Statement of Facts Regarding an Instance of Thermal Decomposition in a 40-mm TSE

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Outline

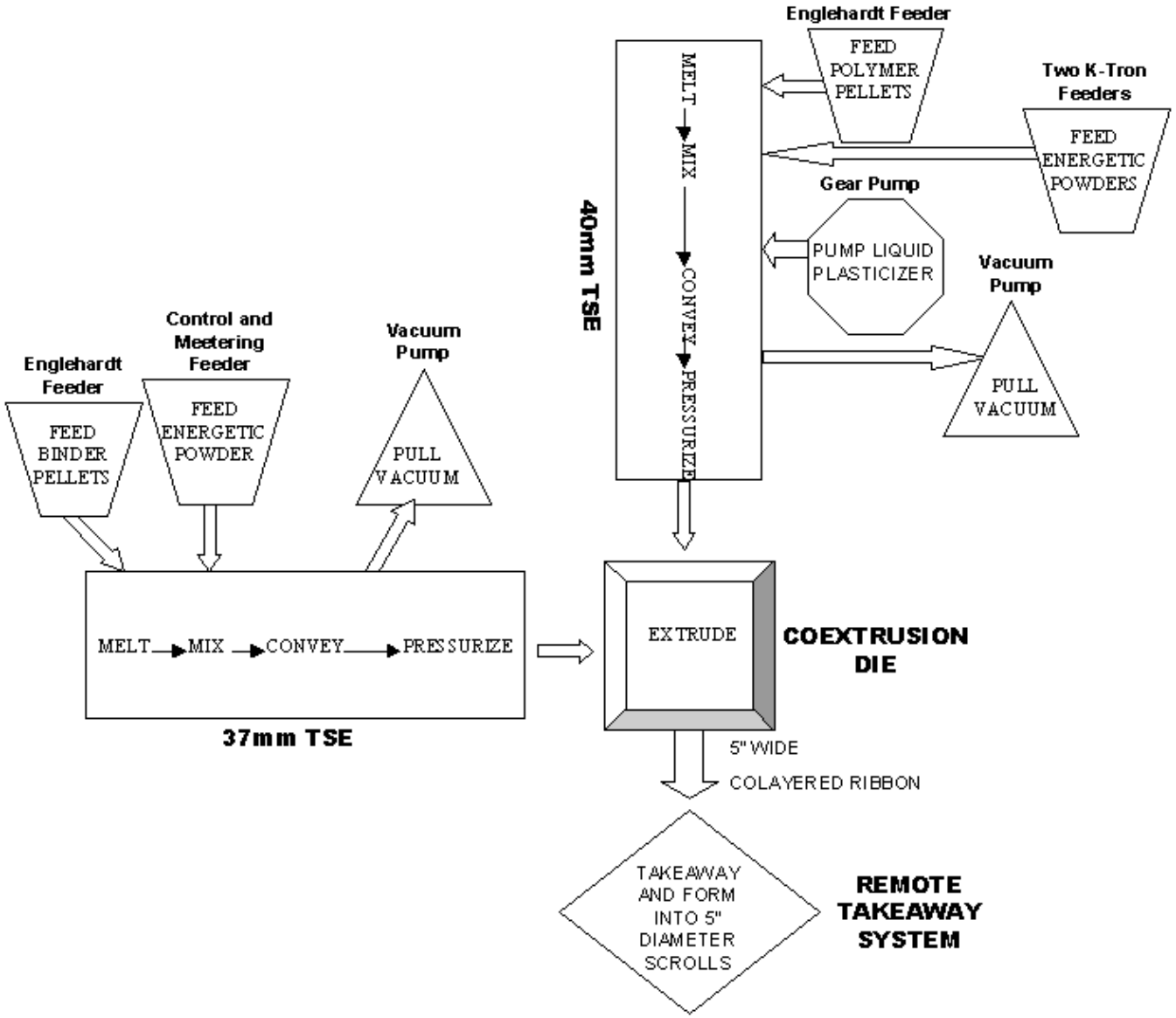
- Program Overview/Objectives
- Co-Layered Manufacturing Process
- Simulant Slow Burning Experimental Run Objectives
- Simulant Run Parameters
- Thermal Decomposition Information
- Causal Relationships

