How is N2 Produced

What is Nitrogen and How is it Produced

Nitrogen (N2) is a colorless, odorless gas which makes up roughly 78% of the earth's atmosphere. Nitrogen is defined as a simple asphyxiant having an inerting quality which is utilized in many applications where oxidation is not desired.

Nitrogen gas is an industrial gas produced by one of the following means:

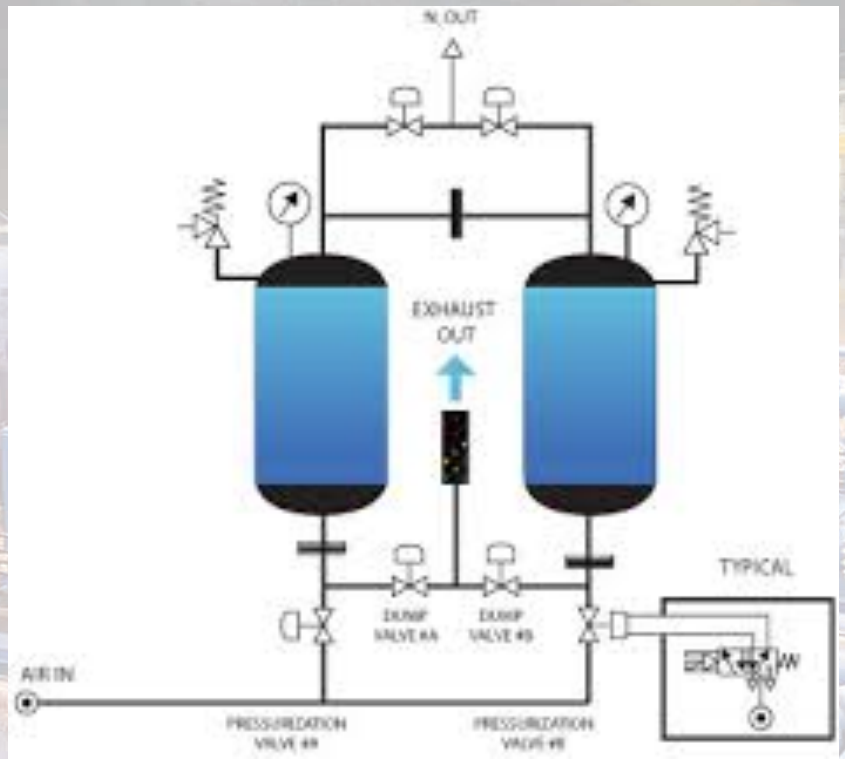
- Fractional distillation of liquid air (Praxair, Air Liquide, Linde, etc)
- By mechanical means using gaseous air
  - **Polymeric Membrane**
  - **Pressure Swing Adsorption or PSA**

Fractional Distillation (99.999%)

Pure gases can be separated from air by first cooling it until it liquefies, then selectively distilling the components at their various boiling temperatures. The process can produce high purity gases but is very energy-intensive.

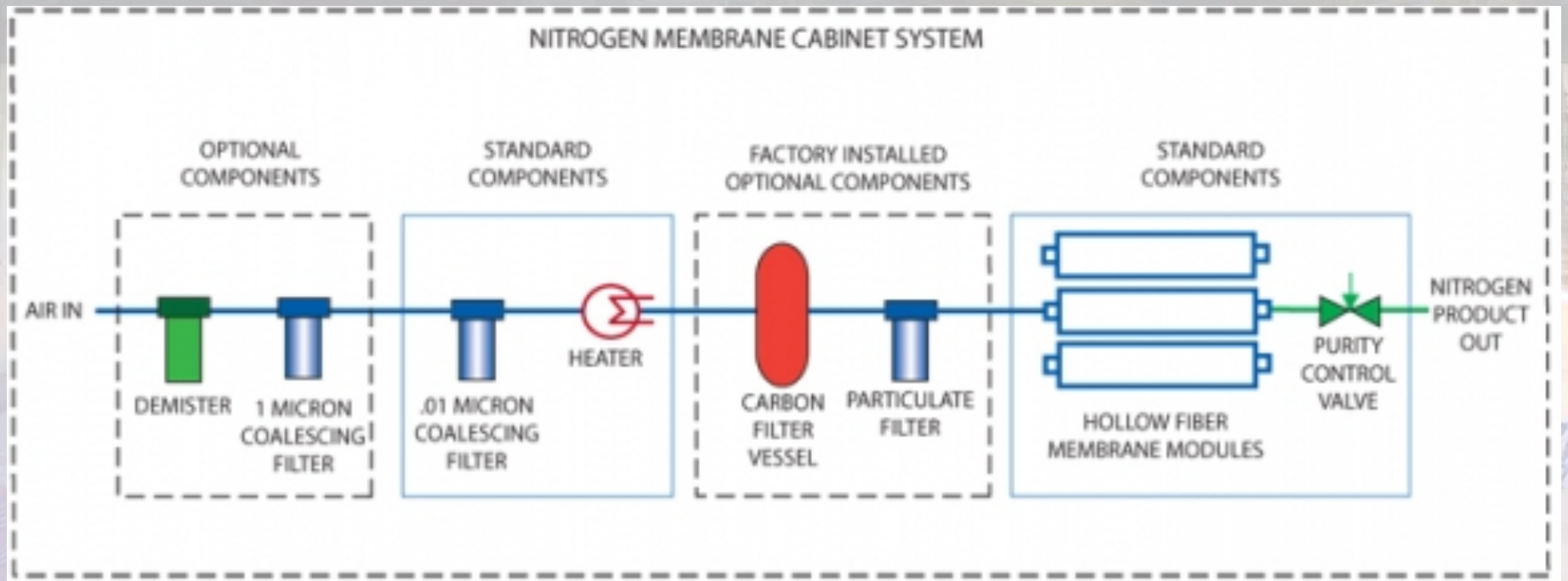
Pressure Swing Adsorption (99 – 99.999%)

