NITROGEN MEMBRANE SYSTEM

NGU LR 1000 RC

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NITROGEN MEMBRANE SYSTEM OVERVIEW

Our equipment is designed and guaranteed for long-term operation. From application design to continuing production, it provides a cost-effective solution with the following benefits:

- Increased space/weight efficiency
- Unparalleled system reliability
- Efficient maintainability, serviceability, and ease of operation
- Long-term durability
- Seamless system integration

Our integrated solutions are built on a foundation of quality and durability to ensure maximum reliability and performance. Research and development enables the Access Group to provide innovative products that meet today's applications and standards which helps to reduce total cost of ownership.

The NGU LR 1000 delivers 1000 scfm of 95% N2 plus inerts. All components are mounted inside of functional DNV 2.7-1 / CSC certified 10 ft Standard (8.6 ft H) container and are suitable for non-hazardous on or offshore.

The membrane system meets the nitrogen requirement of 1000 scfm @ 95% if enough high-pressure feed air is supplied.

Feed Air requirement - 2113 scfm @ 340 psi delivered

Output nitrogen flow chart at different N2 purities (Note: stated in scfm).

Membrane inlet Pressure (PSI)	Nitrogen Purity (%)	Membrane inlet Temp (F)	FN2 Flow rate (scfm)	Feed Air at membrane inlet (scfm)	Modules	Membrane recovery rate N2 (%)
340	95	125	1000	2113	14	47.33
340	96	125	840	1943	14	43.24
340	97	125	675	1746	14	38.66
340	98	125	500	1504	14	33.26
340	99	125	350	1344	14	26.04

1. INTRODUCTION

1.1 BACKGROUND

The Membrane Nitrogen System will produce up to 1000 scfm 95 % Nitrogen if supplied with a minimum of 2113 scfm feed air @ 340 psi. The discharge nitrogen pressure and temperature will be estimated at 320 psi and 10 to 15 F above ambient temperature.

DESIGN SPECIFICATIONS

Location:	Unknown
Ambient temp. range:	32 F to 150 F
Electric Classification:	Non-hazardous
Electric Power:	+50 kw 480V or 380V 3 phase, 60 Hz or 50 Hz
Maximum Gross weight:	+/- 15,000 lb
Container:	10 ft standard ISO dimensions DNV 2.7-1 / CSC
Documentation:	includes a GAD and P&ID of current design and 3D model.

Upgrades:

1) Eliminate the Carbon tower – combine the carbon filtration with partial filter.
   - Eliminates the possibility of hot spots in the carbon due to oil residue.
2) Additional Pressure Relieve Valve on the feed inlet manifold.
3) PCL controlled re-heater with high temperature shutdown
   - An independent high temperature sensor will shut down power to the electric re-heater.
4) Feed air inlet emergence shut off valve connected to the emergence shut down button.
5) Stainless Steel or painted components will be used to minimize corrosion during offshore operations.
6) Supplied with a set of replacement filters and hand-held Oxygen Analyzer.
7) Includes Laptop computer with software for Data recording and remote operation.