Program Overview

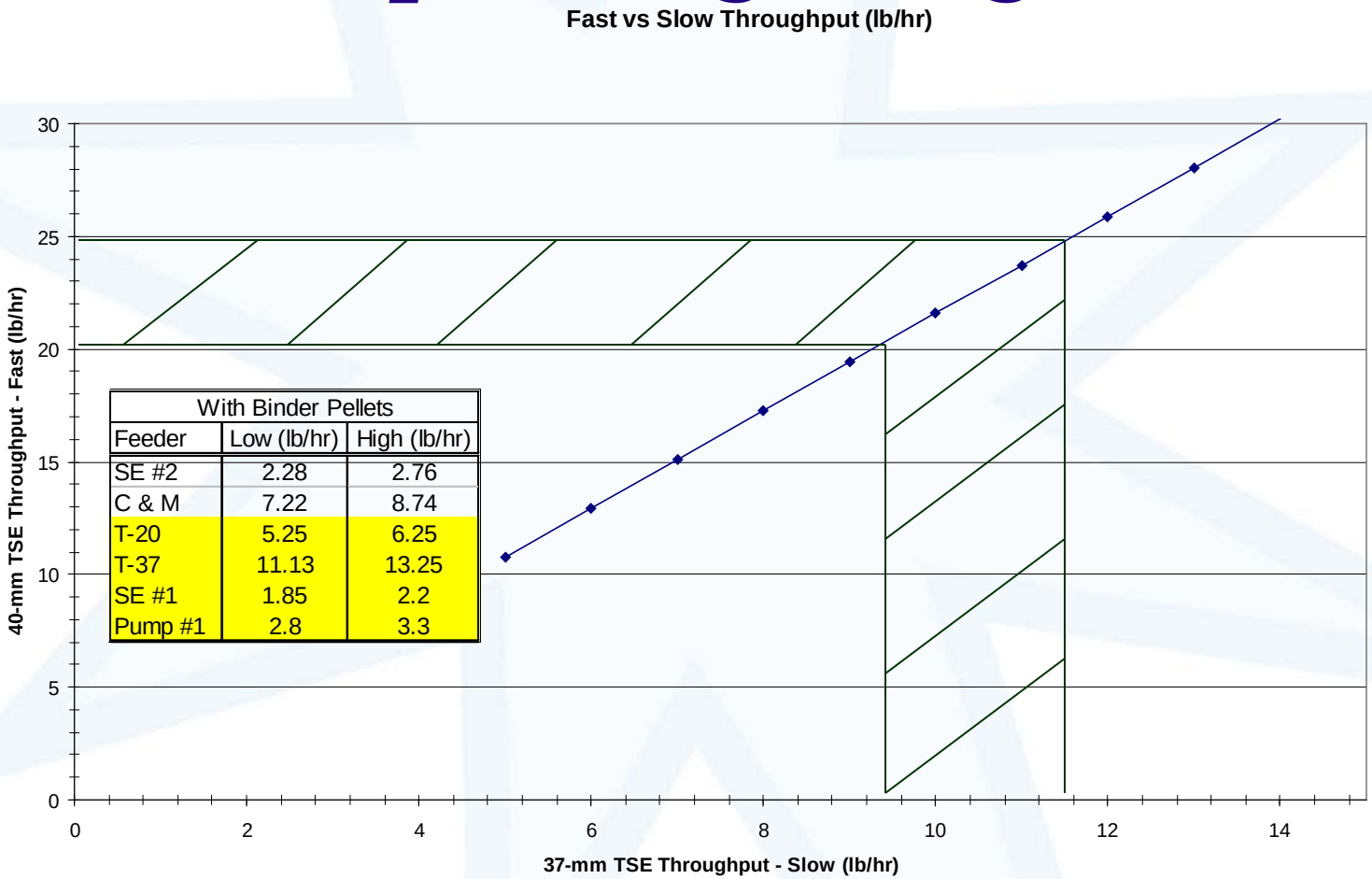
Objectives:

- Develop the technology to manufacture co-layered gun propellant with a fast-burning inner core and slow-burning outer layers using continuous TSE processing technology
  - Propellant burning-rate differential target ratio of 3:1
  - Integrate a 40-mm TSE and a 37-mm TSE to process through a co-extrusion die
  - Operate a continuous take-away system to remotely wrap scrolls and collect the gun propellant charges

Co-Layered Process



Co-Layered Feeder Operating Range



With Binder Pellets		
Feeder	Low (lb/hr)	High (lb/hr)
SE #2	2.28	2.76
C & M	7.22	8.74
T-20	5.25	6.25
T-37	11.13	13.25
SE #1	1.85	2.2
Pump #1	2.8	3.3

Experimental Processing Run

- Objective: To validate the use of feedstock binder pellets of Hytrel / BDNPA/F for the Slow Layer using the 40-mm TSE
  - Prepared binder pellets in batch mixer and pelletized prior to feeding to TSE
  - Determine if the Dechlorane Plus 515 (inert filler) could be successful conveyed by the TSE screws.
- Evaluate the process responses at the anticipated 37-mm TSE throughputs
- Prepare simulant material for remote takeaway system prototype testing

Simulant Run Parameters

- Optimized melting zone temperature to 150 F by visual inspection of the screw elements in the solid feed port
- Mixing, conveying, deaeration and pressurization zones held at 195 F
- Fed inert filler incrementally to set point and examined the feed port to ensure solids were conveying
- Reached first throughput condition of 9.5 lb/hr total
- Extruded through a 0.350-in diameter die
- Ran extruder at 85 rpm

