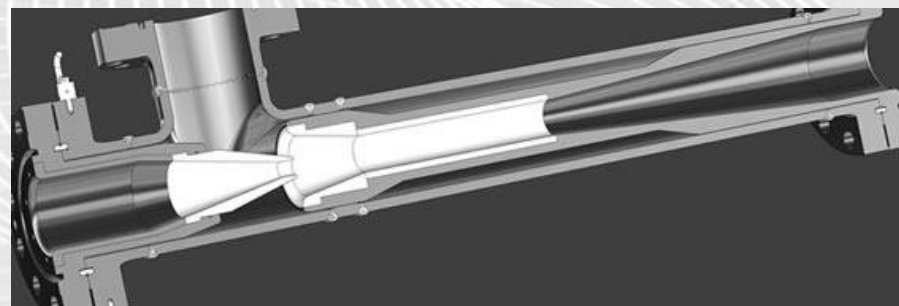




Ejector Technology for Efficient and Cost Effective Flare Gas Recovery



*GPA-GCC 24th Annual Technical Conference,
Kuwait City, Kuwait, May 10-11, 2016*

Trevor Leagas

Flare Gas Recovery Manager – Europe and Middle East Region

Zeeco, Inc

➤ *Outline*

- Company Introductions
- Flare Gas Recovery - General Concepts, Components, and Design Parameters
- Compression Technologies
- Detailed Discussion of Ejectors
- Case Studies



➤ Zeeco Products



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Industrial Burners



Incineration Systems



Flare Systems



Flare Gas Recovery Systems

➤ Zeeco Company Profile



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- Zeeco incorporated in 1979
- Privately held by a family that has been involved in combustion technology for over 80 years.
- Headquarters in Broken Arrow, Oklahoma, USA
- Leading supplier of Flare Systems in the Middle East
- Advanced In-House Engineering Capabilities
- World Class R&D Center



► Zeeco's Global Presence



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Installations in over 72 Countries
1300+ Total Employees ▪ 800+ Engineering & Design Staff



➤ Transvac Company Profile



- Formed in 1973
- Privately held company.
- Headquarters in the UK
- Leading supplier of Ejectors Worldwide
 - Ejectors for gas, liquid, steam, or multi-phase fluids from 3" up to 30"

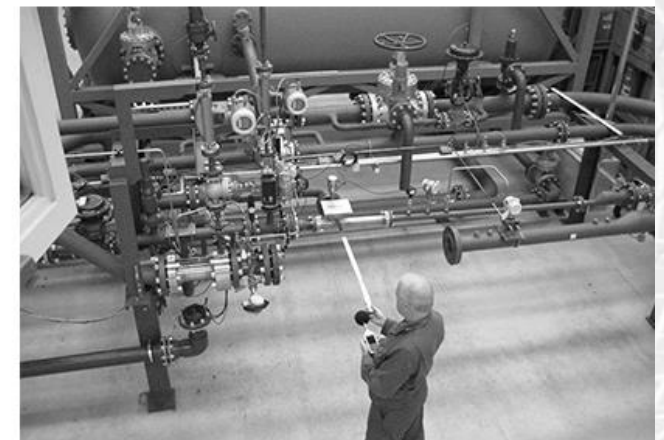


➤ Transvac Company Profile

In-House Manufacturing



Advanced R&D Center



➤ Transvac Company Profile



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Oil & Gas



Water Treatment



Nuclear



Steam & Vacuum



Fluid & Solids Handling



Scrubbing & Pollution Control





Flare Gas Recovery - General Concepts, Components, and Design Parameters

➤ *Why Flare Gas Recovery?*

- Worldwide push for reduction in flaring
 - Reduce CO & HC Emissions
- Middle East
 - Reduction in flaring
 - Reduction in H₂S flaring
- Recover gases that would normally be flared
 - Offset Plant Fuel Gas Usage



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➤ *Why Flare Gas Recovery?*

- Additional Benefits
 - FGRU can eventually “pay for itself”
 - Increase life of flare system
 - Reduce visibility of flare system
 - Improve public perception for facility



➤ Flare Gas Recovery – Main Components

■ Typical Facility

- All waste gases go to flare
- Relief Valve Leakage
- Control Valve Leakage
- Normal Gas Flow Rates
- Purge Gas
- Header Sweep Gas
- Emergency Releases



Refinery/Plant



KO Drum

Flare Header



Flare

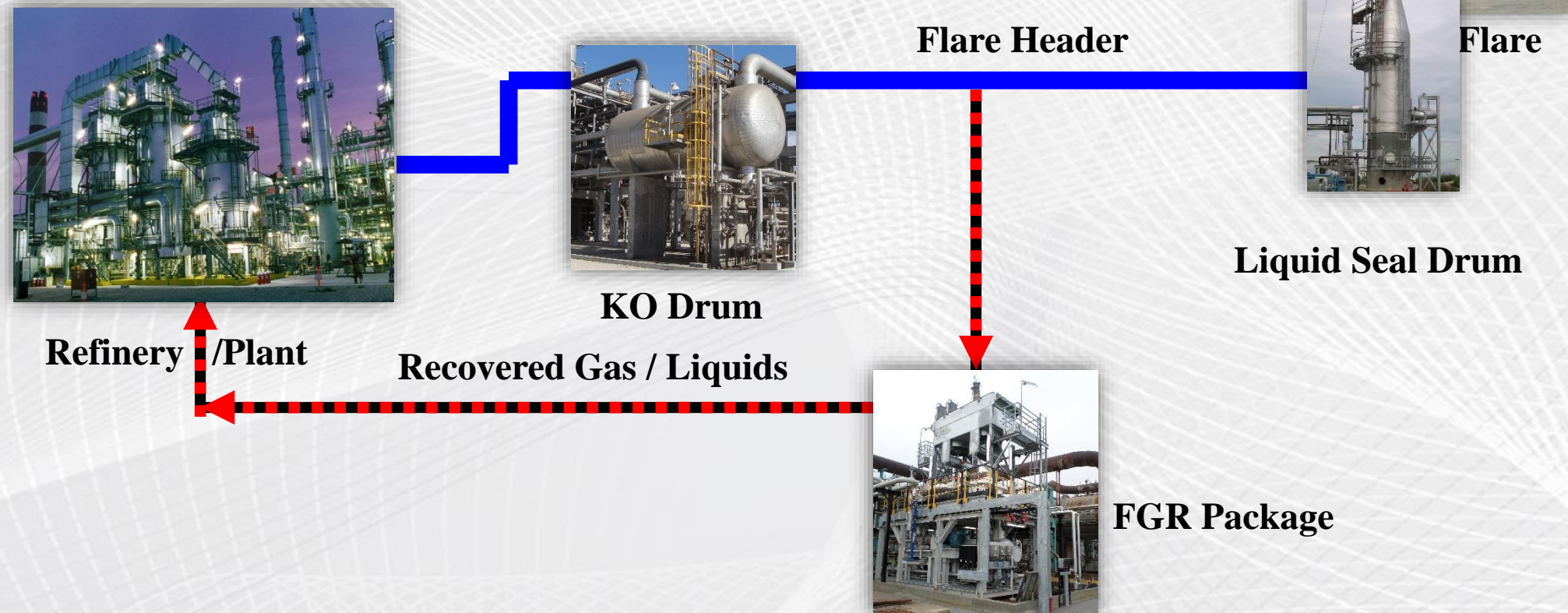


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➤ Flare Gas Recovery – Main Components

■ Facility with FGRU

- Normal Gas Flow Rates (valve leakage, sweep gas, etc) are Bypassed to FGRU System
- Compressed Gas Leaves FGRU System and Returned Back to the Plant
- Emergency Releases are Sent to Flare – Safe Relief Path



► *Types of Facilities for FGRU*



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■ Offshore Platforms

- Clean Service
- Predictable Flow Rates
- Small Temperature and Composition Ranges



