47TH TURBOMACHINERY & 34TH PUMP SYMPOSIA
HOUSTON, TEXAS | SEPTEMBER 17-20, 2018
GEORGE R. BROWN CONVENTION CENTER

Compressor Startup Flaring Avoidance Design Methodology

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Biographical Information

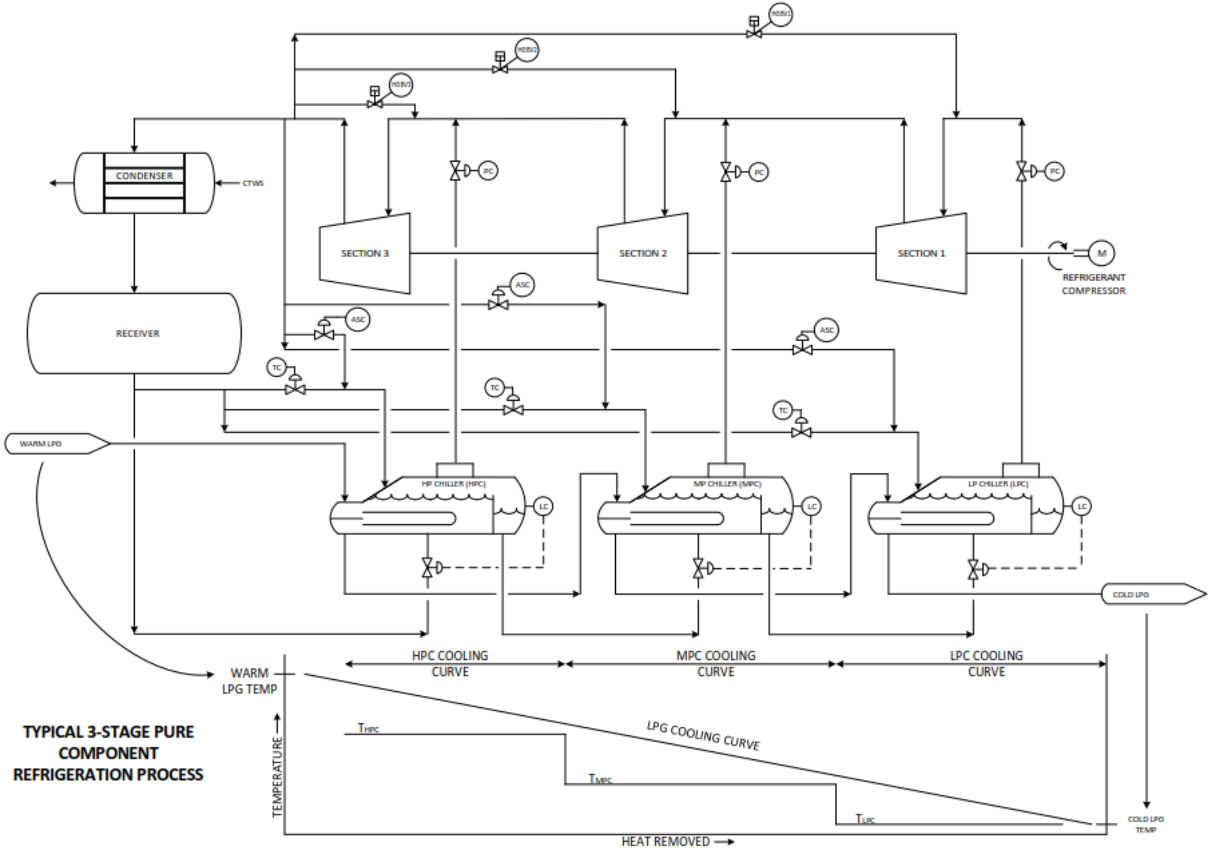
Mr. Amodeo is a Senior Process Specialist with S&B Engineers and Constructors. He has over forty years of experience in the chemical processing industry, with special emphasis on dynamic simulation of compressors and refrigeration systems

