Methane Mitigation Using Linear Motor Leak Recovery Compressor

DOE Project No. DE-FE0031875

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U.S. Department of Energy

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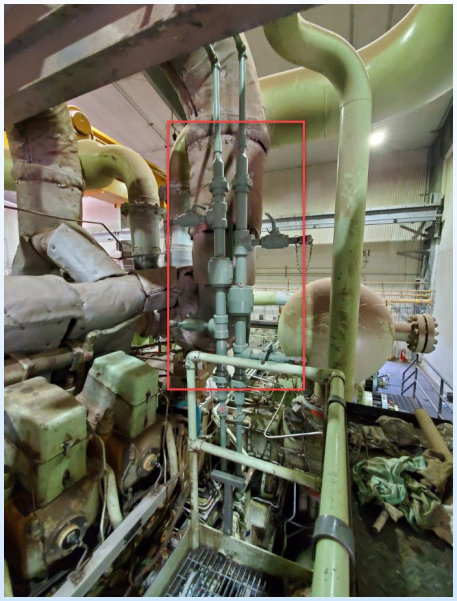
Project Overview

- Funding
  - DOE: $1,499,918
  - CS: $375,002 (Operations Technology Development)
- Overall Project Performance Dates
  - 2/4/2021 – 9/30/2023
- Project Participants
  - GTI Energy
  - University of Texas – Center for Electromechanics
- Overall Project Objectives
  - Design, build, and test a methane leak recovery compressor for midstream compressor stations

Technology Background

- Midstream compressor stations have concentrated methane leaks
  - Compressor packing
  - Engine starters
  - Valves
  - Blowdowns
- Existing solutions are often costly and only partially address leaks
- GTI is developing a unique, linear motor driven compressor
  - Recover gas from any/all sources
  - Compress leaks directly back to pipeline
  - Minimize impact on existing equipment



Competing Technology

- **Other recovery compressors** – limited discharge pressure, inefficient flow control, high maintenance, and/or expensive
- **Fuel gas recovery** – requires operating compressor, adds reliability risk
- **Static seals** – single emission fix for when compressor is taken offline, do not stop emissions when running
- **Low/no-bleed pneumatics** – partial solution, massive retrofit requirement, reliability risk
- **Packing maintenance** – labor-intensive and typically done without regard to actual emissions rate

Tescorp Vent Master
www.tescorp.com

Cook Static-Pac®
www.cookcompression.com

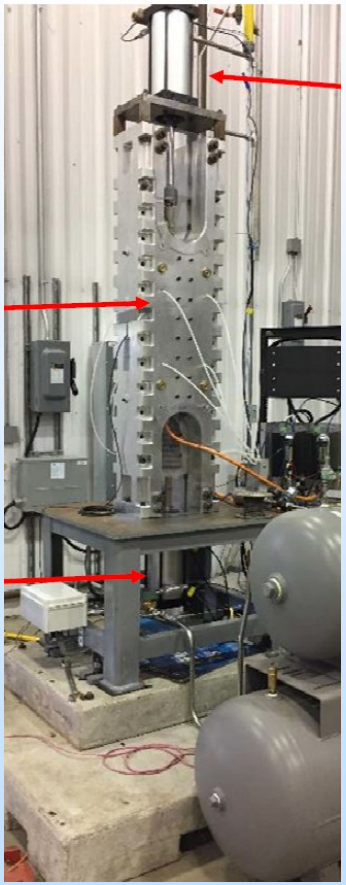
Haug Sirius
www.sauerusa.com

Linear Compressor Advantage

- **Semi-hermetically sealed –** No additional gas leaks during operation
- **High discharge pressure** – Return gas to midstream pipelines
- **Accurate flow control** – Maintain existing vent system at 0 to 0.25 psig
- **No impact on existing equipment** – Existing equipment left unmodified to maintain reliability
- **Single moving part** – Lower cost and maintenance
- **Oil free design** – Reduced maintenance and gas contamination

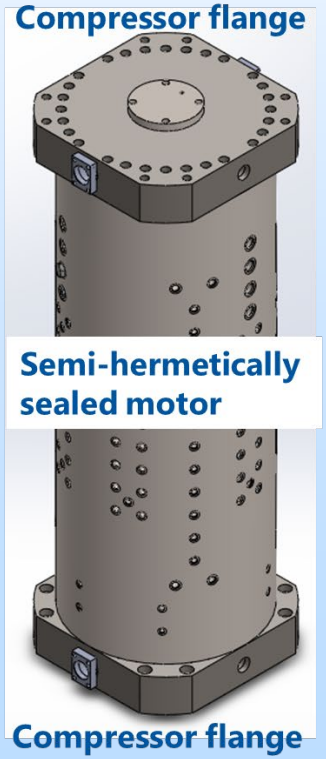
Project Scope

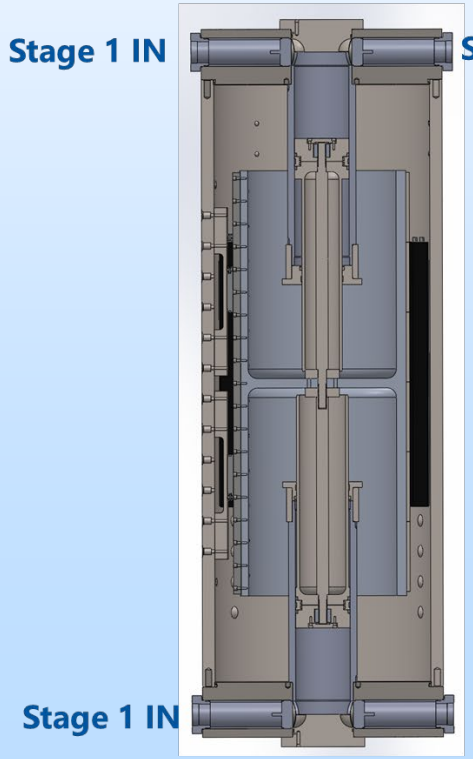
- Design a linear motor leak recovery compressor
  - Inlet: Near atmospheric (0 to 0.25 psig)
  - Discharge: 1500 psig
  - Target flow: 60 SCFM
- Integrate compressor into leak recovery skid
- Install compressor and recovery skid in GTI's environmentally controlled test chamber
- Extensively test complete linear motor leak recovery skid to verify performance and durability
- Success: Show durability and accurate flow control for a reasonable price