Pressure swing adsorption (**PSA**) is a technology used to separate some gas species from a mixture of gases under pressure according to the species' molecular characteristics and affinity for an adsorbent material. It operates at near-ambient temperatures and differs significantly from cryogenic distillation techniques of gas separation. Specific adsorptive materials (e.g., zeolites, activated carbon, molecular sieves, etc.) are used as a trap, preferentially adsorbing the target gas species at high pressure.



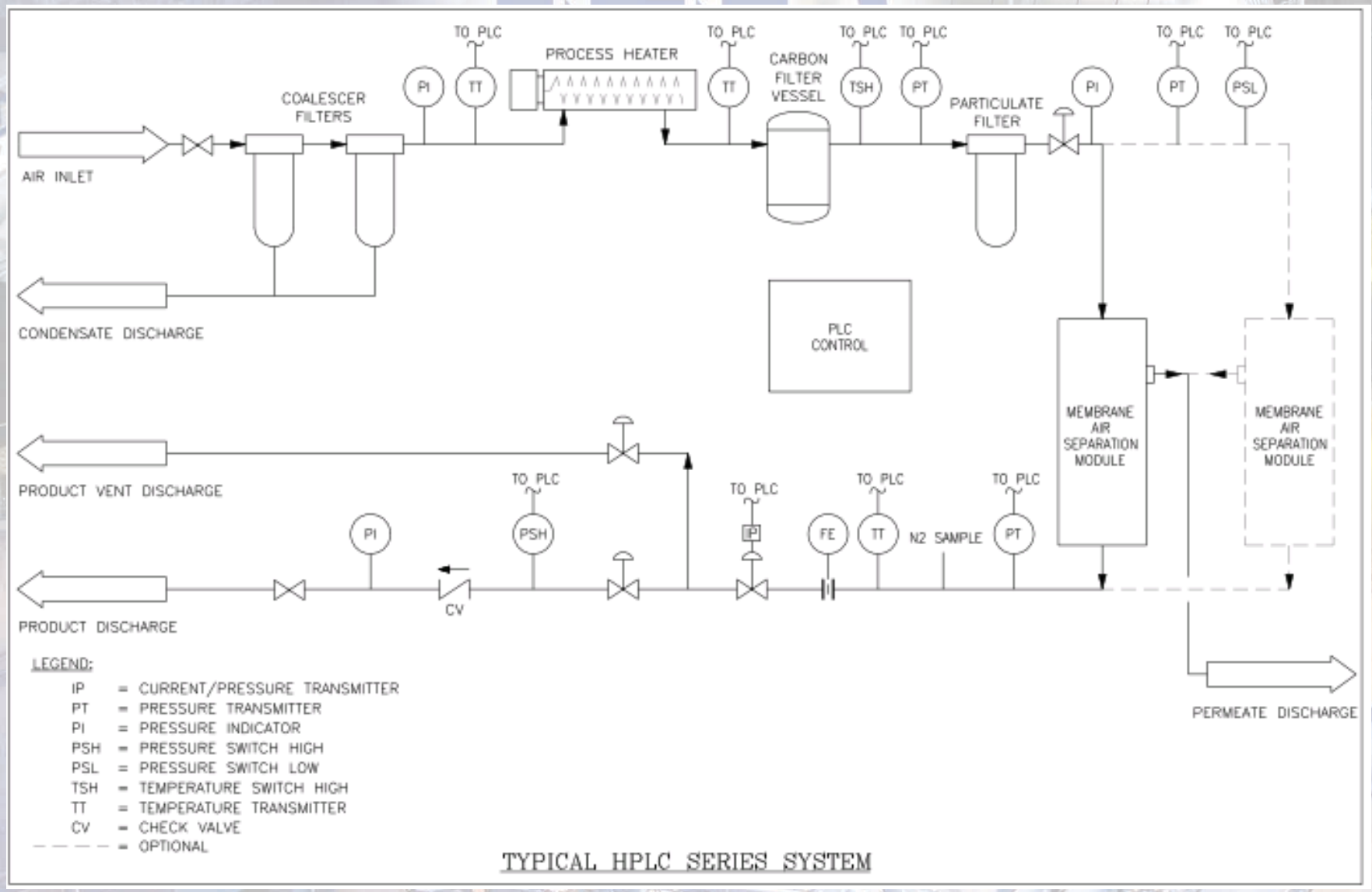
Membrane
(90 – 99.9%)

Membrane Technology utilizes a permeable fiber which selectively separates the air depending on the speeds of the molecules of the constituents. This process requires a conditioning of the Feed air due to the clearances in the fiber which are the size of a human hair.

