GTEN 2021
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Carbon Emissions Reduction for Turbomachinery Guidance During the Energy Transition

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on behalf of
SIEMENS energy

Introduction – Presenters

- Tim is an Application Engineer within the Aftermarket Engineered Solutions division at Siemens Energy.
- Currently tasked with developing aftermarket solutions that focus on adjusting centrifugal compressor performance and operating characteristics.
- Previously worked as a Product Design Engineer on the design, manufacture, and testing of Dresser-Rand centrifugal compressors.
- B.S. in Mechanical Engineering

- Jamie joined Dresser-Rand in 1989, which was acquired by Siemens in 2015
- Has held roles as Engineering Manager for Process Simulation, Package Engineering and Drafting. Plant Manager/Supervisor for Compressor Assembly, Package Assembly and Shipping. Manager for Corporate Product Configurator. Development and Senior Package engineer.
- Experience in Upstream, Midstream and Downstream Oil and Gas applications
- B.S. in Electrical Engineering

Discussion Topics

- Need for Carbon Emission Reduction
- Solutions for Turbomachinery
  - Unit Revamps & Changing Operating Points
  - Internal Leakage: Traditional vs Halo™ Seals
  - Dry Gas Seals
  - Remote Diagnostic Solutions
  - Dynamic Simulations
  - Fugitive Emissions – Reduction & Capture
- Q&A

Methane Emissions - Regulations

Summary of Regulations (per Compressor)

Region / Country	Current	After 1st Jan'23
	SCFM / m3/Hr	SCFM / m3/Hr
Canada Federal	5.0 / 8.4	5.0 / 8.4
Alberta / BC Province	6.0 / 10.2	2.0 / 3.4
USA Federal	6.0 / 10.2	TBD
Globally	6.0 / 10.2	TBD

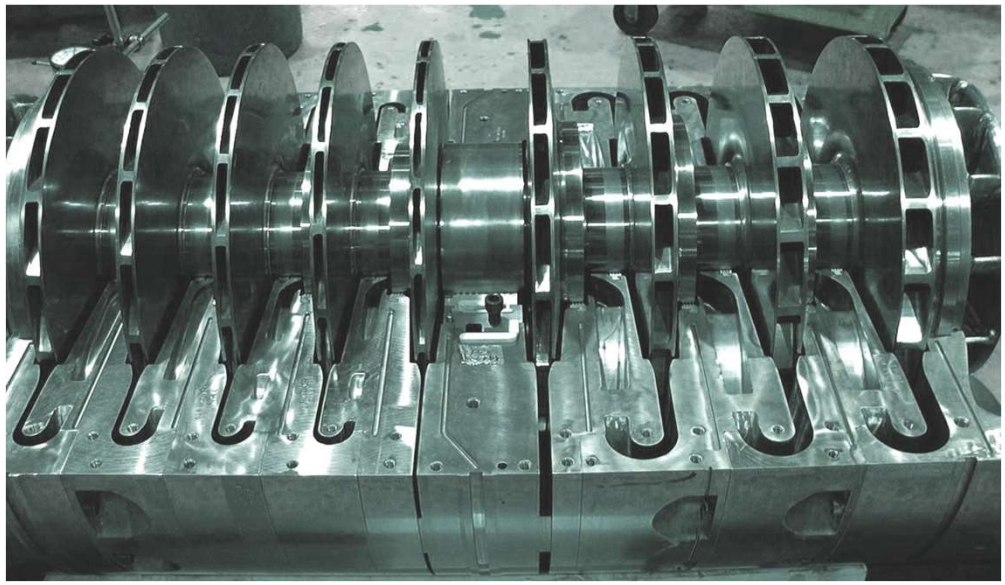
Extract from DACG (Mexico)

- Article 44 from the DOF– Replacing of Wet Seals or Capture the leakage.
- Article 46 from the DOF– Regulated parties must capture the gas from compressor purges (blowdown)
  - Primary: 'self-consumption or conservation'
  - Secondary: Gas is sent to a flare stack
- Article 53 from the DOF- Implement control measures even during maintenance / repair <5% total gas volume per year
- *Overall impact:* Compressor stations will be required to retrofit to reduce methane emissions from compressor seals or route emissions to a Vapor Recovery System

Unit Revamps

Revamp / ReRate (Brownfield)

Changing of existing compressor internals to adjust operating characteristics, either aerodynamic and / or mechanical



PROS

- Low Scope
- Fast Turnaround Time
- Great time to bundle upgrades (DGS) or use in place of parts order

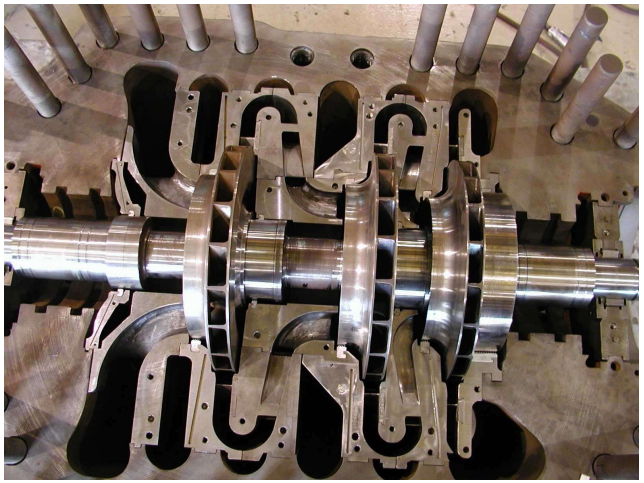
CONS

- Has limitations based on existing equipment

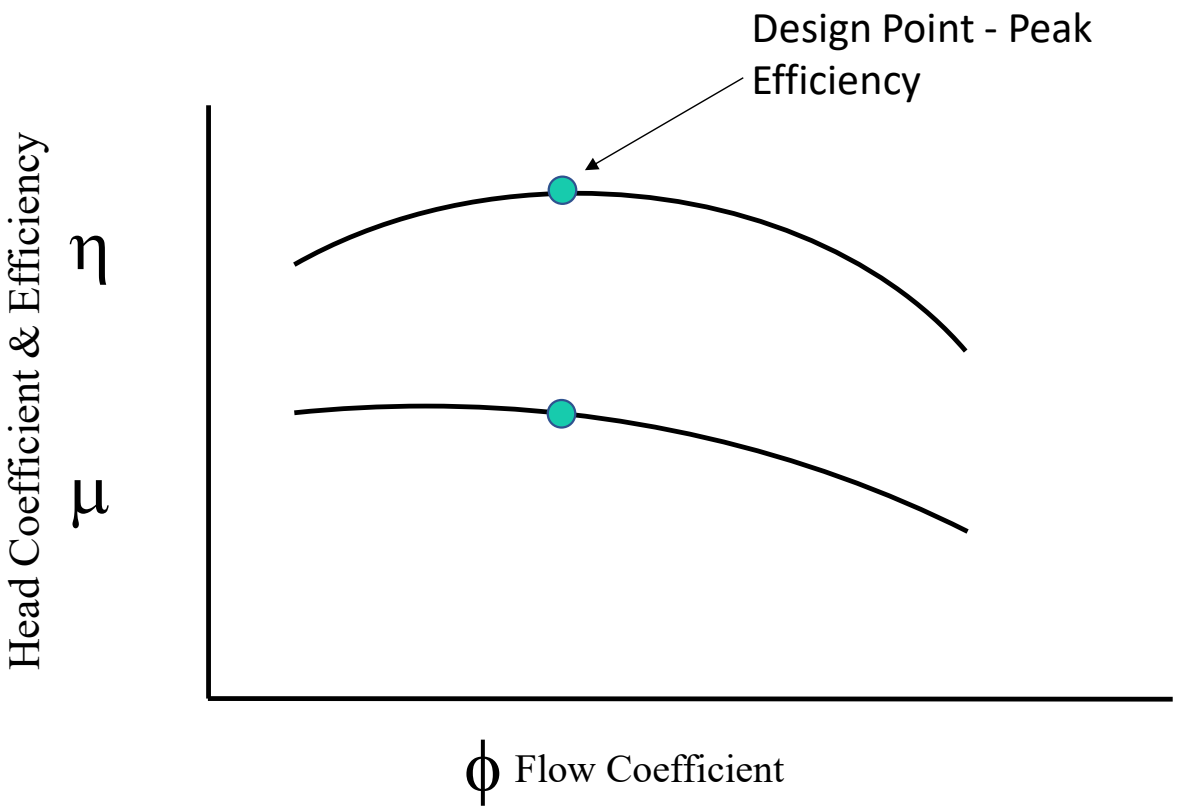
Unit Revamps

Revamp Examples

- Add / Remove Impellers
- Adjust Impeller Designs
- Speed Increase / Decrease
  -Driver or Gear Change
- Process Control Change
  -Fixed → Variable Speed
- OEM or oOEM