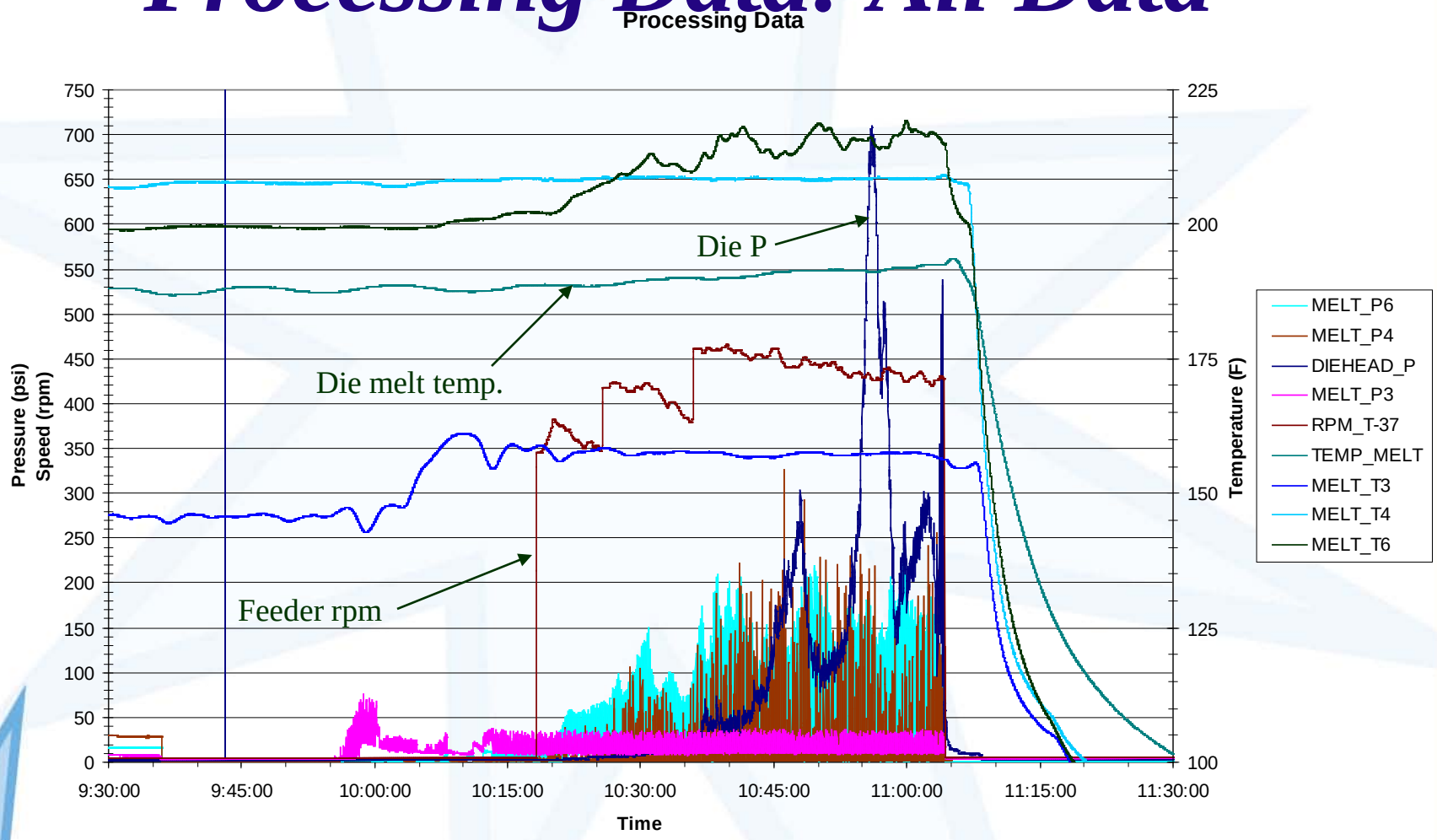
Resulting Sequence of Events

- About 10 minutes after reaching set point the pressure at the die spiked to 300 psig and dropped to 100 psig
- Later, the pressure at the die increased to 700 psig and dropped to 150 psig
- An operator in the bay notified that white powder appeared to be “puffing” out of the vacuum port
- Immediately there was a loud pop with material expelled from the die followed by decomposition gases
- Extruder was shut down, feeders stopped and die holder door opened

