STANDARD-PLUS™

A new standard for standard NGL plants.
Introduction.

Dating back to the early 1970’s, Linde Engineering North America Inc. (LENA) has been designing and producing modular units for gas processing plants worldwide.

With the evolving shale gas market, the demand to build gas processing plants faster, without affecting quality and high performance, continues to develop. Many engineering companies have developed their own standard designs for core cryogenic equipment. However, few have attempted to develop a completely pre-engineered modularized standard Natural Gas Liquids (NGL) recovery plant that covers the wide range of gas processing conditions required for shale gas.

The realized cost and time savings when constructing a complete standard NGL recovery plant can be as much as 4-6 months when compared to only using the core standard cryogenic equipment and custom designing all other components, e.g. balance of plant equipment and utilities. This can mean a difference of more than 50 million USD in revenue during the first year for the plant operator. The STANDARD-PLUS™ product line was developed to meet demand without compromising quality, safety, and reliability.

Linde Engineering North America Inc. – Natural gas has been a vital part of our business since 1969.
Our approach - a standardized concept.

The development of a completely pre-engineered standard NGL recovery plant started with defining the design basis to cover the majority of the US shale gas compositions and market conditions.

The technology was evaluated by performing techno-economic analysis and optimizing the design for best performance across the range of feed gas compositions for each piece of equipment.

LENA’s proprietary gas processing technology, CRYO-PLUS™, was selected based on its ability to provide better ethane and propane recoveries across variable feed gas compositions and operating ranges than any other technology. Additional equipment, such as slug catchers, stabilizers, acid gas treatment, dehydration, and residue gas compression, were evaluated, sized, and selected based on customer feedback, best cost-to-value, and design optimization.
CRYO-PLUS™ technology - how it works.

CRYO-PLUS™ is a cryogenic NGL recovery technology which utilizes a turbo-expander to recover energy while cooling the low- to high-pressure gas streams. CRYO-PLUS™ technology is unique in its ability to process low-pressure gas streams and obtain high recoveries with less compressor and/or refrigeration horsepower than conventional cryogenic processes.

The feed gas from the dehydration unit flows into the cold section of the process, where cooling by exchange of heat with the residue gas and cold separator liquids takes place using a brazed aluminum plate-fin heat exchanger. Although not always a requirement, the gas may be further cooled using external refrigeration before it goes to the cryogenic portion of the process.

Following cooling, the feed gas is partially condensed and delivered to a vapor/liquid cold separator. Depending on mode of operation, e.g. ethane recovery or rejection, the liquid then flows either directly or via the inlet exchanger to the Heavy Ends Fractionation Column (HEFC). The vapor flows to the inlet of the expander/compressor. As the gas expands, it provides the work/energy for the compression. The expansion and removal of energy cools the gas further and causes additional condensation. The expander discharges into the Light Ends Fractionation Column (LEFC), which is the first tower of a two-stage fractionation process. The configuration and the combination of fractionation and heat transfer between these two columns is the proprietary, patented technology that gives CRYO-PLUS™ its advantages (higher recovery at reduced horsepower) over competing technologies.

A residue gas and a demethanized/deethanized liquid product are produced from this two tower scheme. The residue gas is produced at pressures comparable to other competing technologies. Following exchange with the feed gas in the inlet cooling step, it arrives at the residue gas compression system as a dry, stable heating value gas. The liquid product from the fractionation system is the recovered C₂ or C₃ liquid hydrocarbons. The liquid often undergoes additional processing, such as additional fractionation in downstream columns.

Schematic of the CRYO-PLUS™ NGL Recovery Process
Benefits.

Higher recovery with less energy
Designed to be used in conventional natural gas, or shale gas applications, the patented CRYO-PLUS™ process recovers more ethane and heavier components with less energy required than traditional liquid recovery processes.

Higher flexibility
Enhanced CRYO-PLUS™ is more robust and flexible over a wide range of pressure and feed gas compositions. This feature is especially important for treatment of rich shale gas, which is known for having large compositional variability over time.

CRYO-PLUS™ provides a high level of ethane recovery in ethane recovery mode, and high level propane recovery in ethane rejection mode. The process can quickly and easily change between the two modes of operation.

Reduced feed and product compression
The proprietary process has been optimized to operate more efficiently, resulting in lower inlet pressure requirements while still providing the same product discharge pressure.

Reduced fuel consumption
The CRYO-PLUS™ process requires less power than a typical gas processing plant for equivalent recovery.

\[ C_2 \text{ Recovery Comparison} \]

- Enhanced CRYO-PLUS™ provides a higher recovery over a wider range of pressure and composition.
The STANDARD-PLUS™ NGL recovery plant includes all the equipment needed for a complete gas processing facility, such as inlet receiver, slug catchers, sour gas removal, dehydration, cryogenic unit, NGL product pumps, residue gas compressor and all utilities.

