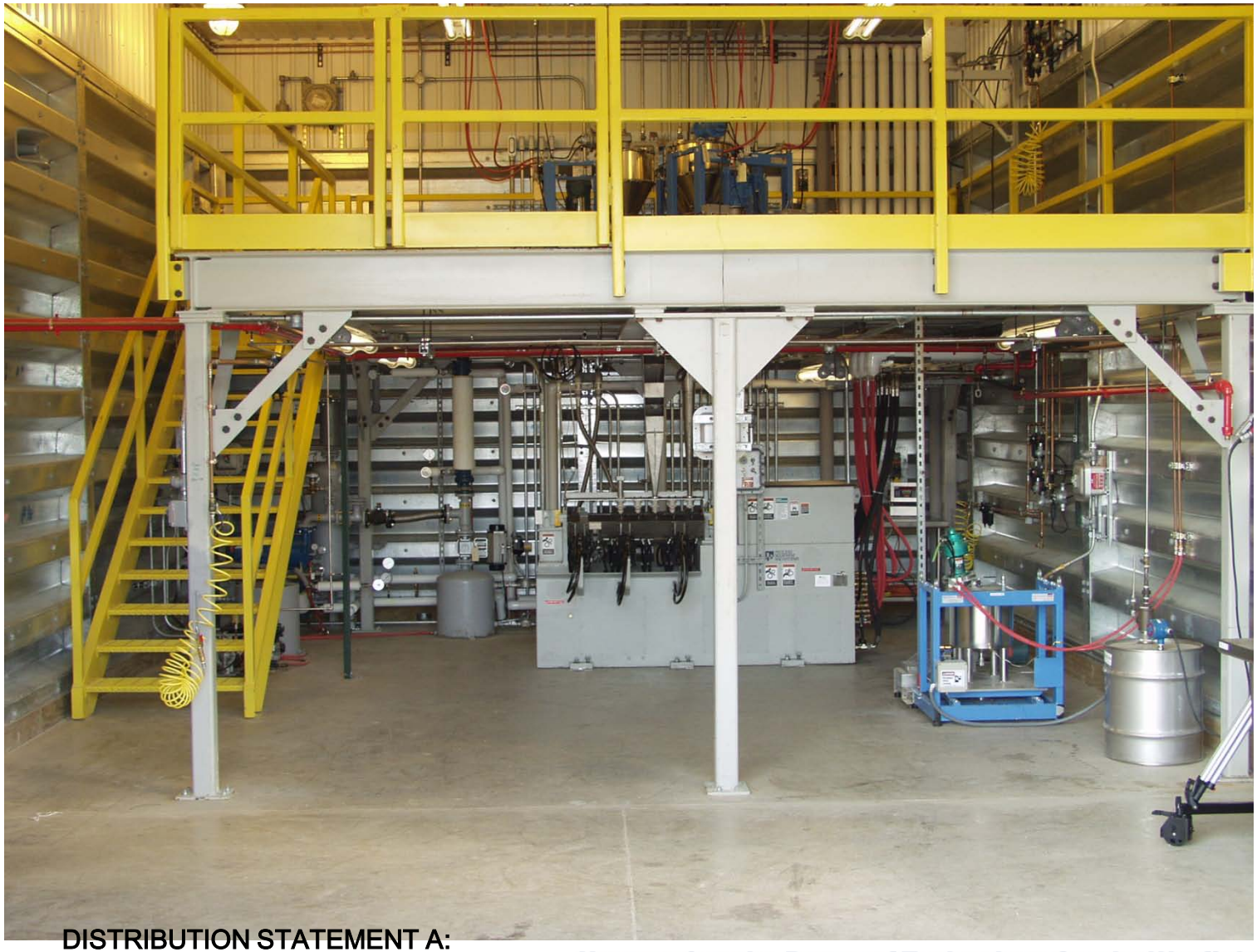
NSWC Crane Facility



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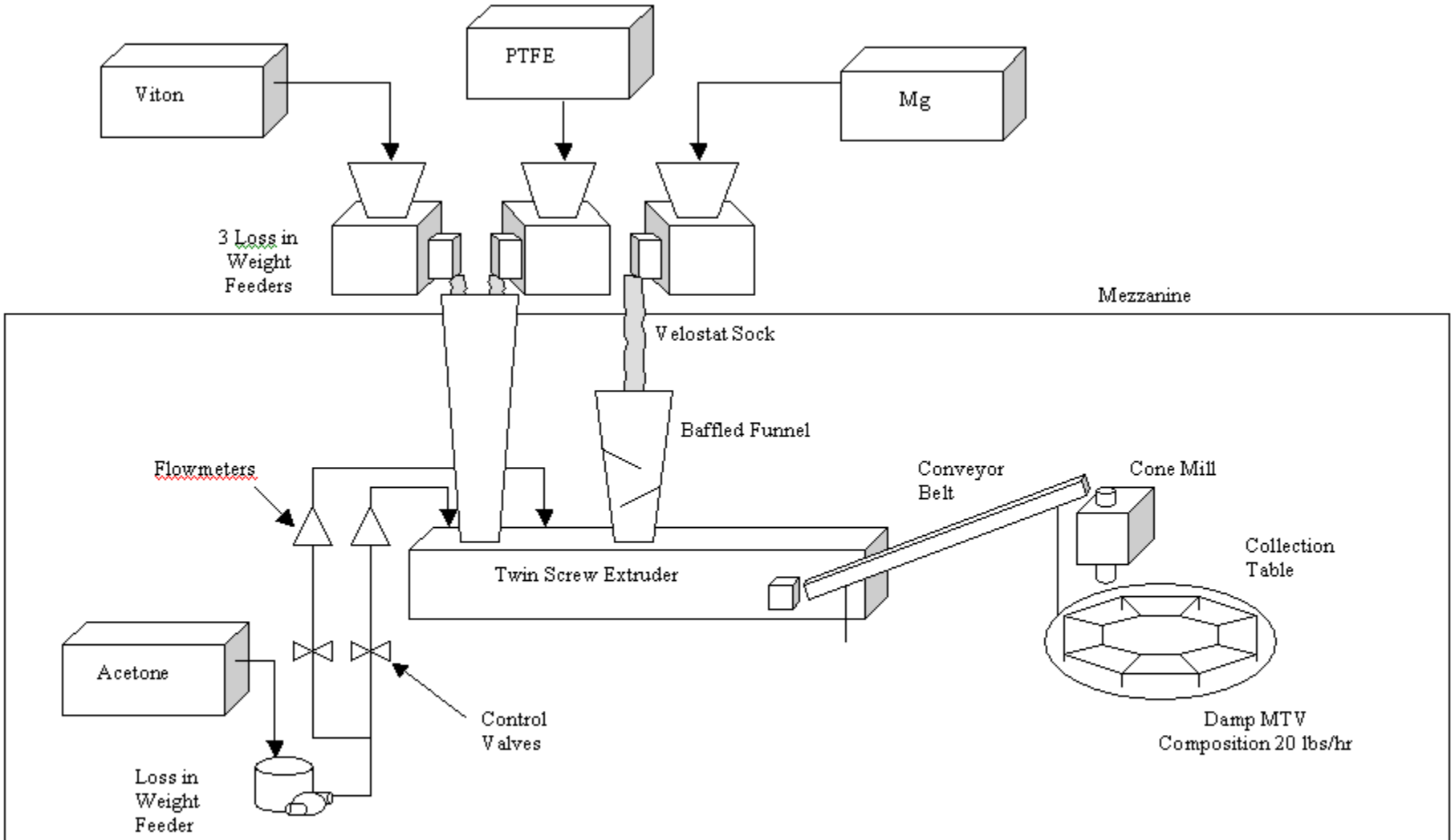
