



Continuous Processing Scale-Up Facility Start Up

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Picatinny Arsenal

Start-Up Team

- Processing
 - Robert Branson
 - Christopher Gonzalez
 - Virginia Hintze
 - Ronald Myers
 - Richard Muscato
 - Suzanne Prickett
 - Wayne Thomas
- Facilities
 - Collier Cline
 - Ray Lee
 - Bill Newton
 - Robert Peranich
 - Stuart Richman
 - Wayne Thomas
 - Robert Thompson

Background

- Obtained approval for processing of Eurenco Bofors powder from Process Review Board.
- Modified MATCON bins to reduce the bulk discharge potential.
- Indian Head has proceeded with live processing of energetic materials.
 - MK 99 propellant for the 5 inch 54 caliber naval gun round.
- Nine live runs to date.

Continuous Processing Scale-Up Facility

Functional Sub-Systems

- Liquid, solid and extruder sub-system.
- Pelletizer and cut grain collection sub-system.
- Automatic crane refill sub-system.

Live Run Processing Condition Synopsis

- Three screw profiles: evaluated single and dual flight
- Three temperature profiles: 70°F to 90°F
- Four screw speeds: 30, 40, 60 and 80 rpm.
- Solid feed rate range: 200 to 350 pounds per hour.
- Solvent percentage: 12.5 to 15 percent.

Liquid Pump

- The liquid pump systems consist of:
 - Overall design by ProFlow, Inc.
 - 3 separate systems
 - Zenith gear pumps
 - One 150 gallon and two 75 gallon stainless steel vessels with agitators.
 - The vessels can be pressurized to 75 psig with nitrogen or air.
 - The vessels are jacketed and can be heated or cooled.
 - Closed loop mass flow control with Micromotion mass flow sensors.
 - One slurry pump.

Liquid Pump Testing



Set Point (lb/hr)	Actual Throughput (lb/hr)	Avg. Nozzle P	Avg. Pump Speed	Data Analysis		
				Analysis Interval (sec)	Std. Dev.	CoVar (%)
30.0	29.8	35.4	144	15	0.0131	10.74%
				30	0.0256	10.25%
				60	0.0162	3.21%
41.4	39.0	40.6	205	15	0.0160	10.23%
				30	0.0249	7.66%
				60	0.0125	1.88%
52.3	49.9	42.6	255	15	0.0206	9.49%
				30	0.0268	6.34%
				60	0.0252	2.97%

Solid Feeder Hardware

- Four KTRON loss-in-weight feeders with MATCON discharge stations attached to them. The discharge station can hold a MATCON 1000 liter intermediate bulk container. The feedrate range is from 5 to 500 pounds per hour.
- One KTRON volumetric feeder. This is used for purging the extruder.