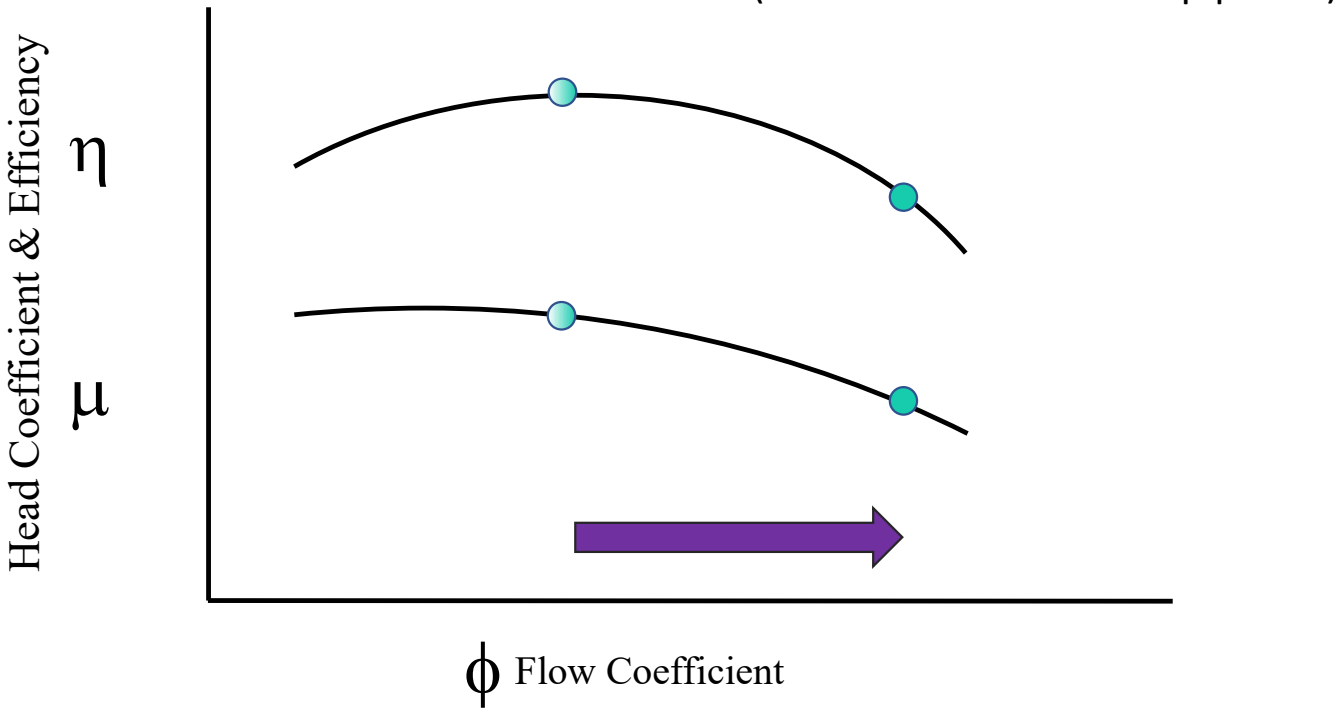


Unit Revamps – Change in Operation

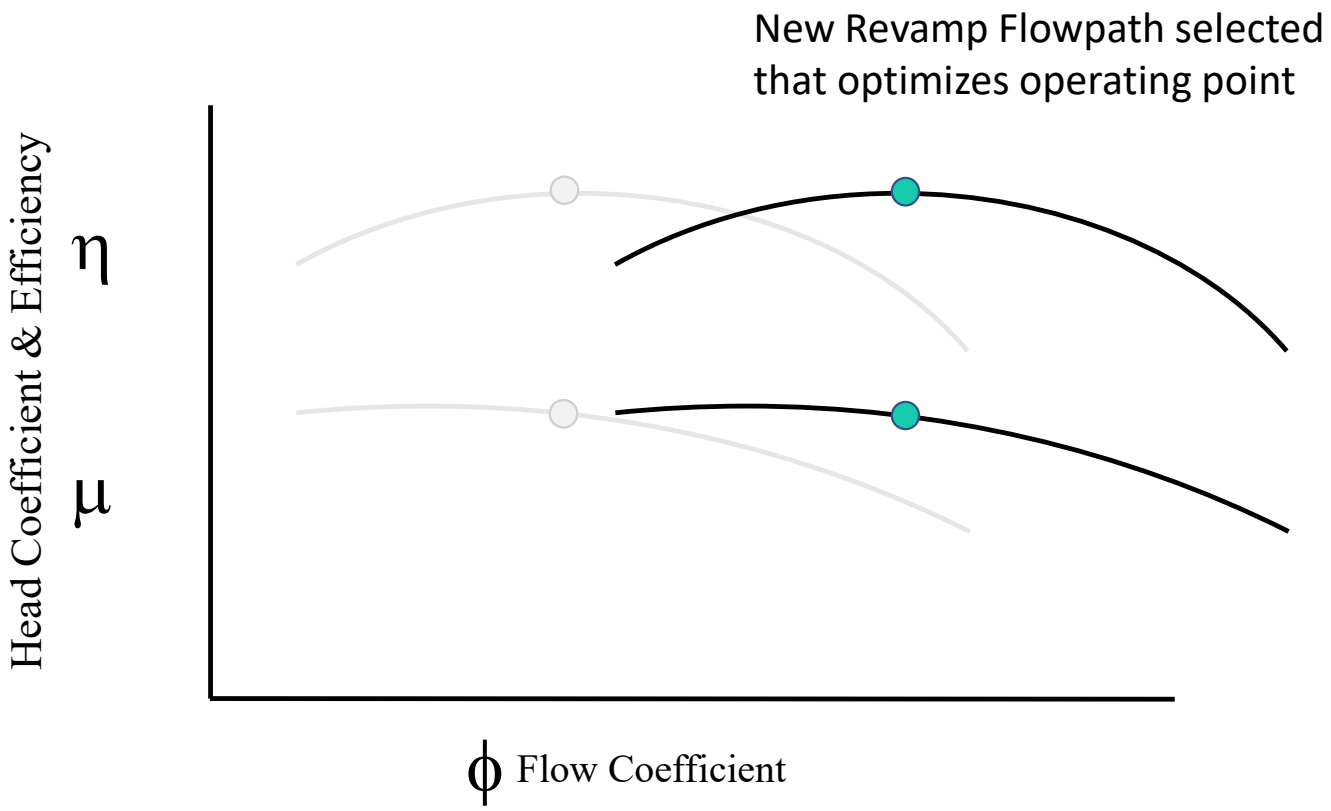


Unit Revamps – Change in Operation

Over time, the condition alters
(ie. more flow added to pipeline)



