Thiokol Propulsion

Twin Screw Extruder Production Engineering Study

Contract No. N00164-98-C-0085

Presented by:

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Outline

- Background
- Program Objectives
- Process Development
- Program Accomplishments

Background Information

- Magnesium/Teflon/Viton (MTV) flare compositions are proven countermeasures against heat-seeking missiles
  - Utilized by helicopters and fixed wing aircraft

Rationale for Twin Screw Extruder Production Engineering Study

- Need for safer process
  - Historical precedence for industry-wide incidents
  - Eliminate personnel exposure/handling
  - Reduce ignition potential due to volatile/flammable solvents
- Environmental implications
  - Batch process requires up to 198 lb of solvents to produce 100 lb of product
    - Disposal of excess solvent
    - Air quality regulations/permits
- NSWC Crane
  - Crane views TSE as a viable option for process evolution

Program Objectives

- Demonstrate that twin screw extrusion technology improves safety to personnel and equipment for processing MTV compositions
- Reduce the amount of process solvent required to manufacture MTV comp and show recovery capability
- Manufacture and deliver 300 lb of IR decoy flare composition for product evaluation
  - Three formulations tailored to specific burn times
  - 100 lb of each formulation

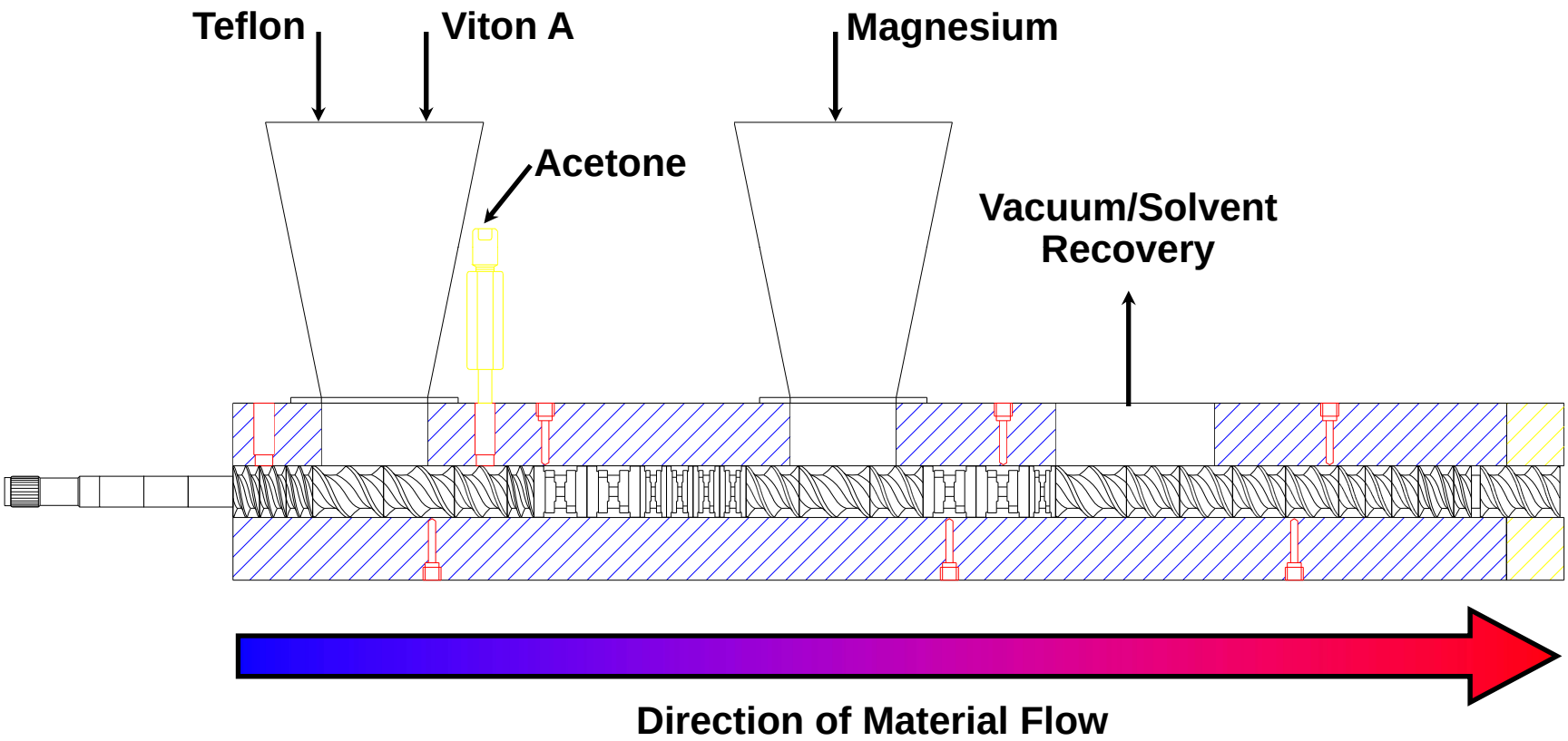
Process Development

- Techniques to manufacture MT compositions in an extruder were developed at Thiokol (Longhorn)
  - Dr. Dave Dillehay, Dave Turner, and Jim Blackwell spearheaded initial extrusion of MT compositions
  - The majority of work focused on MT compositions with Hycar as the binder system
- The MTV formulation for this effort utilized Viton A as the binder system at significantly higher concentrations
- Due to differences in binder and concentration, Thiokol (Utah) developed a different processing technique to accomplish program objectives

Advanced Process for MTV Extrusion

- Ingredients fed as individual feed streams into the extruder
- Advantages
  - Solid ingredients are metered into the process using loss in weight (LIW) feeders
  - Each feed stream is monitored separately for feeding accuracy
  - Processing solvent can be metered and independently adjusted
  - Requires less processing solvent for operation
  - Reduces amount of energetic material in process
- Issues
  - Materials generate electrostatic energy (ESE) during transport
  - Teflon and Viton A do not dissipate ESE readily
  - The sensitivity of magnesium powder to electrostatic discharge (ESD)
- Material order of addition and location were critical to mitigate issues