KTron Solid Feeder Testing T-60



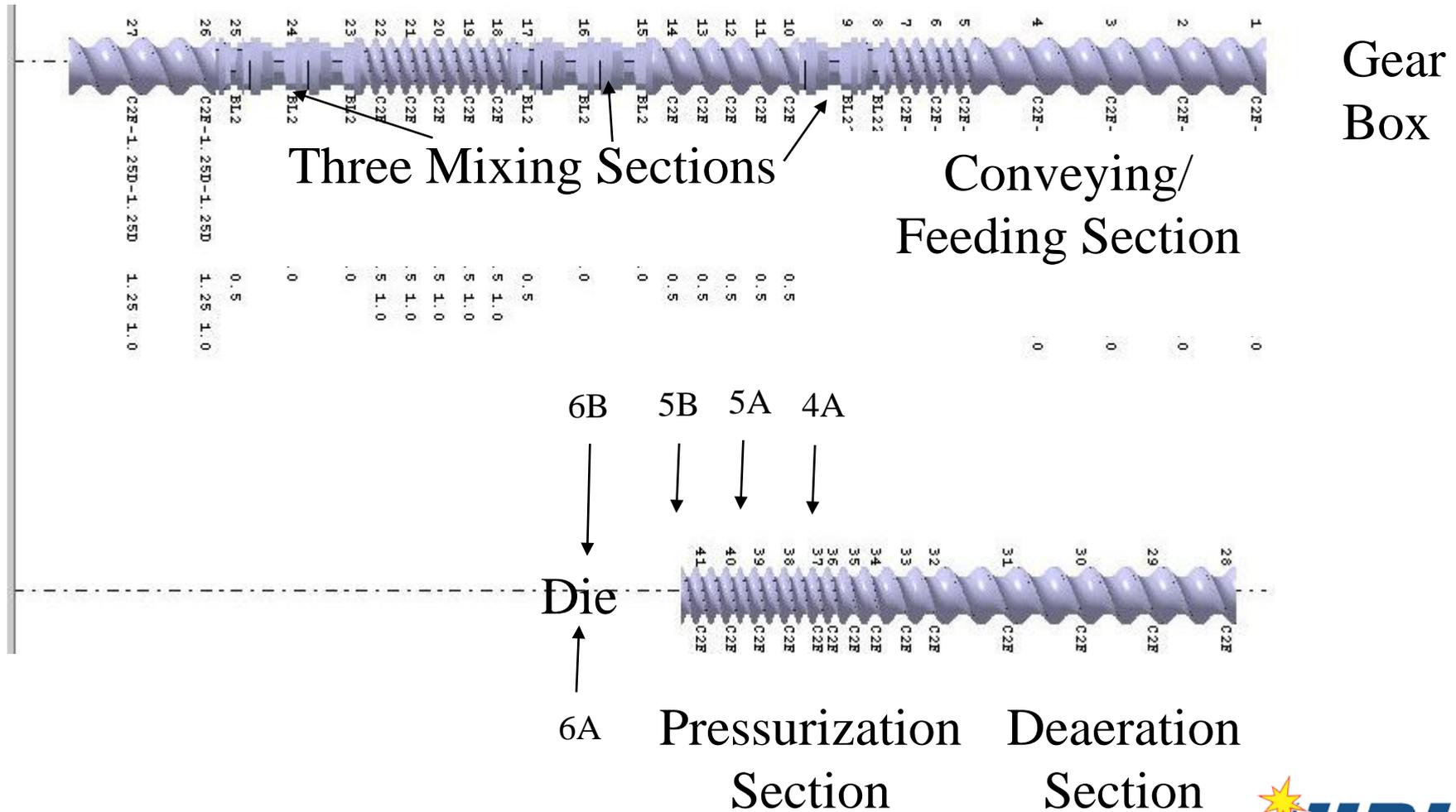
- Feeder Accuracy
 - 200 – 350 lb/hr
 - Vibration level
 - With and without refill
 - Adjusted Gain
 - Full-up feeder testing with an ATK designed propagation break funnel
- Refill Request
 - Adjustable Parameters
 - refill complete time, refill request weight