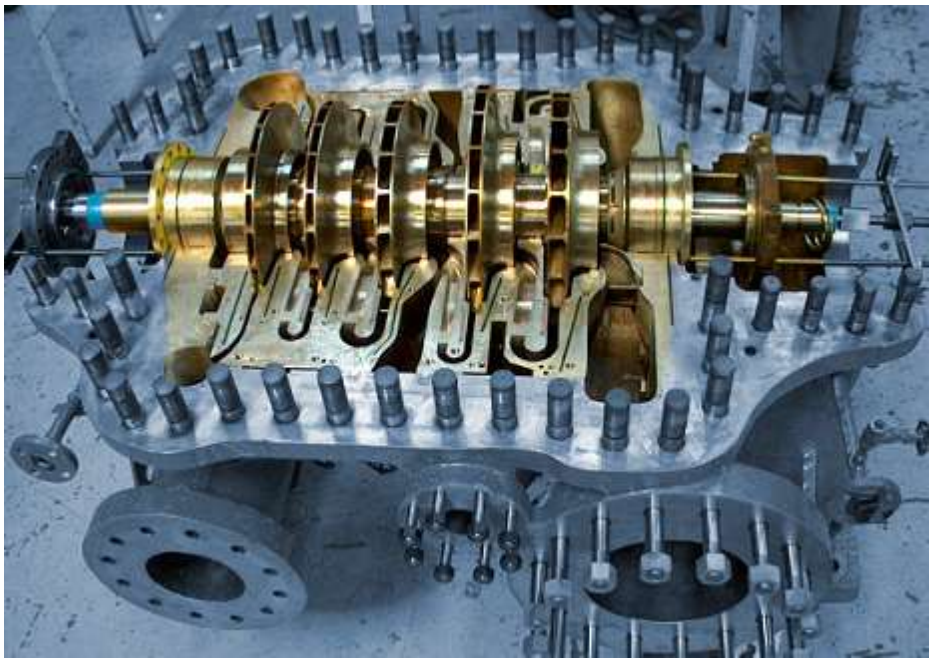
Unit Revamps – Change in Operation



Unit Revamps

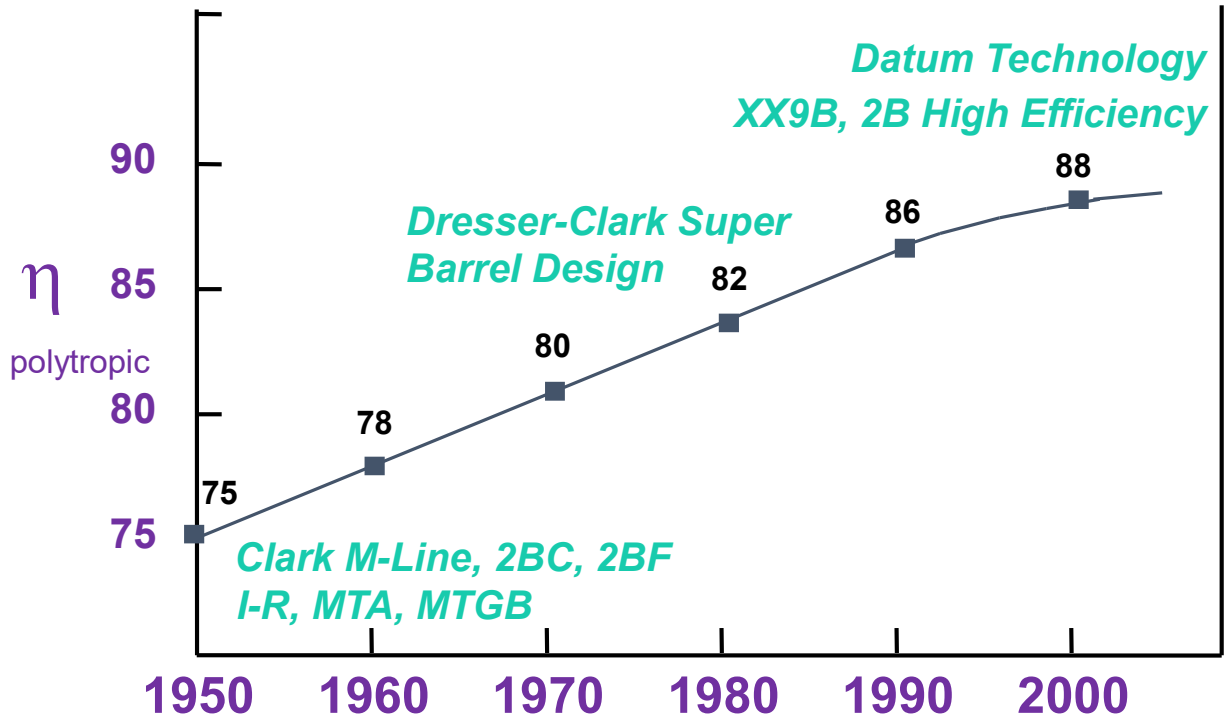
When to Revamp

- Changes in operating conditions
  - Gas composition/molecular weight
  - Capacity
  - Temperatures
  - Pressures
- Units built before mid-1980's
- Units over 10,000 horsepower
- During the early stages of outage planning
- During routine evaluations of your plant process
- Change in nominal operating point
- Before you purchase rotor/bundle spare parts
- Before you proceed with repairs to rotors/bundles



Unit Revamps - Efficiency

- Efficiency versus optimum flow range
- Improvements in compressor stage design
- Improvements in stage-to-stage selection of components
- Improvements in manufacturing technique
- Effects of operating off the peak design point



Unit Revamps – Value Proposition

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Below is an example for a set of two Cooper RFA24 Pipeline units with Gas Turbine drivers

Existing Design:				
Casing	RFA24x2			
Machine	LP	HP		Total Power
Power (hp)	10,000	10,000		20,000
Proposed Revamp:	Assume ~10% More Efficient			
Casing	RFA24x2 RVP			
Machine	LP	HP		Total Power
Power (hp)	9,000	9,000		18,000
Power Savings (hp):	1,000	1,000		2,000
Power Savings:	10.00%	10.00%		10.00%

Cost Savings Analysis		
Train HP Savings	2,000	hp
Eff.	8,000	(BTU/hr)/HP
Total Energy Saved	16.000	MM BTU/hr
Hrs. of Operation	8,760	hrs/yr
Total Energy Saved	140,160	MM BTU
Average Cost of Natural Gas USD	$ 5.29	/ MM BTU
ESTIMATED ANNUAL SAVINGS	$741,446	

Stationary Seals / Internal Leakage

- Labyrinth Seal
  - Tooth Design
  - Aluminum Standard

•Upgrades / Non-Standard

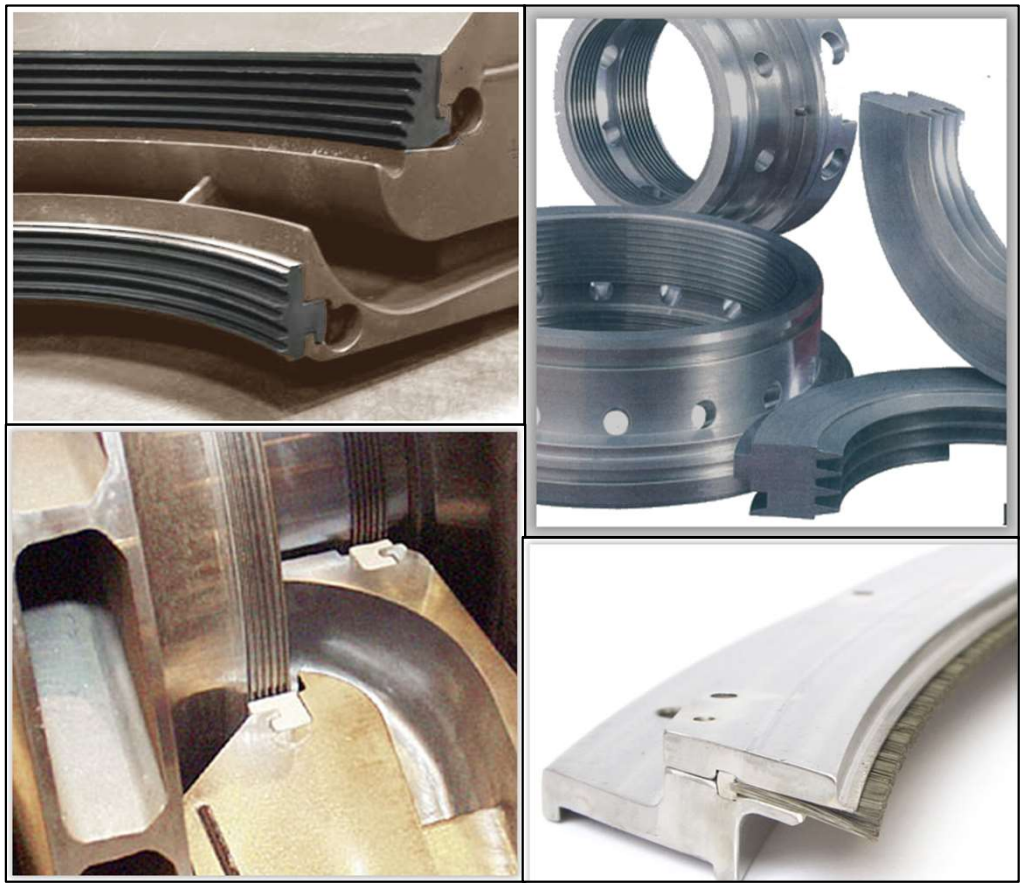
- Polymer
  - Corrosion Resistance
  - Improved wear resistance