■ Refineries

- Dirty Service
- Varying Flow Rates
- Large Temperature and Composition Ranges



■ Gas Plants

- Dirty Service
- Varying Flow Rates
- Large Temperature and Composition Ranges

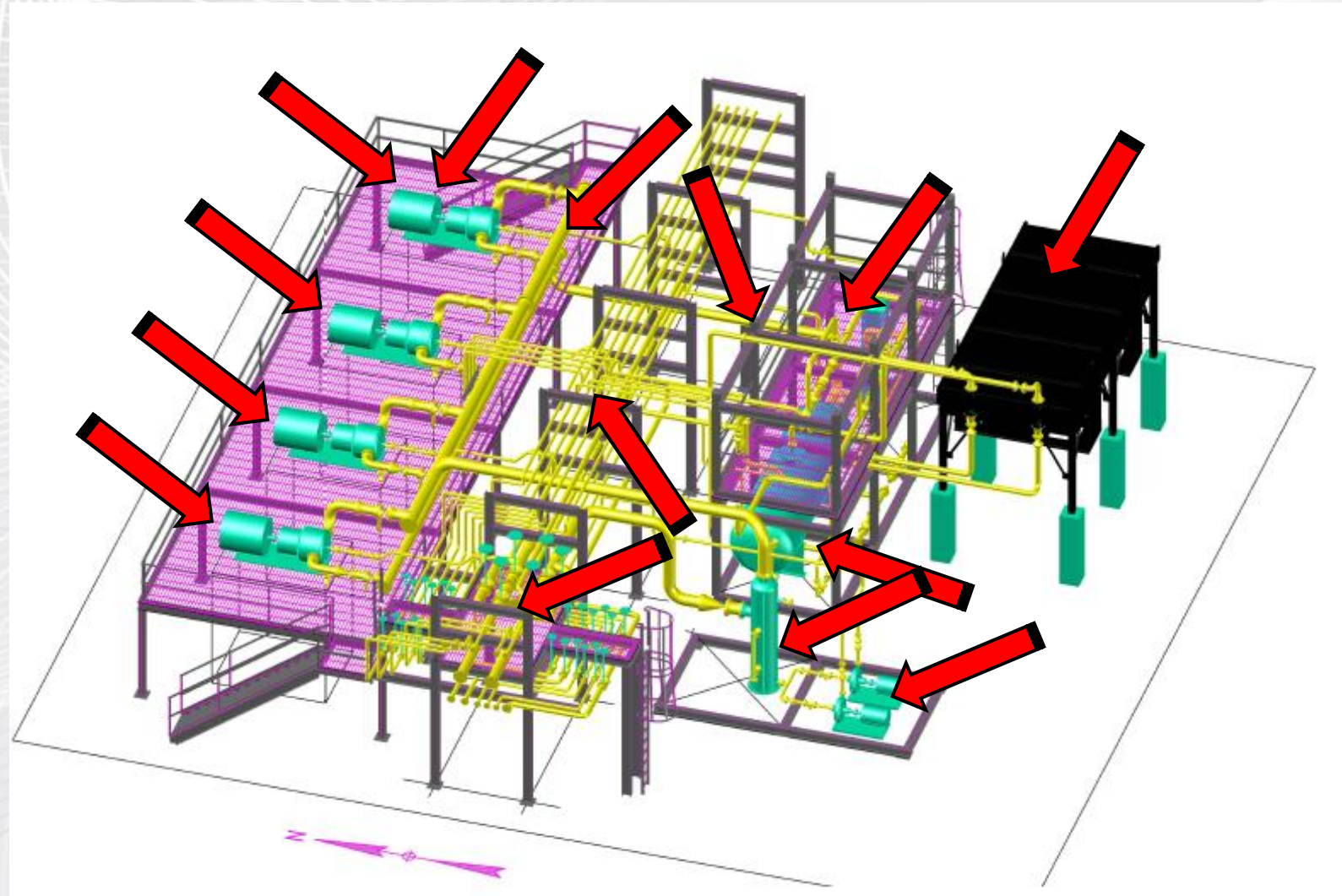
► Typical FGRU Package



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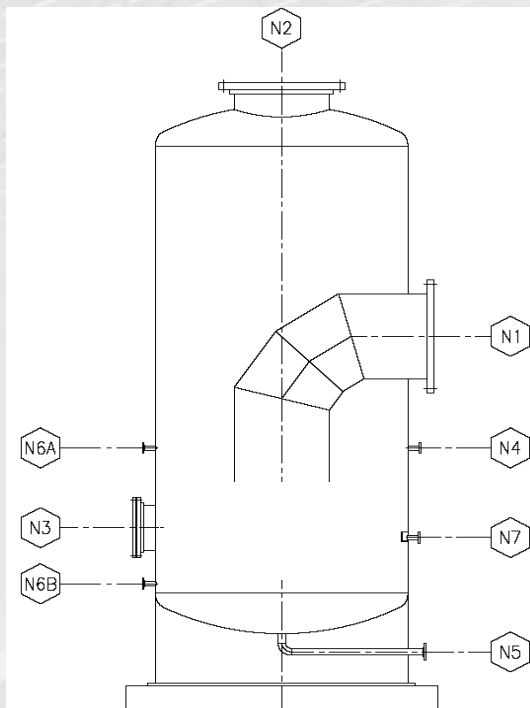
Main Components

- Compression Equipment
- Separator Vessel
- Control/Recycle System
- Heat Exchanger(s)
- Control Panel / PLC
- Piping
- Access Platforms
- Misc Items
 - Pumps
 - Inlet/Outlet KO Drums
 - Pipe Racks



➤ Flare Gas Recovery – Main Equipment

- Liquid Seal or Staging Valve
 - Divert gases to Compressor System
 - Provide safe relief path for emergency cases or during FGRU shutdown.



➤ Flare Gas Recovery – *Liquid Seal Drum*



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➤ *Flare Gas Recovery – Liquid Seal Drum*

- Liquid Seal Drums



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➤ *Flare Gas Recovery – Staging Valve / Buckling Pin*



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➤ Design Parameters for FGRU



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- **System Capacity**
- **System Suction and Discharge Pressure**
- **Flare Gas Composition**
- **Gas Temperatures**
- **Ambient Conditions / Jobsite Location**
- **Available Utilities**
- **Location of FGRU**
- **How many flares will be tied into the FGRU?**
- **Selection of proper equipment for diverting gas to FGRU system and providing safe relief to flare.**

► Design Parameters for FGRU



- Availability of Water
- Cost of electricity.
- Value of Recovered Gases
- Required System Turndown
- Frequency of Plant Shutdowns
- Required Service Life of Equipment
- Redundancy in Design
- Access of equipment for maintenance
- Control system logic (local PLC or DCS)?
- Shaft Seal Types
- Customer Specifications
- Approved Vendor Lists
- Extent of Modularization
- Required Delivery Date

➤ **Special Design Considerations for Hot, Desert Regions**

■ **Availability and Processing of Water**

- Liquid seal vessels.
- Liquid Ring Compressors and Liquid Ejectors
- Water Cooled vs Air Cooled Heat Exchangers

■ **High Ambient Temperatures**

- Evaporation Rates
- Motor Selection
- Protection of Controls and Instruments

➤ **Special Design Considerations for Hot, Desert Regions**

■ **Sand Storms and High Sand Content**

- Protection of Instruments
- Close Tolerances in Compressors and Pumps

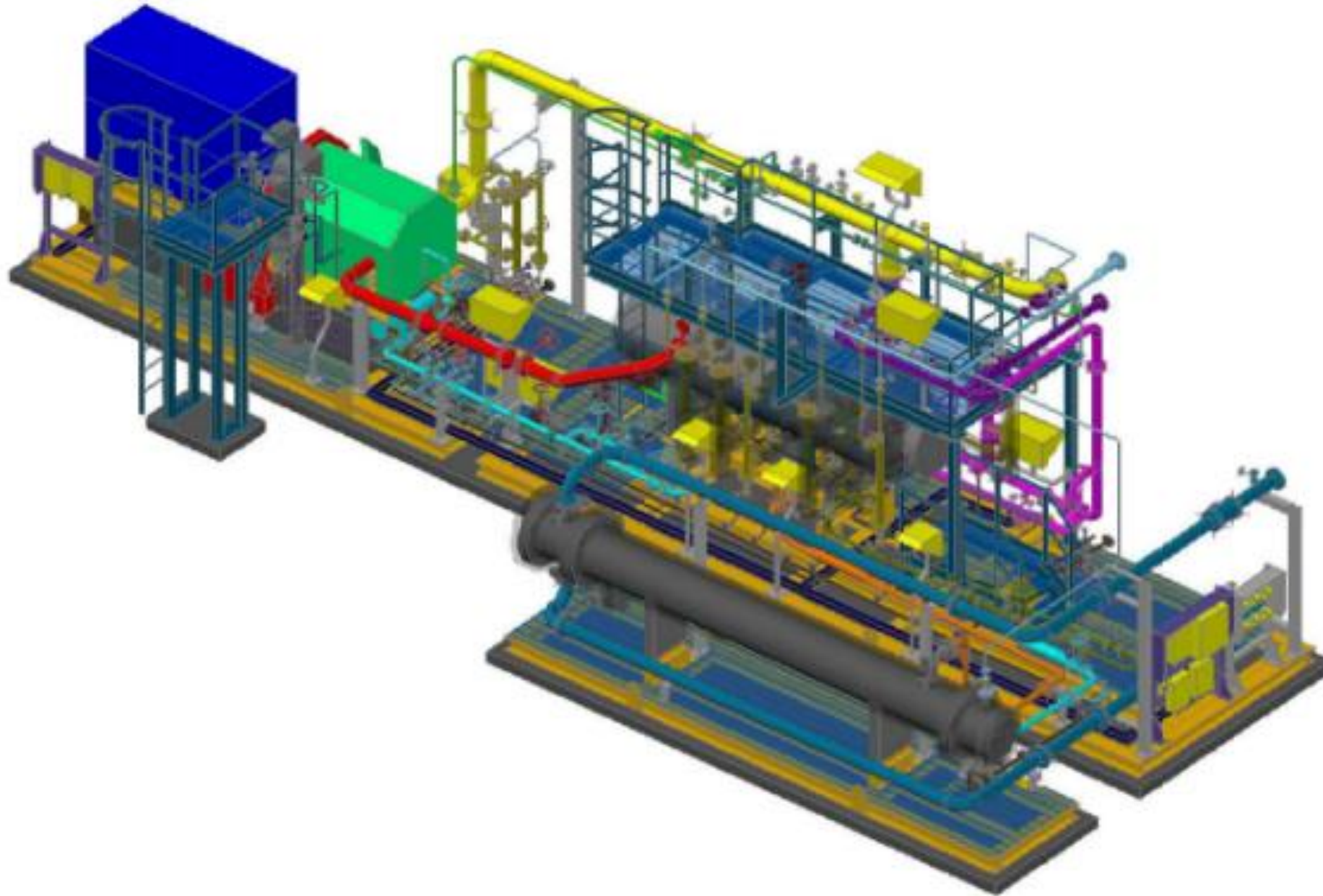
■ **Sour Flare Gases**

- Contamination of Oil
- Contamination of Water
- Special Materials of Construction
- Protection of Personnel

➤ *Typical Zeeco FGR Packages*



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► Typical Zeeco FGR Packages