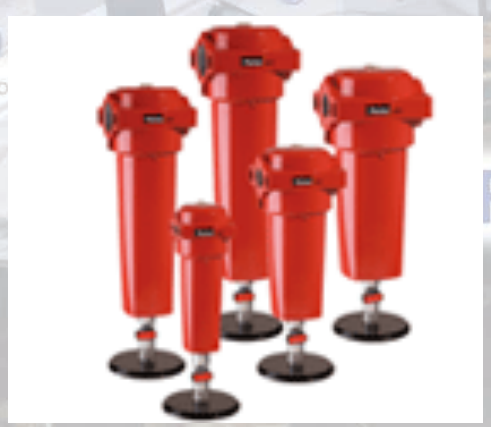


Feed Air Conditioning

Typical One Line Diagram



Filter Coalescers



In every Nitrogen Generation package it is critical that the system be provided with a filtration system that will inevitably protect the Nitrogen Membrane from damage and increase its efficiency. The first two coalescer filters remove incoming moisture up to 0.01 Micron.

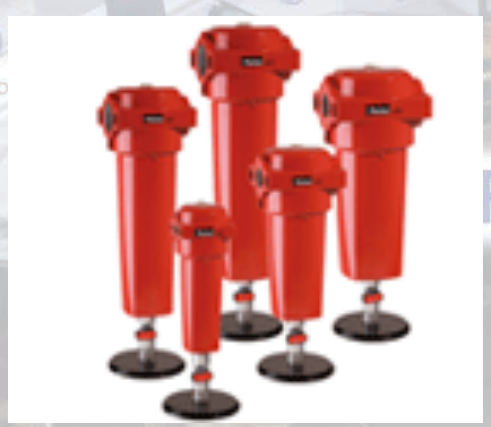
Immersion Heater

An Immersion Heater is an essential component due to any liquids that may have migrated past the Coalescer filters. This heater provides roughly 10 F of superheat to the air thusly insuring no liquids will enter the Nitrogen Membranes.

Carbon Vessel

Once heated the air will then flow through an activated carbon bed or filter to remove any additional Hydrocarbon Vapors prior to entering the membranes.

Particulate Filter



Once the remaining Hydrocarbons are removed, the air will then flow through one last Particulate filter thus removing any remaining particulate down to 0.01 Micron. The air has now been conditioned such that it is ready to enter the Nitrogen Membranes.

Nitrogen Membranes

Nitrogen Membrane Manufacturers

Parker Balston

AIR PRODUCTS

AIR LIQUIDE

Creative Oxygen

GENERON

INNOVATIVE GAS SYSTEMS

Air Products PRISM® Membranes

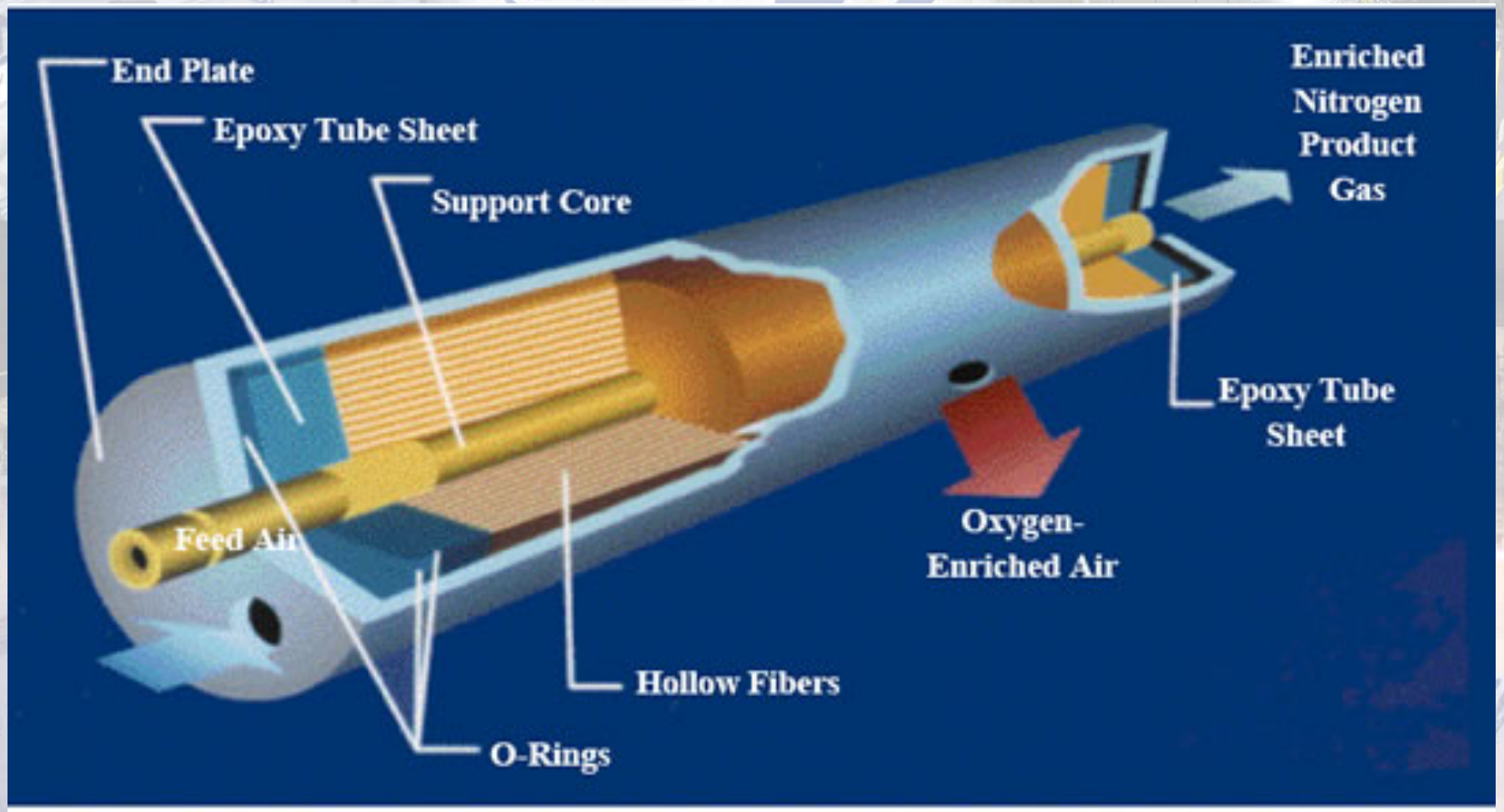
(Often called APPM)