Mr. Narayanan is a Chief Technology Officer with Energy Control Technologies and is a registered P.E in the State of Texas and Iowa. He has over thirty years of experience in the Oil & Gas industry, with expertise in turbomachinery control system design, implementation of advanced surge control algorithms, and dynamic simulation of compression systems

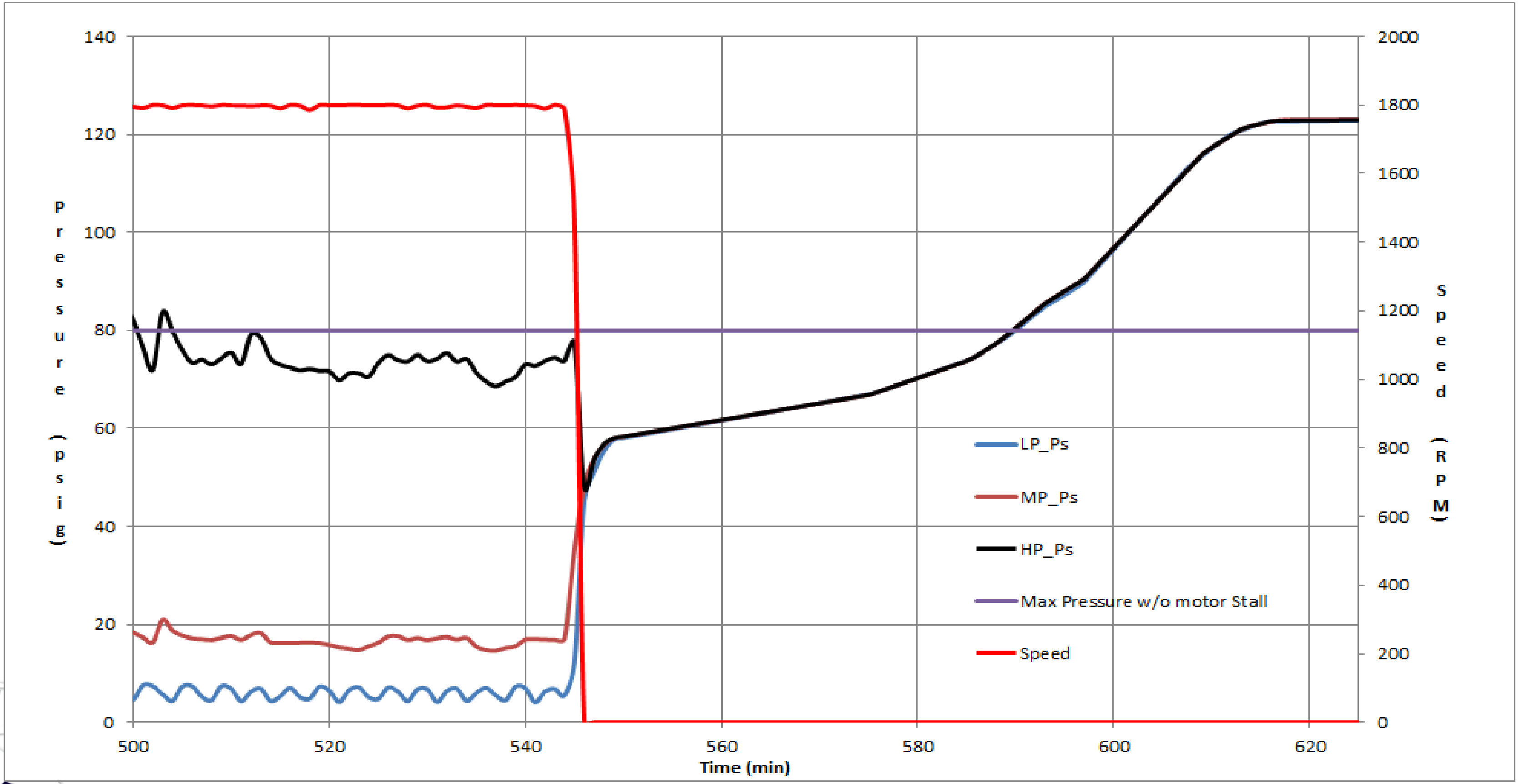
Summary

This case study outlines the methodology used to avoid the flaring of refrigerant inventory during the startup of a 3-section refrigeration compressor used in LPG chilling service. S&B Engineers and Constructors (S&B) and Energy Control Technologies (ECT) conducted a joint analysis of potential problems in the field caused by high settle out pressure in the compressor casing following shutdown. This analysis involved dynamic simulation of the refrigeration system to develop and test various system improvements for preventing refrigerant loss.

Process Description (PFD)



