Flow Solutions Group

Compressor Products & Services – Reduction of Methane Emissions

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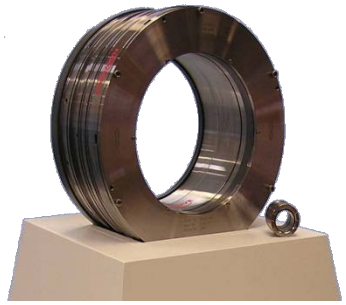
Today's Agenda:

- **Environmental Benefits of Retrofitting From Wet to Dry Gas Seals**
- **Flowserve Compressor Blow Down Gas Recovery System**
- **Summary of Flowserve Global Compressor Products & Services**

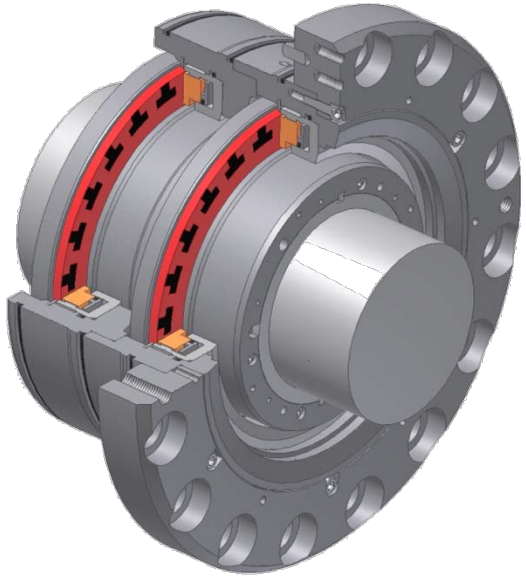
Gaspac Dry Gas Seals *in single/dual/tandem configuration*

- Leading in high pressure applications up to 450 bar
- Leading in high speeds: slow-roll up to 240 m/s (800 ft/s) [~ 850 km/h (530 miles/hr)]
- Leading in high temperatures: -135 C up to 230 C
- Big diameters up to 360 mm (e.g. for the LNG market)



Diameters 1.5“ – 14.5“

Gaspac



ADVANTAGES: DRY SEAL VS OIL SEALS

- Reduced operating costs
- Increased reliability
- Increased efficiency
- Maintenance advantage
- Improved safety
- Environmental impact

JUSTIFICATION PROCESS

TANGIBLE FACTORS

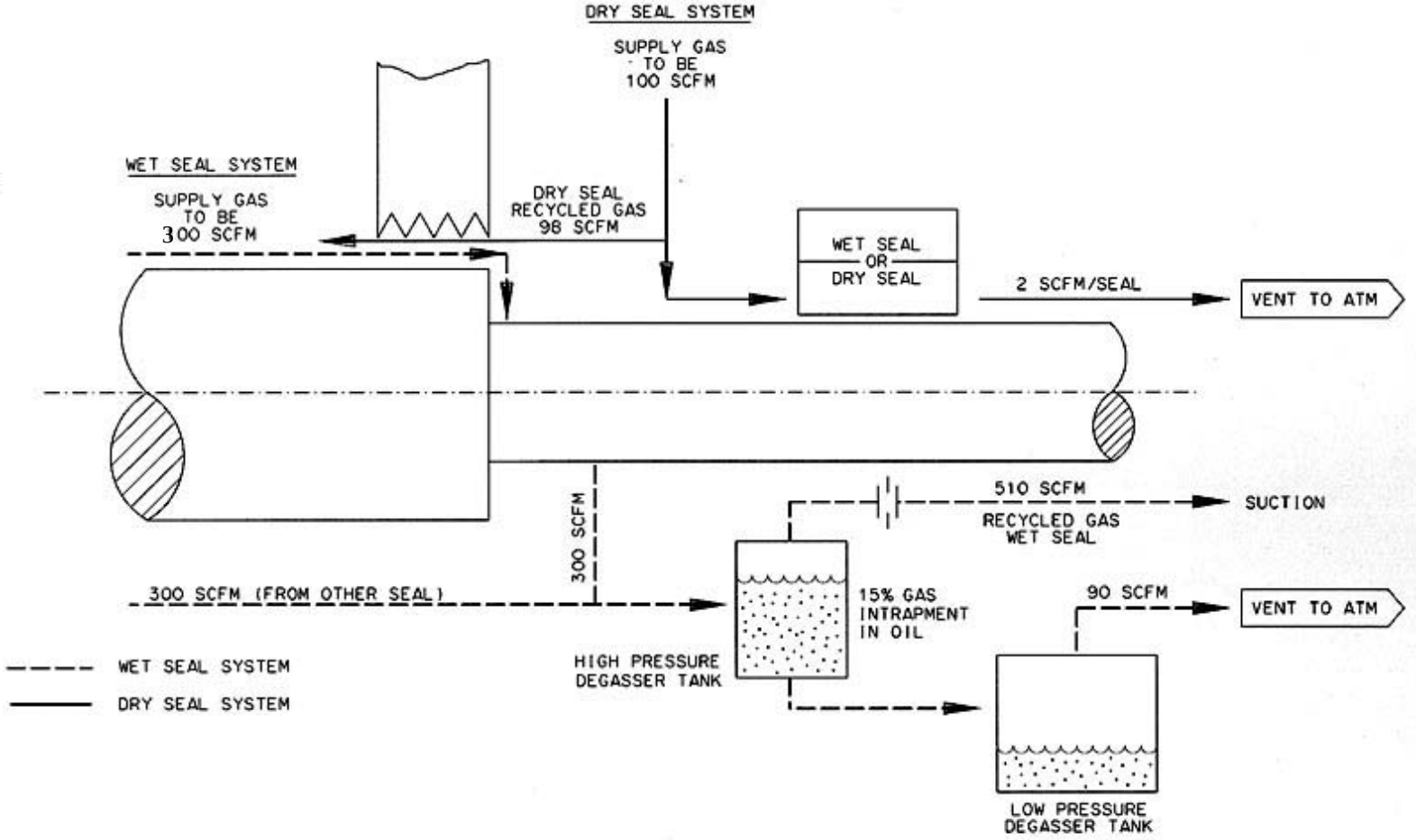
- Oil Consumption, waste management
- Compressor and auxiliary efficiency
- Maintenance, call outs and downtime
- Losses due to process contamination
- Fugitive emissions