The one-of-a-kind manufacturing plant is located in St. Louis Missouri along with the research and development, engineering, and commercial groups. The sales reach is global with additional sales locations in China and Norway.

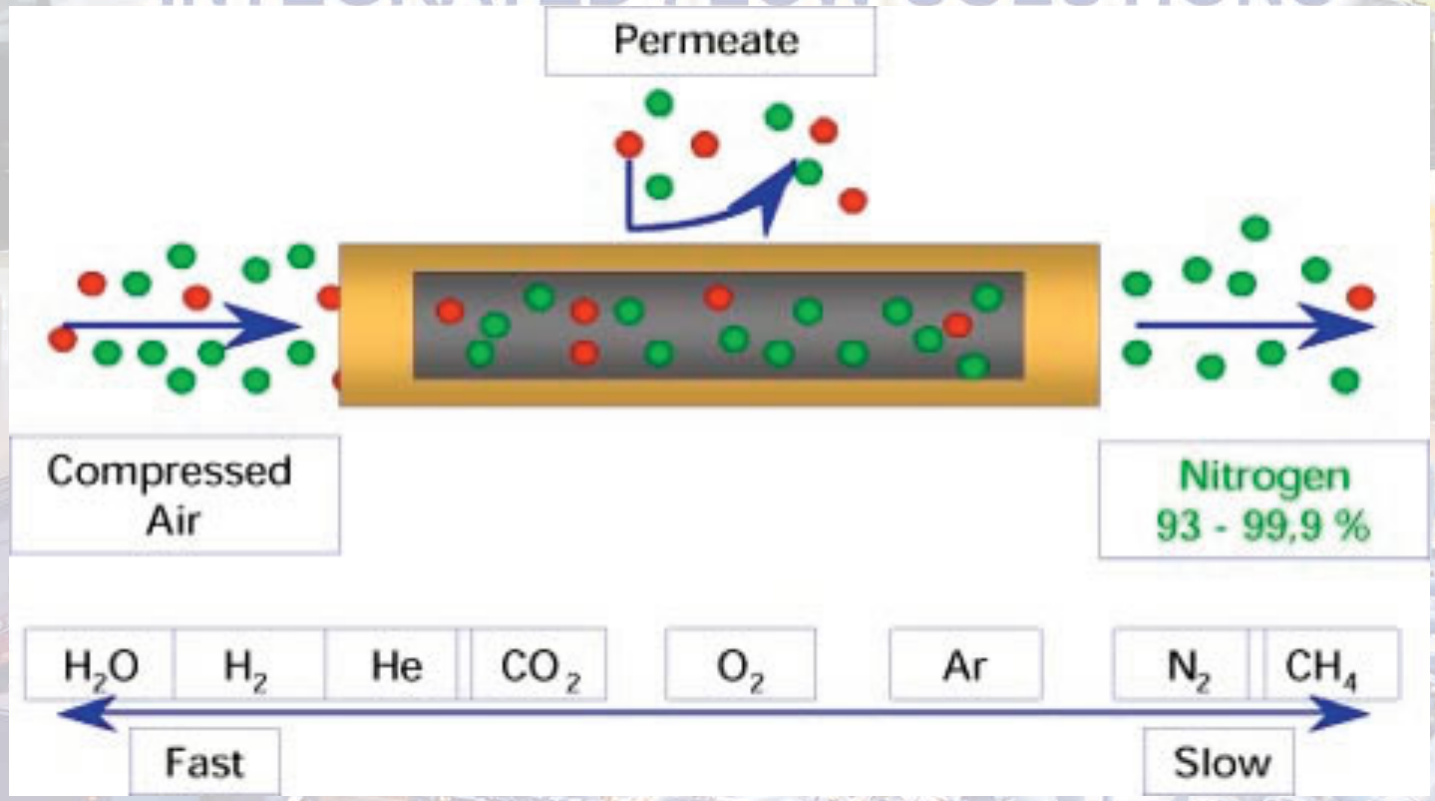
Company Timeline

- 1975-1990 Monsanto owned the original technology and development under the name Permea Inc.
- 1970s & 1980s Permea commercialized membrane separation systems
- 1991 Air Products acquired the business including the PRISM® trademark
- 2000 The business re-organized as APPM focusing on membranes only
- 2007 Facility expansion- addition of west building
- 2008 The company invested in a secondary manufacturing location for additional expansion

