

## 1.5 MMSCFD PSA Nitrogen Reject Unit - Plant #486



Commissioned 2018

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## General Process Description of PSA Nitrogen Rejection Unit

There are three media adsorption beds in the system that at any one time are undergoing a series of process steps simultaneously. The process steps combine to produce a sales gas that has less than 5 vol % N<sub>2</sub>. The overall hydrocarbon recovery is 95% by volume. These processes each have a unique time interval within an overall bed switching time of 120-240 seconds.

The basic process theory is that the hydrocarbon fraction is adsorbed while the N<sub>2</sub> is not adsorbed and continues through the adsorbing bed to storage to be used later in the cycle. The N<sub>2</sub> is the least likely species to adsorb while the methane adsorbs but at a very low rate. Nonetheless a separation is achieved. The sieve material remains filled with unadsorbed feed gas and intermediate purge gas. The beds are purged with reclaimed re-cycle gas that is almost pure hydrocarbon. After the purge a vacuum from the compressors is applied. The evacuated gas is the sales gas and we typically will compress it to about 270 psig.

The rotating equipment primarily consists of a vacuum compressor and sales gas compressor. A multi circuit air cooler does compressor inter and after cooling and the oil cooling for the compressors.

It is necessary that the feed gas not be heavy in C<sub>3</sub>+ hydrocarbons or otherwise the main adsorption beds will develop a heel that will obstruct adsorption. A basic chiller can be used to remove hydrocarbon and water to minimize obstruction. In some cases it is best to have separate adsorption beds before the main adsorption beds that are periodically regenerated with vacuum. The chiller can be designed to produce a cold feed gas that significantly improves adsorption.

The beds switch functions every 120 to 240 seconds depending on gas analysis and gas flow which requires many valve cycles. These valves need to be kept in good working order.

A programmable controller allows for the valve switching and for adjustment of the cycle times. The cycle times can be changed to match changes in process conditions.

# Operational Sequence PSA Nitrogen Rejection Unit

## I. Pretreatment to remove C3+ Hydrocarbons

1. Feed will pass through the vessel V-8 via line 2 or through vessel V-7 via line 3, which are filled with activated carbon to adsorb C3+. The adsorbed C3+ will be evacuated via line 5A when vessel V-8 is online with feed entering the PSA system or line 4A when vessel V-7 is online with feed entering the PSA system. Valves AV-21(line #2), AV-22(line #4), and AV-25 (line #5A) will be open when vessel V-8 is online or Valves AV-23(line #3), AV-24(line #5) and AV-26 (line #4A), will be open when vessel V-7 is online.

## II. Sequence for Vessel V-4 (Bed A)

1. **Repressurization:** Bed will be repressurized by opening the actuator Valves AV-4 (line#10, inlet to Vessel V-4), AV-16 (line#28, high pressure high N2 gas) and AV-17 (line 25, high pressure Purge receiver)  
**Adsorption:** Before Adsorption the valves AV-16 (line#28, high pressure high N2 gas) and AV-17 (line 25, high pressure Purge receiver) will be closed. Valve AV-1 (line #7, Feed to Vessel-4) and AV-4 (Line #10, vent gas to Vent Tank) are opened for the adsorption cycle to adsorb the CH4 on to the activated carbon.
2. **Depressurization 70 PSIA to 35 PSIA:** Before the depressurization AV-1 and AV-4 will be closed. AV-2 (line #13) and AV-18 (line #16) will be opened to depressurize the vessel V-4 to 35 psia.  
**Purge at 35 PSIA:** AV-2 and AV-18 remains open and AV-5 (line #17, purge entry line) and AV-19 (line #30, sales gas recycle to purge) are opened to purge the un adsorbed feed in the voids and collected in Vessel V-1 purge receiver.  
**Depressurization 35 PSIA to 14.7 PSIA:** Before the depressurization AV-18, AV-19 will be closed and AV-2 will be remained open. AV-27 (line #24) and AV-28 (line #26) will be opened to depressurize the vessel V-4 to 14.7 psia. During depressurization the gases are collected in Vessel V-9, secondary purge receiver.
3. **Vacuum Evacuation:** Before vacuum evacuation Av-2, AV-27 and AV-28 will be closed. AV-3 (Line #20) will be opened to evacuate the adsorbed CH4 on the activated carbon at vacuum of 7 psia.  
**Vacuum System and sale gas compression:** P-1(C-1 oil pump) low pressure lube oil pump will be started to fill the C-1. C-1, after cooler, Inter cooler fans, P-2 (C-2 oil pump), C-2 will be started respectively one after the other for vacuum system and sale gas compression. This system once started will remain operated continuously.