FUGITIVE EMISSIONS

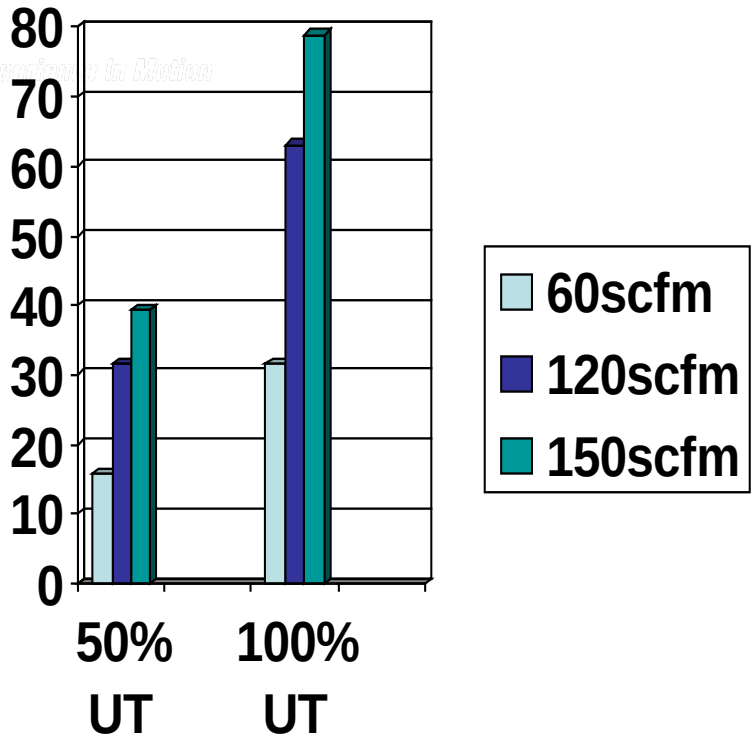
- Wet seals vent 50 to 100 times more than Dry Gas Seals
- Cost of vented gas from Wet seals can range $100,000 to $300,000 / year loss
- Environmental laws and governmental regulations could present additional costs:
  - fines
  - carbon tax

ECONOMIC JUSTIFICATION PROCESS

RECIRCULATION LOSSES



EXAMPLE OF WET SEAL EMISSIONS



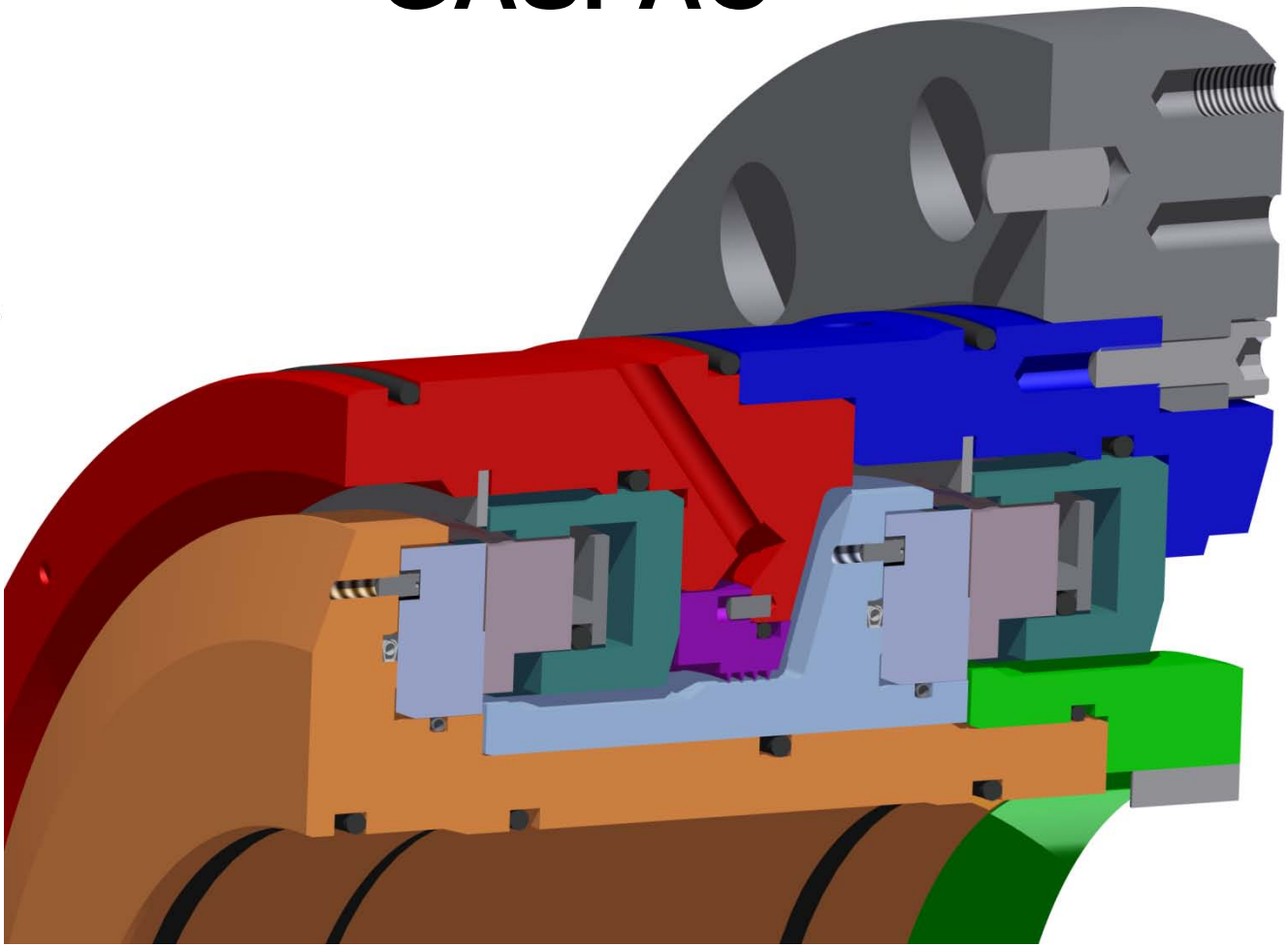
- **80 MM @ $4.5/MSCF**
  = $360K / Year
- **40 MM @ $4.5/ MSCF**
  = $180K / Year
- **20 MM @ $4.5 / MSCF**
  = $ 90K / Year