Nitrogen Membrane Cut Away

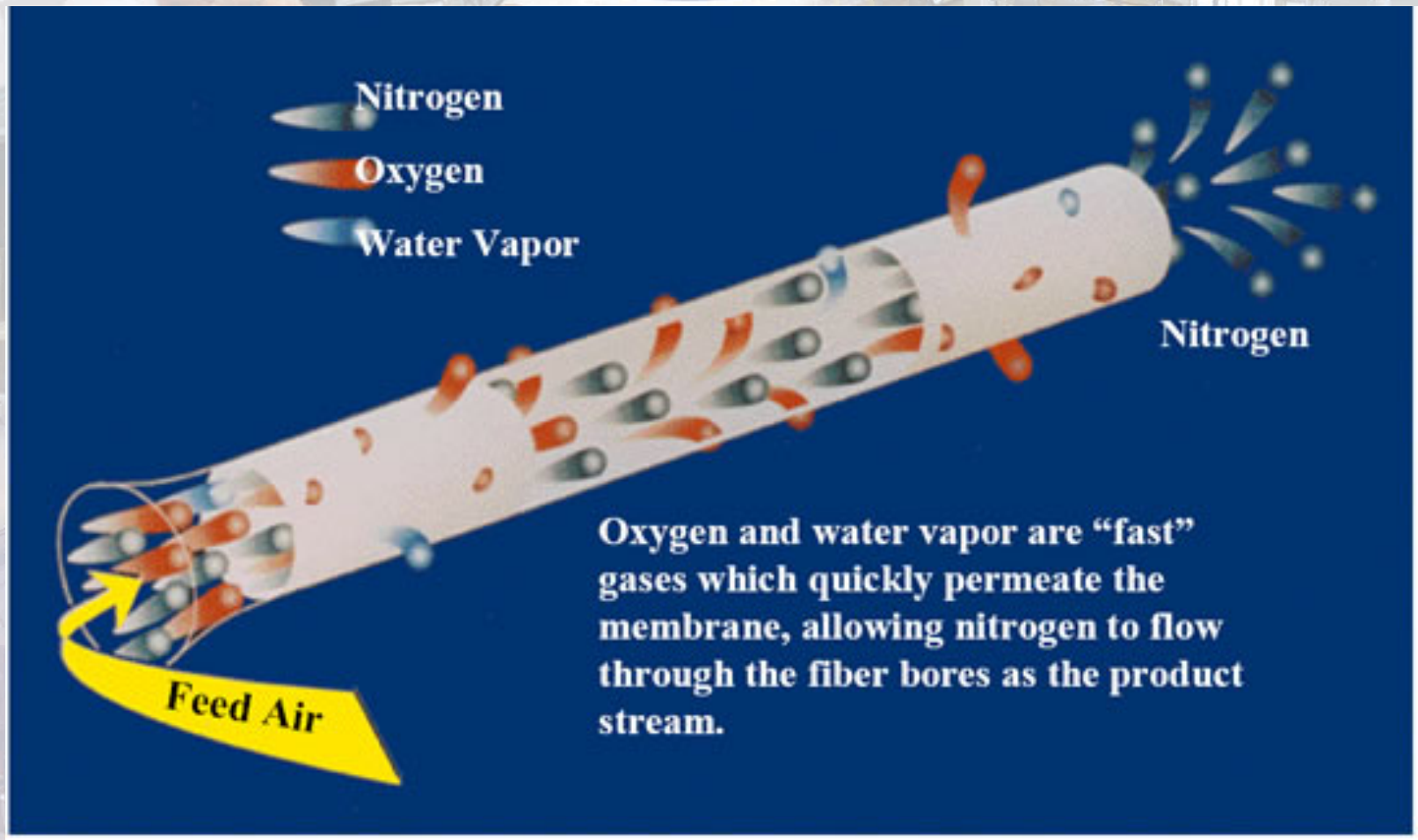


At the heart of the technology are polymeric membrane materials that allow for the rapid passage of one gas while minimizing the passage of another when applying pressure gradient across the membrane. This figure demonstrates the relative rate of common gases with the focus on the separation of O2 from compressed air to provide a high purity N2 stream. Membrane materials are formed into hollow fibers to provide high surface area for high volumetric gas processing rates.

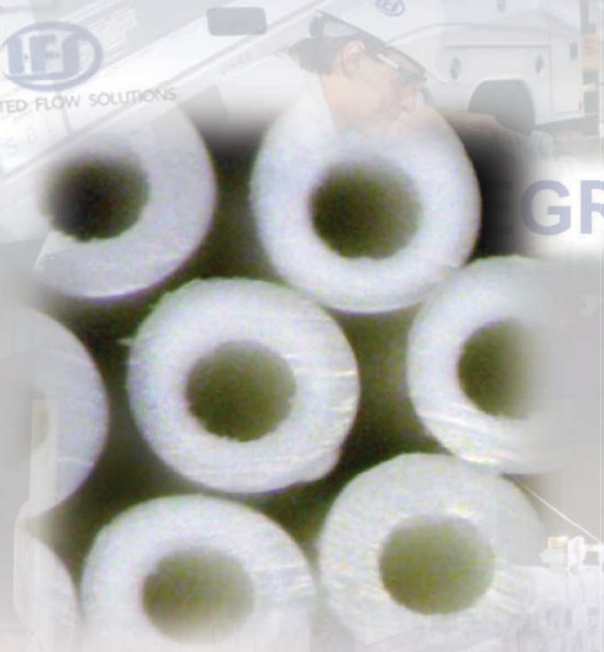


Membrane Operational Dynamics

This illustration shows how fast gases like oxygen and moisture permeate the surface of the individual membrane fibers while nitrogen molecules remain inside and are delivered as the product gas.



