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The Procedure of Extracting Natural Gas liquids in Cryosift Method

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ABSTRACT

The extraction of Natural Gas Liquids (NGLs) plays a pivotal role in the modern energy landscape, serving as both a significant economic driver and a critical component of energy supply chains. This project investigates the comprehensive processes involved in NGL extraction, which includes the separation of ethane, propane, butanes, and natural gasoline from natural gas and crude oil. Key techniques such as cryogenic distillation, absorption, and fractionation are explored in depth, highlighting their operational principles, efficiency, and technological advancements. In addition to the technical aspects, this project examines the environmental impacts of NGL extraction and the strategies employed to mitigate these effects. Innovations in technology and process optimization are discussed, emphasizing their role in reducing carbon footprints and enhancing sustainability.
The economic dimension of NGL extraction is also analyzed, with a focus on market trends, supply chain logistics, and the factors influencing global demand and pricing. Case studies from leading NGL extraction facilities are used to illustrate best practices, challenges, and the implementation of cutting-edge technologies.
Through a multi-faceted approach, this project aims to provide a detailed understanding of the NGL extraction industry. It underscores the importance of NGLs in the global energy market, the technological advancements driving the industry forward, and the economic and environmental considerations that shape its future. The findings offer valuable insights for stakeholders, policymakers, and industry professionals seeking to navigate the complexities of NGL extraction and leverage its benefits for sustainable development.

***Key Words*:** Cryogenic Distillation, Absorption, Fractionation

Introduction

The offset of this report is to provide basic knowledge on NGL extraction operations reference taken from offshore platform named RX which is located in UN-OSO MPN Nigeria production units. This report provides the design parameters as well as the procedures necessary for extracting natural gas liquids from gas produced from wells before it is re-injected into offshore wells for gas lift, also provide procedures to operate, control and shutdown the RX platform under both normal and emergency conditions.

The gas feed to the RX platform comes from the existing RG compression platform. This feed stream is routed from the existing fourth stage compressor suction scrubbers on the RG offshore platform across the RG-RX bridge to the feed preparation section on the new RX platform. The design capacity of the feed system is 600 MMSCFD. Feed stream conditions will be 1275 PSI at 105 Deg F at the RX platform.

Purpose of the RX Platform

The OSO Field is located 12 miles from the coast of Nigeria and 45 miles from the town of Bonny. The existing facilities consist of a Production Platform (RP) for gas/condensate separation and condensate stabilization, Riser Platform (RR) containing manifolds, launchers and receivers for the pipelines, Compression Platform (RG) for injection gas compression, a Quarters Platform (RQ) and several Wellhead Platforms containing wellhead manifolds and test separators. The purpose of the RX Platform is to recover natural gas liquids (NGL) from the OSO injection gas. The RX Platform includes a Feed Preparation Section which removes water and mercury from the incoming gas, NGL Extraction Section which recovers propane, butane and pentane-plus as a mixed stream product in a turbo expander based NGL recovery process, and a Residue Compression Section which boosts the residue gas pressure to 1505 psig, and returns it across the bridge to the RG Platform for further recompression and re-injection into the OSO Field for reservoir pressure maintenance. The liquid propane-plus mixed product is transported via a 10" pipeline from the offshore facilities to the Bonny River Terminal. A separate 12" pipeline transports NGL plant residue gas to the Bonny River Terminal facility to supply its fuel gas requirements.

Incoming Gas Stream

The incoming feed gas from the existing Fourth Stage Suction Scrubbers (RG-D-104A/B) is routed through a shutdown valve, RG-SDV-374 located on the RG side of the bridge. Incoming gas stream is processed in 4 steps they are
1.Feed Preparation section
2.NGL Extraction system
3.Residue gas compression section
4.Product Export

Feed preparation section
The Feed Preparation Section consists of these equipment’s

- Inlet Gas Filter Separators (RX-V-101A/B) for removal of liquid condensate.
- Inlet Gas Dehydrators (RX-D-101A/B/C) for drying and dew point control.
- Dehydrator Dust Filters (RX-V-102A/B) for removal of molecular sieve fines.
- Mercury Guard Beds (RX-D- 104A/B) for removal of elemental Mercury contained in the inlet feed stream
- Mercury Guard Bed Filters (RX-V-103 A/B) for removal of activated carbon fines.
- Feed Gas Cooler (RX-E-104) utilizing seawater to cool the gas stream prior to entering the NGL extraction Section.

Inlet Gas Filter separators
The incoming feed gas from the RG Compression Platform is first routed through an Inlet Gas Filter Separator (RX-V-101A or B). Each filter separator is designed to process 600 MMSCFD of gas. The vessels are constructed of normalized carbon steel and lined with 316 stainless steel to reduce corrosion. The filter separator is separated into two stages. The

first stage contains replaceable molded fiberglass elements mounted on supporting corners welded in a tube sheet separating the inlet compartment from the second stage compartment.

