# Fermilab

## Particle Physics Division

## Mechanical Department Engineering Note

Number: MD-ENG - *077* **Date:** *3/20/05*

Project Internal Reference: ***NMI-019***

Project: ***NuMi***

Title: ***MI-65 Air Compressor II (replacement)***

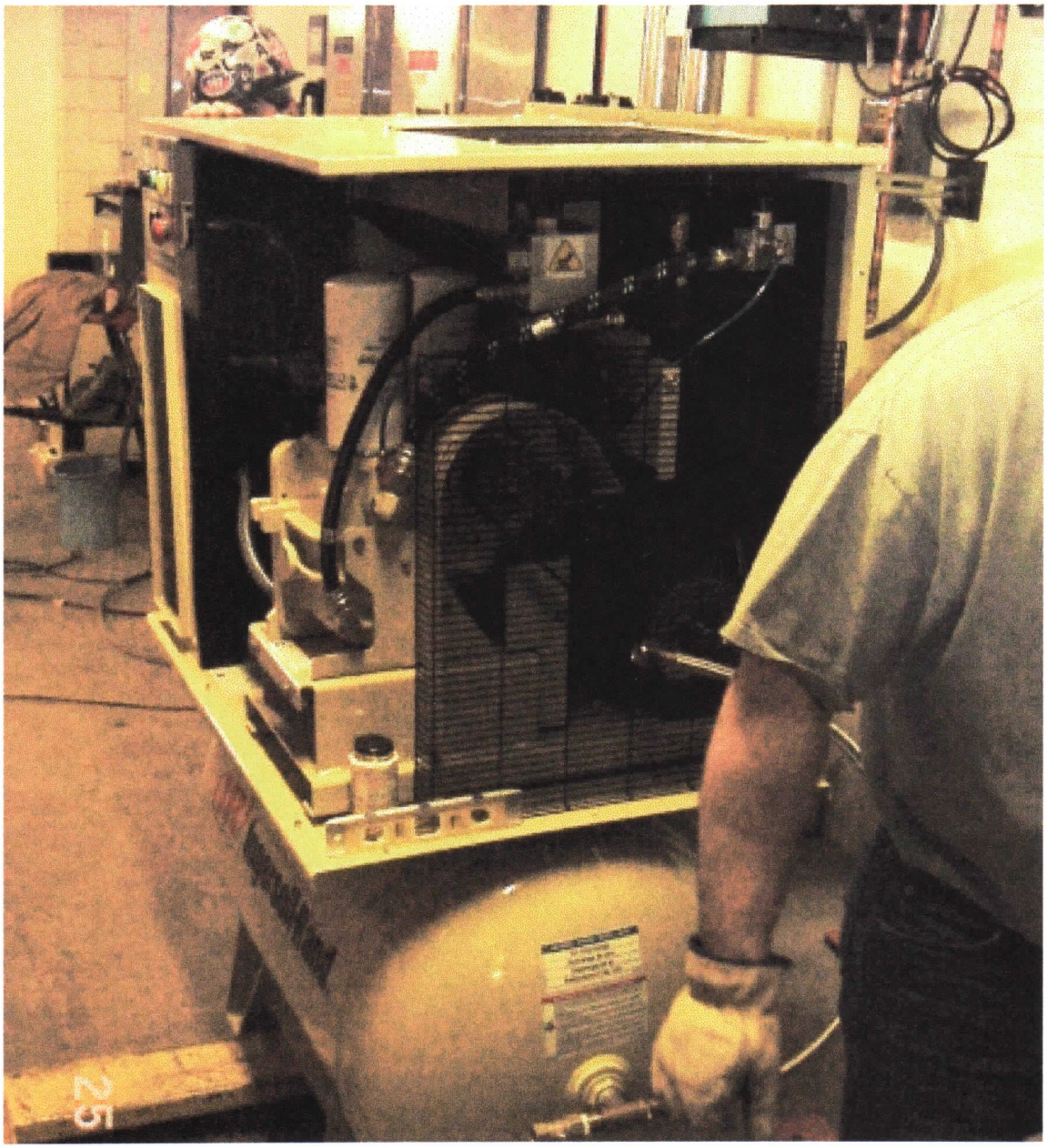
Author(s): ***Ed LaVallie PPD-MD***

Reviewer(s):

Key Words:

Abstract Summary:

Applicable Codes: ***ASME Boiler & Pressure Vessel Code***




***Ingersoll Rand UP6-15c-125 Rotary Screw Compressor @ MI-65 Mechanical Room***

## UP Series 5-15C HP

☑ HP ☑ Capacity cfm ☑ dBA ☑ Dimensions & Weights inches (lbs.)-Base Mount

☑ Dimensions & Weights inches (lbs.)-80 Gallon Tank ☑ Dimensions & Weights inches (lbs.)-120 Gallon Tank

Specifications

| Model | Capacity cfm | dBA | Dimensions & Weights inches (lbs.)-Base Mount | Dimensions & Weights inches (lbs.)-80 Gallon Tank | Dimensions & Weights inches (lbs.)-120 Gallon Tank |
|---|---|---|---|---|---|
| UP6-5-125 | 10.5 | 65 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-5-150 | 16 | 65 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-7-125 | 28 | 65 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-7-150 | 25 | 65 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-7-210 | 17.5 | 65 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-10-125 | 38 | 68 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-10-150 | 34 | 68 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-10-210 | 24 | 68 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-15C-125 | 55 | 69 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-15C-150 | 50 | 69 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |
| UP6-15C-210 | 38 | 69 | 41x28.9x36/650 | 53.6x23.9x60.7/925 | 74.7x28.9x60.7/960 |