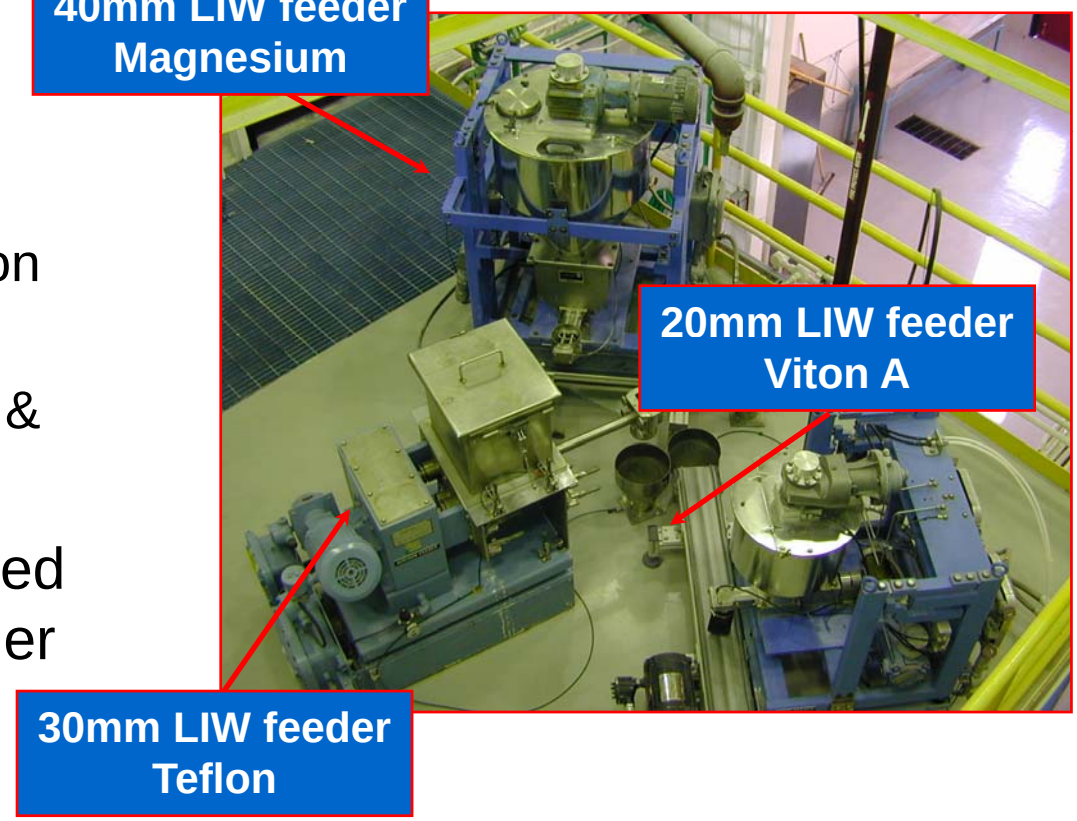
Process Flow Description



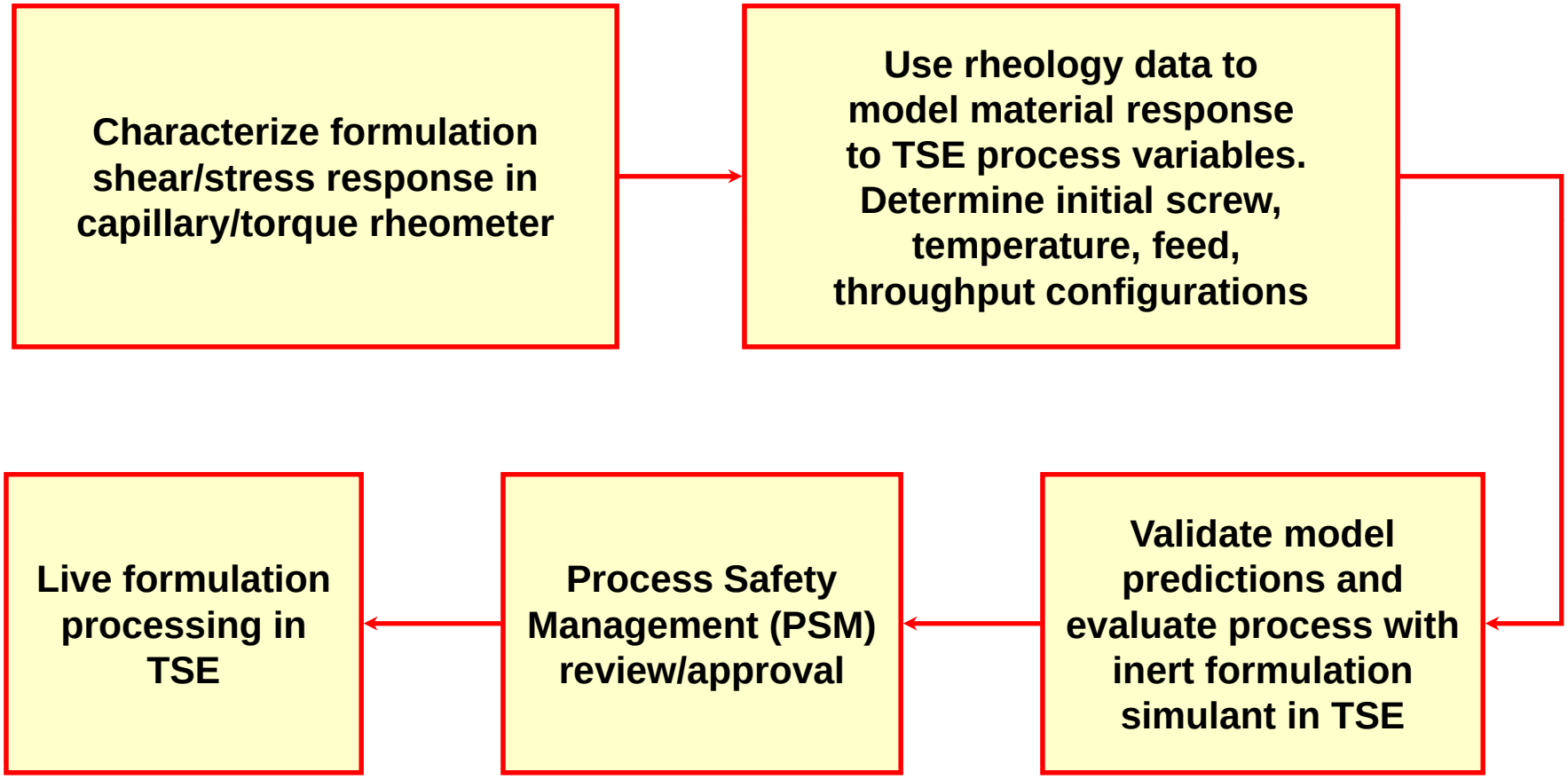
Inert Material Energetic Material

Solid Feed System Layout

- The 58mm extrusion facility is equipped with three LIW feeders
  - 40mm twin screw Control & Metering feeder
  - 30mm single screw Acrison feeder
  - 20mm twin screw Control & Metering feeder
- Each feeder can access feed ports located on the extruder