Inlet Gas Dehydrators

The Dehydration System consists of three vessels (RX-D-101A/B/C) installed in parallel. The system is designed such that two vessels are in service while the third vessel is being regenerated. Each vessel will be on- line for a minimum of 16 hours and on the regeneration cycle for eight hours. The dehydration of the inlet gas is achieved using beds of molecular sieves and alumina. The bottom head of each dehydrator is filled with 1" inert balls followed by a 6" layer of balls and 6" layer of balls to support the catalyst. The catalyst bed consists of a 7-6" layer of 1.6 mm Type 3 ASC molecular sieve, 10-3" layer of 3.2 mm Type 3 ASC molecular sieve and a 3'-9" layer of 2-5 mm Spheralite 501A alumina balls to adsorb free water. A 6" layer of 1" inert balls for bed hold down is placed on top of the bed. The system is designed to achieve a water dewpoint of -150°F for the outlet gas. The design life of the molecular sieve is approximately three years and is primarily dependent on the number of regenerations.

Dehydrator Dust Filters

The dehydrated gas enters a Dehydrator Dust Filter RX-V-102 A or B to remove any dust and fines carried over from the dehydrators. Each dust filter is designed to process 600 MMSCFD of gas and remove all solids 3 microns and larger in size. The vessels are constructed of carbon steel.

Each vessel contains 28 replaceable molded fiberglass elements mounted on supporting carriers welded in a tube sheet separating the inlet and outlet compartments. A quick opening enclosure is provided for removing or installing the elements.

Mercury guard beds

The gas enters a Mercury Guard Bed (RX-D-104 A or B) which are each designed to process 600 MMSCFD of gas while removing a minimum of 99.9% of the elemental mercury from incoming gas stream Failure to remove the mercury will cause corrosion in the downstream brazed aluminate cold box. Mercury concentrations of up to 10 parts per billion by weight (ppbw) are expected. The vessels contain a bed of activated carbon impregnated with sulfur. The sulfur chemically reacts with the mercury in the gas stream to form mercuric sulfide which is retained in the bed. The vessels are constructed from normalized carbon steel.

Mercury guard bed filters

The mercury free gas enters a Mercury Guard Bed Filter (RX-V-103 A or B)to remove any dust and fines carried over from the Mercury Guard Beds. Each dust filter is designed to process 600 MMSCFD of gas and remove all solids 3 microns and larger in size. The vessels are constructed of carbon steel.

Feed gas Cooler

The Feed Gas Cooler (RX-E-104), is a shell and tube exchanger utilizing seawater to cool the gas stream prior to entering the core exchangers and the NGL Extraction Section Seawater is pumped by Cooling Water Pumps, (RX-G-105A or B), via the Cooling Water Filters, (RX-V-107A or B), to the tube side of the exchanger and is then dumped overboard. The seawater enters at 90°F and exits at 100°F.

Feed gas cooler outlet

The shell side is single pass and is constructed of carbon steel. The process gas enters the shell side of the exchanger at 105°F and exits at 90°F. A full flow bypass is provided around the process side to allow the exchanger to be taken out of service while maintaining full flow of gas through the platform A 2" valved flushing connection is supplied on the inlet and outlet of both the tube side and shell side to facilitate the cleaning of the exchanger.

NGL Extraction System

The NGL Extraction Section extracts C3+ liquids from the treated incoming gas from the Feed Preparation Section via a turbo-expander process and yields a lean residue gas.

Inlet gas core Exchanger

The Inlet Gas Core Exchanger (RX-E-105), and Deethanizer Overhead Core Exchanger (RX-E-106), each have three cores and are combined into one cold box together with the High-Pressure Liquids Separator (RX-D- 106). The Cold Box contains six brazed aluminum plate fin exchangers or cores. The Inlet Gas Core Exchanger consists of the following cells:

Cell 1- Cools the gas/liquid stream from the Feed Preparation Section, which is then routed to the High-Pressure Separator.

Cell 2- Connected to Cell 5, heats the gas from the Low-Pressure Absorber and Deethanizer Section, which is then routed to the Expander Compressor.

Cell 3- Heats the gas/liquid stream from the High-Pressure Separator, which is then routed to the Deethanizer. The basic construction of the exchangers is layers of corrugated fins which are furnace brazed between parting sheets. The exchanger dimension created by this stack of layers is referred to as the stack height dimension of the exchanger. The rectangular plate-fin block created by this stack of layers is referred to as a core.

The major components of the cold box are as follows:

Nozzles

Nozzles are pipe sections used to connect the heat exchanger headers to the external process piping.

Headers

Headers are the half cylinders which provide for the distribution of fluid from the nozzles to or from the ports of each appropriate layer within the heat exchanger.

Ports

Ports are the openings in either the side bar or end bar, located under the headers, through which the fluids enter or leave individual layers.

Distributor Fins

Distributor fins distribute fluid between the port and the heat transfer fins. The distributor fin used adjacent to a port is called a port fin. The distributor fin used between a port fin and a heat transfer is called a turning fin.

Heat Transfer Fins

Heat transfer fins provide an extended heat transfer surface. All fins, both heat transfer and distributor, provide a connecting structure between the parting sheets, thereby creating the essential structural and pressure holding integrity of the heat exchanger.

Parting Sheets

Parting sheets or separator sheets contain the fluids within the individual layers in the exchanger and also serve as primary heat transfer surface.