LP/MP/HP Stage Settle out Pressure (before)



Existing Control System

- Compressor control system (Independent PLC)
  - Antisurge and Performance controller (inlet pressure)
- Process control system (DCS)
  - Quench and Chiller level controller
- Field data conclusions
  - Unstable control loop response @ no-load startup conditions and during load changes
  - Settle out pressure exceeded maximum allowable casing pressure after a compressor trip
  - Flaring of refrigerant from the casing was necessary to prevent motor stall on start

Methodology

Goal: *create a 'hi-fi' model of real plant that provides cause/effect insight, has predictive capability, & can be successfully back-tested against operating data*

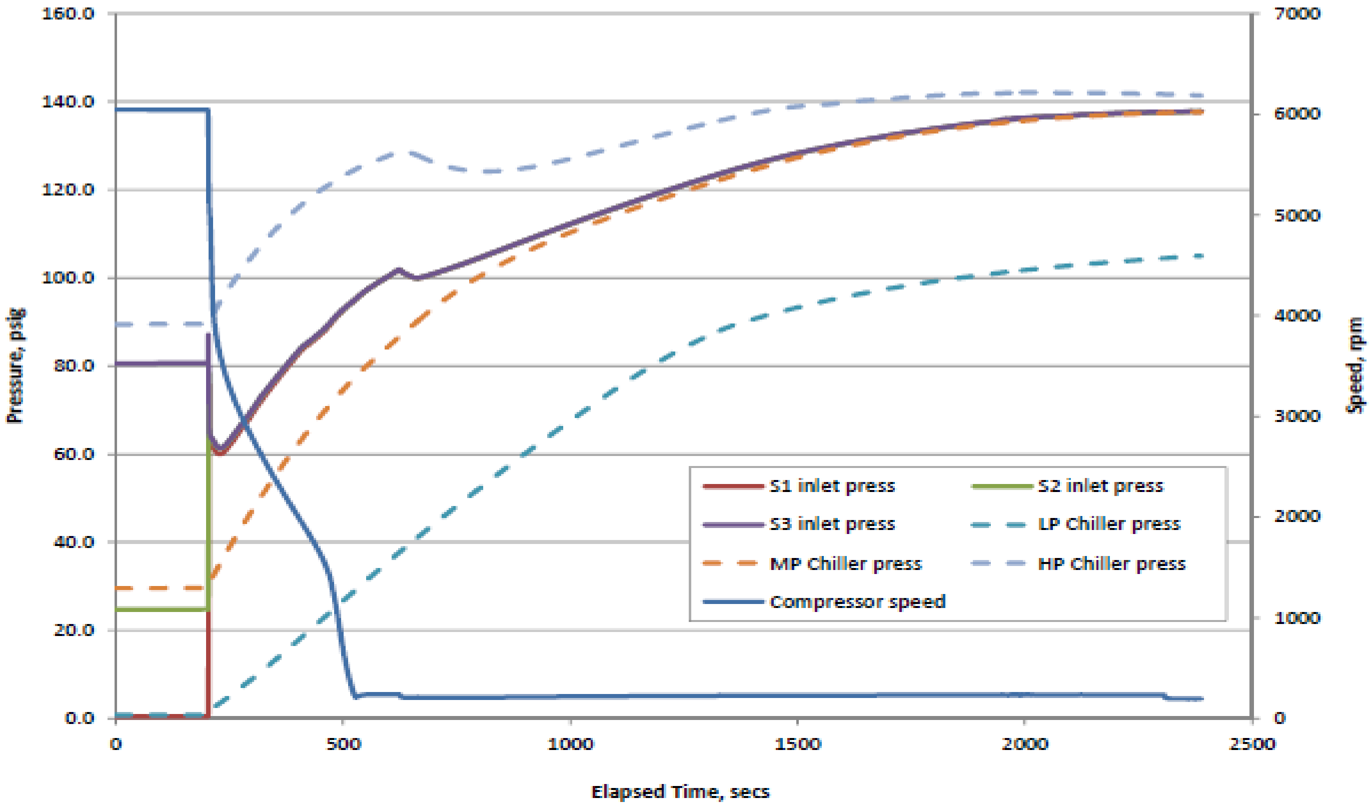
Constraints: *a)no changes to physical plant (vessels, pipework, control valves, rotating equipment); b) no change to process requirements (X BPD of LPG chilled from Twarm to Tcold); c) HSE☺c) TX ambient temps…*