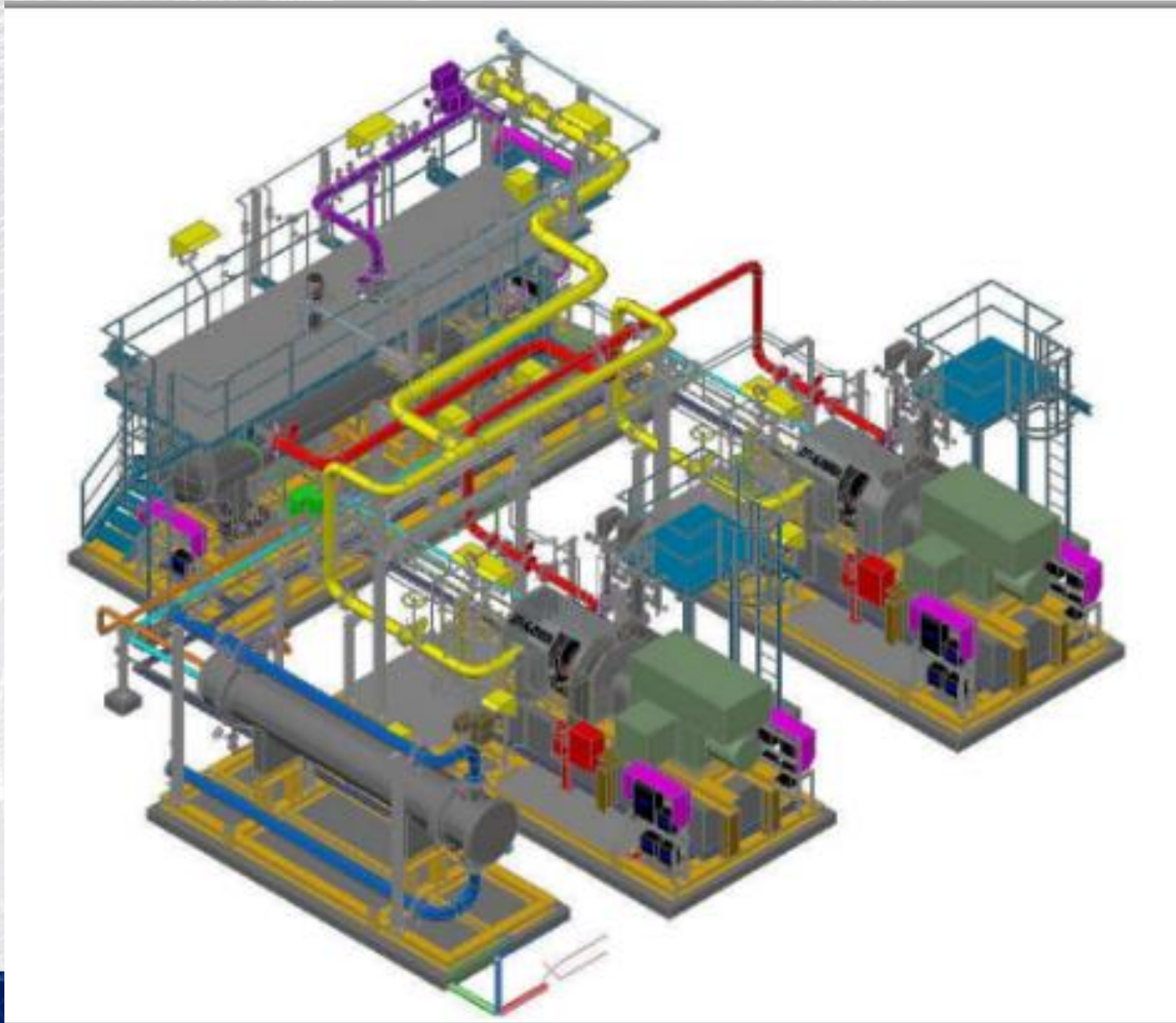
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➤ *Typical Zeeco FGR Packages*



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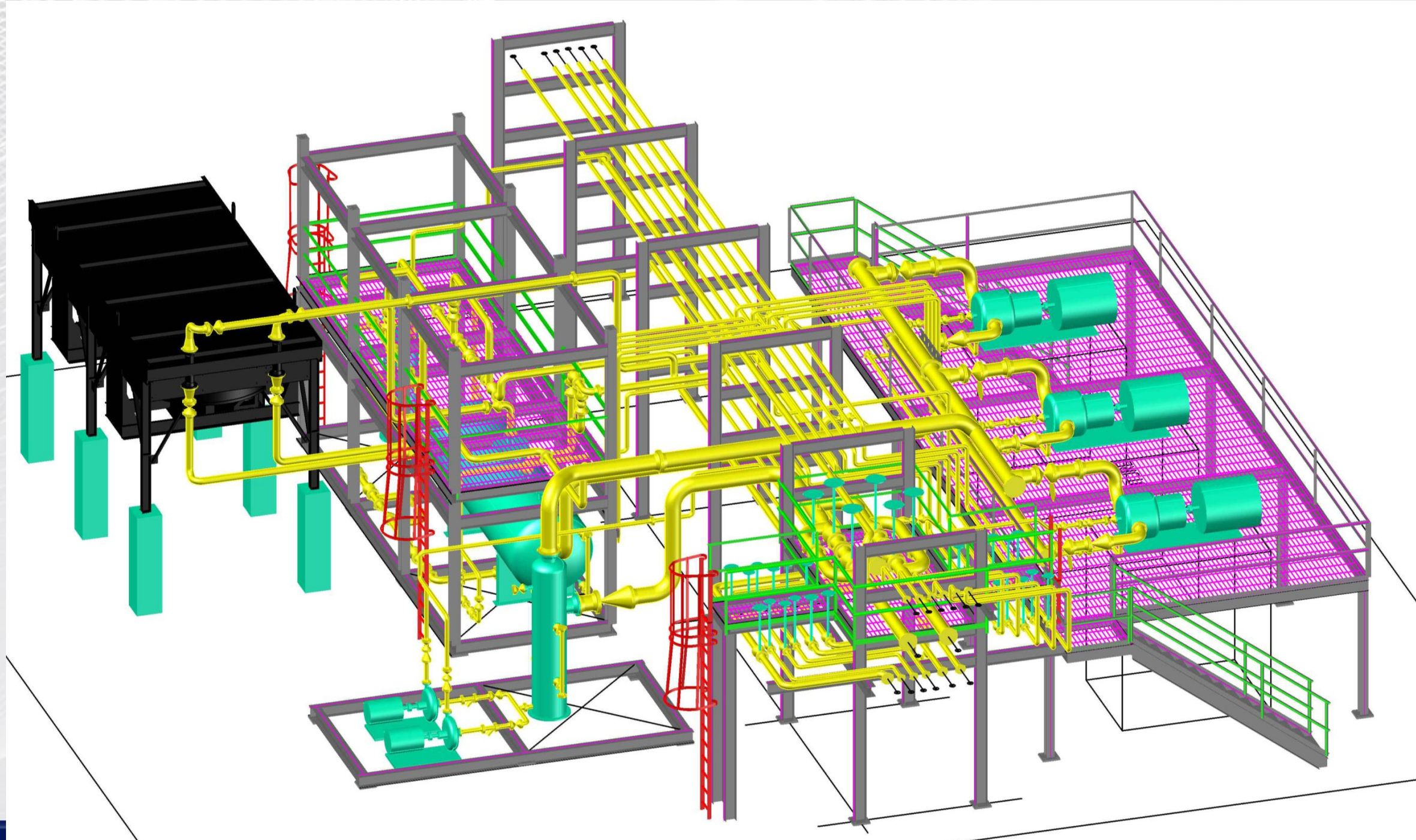
➤ Typical Zeeco FGR Packages



► Typical Zeeco FGR Packages



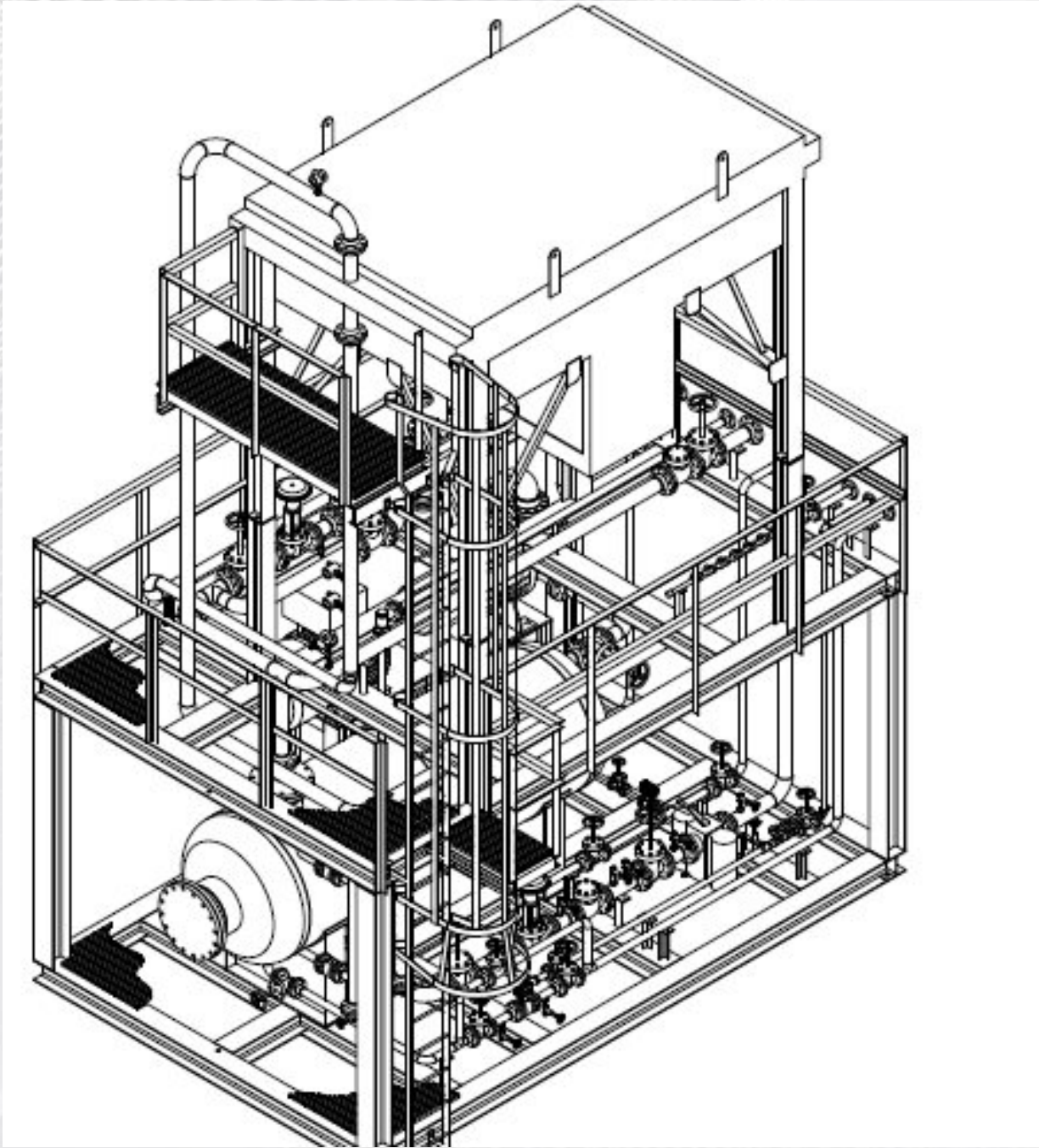
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➤ Typical Zeeco FGR Packages