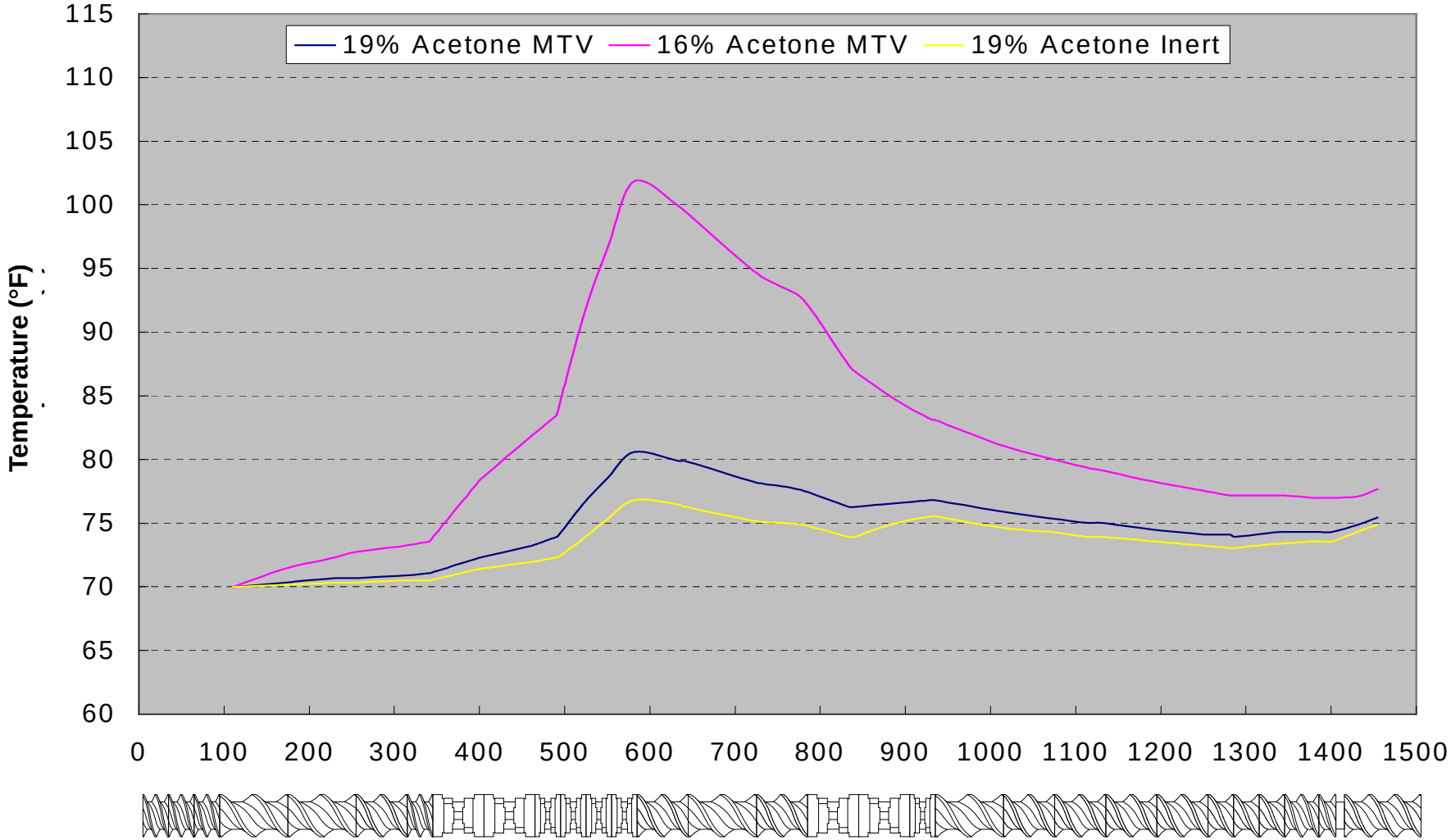
Extruder Process Development Protocol



Extruder Modeling Effort

- Model calculations include MTV and inert formulations at different solvent concentrations
  - MTV composition with 19% acetone
  - MTV composition with 16% acetone
  - Inert composition with 19% acetone
- Temperature prediction
  - First mix zone temperatures predicted to approach 105°F when processing with 16% acetone and then cool off throughout the remaining process
- Data from the model show that the inert simulant behaves similar to MTV compositions