Outside Sheets

Outside sheets or cap sheets serve as the outside parting sheets. They serve as the outer protective surface of the exchangers as well as a land for weld attachment of the headers.

Side and End Bars

Side and end bars enclose individual layers and form the protective perimeter of the exchanger. Solid extruded forms are used

Cold Box

A cold box consists of welded air tight carbon steel casing, which supports and houses heat exchangers, piping, and other related cryogenic equipment, and Perlite insulation material. The cold box is permanently purged with dry nitrogen from the Nitrogen Generator Package (RX-ME- 108). The cold box is protected from overpressure/vacuum by pressure safety valve RX-PSV-135.

High Pressure Separator

The two-phase stream is routed to the High-Pressure Separator for gas/liquid separation. The vessel is fabricated from low temperature carbon steel. The vapor phase is routed to the Expander (RX-KE-102).

The liquid line from the High-Pressure Separator has a shutdown valve RX-SDV-104 installed which can be closed in the event of a leak. The liquid is then flashed across level control valve RX-LV-110 A/B (100% spare), filtered and routed to the High-Pressure Liquids Separator (RX-D- 106), located within the cold box. The pressure drop across the strainer is measured by DCS monitored pressure differential indicator RX-PdI-506. The vapor and liquid streams are separated in the High-Pressure Liquids Separator and routed individually to Cell 3. A bypass line to the Low-Pressure Absorber (RX-C-101) with a hand control valve RX-HV-101 is provided on the vapor stream from the High-Pressure Liquid Separator. This allows any build-up of ethane to be routed to the Low-Pressure Absorber. The streams are recombined before exiting the cold box. The outlet temperature is controlled by temperature controller RX-TIC-110 which modulates valve RX-TV-110 in the bypass around Cell 3. The controller receives a remote set point from level controller RX-LIC-110 on the High-Pressure Separator to maintain the level in the vessel within the control limits. The two-phase stream from Cell 3 is routed to the Deethanizer.

The High-Pressure Separator is protected by overpressure due to fire by pressure relief valve RX-PSV-187 located on the inlet piping. A blowdown valve RX-BDV-501 allows the DE pressuring, of Inlet Gas Core exchanger.

Expander

The gas from the High-Pressure Separator is routed to the Expander (RX- KE-102). The expander provides the chilling required to recover the NGL from the gas. The expander converts the energy of the gas into mechanical work as it isentropically expands through the turbine. The expansion process occurs very rapidly and the heat transferred to or from the gas is small. Consequently, the internal energy of the gas decreases as work is done, and the resultant temperature of the gas is low giving the expander the ability to act as a refrigerator as well as a work producing device. The work produced in the expander is used to drive the Expander-Compressor which is on the same shaft. The expander operates at a speed of 11750 RPM at its design point.

During start-up and periods when the expander is out-of-service, the facility can remain in operation by utilizing the Joule-Thomson (J-T) valve RX-PV-137A provided around the expander. The amount of NGL produced is reduced to 60% of the design production rate, because the J-T valve produces an adiabatic expansion rather than an isentropic expansion. The net result is that the NGL Extraction equipment operates at a higher pressure and temperature during J-T valve operation.

The expander outlet is a two-phase stream which is routed to the Low-Pressure Absorber (RX-C-101). The expander is depressured during a shutdown using blowdown valve RX-BDV-174.

The expander is a radial flow machine in which the gas flow is essentially at right angles to the turbine shaft. The perimeter of the expander wheel is surrounded by a variable nozzle assembly located in the expander housing.

The nozzles are matched to the expander wheel such that minimum to maximum flow regulation is directed to yield optimum velocity vectors and maximum machine efficiency. A low friction coating is used on the contact surfaces of the nozzles between the adjusting and fixed ring to increase the reliability and life of the nozzle assembly. There is no blowby and thus no loss of efficiency. The entire assembly is located in the cold section and is isolated from the warm bearing housing by a thermal barrier. The result is high efficiency over a wide operating range, reduced heat leakage and associated power losses. A pneumatic nozzle actuator with positioner and a hand indicating controller allows for precise nozzle adjustment. The nozzles are controlled by flow controller RX-FIC-151 which receives a remote set point from pressure controller RX-PIC-137 which controls the discharge pressure of the Expander Compressor (RX- K-102).

Low Pressure Absorber

The two-phase stream from the expander enters the Low-Pressure Absorber, where the vapor and liquid are separated and further NGL is extracted from the gas by contacting it with reflux liquid from the Deethanizer (RX-C-102) reflux system. The liquid is distributed by a VEP distributor, which consists of open arm channels with one main channel placed on top. The Low-Pressure Absorber contains 16'-6" of Sulzer Melaka 2X structured packing which is equivalent to seven theoretical stages. The packing has a thickness of 0.004 in. The vessel is fabricated from 304 stainless steel for low temperature service.

