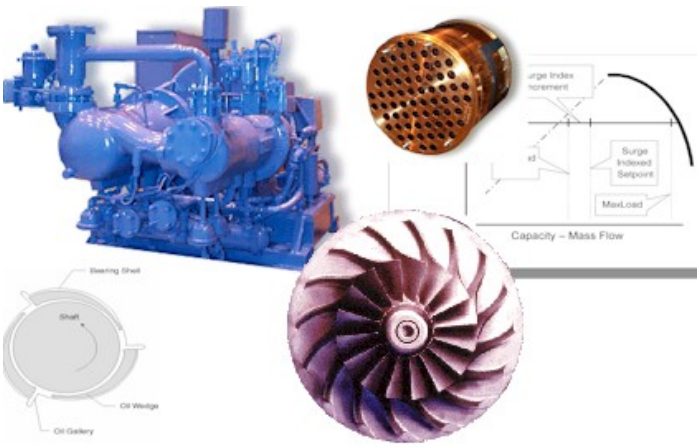
OPERATION & MAINTENANCE MANUAL

CENTAC Models



Ingersoll-Rand - Air Solutions Heavy Industrial Systems
Strada Statale Cassanese, 108 20060 Vignate (MI), Italy

Index

1 Data sheet

General

- **FRAME** . . . . . .
- **MODEL** . . . . . .
- **GAS TYPE (note 1)** . . . . . A

  (Air = "A", Nitrogen = "N")
- **AREA (Safe, Classified)** . . . . . S

  (Safe= "S", Classified = "H")
- **AREA CLASSIFICATION** . . . . . .

  (for Classified Area only)
- **SERIAL NUMBER** . . . . . .
- **ORDER NUMBER** . . . . . .
- **CUSTOMER** . . . . . .
- **DESTINATION COUNTRY** . . . . . .
- **“PED” UNIT** . . . . . Y

  (Yes = “Y”, No = ”N”)
- **QUANTITY SUPPLIED** . . . . . .
- **MANUFACTURING YEAR** . . . . . .
- **OVERALL DIMENSIONS**
  - **LENGTH** . . . . . .
  - **WIDTH** . . . . . .
  - **HEIGHT** . . . . . .
- **"PACKAGE" TOTAL WEIGHT** . . . . . .
- **WEIGHT W/O MAIN DRIVER"** . . . . . .
- **MAIN DRIVER WEIGHT"** . . . . . .
- **NOISE LEVEL (SOUND PRESSURE), db(A)** . . . . . .
- **SILENCED UNIT (WITH SOUND ENCLOSURE)** . . . . . Y

  (Yes = “Y”, No = ”N”)

		ALLOWED FORCES AND MOMENTS					
CONNECT. TYPE	DIAM. (Inches)	AXIAL		VERTICAL		HORIZONTAL	
		Force Kg	**Moment** Kg x m	**Force** Kg	**Moment** Kg x m	**Force** Kg	**Moment** Kg x m
Input							
By-Pass							
Delivery							

Compressor performance characteristics

- **BAROMETRIC PRESSURE** . . . . . .
- **INPUT PRESSURE** . . . . . .
- **INPUT TEMPERATURE** . . . . . .
- **RELATIVE HUMIDITY** . . . . . .
- **OPERATIONAL PRESSURE** . . . . . .
- **MAXIMUM PERMISSIBLE PRESSURE**. . . . . .

  (only for PED Unit)
- **MINIMUM AND MAXIMUM PERMISSIBLE TEMPERATURE** . . . . . .

  (only for PED Unit)
- **INPUT FLOW RATE** . . . . . .
- **DELIVERY FLOW RATE**. . . . . .
- **COOLING WATER TEMPERATURE** . . . . . .
- **ABSORBED POWER**. . . . . .
- **MAIN DRIVER NAMEPLATE POWER** . . . . . .
- **RATED SPEED** . . . . . .
- **COLD TEMPERATURE DIFFERENCE (CTD), °C**

  (Difference between output air temperature and input water temperature)
  - **CTD 1st stage** . . . . . .
  - **CTD 2nd stage** . . . . . .
  - **CTD 3rd stage** . . . . . .
  - **CTD 4rd stage** . . . . . .
  - **CTD 5rd stage** . . . . . .
- **EXCHANGED HEAT, Kcal/h**
  - **1st stage**. . . . . .

- **2nd stage . . . . . .**
- **3rd stage . . . . . .**
- **4rd stage . . . . . .**
- **5rd stage . . . . . .**
- **Oil coolant . . . . . .**

- **GUARANTEED TOLERANCES**
  - **ON FLOW RATE, % . . . . . .**
  - **ON SPECIFIC CONSUMPTION, % . . . . . .**

Cooling water characteristics

- **MAXIMUM INPUT TEMPERATURE . . . . . .**
- **MINIMUM PRESSURE . . . . . .**
- **MAXIMUM PRESSURE . . . . . .**
- **RATED FLOW RATE (oil coolant included), Liters/min . . . . . .**
- **MAXIMUM PRESSURE DROP BETWEEN INPUT AND OUTPUT . . . .**
- **ΔT BETWEEN INPUT AND OUTPUT . . . . . .**

Lubrication characteristics

- **TANK CAPACITY, liters . . . . . .**
- **OIL INPUT PRESSURE . . . . . .**
- **OIL INPUT TEMPERATURE . . . . . .**
- **OIL MINIMUM PRESSURE UPON STARTING . . . . . .**
- **OIL MINIMUM TEMPERATURE UPON STARTING. . . . . .**

Vibration limits

	Radial X	Radial Y	Axial Z
• **1ST STAGE**			
- Alarm			
- Block			
• **2ND STAGE**			
- Alarm			
- Block			
• **3RD STAGE**			
- Alarm			
- Block			
• **4TH STAGE**			
- Alarm			
- Block			
• **5TH STAGE**			
- Alarm			
- Block			

Main driver

In case of electric motor driven compressor

- **MANUFACTURER** . . . . . .
- **POWER** . . . . . .
- **SPEED, rpm** . . . . . .
- **SERVICE FACTOR** . . . . . .
- **VOLTAGE, VOLTS** . . . . . .
- **FREQUENCY, Hz** . . . . . .
- **PROTECTION DEGREE** . . . . . .
- **INSULATION CLASS.** . . . . . .
- **TEMPERATURE CLASS** . . . . . .
- **SUPPLIED BY INGERSOLL-RAND** . . . . . .

  (Yes = "Y", No = "N")

In case of turbine driven compressor

- **MANUFACTURER** . . . . . .
- **POWER** . . . . . .
- **SPEED, rpm** . . . . . .
- **MAXIMUM SPEED, rpm** . . . . . .
- **STEAM FLOW** . . . . . .

  (Design; Maximum; Minimum)
- **INPUT STEAM FLOW TEMPERATURE** . . . . . .

  (Design; Maximum; Minimum)
- **OUTPUT STEAM FLOW TEMPERATURE** . . . . . .

  (Design; Maximum; Minimum)
- **INPUT STEAM PRESSURE** . . . . . .

  (Design; Maximum; Minimum)
- **OUTPUT STEAM PRESSURE** . . . . . .

  (Design; Maximum; Minimum)
- **SUPPLIED BY INGERSOLL-RAND** . . . . . .

  (Yes = "Y", No = "N")

Controls

- **PANEL TYPE** . . . . . .
- **VOLTAGE, Volts** . . . . . .
- **PROTECTION DEGREE** . . . . . .
- **MANUFACTURER** . . . . . .
- **SUPPLIED BY INGERSOLL-RAND** . . . . . .

  (Yes = "Y", No = "N")

Electric Components characteristics

	No.	Volt	kW/HP
• **PRE/POST LUBRICATION PUMP MOTOR**			
• **HEATER/S OIL**			
• **OIL VAPOR EXTRACTION FAN MOTOR** (where PROVIDED)			
• **SAND EXTRACTION MOTOR FOR INRTIAL FILTER** (where PROVIDED)			
• **FAN MOTOR FOR SOUND ABSORBING HOUSING** (for models where contemplated)			

Minimum recommanded spare parts

Description	Quantity	Part Number
• **Absolute air filter**		
• **Air prefilter**		
• **Oil filter cartridge**		
• **Oil fume separator cartridge**		
• **Lubrificant barrel (5 gallons)**		
• **Lubrificant barrel (55 gallons)**		

 **NOTE**	**Note 1: For Nitrogen compressors, all references to the term “air” must be read as “Nitrogen”.**

2 Safety precautions. Read carefully before installing the compressor

In any work concerning the operation, conversion or adjustment of the machine and its safety devices or any work related to maintenance, inspection and repair, always observe the start-up and shut-down procedures set out in the operating instructions and the information on maintenance work.

	**BEFORE YOU OPERATE, MAINTAIN OR IN ANY OTHER WAY OPERATE THIS UNIT: READ and STUDY this manual. KNOW how to safely use the unit's controls and what you must do for safe maintenance.**
NOTE	

The machine has been built in accordance with state-of-the-art standards and the recognized safety rules.

ALWAYS wear or use the proper safety items required for your personal protection. For reasons of security, long hair must be tied back or otherwise secured, garments must be close, fitting and no jewellery - such as rings- may be worn. Injury may result from being caught up in the machinery or from rings catching on moving parts.

If you have ANY QUESTIONS about safety or maintenance procedures not included in this manual, ASK YOUR SUPERVISOR OR CONTACT ANY INGERSOLL-RAND OFFICE OR QUALIFIED INGERSOLL-RAND DISTRIBUTOR. NEVER GUESS, ALWAYS CHECK.

Never make any modifications, additions or conversions which might affect safety without the supplier's approval. This also applies to the installation and adjustment of safety devices and valves as well as to welding work on load-bearing elements.

LOOK FOR THESE SYMBOLS WHICH POINT OUT ITEMS OF EXTREME IMPORTANCE TO YOU AND YOUR CO-WORKERS' SAFETY, READ AND UNDERSTAND THOROUGHLY, READ THE DANGERS, WARNINGS, CAUTIONS AND NOTES AND FOLLOW THE INSTRUCTIONS.

	**DANGER is used to indicate the presence of an immediate hazard which WILL result in SEVERE personal injury or death.**
DANGER	

 **CAUTION**	**WARNING is used to indicate the presence of a hazard or unsafe practice which could result in SEVERE personal injury or death.**

 **WARNING**	**CAUTION is used to indicate the presence of a hazard or unsafe practice which could result in MINOR personal injury or product or property damage.**

 **NOTE**	**NOTE is used to indicate an important installation, operation, or maintenance information.**

 **CAUTION**	**This manual contains instructions for installation, operation and maintenance of your INGERSOLL-RAND Centrifugal compressor which has been designed to provide safe and reliable service. However, remember that the unit is a rotating machinery with pressure system. Therefore, the operator(s) must exercise good judgement and proper safety practices to avoid damage to the equipment and surroundings and prevent personal injury. The instructions in this manual are intended for personnel with a general training in operation and maintenance of centrifugal compressors.**

SAFETY PROGRAM

It is assumed that your Safety Department has established a safety program based upon a thorough analysis of industrial hazards. Before installing and operating or performing maintenance on the compressor and associated components described in this manual, it is required that the safety program be reviewed to ensure that it covers the hazards arising from high speed rotating machinery.

It is also important that due consideration be given to those hazards which arise from the presence of electrical power, hot oil, high pressure and temperature liquids and gases. Proper installation and care

of protective guards, shutdown devices and overpressure protection equipment should also be considered an essential part of safety program. Also essential are special precautionary measures to prevent the possibility of applying power to the equipment at any time when maintenance work is in progress. The prevention of rotation due to reverse flow must be assured.
During maintenance insure that the air system block valve is closed and tagged. In general, all personnel should be guided by all the basic rules of safety associated with the equipment and the process.
Durante le operazioni di manutenzione a bordo del compressore assicurarsi sempre che la valvola di intercettazione sulla mandata sia chiusa e bloccata. In generale tutto il personale che deve esercire il compressore deve essere a conoscenza delle regole basilari relative alla sicurezza nella conduzione di questo tipo di apparecchiature e dei processi ad esse associate.

SAFETY PROCEDURES

Safety is everyone's business and is one of your primary concerns. Knowing the guidelines covers in the following paragraphs and in this Section will help provide for your safety, for the safety of those around you, and for the machine's proper operation.
The following safety procedures are to be used in conjunction with the installation, operation and maintenance instructions contained in this manual.
The information in this manual does not relieve operating and maintenance personnel of the responsibility of exercising normal good judgement in operation and care of the compressor and its components. The company accepts no responsibility for errors in translation of this manual from the original English version.

	**IN ADDITION TO THE MANY OBVIOUS SAFETY RULES, THE FOLLOWING SAFETY PRECAUTIONS ASSOCIATED WITH THIS TYPE OF EQUIPMENT MUST BE FULFILLED.**
NOTE	

1. PULL MAIN DISCONNECT SWITCH AND DISCONNECT ANY SEPARATE CONTROL LINES, IF USED, BEFORE ATTEMPTING TO WORK OR PERFORM MAINTENANCE ON THE UNIT.
2. DO NOT ATTEMPT TO REMOVE ANY COMPRESSOR PARTS WITHOUT FIRST RELIEVING THE ENTIRE SYSTEM OF PRESSURE.
3. DO NOT ATTEMPT TO SERVICE ANY PARTS WHILE MACHINE IS OPERATING.
4. DO NOT OPERATE THE COMPRESSOR AT PRESSURES IN EXCESS OF ITS RATING AS INDICATED ON THE COMPRESSOR NAMEPLATE.
5. DO NOT OPERATE THE COMPRESSOR AT SPEEDS IN EXCESS OF ITS RATING AS INDICATED ON THE MOTOR NAMEPLATE.

6. DO NOT REMOVE ANY GUARDS, SHIELDS, OR SCREENS WHILE THE COMPRESSOR IS OPERATING.
7. PERIODICALLY CHECK ALL SAFETY DEVICES FOR PROPER OPERATION.
8. DO NOT USE THE COMPRESSED AIR IN IMPROPER WAY. PRESSURIZED AIR CAN CAUSE SERIOUS INJURY TO PERSONNEL.
9. BE SURE NO TOOLS, RAGS, OR LOOSE PARTS ARE LEFT ON THE COMPRESSOR OR DRIVE PARTS.
10. DO NOT USE FLAMMABLE SOLVENTS FOR CLEANING PARTS.
11. EXERCISE CLEANLINESS DURING MAINTENANCE AND WHEN MAKING REPAIRS. KEEP DIRT AWAY FROM PARTS BY COVERING PARTS AND EXPOSED OPENINGS WITH CLEAN CLOTH OR KRAFT PAPER.
12. DO NOT OPERATE THE COMPRESSOR WITHOUT GUARDS, SHIELDS, AND SCREENS IN PLACE.
13. NOT OPERATE COMPRESSOR IN AREAS WHERE THERE IS A POSSIBILITY OF IT INTAKING FLAMMABLE OR TOXIC FUMES.
14. DO NOT USE DIRECTLY THE DISCHARGE AIR FOR BREATHING. IT COULD CAUSE SEVERE INJURY OR DEATH. CONSULT FILTRATION SPECIALIST FOR ADDITIONAL FILTRATION AND TREATMENT EQUIPMENT TO MEET HEALTH AND SAFETY STANDARDS.
15. OIL OR AIR UNDER PRESSURE CAN CAUSE SEVERE PERSONAL INJURY, OR DEATH. SHUTDOWN THE COMPRESSOR BEFORE REMOVING ANY CAPS OR PLUGS.
16. SURFACE TEMPERATURE OF THE VOLUTES AND AIR INTERSTAGE AND DISCHARGE PASSAGES MAY BE GREATER THAN 150 °C WHEN OPERATING. EVEN AFTER BEING SHUTDOWN THE COMPRESSOR THESE SURFACES SHOULD NOT BE TOUCHED PER ONE HOUR.
17. DO NOT REMOVE OR RENDER INOPERATIVE, OTHER THAN FOR THE PURPOSE OF MAINTENANCE, REPAIR OR REPLACEMENT, OF ANY NOISE CONTROL DEVICE OR ELEMENT OF DESIGN INCORPORATED INTO THIS COMPRESSOR.
18. DO NOT OPERATE THE MACHINE AFTER MENTIONED DEVICE OR ELEMENT OF DESIGN HAVE BEEN REMOVED OR RENDERED INOPERATIVE.
19. SHUT OFF THE COMPRESSOR BEFORE GOING INSIDE THE SOUND ENCLOSURE FOR WHICHEVER ACTIVITY HAS TO BE CARRIED-OUT.

MAJOR HAZARDS

SITUATIONS WHERE HAZARD CAN OCCUR	"HAZARD" WHAT CAN HAPPEN IF PRECAUTION AND SAFEGUARDS ARE NOT OBSERVED	"SAFEGUARDS" HOW TO AVOID THE HAZARD
• General	• Compressed air and electricity are dangerous and can cause serious injury or death to personnel.	• Before doing any work on the unit, be sure that the electrical supply has been cut off and the entire compressor system has been vented of all pressures.
• Attempt to lift the compressor package by the enclosure (when installed). • Lift the unit by a single or any two of the lifting eyes on the compressor or driver.	• Damage to equipment and personnel could result.	• Follow the instruction given in section "Receiving, handling, storage" • Follow the instruction given in section "Receiving, handling, storage". All three eyes must be used for lifting the compressor driver unit.
• The compressor bull gear is locked to the casing to prevent rotation during shipment.	• Serious damage could result to equipment.	• Locking bolt must be removed prior to coupling the motor to the compressor.
• Moving parts protection.	• Failure to observe this warning could result in personal injury to operating personnel.	• The unit can operate only when coupling guard is in place.
• Operation of the unit without proper lubrication.	• Can result in overheating of the bearings, bearing failures, pump seizures and equipment failure exposing	• Follow the instruction given in Section "Operation".

SITUATIONS WHERE HAZARD CAN OCCUR	"HAZARD" WHAT CAN HAPPEN IF PRECAUTION AND SAFEGUARDS ARE NOT OBSERVED	"SAFEGUARDS" HOW TO AVOID THE HAZARD
	operating personnel to personal injury.	
• Operating the unit with wrong rotation.	• Damage to equipment and personal injury could result.	• The driver rotation must be checked before coupling compressor and motor.
• The use of plastic piping, soldered copper fittings and rubber hose as discharge piping. In addition, flexible joints and/or flex lines can only be considered for such purposes if their specifications fit the operating parameters of the system.	• Failure to adhere to these recommandations can result in mechanical failure, property damage and serious injury or death.	• The piping to and from the compressor must be in accordance with the operative and safety requirements of the plant.
• On larger unit additional motor supports under non-drive end.	• Overhung flange loading without this support can result in severe injury or damage.	• Provide additional motor supports under non-drive end, pre load shims must be maintained for proper motor support.
• Any time secondary side of the current transformer is disconnected from its load.	• Injury or death of personnel and or damage to equipment.	• A jumper must be placed across secondary terminals. Do not disconnect secondary wiring during operation. An appropriate grounding strap should be attached to the baseplate and to suitable ground.
• Hot oil.	• Can cause serious injury to	• Precaution must be taken

SITUATIONS WHERE HAZARD CAN OCCUR	"HAZARD" WHAT CAN HAPPEN IF PRECAUTION AND SAFEGUARDS ARE NOT OBSERVED	"SAFEGUARDS" HOW TO AVOID THE HAZARD
	personnel.	to prevent contact with hot oil.
• Hot parts like diffuser covers, oil cooler shell, etc.	• Can cause serious injury to personnel.	• Precaution must be taken to prevent contact with these parts.
• Lube system pressure may reach 700 kPa(g) and temperature of 70°C or more.	• Can cause serious injury to personnel.	• Do not penetrate lube system while machinery is operating.
• Control panel (normally supplied) is equipped with high voltage components and may include the main motor starter (if supplied).	• Failure to observe this warning may result in serious injury or death.	• Power supply should be shut off before the panel door is opened.
• Condensate by pass valve.	• Condensate are discharged at high pressure and may cause personal injury to operating personnel.	• Condensate by pass valve should be opened slowly. Heating protection must be worn when by-pass valves are open.

Table 2.1

SAFETY LABELS

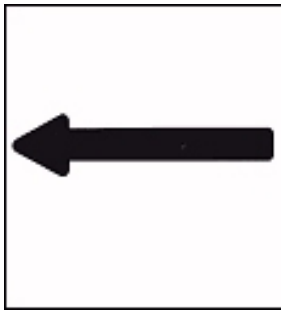
On the unit are fitted the following labels (where applicable):

Warning: do not attempt to lift the compressor package by the enclosure. Damage to equipment and personnel could result.