- Abradable / Rotating
  - Work in during run

- Brush
  - Large bearing drops (Magnetic)

•*All conventional seals wear*, and the performance of the compressor degrades with time and operation

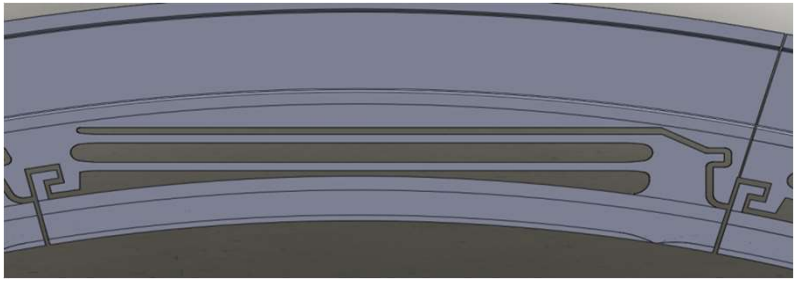
Pick the Right Seal for the Right Application!



HALO™ Seal Technology: Overview

- Directly replaces conventional straight-land seals.
- Offers exceptional hydraulic performance.
- Maintain design clearance and as-tested hydraulic performance through the entire run time, including end-of-run lifespan.

  - Large install clearance
  - Pressure activated
    - Forces acting on the pad sets running design clearance; static pressure above and dynamic pressure below
  - Low Leakage
  - Non-contacting
  - Dynamic
  - Inconel material
  - Infinite Fatigue Life



HALO™ Seal Location and Value

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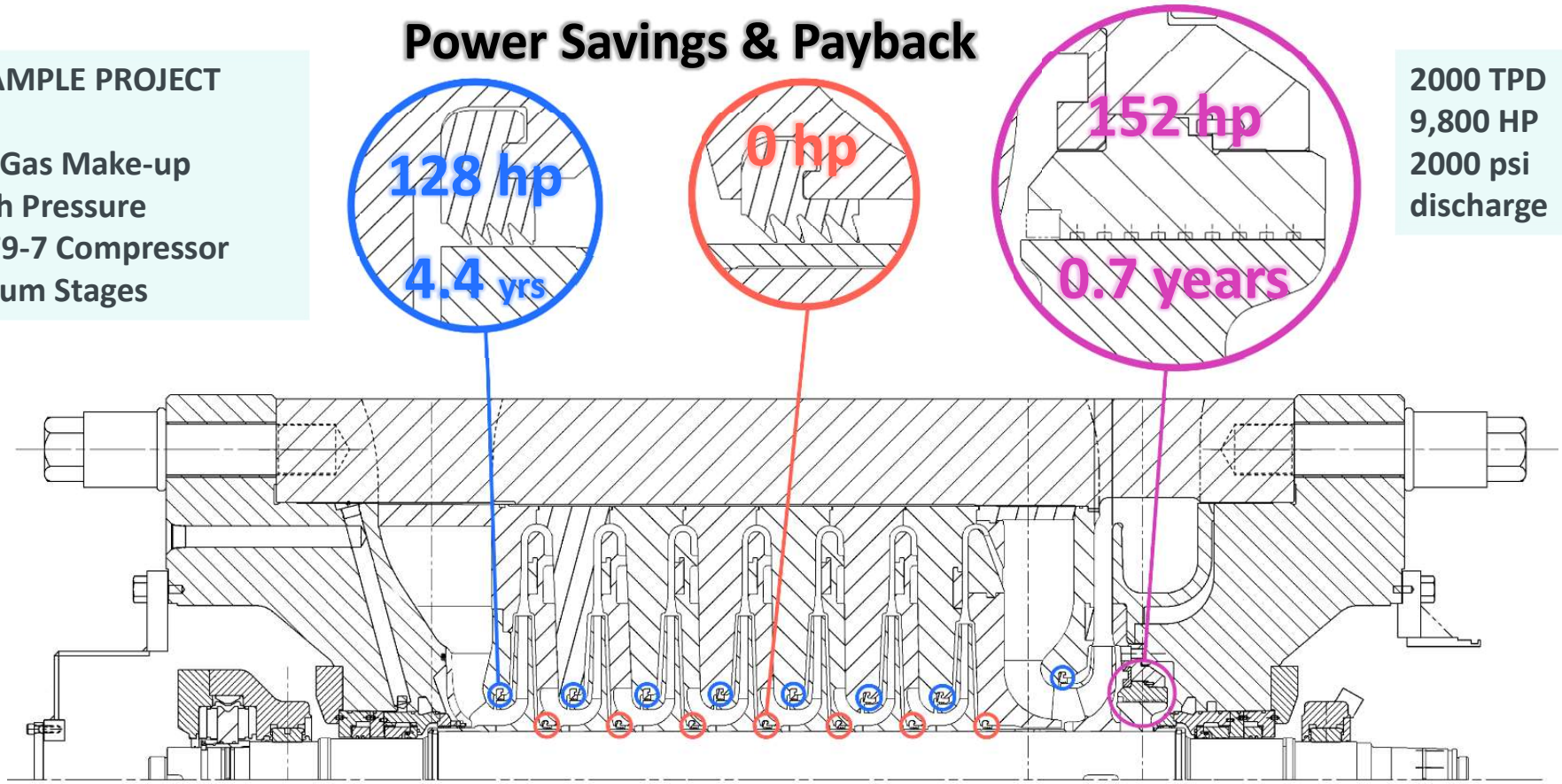
EXAMPLE PROJECT