Facility Configuration



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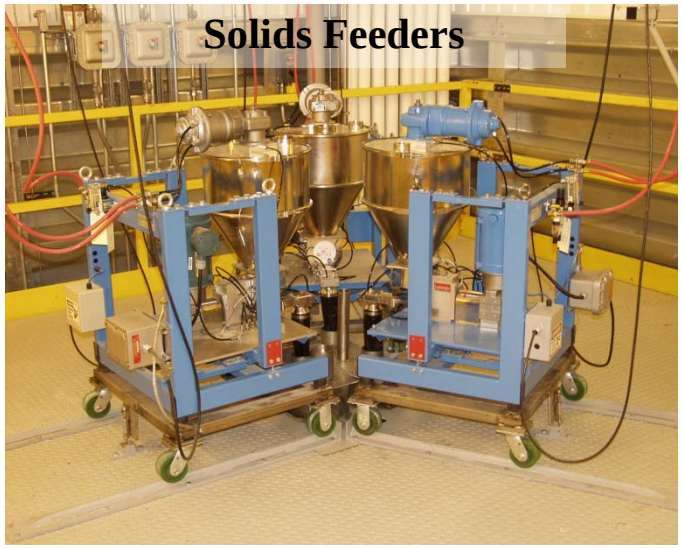