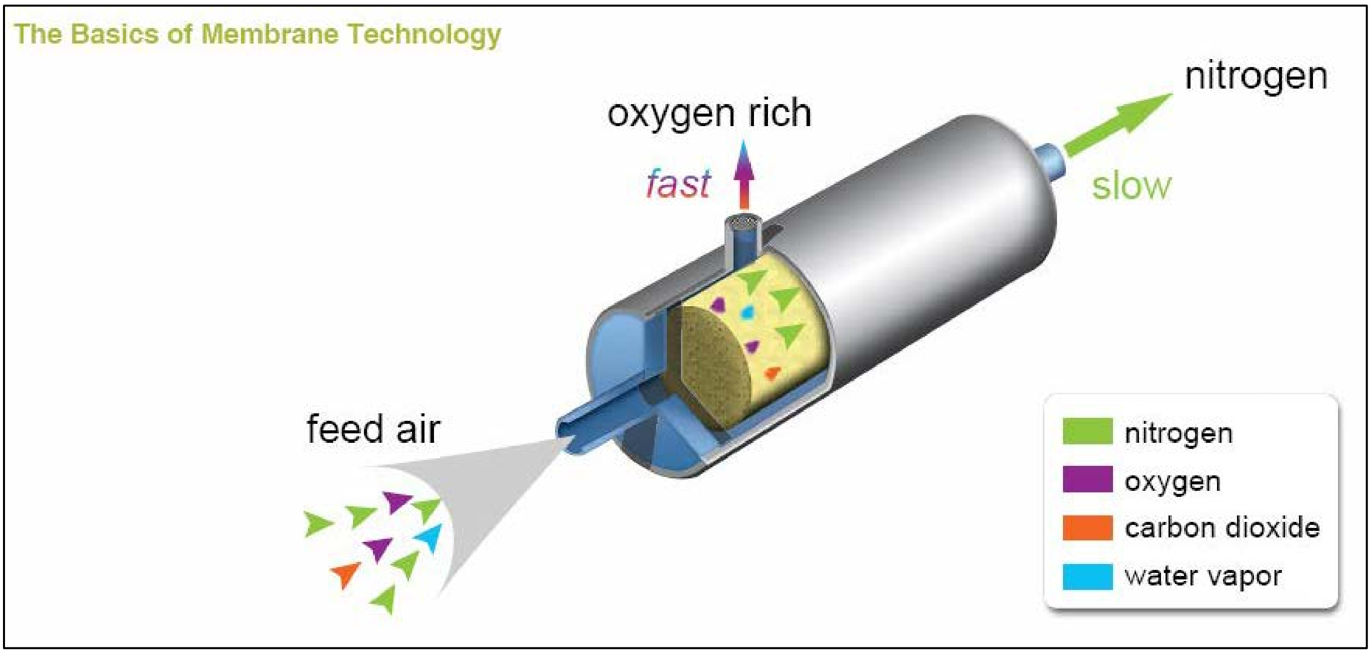
2. PROCESS DESCRIPTION

2.1 AIR SEPARATION

The nitrogen membrane system uses polymeric hollow fibre membranes. Pressurized air enters at one end of the module and product nitrogen exits at the opposite end of the module.

Gas separation takes place as the pressurized air contacts the membranes. "Fast" gases, such as oxygen, carbon dioxide and water vapor, quickly permeate through the fibre walls and exit at atmospheric pressure through the vent port on the side of the module case.

Nitrogen, a slower gas, does not permeate through the fibre walls as quickly under flowing conditions. As a result, enriched nitrogen exits the product manifold on the end of the module housing at a slightly lower pressure than the air entering the housing.



2.2 SYSTEM OPERATION

The NGU requires a pressurized feed air stream and electrical power for the reheater. Feed air for the membranes is supplied by a feed air compressor provided by customer. As shown in Attachment A, the compressed feed air is first stripped of free water and suspended oil particles in a de-mister and fed to a series of fine coalescing filters to remove most of the water/oil vapours. To ensure that the compressed air stream contains no free moisture, an electric heater superheats the air stream. The air then enters a carbon bed to adsorb any residual hydrocarbon vapours that may be present in the compressed air stream. A fine micron filter provides final capture of any remaining particles in the feed air stream.

The air then enters the bank of membrane modules where oxygen and water vapor are removed, and highly enriched nitrogen is collected at the product end of the membrane module.

The purity of the nitrogen product gas is controlled by a backpressure control valve. An alarm is provided to alert the operator to high oxygen levels, and the product control valve will vent out of spec nitrogen to atmosphere if the oxygen concentration reaches an unacceptable level. Permeate gas (waste gas) is also vented to the atmosphere. The nitrogen produced from the membrane banks is collected in the discharge header and fed to the booster compressor, also supplied by customer. An orifice flow measurement system will be provided. The metered nitrogen discharge flow, pressure and purity are constantly monitored and displayed at a central operator control panel.