The vapor from the Low-Pressure Absorber is routed to Cell 5 of the Deethanizer Overhead Core Exchanger (RX-E-106). The stream is then combined internally in the cold box with the vapor stream from Deethanizer Reflux Accumulator (RX-D-107) and routed to Cell 2 of the Inlet Gas Core Exchanger (RX-E-105) before passing to the Expander Compressor (RX-K-102). The Low-Pressure Absorber vapor may be bypassed around Cell 5 using hand control valve RX-HV-355 located in the bypass line. A temperature switches low low RX-TSLL-106 located at the exit of Cell 2 protects the Expander Compressor and associated piping from cold temperatures by causing a Process Shutdown of the RX Platform. The liquid from the Low-Pressure Absorber is routed to the Low-Pressure Absorber Bottoms Pumps (RX-G-101 A/B). The common pump suction contains a shutdown valve RX-SDV-255 which can be closed in the event of a leak. A pressure relief valve RX-PSV-277 is provided around the shutdown valve to protect the system against thermal expansion.

Deethanizer

The Deethanizer (RX-C-102) has 42 trays, high capacity multi downcomer trays for #1 thru #21, two pass valve trays for #22 thru #30 and single pass valve trays for #31 thru #42. Multi downcomer trays are used for large liquid loads and particularly when the volumetric ratio between vapor and liquid rates is low. The multi downcomers give large total weir length and large downcomer areas. The Deethanizer receives two feeds, both two phase, one at tray #30 originating from the bottom of the Low-Pressure Absorber and the other at tray #20, originating from the bottom of the High-Pressure Separator. The pressure drop across each group of trays is measured by local and DCS monitored pressure differential indicators RX- Pdl-317 A/B (one pass trays), RX-PdI-318 A/B (two pass trays), RX-PdI- 319 A/B (multi downcomer trays). The top section of the tower is fabricated from 304 stainless steel for low temperature service, the bottom section is fabricated from low temperature carbon steel.

The overhead vapor from the Deethanizer passes to cell 6 of the Deethanizer Overhead Core Exchanger where it is partially condensed before being routed to the Deethanizer Reflux Accumulator (RX-D-107). The Deethanizer bottoms liquids is Cyt liquid product which is routed to the Deethanizer Bottoms Pumps (RX-G-103) A/B/C which pumps it to the Bonny River Terminal.

Deethanizer Reboiler

The heat for the Deethanizer is provided by the Deethanizer Reboiler (RX- E-107). The heating medium for the shell and tube reboiler is a proprietary heat transfer fluid, Mobiltherm 605. (See Section 14.0 for Hot Oil System). The reboiler is a horizontal thermosiphon. The shell side (process side) is a double split arrangement and produces 30% wt vaporization. The tube side (hot oil) has four passes and contains 1088 tubes. The shell side and tube side are both fabricated from carbon steel.The flow of hot oil through the reboiler is controlled by flow controller. RX-FIC-305 and receives a remote set point from temperature controller RX-TIC-305 which controls the temperature on Tray #5. The flow controller actuates flow control valves RX-FV-305 A/B which control the flow through the reboiler and bypasses the excess.

Deethanizer Bottoms Pumps

The C3+ product liquid from the Deethanizer is routed through shutdown valve RX-SDV-303, which can be closed in the event of a leak to the Deethanizer Bottoms Pumps (RX-G-103 A/B/C) for transfer to the onshore Bonny River

Terminal. Normally two pumps are operating with the other acting as a spare. The discharge of the pumps is routed to the Deethanizer Bottoms Cooler (RX-E-108). A sample is taken continuously from the suction of the pumps and routed to the analyzer house for analysis, to ensure that the C+ shall not exceed an ethane to propane molar ratio of 1.5 percent.

The pumps are vertical turbine type and have ten stages (one stage has been removed during testing due to the high head developed, the eleventh stage is supplied separately for future use). The entire pump and column assembly are suspended in a suction receiver barrel. This special first stage allows operation with extremely low NPSH requirements while running at optimum speeds.

Each stage consists of an impeller, case and case bearing. The impellers are secured to the pump shaft by a split retaining ring and a retaining ring guard with the impeller being locked to the shaft by a key. The pump is supported by the discharge column which directs the flow from the pump into the nozzle head and also holds the housing for the column bearings which maintain the column shaft alignment. All nozzle heads are constructed of fabricated steel with flanged nozzles. The nozzle head supports the entire pump and discharge column and directs the flow from the pump into the discharge piping. The pump shaft is sealed against leakage as it passes through the head by a mechanical seal. Each pump is furnished with seal flush plans API 11 and 52. The nozzle head also supports the pump driver. The driver engages the pump through a four-piece coupling which consists of a drive half coupling, pump half coupling, adjusting plate and a spacer. The adjusting plate raises the pump rotating element into proper running position. The spacer allows removal of the mechanical seal and sleeve assembly without lifting the motor from the nozzle head.

Deethanizer Bottoms Cooler

The Deethanizer Bottoms Cooler removes the heat from the Deethanizer bottoms liquid before it enters the 10" pipeline to the Bonny River Terminal. The cooler is an induced draft air cooler with one bay containing three fans. The fans are protected by vibration switch high high RX-XSHH-307/308/309 which shuts down a motor. The tubes are fabricated from carbon steel.

