Engineered solutions to leverage unused assets & stretch your budget

REPURPOSING EQUIPMENT TO MINIMIZE COST

CANUSA EPC

Introduction

In a climate of tight budgets, there is a growing trend of reusing, relocating and repurposing existing equipment and packages and placing them in new services; examples include but are not limited to:

- Placing existing separators into new services
- Moving compressors or TEG packages to new fields
- Relocating refrigeration or cryogenic processing plants to new locations with change in gas composition

AGENDA

Case Study 1:
Repurposing Pressure Vessels

Case Study 2:
Refrigeration Plant Relocation

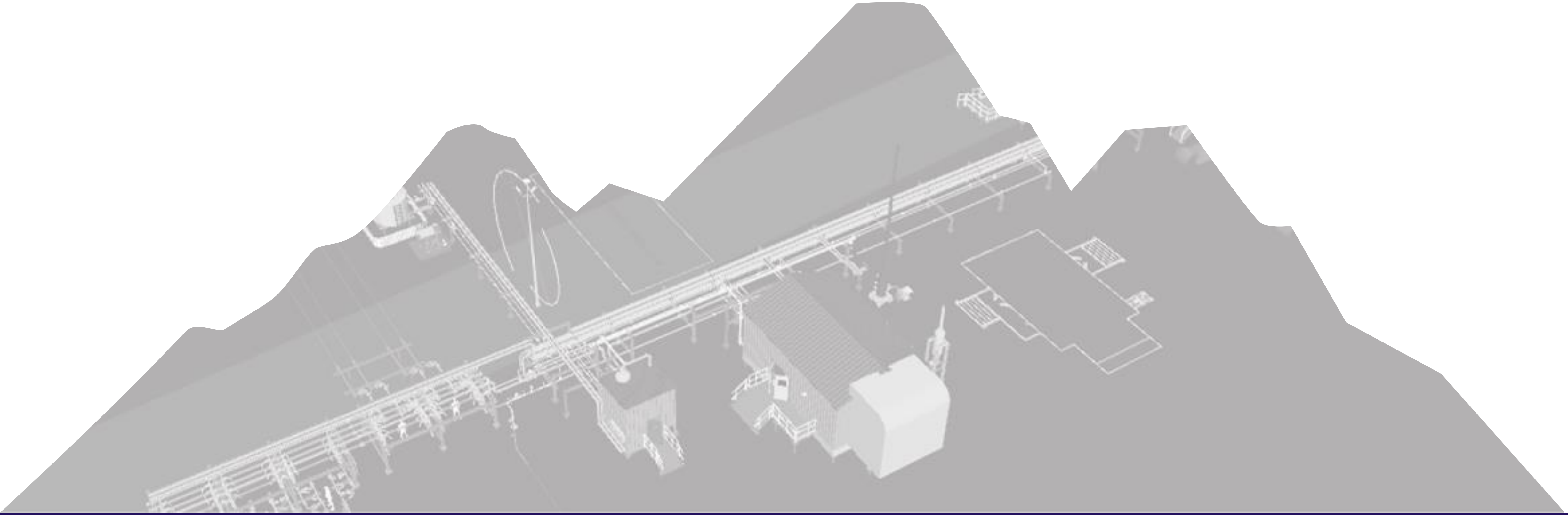
Case Study 3:
Repurposed Cryogenic Processing Plant

Lessons Learned with Repurposed Equipment

Summary & Conclusions

CASE STUDY 1:

REPURPOSING PRESSURE VESSELS



Case Study 1: Repurposing Vessels

The secondary market is full of pressure vessels that can be put back into service with minor rework, including:

- Separators (vertical and horizontal)
- Towers and contactors
- Surge drums

Other considerations when choosing to repurpose vessels

- ASME section VIII Div. I, 1999 Addenda and Code Case 2290 changed design factor from 4 to 3.5
- Vessels built to 1968 or later code can be re-rated to new edition provided they are in non-cyclic and non-lethal service
- An example vessel currently rated to 1000 psig could be re-rated to 1140 psig

Case Study 1: Repurposing Bullets

Typical NGL storage bullet tanks can often be used for a simple slug catcher.

- They can be effective 2 or 3 phase separators with large liquid capacities.
- Typical modification include adding a mist extractor, weir or water boot, new manways etc.
- Decreased lead times and cost over new, purpose-built separators due to large supply on the secondary market
- Savings over harp or finger type slug catchers with reduced field welding time

Case Study 1: Reuse Again and Again

Slug catcher that was formally a bullet tank, was taken from mothballed plant to be used as a flare knock-out drum at a nearby facility.