2.3 SYSTEM PERFORMANCE

Each membrane NGU is designed to accept the required after cooled feed air up to 365 psig (25 bar) to generate nitrogen over a wide range of inert gas purities, with N2 production inversely proportional to nitrogen purity from the existing bank of membranes. Nitrogen production is also directly proportional to the inlet feed pressure and temperature to the membranes.

Low Recovery N-1 membranes performance

Membrane inlet Pressure (PSI)	Nitrogen Purity (%)	Membrane inlet Temp (F)	FN2 Flow rate (scfm)	Feed Air at membrane inlet (scfm)	Modules	Membrane recovery rate N2 (%)
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340	99	125	350	1344	14	26.04
140	95	125	350	797	14	43.92
140	99	125	125	542	14	23.06
140	95	145	400	971	14	41.18
140	95	150	425	1050	14	40.49
140	99	150	140	711	14	19.68

3. DESIGN BASIS

Max feed air pressure	365 psig at skid edge	25 bar
Membrane performance inlet temp	130ºF @ 350 psi	55 ºC @ 24 bar
Max membrane inlet temperature	180ºF @ 260 psi	80 ºC @ 18 bar
Membrane nitrogen recovery rate	>47%	
Container weight	15 klbs	6.818 kg
Length	10.0 ft	3.05 m
Width	8.6 ft	2.62 m
Height	8.6 ft	2.62 m
Maximum ambient temperature	130ºF	55 ºC
Air pre-treatment	Water / Coalescing carbon tower / Particulate	
Air re-heater	Electric 480 V, 3 phase, 60 Hz / 380 V, 3 phase, 50 Hz	
Classification	Non-Hazardous,	

4. SCOPE OF SUPPLY

The NPU is a containerized membrane system that includes air pre-treatment equipment, air separation membranes and control equipment to produce 95% nitrogen plus inerts assuming feed air temperatures, pressures and flow rates are met with the auxiliary compression equipment supplied by the customer (nitrogen purity levels can be adjusted between 95% and 99%). A 3D model representation of this NGU in its containerized configuration is shown in Attachment B.

In this application, the customer will supply the feed air compressor with aftercoolers, and the nitrogen membranes will generate a continuous supply of enriched nitrogen with minimal pressure drop across the membrane bundles. Membranes must be carefully selected based on operating temperatures and desired productivity versus desired recovery of the membrane system. All commercial membranes are subject to trade-offs between productivity (nitrogen production) and recovery (efficient conversion of feed air to nitrogen).

4.1 AIR PRE-TREATMENT

4.1.1 **Centrifugal Water Separator**: water knock-out vessel.

4.1.2 **Water Separator and Coalescing Filters**: Additional removal of water vapor and condensable 0.01 micron 99.97% efficiency.

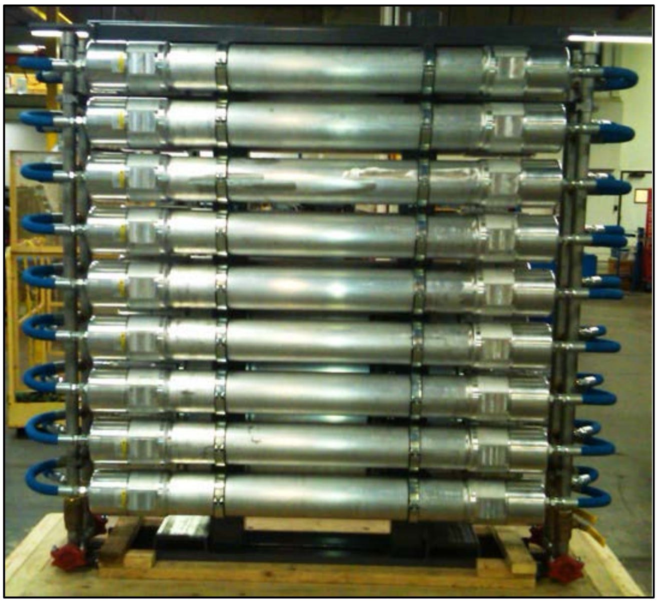
4.1.3 **Electric Reheater**: provides superheating to the feed air stream and stabilizes temperatures for improved process control.