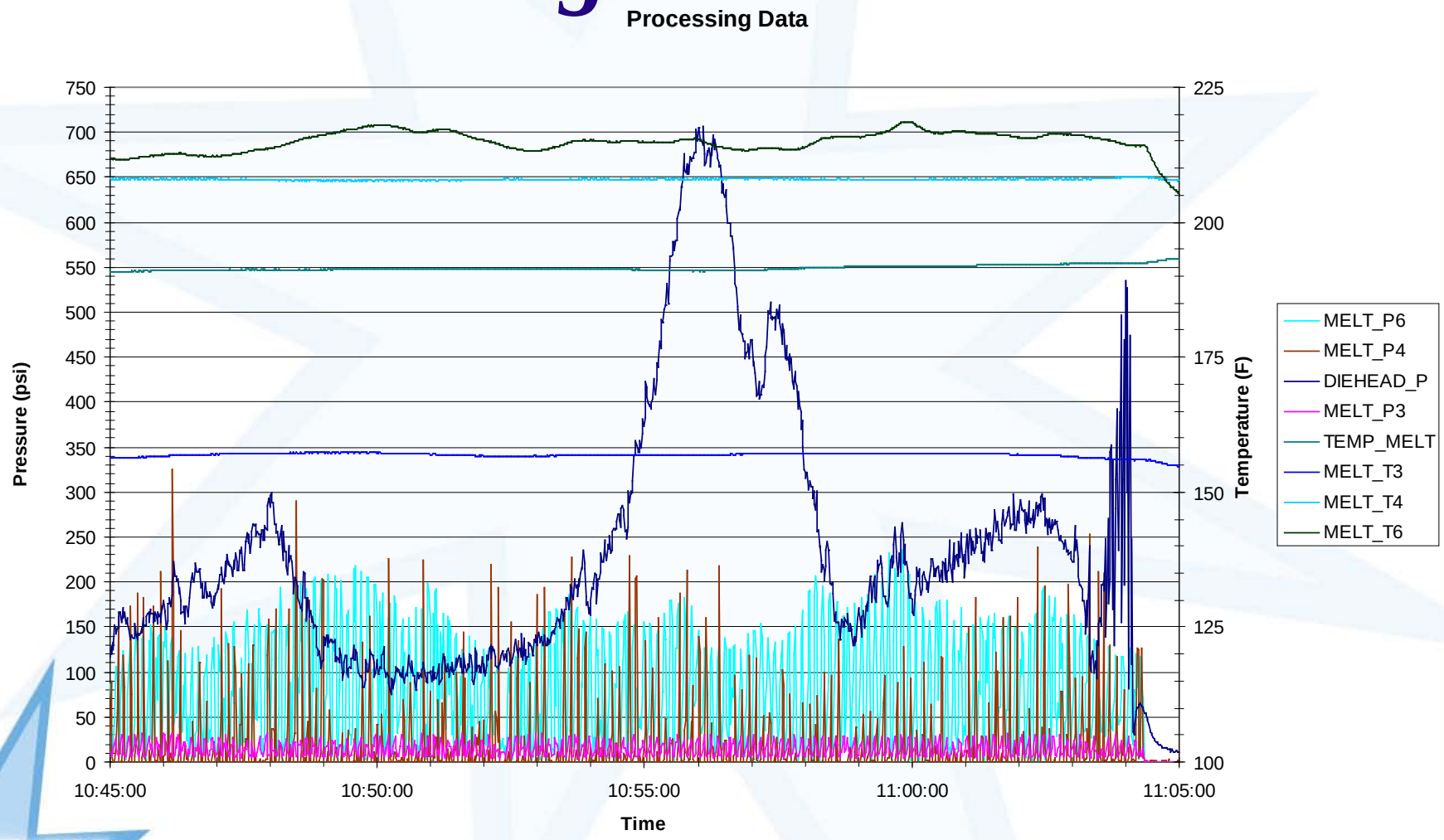
Process observations

- Pertinent observations
  - Die pressure spike of 700 psig was unusually high
  - Feeder's performances, material temperature and pressure responses along the length of the extruder were normal
  - No vacuum pulled at the time of the decomposition
  - Conditions were not severe enough to trigger safety interlocks