The equipment has been modularized into several sub-units, which can be provided separately as equipment supply only or all sub-units combined as a fully installed plant on an EPC basis. A standard plot plan is available for the sub-units as well as the complete plant. The plot plan has been optimized for best CAPEX and maintainability. Each sub-unit comes with its own Power Distribution Center (PDC) and Basic Process Control System (BPCS), which can be connected to the main PDC/BPCS for the balance of plant when installing the complete STANDARD-PLUS™ NGL recovery plant. Each sub-unit can also be connected and integrated with any new or existing centralized PDC/BPCS. The pre-engineered plant is highly modularized resulting in reduced construction cost, risk, and schedule.

*Note, Hot Oil package is only included when Dehy/Cryo unit is sold separately.
Inlet/Stabilizer.

The inlet/stabilizer includes inlet gas receiver, slug catchers, stabilizer, and associated utilities.

The slug catchers are designed in multiple packs of 2 or 3 vessels with a capacity of 500 barrels per vessel piped together with one piping and valve module. The stabilizer, which can be operated intermittent or continuously, can process up to 15,000 barrels per day of liquids from the slug catchers.

The equipment is shown in purple in the block flow diagram and in the 3D model on the previous page.

Amine & amine utilities.

The amine unit is available in two sizes, i.e. 500 gallons per minute and 1200 gallons per minute (gpm) amine circulation rate.

Each unit is designed to process from 40 to 200 MMSCFD gas providing high operating flexibility. The selection of size depends on the CO$_2$ concentration in the feed gas and NGL product specification requirements, as well as type of amine solvent. The unit was designed based on a formulated amine solvent, which typically provides lower energy consumption than other amines and is less prone to degradation. The unit can be rated for usage of other amine solvents based on the customer’s preference.

The equipment is shown in dark blue in the block flow diagram and in the 3D model on the previous page.

Scope Summary

- Inlet gas receiver
- 2 and 3 packs of slug catchers vessel type (optional finger type slug catchers)
- Stabilizer column with reboiler
- Feed heater, separator and filtration
- Overhead compressors, scrubbers and inter-coolers
- Condensate storage tank with truck loading
- Hot oil system
- PDC and control system
- Pipe racks and off-module pipe and structures

Amine contactor and still column with reboilers
- Amine flash vessel
- Amine air coolers, filters, and circulation pump
- Amine still reflux equipment
- Off-module pipe and structures
- Amine storage and drain tanks
- Hot oil system
- Demineralized water tank
- Anti-foam injection
- PDC and control system
Dehydration/Cryogenic unit.

With a capacity ranging from 80 to 200 MMSCFD, the Dehydration/Cryogenic Core Unit is the heart of the gas processing plant and it includes dehydration, cryogenic unit, refrigeration, and associated utilities.

The dehydration system includes 3 adsorbers and is designed for a water saturated inlet gas at 900 psig. The cryogenic unit is based on the CRYO-PLUS™ technology using two fractionation columns. Besides the columns, the core equipment includes the Plate-Fin Heat Exchanger (PFHE), Expander/Compressor, and, if required, refrigeration packages. The refrigeration is available in multiple sizes depending on the richness of the feed gas, i.e. gallons of theoretically recoverable natural gas liquids (ethane, propane, butane, etc.) in the feed gas.

The equipment is shown in red in the block flow diagram and in the 3D model on the previous page.

Scope Summary

- Inlet gas filter/coalescer
- Dehydration vessels, (3x50%) with regeneration system
- Light and heavy ends fractionation columns
- Brazed aluminum PFHE
- Expander/compressor module
- Air coolers and NG liquids pumps
- Refrigeration package
- Hot oil and methanol injection
- PDC and control system
- Pipe racks and off-module pipe and structures

Balance of plant.

The Balance of Plant (BOP) includes all the remaining equipment and utilities required to operate the plant.

Key equipment includes the residue gas compression, NGL product pumps, flare, drain tanks and the main power distribution center (PDC) & Basic Process Control System (BPCS), which can also integrate the other decentralized PDCs/BPCS.

The equipment is shown in light blue in the block flow diagram and in the 3D model on the previous page.

Scope Summary

- Integrally geared centrifugal compressor (optional reciprocating compressors) with electric motor
- Compressor scrubbers and air coolers
- NGL product pumps and filter
- Closed drain tank and slop water tanks
- Fuel gas scrubber and heaters
- Main flare with knock-out drum and pumps
- Instrument air package
- Gas chromatograph
- PDC, transformers and control system
- Pipe racks and off-module pipe and structures
Design envelope.

The STANDARD-PLUS™ cryogenic unit was designed to operate between 4 and 8 GPM (gallons of theoretically recoverable liquids per thousand cubic feet) feed gas.

This range covers the shale gas compositions from a majority of the shale basins in the US. The unit is rated for 200 MMSCFD gas flow at 900 psig inlet pressure and 120°F average inlet temperature with a turn down to 40% load.

Linde will predict your plant performance based upon your specifications including feed gas composition, pressure and temperature. A rating simulation tool can predict the performance for any feed gas conditions. Generic feed gas compositions to the cryogenic unit used for optimizing the design are shown below.