Fiber



Every PRISM ® Membrane Separator is filled with thousands of hollow fibers that act as a molecular filter. Though the concept is relatively simple, there is a continuous need for research & development, improvement and reliability…making FIBER production the core competency for PRISM Membranes.

Membrane Fiber Up Close

PA6050 Nitrogen Membrane Product

- High operating temperature (up to 180 F)
- PED and DNV Certified
- Available with N1 or P3 fiber inside
  - P3 has the highest recovery of any membrane on the market

Products and Applications

Nitrogen Generation

- General Inerting in Oil & Gas Industry
- Food storage & transportation
- OBIGGS (inerting on airplanes)
- Tire filling
- Beverage Dispense
- Marine inerting systems
- Oxygen Enriched Air

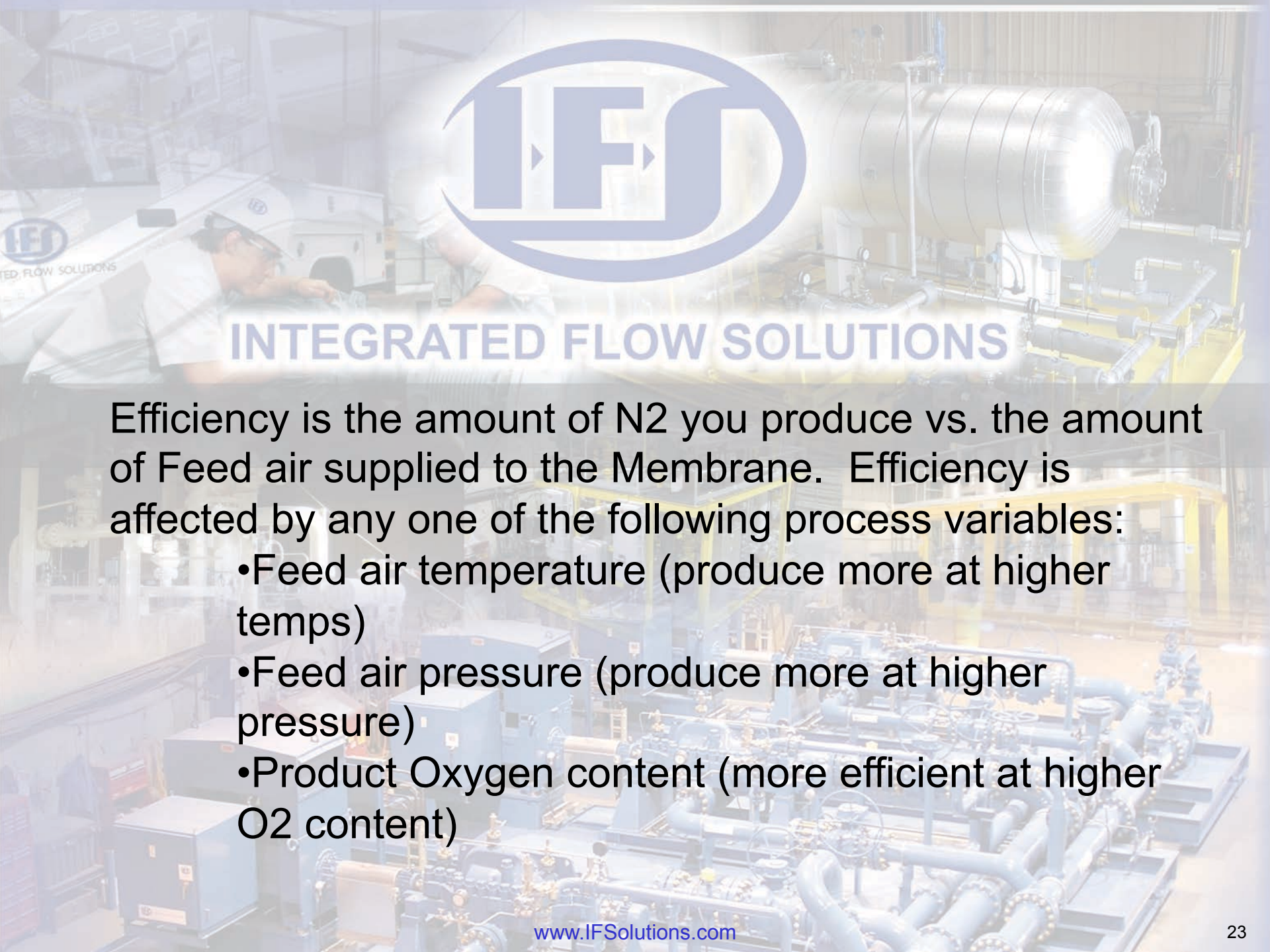
Process Gas Separations

- H2 purification in refineries
- Ammonia plant purge recovery
- Syn Gas ratio adjustment
- Helium purification

Dehydration

- Low pressure clean dry air
- High pressure inter-stage air dehydration applications
- Natural gas dehydration

Control System



Efficiency is the amount of N2 you produce vs. the amount of Feed air supplied to the Membrane. Efficiency is affected by any one of the following process variables:

- Feed air temperature (produce more at higher temps)
- Feed air pressure (produce more at higher pressure)
- Product Oxygen content (more efficient at higher O2 content)