### III. Sequence for Vessel V-5 (Bed B)

- 1. Depressurization 70 PSIA to 35 PSIA:** Before the depressurization AV-6 (Line #8) and AV-9 (Line # 11) will be closed. AV-7 (line #14) and AV-18 (line #16) will be opened to depressurize the vessel V-5 to 35 psia.  
**Purge at 35 PSIA:** AV-7 (Line #14) and AV-18 (line #16) remains open and AV-10 (line #18, purge entry line) and AV-19 (line #30, sales gas recycle to purge) are opened to purge the un adsorbed feed in the voids and collected in Vessel V-1 purge receiver.  
**Depressurization 35 PSIA to 14.7 PSIA:** Before the depressurization AV-18 (line #16) remains open and AV-10 (line #15, purge entry line) and AV-19 (line #30, sales gas recycle to purge) will be closed and AV-7 (line #14) will be remained open. AV-27 (line #24) and AV-28 (line #26) will be opened to depressurize the vessel V-5 to 14.7 psia. During depressurization the gases are collected in Vessel V-9, secondary purge receiver.
- 2. Vacuum Evacuation:** Before vacuum evacuation AV-7 (line #14), AV-27 (line #24) and AV-28 (line #26) will be closed. AV-8 (Line #21) will be opened to evacuate the adsorbed CH<sub>4</sub> on the activated carbon at vacuum of 7 psia. Vacuum system and sales gas compression will be continuous once it is started.
- 3. Repressurization:** Before repressurization AV-7 (Line #21) will be closed. Bed will be repressurized by opening the actuator Valves AV-4 (line#27, inlet to Vessel V-5), AV-16 (line#28, high pressure high N<sub>2</sub> gas) and AV-17 (line 25, high pressure Purge receiver)  
**Adsorption:** Before Adsorption the valves AV-16 (line#28, high pressure high N<sub>2</sub> gas) and AV-17 (line 25, high pressure Purge receiver) will be closed. Valve AV-6 (line #8, Feed to Vessel-5) and AV-9 (Line #11, vent gas to Vent Tank) are opened for the adsorption cycle to adsorb the CH<sub>4</sub> on to the activated carbon.

### IV. Sequence for Vessel V-6 (Bed C)

- 1. Vacuum Evacuation:** Before vacuum evacuation AV-12 (line #15), AV-27 (line #24) and AV-28 (line #26) will be closed. AV-13 (Line #22) will be opened to evacuate the adsorbed CH<sub>4</sub> on the activated carbon at vacuum of 7 psia. Vacuum system and sales gas compression will be continuous once it is started.
- 2. Repressurization:** Before repressurization AV-13 (Line #22) will be closed. Bed will be repressurized by opening the actuator Valves AV-14 (line#12, inlet to Vessel V-6), AV-16 (line#28, high pressure high N<sub>2</sub> gas) and AV-17 (line 25, high pressure Purge receiver)  
**Adsorption:** Before Adsorption the valves AV-16 (line#28, high pressure high N<sub>2</sub> gas) and AV-17 (line 25, high pressure Purge receiver) will be closed. Valve AV-11 (line #9, Feed to Vessel-6) and AV-14 (Line #12, vent gas to Vent Tank) are opened for the adsorption cycle to adsorb the CH<sub>4</sub> on to the activated carbon.