Warning: electrical shock risk.

Warning: prohibited to walk on the canopy roof.

Do not breathe the compressed air from this unit.



Indication where the instruction book is located.

Warning: hot surface.

Do not remove the operating and maintenance manual from this compressor.

Do not operate the machine without the guard being fitted.

Oil fill

Lifting point

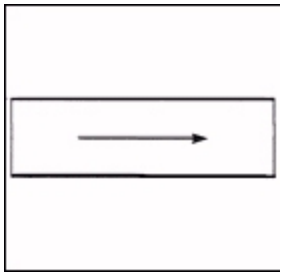
	Warning: Automatic start compressor		Direction of rotation of the compressor gear
	Do not stand on any service valve or other condensate discharge parts of the pressure system		

Table 2.2

Recommended Lifting Method for CENTAC in Enclosed and Unenclosed Version.

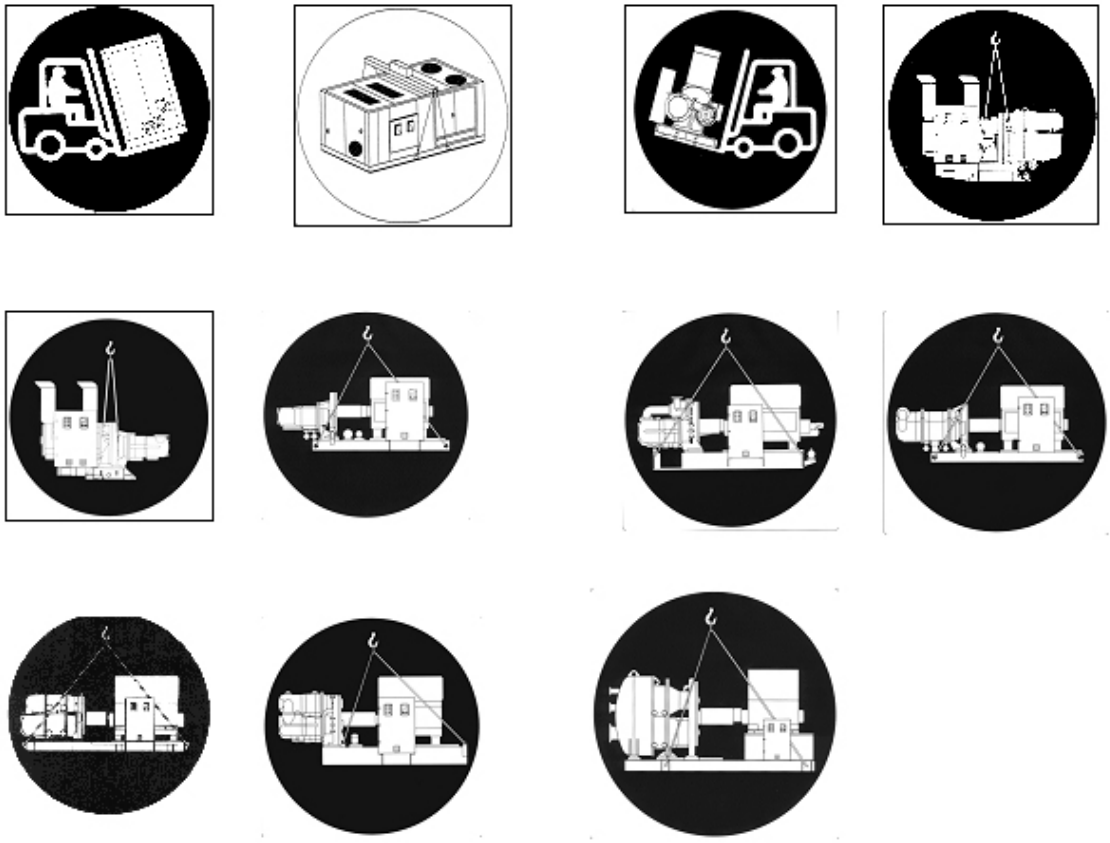


Figure 2.1

Please refer to the assembly drawing, for the lifting procedure specifically suggested for your compressor.

	**The owner, the operator and whoever uses the compressor, must be aware that any failure to comply with safety rules, both contained in this manual and not, may cause damages and personnel injuries. INGERSOLL-RAND expressely denies any direct and indirect responsibility for any damage and injury caused by non-observance of safety rules both contained in this manual and normally followed safety rules, as well as non-observance of normal precautions required for machinery operation and maintainance, although not explicitely mentioned in this manual.**
NOTE	

3 Receiving/Handling/Storage

3.1 Receiving

Centac compressors are shipped in first class condition. They have been inspected prior to leaving the factory and loading has been supervised by INGERSOLL RAND personnel to insure that the unit has not been damaged during loading and that all accessory equipment has been properly documented. Inspect the compressor for possible shipping damage when received. Make the examination before removing from carrier vehicle. If damage or indication of rough handling is evident, file a claim with the carrier at once, and notify your local INGERSOLL RAND OFFICE or qualified INGERSOLL RAND DISTRIBUTOR. Remove only the shipping notice. Do not remove tags pertaining to lubrication, operating and storage. Read all tags and instructions, i.e.:

1. SERIAL NUMBER NAMEPLATE
2. CAUTION NON-BREATHABLE AIR
3. MOTOR ROTATION
4. RECOMMENDED SYSTEM FOR LIFTING.

All items in the shipment with the compressor, but packed separately, shall be documented as received or short. These items shall be stored with the compressor or separately in an area deemed more appropriate. Such storage shall provide security adequate to preclude the loss or misappropriation of the items.

	**THE UNLOADING AND ALL THE RELATED OPERATIONS CONCERNING THE POSITIONING OF THE CENTAC COMPRESSORS AT SITE MUST BE DONE BY QUALIFIED AND TRAINED PERSONNEL.. IT IS REQUIRED THE PRESENCE OF PROFESSIONAL AND RESPONSIBLE PERSONNEL TO MAKE SURE A SAFE TRANSPORTATION OF THE GOODS AT SITE.**
NOTE	

Please refer to the general assembly drawing enclosed in this maual for the dimensional data of the compressor.

3.2 Handling

	**ANY WEIGHT HANDLING EQUIPMENT, INCLUDING ROPES EQUIPMENT, MUST BE CERTIFIED SAFE FOR INTENDED USE. FAILURE TO USE TESTED AND CERTIFIED LIFT EQUIPMENT CAN RESULT IN SERIOUS INJURY OR DEATH AND DAMAGE TO EQUIPMENT.**
WARNING	

	**IF THE COMPRESSOR IS SUPPLIED WITH ENCLOSURE, DO NOT ATTEMPT TO LIFT THE COMPRESSOR PACKAGE BY THE ENCLOSURE.**
CAUTION	

	**NEVER USE THE INSTALLED EYE BOLTS TO LIFT THE ENTIRE MACHINE BECAUSE THEY WILL NOT SUPPORT THE MACHINE'S WEIGHT. EYE BOLTS ARE DESIGNED TO LIFT THE COMPONENT PART TO WHICH THEY ARE ATTACHED.**
CAUTION	

	**ONLY THOSE SLINGS THAT HAVE KNOWN STRENGTH SHOULD BE USED FOR LIFTING. USING UNTESTED SLINGS IS HAZARDOUS.**
NOTE	

	**THE TASK OF LIFTING A MACHINE SHOULD BE DONE ONLY BY QUALIFIED AND EXPERIENCED PEOPLE.**
NOTE	

3.2.1 Recommended lifting method for CENTAC model

Different compressor models are designed for lifting with various means, such as by a FORKLIFT, by using the two openings provided at the baseplate, Figure 3.1 , or with slings which must lift the unit through both casing ribs and under the motor flange Figure 3.2 or by using the lifting points arranged on the unit basement Figure 3.3

Figure 3.1

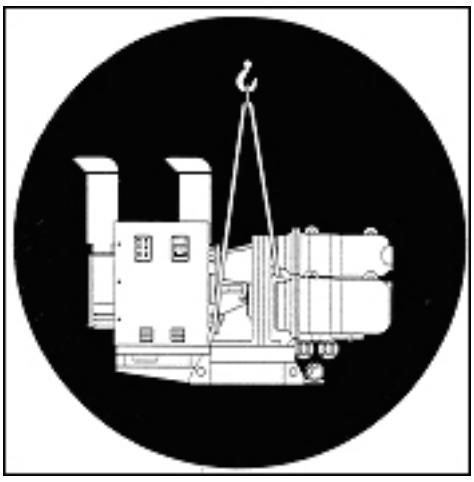


Figure 3.2

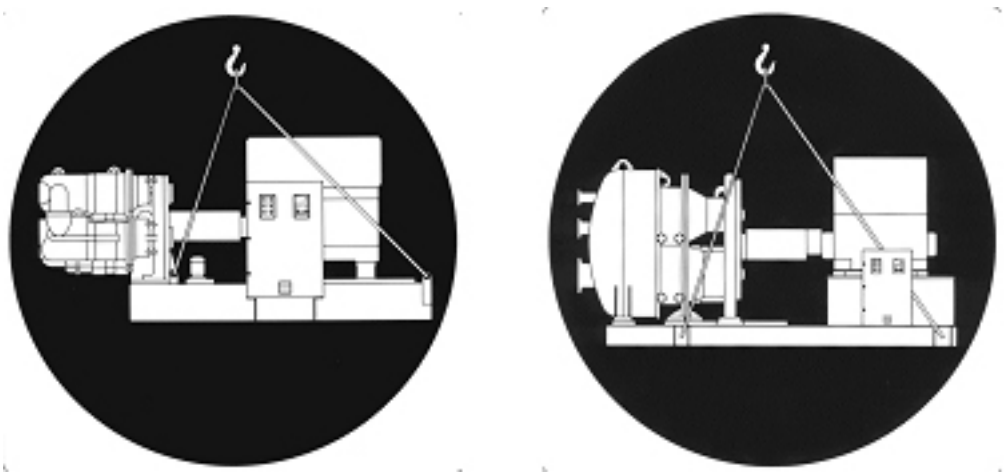


Figure 3.3

Each unit has a suggested lifting procedure. Please refer to the assembly drawing contained in this manual, for the lifting procedure specifically suggested for Your compressor.

3.2.2 Recommended lifting method for air filter (when supplied)

	**ALTHOUGH SHARP CORNERS AND EDGES HAVE BEEN GROUND AND SOFTENED NEVERTHELESS SOME RISK MAY BE LEFT: ALWAYS WEAR PROTECTION GLOVES WHILE HANDLING.**
CAUTION	

Lifting and handling (please refer to the filter section of this manual, Enclosure A):

- Handling and lifting the filter of some model is foreseen only by fork lift.
- Avoid to turn, to lay down, to jolt the unit.
- See that flange gauge connections are perfectly closed.
- Avoid to open the access door (if installed).
- Do not remove the flange opening protection sheet until connecting the piping.
- Protect from heat sources, corrosive and dusty atmosphere etc.

Figure 3.4

	**TO EVENTUAL OTHER LOOSE SUPPLIED COMPONENTS (IF PRESENT) (NOT ASSEMBLED WITH THE COMPRESSOR) PLEASE REFER TO SPECIFIC LITERATURE CONTAINED IN THIS MANUAL FOR HANDLING DETAILS.**
NOTE	

3.3 Storage

The CENTAC should be stored on a level surface in a climate controlled area (10-35°C). The compressor bullgear is locked to the casing and coupled to the motor to prevent rotation of these components during shipment. At termination of storage, the locking bolt must be removed, and the motor (for Centac equipped with motor) should be "meggered" to ground before connecting to power line. We always recommend to refer to Motor or other motion device Instruction Manual for proper storage procedure.

	**IF THE UNIT IS TO BE STORED FOR PERIODS LONGER THAN 180 DAYS OR IN AN UNCONTROLLED CLIMATE, THE UNIT WILL REQUIRE ADDITIONAL PROTECTION. CONSULT YOUR LOCAL I-R OFFICE FOR LONG TERM STORAGE REQUIREMENTS AND EXTENDED WARRANTY COVERAGE.**
WARNING	

Consider a unit in storage when:

1. IT HAS BEEN DELIVERED TO THE JOB SITE AND IS AWAITING FOR INSTALLATION.
2. IT HAS BEEN INSTALLED: BUT OPERATION IS DELAYED PENDING COMPLETION OF PLANT CONSTRUCTION.
3. THERE ARE LONG PERIODS (30 DAYS OR MORE) BETWEEN OPERATING CYCLES.

4. THE PLANT (OR DEPARTMENT) IS SHUT DOWN (30 DAYS OR MORE).

INGERSOLL-RAND is responsible for compressor parts disassembly and correct packing for shipping. Separately supplied parts must be assembled by the customer in the presence of Ingersoll-Rand technicians. The customer must follow indications of the manufacturer of motor or other motion device, eventually necessary to ensure preservation during storage. Both compressor and separately supplied parts must be stored in a dry and clean place, at constant temperature between 10°C and 35°C.

	**THE CUSTOMER IS RESPONSIBLE FOR THE CORRECT COMPRESSOR STORAGE ACCORDING TO INSTRUCTIONS CONTAINED IN THIS MANUAL, OR SUCCESSIVELY SUPPLIED BY INGERSOLL-RAND IF THE UNIT IS STORED FOR MORE THAN 180 DAYS. FAILURE TO COMPLY WITH SUCH INSTRUCTION MAY CAUSE GUARANTEE VOIDNESS.**
NOTE	

	**ANY ALTERNATIVE PROTECTION MEASURE NOT INCLUDED IN THIS MANUAL OR NOT SUPPLIED BY INGERSOLL-RAND IN CASE OF STORAGE FOR MORE THAN 180 DAYS, WILL MUST BE APPROVED IN ADVANCE BY INGERSOLL-RAND.**
NOTE	

	**IT IS ADVISABLE TO USE ONLY LUBRICANT OILS WITH ANTI-OXIDANT ADDITIVES.**
NOTE	

4 Machine description

4.1 General description

The CENTAC is defined as a dynamic centrifugal type compressor. As shown in Figure 4.1 , air enters the compressor through the inlet control valve and flows to the first stage where the impeller (1) imparts velocity to the air. The air proceeds through the diffuser section (2) which converts velocity to pressure. The built-in intercooler (3) removes the heat of compression, which improves efficiency.
Air passes through a stainless steel moisture separator (4) in a low velocity zone to remove condensate. Moisture carryover is eliminated when the air is forced to change direction 180° to enter the next stage. This sequence repeats in each succeeding stage until the compressor achieves desired operating pressure.

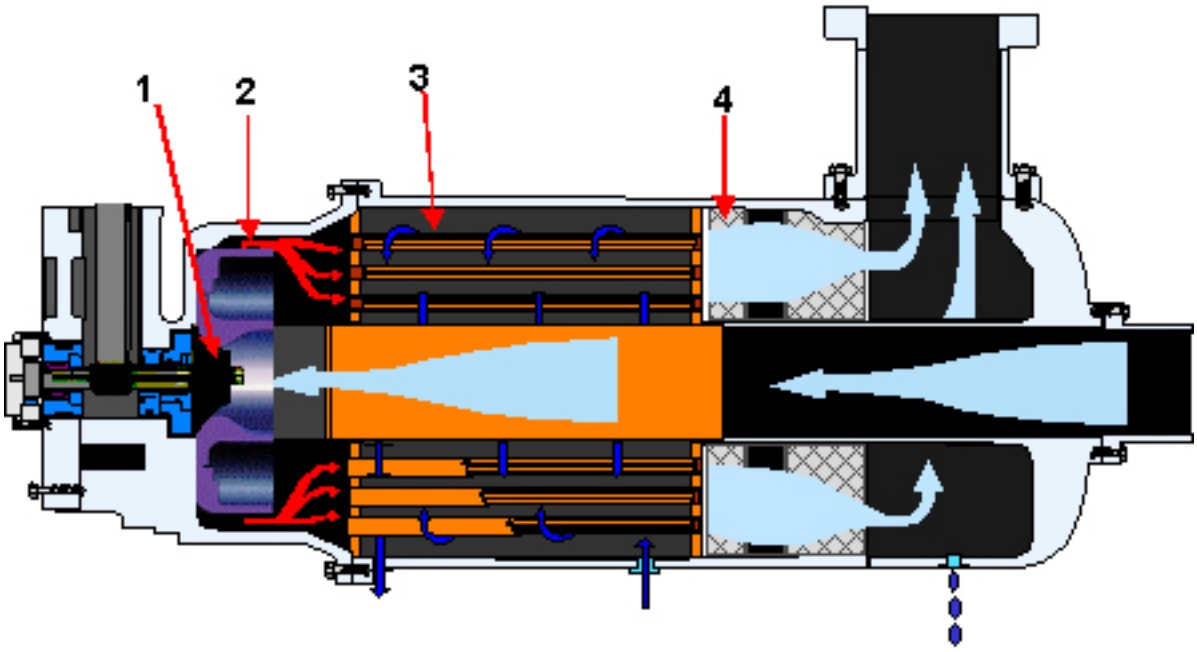


Figure 4.1

The CENTAC compressor is an oil-free high efficiency centrifugal air compressor, generally driven by an electric motor (in some applications by a turbine), directly coupled by means of a joint. The compressor and the driver are directly coupled by a coupling.
The entire unit is mounted on a common rigid structural steel baseplate, with its own lube system, control system (is purchased) and auxiliary systems.
The CENTAC compressor is a single-stage or multi-stage constant speed unit; each compression stage consists of an impeller mounted on its own shaft, enclosed within a common cast-iron casing.
Each rotor consists of an integral pinion gear driven at its optimum speed by a common bull-gear.
After each compression stage an air to water heat exchanger complete with a suitable moisture separator and a condensate trap, to remove condensate, is supplied. Nitrogen compressors are

obviously not equipped with moisture separators and traps
The intercooler(s) and aftercooler (if installed) are located adjacent to the diffuser assembly eliminating the need of extensive field piping.
Some compressors (if required) may be equipped with intercoolers and/or aftercoolers installed externally of the compressor head.

4.2 Air end

The Air End consists of a casing and a cover; the joint between the casing and cover is VERTICAL. The bolted assembly is only opened for servicing the bull-gear and bull-gear bearings. The cooler(s) which are mounted in the casing can be easily removed for inspection.
The Gear Case cover contains separate pinion bearing covers. Access to these covers provides a means for inspection of the bull-gear and pinions teeth.

4.3 Bull-gear

The unit is equipped with a forging helical bull-gear, AGMA quality, running on oil lubricated antifriction ball bearings or, for larger units, on oil lubricated hydrodynamic sleeve bearings.

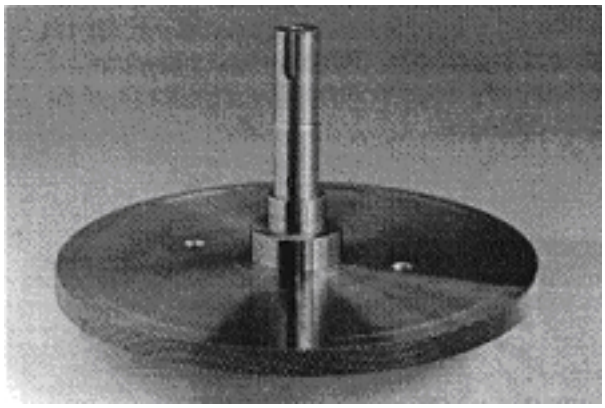


Figure 4.2

4.4 Rotor assembly

The rotor assembly is composed of:

- An helical geared pinion shaft precision machined and balanced. Pinion gear is AGMA quality.
- An high efficiency stainless steel semi open impeller with backward leaning vanes, mounted on the pinion using a polygon attachment Figure 4.3 or a conical attachment, according to the model. Figure 4.4
- A removable double acting thrust collar, secured with polygon attachment and retained with a bolt.

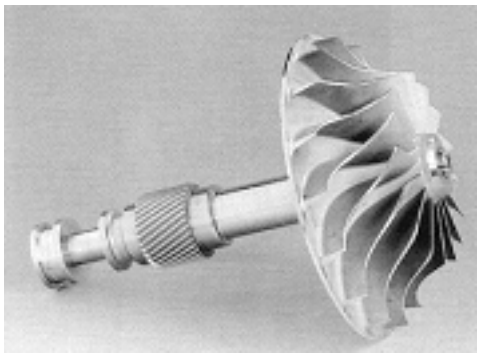


Figure 4.3

Figure 4.4

All rotating parts are dynamically balanced.