JUSTIFICATION PROCESS

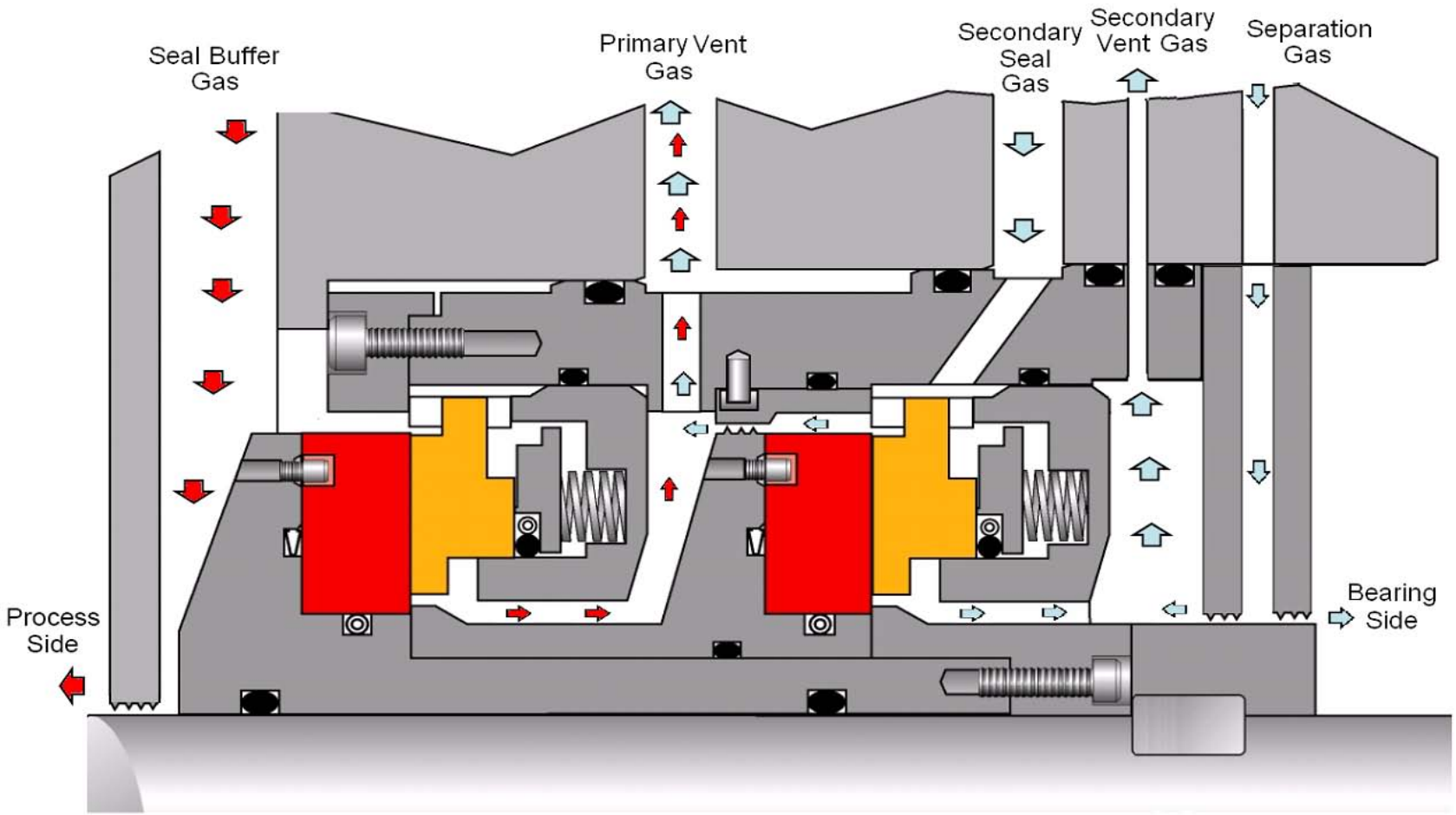
INTANGIBLE FACTORS

- Lost production due to contamination
- Efficiency loss due to contamination of pipeline, exchangers, catalysts
- Safety and asset risk management