Extruder Equipment

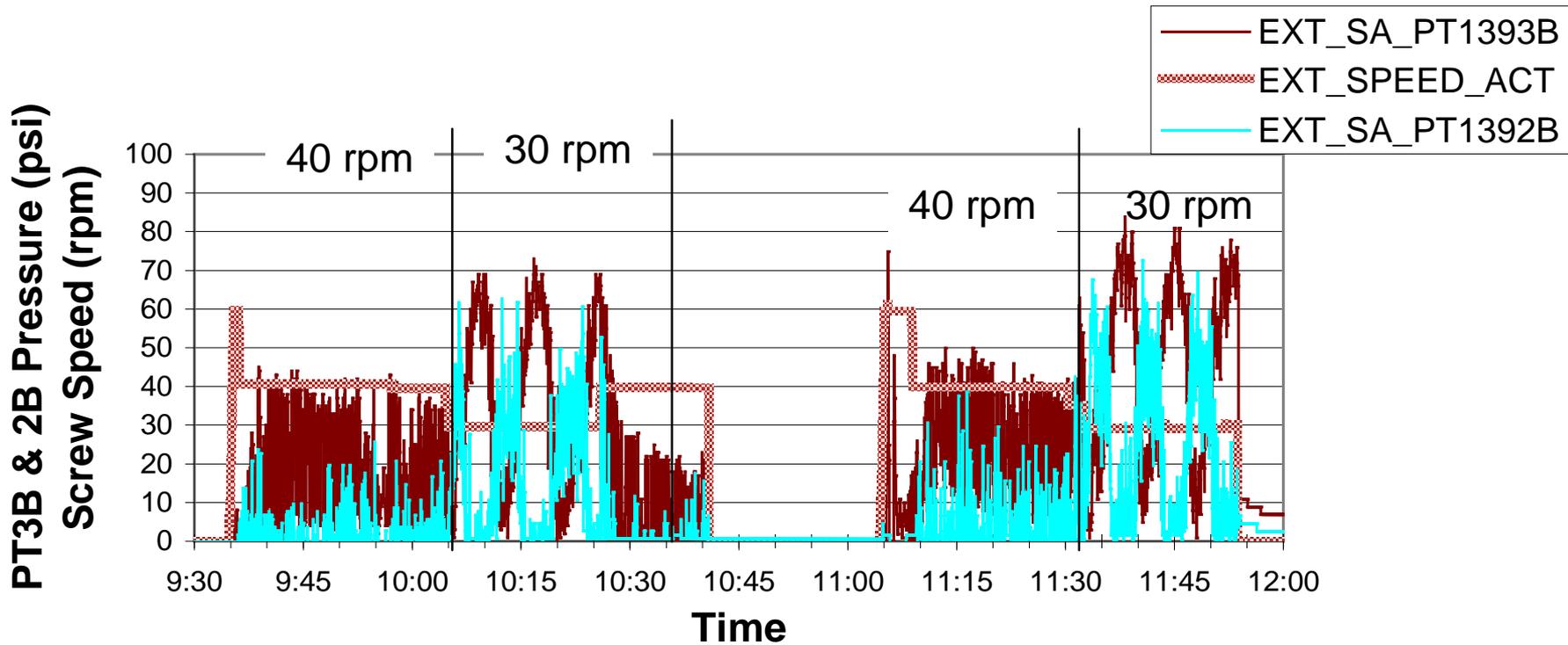


- Clextral Evolum 88 MM
 - This extruder has a 30 L/D.
 - It has five temperature control zones.
 - It is fully instrumented for pressure and temperature along the extruder barrel.
 - We have the capability to extrude 500 pounds per hour of gun propellant.