4.5 Diffuser

A diffuser is located between each impeller and cooler.
Diffusion and pressure recovery are accomplished by a double row of fins. The first row, near the impeller, is formed by individual stainless fins located on the face of the diffuser body Figure 4.6 diffusion is in a radial direction. The second row of fins are located in the axial passageway Figure 4.7 leading to the cooler inlet: this second stage of diffusion rectifies the air flow for the highest overall stage efficiency.

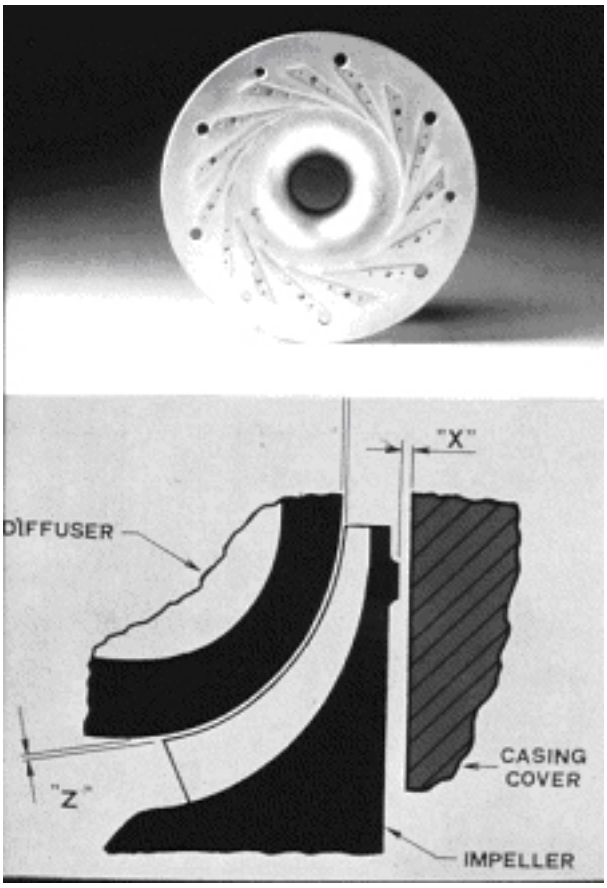


Figure 4.5

Figure 4.6

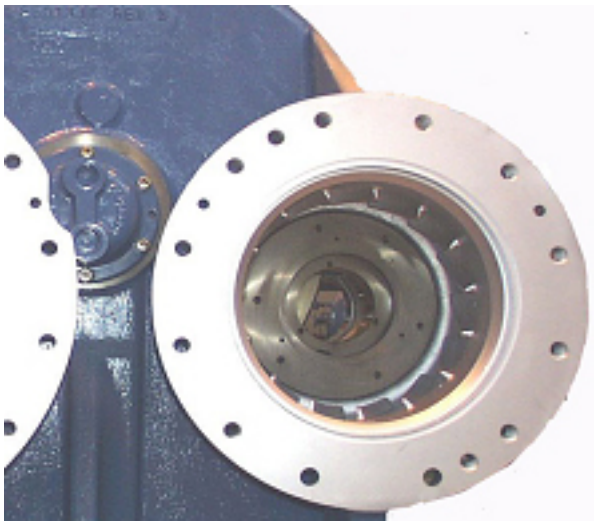


Figure 4.7

4.6 Plain (or radial) bearings

Figure 4.8

Plain Bearings are of the fixed geometry tilted pad design, Figure 4.9 , or of the orientable pad (TPJ) design, Figure 4.10 with the high temperature babbit, mounted on a steel insert, which fits into the bearing housing.

Each plain bearing is designed for the speed and horsepower loading of its own rotor assembly to ensure maximum stability during operation.

Figure 4.9

Figure 4.10

4.7 Thrust bearings

Thrust bearings contain a plain bearing section similar in design to that detailed above, plus a hydrodynamic pocket thrust bearing face, Figure 4.11 which carries the axial thrust generated by the rotor assembly when in operation.

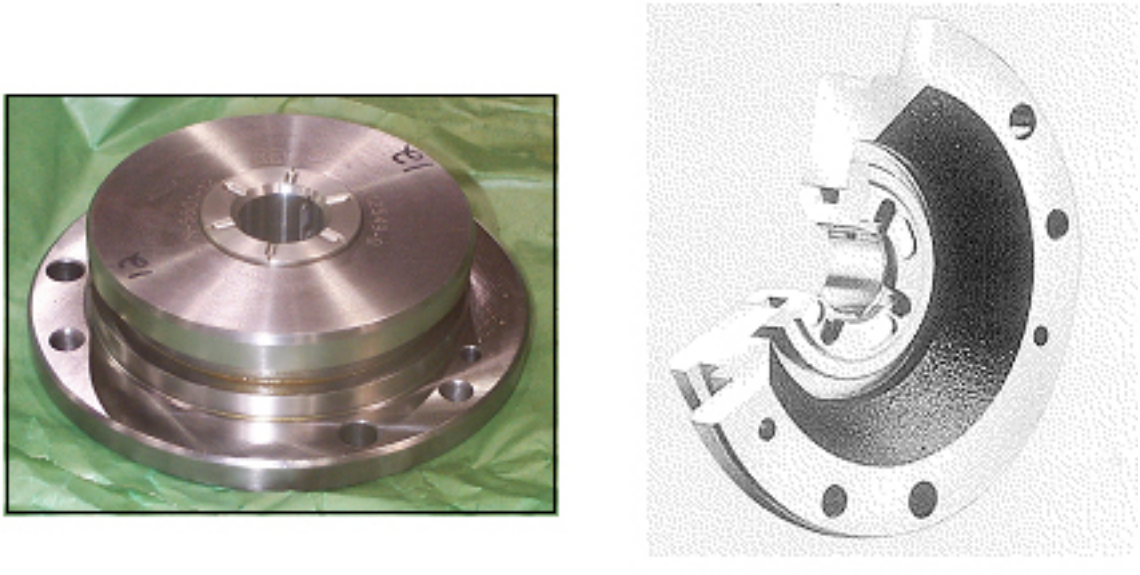


Figure 4.11

The inactive thrust bearing limits the movement of the rotor assembly during start-up or unloaded operation.

4.8 Shaft sealing

Cartridge Seals, Figure 4.12 , are mounted in the plain bearing housing behind each impeller.
The cartridge consists of one piece fully floating non-contact carbon rings. One ring set is used as an air seal, and the others as an oil seal. Seal air is injected between the oil seals to ensure that the compression occurs without oil passage, and therefore the air is without oil.
A vent is provided between the air and oil seals for pressurization air discharge.

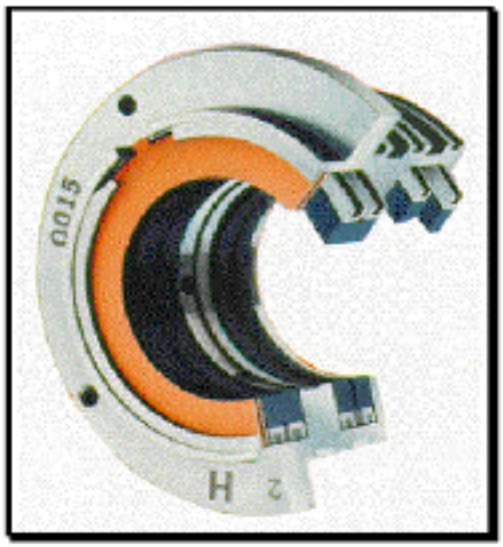


Figure 4.12

4.9 Vibration probes

One radial vibration probe, Figure 4.13 , (if not differently specified in the contract) is located next to the plain bearing assembly and connected to a vibration transmitter, which will be then connected to the control unit.

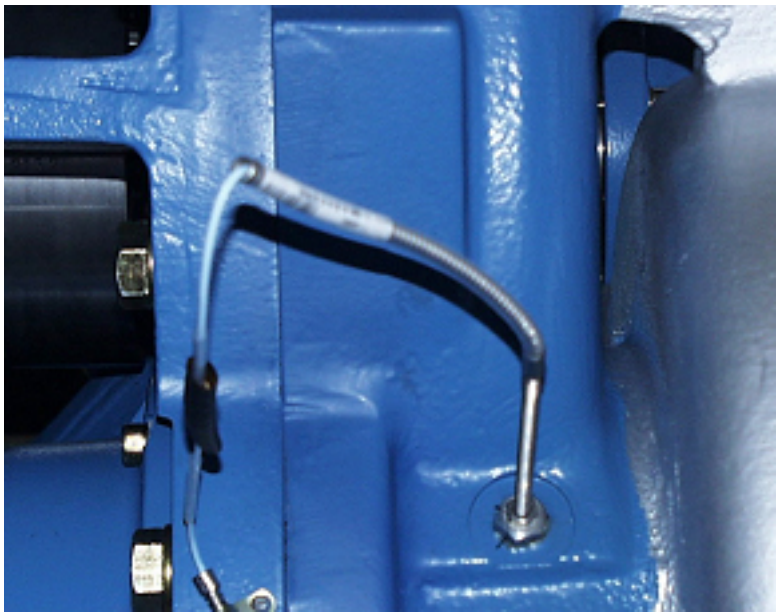


Figure 4.13

4.10 Air system

The Air System of the CENTAC compressor includes:

	**PLEASE SEE COMPRESSOR FLOW SHEET ISA (P&I) CODE ON SECTION #DRAWINGS# OF THIS MANUAL.**
NOTE	

Inlet Air Filter

The CENTAC suction air must be properly filtered, to ensure Centac performances.
The air filter is generally (unless differently specified in the contract) supplied as part of the IR supply. If not forseen in the IR supply, the system must however include a filter with minimum efficiency of 98% at 4mm

	**PLEASE REFER TO AIR FILTER SECTION (IF INCLUDED IN IR SUPPLY) FOR MORE DETAILED INFORMATION.**
NOTE	

Suction adjustment and by pass valves

A suction adjustment valve Figure 4.14 installed on the compressor end allows suction flow adjustment. A by-pass valve Figure 4.15 , generally installed on the compressor end, unless differently located due to configuration requirements, allows discharging the compressor when needed. (surge, stop, etc) Valves are equipped with electro-pneumatic positioner and pneumatic controlled actuator.

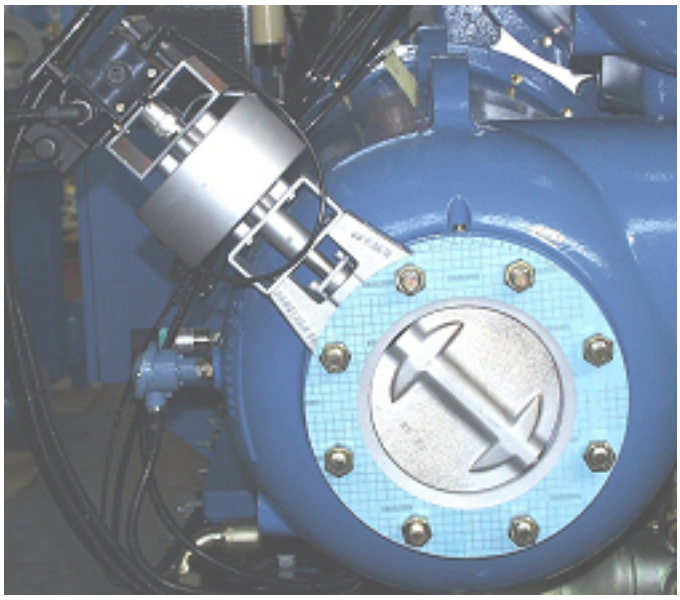


Figure 4.14

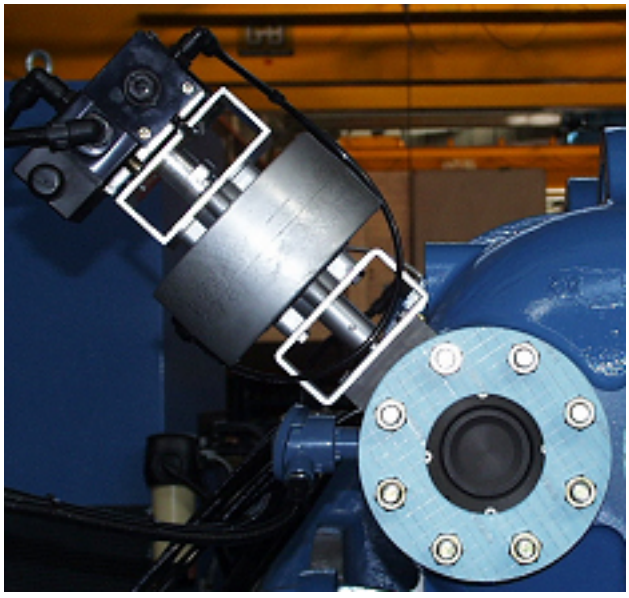


Figure 4.15

Intercooler(s) and Aftercooler

NOTE	**THE CENTAC MAY BE EQUIPPED, UPON CUSTOMER'S REQUEST, WITH TWO EXTERNAL COOLERS DIFFERENT FROM STANDARD ONES (INCLUDED IN THE COMPRESSOR BODY). PLEASE REFER TO THE SPECIFIC SECTION OF THIS MANUAL, IF NECESSARY.**

The Standard air coolers are of the shell and tube type, with the compressor casing acting as the shell. The coolers are of the high efficiency cartridge design Figure 4.16 with air passing through the tubes and water passing over the tubes. The passage of the heat from the air to water is assisted by the internal fins in the air passages Figure 4.17
, which greatly increase the effective heat transfer area on the air side. The passage leading to the impeller is formed by the center section of each cooler and diffuser.

Figure 4.16

Figure 4.17

Moisture Separators

Built-in Moisture Separator after each air cooler Figure 4.18 . The moisture separator is of stainless steel mesh screen type construction and the thickness of the separator is designed to separate the maximum amount of moisture at a minimal pressure drop.

Figure 4.18

The separators are located at points in the compressor where air velocities are relatively low, permitting effective moisture separation.

Condensate Traps (not installed for Nitrogen compressors)

These traps are mounted below each moisture separator, to discharge the machine moisture.
Standard supply traps are of the single float type. Upon customer's request, it is possible to supply special design traps, such as electric, pneumatic, etc.

	**PLEASE REFER TO TRAPS SECTION OF THIS MANUAL (IF INCLUDED IN IR SUPPLY) FOR MORE DETAILED INFORMATION.**
NOTE	

Atmospheric By-Pass Silencer

The silencer is usually supplied loose for field installation. If not purchased by the customer, the system must however include a silencer, which must be installed near the valve, to reduce the by-pass air noise.
In some CENTAC models, when required in the contract, the silencer may be replaced with by-pass valve inlet air re-circulation piping, as shown in the following sketch.

Discharge Check Valve

The Check valve is a simple non-return valve Figure 4.19 This valve is generally installed on the compressor, unless for special configuration where the valve is supplied loose.

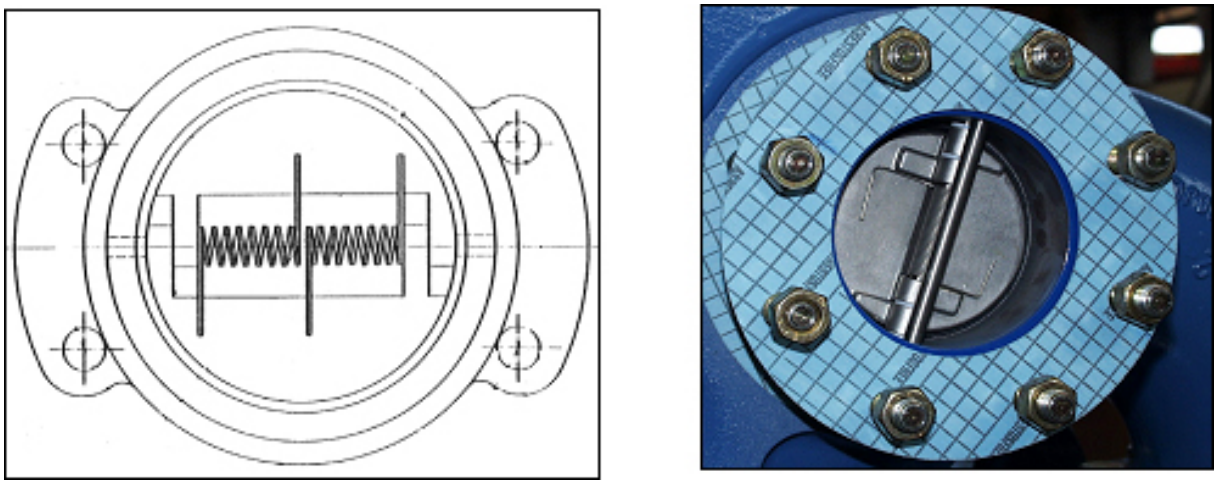


Figure 4.19

Instrumentation

Unless differently specified in the contract, the CENTAC air system is equipped with:

- Set of temperature transmitters, downstream each cooler, to detect delivery air temperature
- Set of pressure transducers, downstream each cooler, to detect delivery air pressure and one downtream the check valve, for compressor adjustment.

4.11 Water cooling system

The water cooling system of the CENTAC compressor is including:

	**PLEASE SEE COMPRESSOR FLOW SHEET ISA (P&I) CODE ON SECTION #DRAWINGS# of this manual.**
NOTE	

- Cooling Water Manifold

When supplied, the manifold is already installed on the compressor.
The manifold covers cooling water to the stage intercooler(s), aftercooler and oil cooler, and driver (motor or turbine) when water cooling system is required.
The contract may require the supply of pressure gauges and thermometers for each cooler and a flow switch, usually supplied loose, for cooling water flow control.

4.12 Lubrication system

The Lubrication System of the CENTAC compressor is completely self contained and the supply must include, at least:

	**PLEASE SEE COMPRESSOR FLOW SHEET ISA (P&J) CODE ON SECTION #DRAWINGS# OF THIS MANUAL.**
NOTE	

- Lube Oil Reservoir:
  Built into the compressor baseplate and coated with epoxy to resist corrosion.
  The reservior is designed according to the specific compressor needings.

- Suction Oil Strainer(s):
  Installed inside the reservior, on the main pump suction piping and pre/post lubrication (when forseen).
- Pre and Post Lubrication Oil Pump:
  Driven by an electric motor. This pump is not intended to function as an auxiliary oil pump to back up the main oil pump.
  The pump supports the main pump during compressor start up and stop. Some compressor models do not include this pump.
- Positive Displacement Main Oil Pump:
  Of the geared type, mounted on Main Compessor Shaft or driver shaft, according to the model.
- Check Valves:
  To prevent reverse flow through the pumps.
- Cast-iron Adjustable Relief Valve:
  Unless specific contractual requirements, this is a self-operated valve, used to control oil pressure to the gears and to the compressor bearings.
- Oil Filter:
  Single or double element, according to model and contract requirements.
  With replaceable cartridge, 10 micron rating. For more detailed information, please refer to the specific section of this manual.
- Oil Cooler(s):
  Of the pipe bundle type, is installed on the compressor. Upon specific contractual request, and for some compressor models, it is possible to supply a double type cooler, with a cooler used as stand-by.
  For more detailed information, please refer to the specific section of this manual.
- Three way thermostatic mixing valve:
  to deliver the mixed oil at the correct temperature to the compressor.
- Oil Level Indicator
- Mist Arrestor
- Oil Reservoir Electric Heater:
  Single or double, according to compressor model, heats the oil to the minimum allowed temperature before re-circulation.
- Instrumentation.
  All instrumentation necessary for oil temperature and pressure control.

4.13 Driver

The CENTAC is generally driven by an electric motor, of the induction, asynchronous three phase type. According to the compressor model, it can be either of the flanged type or equipped with support feet. In some applications, the CENTAC can be driven by a turbine.

	**PLEASE REFER TO THE DRIVER SECTION (IF INCLUDED IN IR SUPPLY) FOR MORE DETAILED INFORMATION.**
NOTE	

4.14 Coupling

Non-Spacer Gear type Coupling, self grease lubricated, complete with coupling guard, between Main Driver and Compressor.