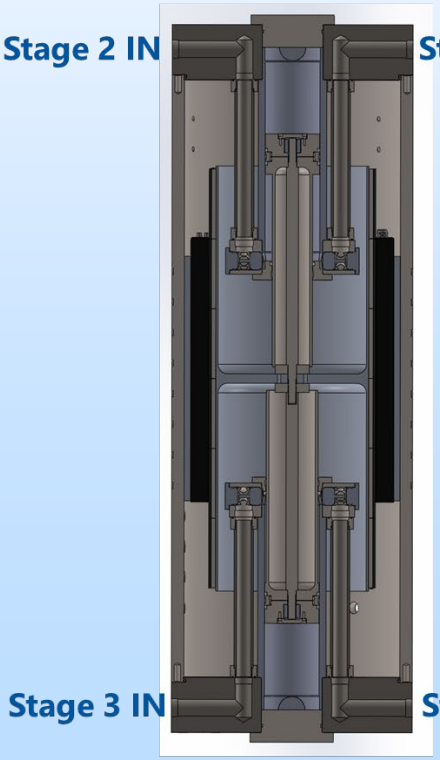


Technology Status

- In BP2 the team moved from a 4-stage to 3-stage design
- 3-Stage, semi-hermetically sealed compressor design complete
- All three stages integrated into a single moving part