- Slug catcher was already owned by client, only required shipping and installation and minor modifications to remove internals and boot

- Foundation design was also reused for saving on engineering costs

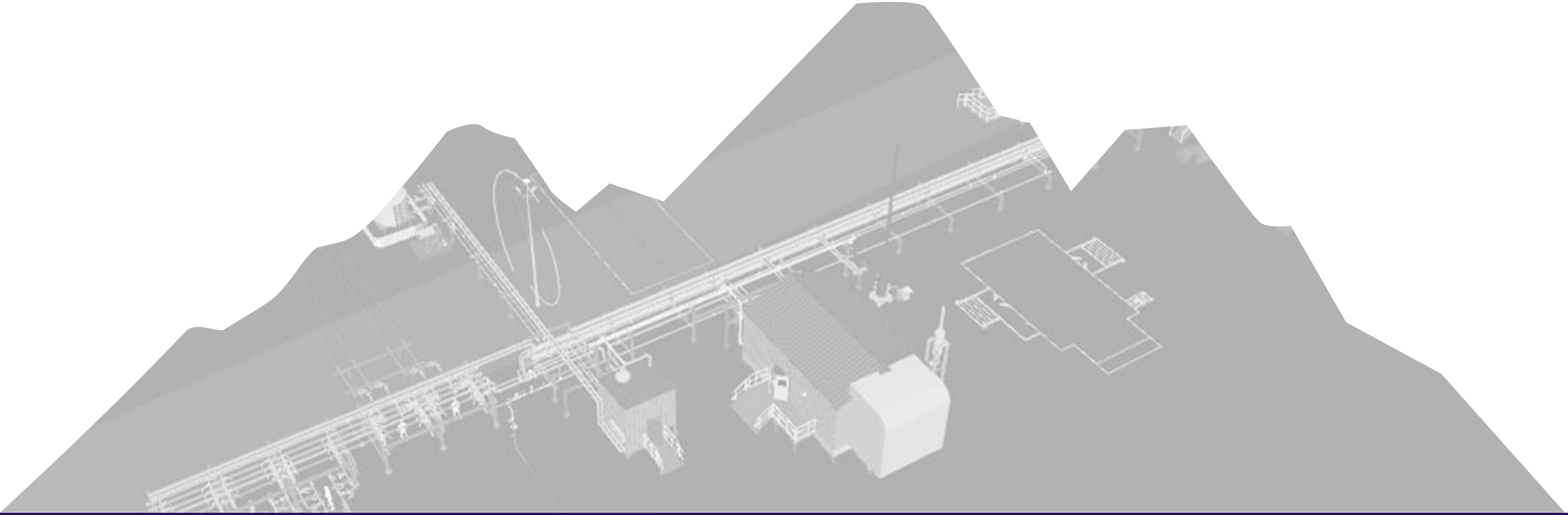
Case Study 1: Vertical Vessels

When design calls for pressures above typical 250 psig MAWP of NGL bullets other vessels types can be used.

- Need for high pressure inlet separator on pipeline from field compressor station.
- A pair of molecular sieve bed vessels (1200 psig) used for liquid surge capacity.
- Vertical orientation allowed for smaller footprint in existing plant environment.
- Large surge capacity needed to work off liquids over time because of existing stabilizer capacity limitations.
- New safety relief valves were sized and installed for liquid service.

CASE STUDY 2:

REFRIGERATION PLANT RELOCATION



Case Study 2: Project Background

Existing refrigeration plant originally sized for processing approximately 14 MMscfd (1338 Btu/scf gas, GHV)

Plant was moved to new site where it is processing 20 MMscfd (1282 Btu/scf gas, GHV)

Key equipment moved were:

- Hot Oil System
- Propane Refrigeration Loop (Compressor, Condenser, etc.)
- Processing Equipment (Chiller, Low Temperature Separator, Gas/Gas, Gas/Liquid, Stabilizer, etc.)

Case Study 2: Hot Oil System

Existing Hot Oil heater had a capacity of 1.5 MMBtu/hr

- Two 150 gpm hot oil circulation pumps
- Hot oil used as heat source for both the stabilizer reboiler and Ethylene Glycol (EG) reboiler
- BMS, instrumentation and safety shutdown valves were adequate (heater previously used in plant environment)

Case Study 2: Hot Oil System

Evaluation of the new process demands determined that the hot oil heater would not meet new duty for both the EG reboiler and stabilizer reboiler.

- EG reboiler demand: 0.4 MMBtu/hr
- Stabilizer reboiler demand: 1.2 MMBtu/hr

EG system was undersized for new gas flow and was ultimately replaced anyway due to poor reboiler condition.