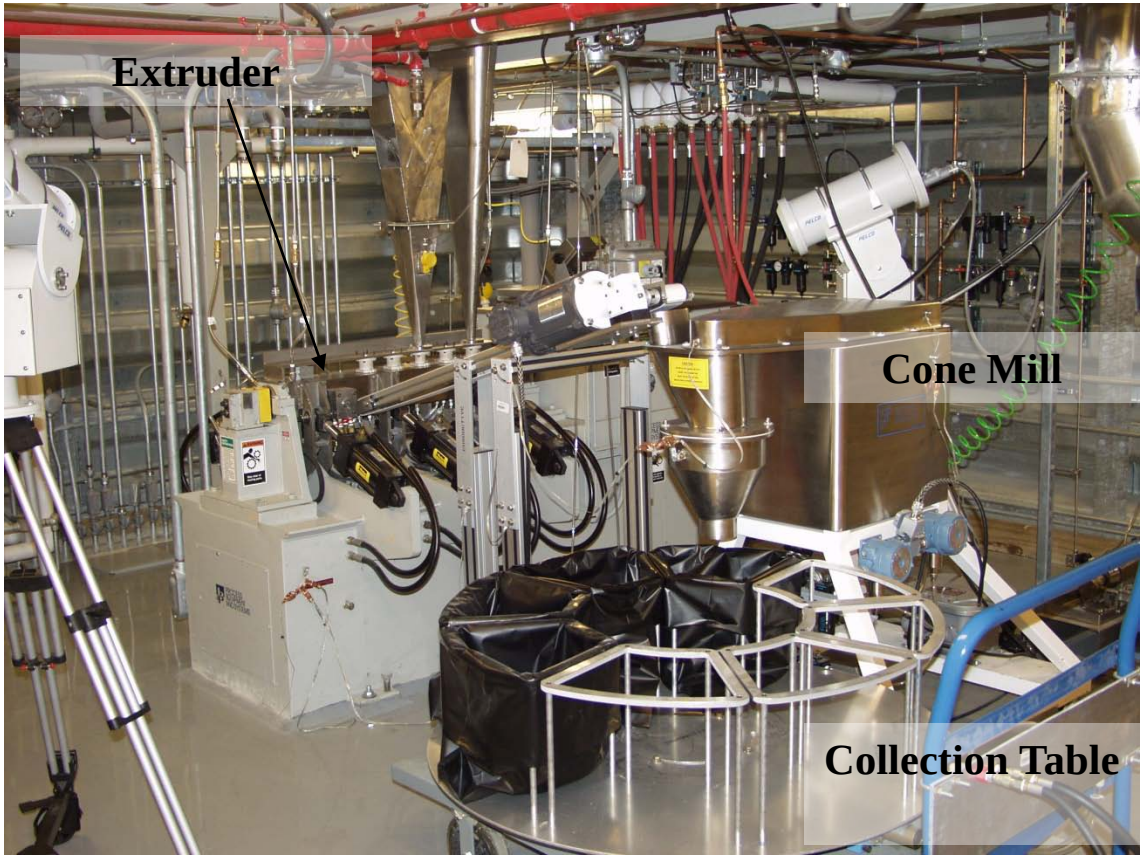

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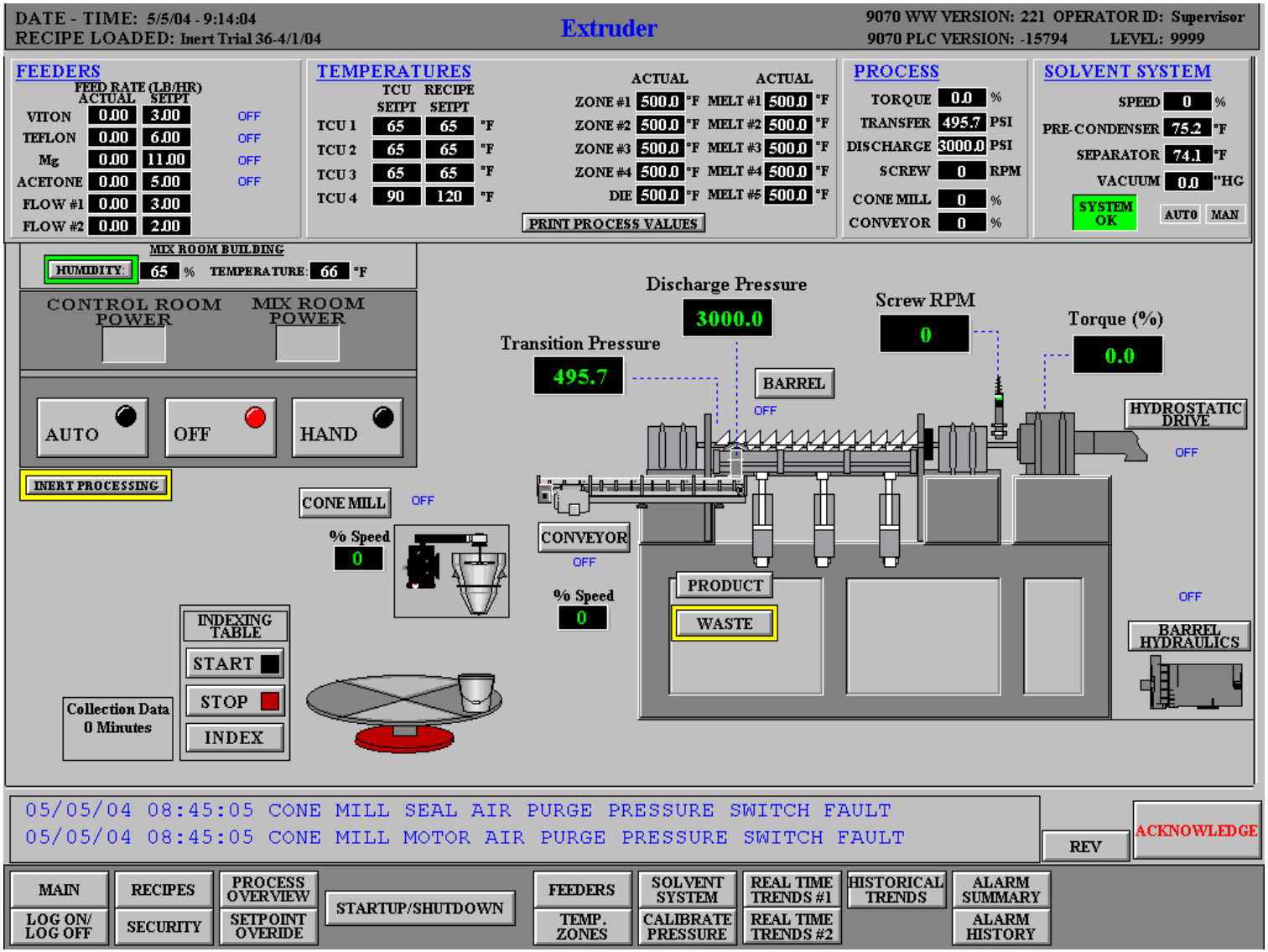
Wonderware Control Screen



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Pre-Live Work

- **37 Inert Trials Established:**
  - **Manufacturing Parameters**
  - **Downstream Process Equipment**
  - **Operating Procedures and Checklist**
  - **Data for Safety Approval**
- **Comprehensive Safety Analysis Completed:**
  - **Findings of Interest**

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Findings of Interest

- **Grounding/Bonding Analysis**
  - **All Process Equipment must be Grounded to less than 1 ohm**
  - **Vertical Agitators and Feed Screws were not Properly Grounded**
- **ESD Analysis**
  - **Step by Step Analysis using a Digital Stat Arc 2 Model 282 Fieldmeter (Monroe Electronics)**
  - **Teflon**
    - **Loading of Feeders**
    - **Purge Teflon Funnel with Nitrogen**

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Findings of Interest (cont.)