*UP6-15c-125 *** 55 CFM Capacity x 14.3/14.7 = 53.6 SCFM*

# ENGINEERING MANUAL

## SSR
## UP SERIES

Ingersoll-Rand

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Page : 98
Date: 15th January 2003
Cancels: 1st Issue

**Point of Manufacture - Campbellsville Facility, Kentucky**
**SSR UP6-15-125 , UP6-15-150 ,**
**60 HERTZ ENGINEERING DATA**

| Model | | 15-125 | 15-150 | |
|---|---|---|---|---|
| **GENERAL COMPRESSOR DATA** | | | | |
| Capacity (Ref. Intake Cond.) FAD (1) | cfm (m³/min) | 65 (1.85) | 58 (1.64) | |
| Maximum Operating Pressure | psig (barg) | 125 (8.5) | 150 (10.3) | |
| Minimum Operating Pressure | psig (barg) | 65 (4.5) | 65 (4.5) | |
| Maximum Operating Temperature | °F ( °C ) | 122 (50) | 122 (50) | |
| Minimum Operating Temperature | °F ( °C ) | 36 (2) | 36 (2) | |
| **SOUND LEVEL (2)** | | | | |
| Base mounted Enclosed | dB(A) | 68 | 68 | |
| **COOLING DATA** | | | | |
| **Air-cooled (Ambient Temperature 104°F/40°C)** | | | | |
| Max Airend Discharge Temperature | °F (°C) | 212 (100) | 212 (100) | |
| A/E Injection Temperature | °F (°C) | 175 (80) | 175 (80) | |
| (3) Aftercooler - Inlet | °F (°C) | 182 (83) | 179 (82) | |
| Aftercooler - Outlet | °F (°C) | 117 (47.2) | 117 (47.2) | |
| Heat Removal Oil Cooler | 1000 Btu/hr (kW) | 47.4 (13.9) | 48.8 (14.3) | |
| Heat Removal Oil and Aftercooler | 1000 Btu/hr (kW) | 60.7 (17.8) | 61.4 (18.0) | |
| Oil Flow | US gpm (lpm) | 2.86 (10.8) | 3.56 (13.5) | |
| Fan Air Flow | cfm (m³/min) | 2100 (59.5) | 2100 (59.5) | |
| Cooling Air CTD | °F (°C) | 24 (13.5) | 24 (13.5) | |
| Aftercooler CTD ( 3 ) | °F (°C) | 13 (7.2) | 13 (7.2) | |
| **CONSTRUCTION FOUNDATION AND MOUNTING DATA** | Base mounted - see installation drawing | | | 22063333 |
| | 120 Gal receiver mounted - see installation drawing | | | 22063366 |
| | 240 Gal receiver mounted - see installation drawing | | | 22063374 |
| **PIPING CONNECTIONS** | | | | |
| Air Discharge Base Mount | Inches NPT | 1.0 | 1.0 | |
| Air Discharge from Receiver | Inches NPT | 1.0 | 1.0 | |
| Coolant Drain | Ball Valve -Inch NPT | ¼ | ¼ | |
| Power Inlet | Inches | 1¼ | 1¼ | |
| **COOLANT LUBRICATION DATA** | | | | |
| Coolant Sump Capacity | US Gal | 1.82 ( 7.0 ) | 1.82 ( 7.0 ) | |
| Total coolant fill capacity | US Gal | 3.38 ( 13.0 ) | 3.38 ( 13.0 ) | |
| **DIMENSIONS** | | Base Mounted | 120 Gal Rec | 240 Gal Rec |
| length, width, height | Inches | 52 / 36 / 42.5 | 77.5 / 36 / 71 | 94 / 36 / 76.5 |
| | mm | 1321/ 914/ 1080 | 1962/ 914/ 1796 | 2390/ 914/ 1940 |
| **SHIPPING DATA - NET WEIGHTS** | | Base Mounted | 120 Gal Rec | 240 Gal Rec |
| | lb. (kg) | 1183 ( 538 ) | 1510 ( 685 ) | 1779 ( 807 ) |

# ENGINEERING MANUAL

## SSR
## UP SERIES

Ingersoll-Rand

Ref.: 9904
Page : 99
Date: 15th January 2003
Cancels: 1st Issue

Point of Manufacture - Campbellsville Facility, Kentucky
SSR UP6-15-125 , UP6-15-150 ,
60 HERTZ ENGINEERING DATA

| Model | | 15-125 | 15-150 |
|---|---|---|---|
| **AIREND DATA** | | | |
| Rotor Diameter ( male ) | inches | 4.21 | 4.21 |
| Male Rotor Speed | rpm | 2335 | 2093 |
| Tip Speed | ft/sec | 42.92 | 38.47 |