GASPAC



TANDEM SEAL WITH INTERSTAGE LABYRINTH = GASPAC L

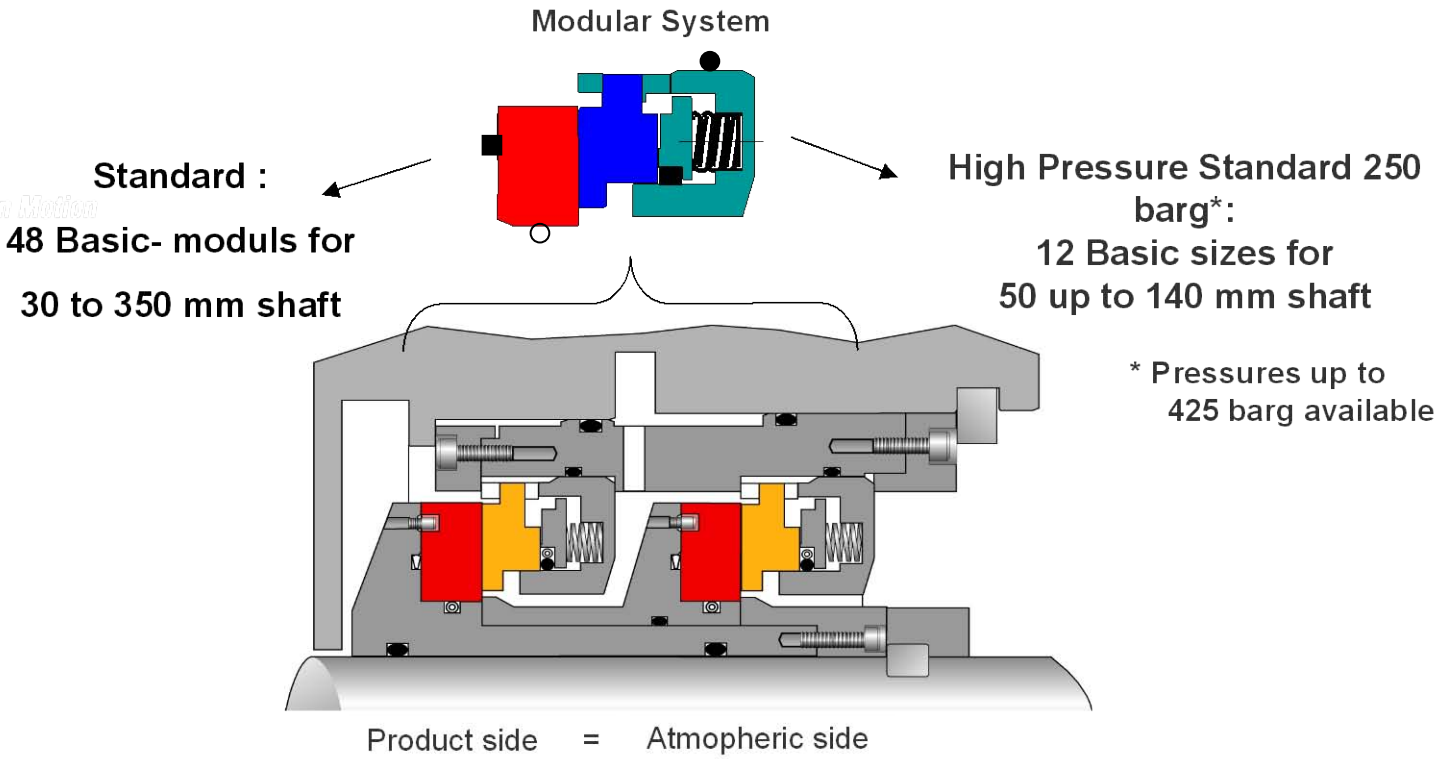


FLOWSERVE

Flow Solutions Group - Compressor Seals

Compressor Seal Fundamentals

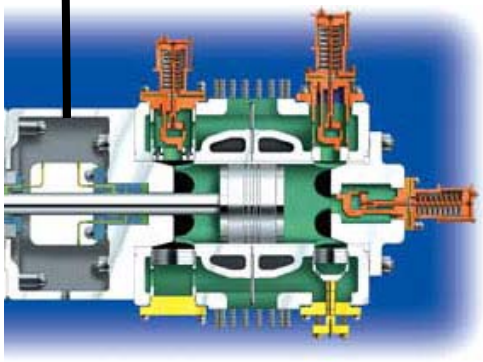
The Modular System

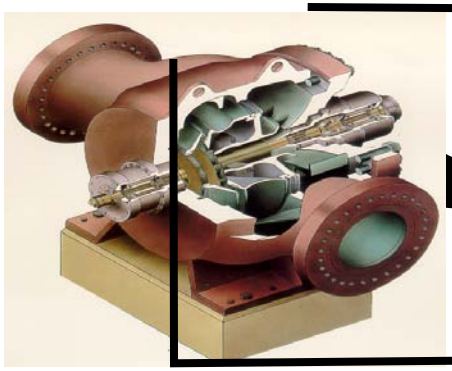