- **Material Hazards Analysis**
  - **Collection Configuration and Confinement**

VS

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Material HA Background

- **TSE Facility**
  - **C/D 1.3 Facility (150 lb limit)**
  - **Constructed to contain hazards of 37.5 lbs of C/D 1.1 Material**
  - **Continuous Process, <u>but</u> batch collection**
- **MTV Composition**
  - **Wetted Composition – C/D 1.3 Material**
  - **Dry Unconsolidated Composition–TNT Equivalency**
    - **Treated as 4:1: 4 lbs MTV ≈ 1 lb TNT**
    - **UK's Royal Armament Research and Development Establishment (RARDE)** DDESS 1980

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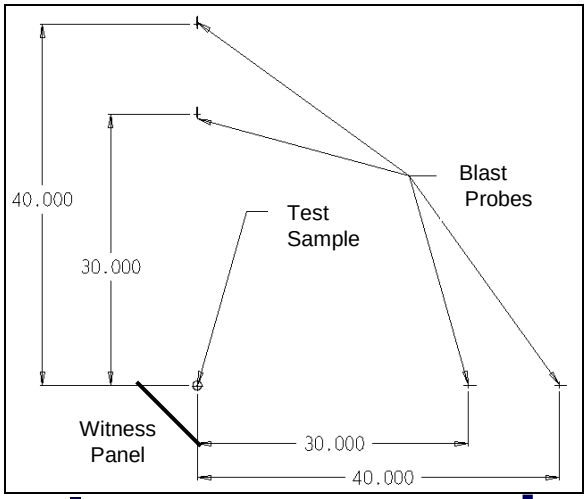
Test Setup



- **Instrumentation:**
  - **Blast Probes**
  - **High Speed Video**
  - **Standard Video**
- **Ignition**
  - **M-100 Electric Match**
  - **From top**

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Test 2 Results-Steel Can

- **22.5 lbs Composition**
- **15% Acetone Wetted**
- **Burntime: 13 Seconds**
- **No audible report**
- **Heat induced response of pressure transducer**

Similar Results for:

20% Wetted (23 Second BT for 11 lbs)

10% Wetted (9 Second BT for 22.5 lbs)

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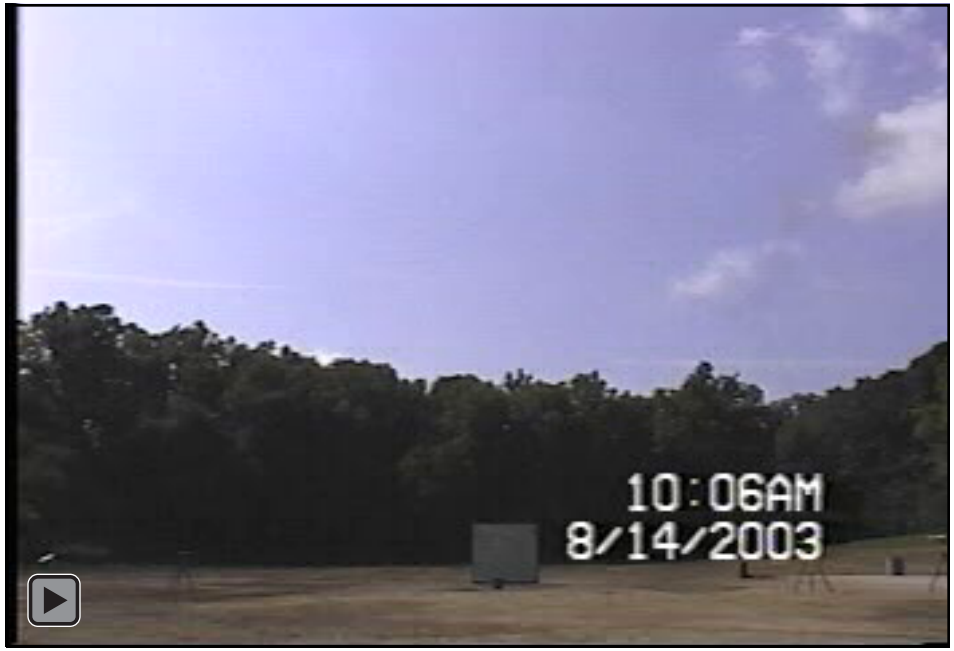
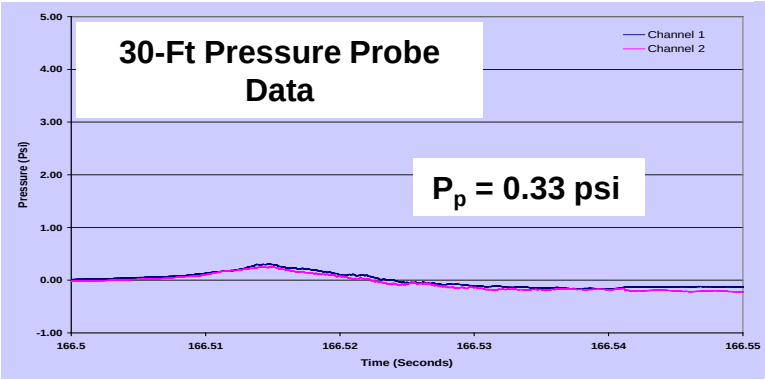
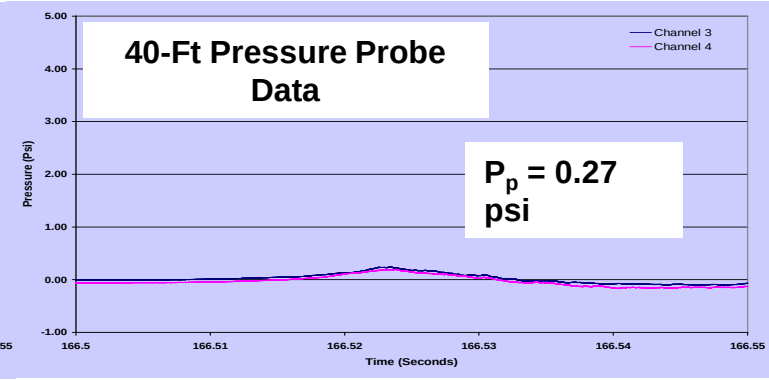
Test 4 Results-Steel Can