- A direct fired EG reboiler was procured allowing all hot oil duty to be dedicated to stabilizer reboiler.
- Hot oil circulation capacity was adequate, circulation pumps were kept and refurbished with new bearings, seals, etc.

Case Study 2: Propane Loop (Refrigeration Compression)

The propane refrigeration loop was also investigated for reuse at the new location and higher flowrates.

- The process simulation revealed a total propane mass flow rate of approximately 31,500 lb/hr and 960 HP of compression would be required under worst case summer conditions (120˚F in propane accumulator)
- The relatively warm MDMT of -40˚F of the low temp. separator, due to its carbon steel construction, resulted in minimum operating temperature of about -30˚F. This limited NGL recoveries.

Case Study 2: Propane Loop (Refrigeration Compression)

Only one refrigeration compressor with 680 HP available was to be moved to the new facility

- 30% less propane flowrate than desired
- Resultant Low Temp. Separator Temperature: -11°F

Without additional refrigeration compression available, a two-part solution was instituted

- Increased pressure on high pressure process side (inlet compression discharge)
- Installed J-T valve on the process side downstream of the chiller
  - Resultant Low Temp. Separator Temperature: -31°F
- Effectively shifted horsepower demand to inlet compressors

Case Study 2: Propane Loop (Other Equipment)

Other Equipment limitations:

- Required duty for the Propane Condenser in the new service was be 4.6 MMBtu/hr (at 680 HP comp.)
  - Existing Condenser duty: 1.7 MMBtu/hr
  - It was determined that a propane condenser better fitting the increased service would be needed
  - Both new and used equipment was quoted for this service

Propane Accumulator and Economizer found to be satisfactory for new service.

Case Study 2: Propane Loop (Propane Condenser)

New vs Used Comparison (June 2015):

	New	Used
Price	$105,000	$185,000
Lead Time	14-16 weeks	4-6 weeks

- Used unit quoted was oversized for the service but was closest on-hand to specifications whereas new unit could be built to what was specified
- Buying used equipment is not always the more cost-effective option, however, delivery is typically faster
- New option was ultimately selected as the schedule allowed for the lead time

Case Study 2: NGL Stabilizer

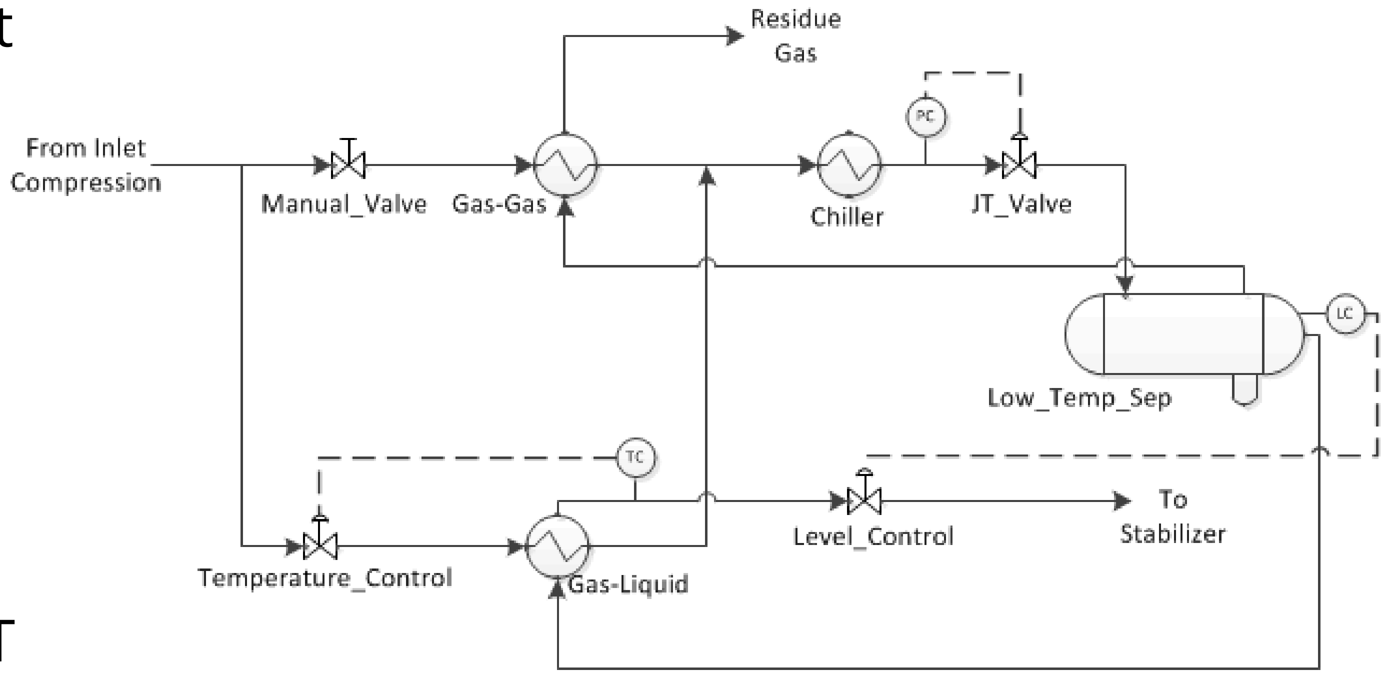
Stabilizer specifications:

OD: 20 inches **Length:** 47 feet S/S **MDMT:** -20°F **Packed tower**

- In evaluating the stabilizer, its size was adequate for increased throughput, however, recovery was limited by MDMT of only -20°F
- Due to the -20°F MDMT of the stabilizer, inlet liquid stream was limited to a minimum temperature of -15°F (operation margin). Colder feed could have provided more "reflux" at the top of the tower for better recoveries of propane.

Case Study 2: NGL Stabilizer

- Stabilizer packing size was reduced to optimize HETP (Height Equivalent to a Theoretical Plate)
- Gas/Liquid exchanger put on temperature control loop to ensure liquids to stabilizer not too cold.
- Reworking stabilizer to lower MDMT was explored (impact testing, calculating stress ratio, etc.) but ultimately not needed with sufficient propane recovery at 62%



Case Study 2: Exchangers

Propane Chiller was adequate with a 12°F temperature approach between process and propane streams.

With temperature control on gas/liquid exchanger, majority of flow went through gas/gas exchanger (~95% of process flow).

- Gas/Liquid exchanger was then oversized for service leading to 9°F worst case temperature approach between liquid and inlet fluid
- Gas/Gas exchanger was slightly undersized for service leading to 32°F worst case temperature approach between overhead gas from low temp separator and inlet gas
- Even with higher than optimal temperature approach, it was considered workable, and exchanger was not replaced

Case Study 2: Results

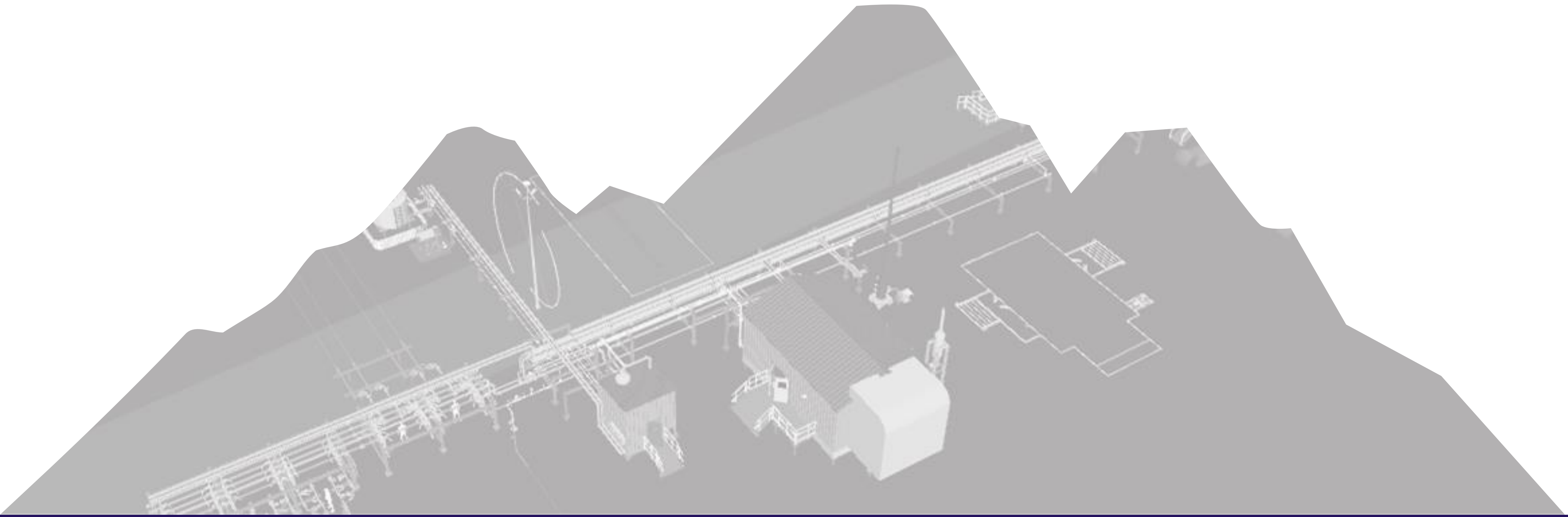
With the minor modifications required to add J-T valve:

- 12% increase in propane recovery
- 20% increase in NGL production rate
- Cost associated with J-T valve addition include installation (~$10,000) and added fuel gas consumption in inlet compression.