Processing Data: All Data



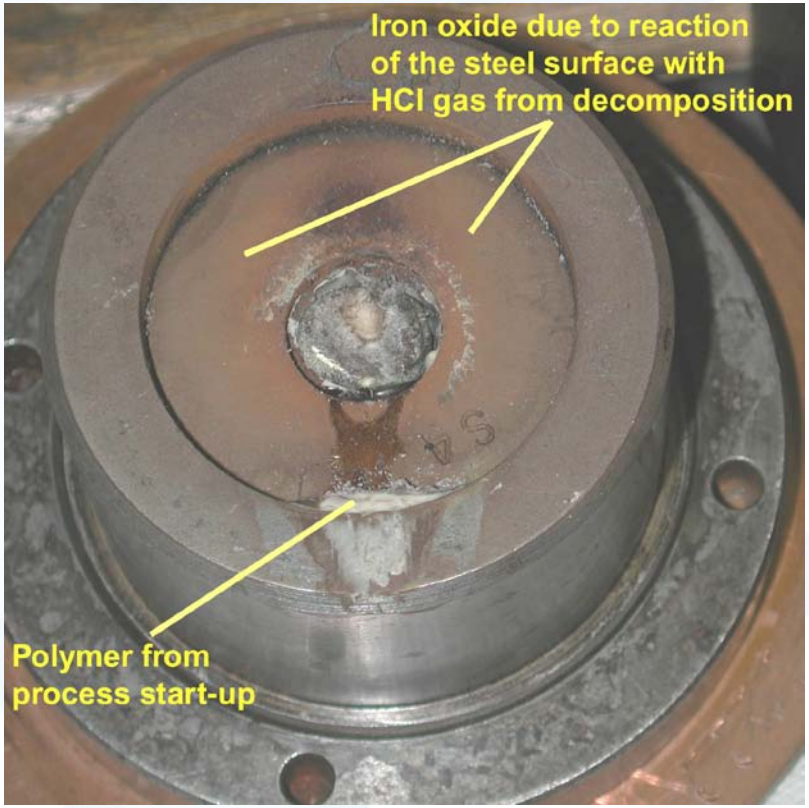
Processing Data Narrowed



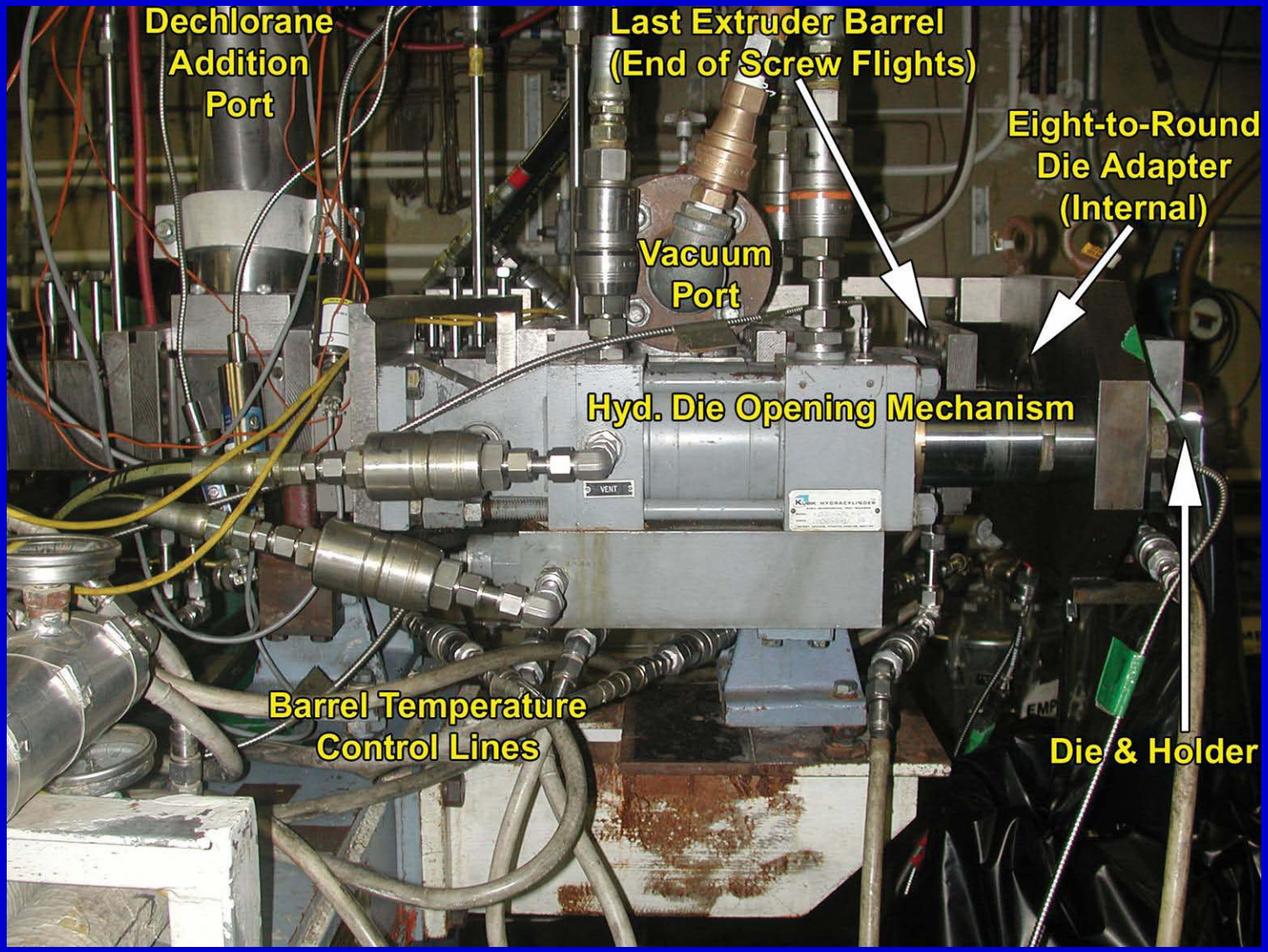
Thermal Decomposition Information

Die

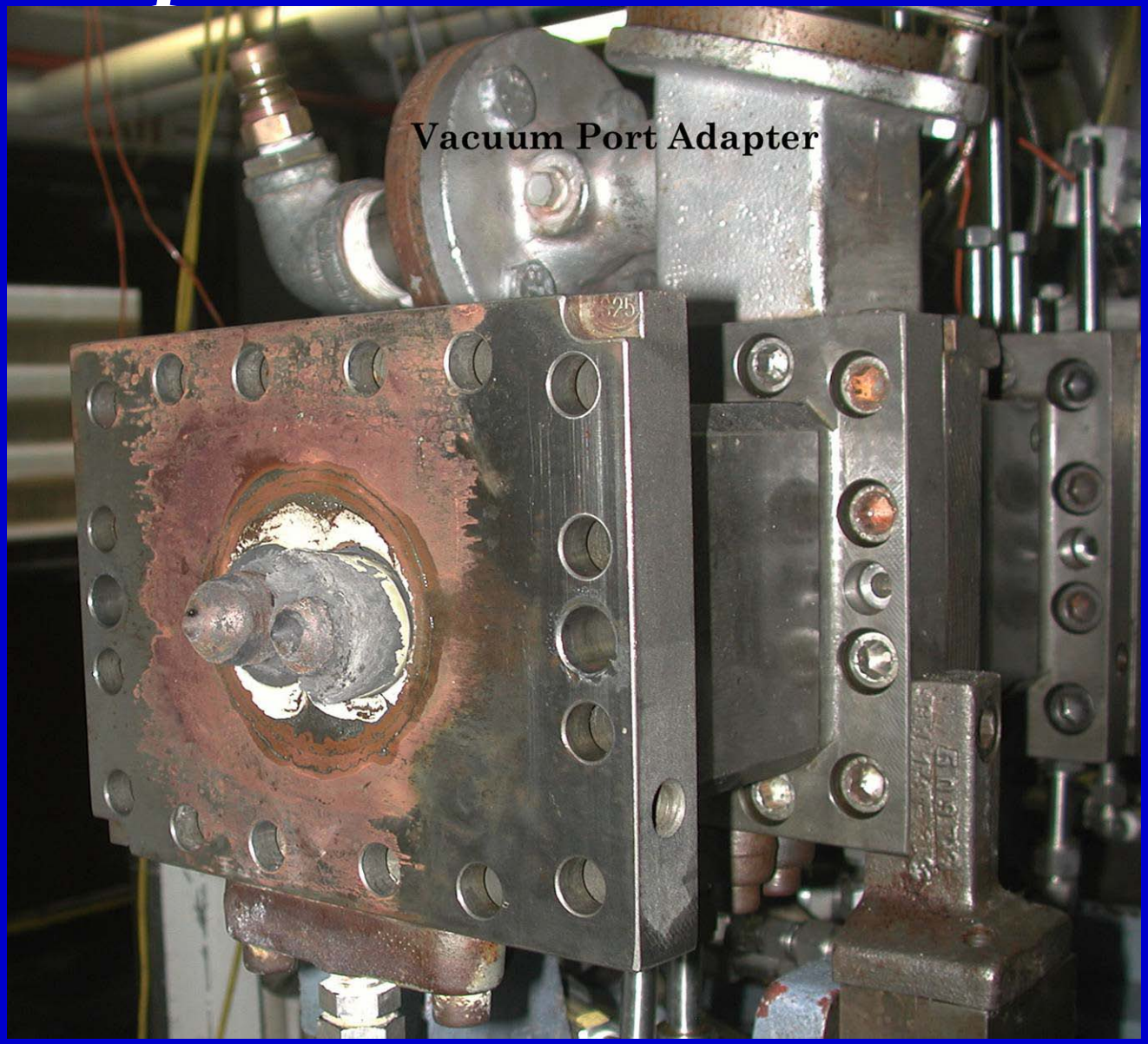
- 12 Aug 2004, NSWC, 40 mm twin screw extruder (Bldg. 1119)
- Process parameters
  - 9.5 lb/hr total throughput
  - Two solid feed streams
  - 0.350-in diameter die at 195 F
- Die pressure spiking preceded event; however, surface temperatures were stable