Engine coolant heat exchanger optional

4.1.4 **Carbon and Particulate Filter:** Adsorbs any remaining oil aerosols or vapours in the feed air and final protection against particulates 0.01 micron 99.97% efficiency

4.2 MEMBRANE BUNDLES (EXAMPLE)

Adequate membranes have been piped in parallel to meet or exceed process requirements. We use Air Products' 6050 N-1 High Recovery, High temperature and pressure membrane modules.



4.3 INSTRUMENTATION AND CONTROLS

Nitrogen flow measurement, flow control valve, oxygen process analyzer and all necessary shut down and alarms are included.

4.3.1 PRODUCT PURITY CONTROL

- Capable of providing the customer adjustable control of product purity from 95% to 99%.
- Process regulation by a pilot-operated backpressure regulating valve to control flow rate and corresponding oxygen level in the product gas.
- Diminishes possibility of intermittent shutdown due to product purity and provides smoother (quicker) recovery from feed air upsets.
- High accuracy nitrogen orifice flow measurement system will be provided on the NGU outlet.

4.3.2 SAFETY FEATURES

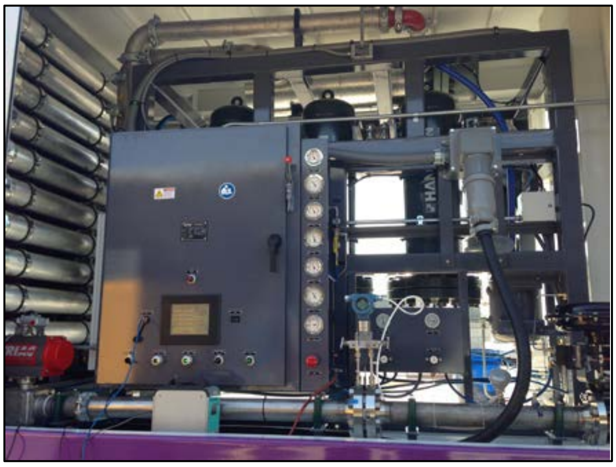
- Oxygen analyzer (zirconium-type) to ensure product integrity and process safety.
- Over temperature protection.
- Over pressure protection (PRV).
- Emergence air inlet shut off valve.

4.3.3 CONTROL SYSTEM

This system provides a continual monitoring of oxygen content as a percentage of the product stream and allows the user to establish and control product oxygen content. Components, features and benefits include the following.

- NEMA enclosure.
- Interface alarms, shutdowns, and status conditions for start-up.
- High differential pressure gauges across filters.
- High oxygen in product gas alarm.
- Oxygen analyzer meter with zirconium cell for extended life and higher accuracy.
- Inlet Feed air flow meter (included).
- Data recording and remote control via laptop computer.
- Auto / manual controls.
    - Flow rate – Flow rate can be auto set and the system will maintain a set flow rate automatically.

- o N2 purity – The required N2 purity can be auto set and the system will maintain the set N2 purity. Will override the flow rate.
- o Final discharge pressure – With a final discharge pressure set the system will override flow the N2 purity and flow rate set point to main pressure set point.



4.3.4 CONTAINER

The nitrogen membrane system will be housed in a functional 20ft High cube container.

- Container Access, fork lift pockets and DNV sling set.
- DNV 2.7-1 / CSC.
    - External dimensions are 20x8x9-6.
    - 2x sets of double cargo doors (one at each end).
    - Locking mechanisms are galvanized.
    - Hinges are painted with s/s hinge pin.
    - 1 set of sling set.
    - Load test (2.5xMGW).
    - 3 coat offshore paint schedule.
        - Zinc rich primer (2-3 mills -inside and outside).
        - Epoxy intermediate (6-8 mills, inside and outside).
        - Polyurethane (2-3 mills, outside only).
    - All necessary decals.
    - 3. Party certificates (Offshore & CSC - issued by DNV).