Cases	As Is	JT Valve @ 850 psig inlet
Refrig Compression HP	677 hp	677 hp
Ethane Recovery	17.0%	23.1%
Propane Recovery	50.2%	62.3%
Liquids Production	35.1 gpm	42.0 gpm
Sales Gas GHV	1146 Btu/scf	1124 Btu/scf

CASE STUDY 3:

REPURPOSED CRYOGENIC PROCESSING PLANT



Case Study 3: Cryogenic Plant

Project Background: A new facility capable of processing 25 MMscfd using repurposed equipment for the bulk of the plant.

- Inlet Compression (repurposed)
- Amine treatment for CO_2 removal (new old stock)
- TEG Dehydration (repurposed)
- Cryo skid (repurposed)
- Residue Compression (repurposed)

Case Study 3: Inlet Compression

Four inlet compressors were used to bring the field gas from approximately 20 psig to 1000 psig. Upon review of performance runs, compressors did not have required capacity.

- If compressor cylinders are too large, pockets can be backed out and valves can be unloaded to reduce capacity and lower horsepower
- In this case there was not enough throughput capacity, so cylinders had to be reconfigured to meet desired performance

Case Study 3: Inlet Compression

Skid base, scrubbers, interstage cooler assembly, piping, etc. were able to be saved resulting in savings over new package.

- Inlet compressors had all cylinders replaced to allow for higher flow
- Caterpillar 3516 engine fully rebuilt and updated engine management package installed

Case Study 3: Inlet Compression

(Local Regulations)

Inlet compressors were in arctic packages that did not meet local regulations (Colorado Division of Housing Resolution 35).

- Third party vendor was utilized to rebuild buildings for proper compliance
- This is a case where there is more than just equipment performance that needs to be considered
- Gas detectors, fire-eyes and ventilation fans were also added to new building

Case Study 3: TEG Dehydration

TEG dehydration was used downstream of amine treating and upstream of mole sieve beds. Unit slated for use had several shortcomings:

- Field style unit was pneumatically controlled and lacked burner management system (BMS) on TEG reboiler
- Reboiler and contactor were mounted to common skid with building.
- Subsequent modeling also showed existing TEG pump circulation rate was insufficient to reach desired dehydration levels

Case Study 3: TEG BMS System

TEG unit was missing several key pieces of safety system requirements, including:

- BMS panel rated for the service
- Redundant set of shutoff valves on pilot and main fuel systems
- Required instrumentation
- Gas and fire detection inside building

New instrumentation and valves were specified and installed during construction.

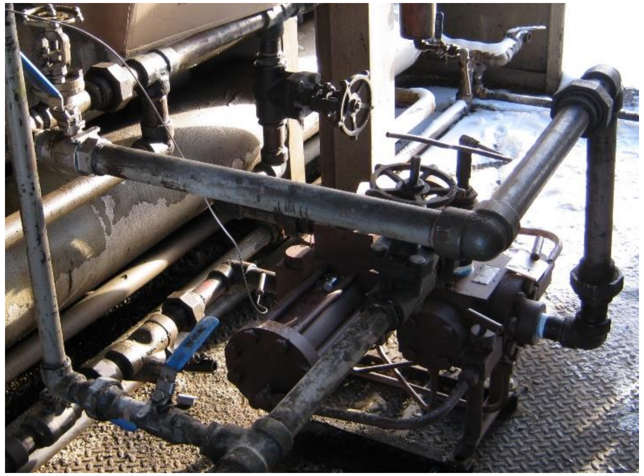
- Schedule impact was minimal for package as TEG contactor, reboiler, flash tank, etc. were left as-is

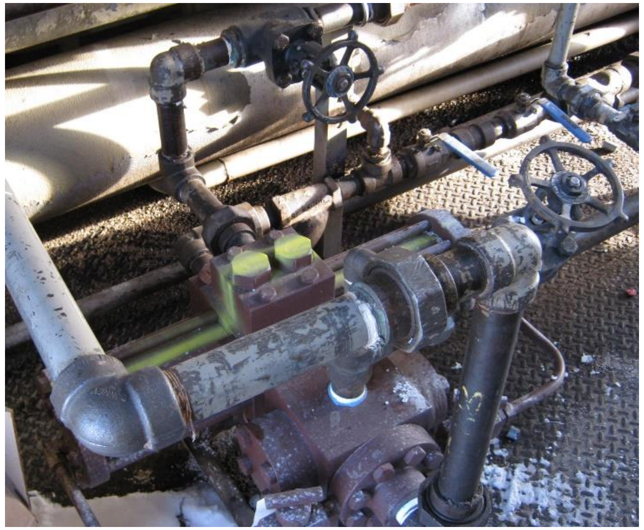
Case Study 3: TEG Circulation Rate

Existing circulation pumps that came on skid were only capable of approximately 3.3 gpm.