	**PLEASE REFER TO THE COUPLING SECTION (IF INCLUDED IN IR SUPPLY) FOR MORE DETAILED INFORMATION.**
NOTE	

4.15 Control system

Generally the control panel, if included in Ingersoll-Rand supply, is of the microprocessor type, installed on the compressor metal baseplate. The panel is complete with a pneumatic system which includes the instrumentation necessary for compressor control valves and seals air supply and control. In some applications, where required in the contract, a PLC panel may be supplied, or a terminal board (junction box, supplied by the customer or remotely installed, which replaces the panel) for the whole electric instrumentation and components.

	**PLEASE REFER TO THE CONTROL SECTION (IF INCLUDED IN IR SUPPLY) FOR MORE DETAILED INFORMATION.**
NOTE	

4.16 Baseplate

Fabricated steel baseplate with integral lube oil reservoir coated to resist corrosion, supports the compressor casing, lube oil system, eventual control panel or junction box and sound enclosure. The baseplate has provision for foundation bolts. The Customer must purchase the foundation bolts.

4.17 Sound enclosure for enclosed version

When required, the compressor package is equipped with a sound attenuating enclosure to reduce the overall noise level of unit.
Please refer to the Data Sheet section of this manual for the sound pressure value referred to the specific unit.

	**NOISE LEVELS ARE CALCULATED DURING WORKSHOP TESTS. THEREFORE VALUES MAY DIFFER, ACCORDING TO LOCAL ENVIRONMENTAL AND OPERATIVE CONDITIONS.**
WARNING	

5 Installation

5.1 General

Proper installation is the most important requisite for satisfactory operation of rotating machinery.
The proper design of a foundation and piping arrangement requires an intimate knowledge of local conditions.
It is recommended that it be designed by someone who has experience with machinery foundations.
Proper support of the machinery is required to give maximum reliability at minimum operating cost.

5.2 Plant layout

	**THE COMPRESSOR NEEDS A SURROUNDING CLEAR AREA (OPERATION AREA) FOR START UP AND MAINTENANCE OPERATIONS. SUCH AREA IS DEFINED IN THE GENERAL ASSEMBLY DRAWING CONTAINED IN THE SPECIFIC SECTION OF THIS MANUAL.**
NOTE	

A well-designed installation will result in lower installation and operating costs.
Operation and maintenance personnel will generally give better attention to a compressor that has been installed with good planning and consideration for all the various needs.
The CENTAC's location within a plant facility is very important.
The compressor must be located in an area that is accessible to operators and maintenance personnel. It must be in a climate controlled environment (heated building) if the compressor has not been specifically designed for outdoor use. The CENTAC can best be handled with an adequate overhead crane facilities for installation and maintenance. An adequate overhead rail with chain hoist or crane will simplify removing the largest component parts, if and when it becomes necessary to inspect or replace them.
Overhead lifting facilities must be included in the installation.
Floor space must be provided so that compressor parts may be laid aside during any tear down for inspection or repair of the rotating elements and other internal parts.
Ventilation around the machine is important.
Provisions for clearance limitations given on the General Arrangement drawing must be met and adequate ventilation must be provided.
On electric motor driven-machines, the heat radiated into the rooms air will be approximately 8% of the total horsepower.
In areas where noise could be a problem, steps should be taken in treating hard reflective surfaces in the area.
Installing the unit in an area with low hard ceilings and walls should be avoided. The machine should not be installed in a damp or dusty atmosphere or where corrosive vapors may enter the compressor or the driver.

Excessively dusty and humid places may deteriorate motor's internal components and will shorten the motor's lifetime. Damp and/or corrosive atmospheres will quickly deteriorate control and driver insulation causing premature failure.

5.3 Foundation

Proper foundation design requires an intimate knowledge of local conditions. The user assumes full responsibility for an adequate foundation. It is strongly recommended that foundation design be provided by those who have experience with machinery foundations.

	**THE CONSTRUCTION OF THE FOUNDATION IS THE RESPONSIBILITY OF THE CUSTOMER. THE FOLLOWING SUGGESTIONS ARE OFFERED AS AN AID TO ASSURE A SUCCESSFUL OPERATION. WE RECOMMEND THE CUSTOMER CONSULT A SPECIALIST SKILLED IN THE DESIGN OF MACHINERY FOUNDATIONS.**
WARNING	

The CENTAC foundation must be able to support the weight of the unit and other dynamic loads, when specified (please refer to the General Assembly drawing).

	**The foundation must be constructed in a manner that assures that vibrations from other sources are not transmitted to the CENTAC (i.e. near by reciprocating compressors).**
WARNING	

The foundation must be constructed in a manner that assures that vibrations from other sources are not transmitted to the CENTAC (i.e. near by reciprocating compressors).
For the CENTAC compressors, a simple concrete pad or steel support is recommended for each compressor.
It is recommended that the concrete pad be level and flat so that the bottom of the baseplate is in full contact with the pad.
Anchor bolts or similar fixtures are required to hold the compressor in place.
The base-plate footprint and anchor bolts holes positions are shown on the drawings supplied with this manual.

	**FOR FURTHER DETAILS, PLEASE, REFER TO THE CERTIFIED GENERAL ARRANGEMENT DRAWING ON SECTION #DRAWING# of this manual.**
NOTE	

5.4 Leveling

Driver, compressor and base levels are important for the following reasons:

1. If the machine is not level longitudinally, the starting and stopping weight of the driver rotor will bear on the thrust bearings (uphill or downhill), resulting in possible premature wear.
2. The same force will burden the compressor bullgear thrust bearings and put stress on the coupling.
3. If the level is off, the oil sump level, de-mister function and the coolers high point venting could be affected.
4. Motor bearing lubrication and lubrication drain-off could be affected resulting in possible premature failures.
5. Proper drainage of condensate and general pipe fit up could be affected by an out-of-level condition.

Before level readings can be taken, the compressor must be resting on the foundation pad in its final position with the anchor bolts (or nuts) snug. If it is known or suspected that the pad is not level, shims or wedges can be installed at the anchor bolt positions when the unit is set in place.
Level condition is determined by using a transit level, machinist level or other higher-technology means.
The specification for level these units is 0-0.5 mm/m.
Scraping off paint to expose a bright metal surface is not required to take level readings, because the painted surface normally provides a sufficiently smooth surface for level measurements.
Figure 5.1 shows the location for taking level on these models.

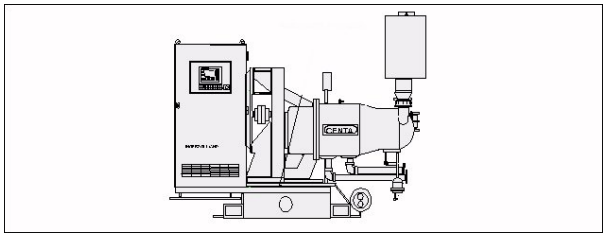


Figure 5.1

5.5 Adjusting the compressor for level

Shims or wedges are placed at each side of each of the anchor bolts and adjusted until a level is achieved.
Figure 5.2 illustrates the use of wedges and shims.

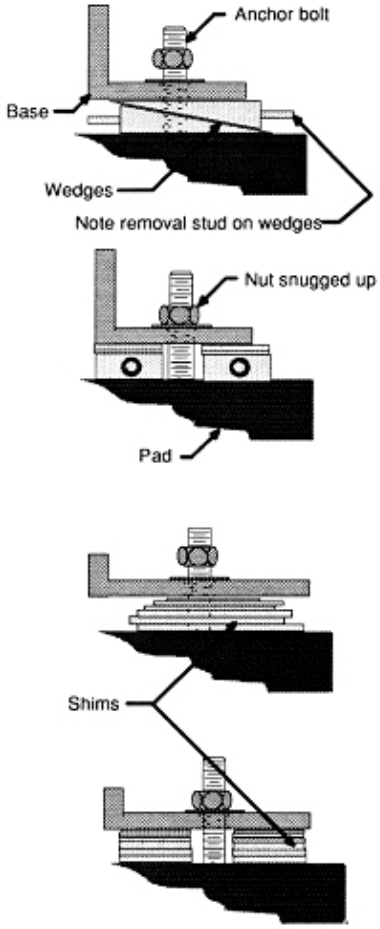


Figure 5.2

Wedges are the preferred adjusting devices because they can be easily removed. Shims serve the same function as the wedges but are difficult if not impossible to remove.

Once the machine is leveled within specifications, the anchor bolt nuts are snug tightened with the machine resting on the wedges or shims.

Actual leveling is done with levers or jacks, whichever are available at the site.

A rough driver to compressor alignment should be done before any grout is poured. The rough alignment check is to verify that no abnormal conditions exist which will interfere with the precise alignment to be done after the grout has set.

The rough alignment position is achieved when the driver is within 1.5 mm of its final aligned position.

5.6 Grouting

Grouting forms are prepared and grout is poured after level has been verified. When the grout has set up, the wedges or shims are removed. The void space left in the wedge or shim area is then back-filled with grout. If the wedges or shims are not removed, corrosion will upset the level at a future time.

A nut used on the underside for leveling of the base is not recommended because it too will corrode over time and upset the level.
Grouting serves two significant purposes; the first purpose is to provide full area support for the machine's weight-bearing base structures, the second purpose is to provide the means of support when a machine needs to be leveled. There are other non-structural purposes for grouting which have to do with housekeeping
Epoxy grouts are recommended because they have proven to be superior to the mortar based grouts. Epoxy grouts are not affected by spilled lubricants and are easy to clean. Mortar grout does not have these advantages.
For CENTACs with flange-mounted motors, no base grouting is required as long as there is full base-plate support contact with the pad and the machines within the specification for level.
On these machines there is little flexibility possible between the compressor and the driver. The drive and driven shafts are aligned by the flange that rigidly holds the two together. Grouting this configuration serves no structural purpose and is not necessary as long as the base is supported and level. Grouting does enhance the ease of housekeeping and overall appearance of the installation. The exception to this is when the foundation pad is not level. In this instance grouting the base to a specified level plane is required.
The supporting surfaces (underside) of all the various CENTAC baseplates are not machined surfaces. The small imperfections in these surfaces relative to a #machined surface# are insignificant regarding the ability to support weight.
If undiffused light can be seen, the surface is too rough and grouting is needed. Regardless of which surface is rough, the corrective action is to install grout.

5.7 Inlet air filter (if supplied loose)

If the filter is not directly mounted on the compressor, but installed remotely, in order to minimize contamination and pressure drop, the filter should be as close as possible to the unit. Access to the filter should be provided with ample room around the filter to perform maintenance. A permanent platform should always be built around elevated filters to provide safety for personnel assigned to changing filter elements. If the filter is located outside the compressor building, the inlet should be located up-wind from any stack emitting corrosive gases including water cooling towers and steam or gas engine exhaust.
Provide, where necessary, on installation site, suitable supports (frames, studs, brackets, etc.). For fixing, use only the holes on clamping plates, do not drill or weld the metallic housing. The unit is designed to operate in outdoor installations, however in this case, it is advisable to provide hot water or steam heated coils, if the filter is to be installed in zone where icing or humidity could occur; this will prevent condensate or icing in filters. Ensure a free space of at least 800 mm in front of the inlet louver. Ensure a free space of 1500 mm in correspondence of the doors in order to let an easy change of the filters. Connect the outlet flange of the unit to the connecting piece of compressor ensuring:

- The utmost cleanliness during the mounting or installation operation.
- A perfect air-tight connection.
- Easy access for eventual inspections, etc.

- Keep the flange protection sheet to its place until the connection is made.

Filter performance entirely depends on how the above operations have been carried out.

5.8 Atmospheric by-pass silencer mounted at a remote location

When foreseen, it must be installed as close as possible to the BV valve, to improve performances.
It must be installed in such manner so the discharge does not create dangerous conditions to people and objects.

5.9 Piping

	**PLEASE, SEE CERTIFIED GENERAL ARRANGEMENT DRAWING IN SECTION #DRAWING# OF THIS MANUAL.**
NOTE	

	**THE COMPRESSOR IS NOT AN ANCHOR POINT FOR THE SYSTEM PIPING.**
CAUTION	

	**THE DESIGN AND CONSTRUCTION OF THE PIPING SYSTEM, IF NOT DIFFERENTLY SPECIFIED IN THE CONTRACT, IS THE RESPONSIBILITY OF THE CUSTOMER. INGERSOLL-RAND IS NOT RESPONSIBLE FOR THE PROJECT. THE FOLLOWING SUGGESTIONS ARE OFFERED AS AN AID TO ASSURE A SUCCESSFUL OPERATION. WE RECOMMEND THE CUSTOMER CONSULT A SPECIALIST SKILLED IN THE DESIGN OF PIPING TO SUPPLEMENT AND INTERPRET THE INFORMATION GIVEN AND A PROFESSIONAL PERSONNEL FOR THEIR CONSTRUCTION.**
WARNING	

The discharge, inlet, bypass, water and other piping connected to the machine must be self-supporting. Piping alignment to the compressor mating flanges is essential, but strains in excess of limits on the casing must be avoided. The limits and specifications for maximum allowable force and moment for the specific compressor are shown in Data Sheet section of this manual.
Piping strains have three sources:

1. Dead weight of the pipe

2. Expansion or contraction of piping as it undergoes temperature change
3. Pressure within the pipe.

In the practical sense, if any pipe needs to be levered or pried into position to match up the flange face with the compressor, there will be excessive pipe strain. A properly matched up pipe flange will have just enough space to slip in a gasket, will allow all flange fasteners (bolt, studs, etc.) to pass through the flange bolt bores without adjustment of the mating flanges, and does not twist in any plane when the fasteners are tightened. All piping connected to the CENTAC should have provisions for compressor maintenance. This usually means that there are flanged sections or unions in the connecting pipe.
A sufficient number of removable sections of pipe should be provided to allow ease of maintenance and repair. Customer-provided piping connections are required to make the CENTAC operational. These connections are the inlet piping, the discharge piping, the bypass air piping, the cooling water and casing vent piping, the instrument air (IA) piping, the control air (CA) piping (for some models) and the condensate drain piping.

5.9.1 Air inlet piping (When Inlet Air filter is supplied loose)

Inlet air is the life line to any air compressor. It is imperative that the compressor receive clean filtered air for it to function virtually maintenance free.
Air inlet piping provides this life line and a carefully well thought out design will save many hours and money in maintenance.
Inlet piping should be as short and direct as possible with the combined filter and piping pressure drop not exceeding 1,3 kPa (13 mbar).
The inlet piping from the inlet filter to the compressor must be clean and of a non-rusting material such as stainless steel, aluminum or galvanized steel pipe.
This pipe should be sized to minimize pressure drop. See general arrangement drawing for minimum pipe diameter. The inlet pipe should be suitably flanged so that it may be cleaned in sections. Figure 5.3 illustrates the general requirements for the inlet piping. Where possible, there should be a straight run of pipe approximately four (4) pipe diameters long between the compressor and long sweep elbow. Transitions in pipe diameters will be required and these transitions should be gradual. Any horizontal run of pipe should be installed such that any condensation in the piping will run away from the compressor and form in a low point in the piping. Install a drain valve in this low point to remove the moisture.

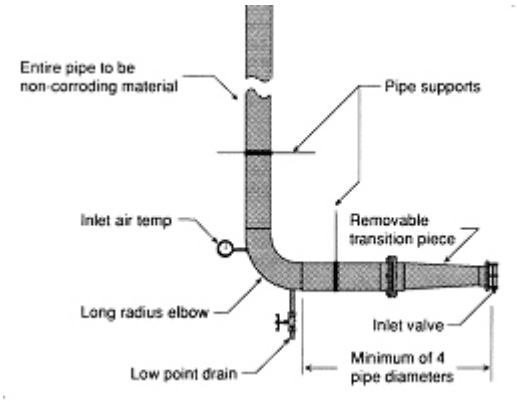
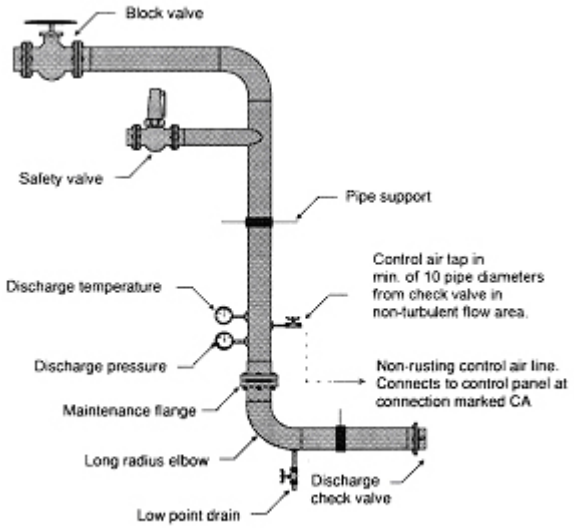


Figure 5.3

Adequate piping supports are necessary to prevent excessive dead weight loads on the compressor flange. Piping supports should normally be of the adjustable type and located as close as possible to the compressor flange. The resultant piping forces and moments on the compressor flange shall not exceed those values listed in the Data Sheet of this manual. An expansion joint is not required, but it is important that the piping be designed such that all alignment may be made in the piping and not the compressor. If inlet piping is installed in an area where sound could be a problem, the inlet piping should be lagged. Furthermore for a better acoustical efficiency, specially needed when air filter is used for indoor installation, an absorptive type inlet silencer should be mounted with limited pressure drop (max 50 mm column of water) as much as possible near the compressor suction.

5.9.2 Air discharge piping

The discharge pipe should be, at least, the full size of the compressor discharge connection (see general arrangement drawing in #drawing# section).
Where pipe diameter conversion and change of direction are necessary, the use of long-radius elbows is recommended. Figure 5.4



Model discharge pipe

Figure 5.4

illustrates the general requirements for the discharge pipe. For best performance, a straight run of pipe approximately three (3) pipe diameters long should be interposed between the discharge check valve and a long-radius elbow to allow for smooth operation of the discharge check valve. A block valve should be installed in the discharge line to prevent backflow through the compressor during any repairs on the compressor.

	**IT IS ADVISABLE TO INSTALL A VALVE BETWEEN THE CHECK VALVE AND THE BLOCK VALVE TO PREVENT OVER PRESSURIZATION OF THE DISCHARGE SYSTEM.**
NOTE	

	**THE DISCHARGE OF THE SAFETY VALVE MUST BE POSITIONED IN SAFETY AREA TO AVOID POSSIBLE INJURY TO OPERATING PERSONNEL AND/OR DAMAGE TO THE EQUIPMENT.**
WARNING	

A thermometer and pressure gauge should be installed in the discharge line to facilitate troubleshooting and to provide backup information. Piping supports are required to prevent excessive strain (dead weight loads) on the compressor flange. The resultant piping forces and moments on the

compressor flange shall not exceed those values listed in the Data Sheet of this manual. As with all pipes connected to the compressor, provisions should be made to make any alignment changes in the piping and not the compressor.

- Check valve in the delivery piping
  Any system check valve in the downstream discharge piping must not be installed between parallel compressors (not the one supplied with the compressor). Diagrams 1A and 1B show Customer system check valves. Check valves installed in the wrong location, as in Diagram 1A will prevent the control system from controlling when operating on line another compressor. In Figure 5.5 , if compressor #2 has a higher discharge pressure than #1, the check valve E will block and prevent the pressure from being seen by the CA line of #1.
  Number 1 will control the pressure in the pipe between its CA line and the downstream check valve but will not contribute flow to the system. Attempts to control this situation with setpoint pressure results in just switching the no-control problem from one machine to the other. In Figure 5.6 , the check valves are correctly positioned where both compressors are sensing the header pressure. Any downstream check valves in parallel compressor installations must be located, so they will not interfere with the compressor control pressure sensing (CA) ability.

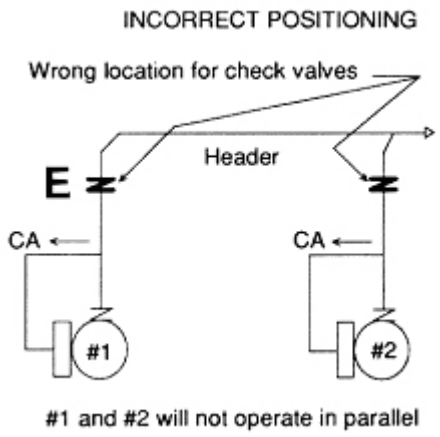


Figure 5.5

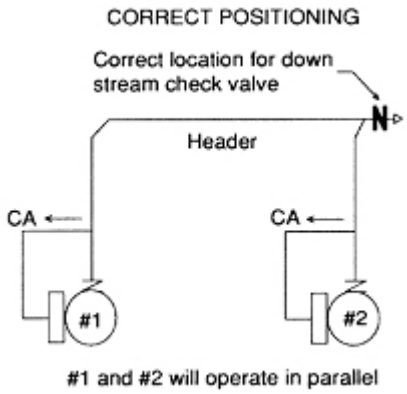


Figure 5.6

- Parallel operation with reciprocating and/or screw compressors
  It is essential that the system into which a single or multiple CENTAC installation will discharge will not upset the dynamic nature of the machines.