SynGas Make-up
High Pressure
2BF9-7 Compressor
Datum Stages

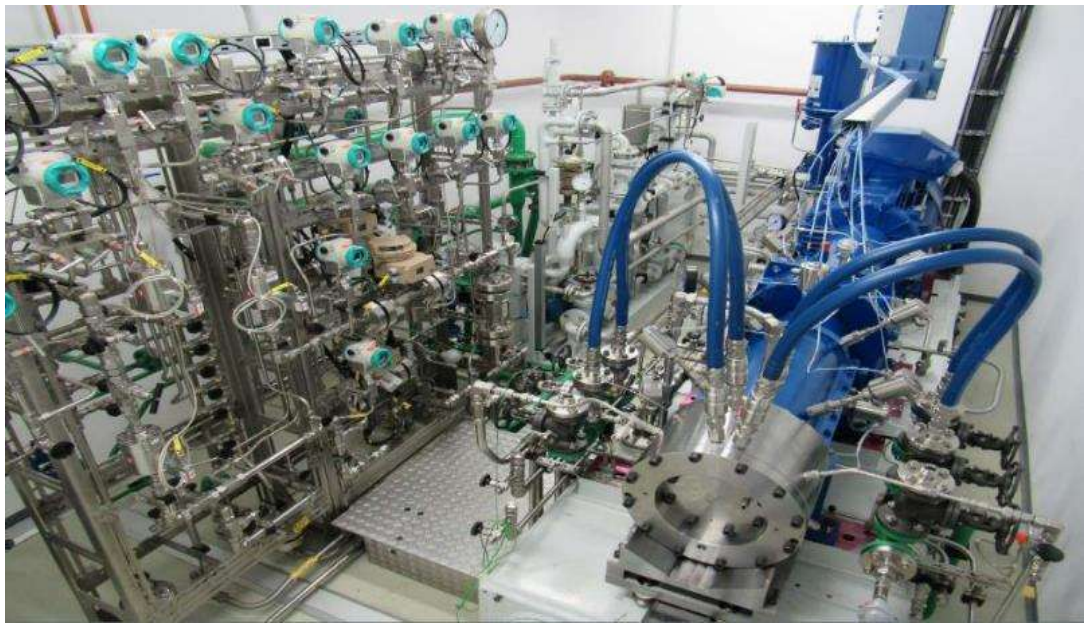
Power Savings & Payback



2000 TPD
9,800 HP
2000 psi
discharge

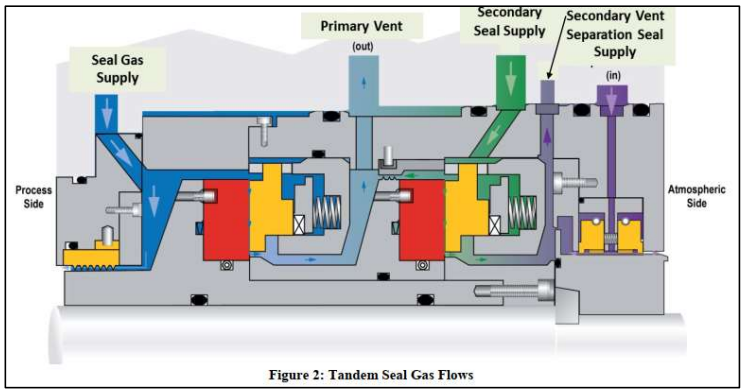
Methane Emissions - Reduction
Dry Gas Seals

- Reduce the amount of Primary Vent leakage to atmosphere.
- In-house Technology: Engineering, Production, Services.
- 25+ Years of Experience / 30M+ Operating Hours
- API 692 Complaint
- Standard offering on New Equipment Solution.
- Ability to retrofit existing Installed Base – Dry or Wet Seals



Siemens DGS on Test Stand

Secondary Seal Supply (requires Nitrogen Source).

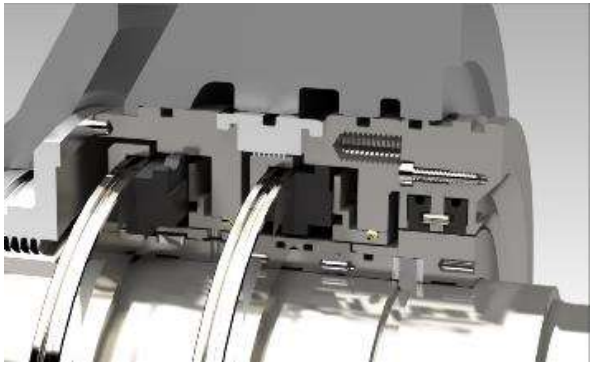


Courtesy: TAMU

Dry Gas Seal Upgrades - Benefits

Case Description	Wet Seals	Dry Gas Seals
Seal oil support system costs	Pumps, reservoirs, filters, Traps, coolers, consoles	None
Seal oil consumption	1-100 gallons/day	No seal oil
Maintenance costs	A major expenditure over equipment life	Negligible
Energy Costs	**Seal power loss: 10-30 HP** **Unit driven pumps: 20-100 HP**	**1-2 HP**
Process gas leakage	**25 SCFM & Higher**	**<2 SCFM**
Oil contamination	Of Pipeline: High clean-up costs Of Process: Catalyst poisoning	None
Toxic and corrosive applications	**Buffer gas consumption 40-70 SCFM**	**2-4 SCFM**
Unscheduled shutdowns	High down time costs	Very reliable
Rotor stability	Unpredictable with wear	Stable, predictable and reliable
Aborted startups	Frequent	Rare

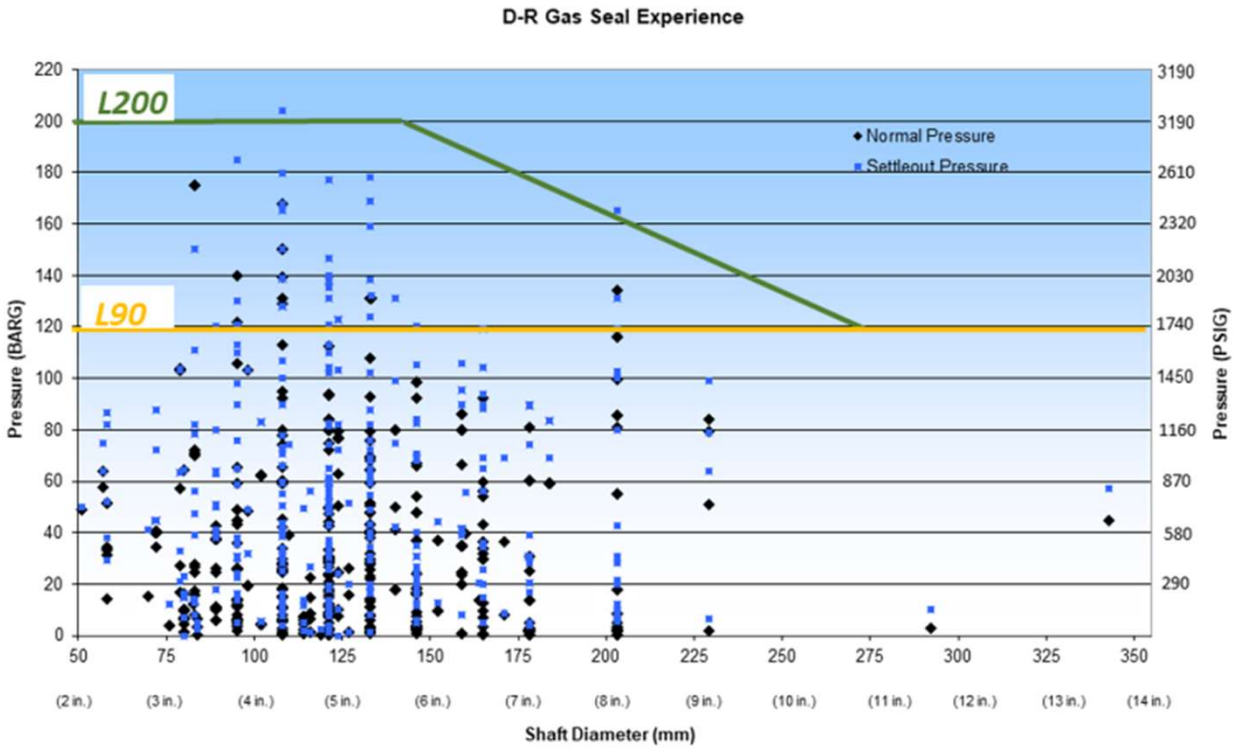
Dry Gas Seal Upgrades - Experience



- ***L-Line***

Standard configuration*

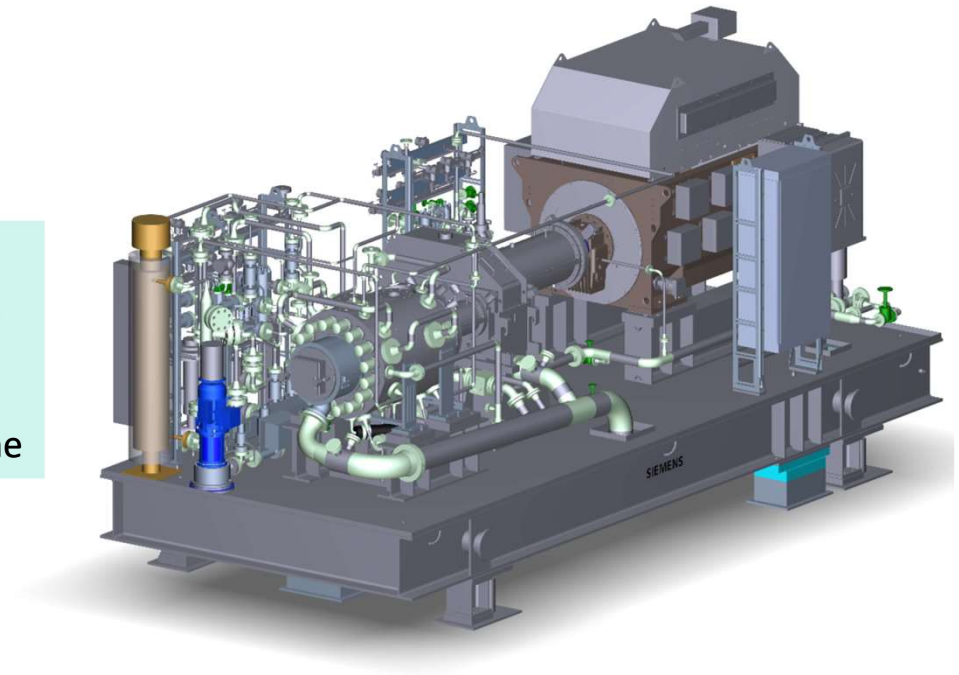
- To 3190 PSIG
- 17,000 rpm
- 356 F
- To 11.5 in
- Minimized hang-up