Oxygen Analyzers

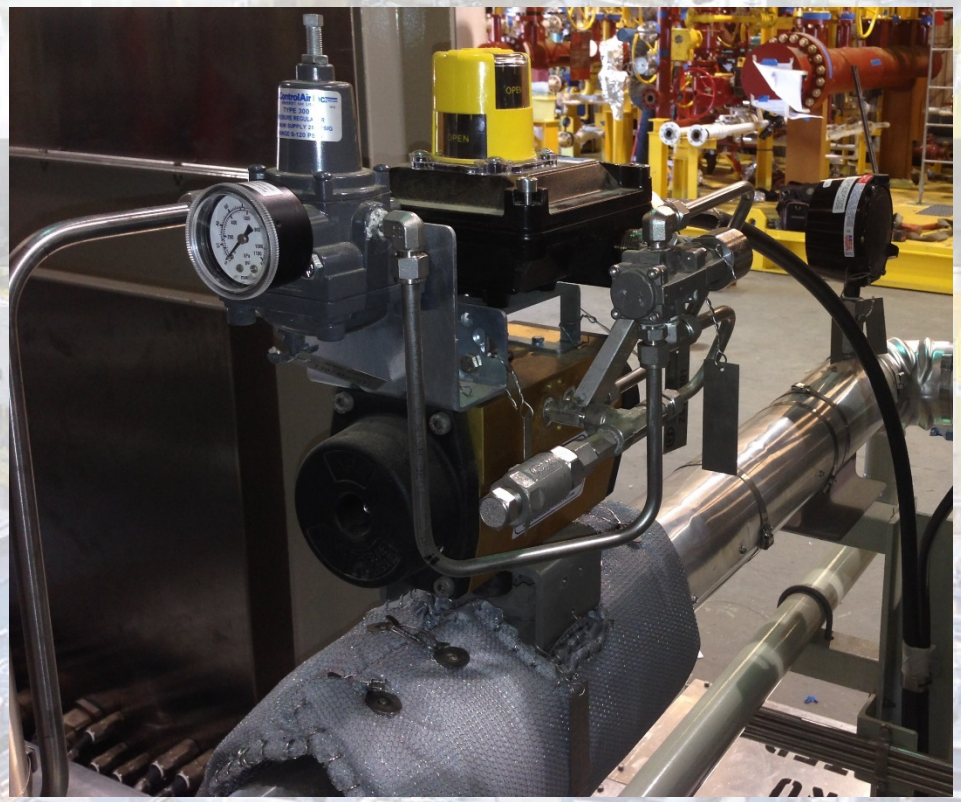
- Zirconium Oxide Type
- Galvanic Fuel Cell Type

Purity Valve

- Works with the Oxygen Analyzer to maintain your set Nitrogen purity

Off-Spec/Product Valve

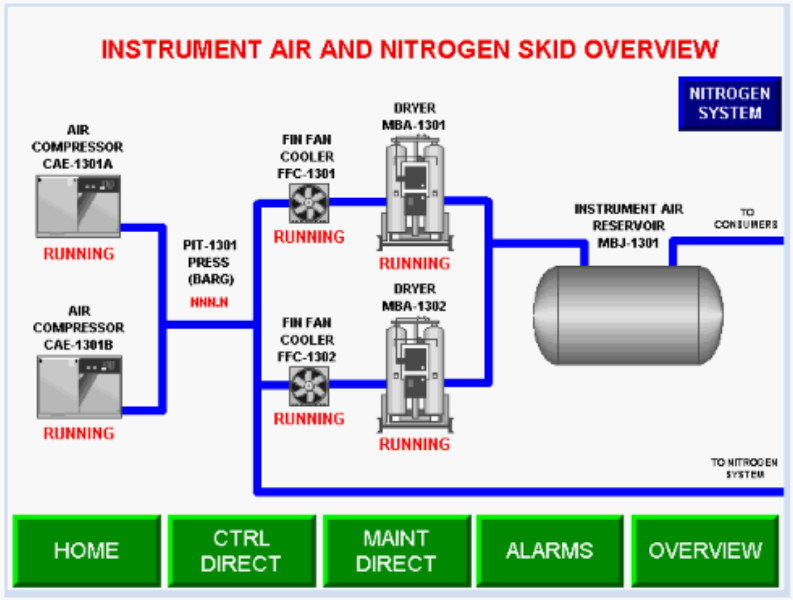
- Automated valves that direct flow of N2 product to process or vent.

