U.S. ARMY TANK-AUTOMOTIVE ARMAMENTS COMMAND

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Processing of M206 Decoy Flare Composition in a Twin Screw Mixer/Extruder

Joint Ordnance Commands Group

Continuous Mixer & Extruder Users Group

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Outline

- The Players
- Background
- Why use TSE Processing?
- Program Objective
- Process Comparison
- Material Characterization
- Inert Processing
- Summary

Players

- Stevens Institute of Technology (HFMI)
  - Material Characterization
  - Rheology
  - Mathematical Modeling
- Technical Consultants, Inc. (TCI)
  - TSE Flare Composition Processing Expertise
- Kilgore Flares Company
  - Press and Load Composition into Casings
- U.S. Air Force at Point Magu
  - Flight Testing
- TACOM-ARDEC, Picatinny Arsenal
  - R&D and Testing
  - Pilot Scale Processing

Background

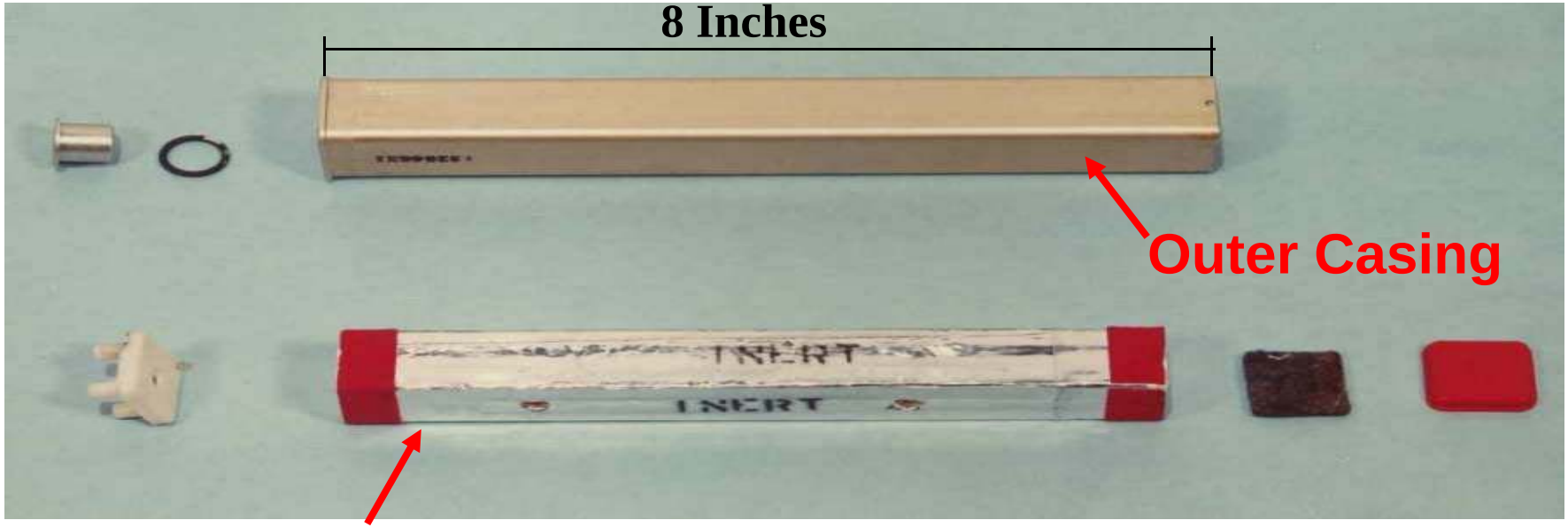
- Current manufacturing method is a <u>Batch</u> operation
- Extensive operator exposure to hazardous materials and operations
  - Decanting bulk quantities of the flare composition
  - Drying composition in large walk-in ovens with solvent vapors
- Environmental Concerns
  - Large amounts of organic solvents utilized
    - Hexane and acetone
    - Generates large quantities of volatile organic compounds (VOCs) released to the atmosphere

Why use a TSE?