The available two sizes of STANDARD-PLUS™ amine units can cover a range of CO₂ concentrations in the feed gas, typically up to 5%, depending on CO₂ requirement in the natural gas liquids product. Higher inlet concentrations can be accommodated by combining two or more amine units.

The STANDARD-PLUS™ dehydration system is designed for a water saturated feed gas at 900 psig.

<table>
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<tr>
<th>Components</th>
<th>Typical Lean Feed Gas Composition</th>
<th>Typical Rich Feed Gas Composition</th>
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<tr>
<td></td>
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Performance.

The STANDARD-PLUS™ cryogenic unit can be operated in ethane recovery or ethane rejection mode.

Typical performance in ethane recovery mode:
- Above 96% C2 recovery
- Above 99% C3+ recovery

Typical performance in ethane rejection/propane recovery mode:
- Less than 50% C2 recovery depending on residue gas heating value limitations
- Above 97% C3+ recovery

Typical performance of 200 MMSCFD STANDARD-PLUS™ NGL recovery plant compared to a GSP plant.
Linde designs modules with an optimized layout accommodating maintenance access with minimized footprint as well as road transportation. In addition, a high degree of fabrication and testing of modules reduces on-site construction, and pre-commissioning activities.

A growing number of gas processing companies recognize the benefits of modular design and fabrication over conventional stick built design and construction. A modular approach provides greater schedule predictability, and high quality. In addition, it minimizes risk and potential downtime associated with construction in an operating plant.

Schedule and Quality
Adverse climate conditions can leave on-site activities at the mercy of the environment often jeopardizing schedule and quality. Module fabrication in the controlled environment of LENA’s facilities ensures the required quality, including cleanliness independent from outdoor conditions. On-site construction activities, including pre-commissioning, are minimized allowing for a more predictable schedule, and thereby the overall project cost and duration are reduced.

Downtime and Construction Risk
High quality, prefabricated, and pressure tested modules minimize not only the overall construction activities on-site, but also the associated risk. Furthermore, in an operating plant, the installation and hook-up of these modules reduces downtime, potentially saving significant cost, and increasing work safety by minimizing time working alongside equipment containing hazardous high pressure material.
About LENA.

Linde Engineering North America Inc. (LENA), a member of the Linde Engineering division of The Linde Group, is a single-source technology, engineering, fabrication, and construction firm.

Technology.
LENA provides value via a variety of process options: proprietary technology developed in-house, or licensed technology from the market or customer.

Engineering.
Basic and detailed engineering services are performed using in-house resources. These comprise highly skilled and experienced engineers of all disciplines required to provide a turnkey project, minimizing costly and time consuming interfaces.

Fabrication.
LENA is a leader in the field of module fabrication. The highly trained, and experienced workforce and well equipped facilities form the foundation of the ISO-9001 certified fabrication plant. In addition to road and rail transportation, the facilities offer access to the Port of Catoosa on the Arkansas River, for transportation of modules on ocean going barges even globally via the Port of New Orleans.

Construction.
LENA is experienced in on-site construction, both stick built and modularized. A multitude of projects have been built successfully even in difficult climate conditions.

LENA’s offerings for the natural gas market include:

- Natural gas processing
  - Gas & liquid treatment (acid removal, dehydration)
  - Sulfur recovery
  - STANDARD-PLUS™ amine

- Recovery & fractionation of natural gas liquids (NGL)
  - CRYO-PLUS™, recovers C3+
  - CRYO-PLUS™ C2™, recovers C2+
  - Deethanizer, depropanizer, debutanizer, & C4-splitter
  - STANDARD-PLUS™ NGL recovery plant
  - STANDARD-PLUS™ fractionation train

- Liquefaction of natural gas (LNG)
  - StarLNG™
  - StarLNG™

- Cryogenic technologies
  - Nitrogen rejection
  - Helium/Hydrogen liquefiers
  - Helium recovery
Engineering excellence – every step of the way.

Linde Engineering North America Inc., a member of the Linde Engineering Division of the Linde Group, is a leading player in the international plant engineering business, covering every step in the design, project management, and construction of turnkey industrial plants. Drawing on our proven process know-how, we set the standards for innovation, flexibility with ground-breaking concepts and a dedication to engineering excellence.

The success of our customers and partners around the globe is of primary importance. With a clear focus on efficiency, sustainability and growth we develop solutions for projects of all sizes and degrees of complexity. We have already delivered more than 4,000 plants worldwide and always aim to find the best technical and economic solution for our customers.

The range of product comprises:
- Petrochemical plants
- LNG and natural gas processing plants
- Air separation plants
- Synthesis gas plants
- Hydrogen plants
- Gas processing plants
- Adsorption plants
- Cryogenic plants
- Biotechnological plants
- Furnaces for petrochemical plants and refineries

Linde and its subsidiaries manufacture:
- Packaged units, cold boxes
- Coil wound heat exchangers
- Plate fin heat exchangers
- Cryogenic standard tanks
- Air heated vaporizers
- Spiral-welded aluminum pipes
- Cryogenic turboexpander/compressors
- Cryogenic pumps

Get in touch – find the best solution.

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