**3. Depressurization 70 PSIA to 35 PSIA:** Before the depressurization AV-11 (Line #9) and AV-14(Line # 12) will be closed. AV-12 (line #15) and AV-18 (line #16) will be opened to depressurize the vessel V-6 to 35 psia.

**Purge at 35 PSIA:** AV-12 (Line #15) and AV-18 (line #16) remains open and AV-15 (line #19, purge entry line) and AV-19 (line #30, sales gas recycle to purge) are opened to purge the un adsorbed feed in the voids and collected in Vessel V-1 purge receiver.

**Depressurization 35 PSIA to 14.7 PSIA:** Before the depressurization AV-18 (line #16) remains open and AV-15 (line #19, purge entry line) and AV-19 (line #30, sales gas recycle to purge) will be closed and AV-12 (line #15) will be remained open. AV-27 (line #24) and AV-28 (line #26) will be opened to depressurize the vessel V-5 to 14.7 psia.

During depressurization the gases are collected in Vessel V-9, secondary purge receiver.

**Note: Following would be the order of the sequence for three beds working simultaneously, Order 1.**

Bed A (V-4) is pressurizing, adsorbing hydrocarbon from feed gas  
Bed B (V-5) is depressurizing and purging  
Bed C (V-6) is evacuating at vacuum.

**Order 2.**

Bed A (V-4) is depressurizing and purging  
Bed B (V-5) is evacuating at vacuum.

Bed C (V-6) is pressurizing, adsorbing hydrocarbon from feed

gas **Order 3.**

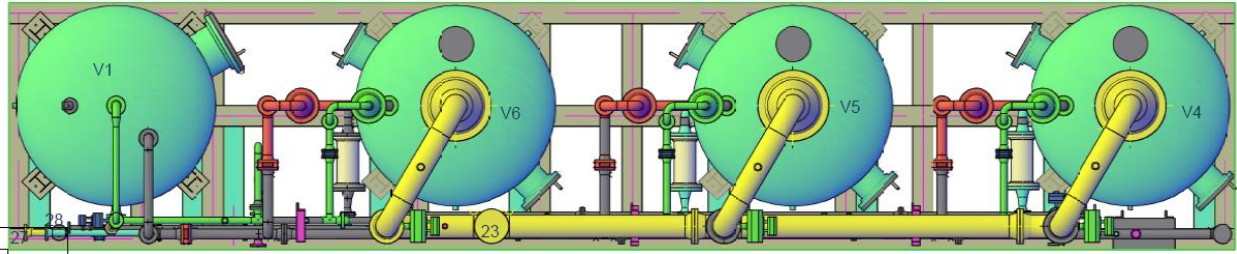
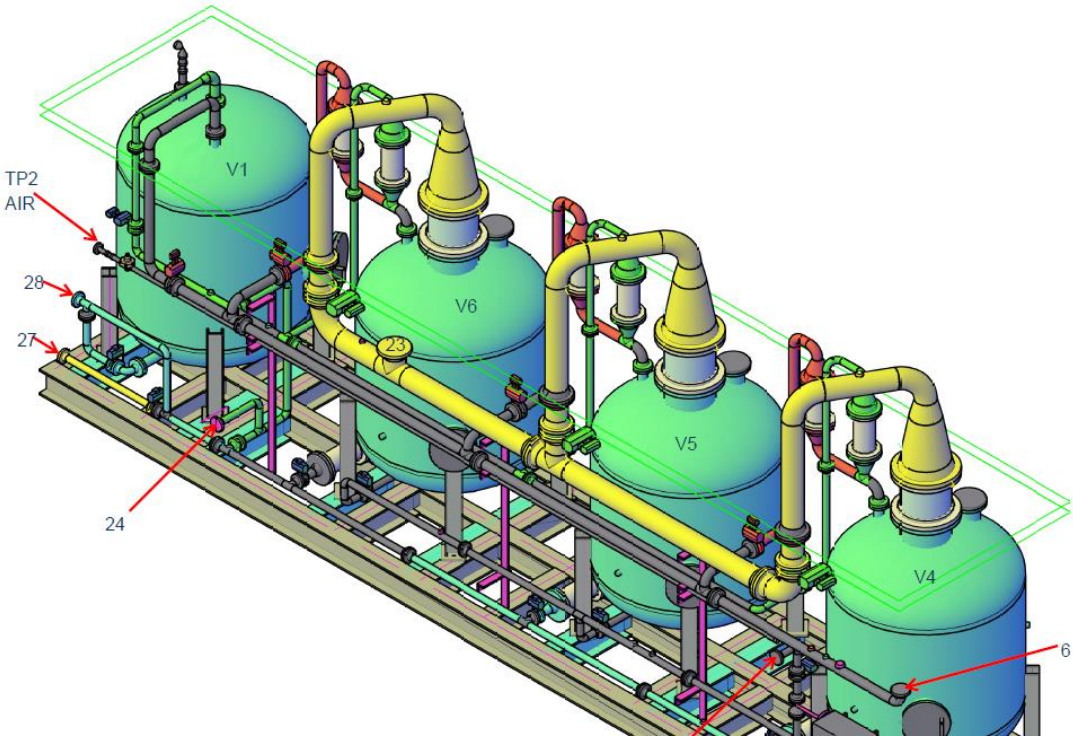
Bed A (V-4) is evacuating at vacuum.