+ ~ 25 special sized modules , eg. for screw compressors

Common Sources of Vented Gas

Reciprocating Compressors: Leakage From Distance Piece

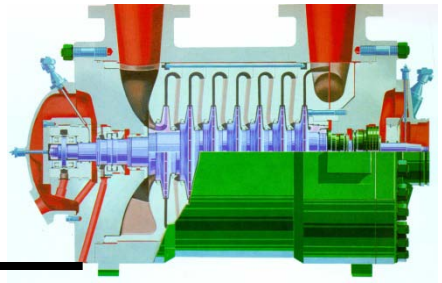




Compressor Dry Gas Seal Leakage

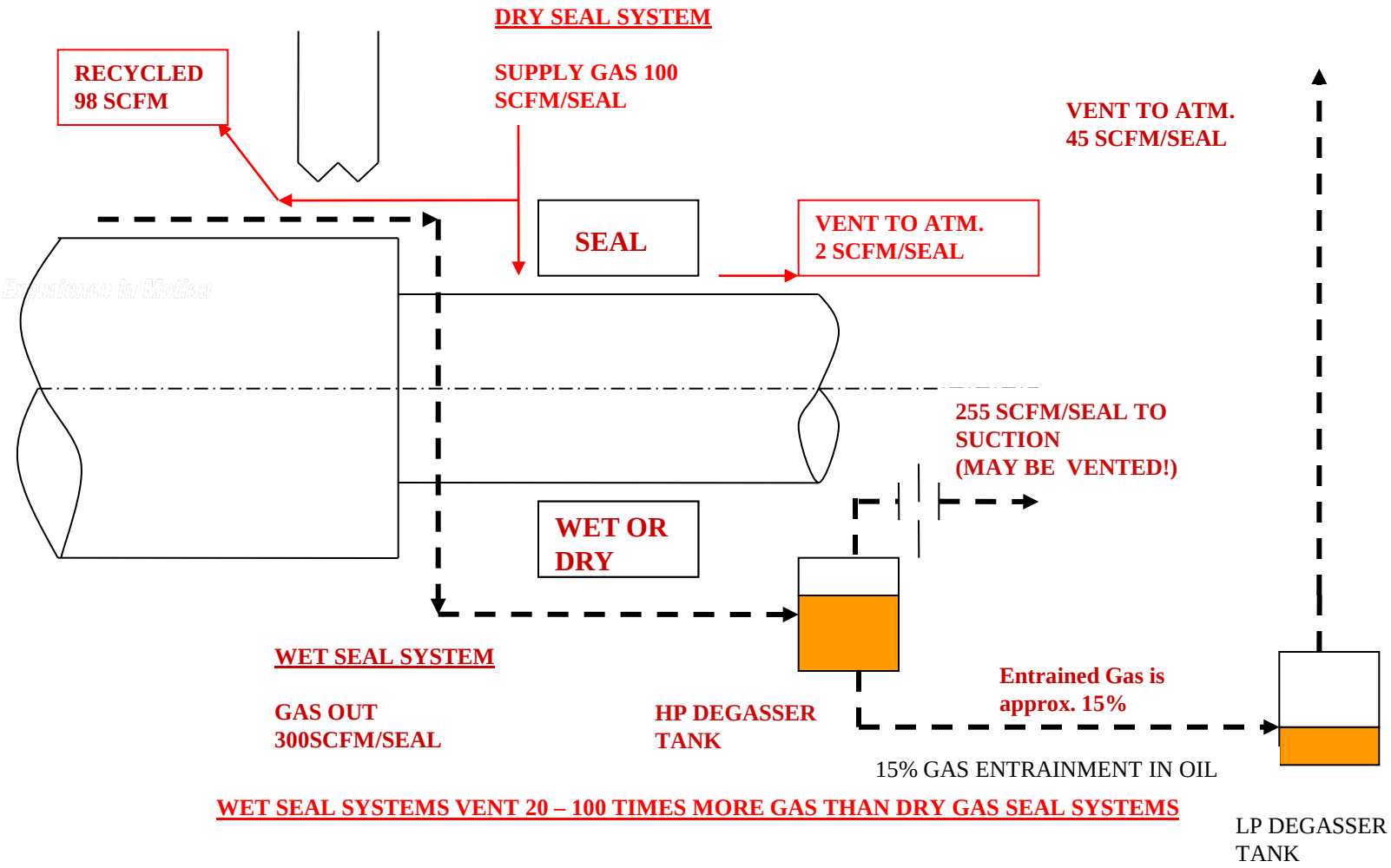
Vent Header

Instrument Vented Gas: Relief Valves, Control Valves, Vent Valves