| ELECTRICAL DATA - ALL UNITS SSR UP6-20 | | 200v | | 230v | | 460v | | 575v | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal Power - Driver | hp | 15.0 | | 15.0 | | 15.0 | | 15.0 | |
| Rated Power - Fan | hp | Main Motor Driven | | Main Motor Driven | | Main Motor Driven | | Main Motor Driven | |
| Maximum Applied Power - Package | hp | 15.0 | | 15.0 | | 15.0 | | 15.0 | |
| | | ODP | TEFC | ODP | TEFC | ODP | TEFC | ODP | TEFC |
| **Motor Enclosure** | | | | | | | | | |
| Nominal Current - Drive Motor ( 8 ) | Amps | 47.3 | 45.3 | 41.2 | 39.4 | 20.6 | 19.7 | 16.4 | 15.8 |
| Package Current - maximum pressure | Amps | 52.2 | 49.8 | 45.4 | 43.3 | 22.7 | 21.7 | 18.2 | 17.3 |
| Drive Motor RPM | | 1765 | 1770 | 1765 | 1770 | 1765 | 1770 | 1765 | 1770 |
| Drive Motor Frame | | 256TZ | 160 L | 256TZ | 160 L | 256TZ | 160 L | 256TZ | 160 L |
| Drive Motor Full Voltage Locked Rotor ( star ) Amps ( 7 ) | | 336.0 | (150) | 292.0 | (130) | 146.0 | (65) | 117.0 | (52) |
| Drive Motor Efficiency ( 10 ) | | 0.895 | 0.91 | 0.895 | 0.91 | 0.895 | 0.91 | 0.895 | 0.91 |
| Drive Motor Power Factor ( 10 ) | | 0.77 | 0.79 | 0.77 | 0.79 | 0.77 | 0.79 | 0.77 | 0.79 |
| Test certificate number | | TBA | | 23512 | S312282 | 23512 | S312282 | TBA | |
| **Electrical Installation** | | | | | | | | | |
| Mains Supply Cable ( 8 ) | Gage | 4 | 4 | 4 | 4 | 10 | 10 | 10 | 10 |
| Suggested Fuse Rating | Amps | 90 | 90 | 80 | 80 | 40 | 40 | 35 | 35 |

**Notes :**

( 1 ) FAD ( Free Air Delivery ) is full package performance including all losses. Tested in accordance with ISO 1217 : 1996 Annex C.
( 2 ) Measured in free field conditions in accordance with PNEUROP/CAGI test codes, with +/- 3 dB(A) tolerance.
( 3 ) 40% Relative Humidity Inlet Air
( 4 ) Predicted CAT cell data at rated discharge pressure.
( 5 ) Electric motor data relative to applied output power. For comparison, prorata the amps for the duty shaft power against the motor full power current values given.
( 6 ) Motor applied output power, basis 58.7°K temperature rise of stator.
( 7 ) Star Delta Starting Inrush excluding transient spike.
( 8 ) This is a minimum requirement based on 90°C wire - It may be necessary to use larger cables to comply with local regulations or if the voltage drop exceeds 5% of the nominal voltage.
( 9 ) CSA NEC
( 10 ) Measured at nominal motor power

# PRESSURE VESSEL ENGINERING NOTE

## PER CHAPTER 5031

Prepared by: ***Ed LaVallie***
Preparation date: ***3/28/05***

1. Description and Identification
Fill in the label information below:

This vessel conforms to Fermilab ES&H Manual Chapter 5031

Vessel Title: ***MI-65 Compressor II***

***Ingersoll Rand #UP6-15c-125***

***Rotary Screw Compressor***

Vessel Number: ***NMI-019 Compressor*** ←Obtain from Division/ Section Safety Officer

*Original Ingersoll Rand # SS3L3 Compressor*

*NMI-015 will only remain in area during transition*

Vessel Drawing Number: ***None (purchased vessel)***

Maximum Allowable Working Pressures (MAWP):

Internal Pressure: ***225 PSIG***
External Pressure:

Working Temperature Range: ***Reciever Tank common to 125,150,and 210 PSIG Models 20°F(-6.6°C) > 650°F (343°C)***

Contents: ***Compressed Air***

Designer/Manufacturer: ***Ingersoll Rand***

Test Pressure (if tested at Fermi) Acceptance Date: _____ ←Document per Chapter 5034 of the Fermilab ES&H Manual

_____PSIG, Hydraulic_____ Pneumatic _____
Accepted as conforming to standard by

of Division/Section_____ Date:_____ ←Actual signature required

NOTE: Any subsequent changes in contents, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review.

Reviewed by:_____ Date:

Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the chapter.

_____ Date:

| Amendment No.: | Reviewed by: | Date: |
|---|---|---|
| _____ | _____ | _____ |
| _____ | _____ | _____ |

Lab Property Number(s): ***None***

Lab Location Code: ***MI-65 Mechanical Room*** (obtain from safety officer)

Purpose of Vessel(s): ***Operate Pneumatics, Mechanical Room & Tgt. Hall***

Vessel Capacity/Size: ***80 Gal.*** Length: ***53.6"*** Depth ***28.9"*** Height ***60.7"***

Normal Operating Pressure (OP): ***110 PSIG to 125 PSIG***

MAWP-OP = ***125 PSIG (will then be regulated from 90 PSIG > 100 PSIG)***

List the numbers of all pertinent drawings and the location of the originals.

| Drawing # | Location of Original |
|---|---|
| ***None (Purchased Vessel)*** | |
| | |
| | |
| | |
| | |
| | |