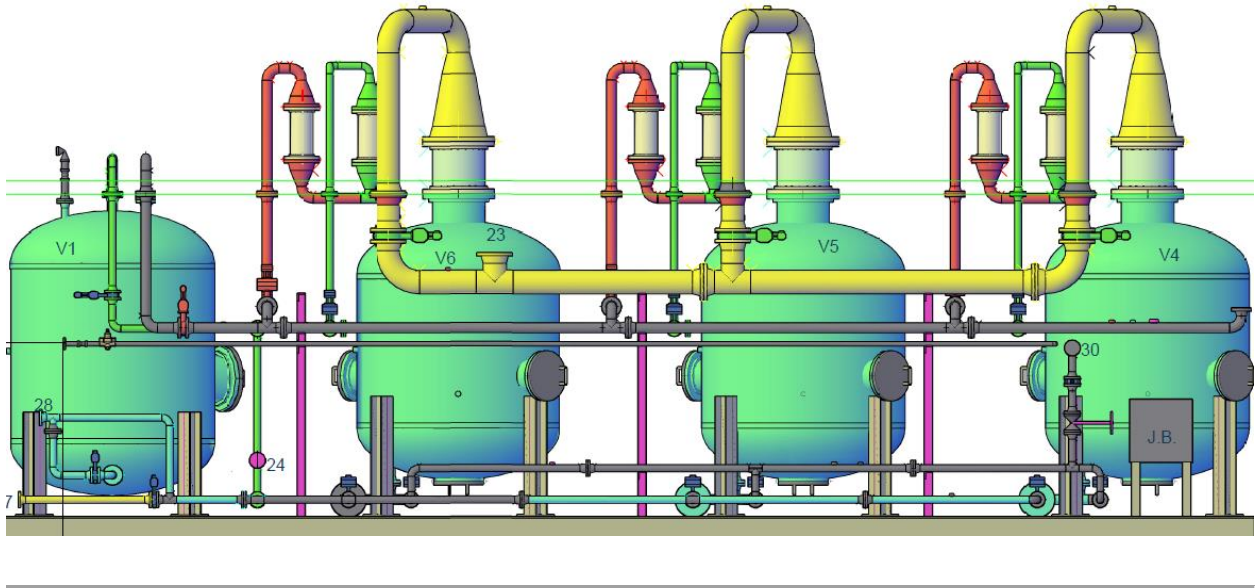
Bed B (V-5) is pressurizing, adsorbing hydrocarbon from feed gas