- Thermodynamic model and calculations estimated about 7-10 gpm required
- TEG reboiler and contactor were modeled and could accommodate increased flow demands
- Water content reduced to approximately 5 lb/MMscf after TEG

Due to higher flow requirements, pumps were replaced with larger units of similar style.





Case Study 3: Cryo Skid

Cryo skids utilized the gas subcooled process (GSP) and consisted of:

- Molecular Sieve Dehydrators
- Brazed Aluminum Heat Exchanger
- Cold Separator
- Subcooler
- Demethanizer Tower
- Expander-Compressor
  - * On separate skid

Missing:

- Trim Reboiler
- Transfer Pumps

Case Study 3: Cryo Skid (U1As)

All equipment was without U-1A's and design documentation (1980's vintage). Original equipment manufacturer was tracked and was able to provide records of equipment that was kept on file (for a fee).

- Without documentation, another solution would be to reverse engineer the equipment, then create drawings and apply for a variance with the state boiler/pressure vessel inspector. This was not investigated further after receiving documentation.

All equipment repurposed for this facility was inspected:

- API 510 – Vessels
- API 570 – Piping

Case Study 3: Cryo Skid (Molecular Sieve Dehydrators)

Molecular Sieve Dehydrators were large enough to be used without upstream TEG by switching beds every 6 hours.

- 24 hour switching cycles with TEG
- Regeneration gas heater sized for fast cycles and sufficient turn- down for slow cycles
- MAWP of 1100 psig limited high pressure side of cryogenic system to operating pressure of approximately 1000 psig

Case Study 3: Cryo Skid (Brazed Aluminum Heat Exchanger)

- Heat exchanger performance was modeled in simulation software and temperature approaches were adequate
- Pressure tested and inspected for fouling
- Passes originally used for integral chiller changed to additional bottoms reboiler duty

Case Study 3: Cryo Skid (Cold Separator)

- Vessel had adequate vapor-liquid disengagement as old liquid flow rates were similar to new service

- 304 Stainless construction

- MDMT was -125°F and not a limiting factor in system

Case Study 3: Cryo Skid (Expander Compressor)

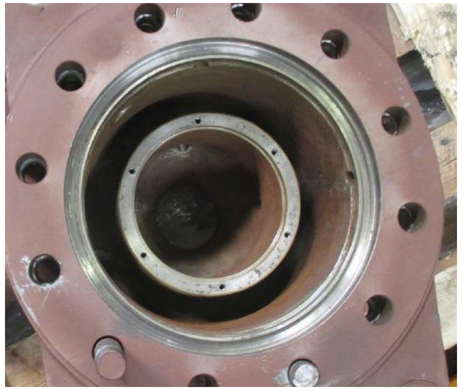
Original Expander-Compressor skid was mostly usable but required major refurbishment.

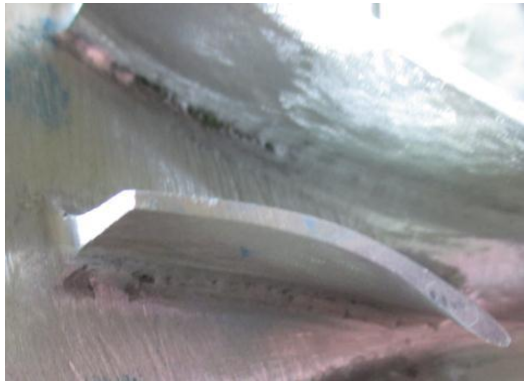
Case Study 3: Cryo Skid (Expander Compressor)

Original expander wheel and case were still in good condition. compressor wheel showed signs of cracking. The expander-compressor was able to be "re-wheeled" and optimized for the new process conditions.

	Original	Refurbish	Optimized	Total
Cost	On hand	$400,000	$190,000	$590,000
Time	-	24 wks	10 wks	34 wks
Efficiency	78% / 72%	72% / 64%	84% / 78%	

Optimizing center section provided a ~13% increase in performance over leaving it as-is, and 6% increase over original design.