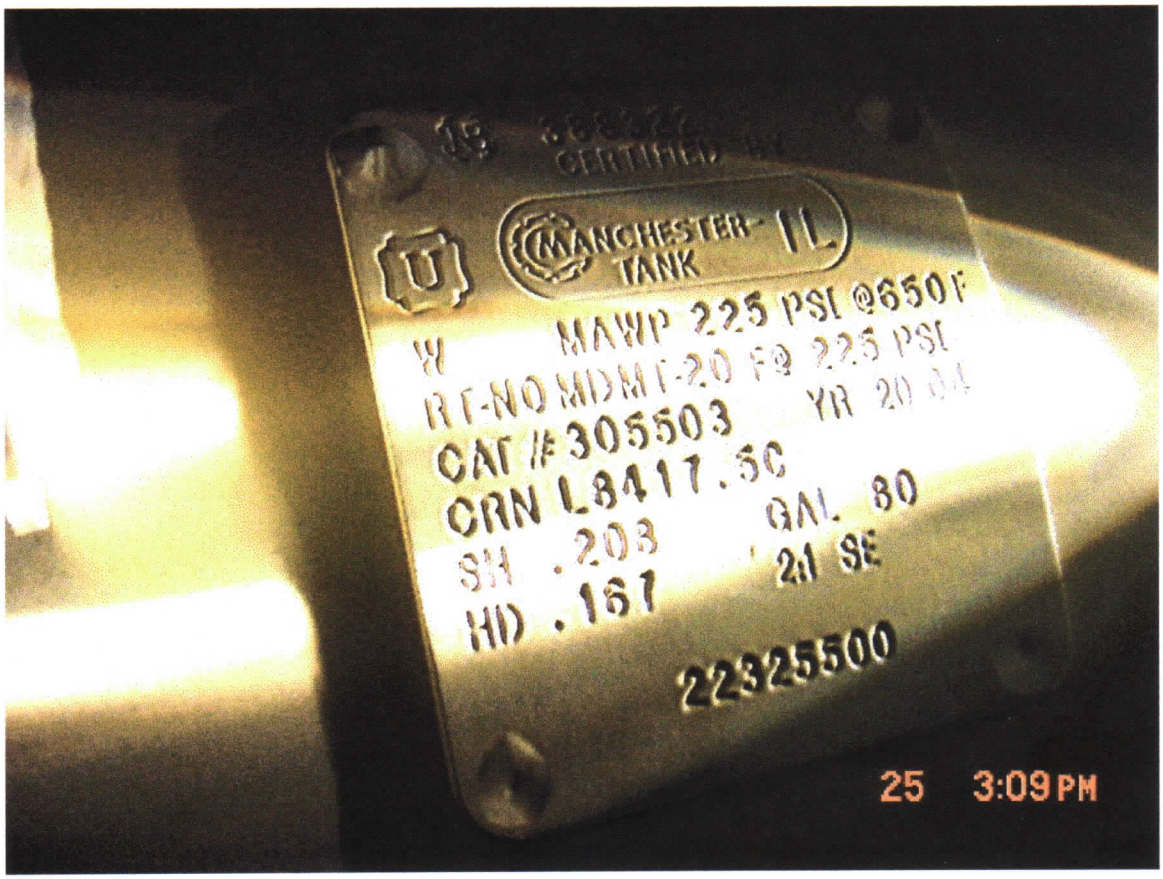
2. Design Verification

Is this vessel designed and built to meet the Code or "In-House Built" requirements?
Yes ***X*** No_____.

If "No" state the standard that was used _____.
Demonstrate that design calculations of that standard have been made and that other requirements of that standard have been satisfied.
Skip to part 3 "system venting verification."

Does the vessel(s) have a U stamp? Yes ***X*** No_____. If "Yes", complete section 2A; if "No", complete section 2B.

A. Staple photo of U stamp plate below.




Copy "U" label data here:

***388322***
***Certified By***
***Manchester Tank***
***MAWP 225PSI @ 650°F***
***RT-NO MDMT-20F @ 225 PSI***
***CAT. #305503 YR. 2004***
***CRN L 8417.5 C***
***SH .208 80 GAL.***
***HD .167 2:1 SE***
***22325500***

Provide ASME design calculations in an appendix. On the sketch below, circle all applicable sections of the ASME code per Section VIII, Division I. (Only for non-coded vessels)