Deethanizer Overhead Core Exchanger

For a description of the cold box, The Deethanizer, Overhead Core Exchanger (RX-E-106) consists of the following cells:

Cell 4

Partially vaporizes the Low-Pressure Absorber bottoms liquid for feed to the Deethanizer (See section 11.1.5).

Cell 5

Heats the vapor from the Low-Pressure Absorber before combining it with the vapor from the Deethanizer System

Cell 6

Partially condenses vapor from Deethanizer

Deethanizer Reflux Accumulator

The two-phase stream from Cell 6 of the Deethanizer Overhead Core Exchanger is routed to the Deethanizer Reflux Accumulator (RX-D-107) for vapor/liquid separation. The vessel is fabricated from 304 stainless steel for low temperature service. The vapor from the accumulator is routed to Cell 2 of the Inlet Gas for Exchanger (RX-E-105). The pressure of the Deethanizer System is controlled by pressure controller RX-PIC- 361 located in the vapor line. A blowdown valve RX-BDV-504 located downstream of the pressure control valve RX-PV-361 allows the blowdown of Cell 2 and 5 of the cold boxes.

The liquid from the Deethanizer Reflux Accumulator is routed to the Deethanizer Reflux Pumps (RX-G-102 A/B). The common suction contains shutdown valve RX-SDV-357 which can be closed in the event of a leak. A pressure relief valve RX-PSV-364 is provided around the shutdown valve to protect the system against thermal expansion if the system is blocked in

Liquid is prevented from entering the cold box by level switch high high RX-LSHH-512 A/B which operates on a one out of two-voting system.

Deethanizer Reflux Pumps

The Deethanizer Reflux Pumps (RX-G-102 A/B) are mechanically identical to the LP Absorber Bottoms Pumps (RX-G-101 A/B). Pressure relief valves RX-PSV-362 (RX-G-102A), RX-PSV-363 (RX-G-102B) are provided on each suction line to protect the pump against thermal expansion if the pump is blocked in. Each pump is protected by an accelerometer RX-ZSH-356 (RX-G-102A) RX-ZSH-359 (RX-G-102B) which causes a pump shutdown.

The pump flowrate is split evenly between the Low-Pressure Absorber and Deethanizer. The flow to the Deethanizer is controlled by flow controller RX-FIC-357. The flow to the Low-Pressure Absorber is controlled by level controller RX-LIC-357. The split of the flow is adjusted manually. An indication of the ratio of Deethanizer flow to total flow is presented in the DCS by flow ratio indicator RX-FFI-505. The operator will manipulate flow controller RX-FIC-357 if required. The pumps are protected by a minimum flow loop containing flow control valve.

Expander Compressor

The Expander Compressor is protected against over temperature by temperature switch high high RX-TSHH-175 located in the discharge piping of the machine. The switch causes a shutdown of the compressor. On a shutdown, the compressor is depressured using blowdown valve RX- BDV-158. The Expander Compressor and associated piping is protected from overpressure by pressure relief valves RX-PSV-192 A/B/C. A bypass is provided around the Expander Compressor for start-up and when the machine is out-of-operation and the NGL Extraction Section is operating under the J-T mode.

Expander Compressor Discharge Cooler

The Expander Compressor Discharge Cooler (RX-E-109) removes the heat of compression from the residue gas generated in the Expander Compressor. The cooler is an induced draft air cooler with three bays each containing two fans. The fans are protected by vibration switch high high RX-XSHH-180/181/182/183/184/185 which cause a shutdown of the respective fan. The tubes are fabricated of carbon steel.

An overpressure control station RX-PV-154 A/B is installed downstream of the cooler, which will open when one of the Residue Gas Compressors.

Expander Compressor Discharge Cooler

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An overpressure control station RX-PV-154 A/B is installed downstream of the cooler, which will open when one of the

Residue Gas Compressors (RX-K-103 A/B, 104 A/B) trips. The control station is sized to vent the flow of one Residue Gas compressor. See Section 10.1.1 for a discussion of the operation of pressure differential control valve RX-PdCV-152 in the discharge piping.

REGENERATION SYSTEM

A Regeneration System is provided to regenerate the Inlet Gas Dehydrators (RX-D- 101 A/B/C). The Dehydrators will require regenerating after 16 hours on-line to remove the absorbed water.

Regeneration Gas Blower

The Regeneration Gas Blower is an electric motor driven single stage compressor with a design capacity (guarantee point) of 39.4 MMSCFD at 60 psi differential. The blower normally takes suction from the discharge of the Expander Compressor Discharge Cooler (RX-E-109), and boosts the pressure to overcome the pressure loss through the regeneration equipment. The gas is returned back to the discharge of the cooler. During start-up the regeneration gas is supplied from the RG Platform Fuel Gas System to the suction of the blower. The gas will then be circulated through the system via line P-1038-8"-ACA2-N back to the suction.

The Lube Oil System for the blower is wholly contained within the package and supplies lubrication to the bearing and gears. The Oil Tank (RX-F- 108) is fabricated as part of the compressor base with baffling to prevent foaming and is of sufficient size for a minimum of five minutes retention time. The bottom is sloped toward the drain at the edge of the base. The tank is equipped with a breather fill pipe, clean out cover, and oil level sight glass with dial thermometer RX-LTI-201.