Case Study 3: Cryo Skid (Subcooler)

Original subcooler was found to be unusable

- Internal corrosion and leaks between plates, unknown cause
- Models of the system without the Subcooler were run. Without the Subcooler, meeting gas sales specifications was marginal:
  - Spec – 1100 Btu/scf
  - Without SC – 1096 Btu/scf
  - With SC – 1071 Btu/scf
- NGL recoveries suffered greatly without Subcooler
- A new subcooler was fabricated by original manufacturer using the same design as the original subcooler, saving engineering time and money

Case Study 3: Cryo Skid (Demethanizer)

- Tower performance was modeled in simulation software and shown to be adequately sized
- Top section is packed, middle has trays, bottom used as sump
- Internals were inspected for corrosion and damage
- 304 Stainless construction
- MDMT was -200°F and not a limiting factor in system

Case Study 3: Trim Reboiler

A new trim reboiler was purchased for the demethanizer tower as the original was missing.

- No heat medium system on site, thus hot gas from residue gas compression used as heat medium source.
- Hot gas taken off upstream of compressor aftercooler.
- New NGL transfer pumps installed on common skid with trim reboiler to save costs.

Case Study 3: Cryo Skid (Controls)

All control valves, instrumentation, gauges, meters, tubing, wiring, etc. were replaced.

- Old pneumatic controls updated
- On-skid PLC installed with local HMI

Case Study 3: Cryo Skid (Safety)

All relief valves were reevaluated under new operating conditions.

- The age and condition of existing relief valves justified new valves to be purchased.
  - Be sure to consider service, set point, relieving capacity, and backpressure limits when evaluating existing relief valves in new service conditions.
  - When reusing relief valves, be sure to inspect them to API 576.

All shutdown valves were replaced with new ones.

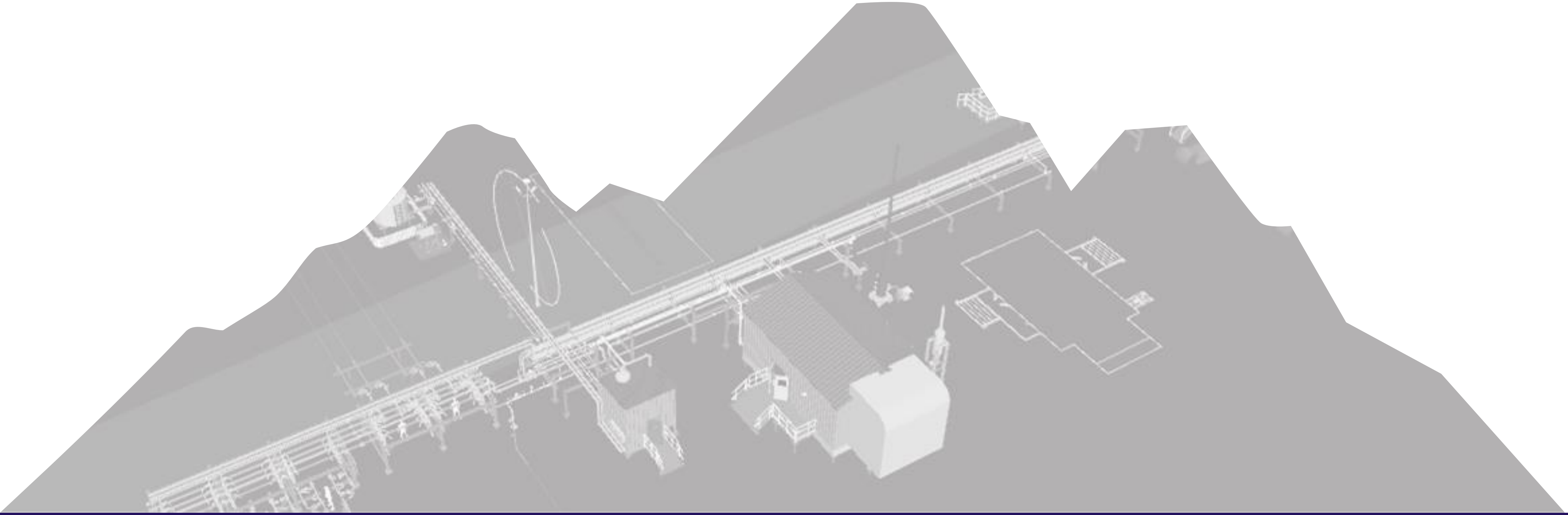
- New automated depressurization valve was added to blow down high pressure side of system during emergency shutdown .

Case Study 3: Final Thoughts

Performance

- Only recovering enough ethane to meet gas sales specification
- Propane recovery at 92%
- 70 gpm NGL production rate
- Deeper cut also prohibited by single stage residue compression and vessels' MAWP

LESSONS LEARNED WITH REPURPOSED EQUIPMENT



Lessons Learned: Background

Occasionally, trying to repurpose equipment has the undesired effect of being more costly and slower than new equipment:

- Stabilizer reboiler switched from direct fired to electric heater
- Advantages of early engineering support

Lessons Learned: Stabilizer Reboiler

5000 bpd (nominal) stabilizer skid package purchased with on-skid direct fired reboiler.