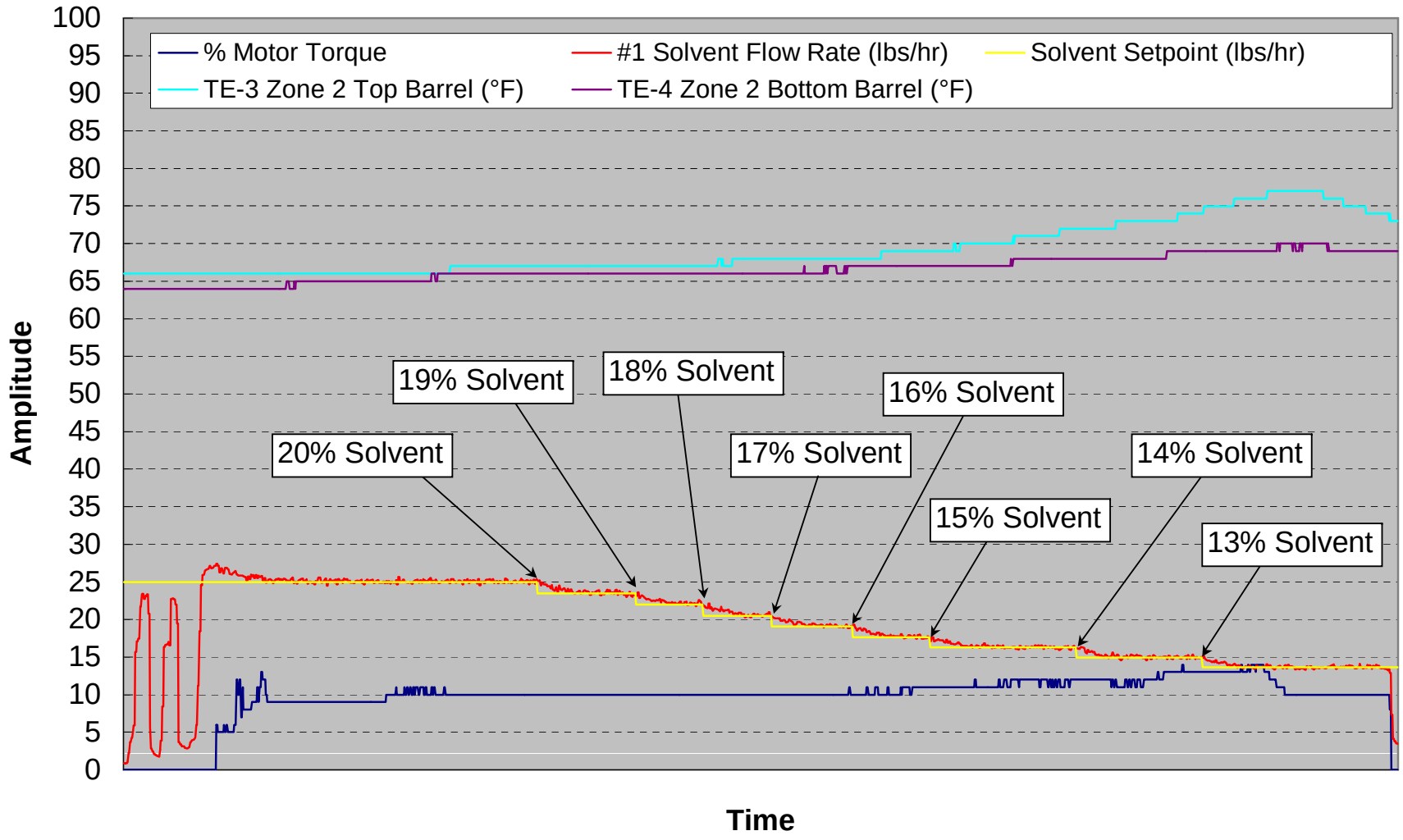
Modeling Data



Inert Process Evaluation

- Inert extrusion studies validated modeling predictions
- Process solvent concentration varied from 20% down to 13% to establish optimal level for processing
- Critical process parameters were monitored
  - Torque
  - Temperature
- Torque remained constant (~10%) through a wide range of solvent concentrations
  - At 16% solvent concentration, torque began to increase and stabilized at 14% torque at 13% solvent concentration