- **22.5 lbs Composition**
- **5% Acetone Wetted**
- **Burntime: ~ 0.5 Second**
- **audible report**
- **Measurable pressure wave**





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Test 5 Results-Steel Can

- **22.5 lbs Composition**
- **Dry**
- **Burntime: ~ 0.3 Second**
- **Loud audible report**
- **Significantly more vigorous than wetted composition**
- **Batch can fragmented**
- **Witness panel deformed**
- **Significant pressure wave recorded**

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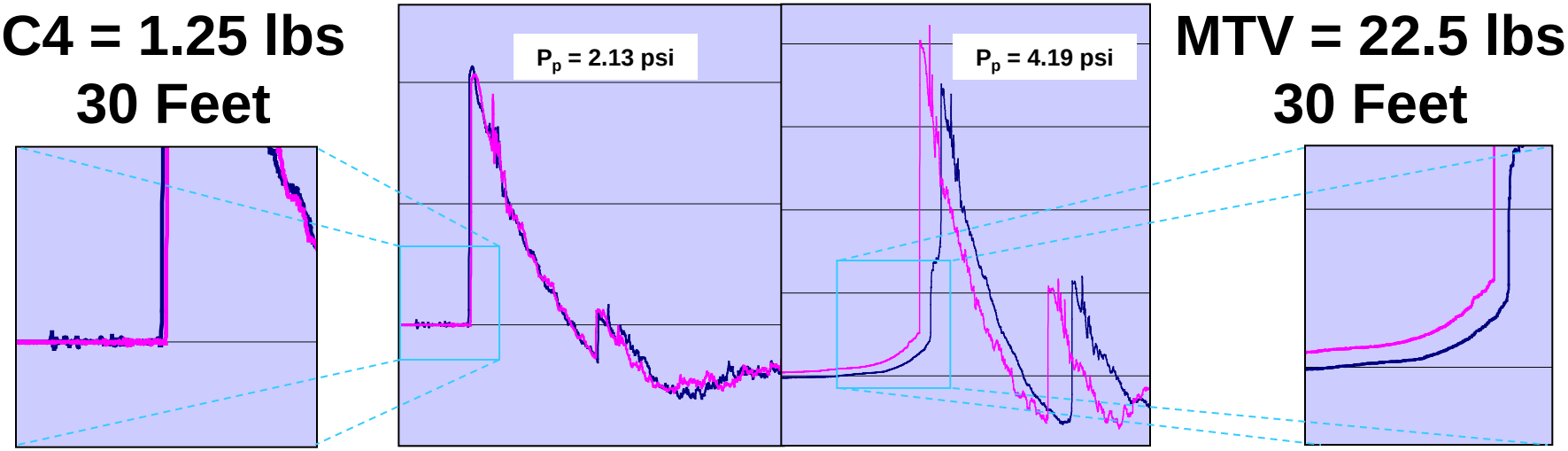
C4 vs Dry Confined MTV

C4 = 1.25 lbs
30 Feet

MTV = 22.5 lbs
30 Feet



- **Instantaneous steep slope**
- **Detonation wave**

- **Gradually increasing slope**
- **"Shocking Up" to steep slope consistent with a detonation**
- **Temperature induced**

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Test 6 Results-Paper Can

- **22.5 lbs Composition**
- **Dry**
- **Minimal Confinement**
  - **Paper Cylinder**
  - **Shape Consistent with Steel Can**
- **Burntime: ~ 1 Second**
- **No audible report**
- **Pressure wave recorded – temperature response only**
- **Less severe than reaction confined in batch can**

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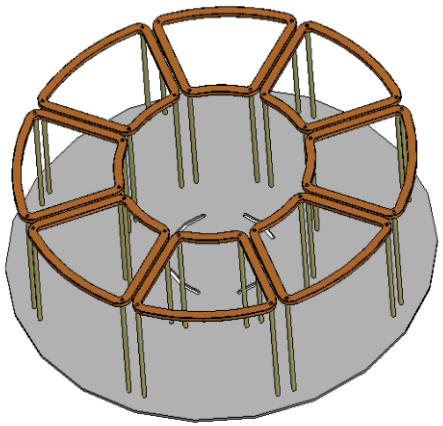
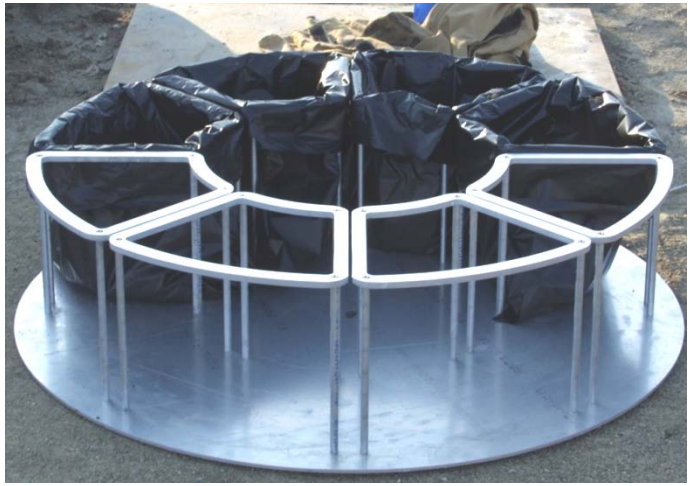
Redesigned Collection Table





- **Frames support Velostat™ bags**
  - **Reduces confinement of composition**
- **Test 9:**
  - **75 lbs comp. total**
  - **Eight Velostat™ Bags**
    - **Four with 18.75 lbs comp. per bag**
    - **Four with equal volume of sand**
  - **Ignition in Center Bag**