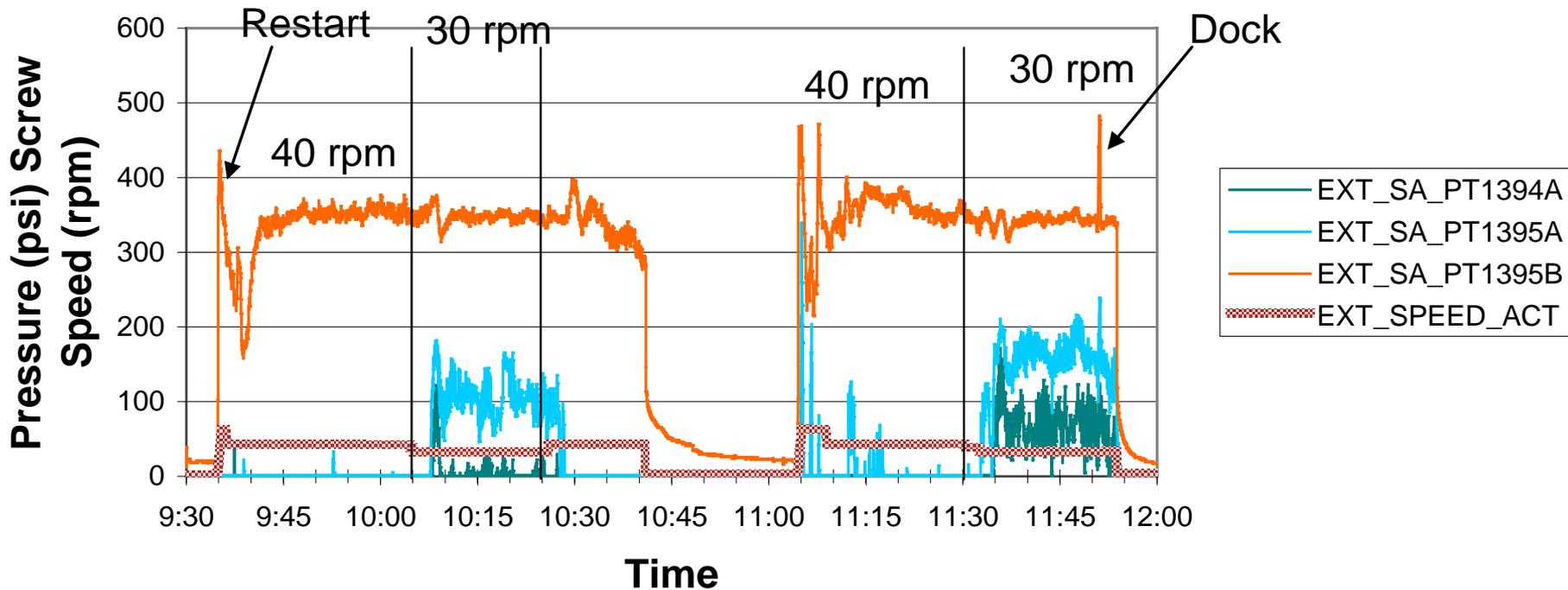
Final MK99 Screw Configuration



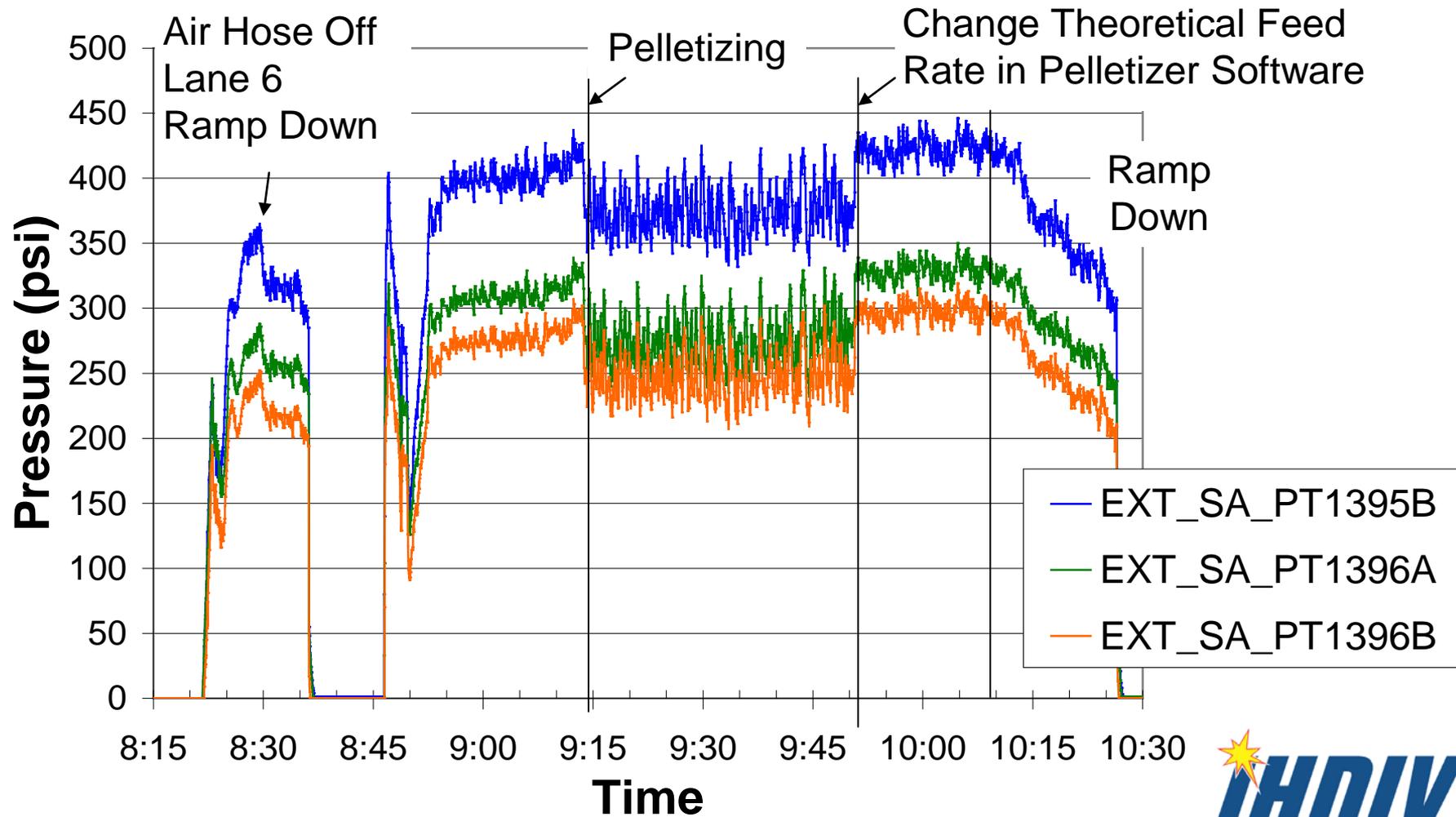
Pressure over Kneading Blocks from Run 5