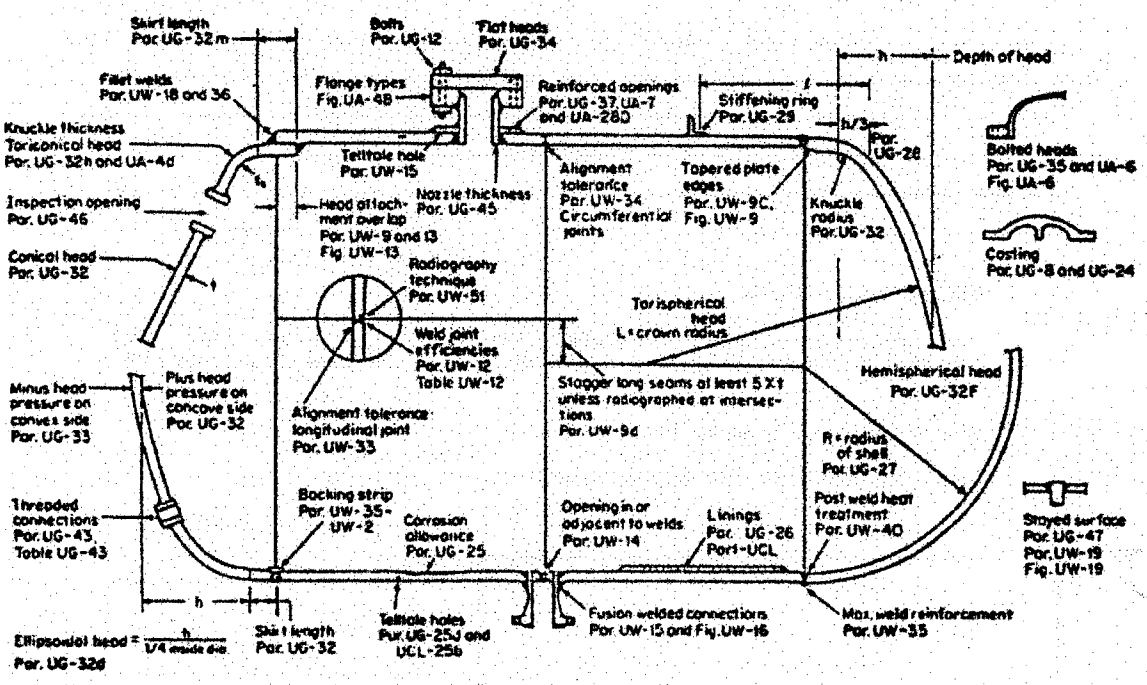



Figure 1. ASME Code: Applicable Sections

**2B.**

Summary of ASME Code

| Item | Reference ASME Code Section | CALCULATION RESULT (Required thickness or stress level vs. actual thickness calculated stress level) |
|---|---|---|
| _____ | _____ | _____vs_____ |
| _____ | _____ | _____vs_____ |
| _____ | _____ | _____vs_____ |
| _____ | _____ | _____vs_____ |
| _____ | _____ | _____vs_____ |

3. System Venting Verification Provide the vent system schematic.

Does the venting system follow the Code UG-125 through UG-137?
Yes ***X*** No___

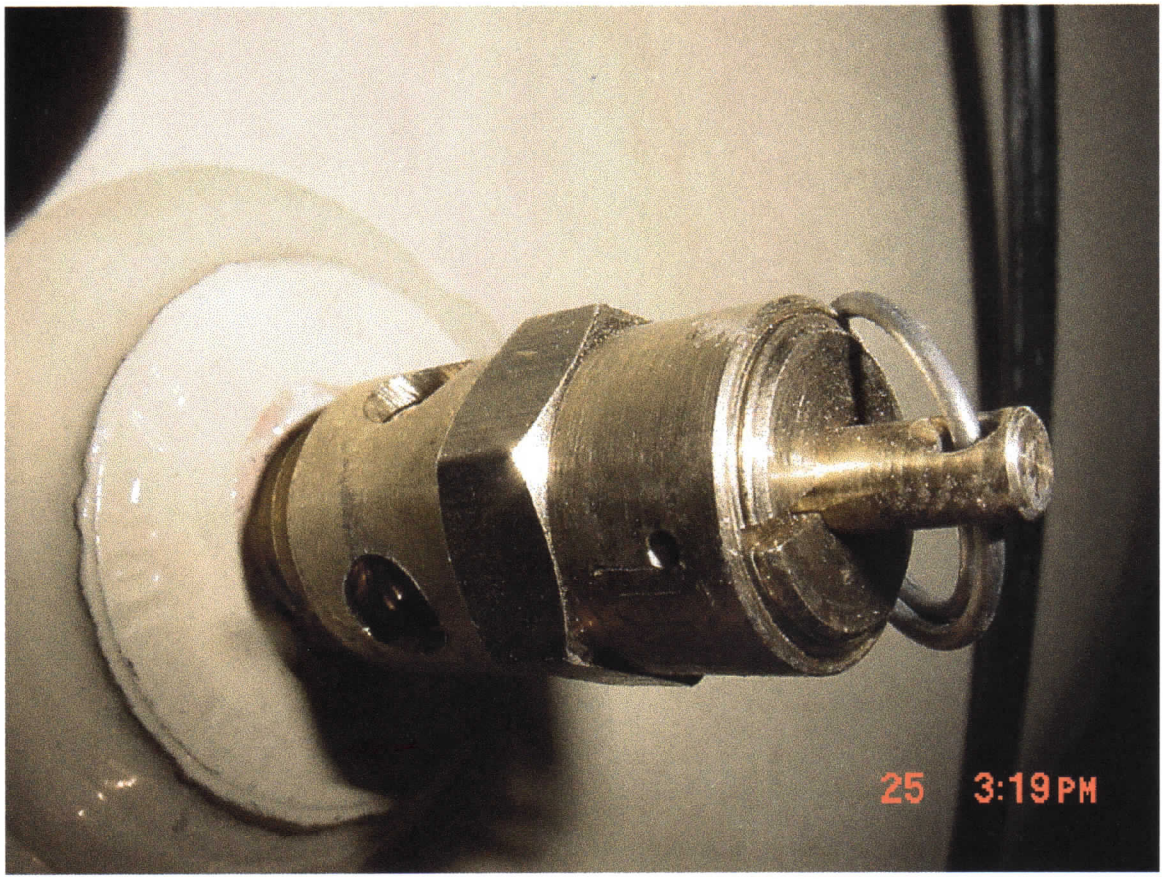
Does the venting system also follow the Compressed Gas Association Standards S-1.1 and S-1.3?
Yes ***X*** No_____