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- **Proper System Design – Safety and Operation Concerns**
 - **The concept of Flare Gas Recovery seems simple; however, the flare system is the single most important piece of safety equipment in the entire facility. Whoever is working on design changes involving the flare system must **COMPLETELY** understand the implications of changes and the dangers / risks associated with these changes.**

➤ Proper System Design – Safety and Operation Concerns

- Manifolding of multiple flares to common FGRU
 - Backflow of flare gas from one header into another.



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➤ Improper Liquid Seal Drum Design



➤ Proper System Design – Safety and Operation Concerns

- Air Flow Into Flare System
 - Improper Seal Design
 - Improper Turndown Design



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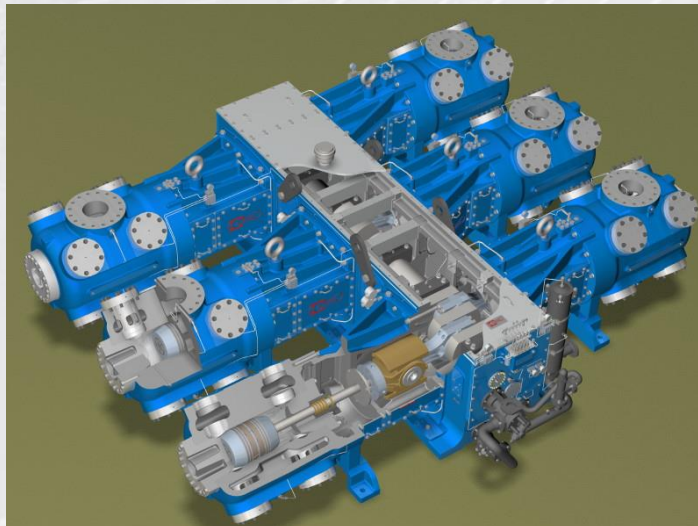
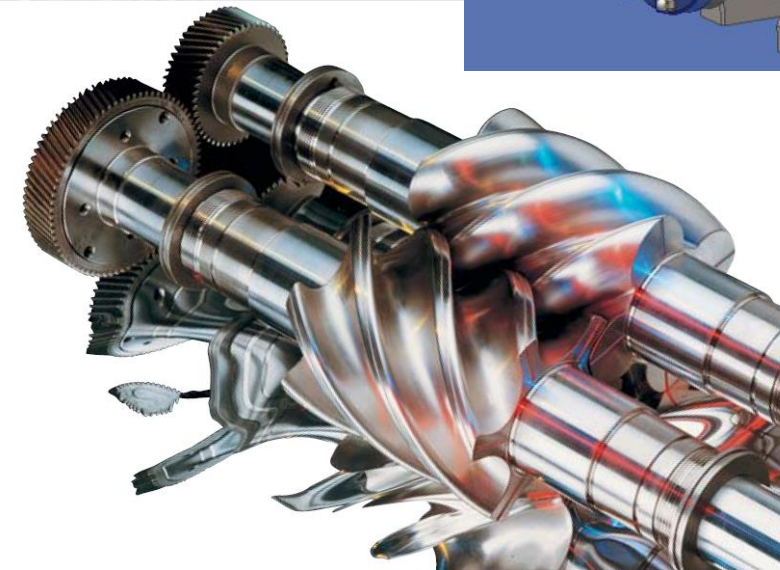
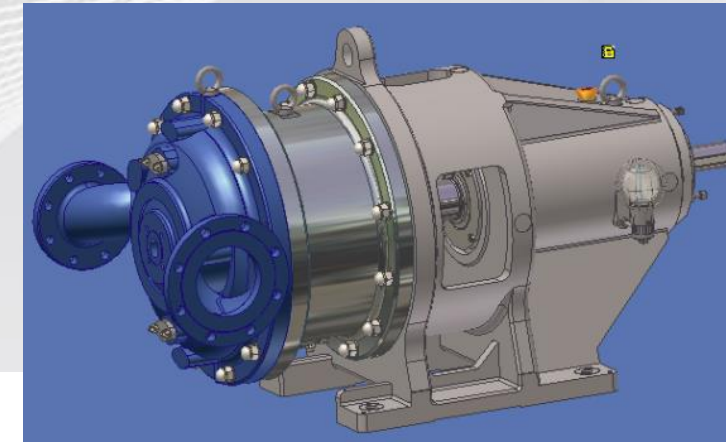




Compression Technologies

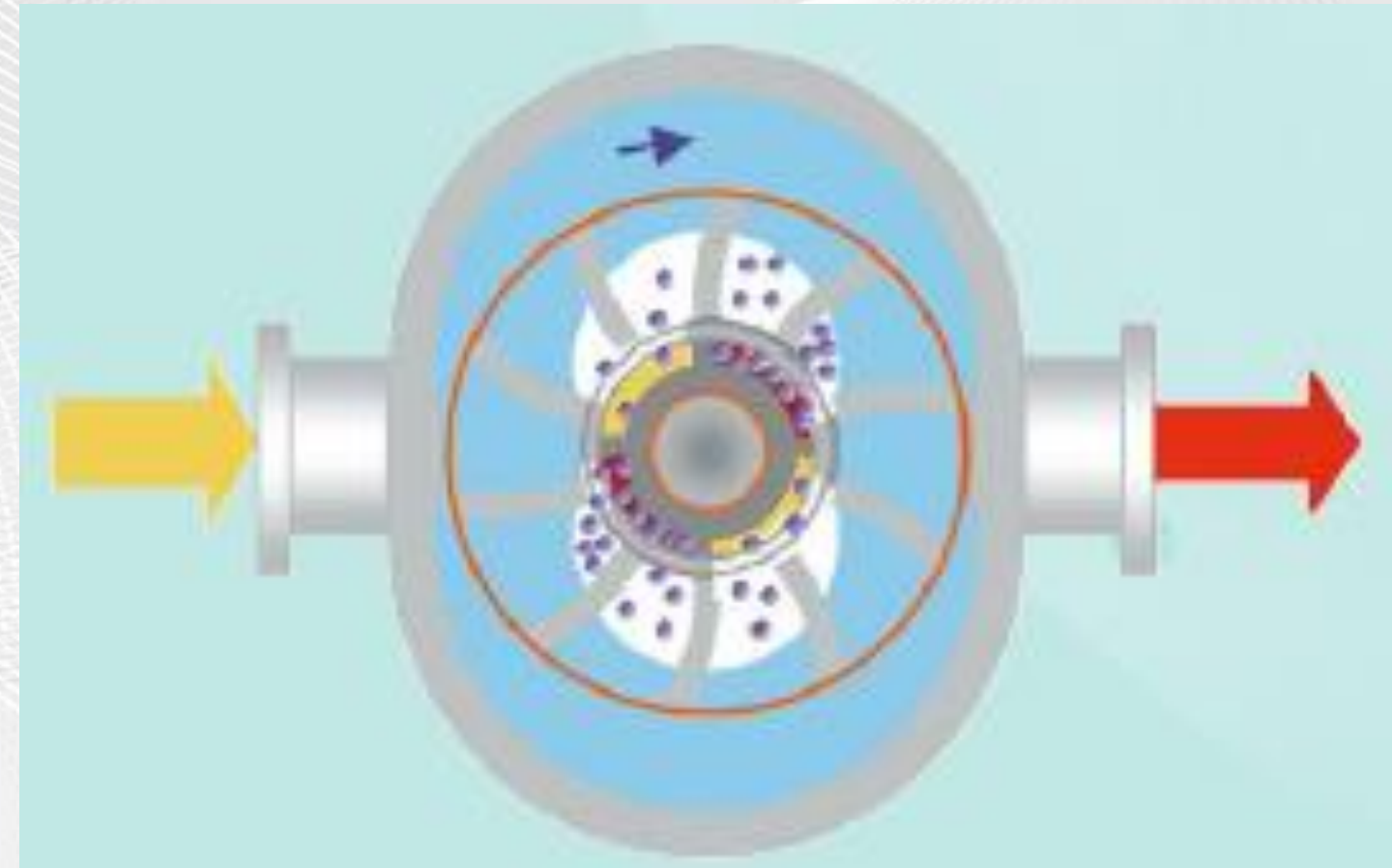
➤ Mechanical Compressor Types

- Liquid Ring Compressors
- Dry Screw Compressors
- Flooded Screw Compressors
- Reciprocating Compressors
- Sliding Vane Compressors



➤ Liquid Ring Compressors

- Operating Concept
 - Rotating impeller produces a rotating ring of liquid.
 - Flare gas is injected into the housing and is compressed by the impeller and liquid ring.