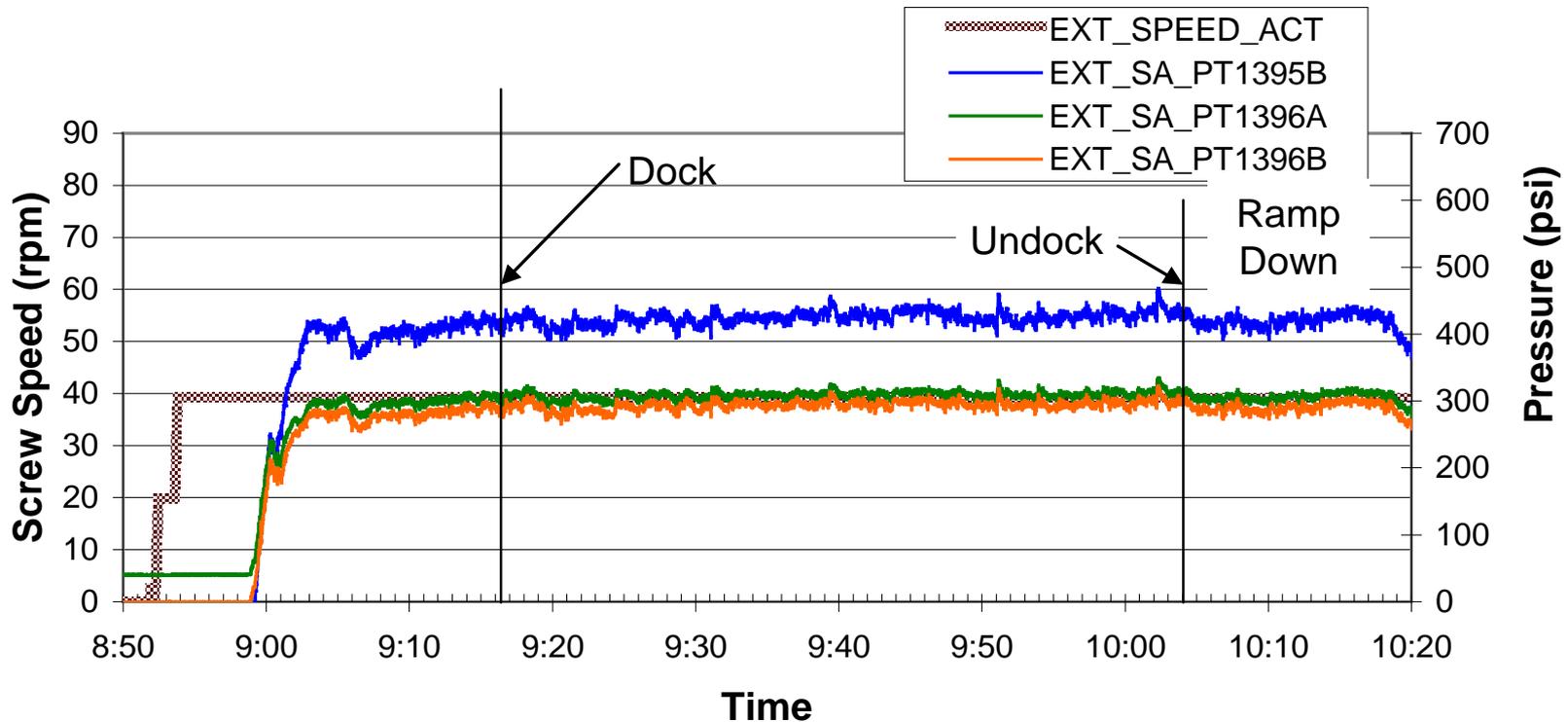
Pressures from Run 5 Single Flight Elements