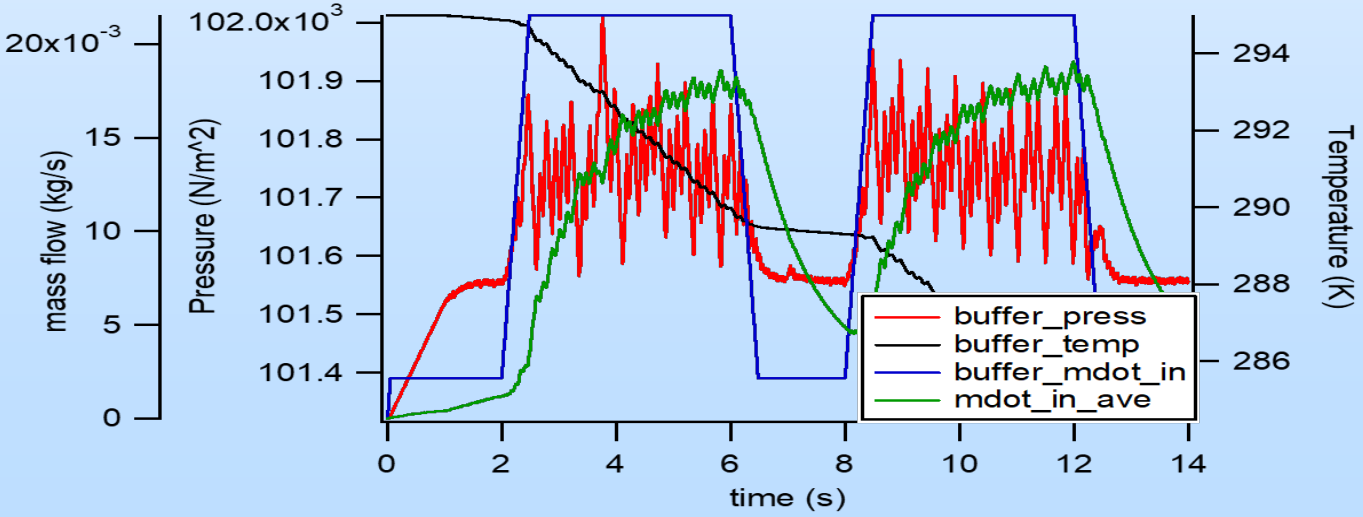






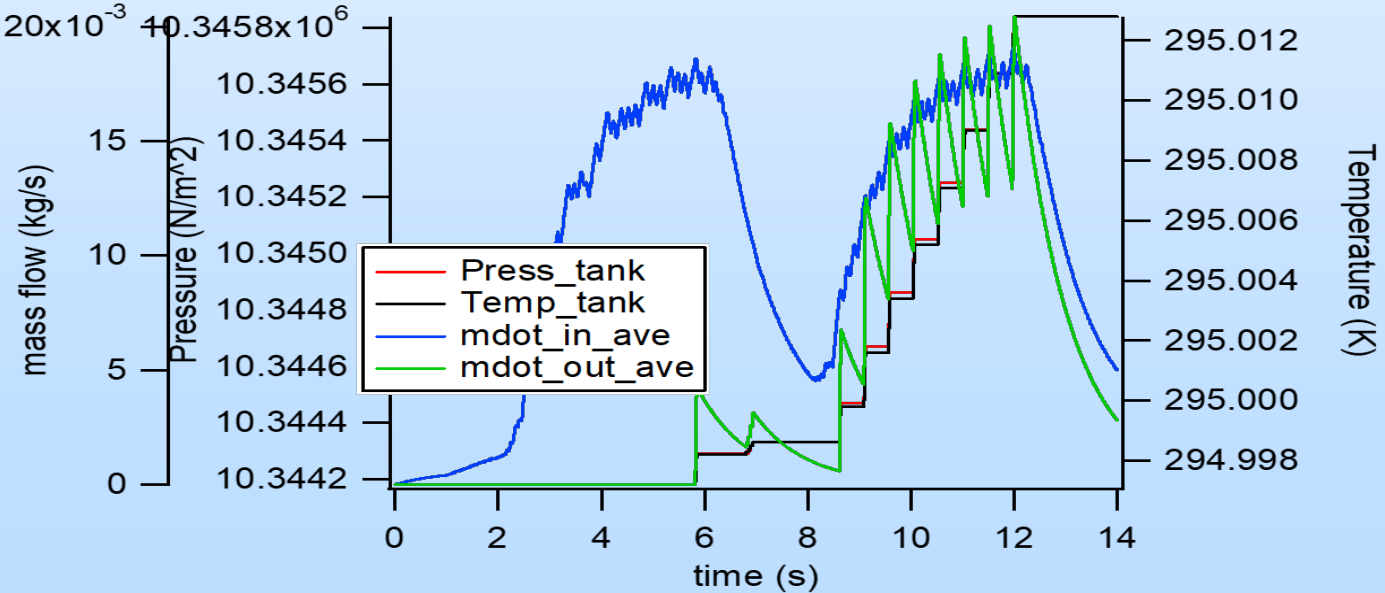
Technology Status

- Dynamic simulation developed in MATLAB Simulink
- Two rapid leak events are simulated to test compressor performance and control dynamics
- Flow alternates from 10%-100% of compressor's target flow rate
- Compressor controller rapidly adapts to maintain buffer and vent gas system between 0 to 0.25 psig



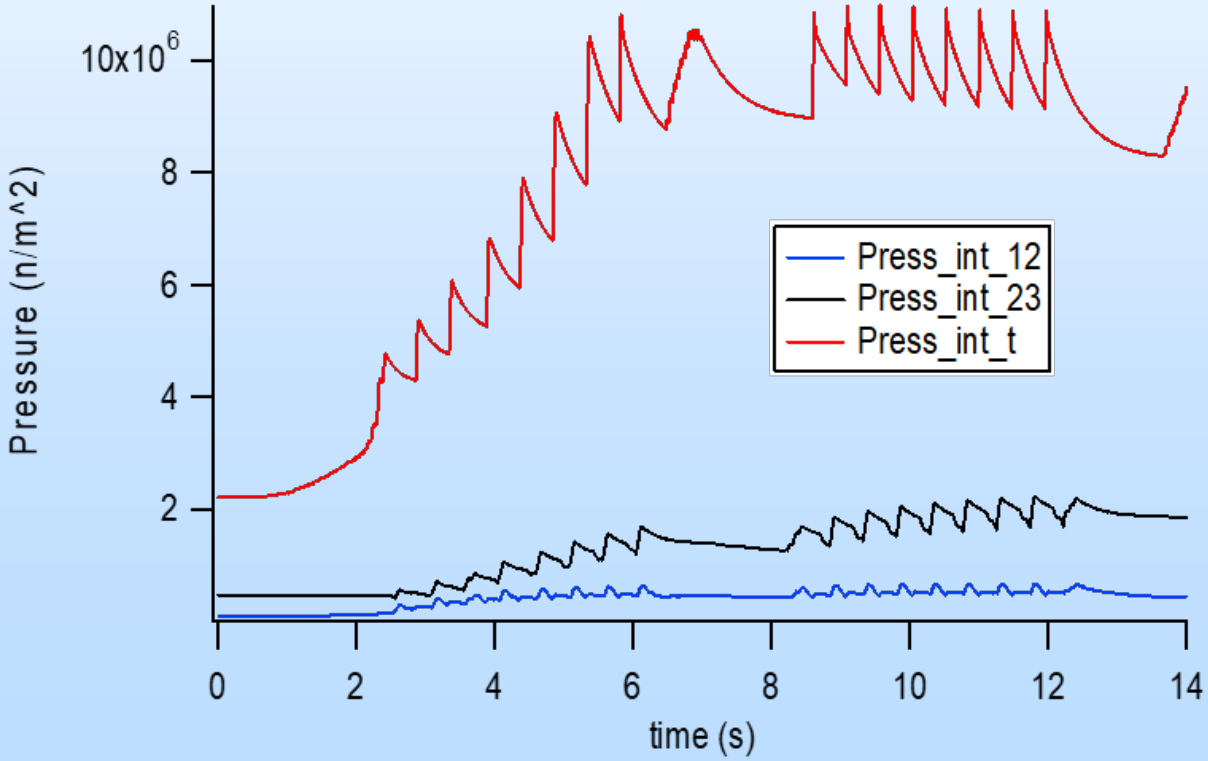
Technology Status

- Compressor suction flow rapidly increases during leak events
- Discharge flow increases during second event only because intercoolers and compression stages are reaching equilibrium during first event
- Discharge pressure in tank/pipe slowly increases as discharge flow increases