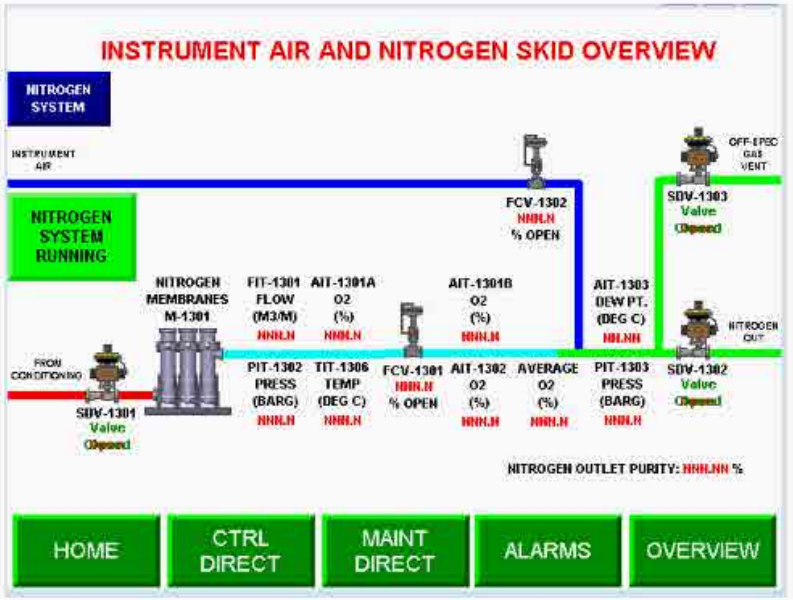


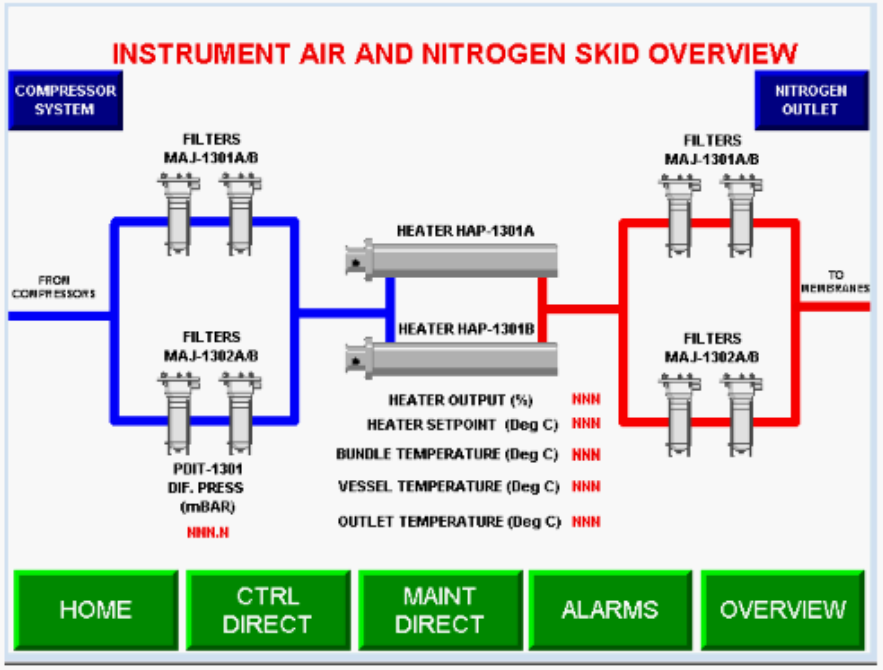
PLC

- Our central brain for Control is an Allen Bradley Compact Logix, but have the capability to meet Project specifications (Siemens, etc)

HMI


INSTRUMENT AIR AND NITROGEN SKID OVERVIEW
NITROGEN SYSTEM
AIR COMPRESSOR CAE-1301A
RUNNING
AIR COMPRESSOR CAE-1301B
RUNNING
PIT-1301 PRESS (BARG)
NNN.N
FIN FAN COOLER FFC-1301
RUNNING
FIN FAN COOLER FFC-1302
RUNNING
DRYER MBA-1301
RUNNING
DRYER MBA-1302
RUNNING
INSTRUMENT AIR RESERVOIR MBJ-1301
TO CONSUMERS
TO NITROGEN SYSTEM
HOME
CTRL DIRECT
MAINT DIRECT
ALARMS
OVERVIEW


INSTRUMENT AIR AND NITROGEN SKID OVERVIEW
NITROGEN SYSTEM
INSTRUMENT AIR
NITROGEN SYSTEM RUNNING
NITROGEN MEMBRANES M-1301
FIT-1301 FLOW (M3/M) NNN.N
AIT-1301A O2 (%) NNN.N
AIT-1301B O2 (%) NNN.N
FCV-1302 NNN.N % OPEN
AIT-1303 DEW PT. (DEG C) NN.NN
OFF-SPEC GAS VENT
SDV-1303 Valve
NITROGEN OUT
FROM CONDITIONING
SDV-1301 Valve
PIT-1302 PRESS (BARG) NNN.N
TIT-1306 TEMP (DEG C) NNN.N
FCV-1301 NNN.N % OPEN
AIT-1302 O2 (%) NNN.N
AVERAGE O2 (%) NNN.N
PIT-1303 PRESS (BARG) NNN.N
SDV-1302 Valve
NITROGEN OUTLET PURITY: NNN.NN %
HOME
CTRL DIRECT
MAINT DIRECT
ALARMS
OVERVIEW


INSTRUMENT AIR AND NITROGEN SKID OVERVIEW
COMPRESSOR SYSTEM
NITROGEN OUTLET
FROM COMPRESSORS
FILTERS MAJ-1301A/B
FILTERS MAJ-1302A/B
PDIT-1301 DIF. PRESS (mBAR) NNN.N
HEATER HAP-1301A
HEATER HAP-1301B
HEATER OUTPUT (%) NNN
HEATER SETPOINT (Deg C) NNN
BUNDLE TEMPERATURE (Deg C) NNN
VESSEL TEMPERATURE (Deg C) NNN
OUTLET TEMPERATURE (Deg C) NNN
FILTERS MAJ-1301A/B
FILTERS MAJ-1302A/B
TO MEMBRANES
HOME
CTRL DIRECT
MAINT DIRECT
ALARMS
OVERVIEW