- Temperature increased in Zone 2 as predicted by the model as solvent concentrations were lowered

Inert Processing Data



Safety Characterization of Raw Materials, Intermediates, and End Product

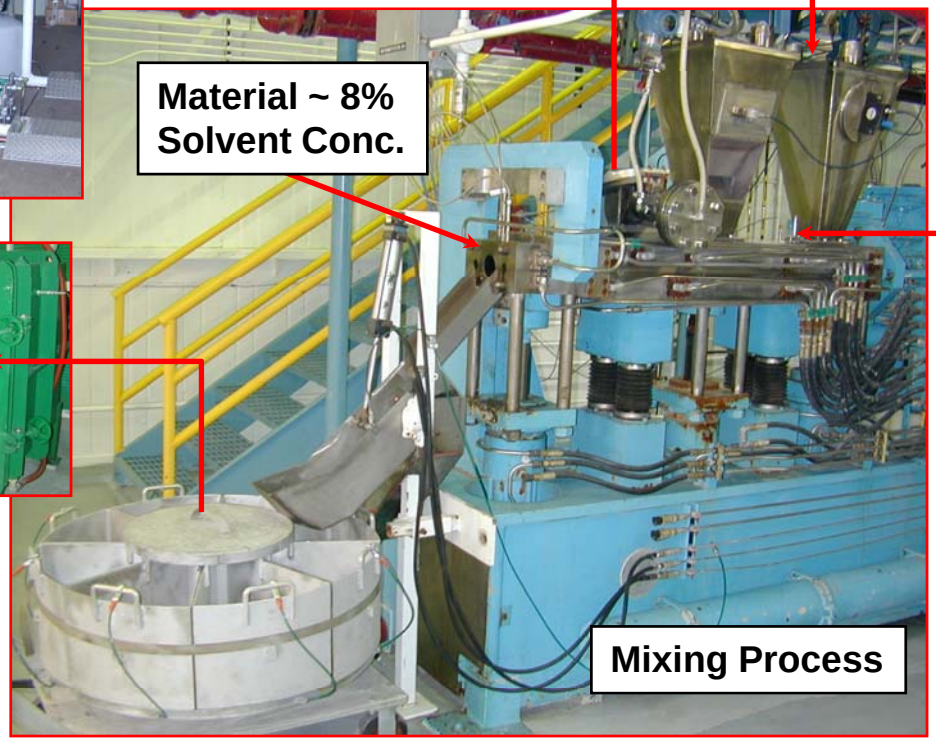
- Mg powder is extremely sensitive to ESD
  - Standard industry practices for handling Mg powder mitigates concerns
- MTV compositions with solvent concentrations > 10% are moderately sensitive to ESD
- MTV compositions with solvent concentrations < 10% are comparable to Minuteman propellant sensitivity