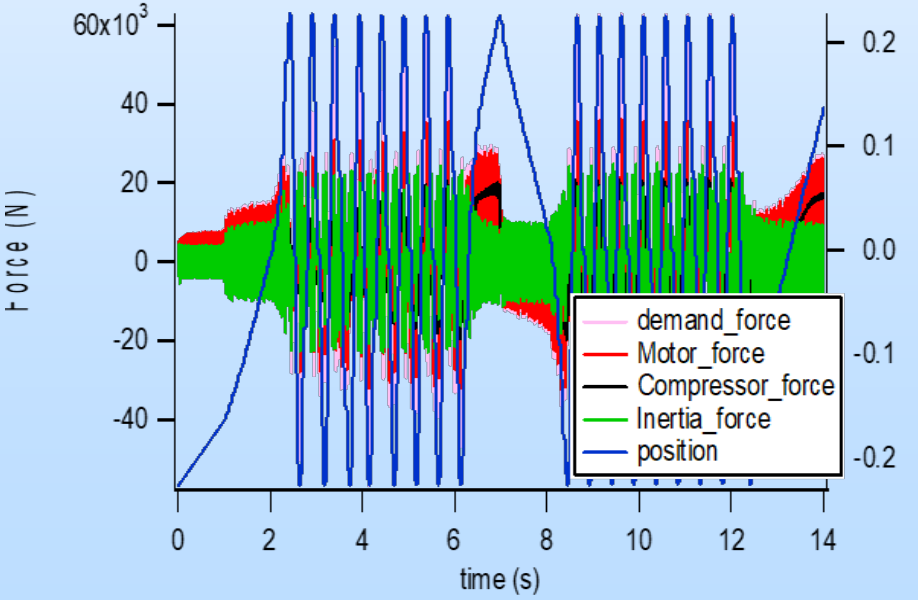
Technology Status

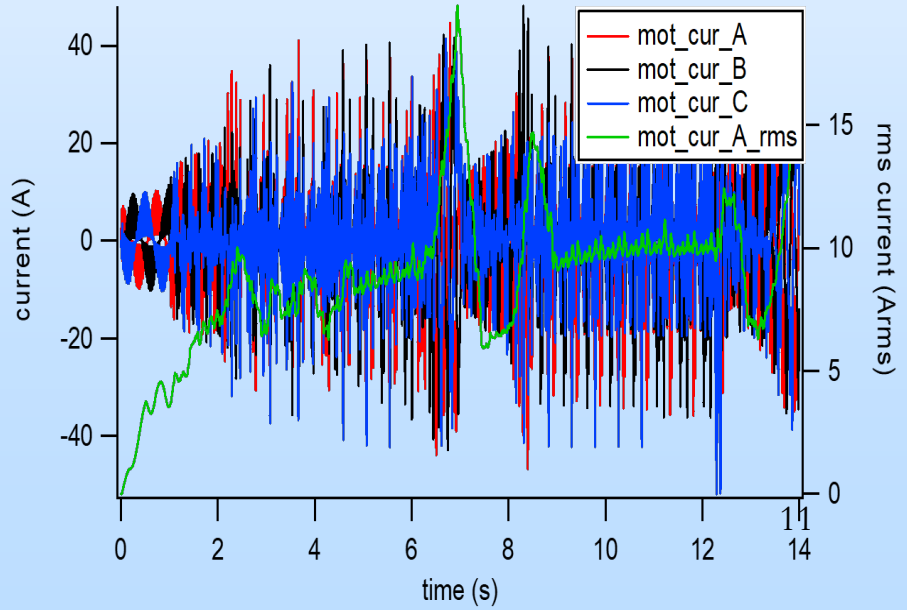
- Compressor intercooler pressures rise until final discharge pressure is reached.
- Intercoolers remove heat from compressed gas before it is compressed further in the next stage



Technology Status

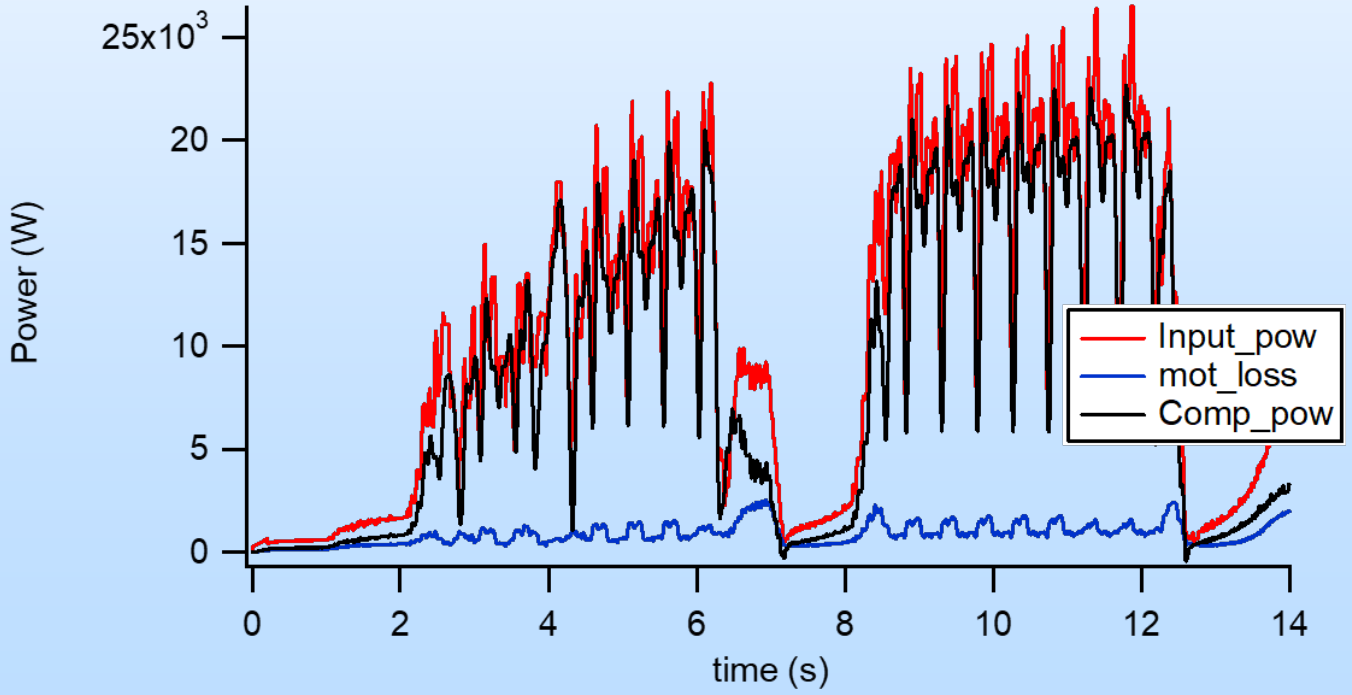
- Simulation includes detailed representation of motor, power electronics, and controls
- The simulation of the motors and controls have both been fully tested and validated using commercial motor tests
- The dynamic forces on the system are shown during each of the leak events