Fair Game: *a)changes to valve sequencing (PLC); b) minor changes to field hardware (positioners, etc)*

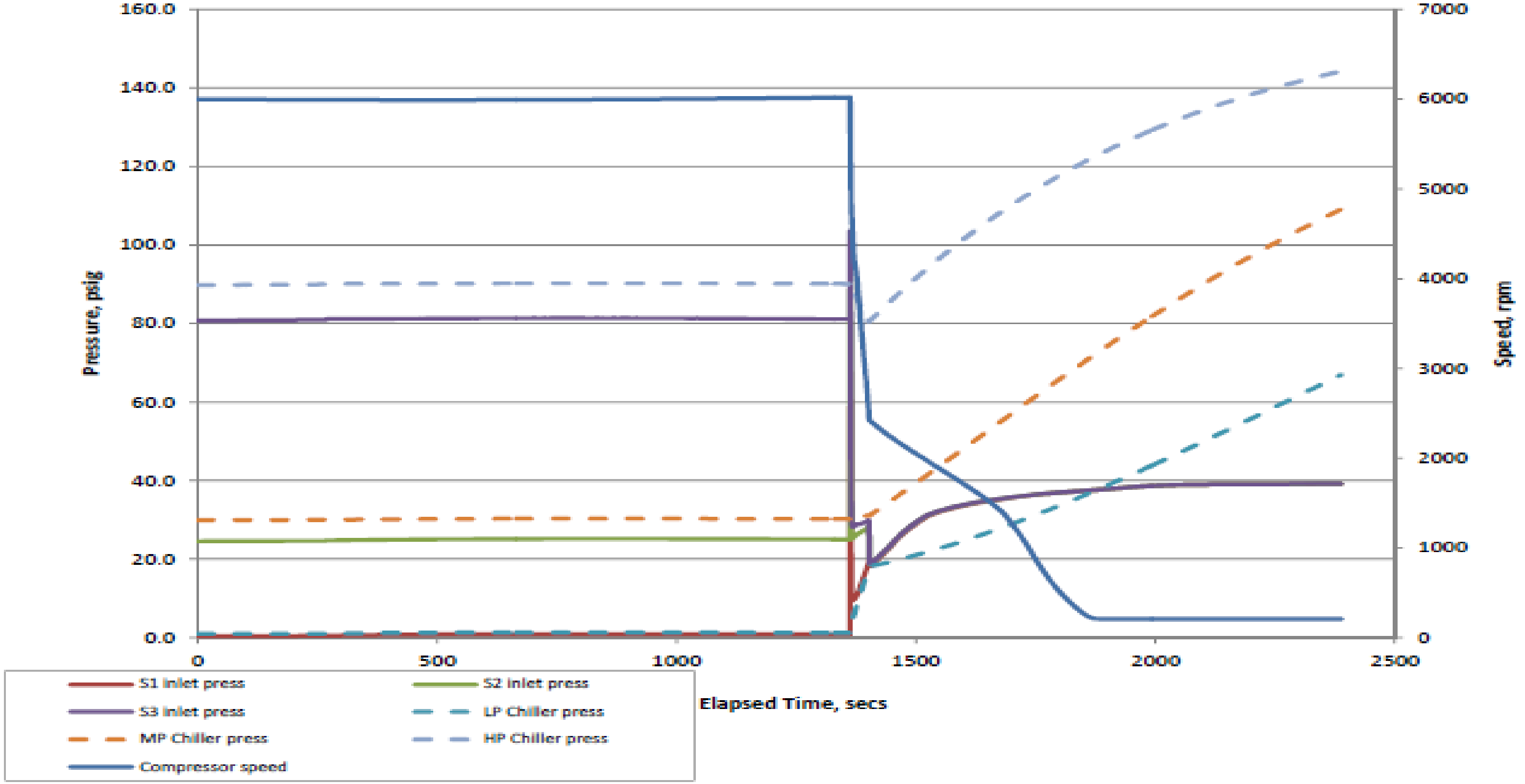
Hypothesis Development

- Potential causes of observed compressor trips
  - Excessive opening of recycle valves during load changes overloads the motor
  - Negative interactions between the anti-surge controllers result in unstable response
- Higher settle out pressure is likely from
  - Compressor casing not completely isolated from the process chillers OR
  - Not isolating the source of heat load to process chillers after a trip