Bed C (V-6) is depressurizing and purging

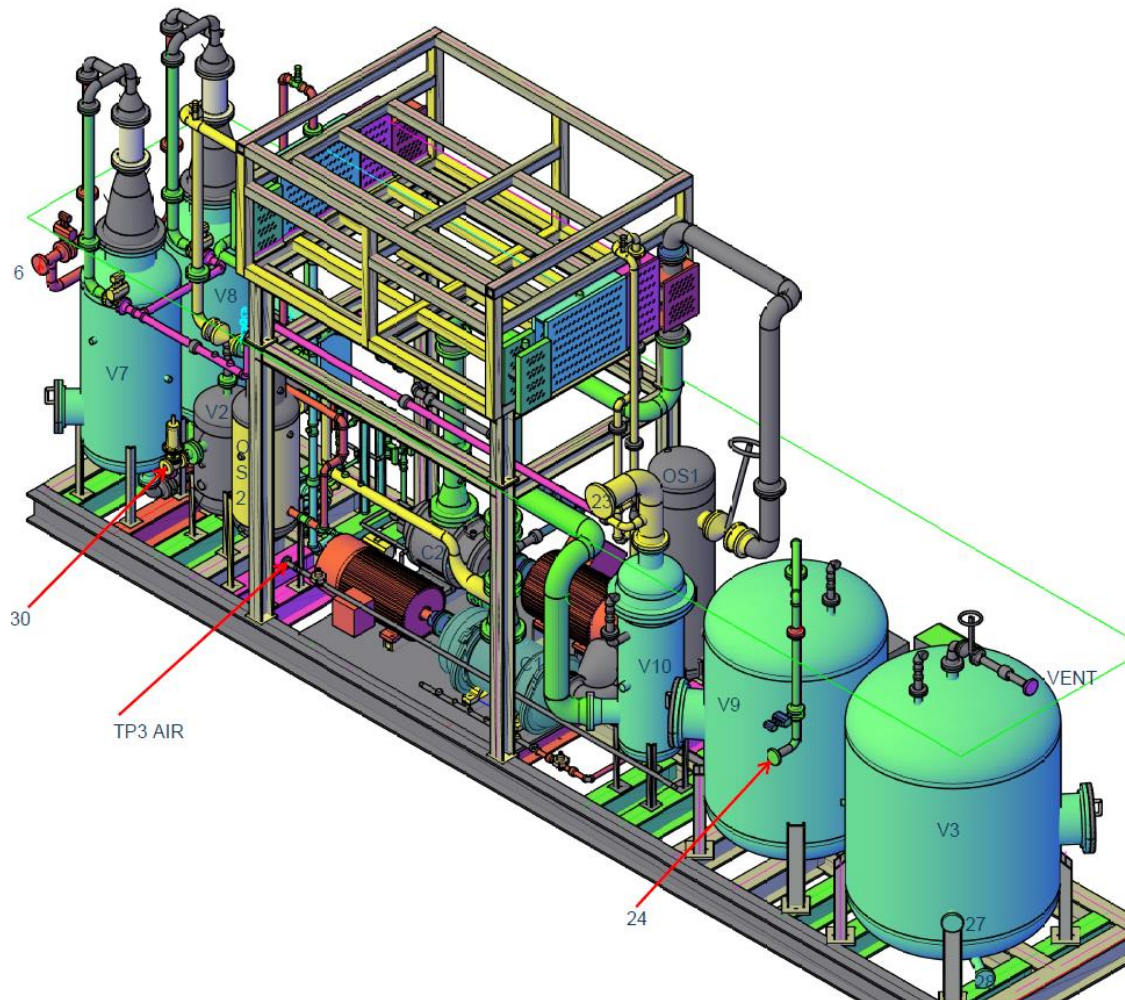
# Skid Layouts:

Skid #1:





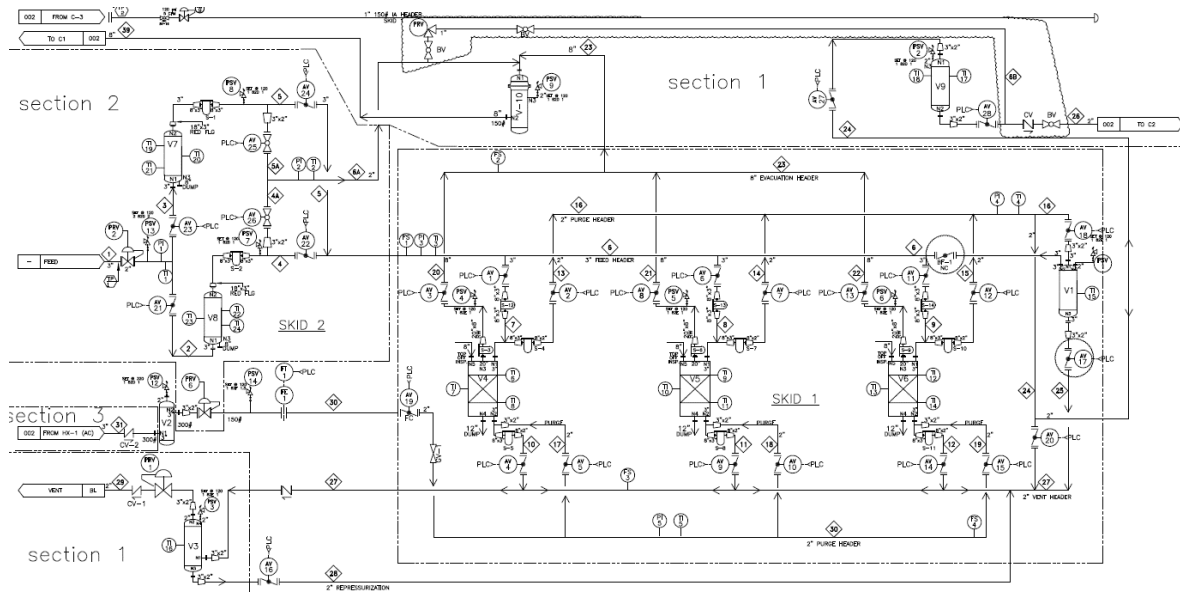
Skid #2



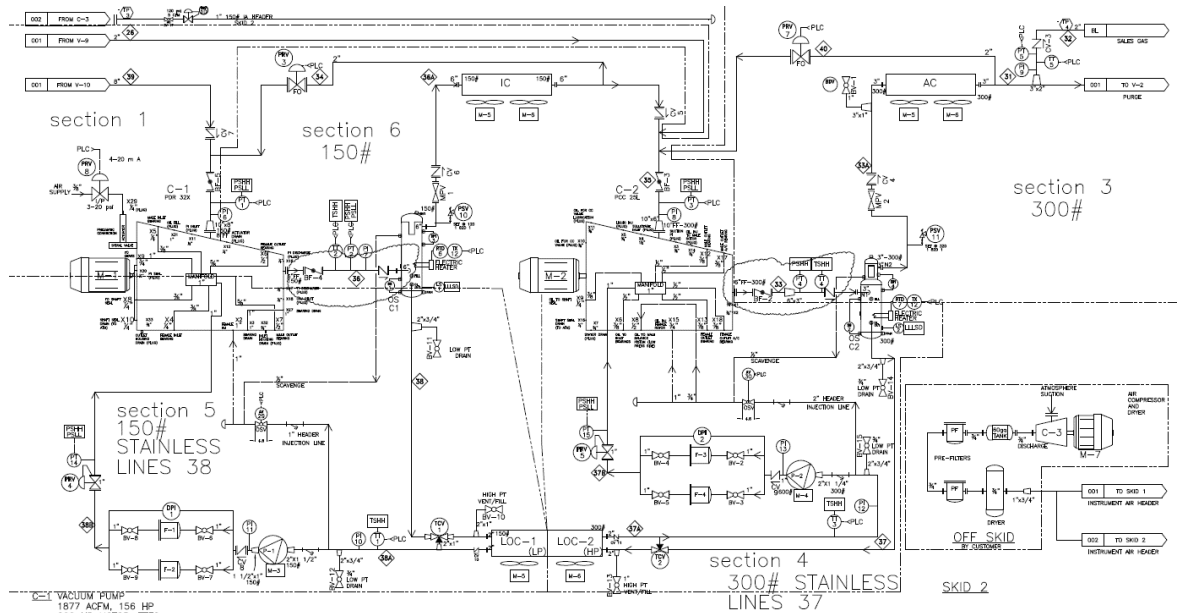




# P&IDs:



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|---|---|---|
| V-1 PURGE RECEIVER<br>DP 120#, 6.5'Ø x 5'-5" S/S    | V-2 PURGE SUPPLY TANK<br>DP 320#, 2'Ø x 2'-4" S/S       | V-7 INLET ADSORBER<br>DP 120#, 3'Ø x 5'-8" S/S    |
| V-4 ADSORPTION VESSEL<br>DP 120#, 6.5'Ø x 4'-7" S/S | V-3 VENT TANK<br>DP 120#, 6.5'Ø x 5'-8" S/S             | V-8 INLET ADSORBER<br>DP 120#, 3'Ø x 5'-8" S/S    |
| V-5 ADSORPTION VESSEL<br>DP 120#, 6.5'Ø x 4'-7" S/S | V-9 SECONDARY PURGE RECEIVER<br>DP 120#, 5.5'Ø x 6" S/S | S-1 - S-14 INLINE BASKET<br>TYPE FILTER STRAINERS |
| V-6 ADSORPTION VESSEL<br>DP 120#, 6.5'Ø x 4'-7" S/S | V-10 SQUON FILTER<br>DP 120#, 2'Ø x 5'-2" F/S           |   |



- |  |                          |                                       |