Compressor Wet / Oil Seal Trapped Gas via Degasser Tank

Typical Flow of Vented Gas in a Sealing System

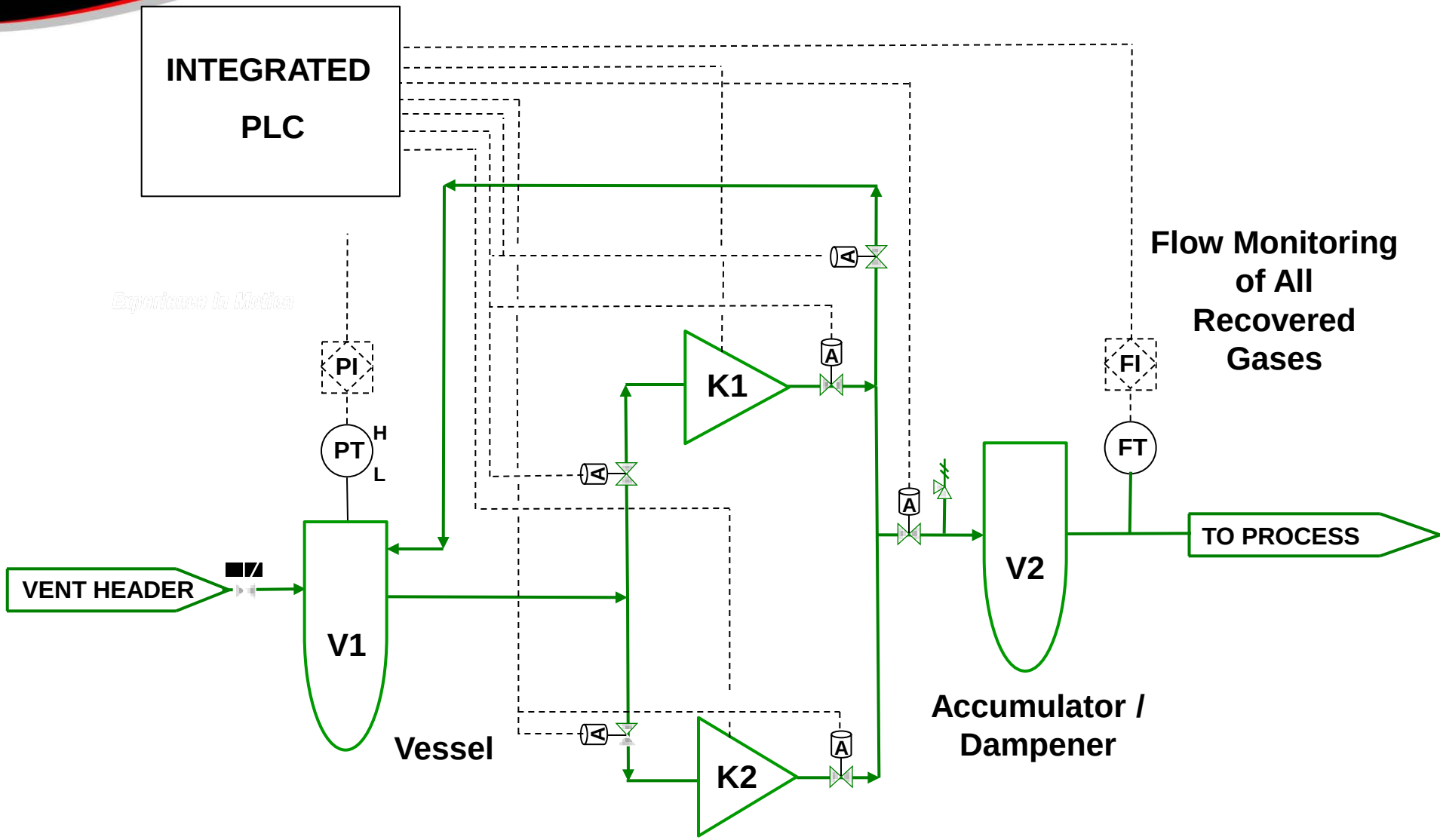


WET SEAL SYSTEMS VENT 20 – 100 TIMES MORE GAS THAN DRY GAS SEAL SYSTEMS

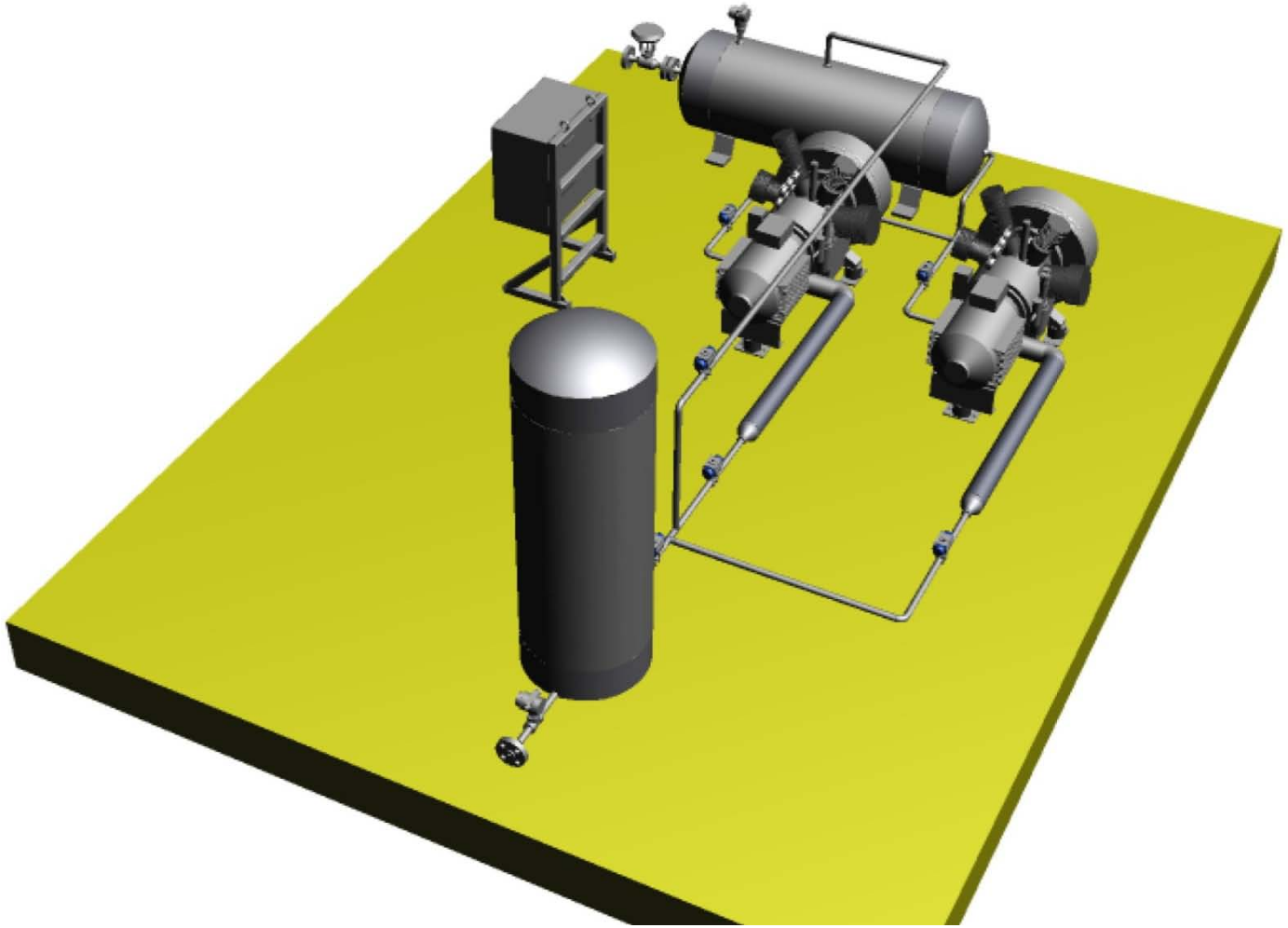
Emissions Example: Mechanical Dry Gas Seals