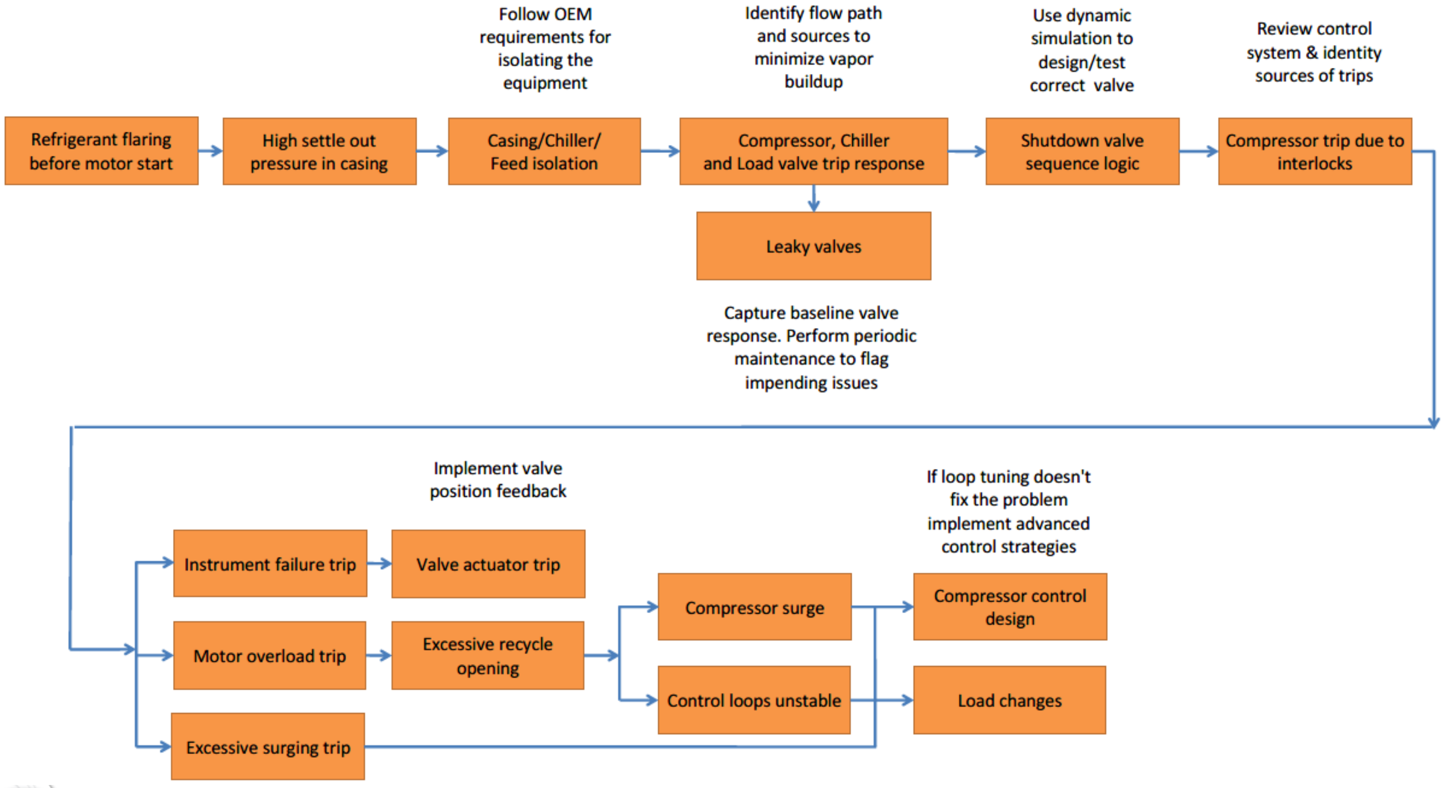
Hypothesis Testing



Simulation design results



RCA - Conclusions



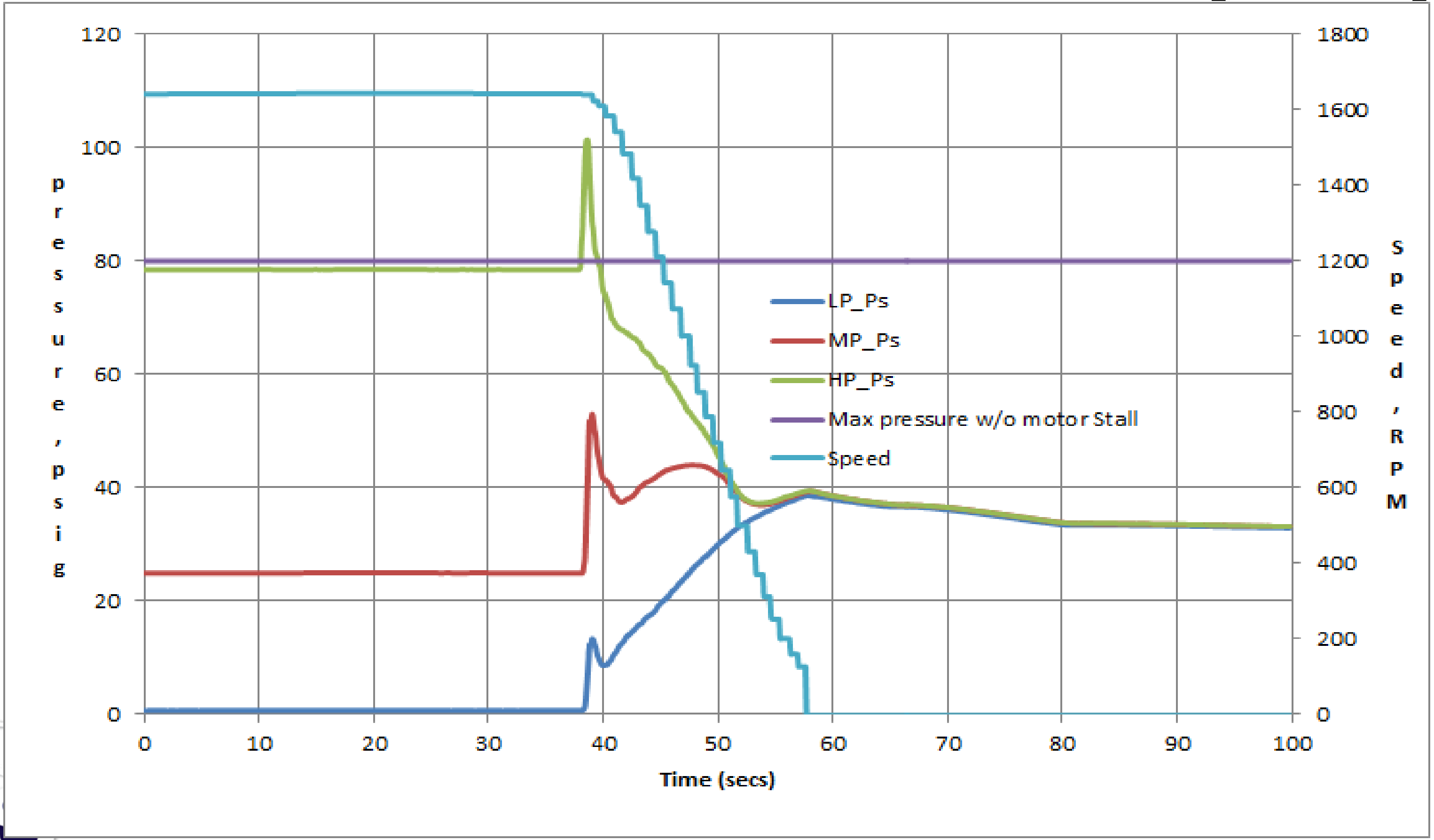
Improvement Plan Implementation

- *Implemented advanced anti-surge control algorithms to prevent trips; quench controllers incorporated with compressor control*
- *Feed forward control design for chiller level loops*
- *Compressor casing isolated from process chillers/suction drums after a motor trip*

Caution: ***Modifying your shutdown sequence logic can result in potential damage to your compressor. We do not recommend implementing any changes to your program without validating the system response using a dynamic simulation tool.***

#	Event	Specified	Condition	Action List	Jump When	Jump To
1	**Motor Trip**	TRUE	1-min wait	Action List 1	Timeout	Run disch SDV SR
2	Run disch SDV SR	TRUE	None	Action List 2	Timeout	Open ASVs