➤ Liquid Ring Compressors - Highlights



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■ Advantages

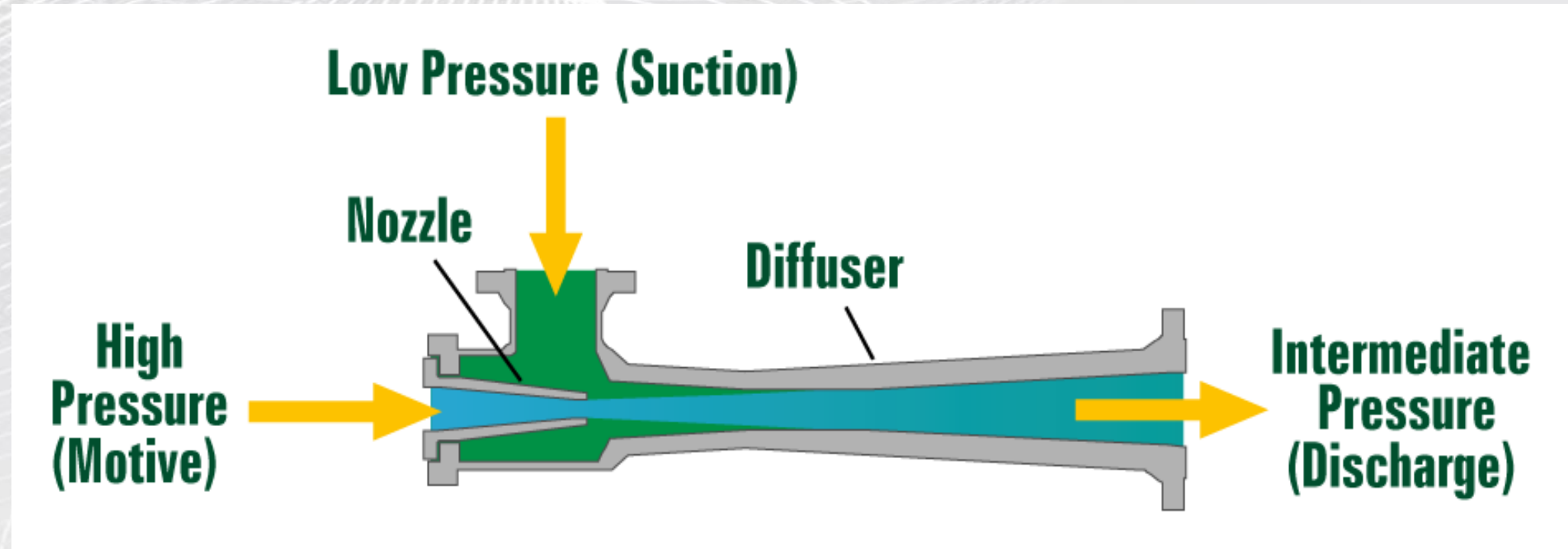
- Easily Handle Liquid Slugs (~10% of normal liquid flow) and Dirty Gases
- Handles Wide Range of Temperatures and Gases
- Low-Speed, Low-Noise/Vibration
- Proven Technology
- Low Heat of Compression

■ Disadvantages

- Maximum Pressure ~150psig
- Fixed Speed – Turndown via recycle or staging
- Relatively inefficient design



➤ Ejectors for FGR Compression



An Ejector is a simple device which uses the energy within a high pressure fluid to entrain and compress a low pressure fluid to an intermediate pressure.

➤ Ejectors - Highlights



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- **Advantages**
 - **Low cost**
 - **Simple construction and installation**
 - **No moving parts in the compression zone**
 - **Up to 150:1 compression ratio achieved without staging**
 - **Ability to handle both solids (such as sand), liquid slugs, and sour gases**



➤ Ejectors - Highlights



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■ Advantages

- Ability to handle wide range of process conditions
- Low maintenance
- Can be performance tested at shop
- 0 to 100% flare gas turndown
- Small plot space



➤ Ejectors - Highlights



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■ Disadvantages

- Low volumetric efficiency compared to some compression technologies.
- High motive fluid flowrate
- High motive pressure required

➤ Ejectors vs Liquid Ring Compressors



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- ***Typical Flare Gas Recovery Package:***
 - ◆ 2200 m³/hr capacity
 - ◆ 7.5bar discharge pressure



➤ Ejectors vs Liquid Ring Compressors



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Technology	Plot Space	Required System Power	System Capital Cost
Liquid Ejector	18m X 20m	600KW	\$3.5MM USD
Liquid Ring Compressor	18m X 27m	600KW	\$4.0MM USD

Notes:

1. Price includes deep liquid seal drum.
2. Liquid Ejector price includes motive liquid pump (assumes 75% efficiency) and separator vessel

If an existing pump at the facility can be used for the Liquid Ejector motive fluid (approximately 1275gpm at 60barg) then the pump package could be removed from the capital cost, reducing the price by another \$680,000 USD.



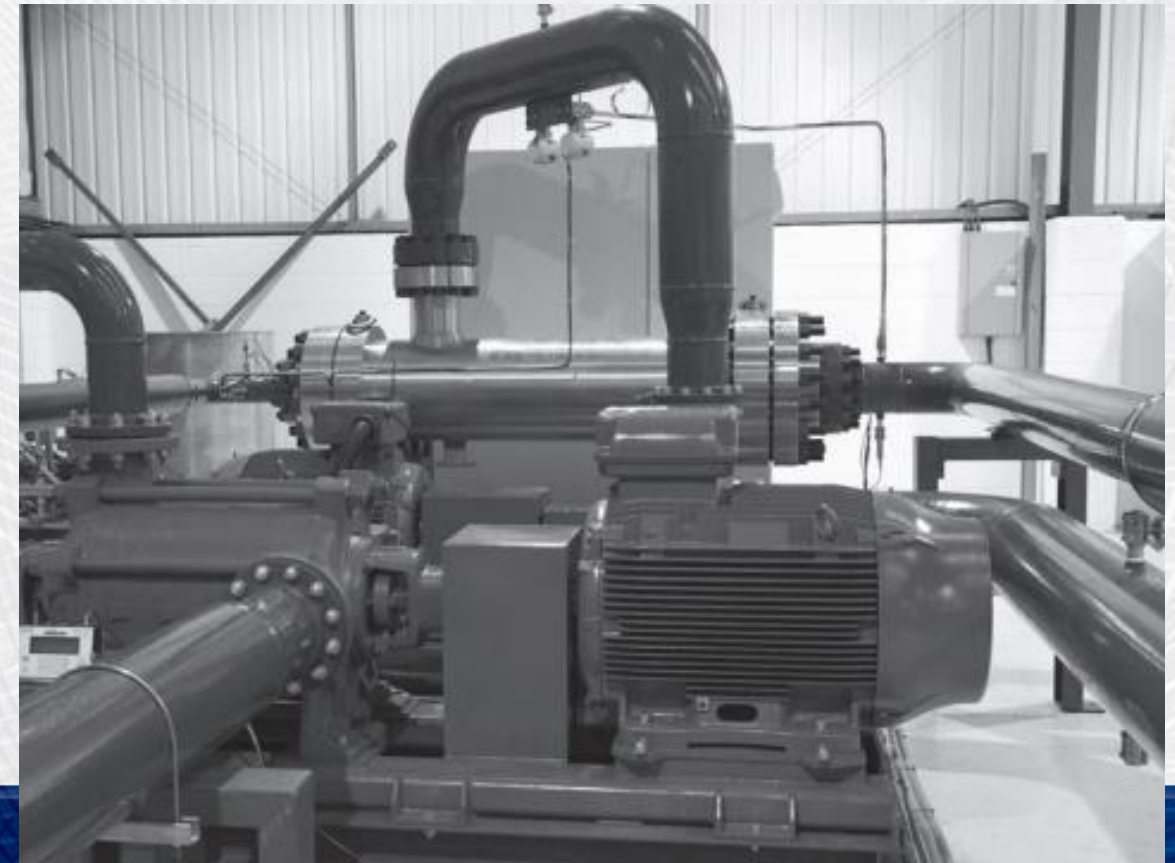
Detailed Discussion of Ejectors

➤ Ideal Applications



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- **Existence of “free” motive fluid at facility:**
 - Water from existing pump
 - Dedicated pump or slipstream excess capacity from pump
 - Extra high pressure gas available.



➤ Ideal Applications

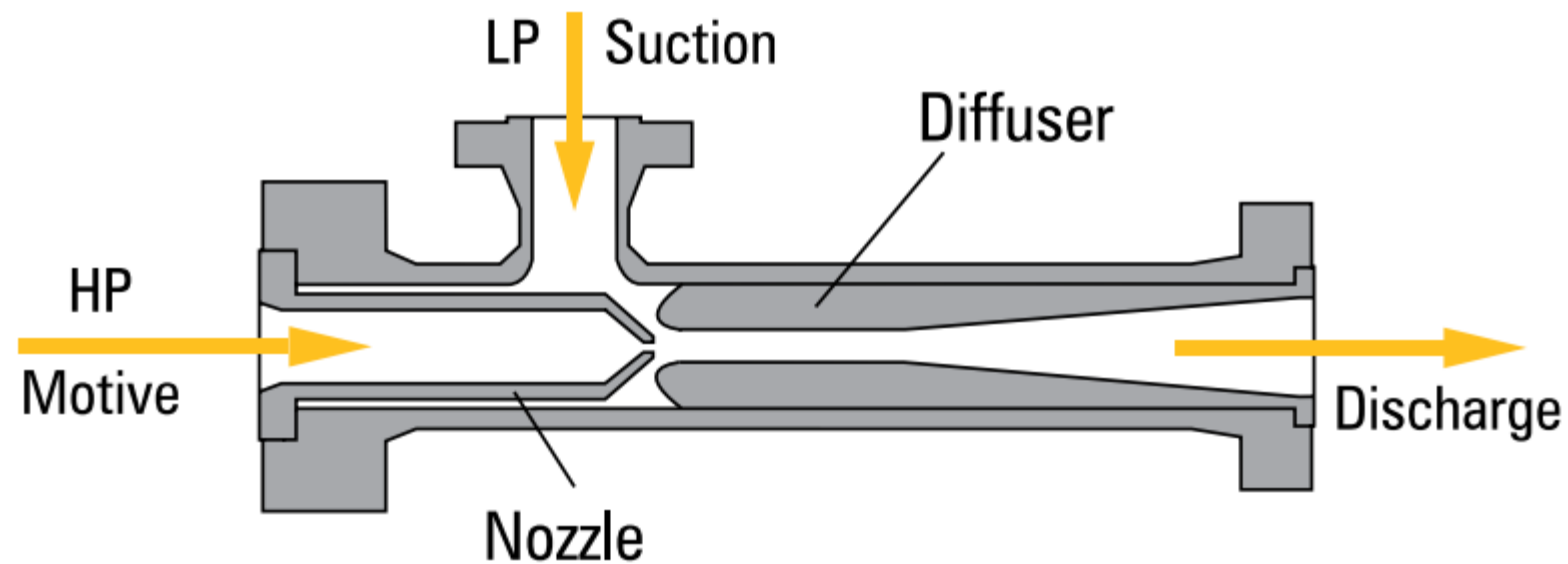
- Existing separator vessel



Gas Oil Separation Plan (GOSP)