	**PISTON COMPRESSORS PRODUCE PULSATION IN THE DISCHARGE LINE AND DEPENDING ON CRITICAL PIPING LENGTHS, THESE PULSATION CAN BE AMPLIFIED CONSIDERABLY CAUSING CHECK VALVE FAILURES. TO PREVENT THESE DISCHARGE LINE PULSATION BEING TRANSMITTED BY PISTON COMPRESSOR, THE CENTAC SHOULD NEVER BE PIPED DIRECTLY TO AN AIR MANIFOLD WITH A PISTON COMPRESSOR(S) CONNECTED TO THE SAME MANIFOLD. THE CENTAC MUST BE PIPED TO A RECEIVER OR PULSATION BOTTLE WHEN OPERATING IN PARALLEL WITH A PISTON COMPRESSOR(S).**
WARNING	

The pulsation's from reciprocating air compressors (if not dampened) will effect the CENTAC discharge and control system in an adverse manner and may cause the CENTAC to surge, not share the load, or cycle up and down and possibly back completely out of the system.
In the event the CENTAC compressor is paralleled with reciprocating or screw compressors, the two discharge lines are routed through a receiver or installed downstream of pulsation dampers.
The receiver will dampen out the pulsation from the reciprocating compressor discharge.

5.9.3 Air by-pass piping

	**BYPASS PIPING SHALL BE DESIGNED SUCH THAT WATER AND CONDENSATION WILL NOT DRAIN INTO THE BYPASS VALVE MOUNTED ON THE COMPRESSOR.**
WARNING	

Atmospheric bypass piping has the function of blow-off, or bypass, flow excess of the compressor when it is running unloaded or operating on constant discharge pressure control and the flow to the system is insufficient to maintain the compressor in the throttling range. Bypass piping should be well supported to minimize loading of the compressor flange. Resultant piping forces and moments on the compressor flange shall not exceed those values listed in the Data Sheet of this manual. Suitable care should be taken in the piping design so that all alignment can be made in the piping. Dilatation joints and piping vibration dampers (if required) should be used for avoiding any acoustical phenomena excitement.

It is recommended that a bypass silencer be installed in the bypass line to reduce noise level.

The best sound attenuation is achieved when the silencer is located as close as possible to the blow-off valve and the total length of bypass piping is kept short. To increase sound attenuation in the bypass piping system: use a straight horizontal run of pipe from the compressor, approximately eight (8) pipe diameters long, before entering a long radius elbow and lag the pipe, and insulate the piping, if necessary.

The assembly scheme for the air by-pass piping is shown in Figure 5.7

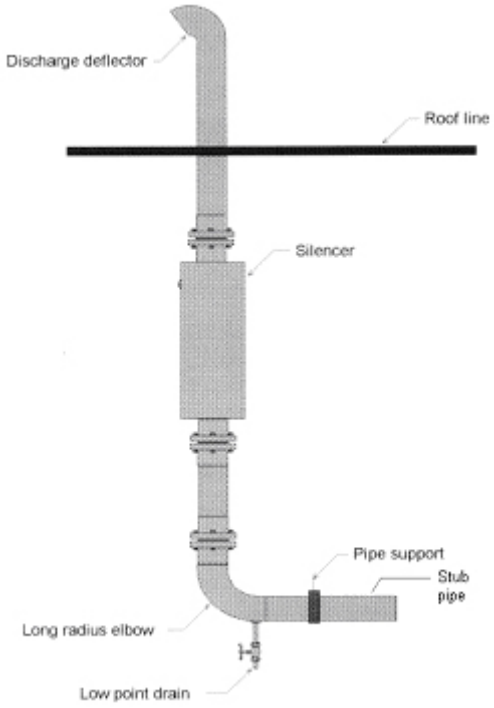


Figure 5.7

In noise critical areas the discharge piping from the silencer may also be lagged to further increase sound attenuation. Discharge piping from the silencer should be sized such that the maximum back pressure on the silencer is 35 kPa(g). The minimum pipe diameter must be equal to the compressor by-pass flange connection diameter (please refer to the General Arrangement drawing in #drawing# section) and minimum diameter of piping between silence to atmosphere must not be less than the silencer exhaust diameter. To reduce maintenance time, the bypass piping should be suitably flanged such that a minimum amount of pipe will have to be disconnected during major maintenance. Although the bypass piping should be as short as possible, bypass air discharging into the atmosphere should not be near the air inlet if the location as a tendency to collect dust and debris. To prevent rain and snow from entering the bypass piping, the end of the pipe should be turned down or have a short horizontal run of pipe.

To remove condensation from the piping, install a drain in the lowest part.

	**THE DISCHARGE DEFLECTOR MUST BE PROVIDED WITH ADEQUATE PROTECTION TO AVOID DANGEROUS INSERTION OF UNDESIRABLE PARTS.**
WARNING	

	**THE DRAWING OF THE SILENCER (when supplied) SHOWS THE CORRECT WAY OF INSTALLATION (ARROW)**
WARNING	

5.9.4 Control air and instrument air piping

5.9.4.1 Control air piping (when supplied)

The control air line supplies a controlled air signal from the compressor discharge line to the control system. The control air source should be located in an area of low turbulence, between the check valve and the block valve. Normally ten (10) pipe diameters after the check valve is sufficient. If the control line is to be installed in the horizontal run of pipe it should be attached to the top of the pipe. The controlled air line should be routed to the control system in such a manner that this line will not have to be disconnected in order to perform maintenance on the compressor. If the control system is equipped with IR, connect the line to the control panel bulkhead fitting marked #CA#.
The controlled air piping should be non-ferrous material such as stainless steel, aluminium, or copper pipe to prevent rusting and scaling.

5.9.4.2 Instrument air piping

Instrument air piping supplies seal buffer air and the motive pneumatic power air to the valve actuators. The air used must be clean dry instrument quality air.
For best results the air should be dried and filtered prior to connection to the control system.
The CENTAC normally requires a 0.5 m3/min air flow at 400¸700 kPa(g) (4-7 bar g).
The final filtering medium (supplied by the customer) should be rated at theorical efficiency of 99.99%, particle size of 0.01 micron. It should be located close to the control system. An isolating valve must be located ahead of the control system inlet.
The instrument air line connected to the control panel bulkhead fitting marked #IA# by a ½ inch NPTF.

Piping should be non corrosive, copper or stainless teel. Separate lines should be used for #CA# and #IA#.

5.9.5 Water piping system

Water piping includes cooling, drain, and air vent piping.
This system covers cooling water to the air and oil coolers of the compressor, a means of removing condensate from the moisture removal systems, and the connection of air vents and cooler drains.
Water used for cooling should be clean and free of corrosive elements.
Since pure water may not be practical, it is best that the water used be treated and filtered to fall within the following range:

- THE TOTAL HARDNESS AS CACO3 SHOULD BE LESS THAN 100 PPM
- THE ACIDITY SHOULD BE WITHIN THE 6.0 TO 8.5 pH RANGE
- THE SUSPENDED SOLIDS SHOULD NOT EXCEED 50 PPM
- THE LANGELIER SATURATION INDEX SHOULD BE BETWEEN + 0.5 AND + 1.0

A water manifold with IR, to the air and oil coolers, may be provided (in the contract) on the compressor with a single inlet and outlet connections for Customer hook-up.
Cooling water piping problems such as high friction loss and noise are relate to flow velocity, caused by inadequate pipe size rather than the quantity of water available from its source.
Elbows, valves and other restrictions in the piping system will create friction which tends to increase the noise level in the water piping system. Cavitation can be a major source of noise in water piping.
Almost all valves will cavitate when the flow rate is great enough or when the valve is partially closed. It is quite difficult to reduce the noise of throttling valves. Adequate pipe lagging can reduce the noise and the use of line silencers might be considered.
In low pressure piping the highest noise is generated on the downstream side of the valves.
In critical applications where they are found to be vibrating, the best approach is to use vibration-isolation techniques to keep them from inducing vibration and noise somewhere else in the system.
Sizing of water pipe may be done by conventional methods. The size of pipe required may be found by using a velocity of 1.8 to 2.1 m/s.
Water piping suggested diameters are equal to compressor cooling water manifold (if supplied) connections, or to coolers single connections (please refer to General arrangement drawing, in #drawing# section).
If it is necessary to consider a closed water system or a cooling tower the heat exchange values shown in the Data Sheet of this manual should be used.
The maximum water pressure recommended at the compressor inlet flange is 600 kPa (6 bar), and a minimum pressure of 250 kPa (2.5 bar). A minimum of 80 kPa (0.8 bar) pressure differential is required between the compressor inlet and discharge piping flanges to obtain proper flow through the unit.
Gate valves should be installed in the coolers water manifold inlet, and throttling valves (globe or ball valves) in the discharge piping.
The gate valve is used to shut off the water flow to the compressor when maintenance work has to be

done.
The throttling valve in the discharge line is used to control flow through the unit.
When cooling water is discharged directly to an open drain, the drain lines should be looped above the highest cooler to insure that the coolers remain full and do not accumulate air pockets. Regardless of the water system used, a strainer must always be used in the water supply line. It is advisable to install a water flow switch in the water manifold; to avoid that the cooling water becomes too low. Air cooler vents with valves are provided at the highest point in the air cooler casings. They are supplied to ensure that the coolers are full of water when the compressor is operating and so that air pockets cannot form in the coolers. Therefore, vent should be held open at all times. These connections must be piped to drain.

5.9.6 Condensate drain piping (not applicable for nitrogen compressors)

Air entering the first stage of the unit carries a certain amount of moisture depending on the temperature and the relative humidity. Moisture is removed from the air immediately after each compression cycle.
This condensation is removed by condensate traps.
Condensate traps are generally factory installed.
The Customer-installed drain lines from the trap and/or the bypass line should be positioned so that the condensate drainage is visible. This provides the operator with a way to check that the trap is working.
The traps drain line termination should not be below the water level in the trough or floor drain.
DO NOT PIPE TRAP DRAIN LINES BELOW WATER SURFACE IN TROUGH, WHEN COMPRESSOR UNLOADS, WATER AND DIRT COULD BE DRAWN BACK INTO TRAP.

	**THE CONDENSED WATER SHALL BE DISPOSED IN THE APPROPRIATE LOCATION.**
CAUTION	

	**ALL AIR AND WATER PIPE TO AND FROM THE INLET AND DISCHARGE CONNECTIONS MUST TAKE INTO ACCOUNT VIBRATION, PULSATIONS, TEMPERATURE, MAXIMUM PRESSURE APPLIED, CORROSION AND CHEMICAL RESISTANCE.**
NOTE	

	**COMPATIBILITY BETWEEN DISCHARGE PIPING, SYSTEM ACCESSORIES, AND CONTROL SOFTWARE MUST BE ASSURED. WHERE COMPATIBILITY QUESTIONS EXIST, CONTACT YOUR NEAREST INGERSOLL-RAND OFFICE.**
NOTE	

	**FOR THE FOREGOING REASONS, THE USE OF PLASTIC PIPING, SOLDERED COPPER FITTINGS, AND RUBBER HOSE AS DISCHARGE PIPING IS NOT RECOMMENDED. IN ADDITION, FLEXIBLE JOINTS AND/OR FLEX LINES CAN ONLY BE CONSIDERED FOR SUCH PURPOSES IF THEIR SPECIFICATIONS FIT THE OPERATING PARAMETERS OF THE SYSTEM. FAILURE TO ADHERE TO THESE RECOMMENDATIONS CAN RESULT IN MECHANICAL FAILURE, PROPERTY DAMAGE AND SERIOUS INJURY OR DEATH. THE PIPING TO AND FROM THE COMPRESSOR MUST BE IN ACCORDANCE WITH THE OPERATIVE AND SAFETY REQUIREMENTS OF THE PLANT.**
DANGER	

5.10 Electrical connections

	**THE ELECTRIC DRIVEN COMPRESSOR IS NOT EQUIPPED WITH AN ELECTRICAL DISCONNECTING DEVICE. THIS DEVICE MUST BE INSTALLED ON THE INCOMING LINE BY THE USER.**
CAUTION	

The CENTAC driven by a main. The electrical installation requirement for the integral electric motor with power up to 630 KW may be supplied (if required in the contract) complete with the motor starter as an integral part of the control system starter configuration is to simply provide the main power source to the control panel. All other electrical cabling is connected on the machinery at the factory. On those units that have remote starters or optional electrical accessories a number of external electrical connections are required. Figure 5.8 illustrates the electrical connections normally required when the starter is separate, where: 1) is the main switch, 2) is the connection for motor power supply, 3) is the connection for CT signal for Ampère reading, 4) is the connection for compressor open contact for operating unit indication, 5) is the connection for starter #feedback# contact.

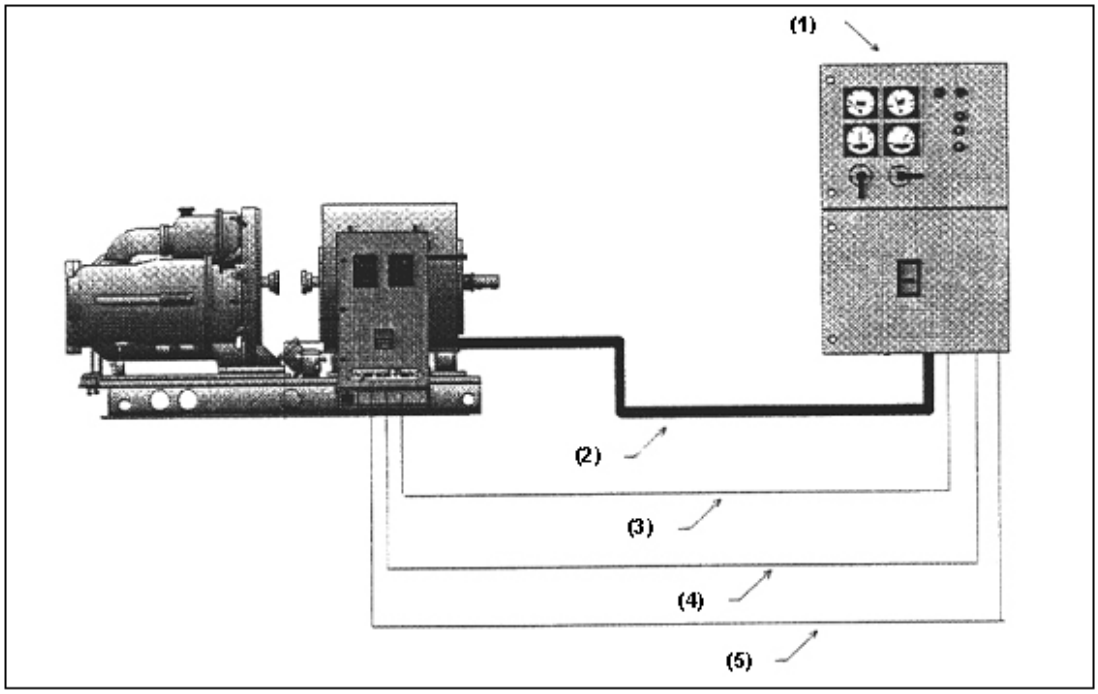


Figure 5.8

	**FOR SAFETY AND OTHER REASONS, THE MAIN POWER CONNECTION MUST BE MADE BY CUSTOMER ELECTRICAL QUALIFIED PERSONNEL.**
WARNING	

In these units with integral star delta starter, the factory pre-wires the CT (current transformer) in the control panel. This CT is connected in a motor winding phase and senses motor phase amperage. The control panel in this case is programmed with a feature that multiplies the motor phase amperage by 1.73. This multiplying feature provides the motor line amperage value that the control panel needs for its control functions. The control panel required current transformer, in remote starter units, could be located in the remote switch gear, in the motor connection box on the motor or in some other location before or after the starter. Location depends on the installation plans for the specific unit.

NOTE	**REFER TO THE ELECTRICAL SCHEME CONTAINED IN THIS MANUAL, TO SINGLE OUT THE TERMINALS FOR THE ELECTRICAL CONNECTIONS.**

Wherever the current transformer is physically located, it must sense only one line phase and monitor motor line amperage alone.
In installations where the line leads are made up of several actual cables, all cables in the sensed phase must pass through the CT. See Figure 5.9

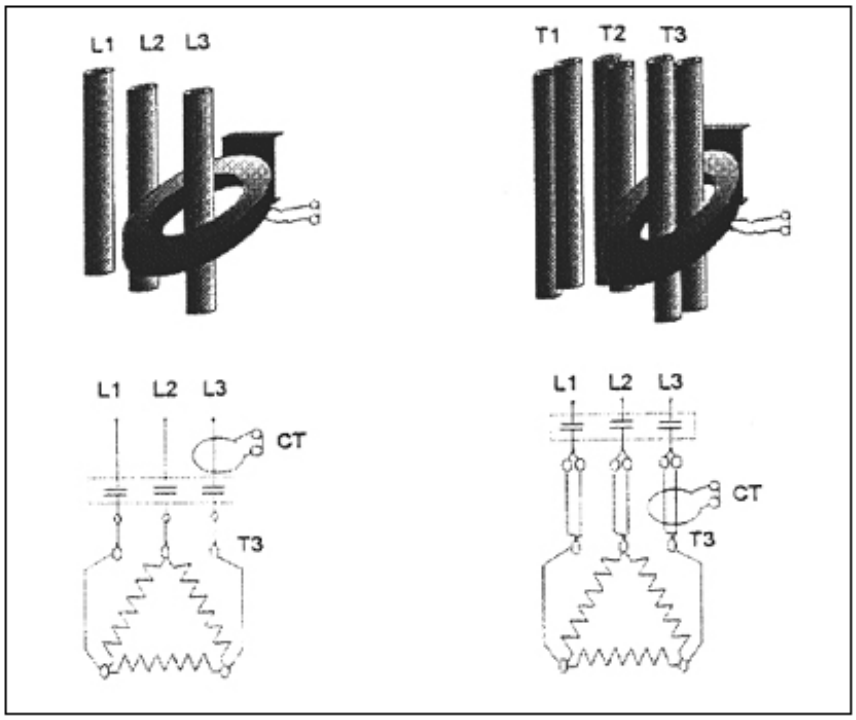


Figure 5.9

WARNING	**ELECTRICAL LINE VOLTAGE MICRO-INTERRUPTIONS AND VOLTAGE DROPS MUST BE AVOIDED. SERIOUS MECHANICAL DAMAGES COULD OCCUR TO THE MAIN MOTOR AND TO THE ELECTRONIC PARTS OF CONTROL PANEL.**

	**THE SECONDARY OF AN ENERGIZED CURRENT TRANSFORMER (CT1 & CT2) MUST NEVER BECOME AN OPEN CIRCUIT. THE SECONDARY MUST REMAIN CLOSED. UNDER OPEN CIRCUIT CONDITIONS A HAZARDOUS POTENTIAL (VOLTAGE) IS DEVELOPED IN A CT SECONDARY WHEN THE PRIMARY HAS CURRENT.**
CAUTION	

	**AN APPROPRIATE COPPER GROUNDING STRAP SHOULD BE ATTACHED TO THE METAL BASEPLATE AND TO SUITABLE GROUND.**
CAUTION	

6 Control System

6.1 General - CMC Panel

The CMC panel is the microprocessor based control and monitoring system for Centac and X-FLO centrifugal compressors. The CMC handles all pressure control and monitoring functions; as well as, control auxiliary equipment such as the main motor starter, oil heater and prelube pump.
The CMC panel has a custom designed computer board called the Base Control Module (BCM). This board has a microcontroller and memory chips that tell the rest of the panel what to do for the various input pressures, temperatures and vibrations. All hardware for data analysis, number of input and output (I/O) points and system memory are optimally selected for accurately controlling and protecting Centac and X-FLO compressors.
Features of the CMC system are:

- Ease of use ... only twelve buttons to push on the operator OUI!
- Multiple function,LCD display to display data and operating status.
- Unload, Modulate and Auto-Dual operating modes.
- Advanced surge detection and control.
- High current limit for main drive electric motor protection.
- First-out indication and event log to help determine the root cause of a compressor trip.
- Pinion vibration alarm and trip for each compression stage.
- Optional port for communicating to the Distributed Control Systems (DCS) via MODBUS protocol.
- Optional reduced voltage motor starter included in panel for some sizes.