The Main and Auxiliary Oil Pumps (RX-G-125/126) are both positive displacement pumps. The Main Oil Pump is driven by the main motor. The Auxiliary Oil Pump is driven by a separate electric motor that assures full system lubrication oil pressure during initial start-up and maintains oil pressure until the Main Oil Pump is operable. If system oil pressure drops to a preset level, the Auxiliary Pump is activated automatically and provides additional pressure. A one-way check valve is provided to prevent flow reversal through the Auxiliary Oil Pump
The lubrication system provides cooled and filtered fight oil to the bearings. The lubrication system provides cooled and filtered light oil to the bearings and the gear mesh through a spray tube. Oil pressure to the bearings and gears is normally maintained by a piston type pressure relief valve RX-PSV-305, which returns the surplus flow to the Oil Tank. The oil returns by gravity to the main sump in the base. The pressurized oil from the Oil Pump discharge is circulated through a Oil Cooler (RX-E-126) and Lube Oil Filters (RX-V-118 A/B) before entering the supply manifold.

A thermostatic mixing valve RX-TCV-222 will mix the oil from the pump and the cooler to maintain oil temperature. During cold operating conditions this valve restricts oil flow through the Oil Cooler allowing for faster warm-up of the oil. As oil temperature rises the valve will open and allow hot oil to circulate through the cooler.

Oil filter cartridges are made of corrugated cellulose and are the throw- away type. Pressure differential indicator RX-PdISH-302B is provided to monitor pressure differential across the oil filter and help indicate when filter cartridges need replacement. An oil strainer located on the suction side of the Oil Pump protects against entry of coarse material.

The blower is equipped with a dry gas mechanical seal system. The seal consists of two major components, a seal

cartridge made of stainless steel which contains the spring mounted carbon primary seal ring and a mating ring which rotates with the pinion shaft. The leakage of the process gas behind the primary ring is prevented by an Oring which seals at the
leakage of hydrocarbon gas.

The blower is protected by an anti-surge flow control valve RX-FV-251. If the flow through the system is restricted, the flow control valve will open. If the control valve opens fully, the blower will shut down. If a shutdown of the blower is experienced, a full-size bypass is provided to continue operation. The gas does not have the boost in pressure to return to the outlet of the Expander Compressor Discharge Cooler. The pressure differential control valve RX-PdV-152 has to be adjusted manually to throttle back the residue gas flowrate to allow the regeneration gas back into the system.

The discharge piping and blower is protected against overpressure by pressure switch high RX-PSHH-259 which causes a shutdown of the Regeneration System. A pressure relief valve RX-PSV-251 located in the discharge piping protects the system against overpressure due to blocked discharge.

Cooling Gas Cooler

The Cooling Gas Cooler removes the heat of compression from the regeneration gas during the cooling cycle and when the whole system is on full recycle. The cooler also acts as a recycle cooler for the Regeneration Gas Blower. The Cooling Gas Cooler is an induced draft air cooler with one bay containing two fans. The fans are protected by vibration switch

Regeneration Gas Heaters

Exhaust gas from the Power Generator Turbines (RX-PGT-101 A/B) is used to heat the regeneration gas during the heating cycle. Each heater is designed for 100% duty. The temperature of the regeneration gas is controlled at the exit of the Regeneration Gas Heaters by temperature controller RX-TIC-280 (RX-E-103A), RX-TIC-281 (RX-E-103B). The controller adjusts the damper RX-HV-280 (RX-E-103A), RX-HV-281 (RX-E-103B) in the exhaust and bypass ducts. The dampers are multi blade devices which reduce the amount of leakage in the bypass operation. The exhaust gas is bypassed around the out of service heating coil to prevent overheating of the coil. The coil is fabricated of 304 stainless steel. The ducting is insulated with acoustic insulation.

The heaters are protected against overpressure due to gas expansion by pressure relief valve RX-PSV-262 (RX-E-103A), RX-PSV-263 (RX-E- 103B) located on the inlet piping. The relief valves discharge to the Non-

Cryogenic Flare Header. A pressure switches low low RX-PSLL-253 (RX- E-103A), RX-PSLL-255 (RX-E-103B) is provided on the outlet of each heater to shut down the unit in the event of a tube rupture in the heater. A temperature switch high high RX-TSHH-263 (RX-E-103A), RX-TSHH- 266 (RX-E-103B) located downstream of the heating coil on the ducting also senses for a high temperature caused by leakage. Two temperatures also senses for a high temperature caused by leakage. Two temperature switch high highs RX-TSHH-251/277 (RX-E-103A), RX-TSHH- 278/281 (RX-E-103B) located on the outlet piping cause a shutdown of the unit on high gas temperature.

The inlet piping and equipment are protected against overpressure caused by a malfunction of a sequence valve around the dehydrators by pressure switch high RX-PSHH-167 which causes a Process Shutdown. The piping and equipment are also protected by pressure relief valves RX-PSV- 500 A/B/C also located on the inlet piping.