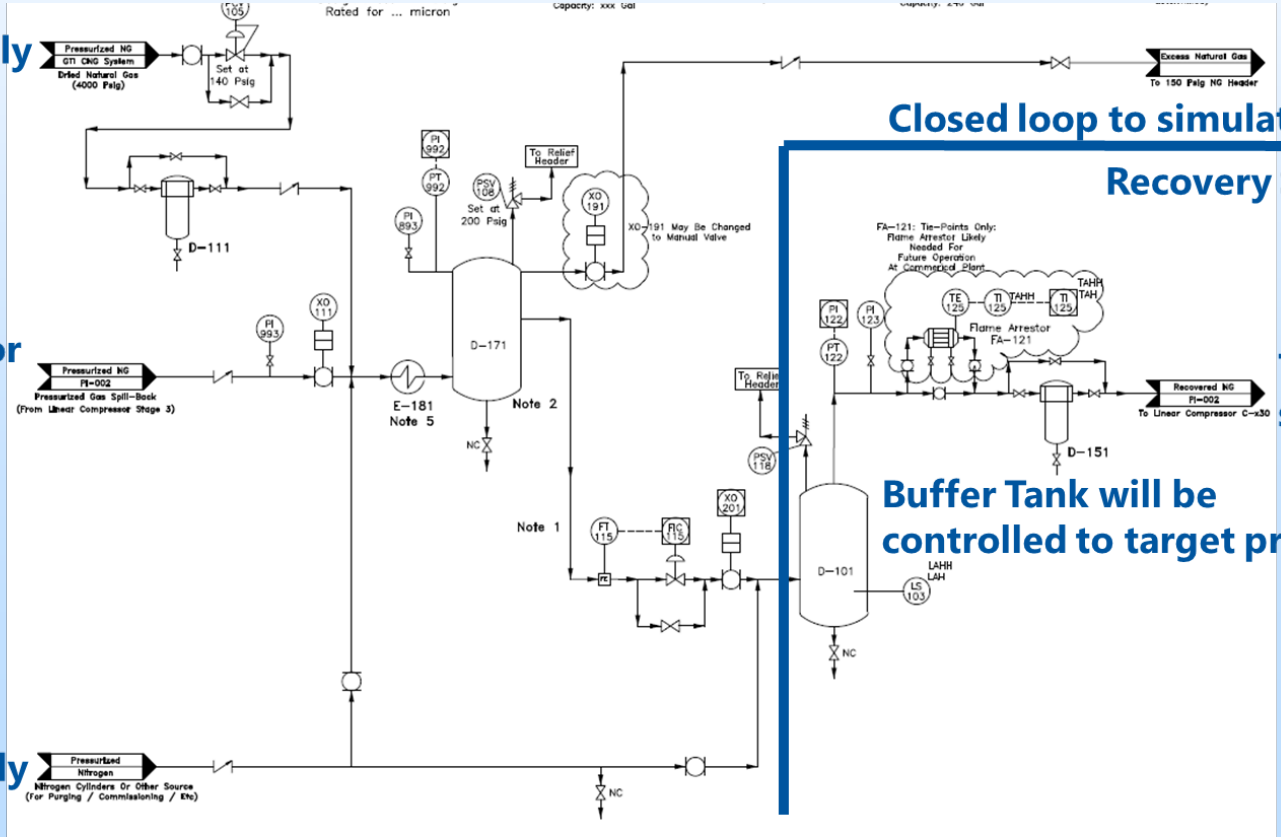
Technology Status

- The controller supplies the instantaneous current required by the motors to maintain desired position and velocity
- Voltage and current through the forcers is used to calculate wall power and motor losses