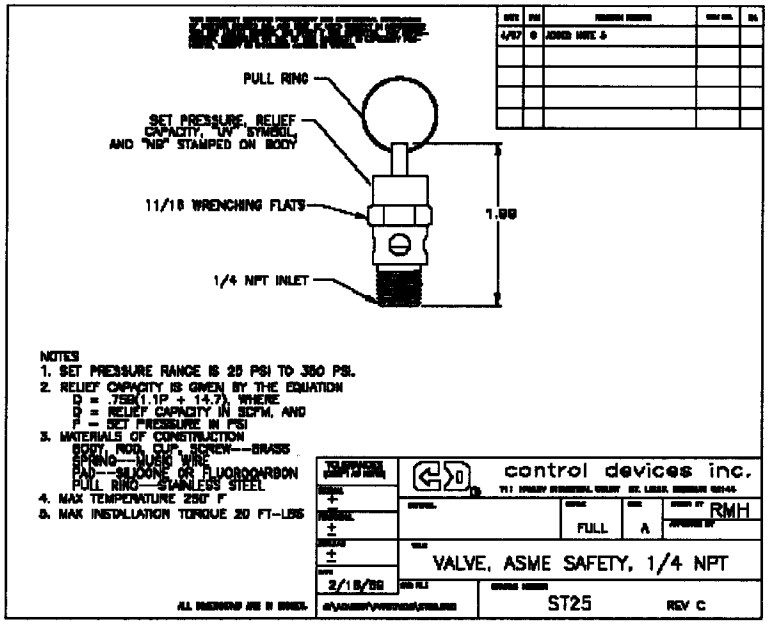
A "no" response to both of the two proceeding questions requires a justification and statement regarding what standards were applied to verify system venting is adequate.

List of reliefs and settings:

| Manufacturer | Model # | Set Pressure | Flow Rate | Size |
|---|---|---|---|---|
| ***CDI Relief Valve*** | ***ST-25*** | ***225 PSI (On Receiver)*** | ***199 SCFM*** | ***¼ NPT*** |
| ***Relief Valve*** | | ***232 PSI (On Compressor)*** | ***205 SCFM*** | ***¼ BSP*** |

***ST-25 Pressure Relief Valve***






$$Q = 0.759(1.1P + 14.7) = 0.759((1.1 \times 225) + 14.7) = 199 \text{ SCFM}$$

***Note: Target Hall Slave Tank NMI-017 (Pressure Relief code stamped 150 PSIG 332 SCFM) OK***

4. <u>Operating Procedure</u>

   Is an operating procedure necessary for the safe operation of this vessel?

   Yes: ***X*** No____ (If "Yes", it must be appended)

5. <u>Welding Information</u>

   Has the vessel been fabricated in a non-code shop? Yes_____ No ***X***

   If "Yes", append a copy of the welding shop statement of welder qualification (Procedure Qualification Record, PQR) which references the Welding Procedure Specification (WPS) used to weld this vessel.

6. <u>Existing, Used and Unmanned Area Vessels</u>

   Is this vessel or any part thereof in the above categories?
   Yes_____ No ***X***

   If "Yes", follow the requirements for an Extended Engineering Note for Existing, Used and Unmanned Area Vessels.

7. <u>Exceptional Vessels</u>

   Is this vessel or any part thereof in the above category?
   Yes_____ No ***X***

   If "Yes", follow the requirements for an Extended Engineering Note for Exceptional Vessels.

**THIS VESSEL CONFORMS TO FERMILAB ES&H MANUAL CHAPTER 5031**

Vessel Title: ***MI-65 Compressor II***

Vessel Number : ***Ingersoll Rand Rotary Screw Compressor UP6-15c-125***

Vessel Drawing Number: ***None (purchased vessel)***

Maximum Allowable Working Pressures (MAWP):

Internal Pressure: ***225 PSIG***

External Pressure:

Working Temperature Range ***20°F (-6.6°C) Min. 650°F (343°C)***

Contents: ***Compressed Air***

Designer: ***None (purchased component)***

Test Pressure (if tested at Fermi) DATE ___/___/_____

_____ _____PSIG, Hydraulic _____Pneumatic _____

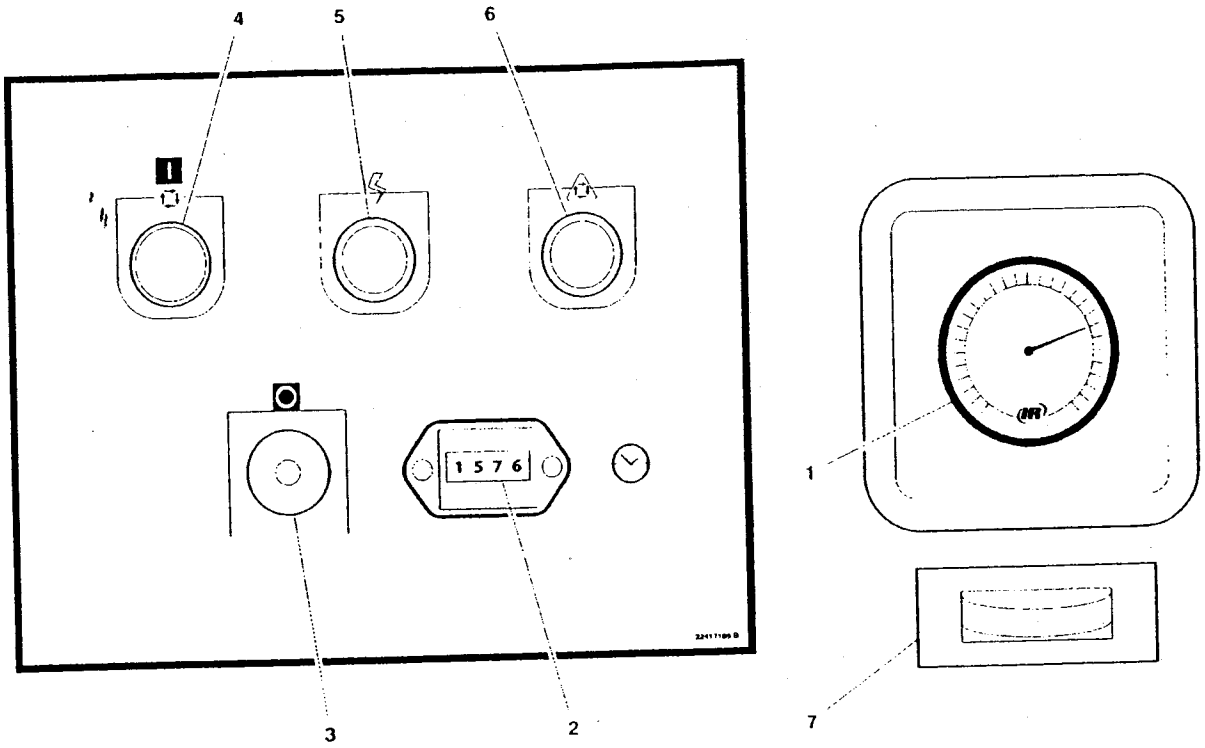
Accepted as conforming to standard by

_____

Of Division/Section _____

NOTE: Any subsequent changes in content, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review and test.

Figure 2. Sample of sticker to be completed and be placed on vessel.




T5972
Revision 02
05/04

1. **PRESSURE GAUGE**
   Indicates the system pressure.

> **WARNING**
> **DO NOT operate the compressor at discharge pressures exceeding the maximum operating pressure.**

2. **HOURMETER**
   Records the total running time of the compressor.

3. **STOP BUTTON / E-STOP**
   When depressed will stop the compressor immediately. The 'Power on' indicator will remain illuminated. The STOP button must be released before the compressor can be restarted.

4. **ON PUSH BUTTON SWITCH**
   When depressed will cause the unit to start and run in a loaded condition if there is a demand for air. If there is no demand, the machine will stop automatically.

5. **POWER ON INDICATOR LIGHT (Green)**
   Indicates the presence of control voltage.

6. **STOPPED/AUTO RESTART INDICATOR LIGHT (Amber)**
   Will illuminate when the machine has shut-down due to low air demand. The machine will restart and load automatically as soon as the demand for air returns.

7. **DEW POINT INDICATOR (Dryer Option)**
   Green indicates good dew point. Red indicates dew point above 50°F (10°C) Blue indicates freezing.

## PRIOR TO STARTING

1. Make visual check of the machine, ensure that all guards secure and that nothing is obstructing the proper ventilation of, or free access to the machine.

2. Check coolant level. Add if necessary.

3. Make sure air discharge valve is open.

4. Turn on electrical isolator or disconnect. The **Power on** (5) indicator will light, indicating that line and control voltages are available.

5. Check direction of rotation at initial start or following interruption in power supply.

> **WARNING**
> **Make sure that all protective covers are in place.**
> **Cooling air flow exhaust may contain flying debris. Safety protection should be worn at all times to avoid injury.**

## STARTING

1. Press the START button. The compressor will start and then load automatically.

## NORMAL/EMERGENCY STOPPING

1. Press STOP button (3) and the compressor will stop immediately.

2. Turn off electrical isolator or disconnect.

> **CAUTION**
> **After shutdown never allow unit to stand idle with pressure in receiver/separator system.**

## COMPRESSOR CONTROLS

**Direct online starting:**

The compressor is equipped for Automatic Start & Stop Control. When the receiver tank pressure reaches the factory pre-set maximum pressure, the pressure switch stops the unit. When the receiver tank pressure drops below the factory pre-set minimum. The pressure switch resets and restarts the unit.

The pressure switch cover can be removed by unscrewing the two screws holding the cover.

**Pressure switch adjustment:**

The compressor package will cut-in and cut-out at factory preset pressure settings. Adjust the pressure switch only if absolutely necessary.

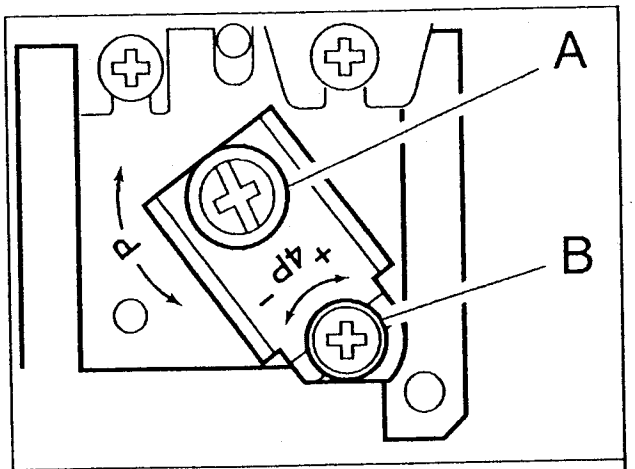
Adjustments are to be carried out only when the switch is mounted, under pressure and voltage-free.