➤ Motive Fluid (Force)




- Ratio of motive fluid pressure to required discharge pressure is important
 - Higher Ratio = Lower Motive Flowrate Required
- Typically preferred to have Motive Pressure ~ 5-10x higher than discharge



➤ Gas vs Liquid Ejectors



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		Suction Fluid		
		Gas	Liquid	Multi-phase
Motive Fluid	Gas		Operation restricted to small units with low compressions. Consider separator on Suction Fluid.	Efficiency depends upon gas volume fraction. Consider separator on Suction Fluid.
	Liquid			Efficiency depends upon similarity of liquids i.e. ratio of oil to water and gas volume fraction.
	Multi-Phase	Use Separator on Motive Fluid	Use Separator on Motive Fluid	Use Separator on Motive Fluid Gas volume fraction required for sizing

➤ Gas Ejectors



■ Potential motive fluids:

- Gas routed from a production separator
- Fuel gas
- Nitrogen
- Small sidestream from a gas lift or gas injection compressor discharge
- Typical usage: 2-8 kg of motive for every kg of flare gas recovered

■ Compression Ratio:

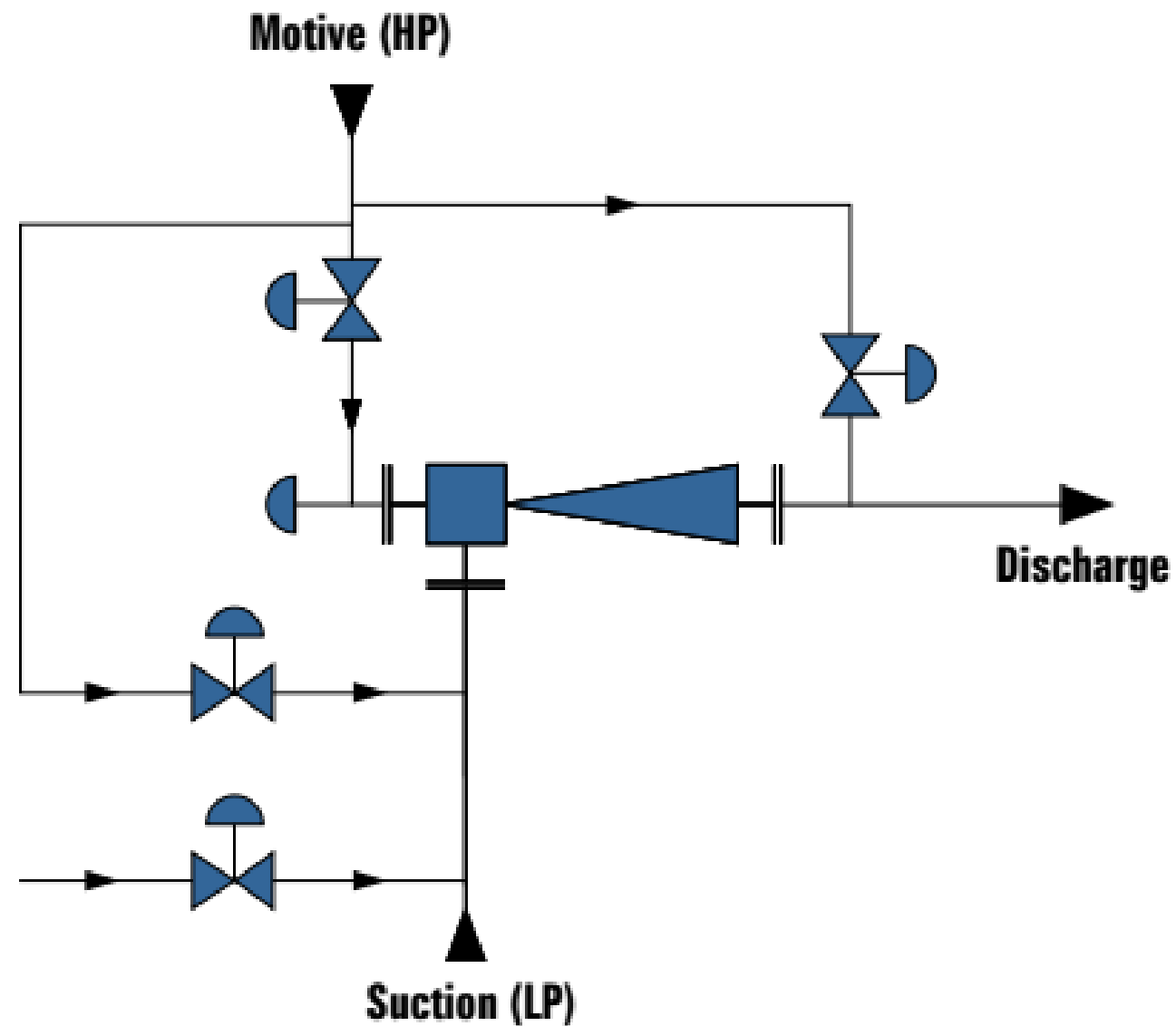
- Up to 8:1 ratio for Transvac 1-stage (other vendors typically to 4.5:1)
- Up to 40:1 ratio for multi-stage Transvac

➤ Gas Ejectors



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Control Options - Gas Ejector Low Compression Duties



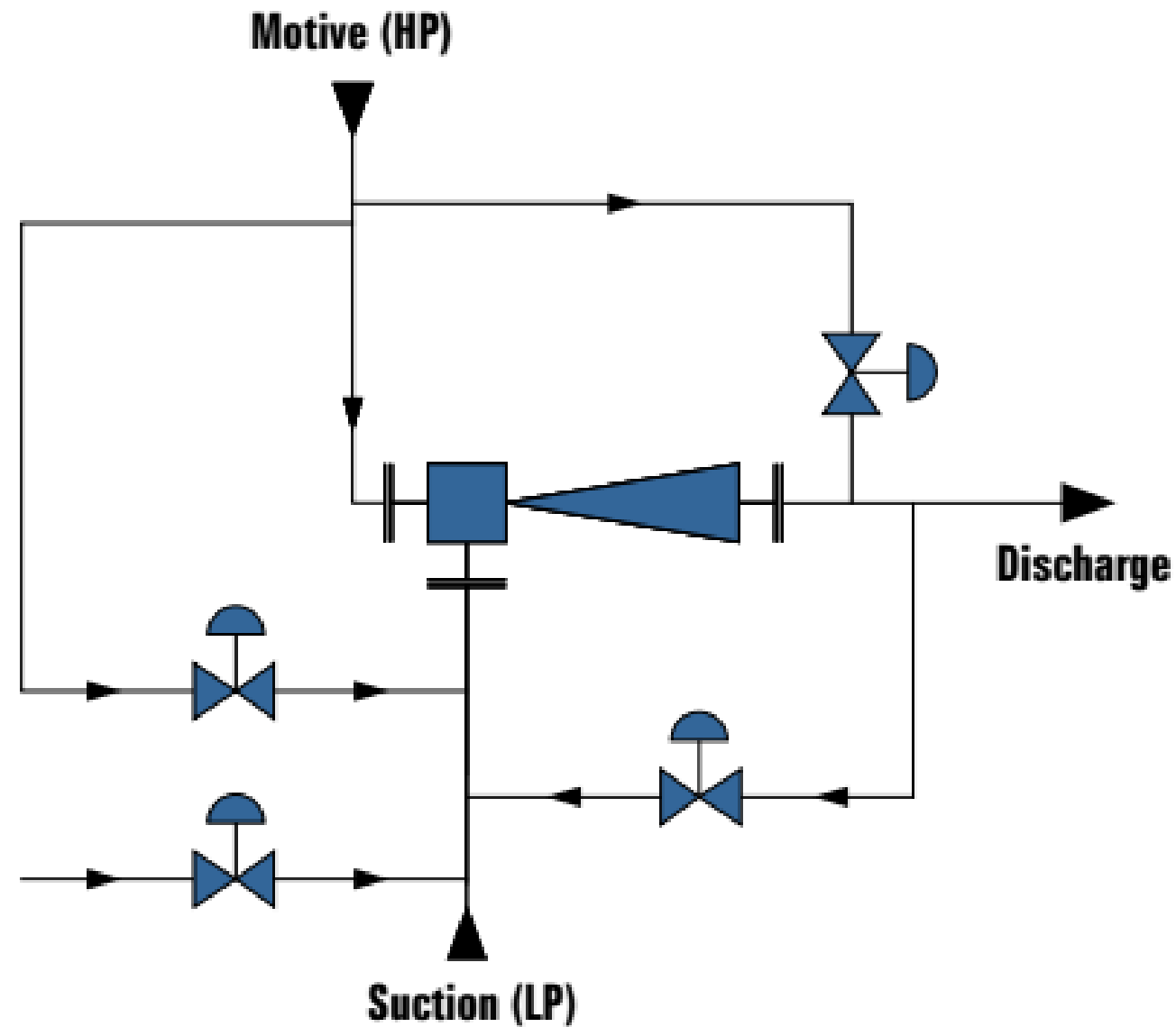
Turndown control by throttling motive gas into ejector.