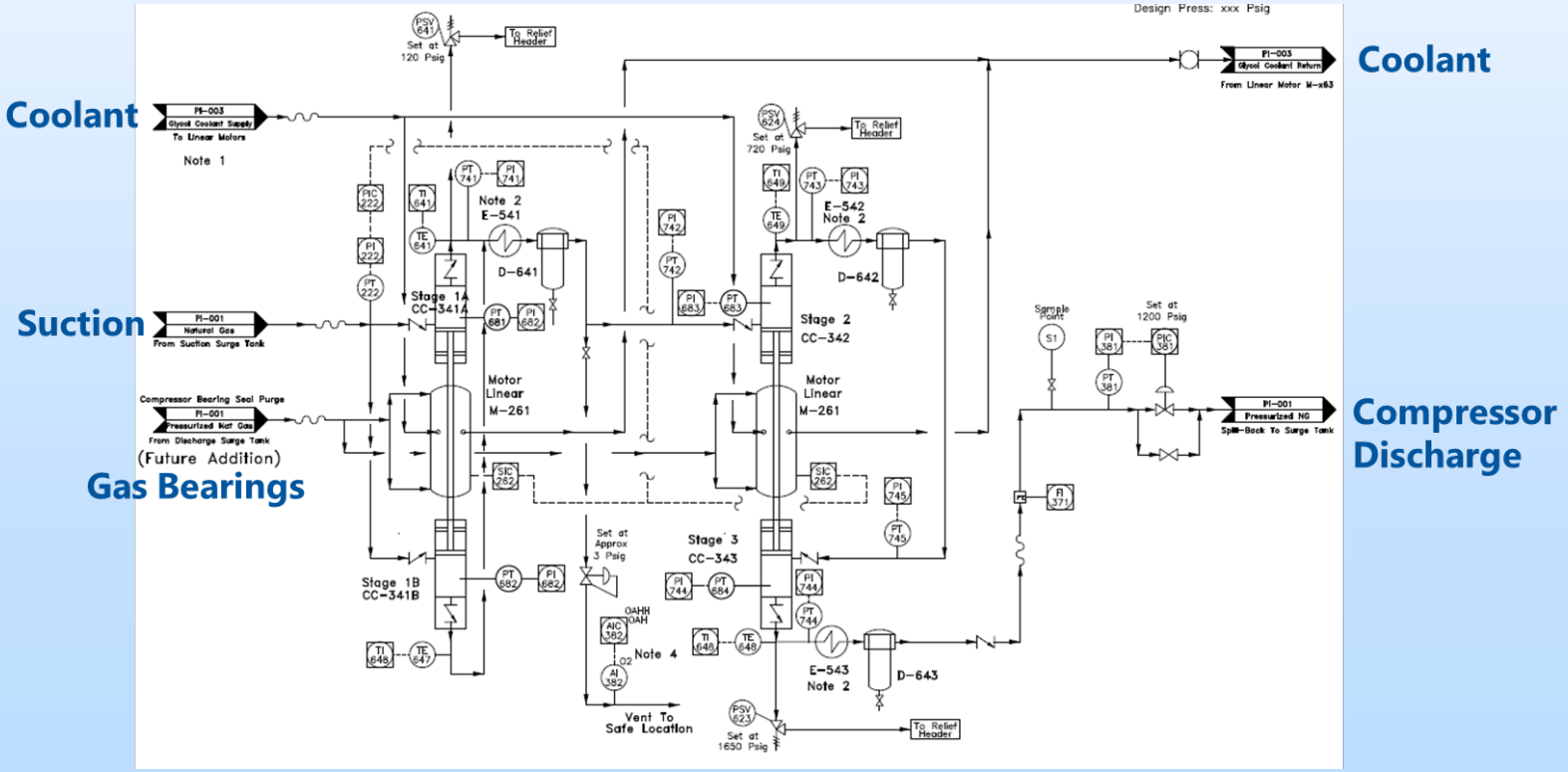
Technology Status

- Compressor tested in closed loop
- Leaks will be simulated by independent control system and will flow into recovery skid buffer tank