6.2 Control Methodology

The CMC utilizes performance and surge control methodologies to meet varying compressed air system needs. The term "performance control" is used for grouping the control modes that affect compressor power consumption through movement of the intake and discharge valves.

6.2.1 Performance Control

The CMC has (3) three standard performance control modes or methods of operation. These modes are a) Unload, b) Modulate and c) Autodual for typical plant air compressors operating in constant pressure applications. For the discussions that follow, Figure 6.1 depicts a typical compressed air system and the relationship between the compressor and the plant air system.

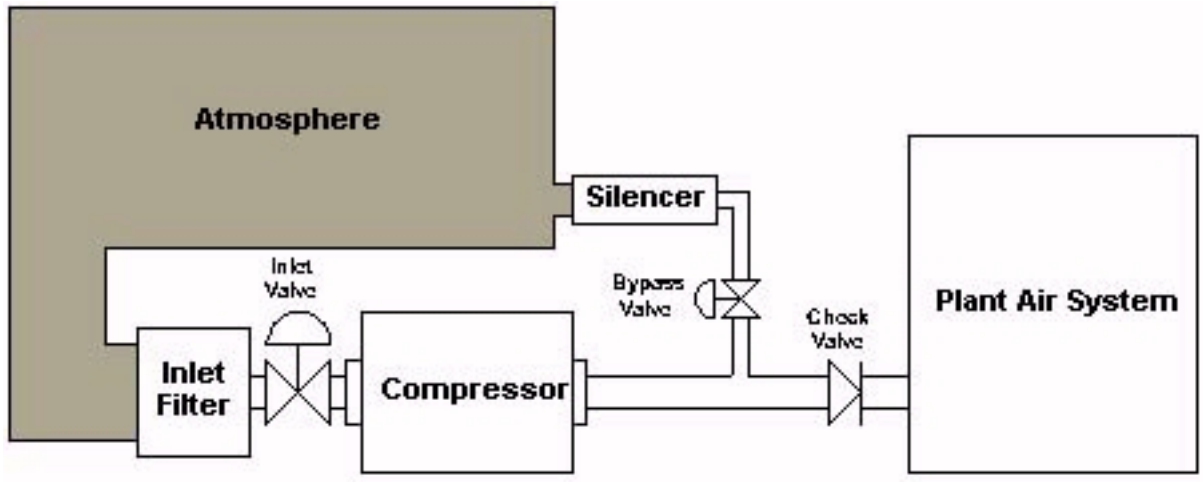


Figure 6.1 Compressed Air System

6.2.1.1 Unload

The compressor is unloaded, when no air is being supplied to the Plant Air System, and all of the air produced by the compressor is being vented to the atmosphere. In this mode, the inlet valve is slightly open to allow enough air to pass through the compressor for internal cooling, prevention of rotor instability and surge avoidance. This air is then discharged through the fully open bypass valve to the atmosphere. Typically, the compressor is set to make a positive pressure across the first compression stage, which produces a discharge pressure something greater than the atmospheric pressure.
The inlet valve opening required to create this positive pressure is directly related to the horsepower consumed; therefore, careful consideration should be given to this inlet valve position for minimizing overall power consumption.

6.2.1.2 Constant Pressure Control - Modulate

Constant pressure control is a frequently required performance control method for Centac air compressors. If left uncontrolled, the compressor's discharge pressure would rise and fall along the natural performance curve as system demand changed. Modulate control satisfies the constant pressure requirement.
Modulate maintains the system discharge pressure at the system pressure set point as entered into the CMC by the user. Once loaded, the compressor will operate along the constant pressure line until the user switches to Unload or presses the stop button.
Control is accomplished by modulating the inlet valve within the compressor's throttle range. When system demand is less than the minimum throttled capacity, the discharge pressure is maintained by modulating the bypass valve and venting some or all of the air to atmosphere. This valve is opened just prior to reaching the surge line. Whenever the bypass valve is open, the inlet valve maintains its position at the minimum throttled capacity setting. Modulate provides a constant discharge pressure with variable capacity from design to zero.

6.2.1.3 Energy Saving Control - Autodual

Autodual automatically loads the machine when demand is high and unloads the machine when demand is low.
When the compressor is controlling to pressure setpoint and demand is within the inlet valve throttle range, constant pressure is maintained in the same manner as Modulate.
When the machine is controlling to the pressure setpoint and system demand is low, the compressor is operated in the bypass valve throttle range. Autodual automatically unloads the machine when the bypass valve is opened beyond the Unload Point for a programmed time period called the Unload Delay Time. The Bypass Valve Unload Point is selected to correspond with the check valve closing since at this point the machine is not supplying the system The Unload Delay Timer should be set to prevent unloading during short excursions through the Unload Point. The Reload Percent determines the System Pressure at which the machine will automatically load into the system.

6.3 Oil System Control

The CMC panel provides control of the pre/post lubrication pump and lube oil heater in the starting sequence, during normal operation and after compressor stop or trip.
The prelube pump is started when the panel power is on and Seal Air is present. The prelube pump stops after the compressor start button is pushed and the programmable timer "Start Time" has expired. The pump does not come on again until the Stop key is pressed, and will remain on until the panel power is turned off or Seal Air is lost.
The oil heater is thermostatically controlled. When the oil temperature is below the set point temperature, the oil heater is energized, above the set point temperature it is de-energized. The oil heater control does not have any interaction with the microprocessor board and is designed to operate with the control panel de-energized as long as three-phase power is available.

6.4 Protection and Monitoring

Each CMC base module is provided with a series of analog and digital inputs, plus a series of analog and digital outputs for control, protection and monitoring. The input functions provide the CMC with information about the compressor. The CMC board uses the output functions to communicate to the user and perform actions like starting the compressor and turning on the pre/post lube pump.
Each input used for protecting the compressor is programmed for alarm and trip indication.
Each of these functions is pre-programmed with the function title, engineering units, range, alarm and trip values, so no configuration is required upon receipt by the customer.

6.5 Compressor Operating Methodology

In the following description of compressor operation, the term "state" is used to indicate what the compressor is doing, or mode of operation, at any given time. These operating states exist in a hierarchy. For example, the two highest level states are "Stopped" and "Rotating". All other states exist at a level below these two states.

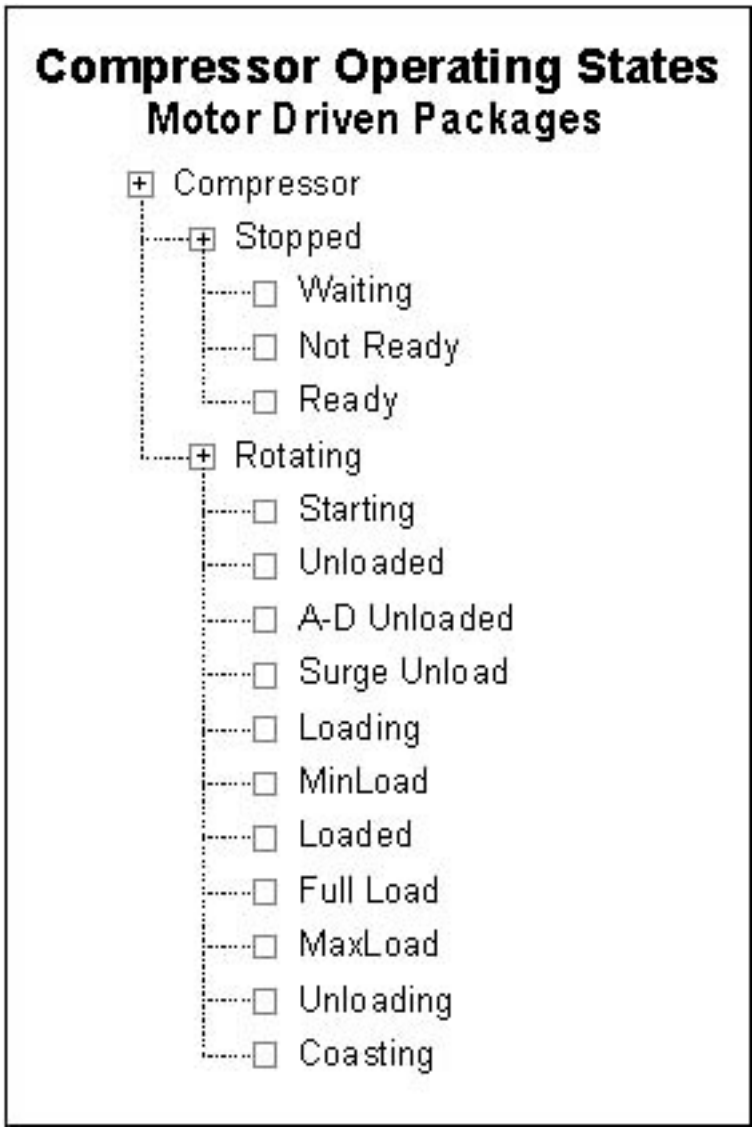


Figure 6.2

Stopped

This state implies that the compressor is or NOT rotating. It is important to note that this is an implication only. If the instrumentation is not working properly or the system is setup improperly, the compressor could be rotating.

Waiting

After the panel power is energized, the controller starts the Waiting Timer and does not allow further User operation until after the timer expires. This timer is set at the factory for two minutes (120 seconds) and is not adjustable. This period allows the compressor prelube pump to circulate oil throughout the casing and prevents restarting while the compressor is coasting down during an electrical interruption.

Not Ready

When in this state, the compressor is "Not Ready To Start". This state is entered when the Waiting Timer has expired and any time that a compressor trip has been identified or a stop command has been issued. A very common and quite often overlooked reason for the compressor being "Not Ready" is when the Emergency Stop push button has been engaged. This state can exist indefinitely.

Ready

Similar to the previous state, this state could be redefined as "Ready to Start". This state is entered when all compressor permissive functions have been satisfied. This state can exist indefinitely.

Rotating

This mode does not necessarily mean that the compressor is actually rotating. It means that it is rotating or rotation is pending and expected.

Starting

Any time after the compressor is ready and a start command is given, this state is entered. The goal for this period is to get the compressor to rated speed and running unloaded. "Starting" is allowed for only the Start Timer period and is adjustable. This time period is limited to a maximum of one minute, or 60 seconds. The reason for the limit is to prevent the compressor from operating in the critical speed for an extended period. Stage vibration alarm and trip setpoints are increased during this period to get the compressor through the critical speed region. After the compressor has "Started", the alarm and trip setpoints are adjusted back to their original values. The same procedure occurs for stage air temperature also.
This state exits only after the Starting Timer has expired. THE COMPRESSOR IS ALWAYS STARTED UNLOADED. On exit of "Starting", the compressor will return to the mode that it was in the last time it ran. For example, typical operation implies that prior to stopping the compressor, the Unload key is pressed. If this occurred, then the compressor will remain in "Unload" after starting. If the compressor is was running and tripped, the compressor will automatically return to the "Loaded" mode on exit of the Starting state. The User may also press the Load or Unload key prior to pressing the Start key to force the compressor to into either post-Starting state.

Unloaded

The compressor is in this state after a start (and Load Selected is not in effect) or when the User issues an unload command. A-D Unloaded and Surge Unload are also considered states. However, these two states are really just reasons for being in the Unloaded state. A-D Unloaded means "AutoDual Unloaded" which occurs when AutoDual is enabled and the system pressure has been high enough for a long enough time to drive an unload command. "Surge Unload" is similar in that a surge event drives the unload command instead of AutoDual. These states can exist indefinitely.

Loading

When a valid load command is issued, the compressor will enter this state. This state exists until the MinLoad state is satisfied. The duration of this state depends upon PID settings for the inlet valve at the MinLoad state and the demand for air.

MinLoad, Loaded, Full Load and MaxLoad

These states transition among themselves as demand for air changes. "MinLoad" means that the bypass valve is controlling pressure and the inlet valve is maintaining the MinLoad Control Setpoint. "Loaded" means that the inlet valve is controlling pressure and the bypass valve is closed. "Full Load" occurs when the inlet valve has reached the full open or 100% position. "MaxLoad" means that the inlet valve is maintaining the MaxLoad Setpoint to prevent motor damage. In both the "Full Load" and "MaxLoad" states, system pressure will be lower than setpoint pressure.

Unloading

This state occurs when a valid Unload command is issued and will persist until the compressor reaches the Unloaded state.

Coasting

When a trip or any stop command is issued and the compressor is running, the motor will be de-energized and the compressor will begin to coast to a Stopped state. This state will remain as long as the adjustable Coast Timer is in effect. At the end of the timer, the compressor will enter either the Ready or Not Ready state.

	**Failure to set the Coast Timer for a period greater than or equal to the actual coasting time can result in compressor damage.**
WARNING	

6.6 User Interface

Figure 6.3

6.6.1 OUI (Operator User Interface)

User interface is defined as the means by which people interact with the compressor control system. The standard configuration of the CMC has two components of the user interface. They are the OUI and the device plate. The key component of "easy to use" is that there are only twelve buttons to press on the OUI and four buttons, lights, and switches on the device plate.

The CMC OUI consists of six command buttons (Start, Stop, Load, Unload, Acknowledge and Reset), four navigation keys (Up, Right, Left and Down), an Edit mode selection key (Enter) and a Contrast key. These keys in conjunction with the 240x128-pixel graphics display make up the user interface to the compressor. The bezel that surrounds the OUI ensures that the NEMA 4 rating is maintained for the OUI.

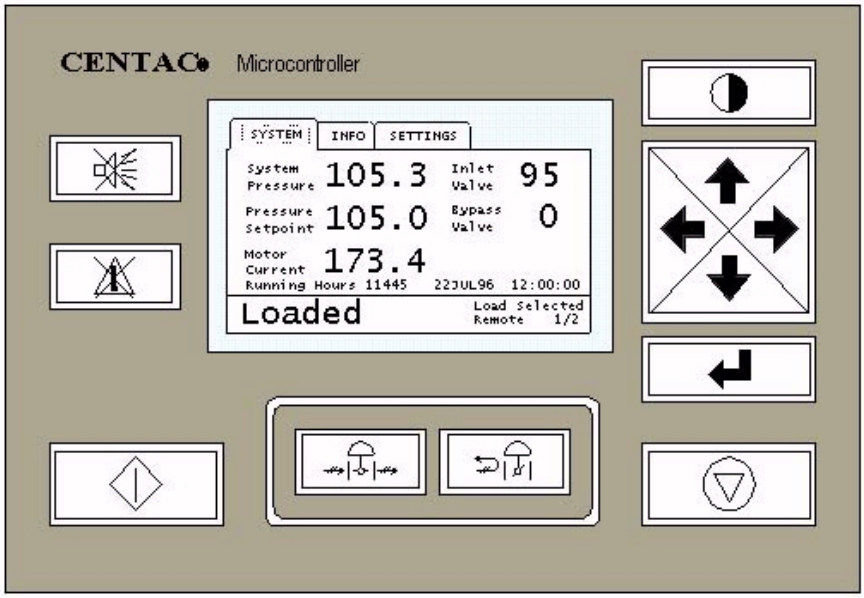


Figure 6.4

6.6.1.1 Command Keys

These keys "command" the compressor to perform actions as specified in the following table. When any of these keys are pressed the action will be logged in the event log.

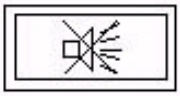
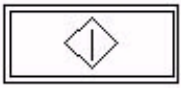
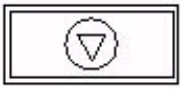
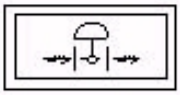
Key	Name	Function
	**Acknowledge**	Silences the optional horn or acknowledges an alarm.
	**Reset**	Clears all trip latches. Required to be pressed after a trip condition to restart the compressor.
	**Start**	Starts the compressor.
	**Stop**	Stops the compressor. This button should be pressed instead of the E-Stop for normal operation.
	**Load**	Engages Modulate or Autodual control mode.
	**Unload**	Unloads the compressor.

Table 6.1

6.6.1.2 Enter Key - Display Operating Mode

The Enter key toggles the display between the NAVIGATION mode and the EDIT mode.

6.6.1.3 Navigation Keys

The arrow keys for Up, Right, Left and Down perform differently depending upon the current display-operating mode.

FOLDER NAVIGATION

To move among the tabbed folders, press the RIGHT or LEFT key. The folder list is circular; that is, when the SYSTEM folder is displayed and the LEFT key is pressed, the SETTINGS folder becomes active. The same is true when the SETTINGS folder is displayed and the RIGHT key is pressed, the SYSTEM folder becomes active.

PAGE NAVIGATION

To move among each folder's pages, press the UP and DOWN keys. The page list is also circular. So, when page 1/4 (pronounced page 1 of 4) is active and the UP key is pressed, page 4/4 becomes active. Also, when page 4/4 is active and the DOWN key is pressed, page 1/4 becomes active. The current page for a folder is persistent. For example, if you begin on the SYSTEM folder page 2, change to the INFO folder and return to the SYSTEM folder, page 2 will be the page displayed.

6.6.1.4 Contrast Key

This key changes the contrast of the backlight for the graphic LCD display. Pressing this key steps among each of the sixteen contrast levels. When stepped to the sixteenth level, pressing the key again returns to the first contrast level.

6.6.1.5 Scroll Mode

Scroll mode is activated by pressing the ENTER key when a folder name INFO is highlighted and the Event Log or the Routine Start / Stop page is visible. The Scroll mode is used to page through the event log. To move among the pages, press the UP or DOWN keys. To deactivate the Scroll mode, press the Enter key.

6.6.1.6 Graphic Display

The 240x128-pixel graphic display allows us to provide a flexible interface between the user and the compressor. The display has three distinct regions as shown in the diagram below.

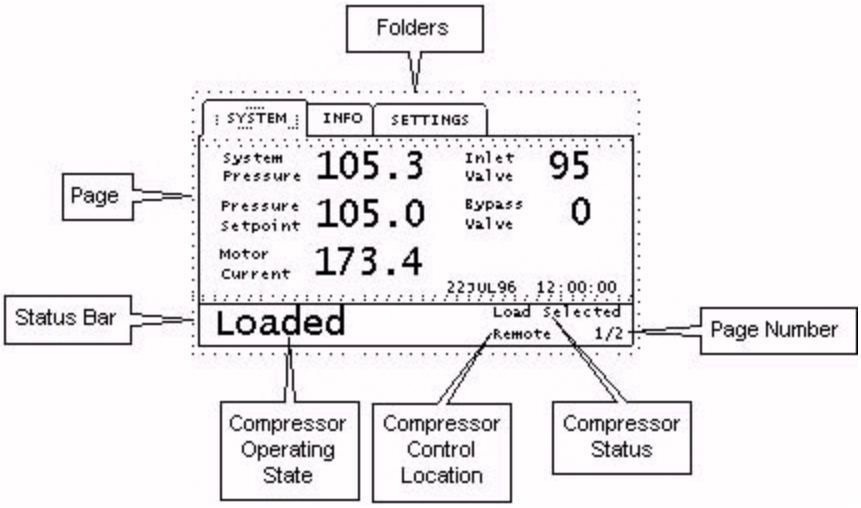


Figure 6.5 Graphics Display Area Definitions

Pop-up Message

In the event of an Alarm or Trip, a pop-up message will appear providing the customer with the phone number of the local Ingersoll-Rand representative. If the event is a Trip, the event log on the SYSTEM folder will be displayed with the pop-up message centered over the displayed page. The message may be removed by pressing the ENTER key. The following are examples of the pop-up message in the event of an Alarm or Trip.