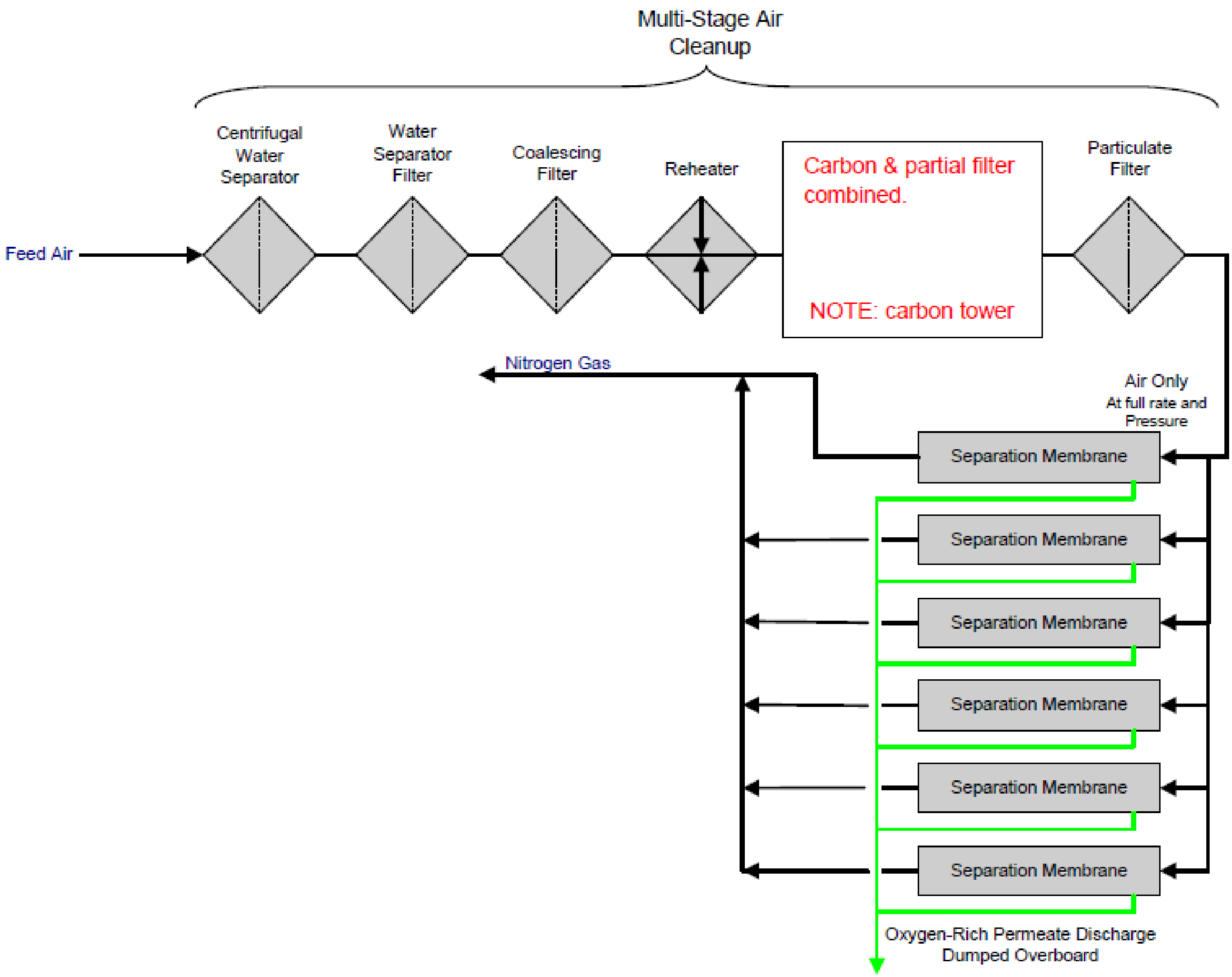
o As-built dossier including.

- GA drawings, Material certificates, Welder certs, Welding procedures, Welding visual inspection reports, MPI reports (before and after load test) Load test reports, 3rd party certs, QA documents.

ATTACHMENT A

Typical process configuration- Air pre-treatment and membrane banks

PROCESS FLOW DIAGRAM



ATTACHMENT B

Typical membrane layout in a 10 ft. Container