|--|--------------------------|---------------------------------------|
| C-1 VACUUM PUMP<br>1877 ACFM, 156 HP<br>200 HP MOTOR, TEFC         | F-1 10 MICRON OIL FILTER | M-1 200 HP, 380V/3/50, 1500 RPM, TEFC |
| C-2 SALES GAS COMPRESSOR<br>443 ACFM, 279 HP<br>300 HP MOTOR, TEFC | F-2 10 MICRON OIL FILTER | M-2 300 HP, 380V/3/50, 1500 RPM, TEFC |
| C-3 AIR COMPRESSOR AND<br>DRYER (OFF SKID)                         | F-3 10 MICRON OIL FILTER | M-3 5 HP, 380V/3/50, 3000 RPM, TEFC   |
| CS=C1 C1 OIL SEPARATOR<br>DP 60#, 2' x 5'                          | F-4 10 MICRON OIL FILTER | M-4 5 HP, 380V/3/50, 3000 RPM, TEFC   |
| CS=C2 C2 OIL SEPARATOR<br>DP 320#, 2' x 5'                         | P-1 C1 OIL PUMP          | M-5 10 HP, 380V/3/50, 1000 RPM, TEFC  |
| HX-1 INTERCOOLER, AFTER COOLER<br>OIL COOLER-LP, OIL COOLER-HP     | P-2 C2 OIL PUMP          | M-6 10 HP, 380V/3/50, 1000 RPM, TEFC  |