- **Eliminate Incidents**
  - Several incidents have occurred over the past 5-years, many involving fatalities
- **Increase Safety**
  - Reduce operator exposure to hazardous materials/operations
  - Minimize transportation of “static sensitive” intermediate products
- **Environmental Benefits**
  - Eliminate hexane, which reduces total quantity of solvents
  - Solvent recovery system

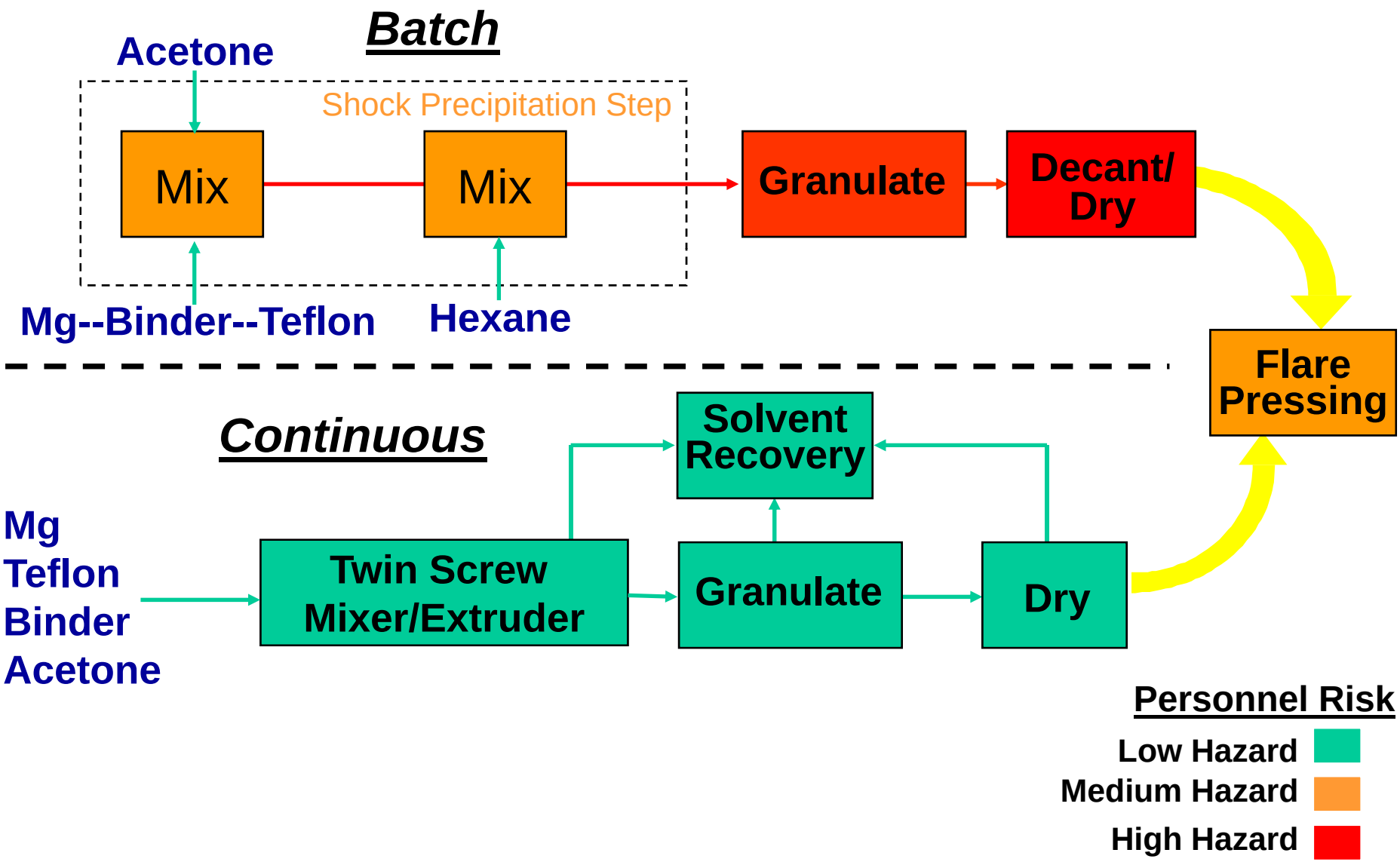
Program Objective

- Develop process data for M-206 infrared decoy flare composition which is transferable to production-scale facilities
- Produce material to press and load into casings for flight testing