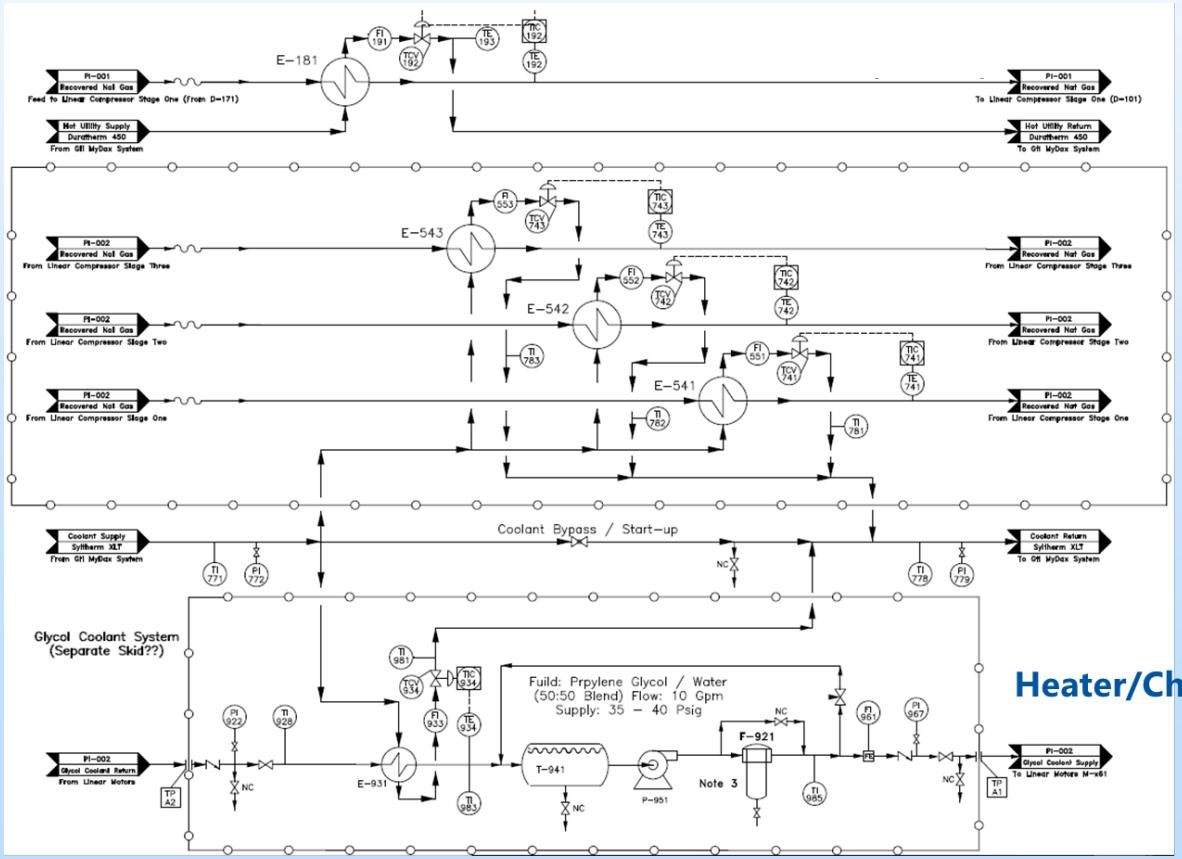
Technology Status

- Filtered gas will flow into 3-stage compressor and compressed to discharge pressure
- Pressures, temperatures, flow and power will be measured to quantify performance



Technology Status

- Simulated leaks, interstage gas, and test chamber will be controlled using heater/chiller to simulate variety of operating conditions



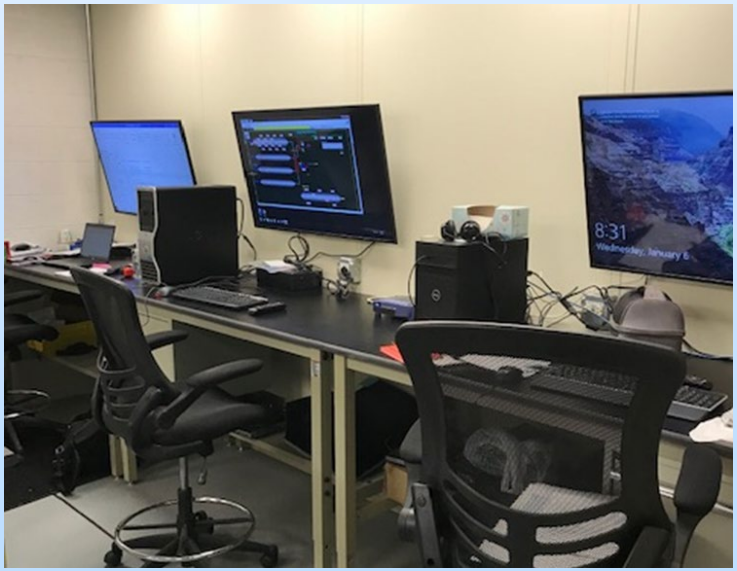
Temp control for leak simulation

Temp control for compressor intercoolers

Heater/Chiller for conditioning gas

Technology Status

- Design is complete
- Fabrication has started using 3rd party machine shops and suppliers
- Components will be assembled as they arrive at GTI



Future Testing

- Project team is working with gas utilities directly and through Operations Technology Development research collaborative
- Several potential test sites have been identified in CA and TX
- Ideally, the unit will be refined and then deployed at those sites to demonstrate reduced sitewide leaks and reliable operation of the recovery compressor
- Project team is interested in hearing from other interested gas utilities as well

Summary Slide

- Design and simulation of compressor and leak recovery skid are complete
- Fabrication is ongoing
- Assembly and testing will begin as soon as fabricated and purchased components arrive at GTI
- Extensive testing planned to fully validate the performance and functionality of the leak recovery system
- Final system will be capable of recovering site wide gas leaks with little to no impact on existing equipment

Questions?

Appendix

Benefit to the Program

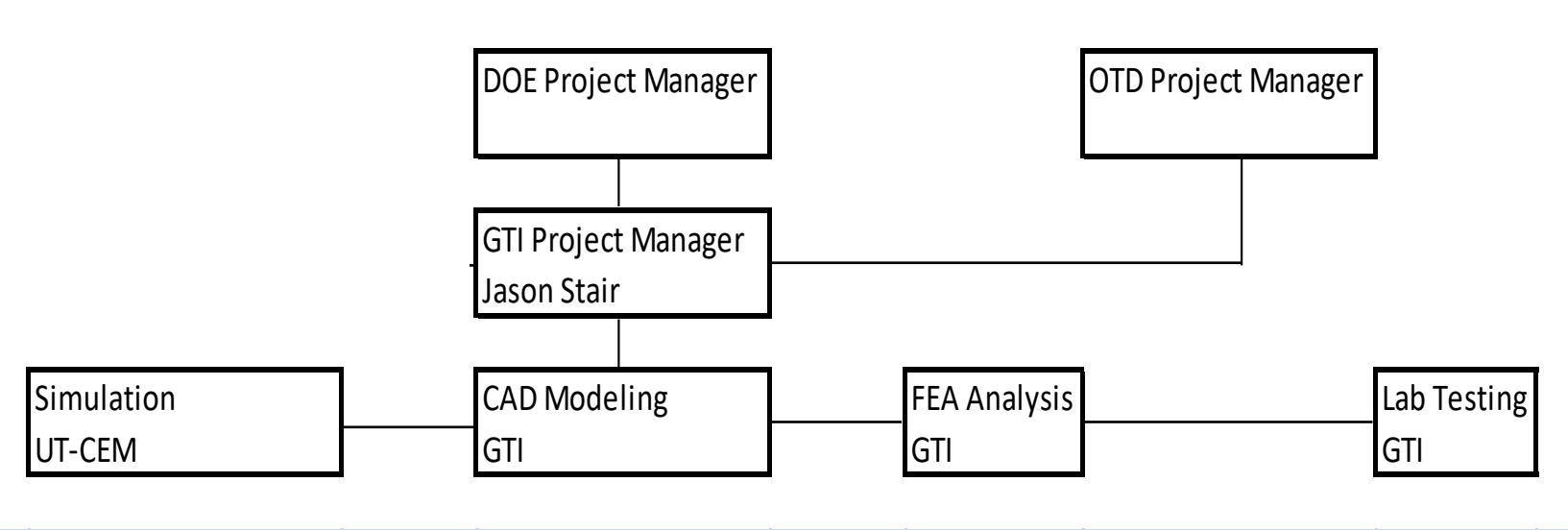
- This project is developing a methane mitigation compressor that is being designed to economically capture methane from multiple leak sources such as compressor packing, valves and blowdown events.