Pressure Responses from Run 8

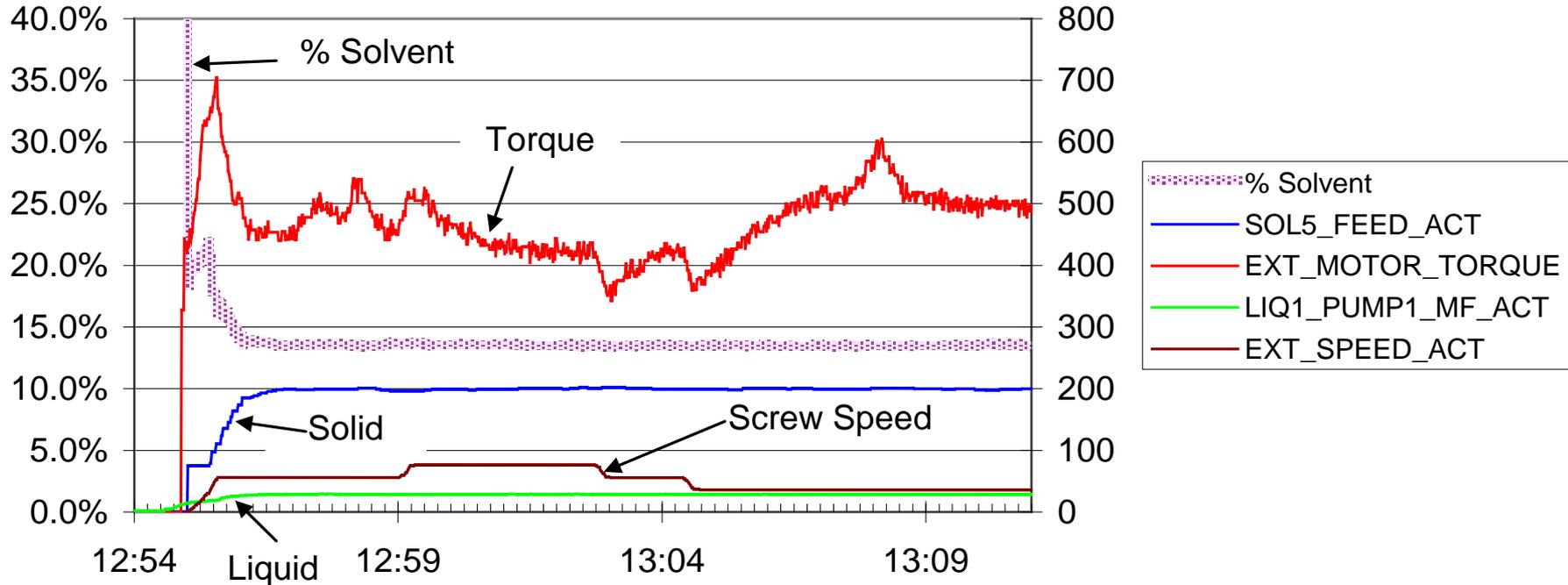


Pressure Responses from Run 9

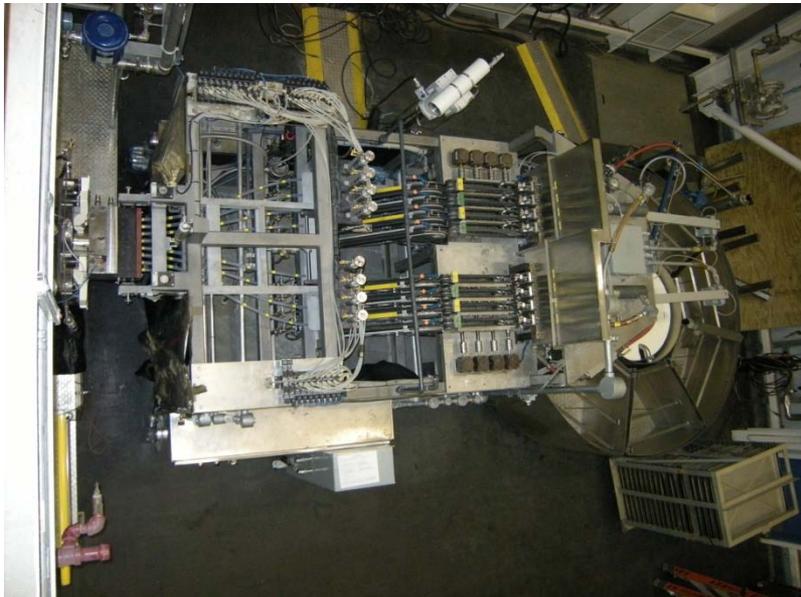


Restart for Run 9

Important for Process Development
Minimize Cleaning Time for Manufacturing



Pelletizer and Rotating-Index Table