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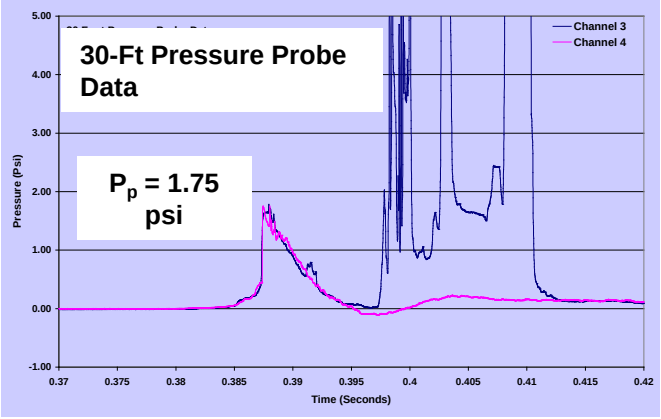
Test 9 Results - Modified Table



- **Large fireball ~ 20-ft diameter**
- **Loud audible report**
- **No fragments**
- **Significant pressure wave recorded**
- **Ignition Transfer in approximately 10 msec**
- **Undesirable result~1.1 material**
- **Need to test TSE MTV at processing conditions**

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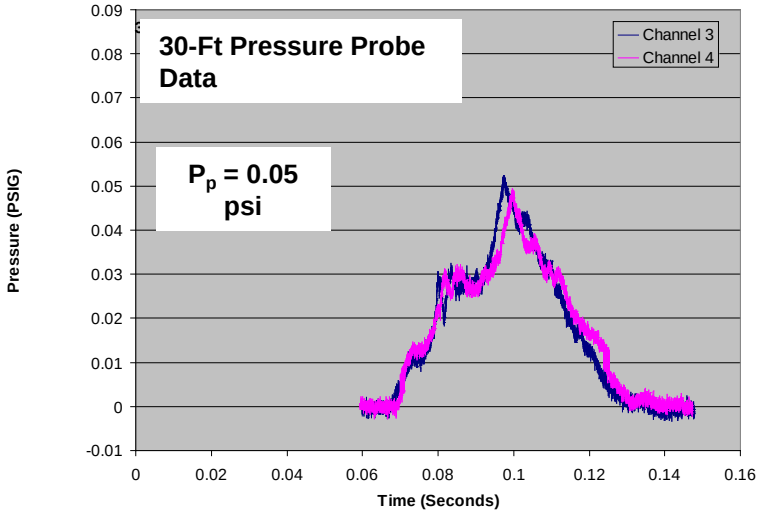
Tests #10 & 11– 37.5 Pounds TSE Processed MTV

- **2 Bags of 18.75 lbs/Bag, TSE MTV**
- **Actual Measured Wetness: 3.7% & 4.9%**

- **Pressure Data:**
  - **Low Peak Pressure**
  - **Temperature induced Response**
  - **Not Characteristic of Detonation**

Test #12 – 75 Lbs TSE Processed MTV

- **4 Bags of 18.75 Lbs/Bag**
- **Measured Wetness 4.9% (Average)**
- **Pressure Data**
  - **Low Peak Pressure**
  - **Not characteristic of a detonation**



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Material HA Conclusions

- **MTV Loose Powder Reaction not Classic Detonation, but**
  - **May generate substantial overpressure**
  - **Confinement increases reaction rate and severity**
  - **Solvent wetness slows reaction**
- **TSE Processing parameters not likely to produce a substantial pressure wave upon accidental initiation (up to 75 lbs)**

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Findings of Interest (cont.)

- **Operator Protection**
  - **Full Flame Suit**
  - **High Speed Deluge System**

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High Speed Deluge System

- **Water Discharge under 50 ms**
- **240 Gallon Pressure Tank**
- **2 UV/IR Detectors**
- **8 Nozzles**
- **Provide Water Barrier**

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Live Processing

- **Received Approval for Live Processing**
  - **2 March 2005**
- **361 pounds MTV Produced to Date**
  - **28 Live Processing Trials**
  - **Burn rates ranged from 4 to 24 sec/in**
- **Similar Sensitivity**
- **Provided 160 pounds Composition to Ongoing Decoy Flare Improvement Effort**
  - **Testing will Qualify TSE Process as Alternate Production Process**