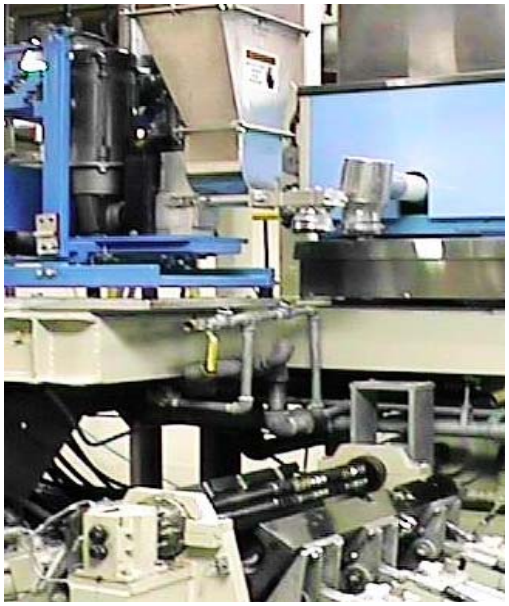


Flare Composition

Batch versus Continuous Processing
(M206 Flare Composition)



TACOM-ARDEC TSE Facility



- 40-mm Baker Perkins
- Clam shell design
- Loss-in-weight feeders
- Solvent recovery system
- In-line granulator
- Throughput: 10-50 lb/hr

Material Characterization

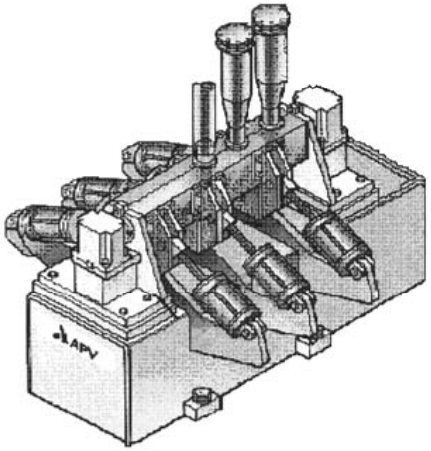
- Inert Simulant:
  - Potassium Sulfate (K_2SO_4)
- Solubility in Acetone
  - HyTemp - 8 grams per 100 grams
    - Requires several hours
  - Teflon - < 0.1 gram per 100 ml
  - K_2SO_4 - < 0.02 gram per 100 ml
- Inert Rheological Characterization
  - ARES rotational rheometer
  - Hytemp/Teflon/Acetone slurry approaches an easily pumped Newtonian fluid with increasing solvent level
  - Determined complex viscosity and the loss and storage moduli as a function of solvent concentration for the formulation

Inert Processing

- Feeder Studies
  - Attempted dry Teflon in several feeder configurations, but were unsuccessful
  - Hytemp/Teflon/Acetone slurry using gear pump
    - Solvent concentration is limiting factor
  - K_2SO_4 with vertical agitated Brabendar feeder
- Initial Processing Conditions
  - Screw Configurations
    - 3-zone: Slurry, K_2SO_4, Vacuum, Die
    - 4-zone: Slurry, Vacuum, K_2SO_4, Vacuum, Die
  - Temperature Range: 90-140°F

Remaining Work

- Optimize Processing Conditions
  - Vacuum Level
  - Granulator Speed
- Validate Computer Model
- Transition to Live Processing
  - Mg Feeder Studies
  - Produce Composition for Testing
- Performance Testing



Summary

- Batch Flare Composition Processing is associated with unacceptable safety hazards
- TSE processing will reduce related manufacturing hazards
- Demonstrated the feasibility of continuous M-206 IR Decoy Flare processing in a TSE