The hot gas is routed to the Inlet Gas Dehydrator and passes upward through the bed when it is being regenerated, see Section 10.4 for the position of the valves during the regeneration sequence. When none of the beds are being regenerated the regeneration gas is bypassed around the Dehydrators by opening the sequence valve RX-XV-169. The gas from the beds is routed to the regeneration gas cooler.

Regeneration Gas Cooler

The Regeneration Gas Cooler condenses the hydrocarbons/water absorbed by the regeneration gas during the heating cycle. The Regeneration Gas Cooler (RX-E-101) is a forced draft air cooler with one bay containing two bays' fans. The fans are protected by vibration switch high high RX-XSHH- 223/224. The tubes are constructed of Incoloy 800 due to the corrosive nature of the fluid. The equipment and piping are protected against overpressure caused by a malfunction of a sequence valve around the dehydrators by pressure switch high high RX-PSHH-503 located on the inlet piping, which causes a Process Shutdown. The equipment and piping are also protected by pressure relief valves RX-PSV-501 A/B/C also located on the inlet pining.

Regeneration Gas KO Drum

The Regeneration Gas KO Drum separates the vapor and liquid from the Regeneration Gas Cooler. The gas is routed via flow control valve RX- FV-202 back to the outlet of the Expander Compressor Discharge Cooler. The flow control valve controls the flow through the Regeneration System. As stated in Section 10.1.1 a start-up line is provided to recycle the gas directly back to the blower suction. The Regeneration System is blown down during an emergency condition by opening blowdown valve RX- BDV-508 located on the gas piping.

The liquid from the Regeneration Gas KO Drum is routed to the Regeneration Condensate Holding Drum via level control valve RX-LV- 203. A level switch high high RX-LSHH-506 located on the drum prevents liquid entering the Residue Gas System. The switch causes a Regeneration Gas System shutdown. A level switch low low RX-LSLL-505 also located on the drum prevents a gas blowby case to the Regeneration Condensate Holding Drum. The switch closes level control valve RX-LV-203.

The vessel is protected against overpressure due to a fire by pressure relief valve RX-PSV-148. The vessel is clad with 316 stainless steel due to the corrosive nature of the fluid.

Regeneration Condensate Holding Drum

The Regeneration Condensate Holding Drum separates the hydrocarbon condensate from the water. The vessel is clad with 316 stainless steel due to the corrosive nature of the fluid. The drum has an inlet weir located approximately 12' from the inlet end and provides a two-phase interface zone for the separation. The interface level is controlled by level controller RX-LIC-206 which discharges the water directly to the Sump Tank (RX-F- 102). A level switch low low RX-LSLL-507 prevents a gas blowby to the Sump Tank by closing level control valve RX-LV-206.

The separated condensate overflows the weir into the condensate compartment. The condensate level is controlled by an on/off level controller RX-LIC-210 which directs the condensate to the oil compartment of the Sump Tank. A level switch low low RX-LSLL-508 prevents a gas blowby to the Sump Tank by closing level control valve RX-LV-210. A level switch high RX-LSHH-509 prevents condensate water from entering the Fuel Gas and/or LP Vent Systems by closing level control valve RX-LV-203.

The pressure in the drum is maintained by a pressure controller RX-PIC- 217 which regulates pressure control valve RX-PV-217A to allow fuel gas in the system and pressure control valve RX-PV-217B which vents any excess. The vessel is protected against overpressure due to fire pressure.

Residue gas compression section

The residue gas from the NGL Extraction Section is compressed in two parallel two-stage centrifugal compressor trains with associated suction scrubbers and discharge coolers. Each compressor train is driven by a LM2500 combustion gas turbine utilizing platform fuel gas as the fuel.

Residue Gas 1st Stage Compressor Suction KO Drums

The residue gas from the Expander Compressor Discharge Cooler is divided between the two Residue Gas Compressor trains. The inlet to each suction KO Drum has a shutdown valve SDV-113 (RX-D-108A), RX-SDV- 264 (RX-D-108B with a pressurization bypass and a shutdown valve RX- SDV-114 (RX-D-108A) RX-SDV-265 (RX-D-108B) which closes on an upset. The flow to each train is measured by flow indicator RX-FI-102 (RX-D-108A), RX-FI-253 (RX-D-108B) which is pressure and temperature compensated. The gas enters the Residue Gas 1st Stage Compressor Suction KO Drums RX-D-108 A/B. Each vessel is designed to process 267 MMSCFD of gas and to remove 100% of liquid droplets 8 microns and larger. The vessels are constructed of carbon steel.

Residue Gas Compressors

The First Stage Compressors have a design capacity (guarantee point) of 267 MMSCFD at a 438-psi differential. The Second Stage Compressors on the same shaft have a design capacity (guarantee point) of 247 MMSCFD at a differential pressure of 700 psi. A flow of 20 MMSCFD is taken from each interstage for fuel gas.