Extruder Setup



Screw Tips



Eight-to-Round Transition

Downstream view

Die Holder Block and Eight-to-Round Transition

Material From Transition

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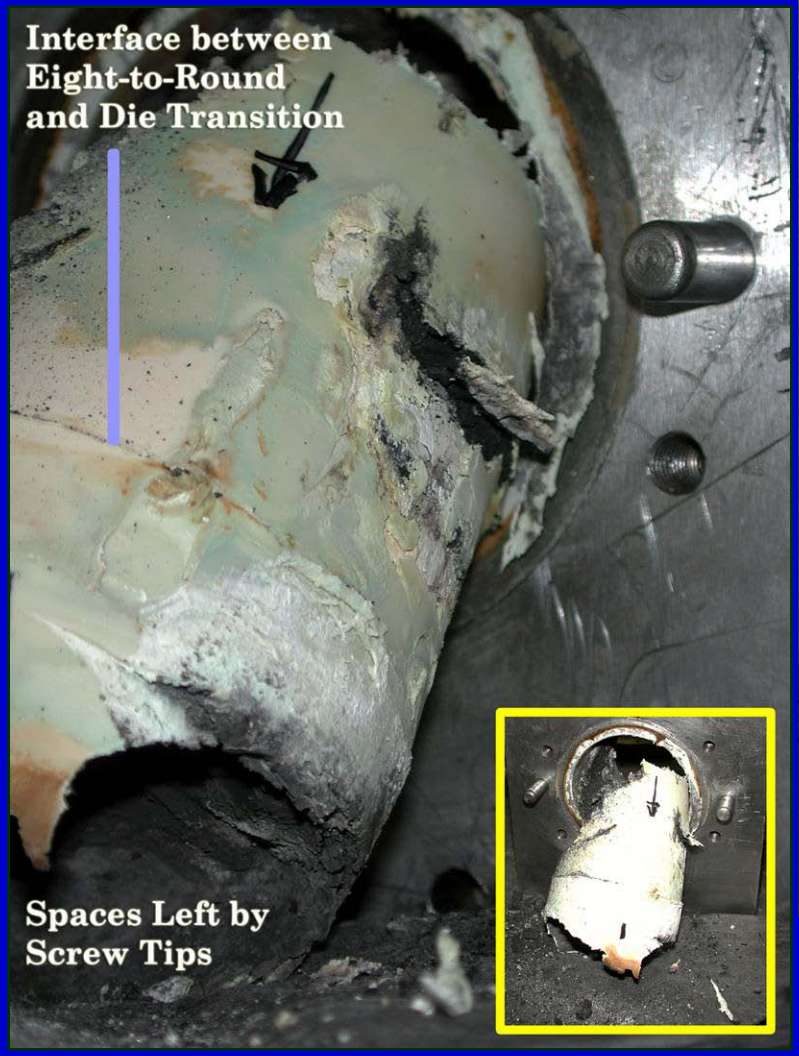
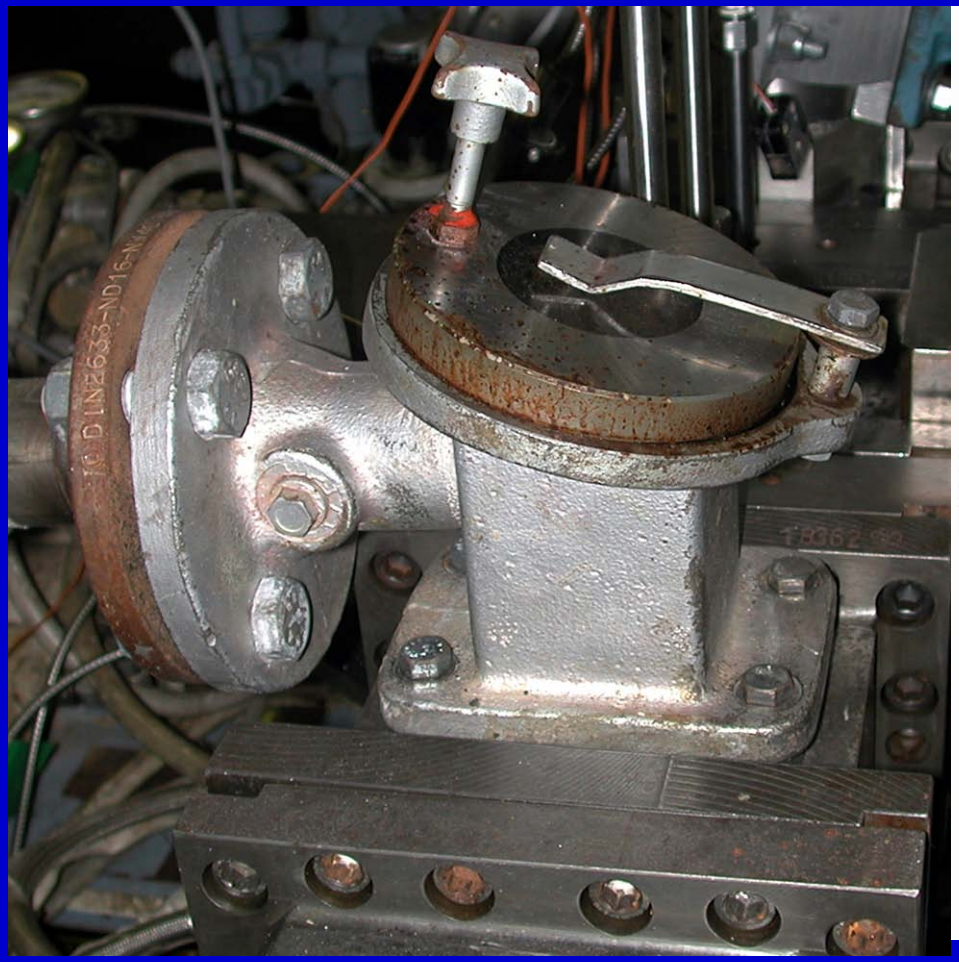
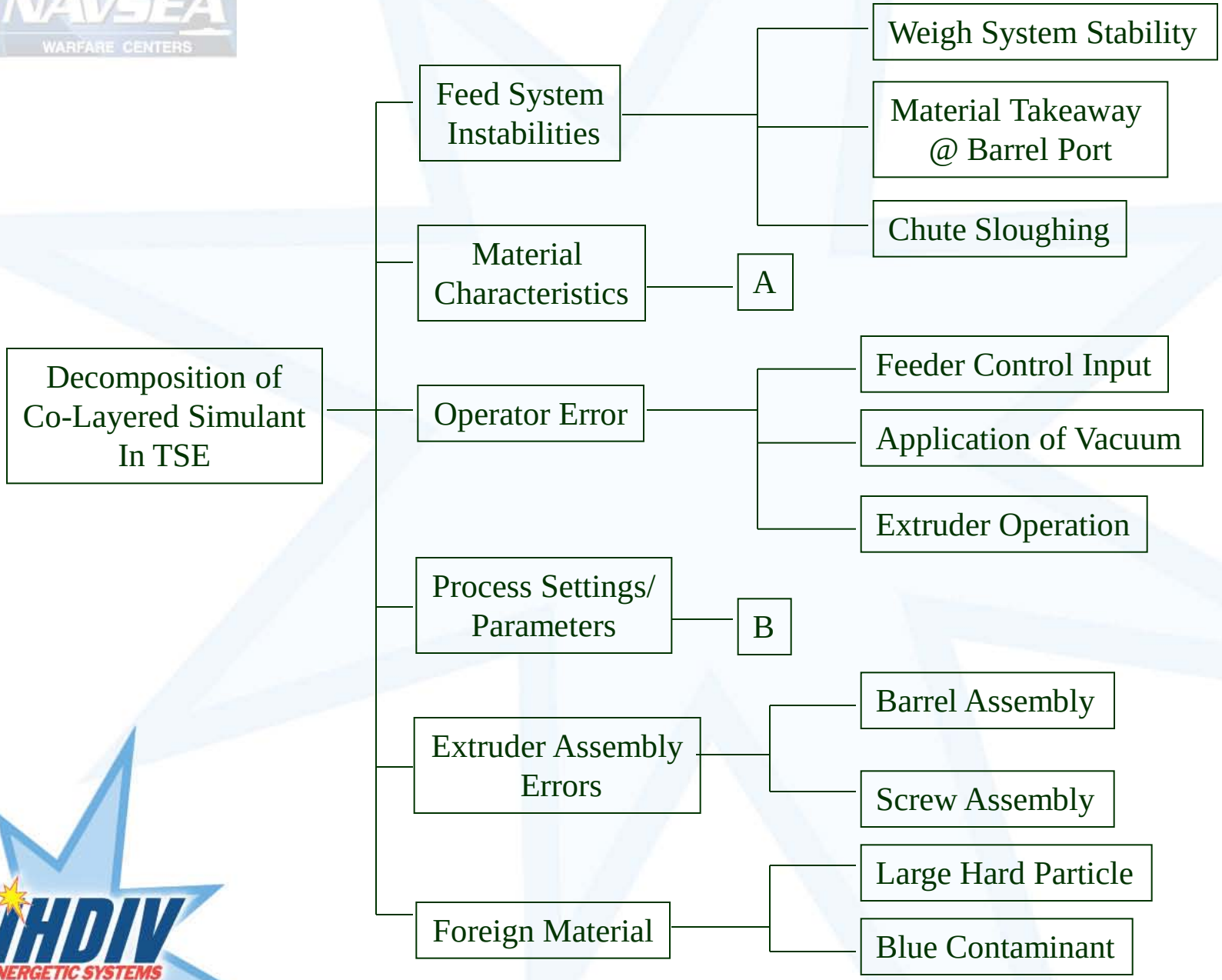
Material From Transition to Die Entrance