- Safety concerns with using fired equipment next to other process equipment
- Burner fire tube was replaced with custom electric heater
- Cost of switching fire tube for electric heater was potentially greater than traditional reboiler and HM skid
- Shop installation time and delivery delays pushed back start-up past the lead times of new unit option

Lessons Learned: Engineering Support

Several of the constraints in the cases above could have been avoided by early involvement from engineering support.

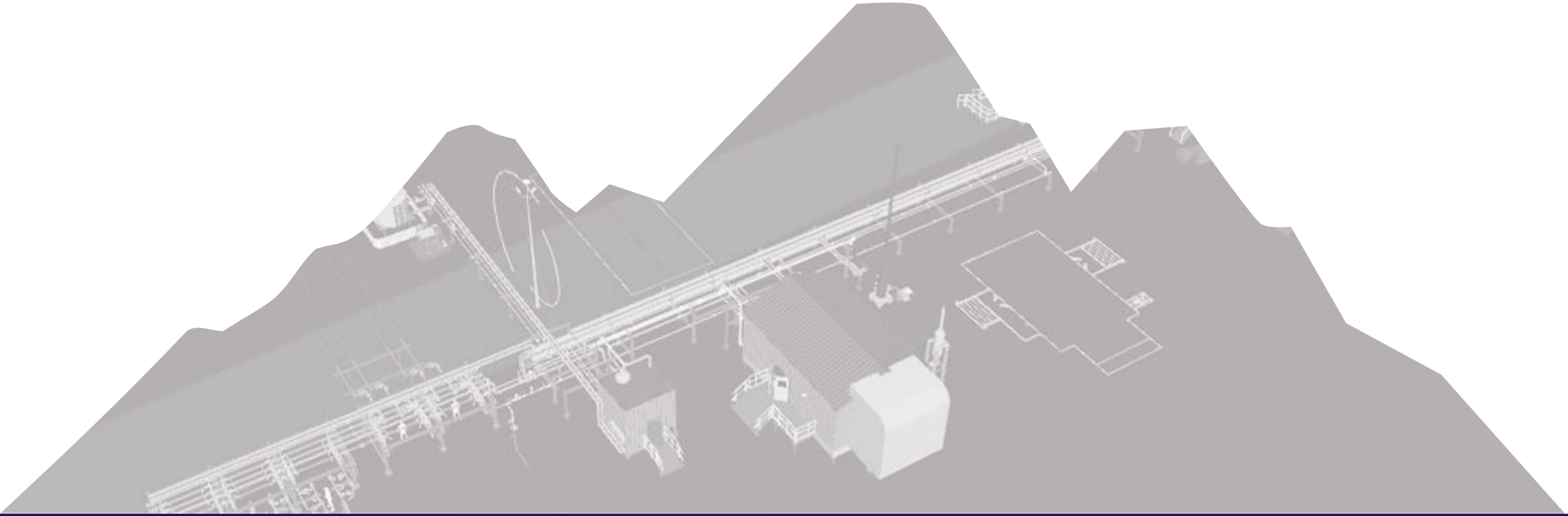
- Refrigeration Plant equipment MDMT limits
- Cryogenic Plant Residue Compressor
  - Operational flexibility severely limited by single stage residue compressor unit. 2 stage unit would have allowed for easier transition from J-T to E/C mode, and allow lower tower pressure, thus better recoveries.
- TEG field style unit
  - By having contactor mounted on the skid, it put processing equipment around fired equipment.
- Direct fired stabilizer skid was purchased before engineering involvement on project

Lessons Learned: Engineering Support

Evaluating equipment before purchase or relocation will be more cost effective than potential equipment modification or design complications.

- One recent project included visiting several idle client sites and evaluating various TEG, Amine and other equipment packages to be relocated from use in the Powder River and Uintah basins to new sites in the Permian basin.

SUMMARY & CONCLUSION



Summary & Conclusions

In today's environment of tight budgets, repurposing equipment can lead to satisfactory and cost-effective solutions.

- Repurposed equipment is not just limited to vessels but to other major process equipment as well
- Verify documentation
  - U-1A forms and National Board number
- Inspect equipment
  - API 510 – Vessels, API 570 – Piping
- Involve engineering early if possible
- Creative solutions may be required to make existing equipment work

However, there may be instances in which new equipment is still the more reliable and effective solution.

CONNECT WITH US

How might repurposing used equipment work for you?

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