The rotor impellers, when rotating at operating speed, impart energy into the process gas which is flowing through them. The process gas enters the intake (suction) volute of the compressor and flows through the inlet wall and first stage inlet guide which directs the gas at a suitable angle into the eye of the first stage impeller. The gas is then discharged from the periphery of the impeller at a high velocity by centrifugal force into the passage formed by the inlet wall and first stage diaphragm

The residue gas exits the first stage and is cooled in the Residue Gas Compressor Intercoolers (RX-E-110 A/B) and then is routed to the Residue Gas 2nd Stage Compressor Suction KO Drums (RX-D-109 A/B)

H. Thrust Bearing is a Michell type with several individual pivoting pads or shoes on either side of the thrust disc. Rotor thrust is normally towards the intake end of the compressor. Lubricating oil at approximately 20 psig is supplied to the bearings, and the active shoes pivot or tilt against their supporting base ring to form an oil film wedge to protect the thinly babbitted faces from excessive wear.

I. Journal Bearings are the tilting pad type comprising a steel shell (bearing housing) and five babbitt faced pads or shoes which tilt to form an oil wedge in a manner similar to that of the thrust bearing shoes. The journal bearing assemblies, split at the horizontal centerline, are doweled and bolted to the heads. Lubricating oil is also supplied to these bearing at approximately 20 psig.

Lube Oil System

Mineral oil for the power turbine and compressor lubrication is drawn from the Lube Oil Reservoir RX-F-103A (Train A), RX-F-103B (Train B). Two Lube Oil Pumps RX-G-110 A/B (Train A), RX-G-110 C/D (Train B), one duty, one standby to circulate the lube oil. The heat is removed from the lube oil by the Lube Oil Cooler RX-E-121A (Train A) or RX-E-121B (Train B). A temperature control valve RX-TCV-A631 (Train A) or RX- TCV-B631 (Train B) is located downstream of cooler maintains the oil temperature to the machines. Two Lube Oil Filters RX-V-118 A/B

Sealing Gas System

The Residue Gas Compressors are equipped with dry gas seals. Clean, dry gas is taken from the compressor interstage, filtered and injected into the seals to act as a sealing medium. The seal gas first passes through the Seal Gas Filters RX-V-120 A/B (Train A), RX-V-120 C/D (Train B), one duty, one standby. The out of service filter can be changed out without interrupting seal operation. A pressure control valve RX-PCV-A673
(Train A), RX-PCV-B673 (Train B) regulates the injection pressure to seal Port As at 10 psi above reference pressure from drive end seal port Ds. (Refer to P&ID 475-16-RX-PR-0040-05/0045-05 for seal port references).
A balance line connects drive end seal port to compressor suction and a gas balance line connects seal ports D. This ensures that the seals are working against the same internal pressure, approximately suction pressure for the compressor.

Residue Gas Intercoolers

The Residue Gas Intercoolers remove the heat of compression from the residue gas generated in the 1st stage of the Residue Gas Compressors Each cooler is an induced draft air cooler with three bays each containing two fans.

Residue Gas 2nd Stage Compressor Suction KO Drums

The residue gas from the Residue Gas Intercoolers is routed the Residue Gas 2nd Stage Compressor Suction KO Drums (RX-D-109 A/B). Each vessel is designed for 247 MMSCFD of gas and to remove 100% of liquid droplets of 8 microns and larger. The vessels are fabricated of carbon steel.

Residue Gas Aftercoolers

The Residue Gas Aftercoolers remove the heat of compression from the residue gas generated in the 2nd Stage of the Residue Gas Compressors. Each cooler is an induced draft air cooler with three bays each containing two fans.

After cooling, the residue gas streams are combined and routed across the RG-RX bridge to the RG Platform for further compression for gas injection. The flow to the RG Platform is measured by flow indicator RX-FI-152 which is temperature and pressure compensated. A future line is provided for the routing of high-pressure fuel gas to the Bonny River Terminal.

A pressure control valve RG-PV-374 located on the RG Platform will open to the Non-Cryogenic Flare if a trip of the High-Pressure Compressors (RG-K-104 A/B, 105 A/B) is experienced. This allows the NGL production to be kept at a maximum by permitting the full gas flowrate to pass through the RX Platform.

CONCLUSIONS

The Extraction of natural gas and the assosciated natural gas liquids (NGLs) is a critical component of the energy sector, providing valuable resources for various industries. The primary methods for extracting NGLs such as natural gas processing and gas field extraction each come with unique advantages and challenges. Natural gas processing involves separating NGLs from the raw gas stream at processing plants, while gas field extraction captures NGLs directly from the production site.

The Choice of extraction method often depends on factors such as the composition of the natural gas, the proximity to processing facilities and economic considerations. Advance in technology continue to improve efficiency and environmental impact of these extraction processes. However, it remains crucial to address environmental and safety concerns associated with natural gas extraction, including methane emissions and potential ground water contamination.

This Conclusion encapsulates the main points discussed, underscores the importance of the topic, suggests a forward looking perspective.

REFERENCES

1.OSO Field Condensate development, Hudson Project
2.OI System work management- UN Safe work practices manual
3.OI System- Work management UN Work management procedure manual
4.Upstream- Nigeria OIMS e-manual

Location: Country/State	Nigeria /Bight of Benin
Area/Field	OSO Field
Related facilities in area	EDOP Complex