Project Overview

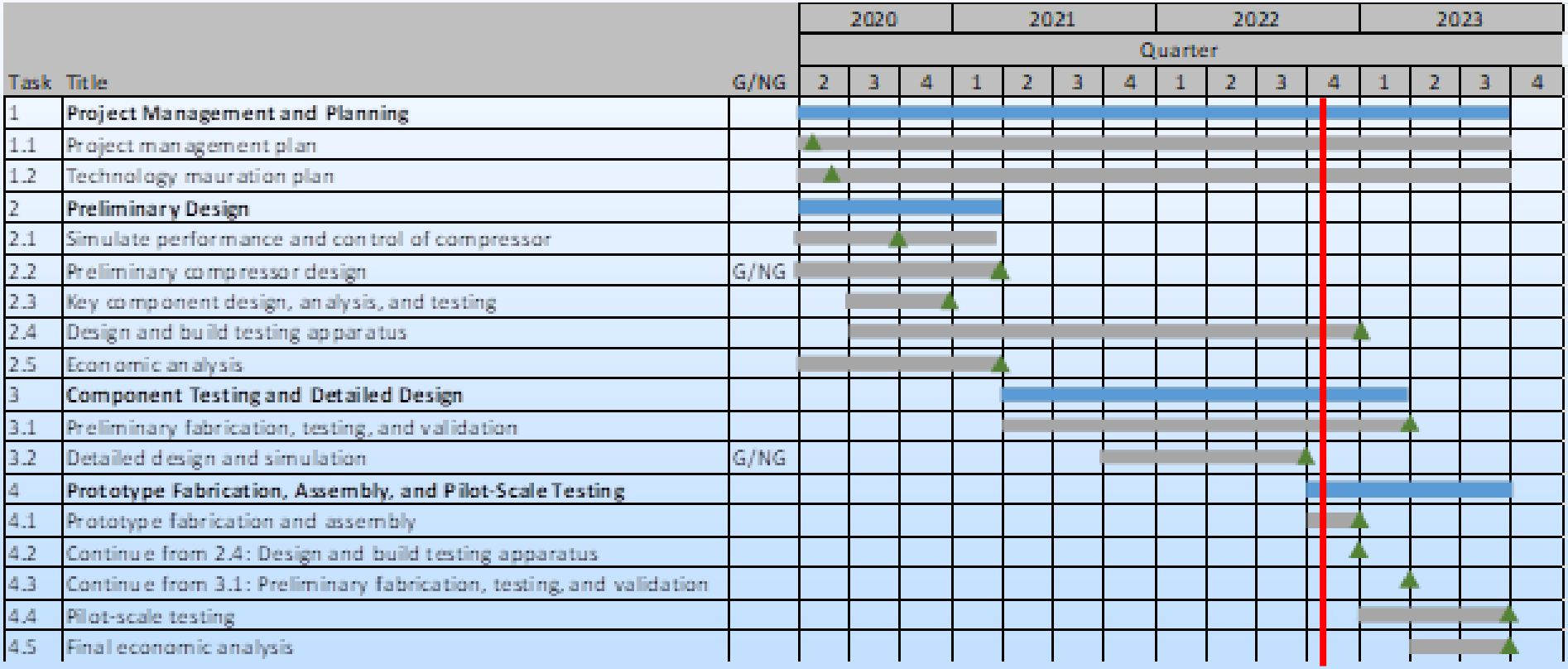
- The objectives of the project are to design, build, and test a high-pressure linear motor leak recovery compressor for cost effective recovery of methane leaks within the transmission, storage, gathering, and processing sectors of the natural gas value chain. The compressor will be designed and built using a proven linear motor compressor architecture. The linear motor compressor enables multiple stages of compression to be integrated into a single moving part, allowing the compressor to function under a broad range of operating conditions and to reach the high discharge pressures required for gas recovery in the midstream, without the cost and complexity of traditional multi-stage compressors.

Organization Chart

- GTI – Project lead, design lead, compressor testing
- UT-CEM – Simulation, Motor testing
- OTD – Industry insight and feedback
- Burckhardt – Compressor design insight



Gantt Chart



Task	Title	G/NG
1	**Project Management and Planning**	
1.1	Project management plan	
1.2	Technology maturation plan	
2	**Preliminary Design**	
2.1	Simulate performance and control of compressor	
2.2	Preliminary compressor design	G/NG
2.3	Key component design, analysis, and testing	
2.4	Design and build testing apparatus	
2.5	Economic analysis	
3	**Component Testing and Detailed Design**	
3.1	Preliminary fabrication, testing, and validation	
3.2	Detailed design and simulation	G/NG
4	**Prototype Fabrication, Assembly, and Pilot-Scale Testing**	
4.1	Prototype fabrication and assembly	
4.2	Continue from 2.4: Design and build testing apparatus	
4.3	Continue from 3.1: Preliminary fabrication, testing, and validation	
4.4	Pilot-scale testing	
4.5	Final economic analysis	