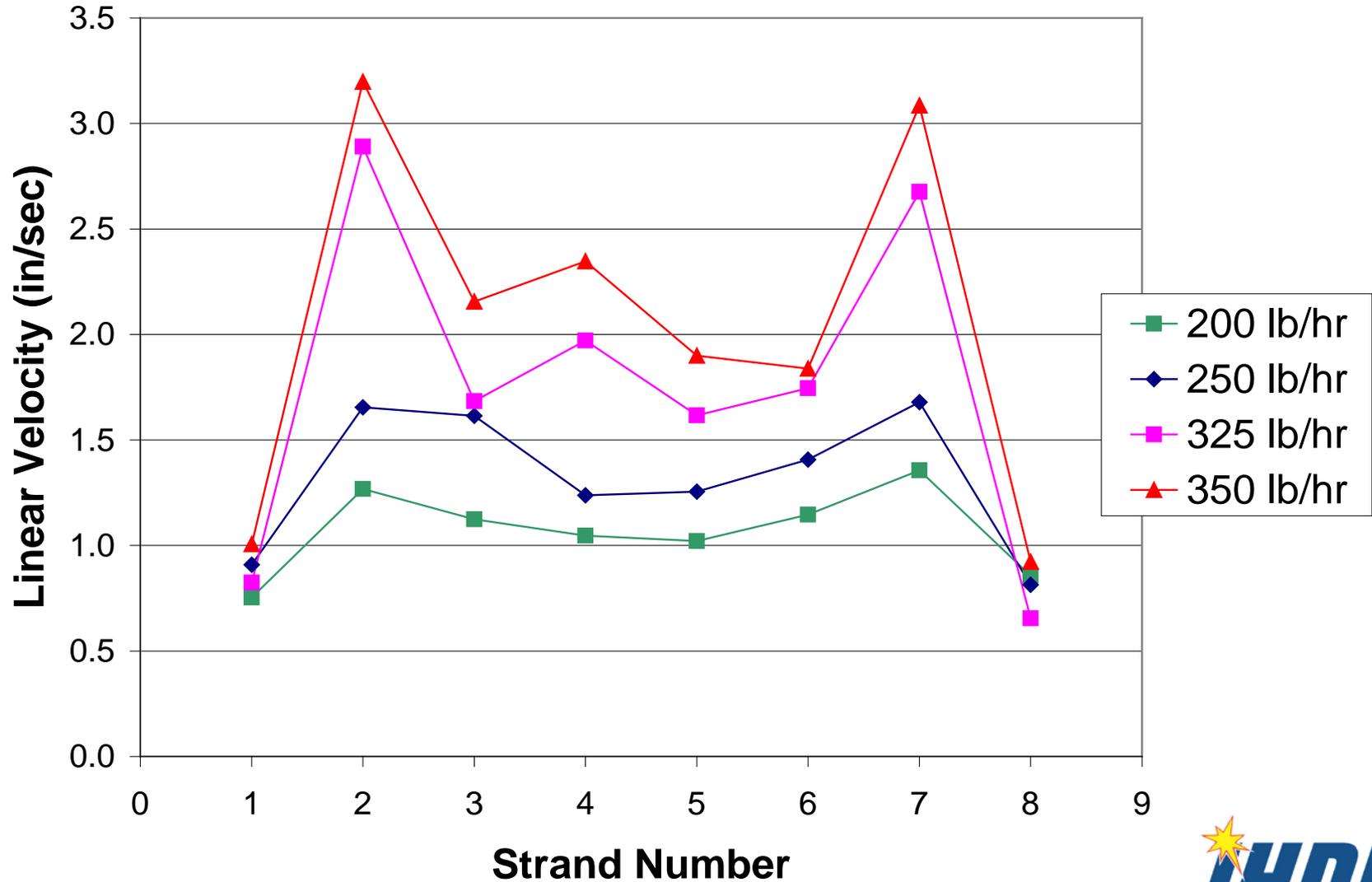


- Romeo Engineering designed system.
 - 3 sub-systems within the pelletizer.
 - Docking
 - Conveying
 - Pelletizing
 - Collection
- Features
 - Water conveying
 - Slack loop
 - 1/4" to 3/4" strand
 - Adjustable pellet length