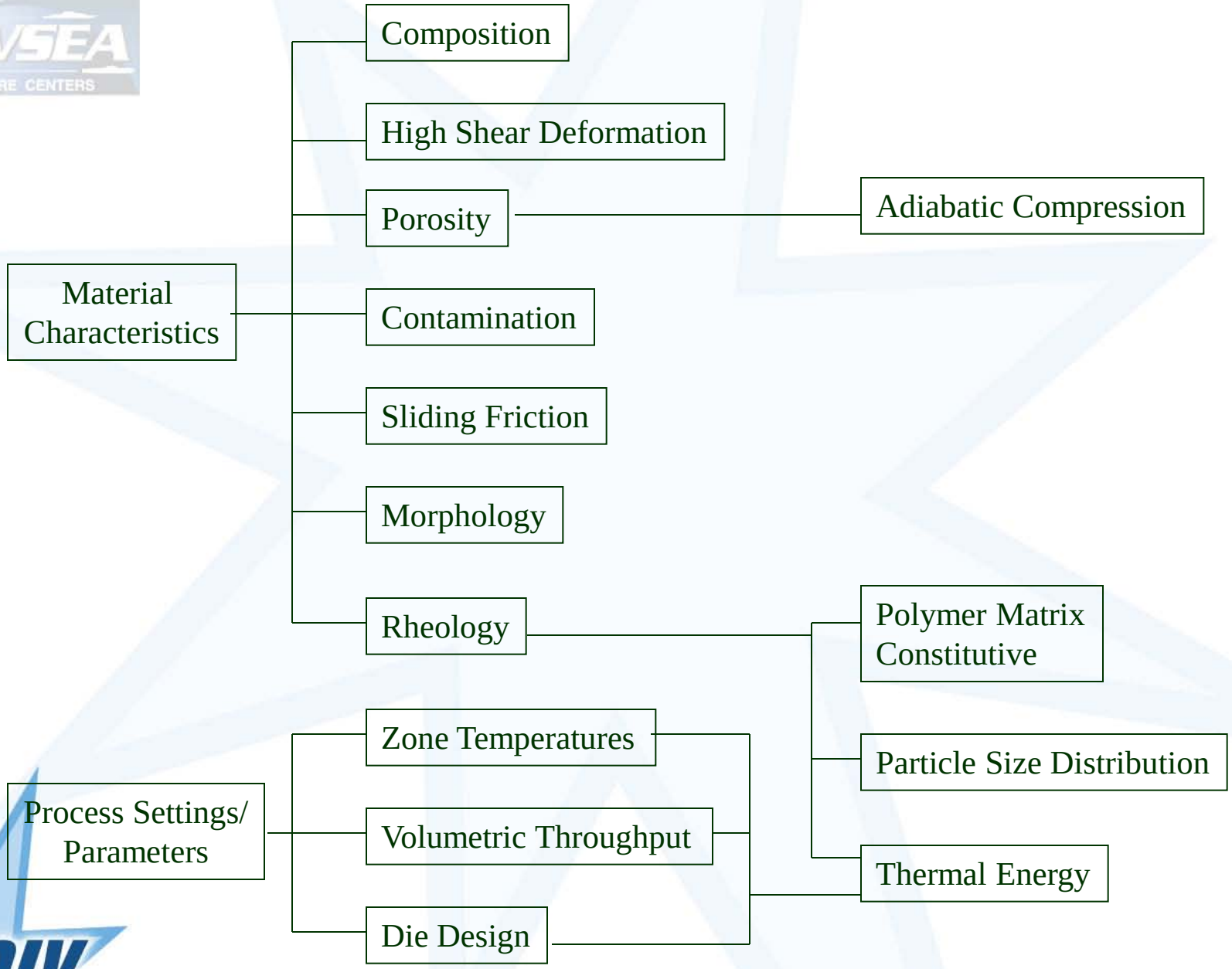


Screws

Vacuum Port Adapter




Decomposition of Co-Layered Simulant In TSE
Feed System Instabilities
Weigh System Stability
Material Takeaway @ Barrel Port
Chute Sloughing
Material Characteristics
A
Operator Error
Feeder Control Input
Application of Vacuum
Extruder Operation
Process Settings/ Parameters
B
Extruder Assembly Errors
Barrel Assembly
Screw Assembly
Foreign Material
Large Hard Particle
Blue Contaminant


Material Characteristics
Composition
High Shear Deformation
Porosity
Adiabatic Compression
Contamination
Sliding Friction
Morphology
Rheology
Polymer Matrix Constitutive
Particle Size Distribution
Thermal Energy
Process Settings/ Parameters
Zone Temperatures
Volumetric Throughput
Die Design