➤ Gas Ejectors



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Control Options - Gas Ejector High Compression Duties



Turndown control by utilizing discharge spillback line.

➤ Liquid Ejectors



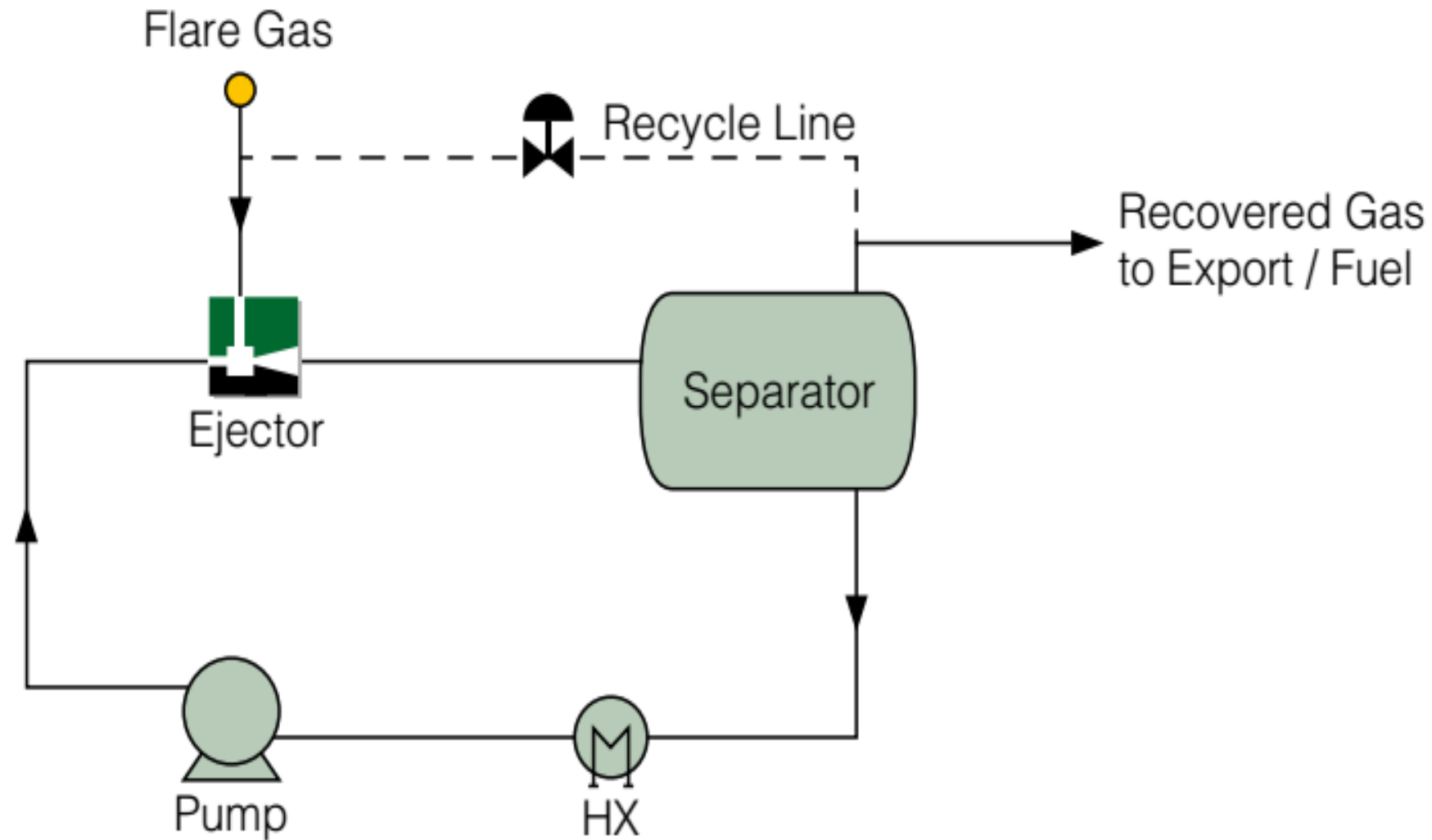
■ Potential motive fluids:

- Dedicated water pump
- Spare capacity (sidestream) from existing water pump
- Typical usage: 0.03 to 0.10 m³ of motive liquid for every m³ of flare gas recovered

■ Compression:

- Up to 150bar discharge pressure available
- Typical Flare Gas Recovery applications are normally 10 bar or less

➤ Liquid Ejectors

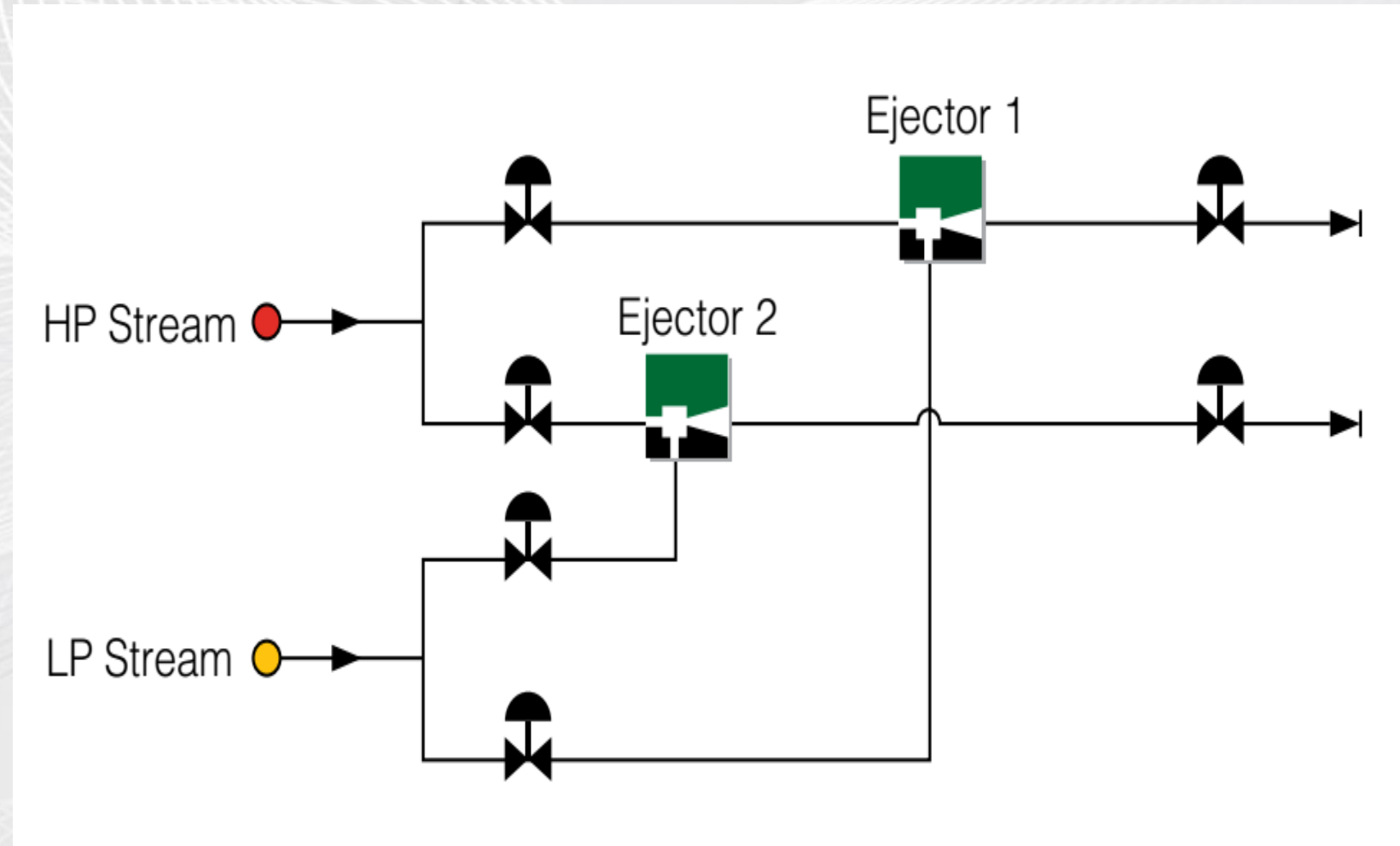


Turndown control by utilizing discharge spillback line.

Arrangement is very similar to liquid ring compressor FGR. Simply replace LR Compressor with Ejector and Pump.