**WARNING**
High voltage is present at the pressure switch contacts when the power supply is connected. Disconnect, lock and tag main power supply before making adjustments.

**WARNING**
Do not adjust the pressure switch to exceed the maximum discharge pressure of the unit

**NOTE**
When replacing the pressure switch cover, ensure the selector knob on the cover and the lever on the switch are both in the "OFF" position.

**NOTE**
When the compressor is equipped with the optional dryer and filters, the pressure switch differential should be increased 10psi to account for the added pressure drop of the filters and dryer.




A. Upper Pressure Setting

B. Pressure Differential

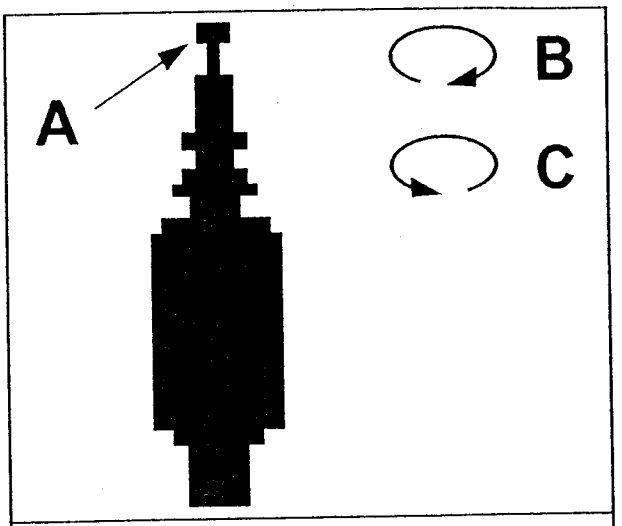
## AUTOMATIC START & STOP CONTROL

**NOTE**
Automatic Start & Stop Control is intended for use when the motor will start no more than 6 times per hour.

When the receiver tank pressure reaches the factory pre-set maximum pressure, the pressure switch stops the unit. When the receiver tank pressure drops below the factory pre-set minimum, the pressure switch resets and restarts the unit.

## DUAL CONTROL

Select either automatic start and stop control or constant speed control by adjusting the knob on the auxiliary valve. For automatic start and stop control, turn the knob on the auxiliary valve fully clockwise to disable the auxiliary valve. The pressure switch will then start and stop the unit.




**Auxiliary Valve.**

A. Knob

B. Clockwise

C. Counterclockwise

Select constant speed control if the unit restarts in less than 10 minute intervals or runs more than 40 minutes per hour. Turn the knob fully counterclockwise to run the unit continually.

**NOTE**
The auxiliary valve is factory pre-set at 5 psig (0,3 bar) lower than the factory pressure switch setting.

**CAUTION**
Running unloaded with no air demand, will cause the unit to be shut off by the pressure switch.

## GENERAL OPERATION

The compressor is an electric motor driven, single stage screw compressor, complete with accessories piped, wired and baseplate mounted. It is a totally self contained air compressor package.

The standard compressor is designed to operate in an ambient range of 35.6°F – 104°F (2°C to 40°C). The maximum temperature is applicable to either version up to a maximum elevation of 3280ft (1000m) above sea level. Above this altitude significant reduction in maximum allowable ambient temperature is required.

Compression in the screw type air compressor is created by the meshing of two (male & female) helical rotors.

The air/coolant mixture discharges from the compressor into the separation system. This system removes all but a few PPM of the coolant from the discharge air. The coolant is returned to the cooling system and the air passes through the aftercooler and out of the compressor.

Cooling air is moved through the coolers by the cooling fan and discharged from the machine.

CAUTION
**Cooling air is drawn in at the end of the machine package passing through the filter and cooler before being discharged from the top of the machine. Care should be taken to avoid blocking the airflow, or causing any restriction in excess of the maximum backpressure allowed for ducting.**
**Do not direct the airflow at face or eyes.**

By cooling the discharge air, much of the water vapour naturally contained in the air is condensed and may be drained from the downstream piping and equipment.

The coolant system consists of a sump, cooler, thermostatic valve and a filter. When the unit is operating, the coolant is pressurized and forced to the compressor bearings.

The compressor load control system is automatic **on–off line**. The compressor will operate to maintain a set discharge line pressure and is provided with an auto restart system for use in plants where the air demand varies sufficiently to allow a compressor to shut down and save power. Significant system volume will assist this and is recommended.

When the compressor is equipped with the optional dryer, the dryer will cycle on and off with the compressor.

WARNING
**When the unit stops running as the result of low air demand, normally indicated by auto restart light, it may restart and return to load at any time.**

Safety of operation is provided as the compressor will shut down if excessive temperatures or electrical overload conditions should occur.

CAUTION
**This unit is not designed or intended to operate when contaminated with silicone. Lubricants, greases or other items containing silicone should not be used on this unit.**