- A pipeline compressor fitted with two 150 mm shaft seals operating at a pressure of 25 bar will leak approximately 120 Nl/min
- Assuming utilization factor of 0.8, in a year of operation, the compressor seals will contribute 4.2 million liters to hydrocarbon emissions

Vented Gas Recovery System



System Description



System Description

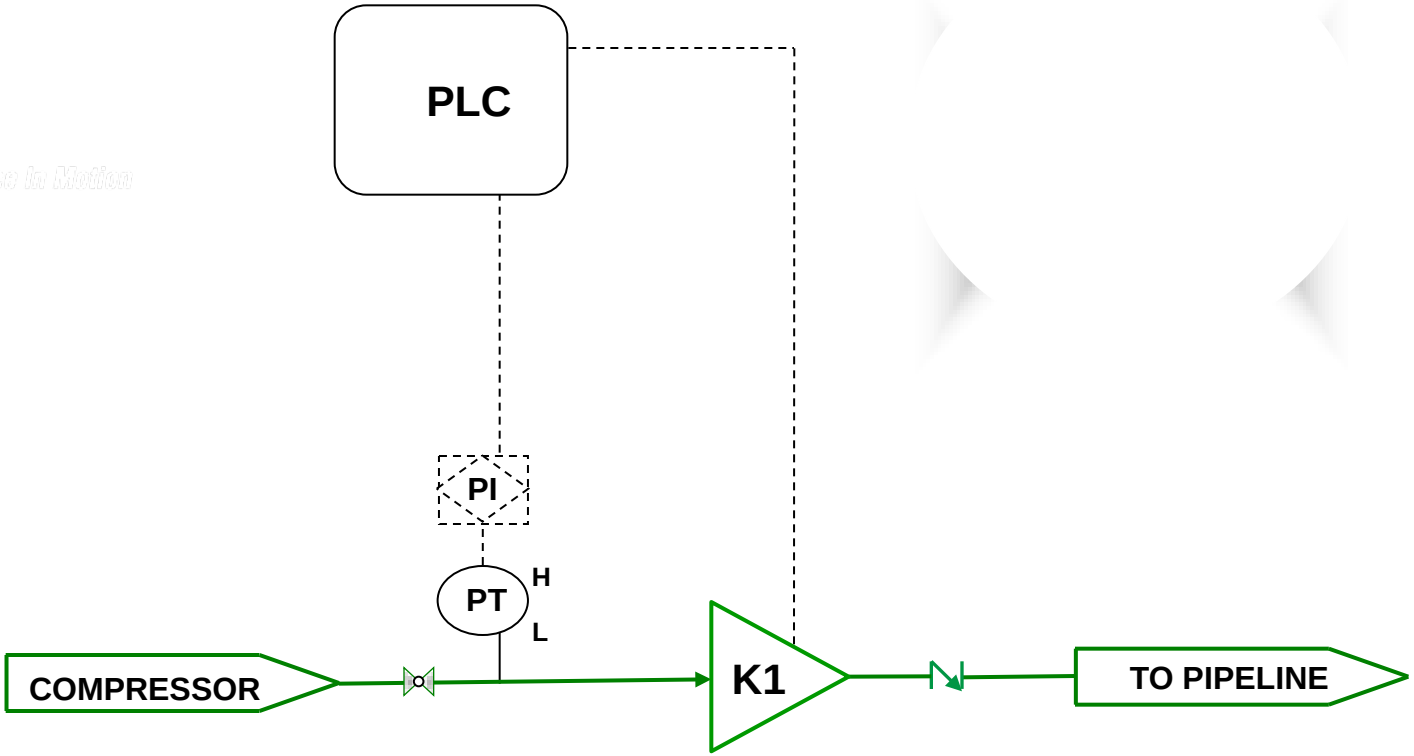
- Available configurations to recover variable volume and pressure of vented gas
- Built in redundancy – two compressors providing non-stop operation
- Mean time between compressor maintenance (MTBCM) – not less than 12 month
- With built in redundancy (0.5 utilization factor) – MTBCM is not less than 24 month.