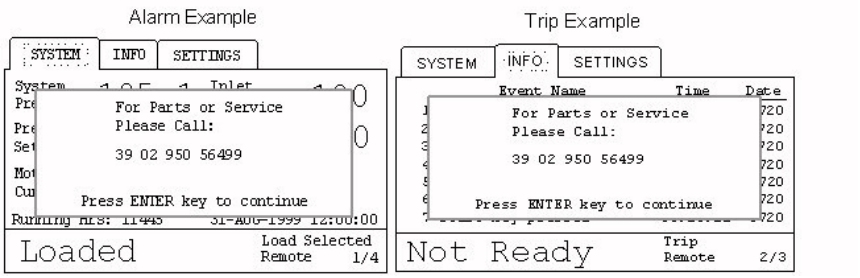


Figure 6.6

Folder and Page

In the design of this system, it is important to provide much of the information required for operating and troubleshooting the compressor. The tabbed folder with multiple pages metaphor has been used to reduce the complexity of a traversing at least ten pages of information. For the standard design, the maximum number of keys required to get to any of the ten pages is four. The SYSTEM folder provides information about the compressor system, the INFO folder gives various types of information about the unit and the SETTINGS folder is used to perform compressor setup.

Status Bar

The Status Bar provides four distinct types of information (Compressor Operating State, Compressor Status, Compressor Control Location and Page Number). This region is always visible from any folder and page combination.
The Compressor Status Field messages are Trip, E-Stop (emergency stop button pressed), RMT-Stop (a remote stop has been pressed), Start Disabled (an optional permissive start condition has not been satisfied), Alarm, Unload Selected (the compressor will stay in "Unload" after "Starting" has been completed), and Load Selected (the compressor will go to "Minload" after "Starting" has been completed).
The Compressor Control Location Field messages are Local, Remote (remote hardwired commands i.e. start, stop, load, unload etc.), Network (MODBUS, communication with a UCM) and Remote/Net (both Remote and Network). This indication is provided to indicate to the operator that a remote location is in control of the compressor and the compressor may start, stop, load, unload, etc. without the local operator initiating any commands.
These three fields combine to provide the operator with the necessary information to create a cursory determination of the status of the compressor. When a more thorough determination is required, the operator can get additional detail by looking through the other pages in the system.
The Page Number indicates the current page for the current folder with the number of pages in the folder. The number of pages is given so that the user always knows where he is in the system.

6.6.1.7 Edit (Setpoint Changes) Mode

Pressing the Enter key to toggle from Navigation to Edit mode can change Setpoints for a page. Once in this mode, the highlight will move from around the folder name to item to be changed. Use the Right and Left arrow keys to move among the changeable items and the Up and Down arrow keys to change the value of the item. When changes are complete, press the Enter key again to return to Navigation mode.

6.6.1.8 Navigation Mode

Navigation mode is active when a folder name (SYSTEM, INFO or SETTINGS) is highlighted. When inactive, press the ENTER key to activate.

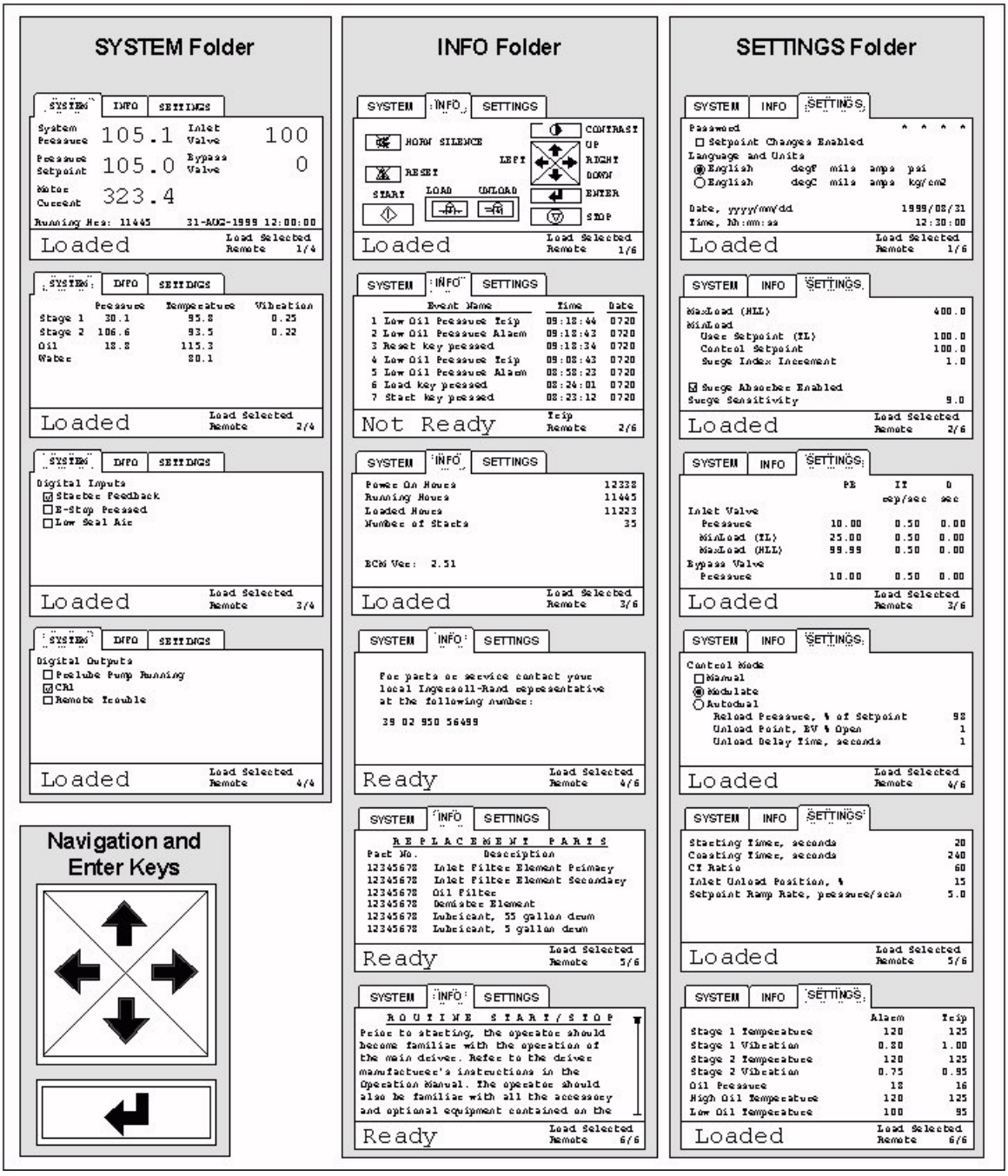


Figure 6.7

6.6.1.9 SYSTEM Folder

The SYSTEM folder provides information about the compressor system. The number of pages in this folder is at least four; but could be more for two stage machines with special analog options purchased, or for compressors with three stages or more.

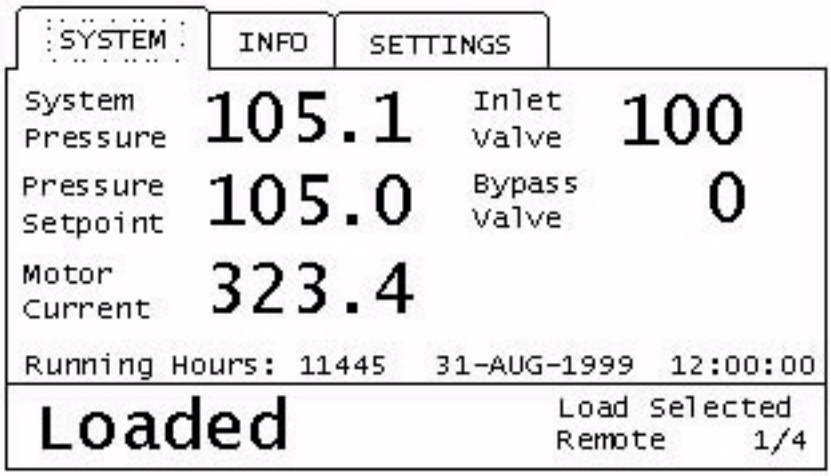


Figure 6.8 System Pressure Page

This page shows the main compressor operating parameters, running hours, date and time. The System Pressure and Pressure Setpoint are in units as defined by the Settings page, Motor Current is in Amps and valve positions are in percent open. Pressure Setpoint is always editable while the Inlet and Bypass Valve positions are edit enabled when in the Manual mode only. These are the only editable settings in any folder other than the Settings Folder.

Info Folder Page 1 Edit Parameters Table				
Variable	**Units**	**Minimum Value**	**Maximum Value**	**Step Size**
Pressure Setpoint	pressure	0.0	999.9	0.1
Inlet Valve Position (manual mode only)	percent	0	100	1
Bypass Valve Position (manual mode only)	percent	0	100	1

Table 6.2

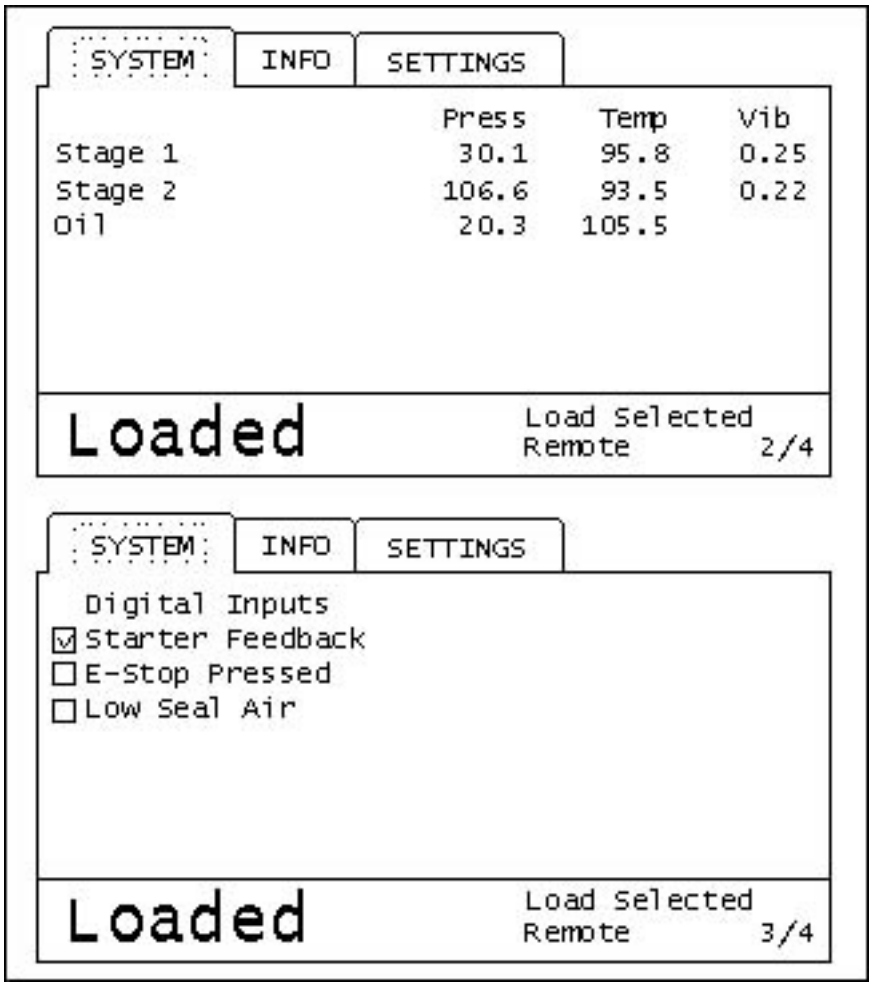


Figure 6.9 Analog/Digital Input Page

The Analog Input page provides the actual value for each stage pressure, temperature and vibration, oil pressure and temperature. If additional analog inputs have been purchased or more stages exist as standard, it is likely that an additional page or pages will be added. The units are as defined by the Settings page. There are no changeable setpoints on this page.

The Digital Input page shows the current state of the digital (discrete) inputs for the system. The number of inputs will vary depending upon the number of optional inputs purchased. A check in the box to the left of the text indicates a TRUE condition, whereas, no check indicates a FALSE condition. For example, a check mark in the "E-Stop Pressed" boxed means that the Emergency Stop push button has been pressed. It is possible to have multiple Digital Input pages.

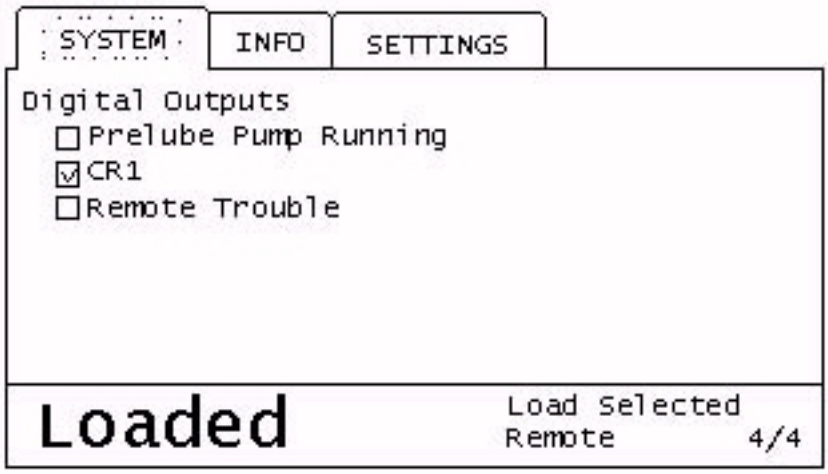


Figure 6.10 Digital Output Page

The Digital Output page is similar to the Digital Input page except that it shows the current state of the digital (discrete) outputs for the system. The number of outputs will vary depending upon the number of optional items purchased. A check in the box to the left of the text indicates a TRUE condition, whereas, no check indicates a FALSE condition. It is possible to have multiple Digital Output pages.
The SYSTEM folder's four pages give the current operating status for the compressor. The User is always within two keystrokes of all operating parameters.

This page of the INFO folder shows the phone number to call for parts or service. This is the number of the local Ingersoll-Rand representative. The number can be changed only by use of Service Tool.

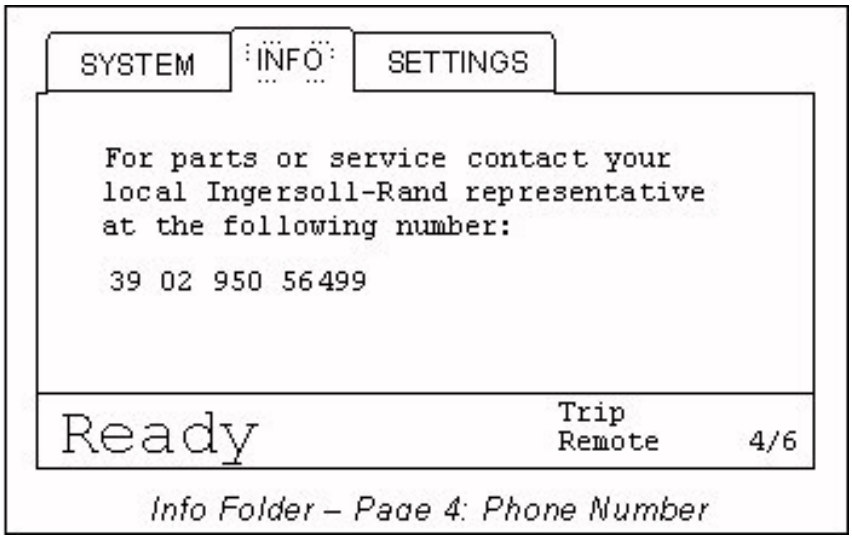


Figure 6.11

This page provides a list of consumable parts found on the compressor package. These parts may also be located in the compressor bill of materials. In the event of a discrepancy, the compressor's bill of materials always takes precedence over this page. In the event that the part numbers are not available, such as retrofitting the CMC on a competitive machine, this screen may not be visible.

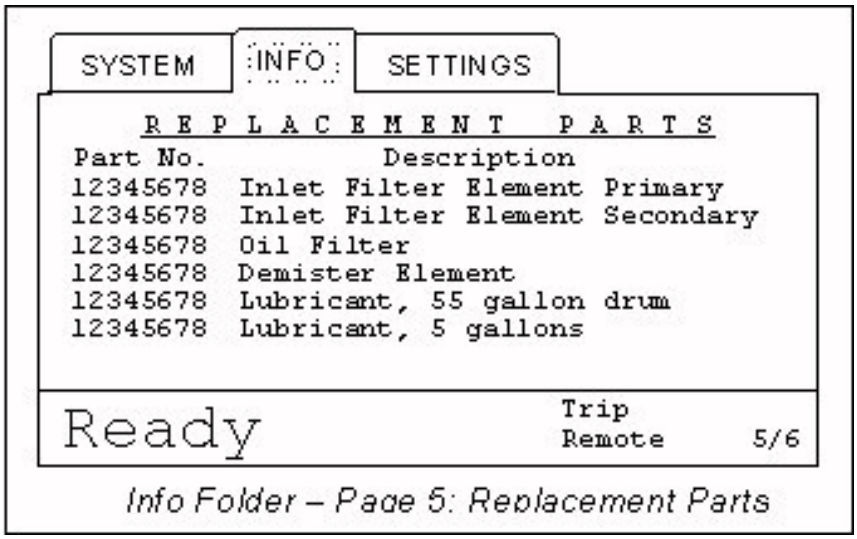


Figure 6.12

Basic operator instructions are provided on the Routine Start/Stop and Maintenance pages. Pressing the Enter key to initiate Scroll Mode allows access to the entire instructions. Scroll Mode is indicated by the reverse video of a slide bar. Each Down Arrow press displays the next eight lines of instructions. An Up Arrow press will display the previous eight lines of instructions. The slide bar on the page indicates current location within the text. If a Trip occurs while on this page, the system will send the display to the event log page.

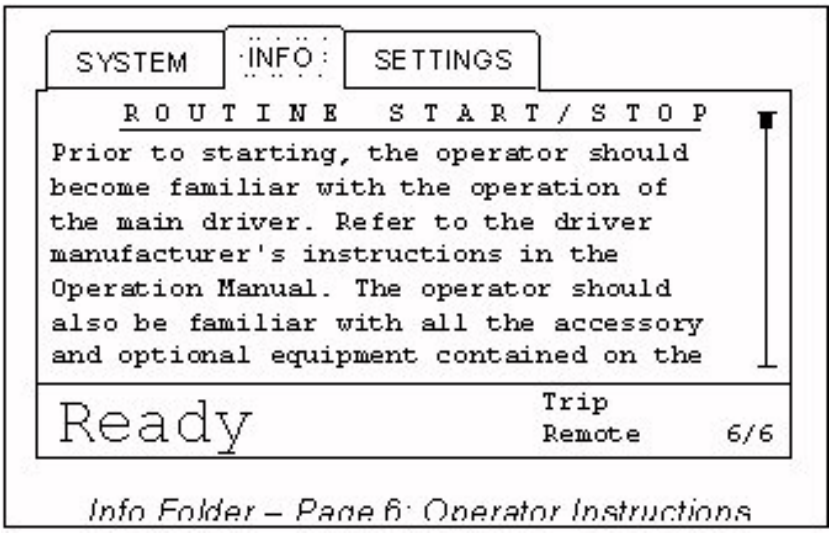


Figure 6.13

6.6.1.10 INFO Folder

The INFO folder contains the OUI key map, the compressor event log and the hour meters. The OUI key map will be the default page on power up. The keys are labeled in English and the local language, depending upon the current language selected.

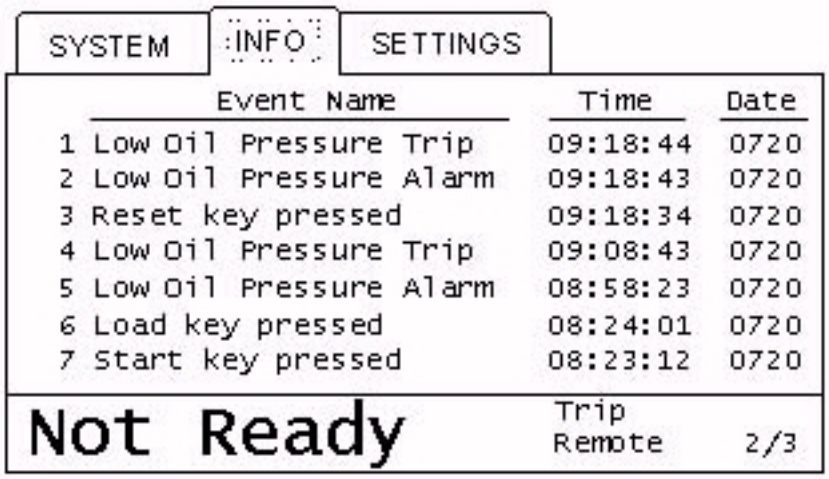


Figure 6.14 Event Log Page

The Event Log details the last two-hundred twenty four (224) "events" that have occurred. Each "event" has a date and time stamp. First-out indication for all Alarms and Trips is satisfied by this log. Any time an Alarm or Trip is indicated on the Status Bar, the detail for that fault is included here.
The event labeled as "1" is the newest event and "7" is the oldest event. Once the list is full, each new

event knocks off the last event.