3	Open ASVs	TRUE	None	Action List 3	Timeout	Open HGBVs
4	Open HGBVs	TRUE	None	Action List 4	Timeout	Close STV2/3
5	Close STV2/3	TRUE	N<2500	Action List 5	Timeout	Close SDV2/3
6	Close SDV2/3	TRUE	None	Action List 6	Timeout	Close ASV2/3
7	Close ASV2/3	TRUE	None	Action List 7	Timeout	Close TVs
8	Close TVs	TRUE	None	Action List 8	Timeout	Close LVs
9	Close LVs	TRUE	None	Action List 9	Timeout	Close SDV1
10	Close SDV1	TRUE	LP drum P>S1 inlet	Action List 10	Timeout	Close ASV1,STV1
11	Close ASV1,STV1	TRUE	None	Action List 11	Timeout	Stop
12	Stop	TRUE	None	Action List 12	Never	

Field results – settle out pressure (after)



Benefits of Methodology Used

- Compressor trip avoidance eliminates production loss and maximizes plant profitability
- Elimination of flaring results in refrigerant savings (~1000s of lb per trip) translating to material cost savings and avoidance of emissions fines
- Risks associated with shutting down the pipeline and compressor equipment precludes iterative testing in the field to develop a viable solution
- Validating root cause analysis before implementing the program in the field avoids costly production delays and equipment damage

Lessons Learned

- Matching the model to field data is important to enhance the accuracy of the simulation results
- Valve step and ramp testing is recommended to fix valve calibration issues (ex: dead band) and in establishing a baseline model for the valves
- Advanced control strategies were instrumental in trip avoidance by stabilizing interactive chiller level controllers, compressor anti-surge and quench controllers
- Installing position feedback transmitter on critical valves was beneficial in identifying potential issues