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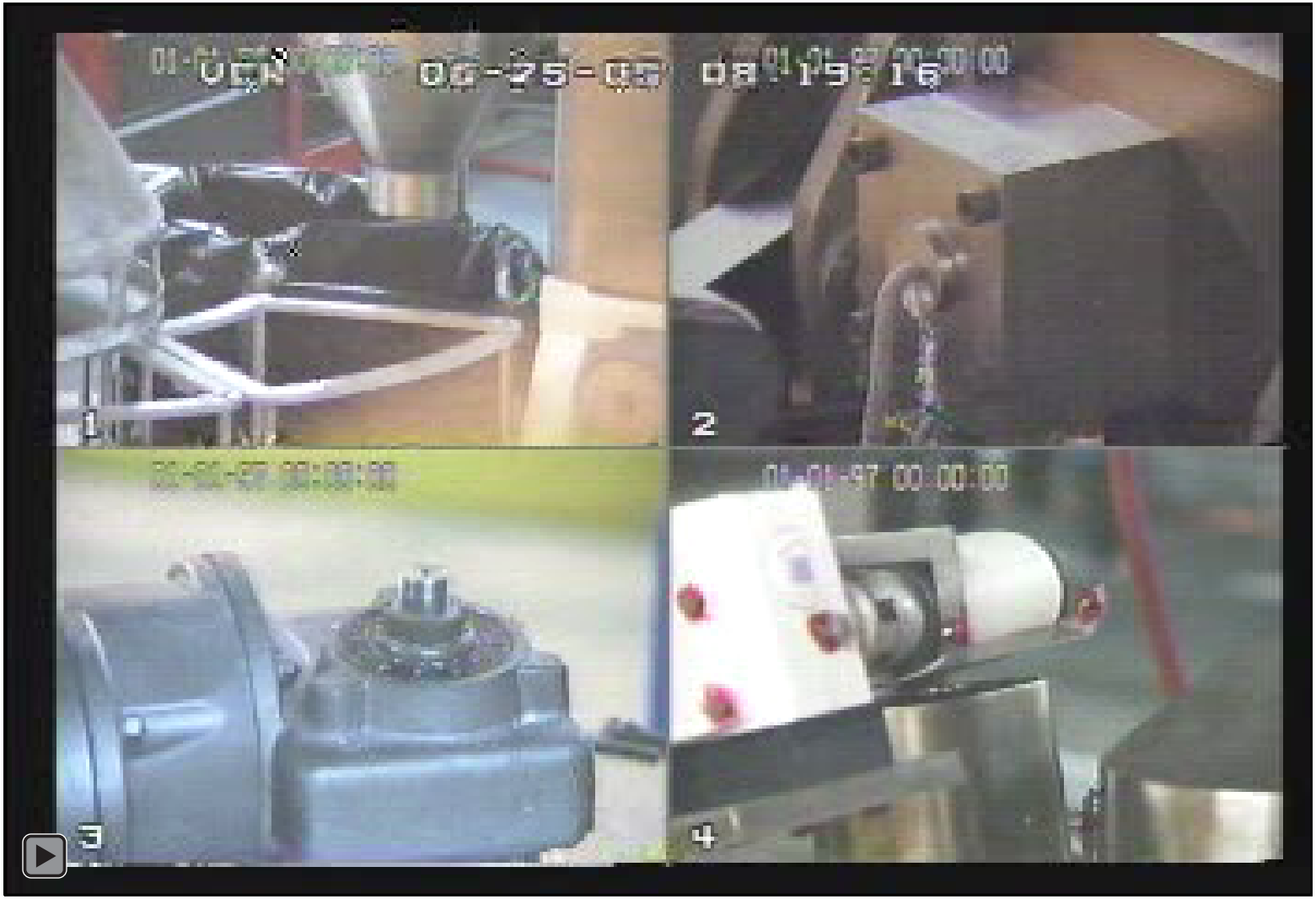
Extended Runs

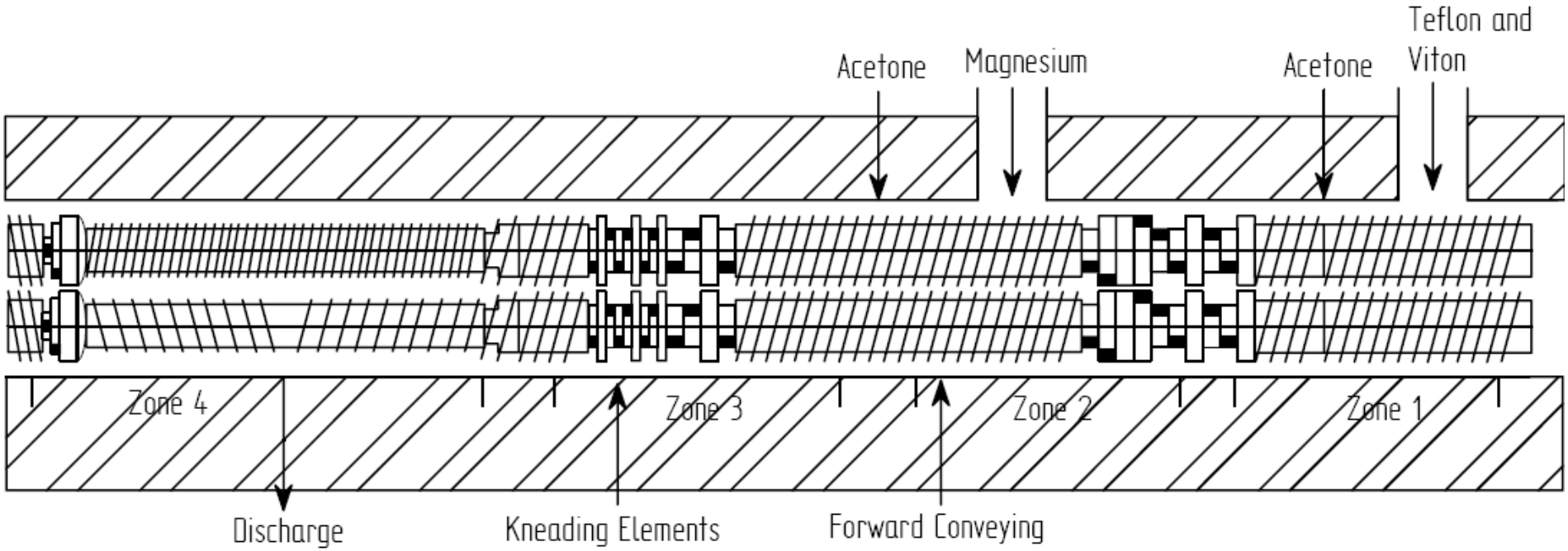
- **Produced 37.5 pounds Continuously on 23 May 2006 and 19 June 2006**
  - **~2 hours of Run Time**
- **Produced 75 pounds Continuously on 19 June 2006**
  - **~4 hours of Run Time**
  - **Consistent Burn Rate Throughout Run**