8 Strand Die



Strand Velocity



Crane

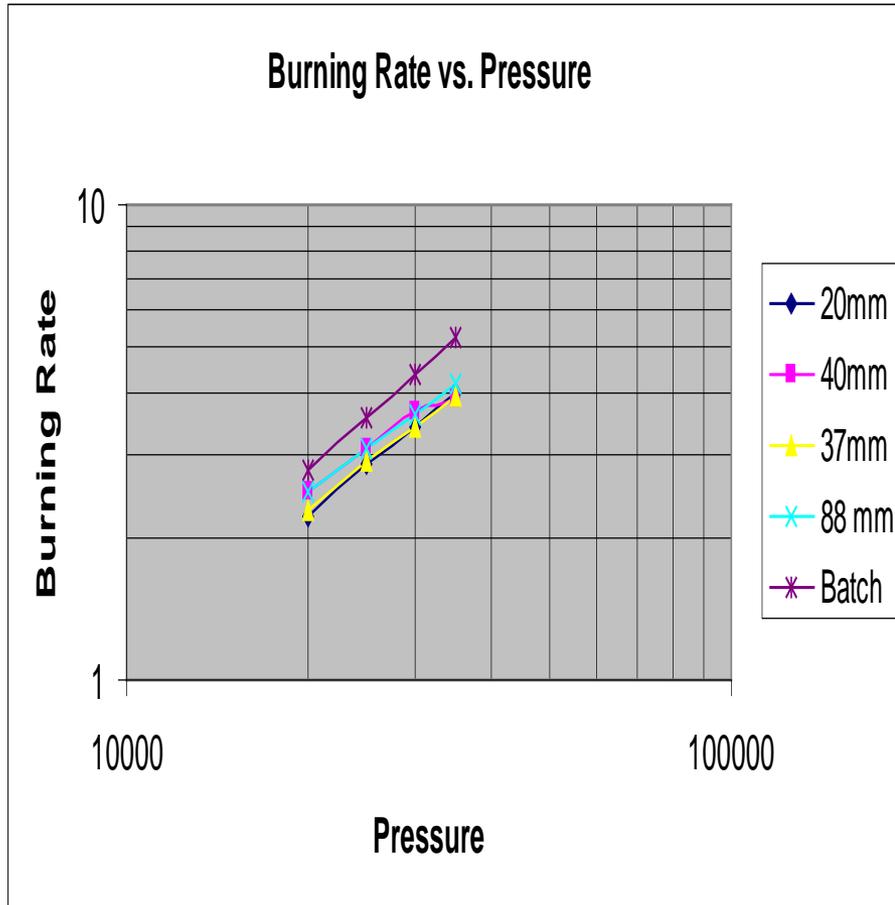


- The crane moves the MATCON bins remotely and automatically for solid feeder refill.
- The crane is a 5 ton primary/3 ton auxiliary hook ACECO bridge crane.
- The primary 5 ton has a MATCON bin grabber.

Control System Overview

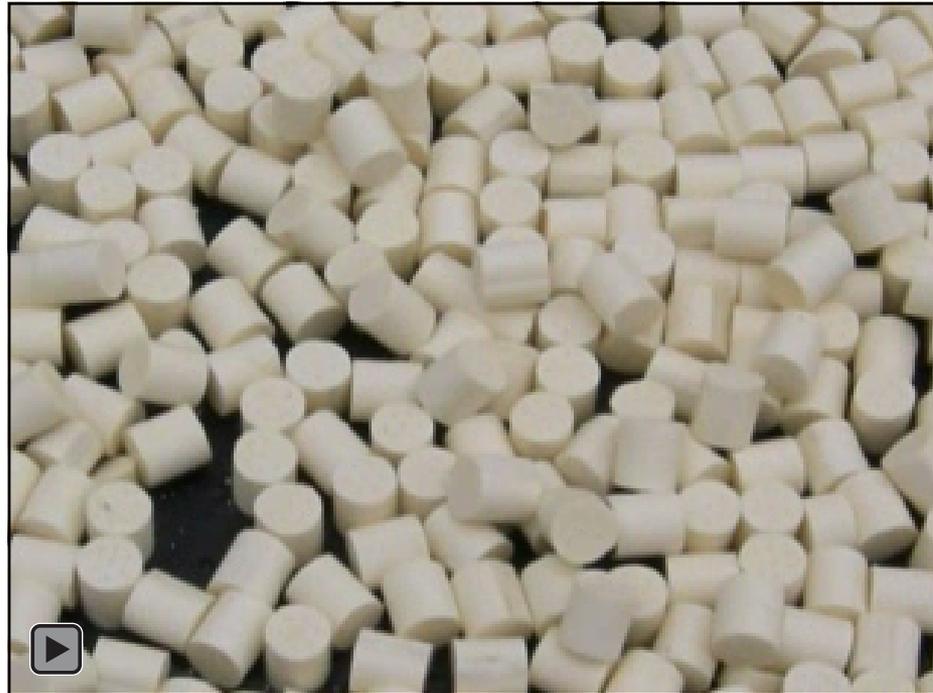
- The control system integrates all the sub-systems into a single user workstation. This allows one operator to run the facility.
- It consists of separate programmable logic controllers (PLC) with one supervisory PLC. The supervisory PLC has an online redundant back up.
- If the primary PLC fails the secondary will maintain a safe operation.
- We have continued with software updates as we have progressed through live operations.

Burn Rate Data for MK 99 Pellets 20 mm through 88 mm



- Burning rate data throughout TSE scale-up: 20mm → 37mm → 40mm → 88mm is consistent.
- Burning rates slower than batch manufactured pellets due to better mixing from the TSE.
 - Make up difference using a smaller granulation.

Remote MK 99 Manufacturing



Conclusion

- Successfully and safely demonstrated the Continuous Processing Scale-up Facility.
- Successfully scaled MK 99 gun propellant manufacturing from torque rheometer through to the 88 mm.
- Indian Head has a full spectrum of continuous processing capability.