Draw Down Gas Recovery System

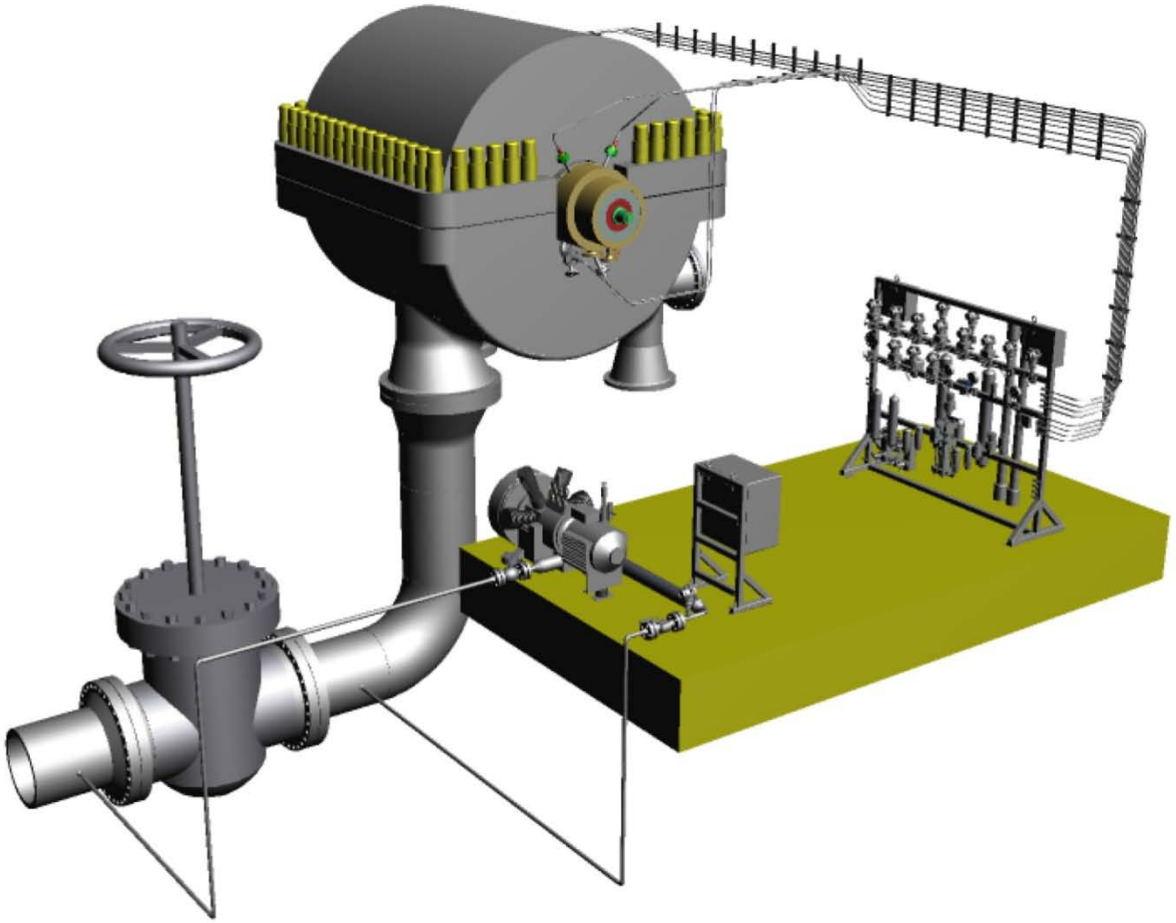
- At shutdown pipeline compressor and isolated piping contain, on average, 10 000 scf / 285 Nm3 of natural gas.

- This gas is usually vented into atmosphere.

Draw Down Gas Recovery System



Draw Down Gas Recovery System



Draw Down Gas Recovery System

Think Twice. Safety First.

Technical Data:

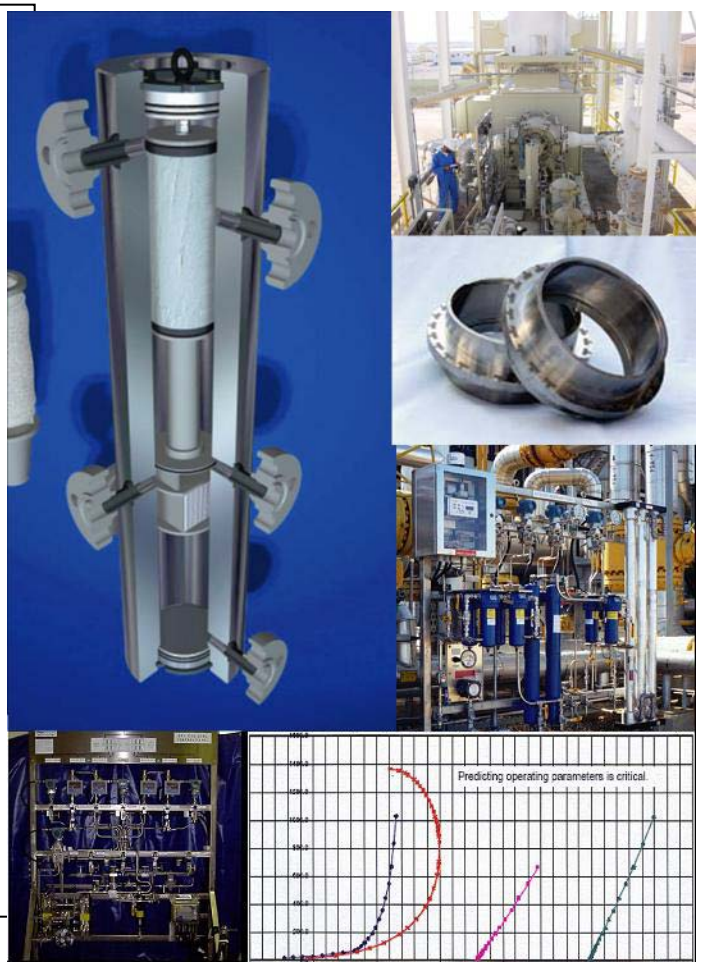
Minimum Drawdown Pressure:	Atmospheric
Recommended Drawdown Pressure:	2 to 4 bar
Injection (Pipeline Pressure):	up to 400 bar
Operating Temperature Range:	+5 to +45^{o}C
Compression Units Capacity:	200 to 1200 L/min
Electrical Area Classification:	Class 1 Div. 1 and 2

Why Recover?

- Provides compliance with Kyoto Accord, eliminates emission and requirement to purchase additional credits
- Provides reduction in cost for HC emission reporting as per EPA 2011 requirements and provides compliance with future emission reduction legislations
- Provides compliance with pending Canadian Emission Control legislation
- Provides compliance with existing and pending EU Regulations (ER4, ER5 and ER6)

A Leader in Compressor Seal Solutions…

- Industry's broadest core products and services:
  - Control Systems
  - Gas Conditioning Systems
  - Application Design
  - System Upgrades
  - System commissioning
- Conditioning systems
  - Large array of systems designed to solve unique problems
    - Dew point, pressure variation, particles
  - **Cleanpac™, Drypac™, Ampliflow™**



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Thank you for your attention.