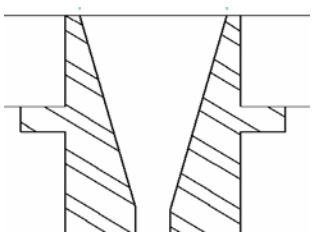
	Density (g/cc)	Burn Rate (sec/in)
Bag 1	1.818	4.83
Bag 2	1.819	4.98
Bag 3	1.822	5.02
Bag 4	1.819	4.90

Quad Video



Final Configuration





0.25 Inch Die

Zone 1-3: 65°F
Zone 4 and die: 120°F
Acetone Rate: 5.25 to 6.25 lb/hr
Solids: Varied depending on burn rate
Screw Speed: 90 rpm
Cone Mill: 20%
Conveyor Belt: 60%

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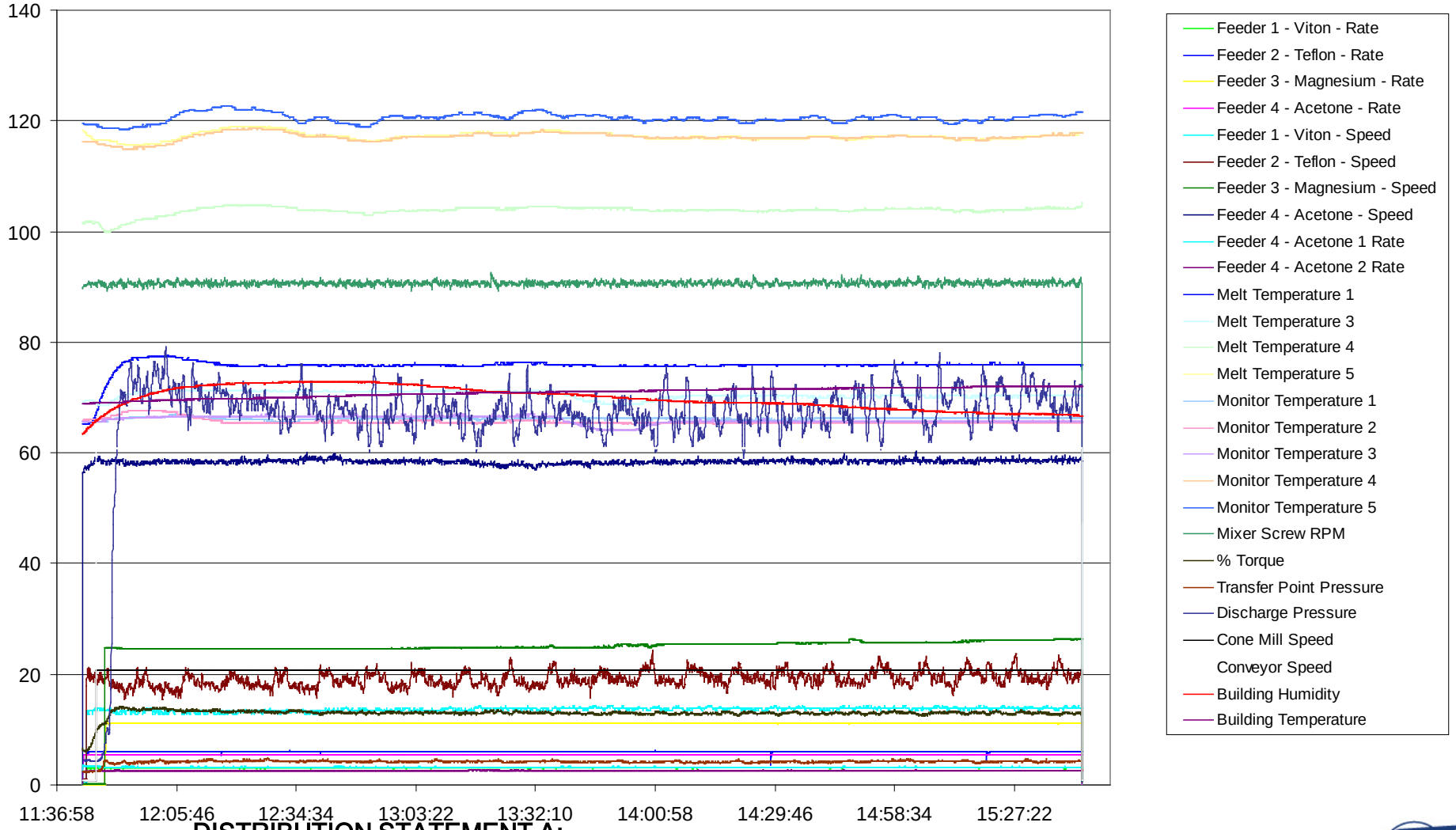
Collected Data

MTV Live Run 26-Run Data



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Road Ahead

- **Burn Rate Prediction**
  - **Batch vs TSE**
- **Decoy Flare Improvement Efforts**
- **Decoy Flare Production**
  - **Increase throughput**
- **Transition Technology to Industry**
- **Continuous Mixing through Extrusion Line**

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"Ideal" State

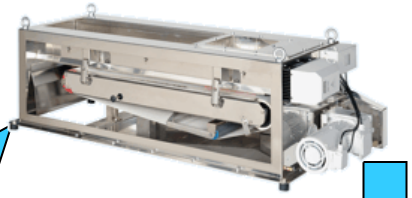
Acetone Wetted, Granular Composition From TSE

Conveyor Belt

Carrier Vibratory Dryer

Conveyor Belt

Brabender Weigh Belt Feeder



Conveyor

Ram Extruder (2 Required)

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Summary

- **TSE is a Viable Process for Making MTV Flare Compositions**
  - **Produce a Range of Burn Rates**
  - **Consistent Burn Rate-Extended Runs**
  - **Similar Sensitivity**
  - **Meets EPA Requirements**
  - **Improves Safety**
  - **Currently in Qualification Test Matrix**

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