Remote Diagnostics - Main Measurements

- Pressure
- Temperature
- Flow
- Speed
- Vibration
- Position (% - open/close)
- Level

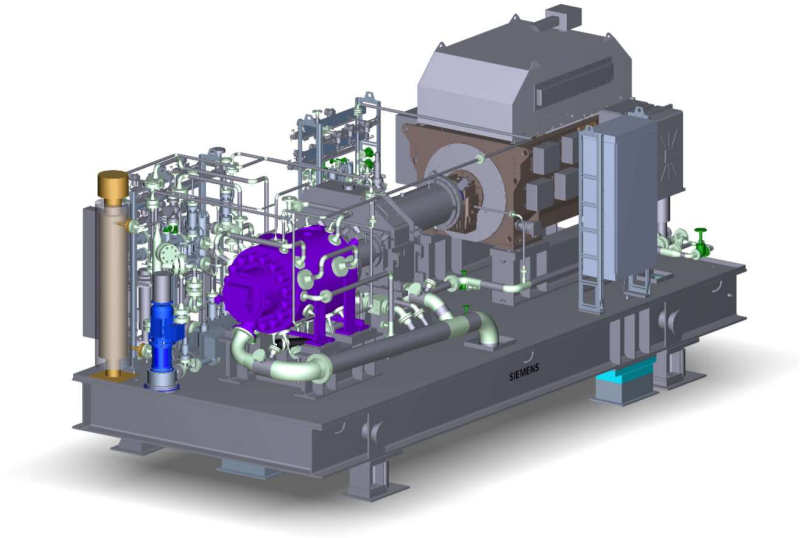
- **Recorded On-Site**
- **Shared in real-time with OEM**
- **Fast Response Time**
- **Pro Active Support**
- **Reduced Troubleshooting Time**

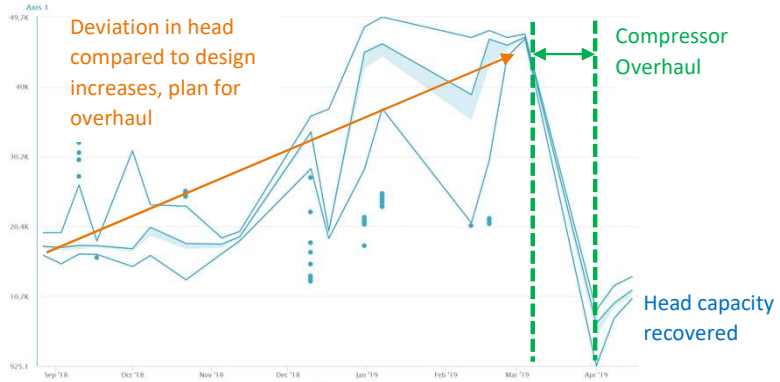


Sensors → DAQ → OPC UA Interface → Cloud

Remote Diagnostics – Failure Modes

Compressor



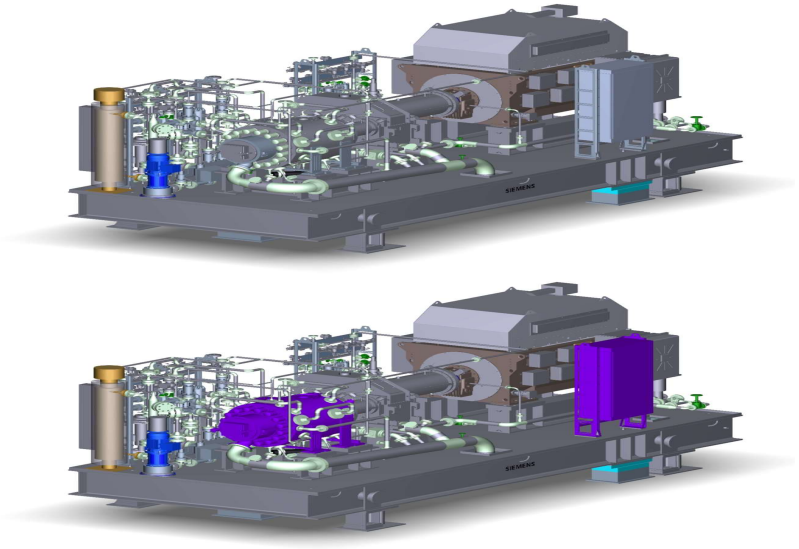


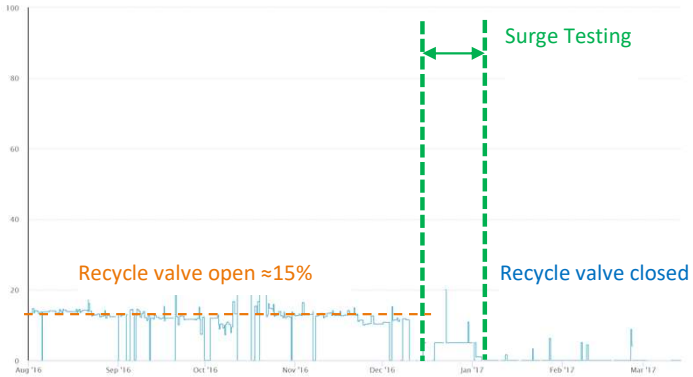
Fouling Causing Vibration

Main families of failure modes	Failure modes	Consequence(s)	Customer benefits
Compressor	• Increased interstage seal clearance • Compressor fouling • Liquid in process gas stream • Off-design gas composition	• Poor compressor performance • High process gas discharge temperature • Reduced production	• Major failure avoidance • Availability / reliability • Maintenance planning • Revamp planning

Remote Diagnostics – Failure Modes

Compressor Control



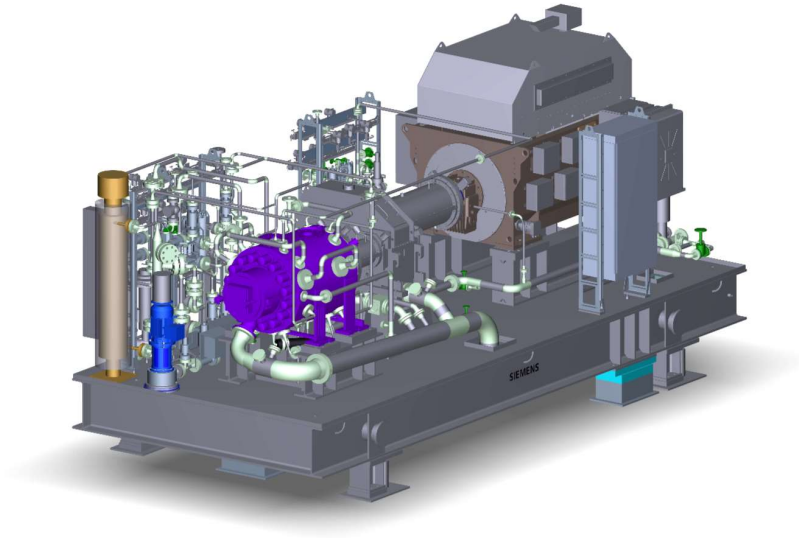


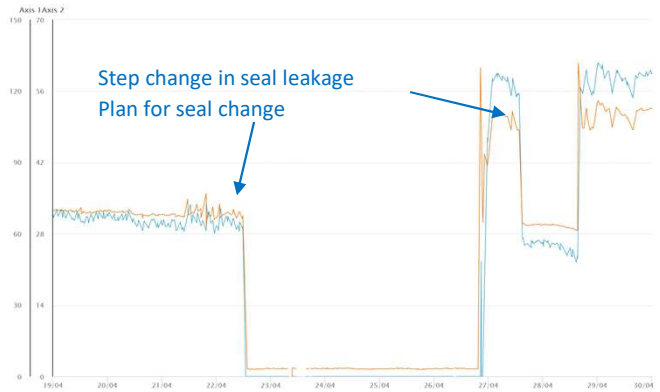
Surge Control Line

Main families of failure modes	Failure modes	Consequence(s)	Customer benefits Reliability & availability
Process Control	• Recycle/surge control valve open • Control system problem • Compressor in surge • Off-design gas composition	• Erratic system operation • Poor compressor performance	• Efficiency Improvement • Major failure avoidance • Availability / reliability