Sensitivity	Ignition Stimulus		
	Friction	Impact	ESD
High	None	None	Mg Powder
Moderate	None	None	MTV Comp (19% Acetone)
Low	MTV Comp (10% Acetone) MTV Comp (dry)	MTV Comp (10% Acetone) MTV Comp (dry)	MTV Comp (10% Acetone) MTV Comp (dry)

Advanced Extrusion Process Flow for MTV Compositions

Solvent Removal/Recovery

Solid Feed Streams



Additional Drying

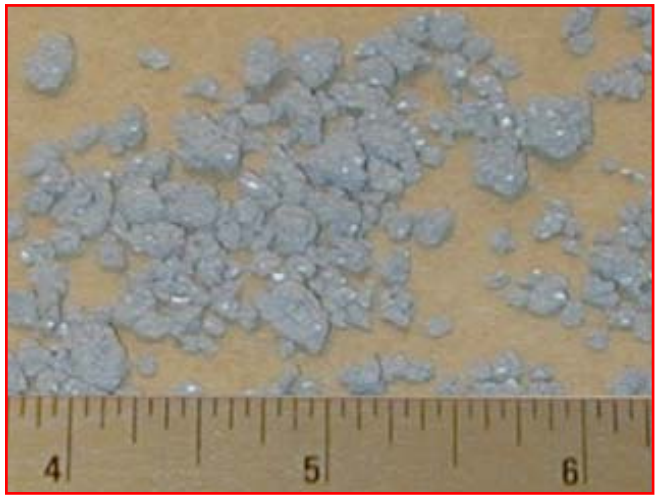
Solvent Injection

Solvent Reduction/Recovery

- Solvent reduction
  - 16.5% solvent concentration was identified as the best level for processing based on modeling data and inert extrusion runs
    - 19 lbs of solvent to produce 100 lbs of material versus up to198 lbs of solvent
- Solvent recovery
  - Vacuum application removed and recovered an additional 55% of processing solvent from the product
    - Product extruded under vacuum did not require post extrusion granulation
- Majority of the delivered material processed at 16.5% solvent due to vacuum level control limitations
  - Product extruded without vacuum required post extrusion granulation

Material Manufactured Under Vacuum

- Solvent concentration ~8%
  - Low sensitivity to ESD ignition stimulus
  - Operators can more safely handle material
- Material actually granulated in the vacuum zone in the extruder
  - Multiple granulation steps eliminated
- Post-processing reduced to a single drying step



Program Accomplishments

- Demonstrated twin screw extrusion technology improves safety to personnel for processing MTV compositions
  - Operators are not exposed to material with high concentrations of flammable solvents
- Reduced amount of process solvent required to manufacture MTV comp and demonstrated recovery capability
  - Processed MTV comp at 16.5% solvent concentration
  - Vacuum application removes and recovers 55% of the solvent
  - Product granulates to a useable form under vacuum
- Manufactured and delivered 300 lb of MTV comp for product evaluation
  - Initial ballistic tests show product met burn rate targets