➤ Multi-Ejectors

- **More efficient turndown can be achieved with multiple parallel ejectors:**
 - 2 x 50%
 - 1 x 30% + 1 x 70%
 - 3 x 33%
 - Etc



➤ Sour Service

- Amine can be used in place of water
- Special materials available:
 - Alloy 625
 - Duplex
 - Super Duplex
 - Etc



Super Duplex Flare Gas Ejector for Cairn, Offshore India

➤ Noise



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- Noise is typically not an issue for liquid ejectors
- Noise for gas ejectors can exceed 80dba without noise reduction steps.
 - Acoustic cladding
 - Inline Silencers

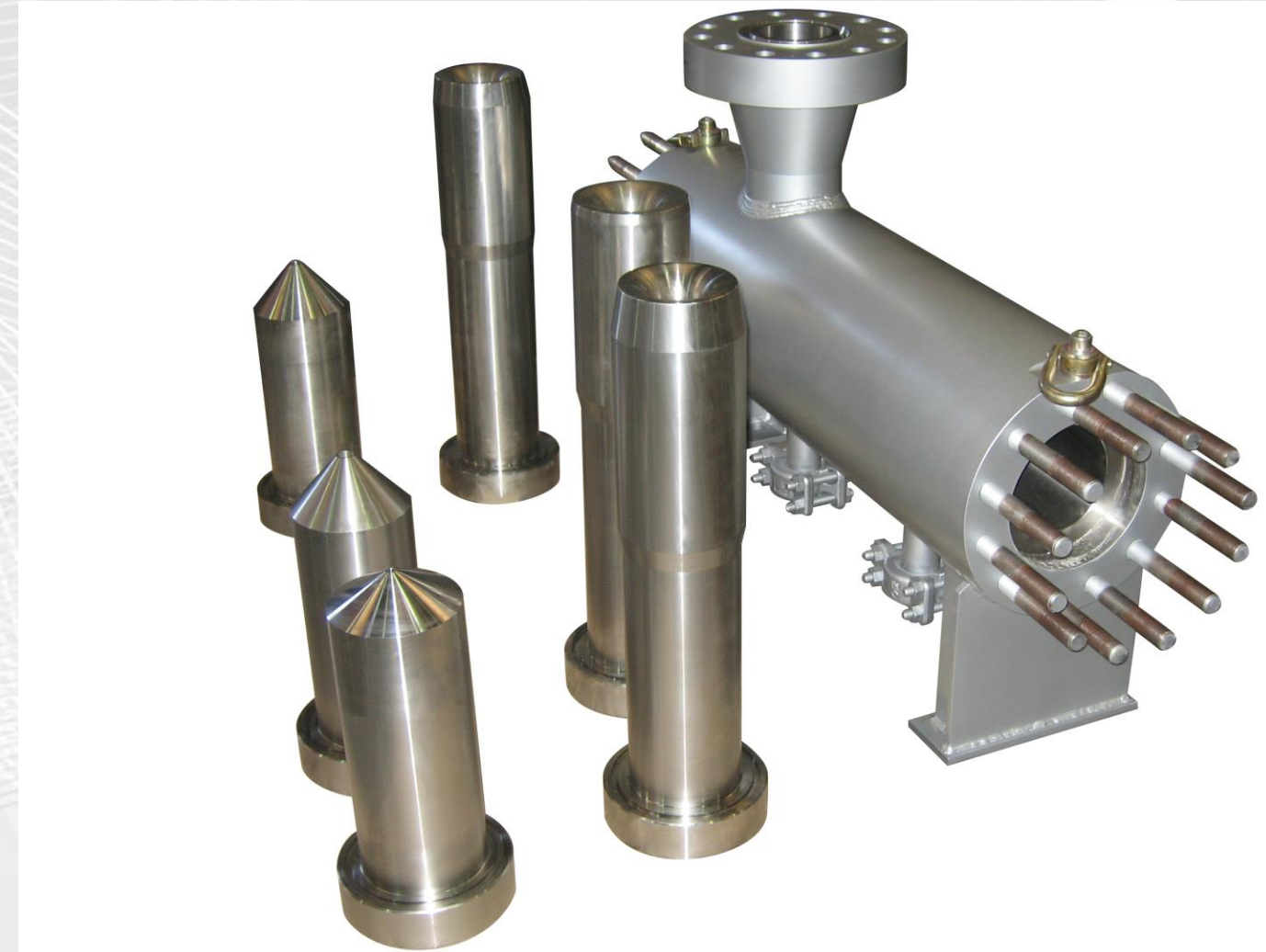


➤ Transvac Universal Design



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- **Patented Technology**
- **Replaceable Internals (nozzle and diffuser)**
- **Easy change-out in the field**
- **Swap internals to for changed process conditions**



➤ Transvac Research and Design



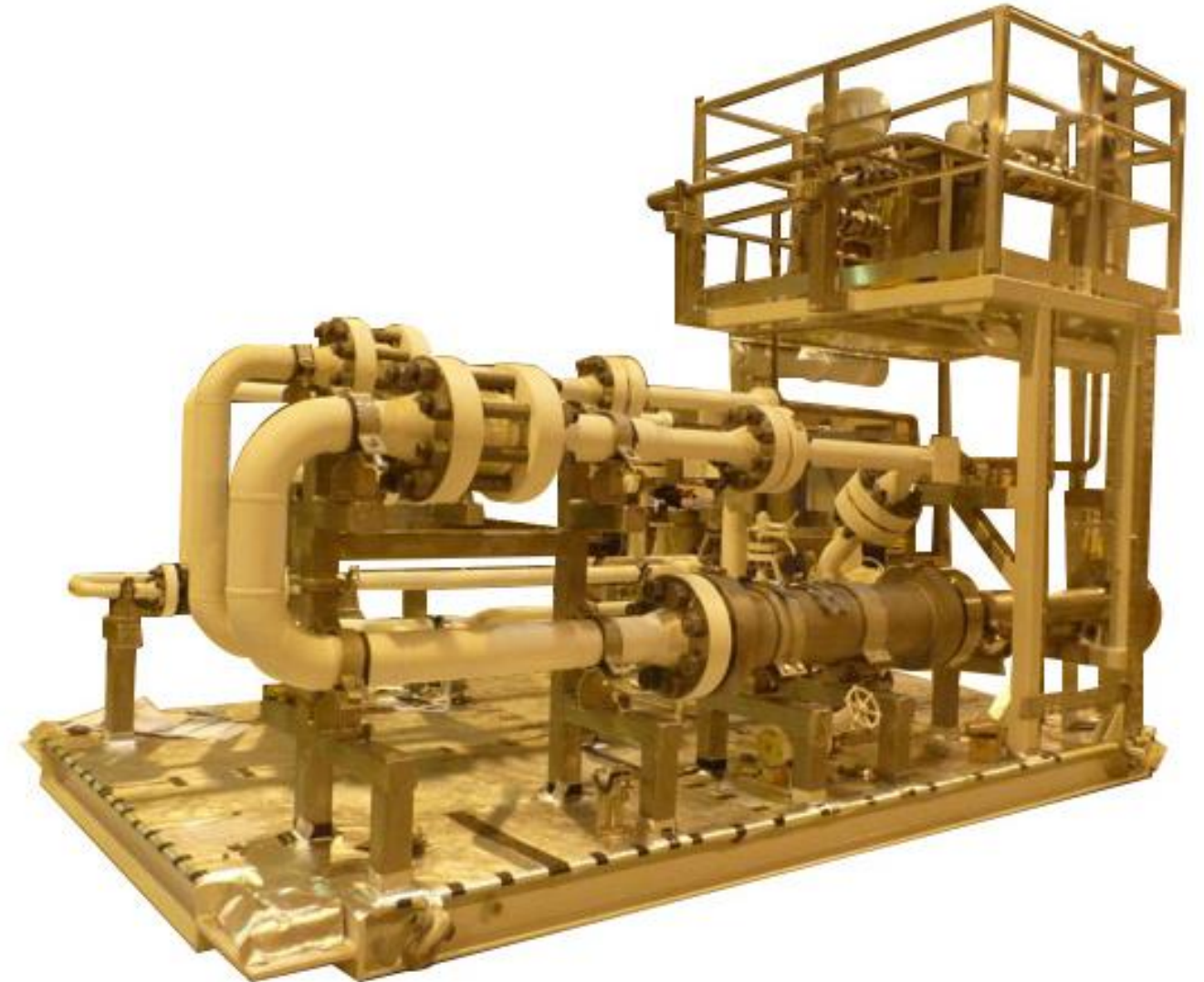
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- **State of the Art R&D Center**
- **Full-Scale Testing of Ejectors**
- **High and low pressure equipment for handling water, gas, multi-phase and slurry**
- **30% efficiency increase for ejector design in last 12 months**



➤ Case Study 1

- **Gas Ejector**
- **Offshore Platform – North Sea**
- **Reduce overall emissions by recovering gases from the flare system, the reject separator, and produced water flash tank.**
- **Recovered gas boosted to 13 barg and utilized in the facility**



➤ Case Study 1



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- **Gas recovered from various sources:**
 - Produced Water Flash Tank: 1.0 barg
 - Flare Knock-out Drum: 0.15 barg
 - Produced Water Reject Separator: 3.5 barg
- **System capacity: 500 kg/hr**



■ Sour Service Application:

- 25 Cr Duplex Stainless Steel (Super Duplex)
- 2-Stage system with multiple ejectors (30/70 split)**



➤ Case Study 1



■ Project Outcome:

- Commissioned in 2014
- Actual gas flowrate less than predicted so normally only the 30% ejector is being utilized.

➤ Case Study 2



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- **Liquid Ejector**
- **Onshore – Middle East**
- **Recover flare gas at oil and gas gathering facility.**
- **Recovered gas routed to the existing plant bulk separator and then to the gas lift compressors**
- **Small sidestream from an existing Water Injection Pump used to provide the motive water to the ejector.**
- **Existing bulk separator had sufficient capacity to accept the multi-phase discharge flow from the ejector**

➤ Case Study 2



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- Gas compressed from 0 barg to 3 barg
- Design Flow was 5,750 Sm³/d at a temperature of 40 °C
- Motive Liquid Flow was 285 m³/d at a pressure of 169 barg
- Sour Service Application:
 - 22 Cr Duplex Stainless Steel
- Full shop performance test
- PROJECT OUTCOME:
 - Successfully commissioned in early 2016



➤ Conclusion



- Flare Gas Recovery offers good solution for reducing flaring and reducing emissions.
- Several technologies exist for gas compression in FGR systems, each having unique benefits and drawbacks.
- In many situations Liquid or Gas Ejectors offer an ideal solution

➤ Contact Information



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Questions?