Remote Diagnostics – Failure Modes

Dry Gas Seal



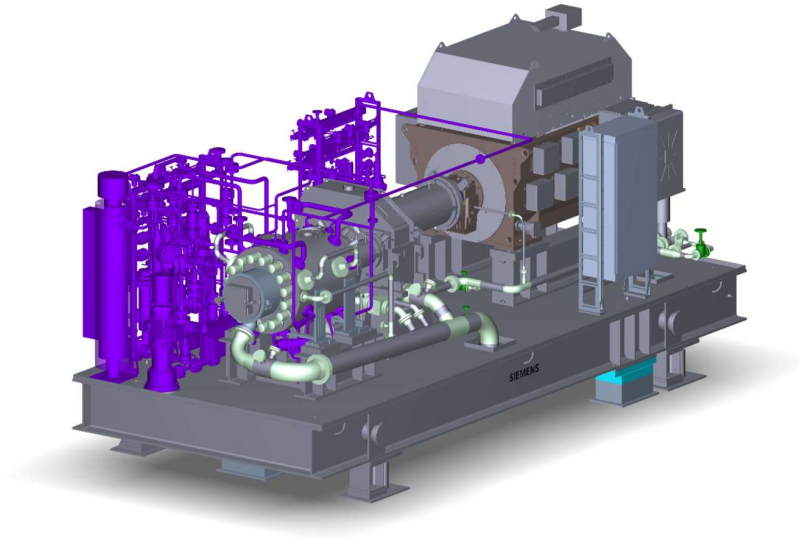


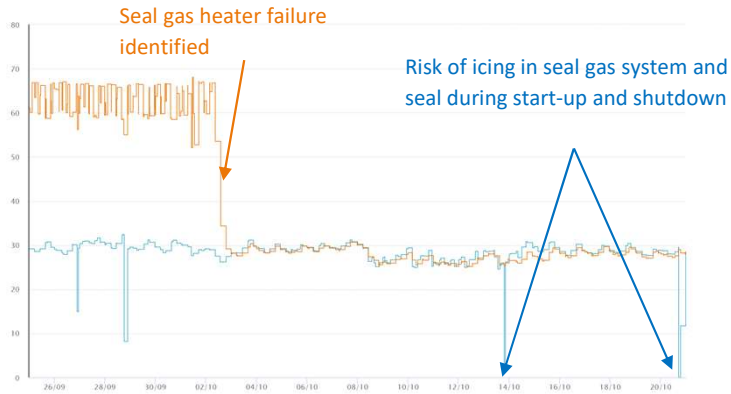
Dry Gas Seal Leakage

Main families of failure modes	Failure modes	Consequence(s)	Customer benefits Reliability & availability
Dry Gas Seal	• Primary gas seal damage • Leaking seal, gasket, or O-ring • Liquid contamination • Start-up / shutdown sequences	• Seal failure	• Major failure avoidance • Availability / reliability • Maintenance planning

Remote Diagnostics – Failure Modes

Gas Seal System





Seal Gas Heater

Main families of failure modes	Failure modes	Consequence(s)	Customer benefits Reliability & availability
Gas Seal System	• Fouled/dirty filter • Valve control • Increased seal clearances • Off design process conditions	• Erratic control • High/low gas supply pressure and flow • Dry gas seal and/or barrier seal failure	• Major failure avoidance • Availability / reliability • Maintenance planning

Dynamic Simulation – Digital Twin Modelling

- Digital Twin = Digital model design to replicate reality
- Full Compressor or Individual Aux System (DGS)
- Pre & Post Event Capabilities
- “Damage” different areas in system to replicate transient events
- Repeat Failures? Replicate site conditions to diagnose

Ex. using DYFLO Model

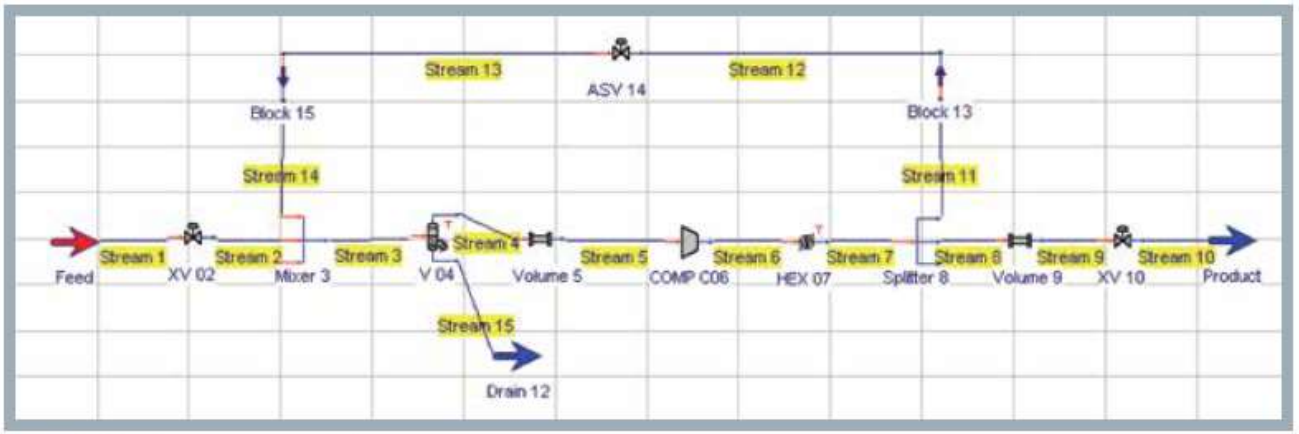
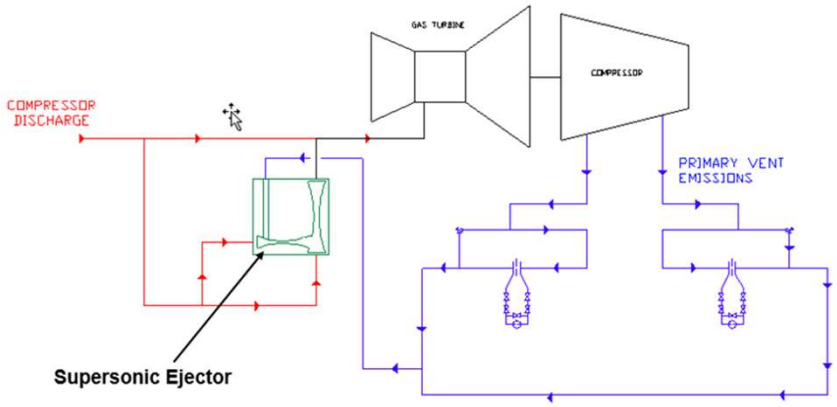


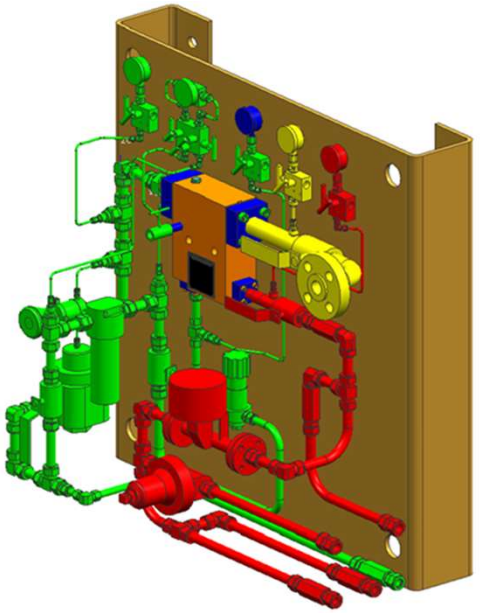
Figure 1 - Simple compressor model.

Greenhouse Gases (GHG) / Fugitive Emissions Capture Various Solutions

Criteria	Supersonic Ejector	GT Inlet	Enclosed Burner	Re-compression
Gas Turbine Driver	X	X	X	X
Electric Motor Driver			X	X
Scalable			X	X
Normal Operation	X	X	X	X
Shutdown Pressurized			X	X
Shutdown Vented			X	X
Shutdown ESD				
Re-injection into Suction	X			X
Re-injection into Discharge				X
Re-injection into alternate gas supply	X			X
Vent to atmosphere		X	X	

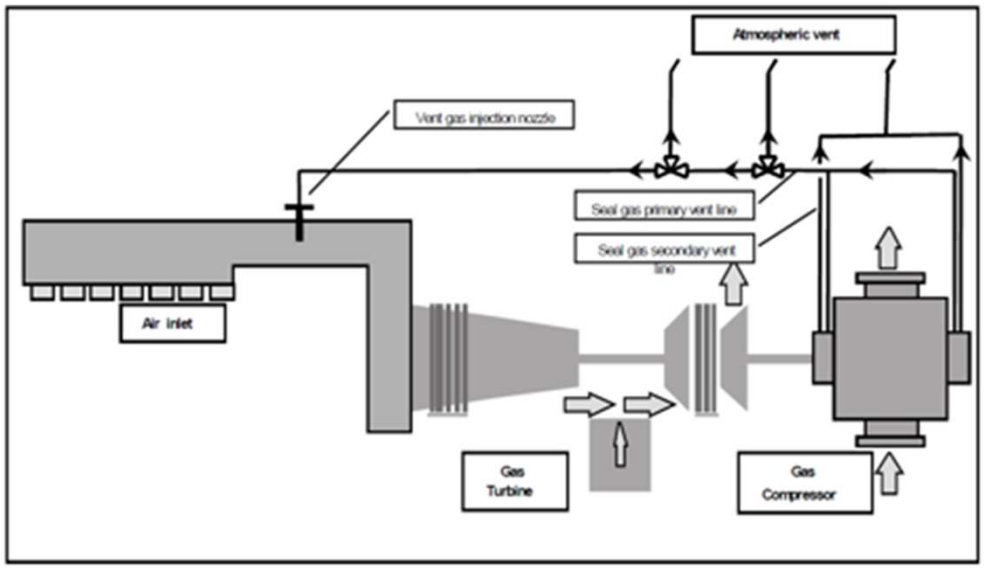
Methane Emissions – Capture
Supersonic Ejector





- Designed for new equipment as well as exiting equipment with a GT driver.
- Scalable to accommodate 1 to 15 SCFM primary vent seal leakage.
- Designed for compressor normal operation.
- Pre-configured to re-inject into a heater inlet, fuel system inlet or alternate gas supply.
- Few moving parts so low maintenance solution

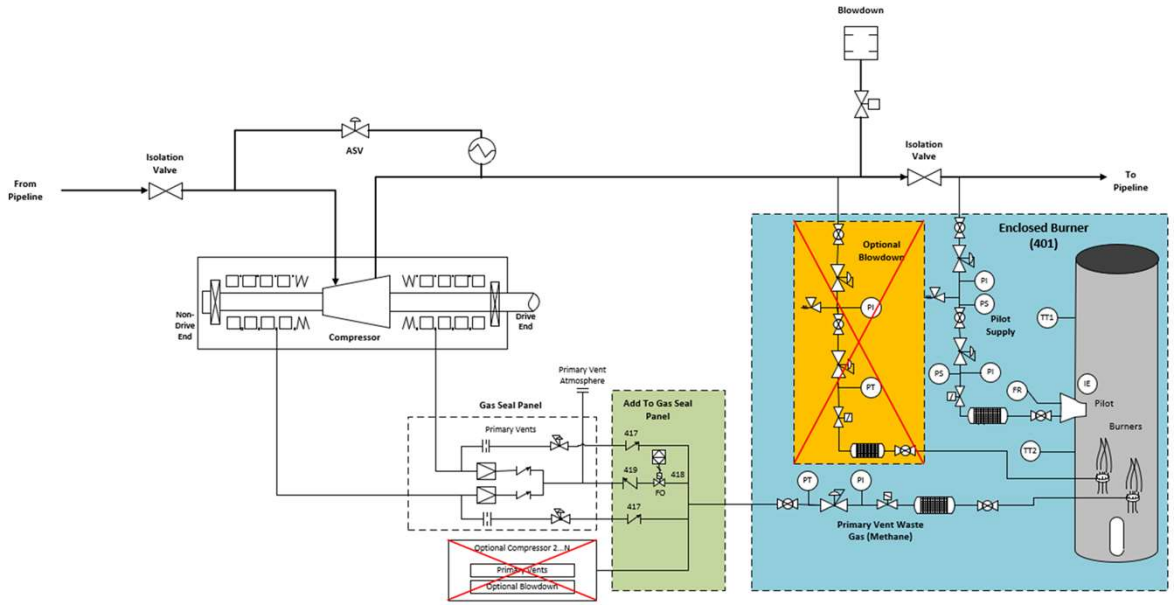
Methane Emissions – Capture
Gas Turbine Inlet Reinjection



Compressor	Gas Turbine
RFBB20, RFA24, RFBB24	SGT-100 / SGT-300 / SGT-400
RFBB30, RFBB36, RFA36, RFBB42	SGT-A35
RFBB30, RFB36, RFA36, RFBB42	SGT-600, SGT-700, SGT-750

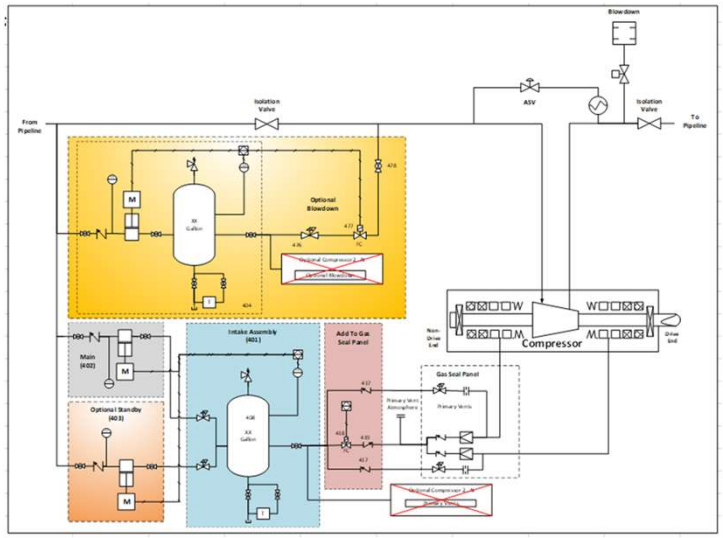
- Designed for new equipment as well as exiting equipment with a GT driver.
- Scalable to accommodate 1 to 15 SCFM primary vent seal leakage.
- Designed for compressor normal operation.
- Pre-configured to re-inject into inlet of GT.
- Few moving parts so low maintenance solution

Methane Emissions – Capture
Enclosed Burner



- Combustors are designed to combust a waste gas stream as efficiently as possible.
- Enclosed burners greater than 99% destruction efficiency.
- Completely enclosed combustion prevents the environment from being exposed to IR radiation, heat and light.

Methane Emissions – Capture Recompression



- Recompress the DGS leakage into Process Pipe.
- Captures blowdown emissions during station depressurization, scheduled maintenance activities and planned shutdowns
- Scalability - one recompression system can be used for multiple centrifugal compressors operating in the same service
- Allows operators to meet or exceed current regulations
- Easily installed on a greenfield project

Q&A

Thank You
&
Any Questions?