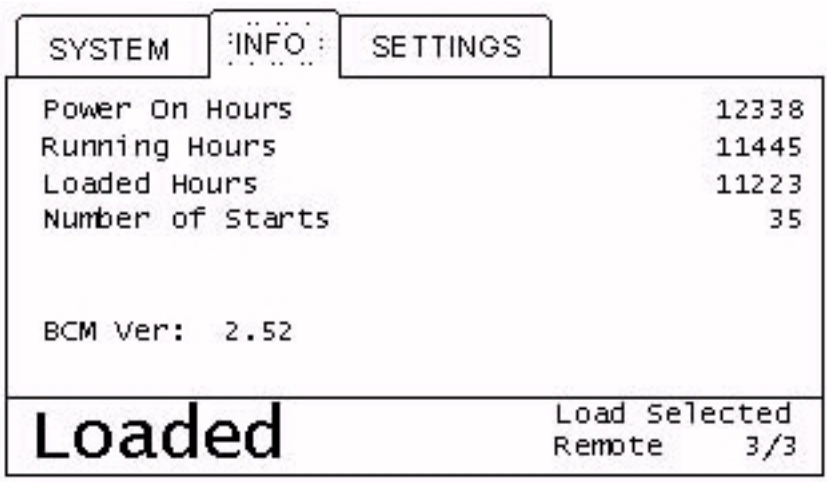


Figure 6.15 Hour Meters Page

For events that have identical Time and Date values, the order is still correct (newest to oldest, top to bottom). Once the list is full, each new event knocks off the last event.
Pressing the Enter key to initiate Scroll Mode allows access to events 17 through 224. Scroll Mode is indicated by the reverse video of the event numbers. Each Down Arrow press displays the next seven events. An Up Arrow press will display the previous seven events. Any time a Trip occurs, the system will send the display to the first seven events.

Possible Events List	
Event Name	Description
* * End of List * *	Displayed for the event name whenever the event list is not full.
A/I Alarm	The actual value for Analog Input “AI” is greater than the Alarm value.
A/I Trip	The actual value for Analog Input “AI” is greater than the Trip value.
Acknowledge (Location)	An Acknowledge command has been issued from Location.
Auto Start	An automatic start occurred (typically from Auto Hot or Cold Start).
Auto Stop	An automatic stop occurred (typically from Running Unloaded Shutdown Timer).
BCM 2 Failure Alarm	Communications have been lost to Base Control Module #2.
BCM 3 Failure Alarm	Communications have been lost to Base Control Module #3.
Compressor Started	The compressor has started.
DI Alarm	The Discrete Input “DI” is in an alarm condition.
Discrete Surge	A discrete surge switch has detected a surge.
DI Trip	The Discrete Input “DI” is in a trip condition.
Edit-x AI Alarm SP	The Analog Input “AI” Alarm setpoint value has been edited from location x.
Edit-x AI Trip SP	The Analog Input “AI” Trip setpoint value has been edited from location x.
Edit-x A/D Reload Pct	The AutoDual Reload Percent value has been edited from location x.
Edit-x A/D Unload Dly	The value has been edited from location x.
Edit-x A/D Unload Pt	The AutoDual Unload Point value has been edited from location x.
Edit-x AHS Pressure	The Auto Hot Start Pressure value has been edited from location x.
Edit-x Auto Stop Time	The Auto Stop Timer value has been edited from location x.
Edit-x BV Position	The Bypass Valve Position value has been edited while in Manual from location x.

Possible Events List	
Event Name	Description
Edit-x BV-PID D	The Bypass Valve Pressure PID Derivative value has been edited from location x.
Edit-x BV-PID It	The Bypass Valve Pressure PID Integral Time value has been edited from location x.
Edit-x BV-PID Pb	The Bypass Valve Pressure PID Proportional Band value has been edited from location x.
Edit-x Coasting Timer	The Coasting Timer value has been edited from location x.
Edit-x CT Ratio	The CT Ratio value has been edited from location x.
Edit-x Day	The Day value for the Date field has been edited from location x.
Edit-x IV Position	The Inlet Valve Position value when in Manual has been edited from location x.
Edit-x IV Unload Pos	The Inlet Valve Unload Position value has been edited from location x.
Edit-x IV-PID D	The Inlet Valve Pressure PID Derivative value has been edited from location x.
Edit-x IV-PID It	The Inlet Valve Pressure PID Integral Time value has been edited from location x.
Edit-x IV-PID Pb	The Inlet Valve Pressure PID Proportional Band value has been edited from location x.
Edit-x MaxLoad SP	The MaxLoad Setpoint value has been edited from location x.
Edit-x MaxLoad-PID D	The Inlet Valve MaxLoad PID Derivative value has been edited from location x.
Edit-x MaxLoad-PID It	The Inlet Valve MaxLoad PID Integral Time value has been edited from location x.
Edit-x MaxLoad-PID Pb	The Inlet Valve MaxLoad PID Proportional Band value has been edited from location x.
Edit-x MinLoad Index	The MinLoad Surge Index Increment value has been edited from location x.
Edit-x MinLoad SP	The MinLoad Setpoint value has been edited from location x.
Edit-x MinLoad-PID D	The Bypass Valve Pressure PID Derivative value has been edited from location x.
Edit-x MinLoad-PID It	The Bypass Valve Pressure PID Integral Time value has been edited from location x.
Edit-x MinLoad-PID Pb	The Bypass Valve Pressure PID Proportional Band value has been edited from location x.
Edit-x Month	The Month value for the Date field has been edited from location x.
Edit-x PSP Ramp Rate	The Pressure Setpoint Ramp Rate value has been edited from location x.
Edit-x Sensitivity	The Surge Sensitivity value has been edited from location x.
Edit-x Starting Timer	The Starting Timer value has been edited from location x.
Edit-x Sys Press SP	The System Pressure Setpoint value has been edited from location x.
Edit-x Time	The Time value has been edited from location x.
Edit-x Year	The Year value for the Date field has been edited from location x.
E-Stop pressed	Emergency Stop push button has been pressed.
Load (Location)	A Load command has been issued from network communications.
Loss of Motor Current	Motor current feedback was lost while running.
MinLoad Clamped	The MinLoad Control or User Setpoint value has been limited to the MaxLoad Setpoint value.
MinLoad Incremented	The MinLoad Control Setpoint value has been incremented as a result of surge.
MinLoad Reset	The MinLoad Control Setpoint value has been reset to the MinLoad User Setpoint value.
Starting Fail	Driver feedback was not received after a Start command was issued.
Starter Failure	Feedback was not received from the starter after a Start command was issued.
Power Down	The Base Control Module (BCM) was de-energized.
Power Up	The Base Control Module (BCM) was energized.
Reset (Location)	A Reset command has been issued from Location.
Start (Location)	A Start command has been issued from Location.
Starter Failure	Starter feedback was not received after a Start command was issued.
Stop (Location)	A Stop command has been issued from Location.
Surge	The controller has detected a Surge.
Surge Unload Alarm	The alarm condition when the compressor has unloaded as a result of multiple surges.
Unload (Location)	An Unload command has been issued from Location.

Table 6.3

	**"Location" is replaced by "Comm" for communications network, "Local" for local compressor display and "Remote" for hardwired remote communications.**
NOTE	

	**"x" is replaced by "C" for edits from a communication network and "L" for edits from the local display.**
NOTE	

	**All Analog Inputs get edit local, edit communications, alarm and trip event messages.**
NOTE	

	**All Discrete Inputs for Alarm or Trip get alarm and trip event messages.**
NOTE	

The next page shows the hour meters and number of starts. Power On Hours is the time that the panel power has been on. The Running Hours is the amount of time that the compressor has been operating between each start and stop sequence. The Loaded Hours is the amount of time that the compressor has been running and not running unloaded. It can also be defined as the number of hours that the inlet valve is not in the Inlet Unload Position. The Number of (Compressor) Starts is self explanatory.

	**Most electric motors are only rated for two cold starts or one hot start per hour. It is the operator's responsibility not to exceed the electric motor's limitation. The control system allows the compressor to be started when the compressor is ready, not the motor.**
NOTE	

The last item on this page is the Base Control Module Version number. This will be used by field personnel for quick reference to determine if newer software is available.

6.6.1.11 SETTINGS Folder

The SETTINGS folder is used for compressor setup. In this folder, the User will enter performance and control operating parameters, analog health monitoring settings for Alarm and Trip conditions, control mode selection, setpoint changes, password, and user interface language. This folder is the primary location for editing setpoints.

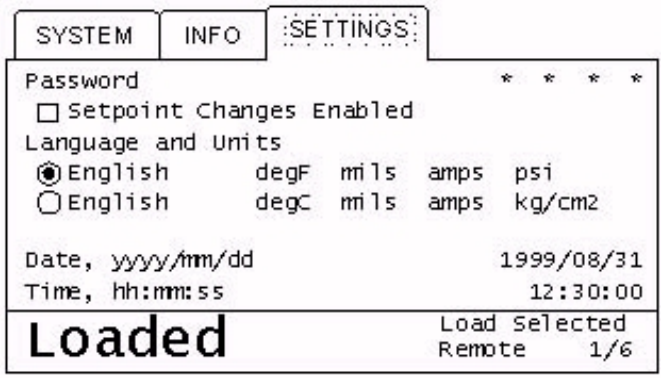


Figure 6.16 Password, Language, Units Page

The Password is used for determining whether Setpoint Changes can be made. The Password takes four numbers. If the Password is entered properly, Changes will be enabled (a check will be in the box); otherwise, they are disabled. This enabling and disabling applies to all changeable setpoints except, Pressure Setpoint, Throttle Limit, language selection and the Password, these items are always modifiable.

Each control system is shipped with two languages and units of measure combinations. The first set is for the English language, pressures in units of PSIG, temperatures in units of degrees F and vibrations in units of mils. The other set will be localized for the customer. The default alternate language is English with Metric units. Language support will be provided as standard for English, all European languages required for the CE Mark, and Chinese. This system has the ability for any language because of the graphics display. Asian character support will require additional screens because these characters require four times the number of pixels. There are no limitations on the units of measure. Each analog input has its own scaling factor and offset.

The Date is set with three separate values (1) Year, including century (2) Month and (3) Day. The Time is also set with three values (1) Hour, (2) Minutes and (3) Seconds.

Settings Folder Page 1 Edit Parameters Table				
Variable	**Units**	**Minimum Value**	**Maximum Value**	**Step Size**
Password Digit	dimensionless	0	9	1
Date (Year)	years	1990	2089	1

Date (Month)	months	1	12	1
Date (Day)	days	1	13	1
Time (Hour)	hours	0	23	1
Time (Minute)	minutes	0	59	1
Time (Second)	seconds	0	59	1

Table 6.4

The Anti-surge Settings and Driver Over-Load Protection Page has all of the settings for controlling and detecting surge conditions and protecting the main driver from over load conditions.

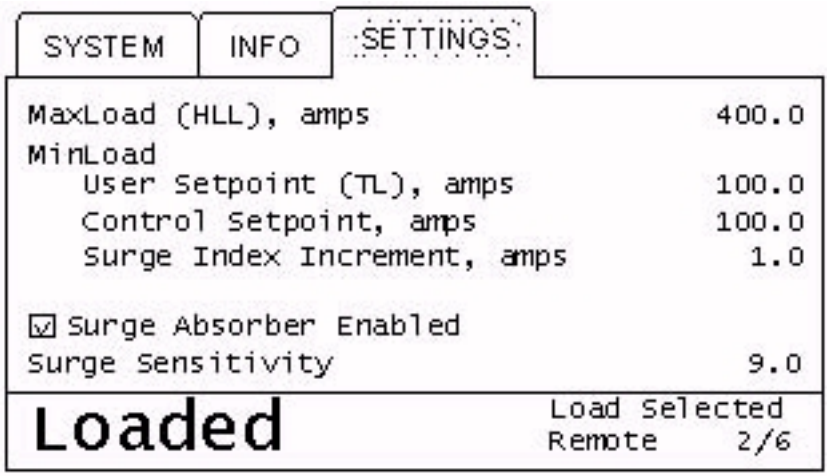


Figure 6.17 Anti-Surge Settings Page

The MaxLoad (HLL) setpoint prevents the compressor driver from overloading.

	**The MaxLoad (HLL) value should not exceed the value determined in the section titled Setting High Load Limit (HLL). Failure to set this properly could result in damage to the motor.**
WARNING	

MinLoad User Setpoint (TL) is the value used to determine what the initial value (before indexing) when the bypass valve begins constant pressure control in lieu of the inlet valve. MinLoad Control Setpoint is the actual value used to determine when the bypass valve begins constant pressure control in lieu of the inlet valve. This value equals the MinLoad User Setpoint plus the number of surges times the index increment value. MinLoad Surge Index Increment is the value that the Control Setpoint is

indexed after a surge has been detected. If the value for Surge Index Increment is equal to zero, Surge Indexing is disabled.

To reset the MinLoad Control Setpoint to the MinLoad User Setpoint, hold the reset key for at least five seconds. The indication that it has been reset will be in the event log. The event message "MinLoad Reset" will be displayed. Another indication is when the MinLoad User Setpoint value equals the MinLoad Control Setpoint value.

The Surge Absorber Enabled checkbox allows the user to turn off or on the Surge Absorber feature. When disabled, the compressor will Unload on any surge condition.

The Surge Sensitivity setting has a range from one (1) to ten (10) where one is not sensitive (a "soft" surge condition could exist without being identified) and ten is very sensitive (a "soft" surge condition would be identified). We ship the machine with a default value of nine (9). This setting will pick up most surge conditions.

Settings Folder Page 2 Edit Parameters Table				
Variable	**Units**	**Minimum Value**	**Maximum Value**	**Step Size**
MaxLoad (HLL)	amps	0.0	9999.9	0.1
MinLoad User Setpoint (TL)	amps	0.0	MaxLoad	0.1
MinLoad Surge Index Increment	amps	0.0	9999.9	0.1
Surge Sensitivity	dimensionless	0.0	10.9	0.1

Table 6.5

	**When Surge Indexing is enabled and the compressor surges several times, the compressor will begin bypassing air sooner than when Surge Indexing is disabled. You should periodically reset the MinLoad Control Setpoint to prevent excessive air bypass.**
WARNING	

	**Repeated surging can cause damage to the compressor; therefore, use caution when desensitizing the Surge Sensitivity setting.**
WARNING	

The Control Parameters Page is used for matching the control system to the local application. The Proportional Band (PB), Integral Time (IT) and Derivative (D) settings are provided for both the inlet

valve and bypass valves. This gives the controller precise control for modeling the air system over the entire operating range of the compressor. With this release, the Derivative constant has been added to give even more capability to match the control system to the air system. However, we recommend that this value remain at zero unless you have full understanding of how this parameter works.

Settings Folder Page 3 Edit Parameters Table				
Variable	**Units**	**Minimum Value**	**Maximum Value**	**Step Size**
Each PB (Proportional Band)	dimensionless	0.0	99.99	0.1
Each It (Proportional Band)	repeats/second	0.0	99.99	0.1
Each D (Proportional Band)	seconds	0.0	99.99	0.1

Table 6.6

	**Setting the Derivative parameter to a value other than zero for any of the PID settings may cause the valve output to change rapidly. Please change this value with caution.**
WARNING	

The Control Mode Selection Page allows the User to select between the two standard control modes, Modulate and Autodual. This selection process is performed with the radio button selector. To change the selection, press the Up or Down arrow key.

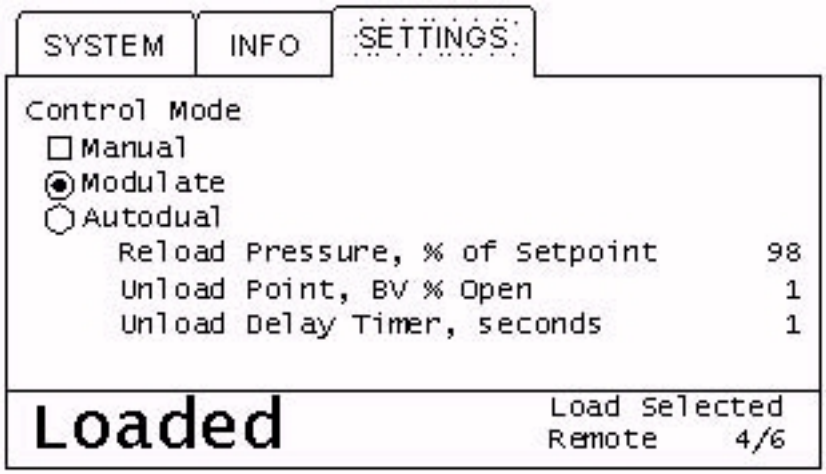


Figure 6.18 Control Mode Selection Page

Reload Percent, Unload Point and Unload Delay Time are all setpoints for Autodual control.
Checking the Manual checkbox enables manual valve control. In this mode, the inlet valve may be stroked when the compressor is not running, and the bypass valve can be stroked at any time. If a surge condition occurs while manually controlling these valves, the CMC will automatically take over the valves.

Settings Folder Page 4 Edit Parameters Table				
Variable	**Units**	**Minimum Value**	**Maximum Value**	**Step Size**
Autodual Reload Pressure	% of Setpoint	0	99	1
Autodual Unload Point	BV % Open	1	99	1
Autodual Unload Delay Timer	seconds	0	999	1

Table 6.7

Starting Timer is the length of time prior to enabling the loading of the compressor. Typically, this time includes the starter transition time (Y-D time). When this timer expires, the prelube pump will turn off and the compressor is enabled for loading.
Coasting Timer is the length of time that it takes for the driver to stop rotating.

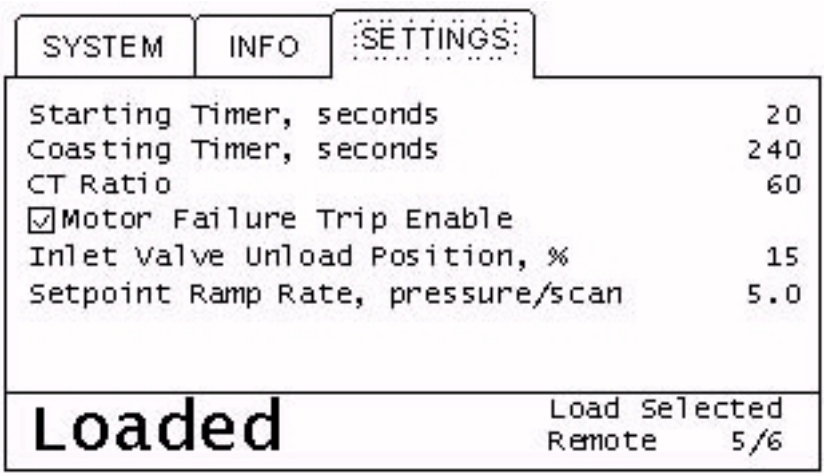


Figure 6.19 Miscellaneous Settings Page

CT Ratio is the ratio of the current transformer primary to the secondary; i.e., if the CT primary winding is 300 and the secondary winding is 5, then the CT Ratio is 60.
When checked, Motor Failure Trip Enable tests that the zero amp motor current has been reached after a start command has been initiated and that motor current is not lost while the compressor is running. Uncheck this box for dry run conditions.
The Inlet Unload Position is the position of the inlet valve when in the unload state.
Setpoint Ramp Rate is used to prevent system pressure overshoot during compressor loading.
Additional settings will be added to this page for "special" features

Settings Folder Page 5 Edit Parameters Table				
Variable	**Units**	**Minimum Value**	**Maximum Value**	**Step Size**
Starting Timer	seconds	5	60	1
Coasting Timer	seconds	0	9999	1
CT Ratio	dimensionless	60	9999	1
Inlet Valve Unload Position	percent	0	100	1
Setpoint Ramp Rate	pressure/scan	0	999.9	0.1

Table 6.8

 **WARNING**	**Failure to set the Coast Timer for a period greater than or equal to the actual coasting time can result in compressor damage.**

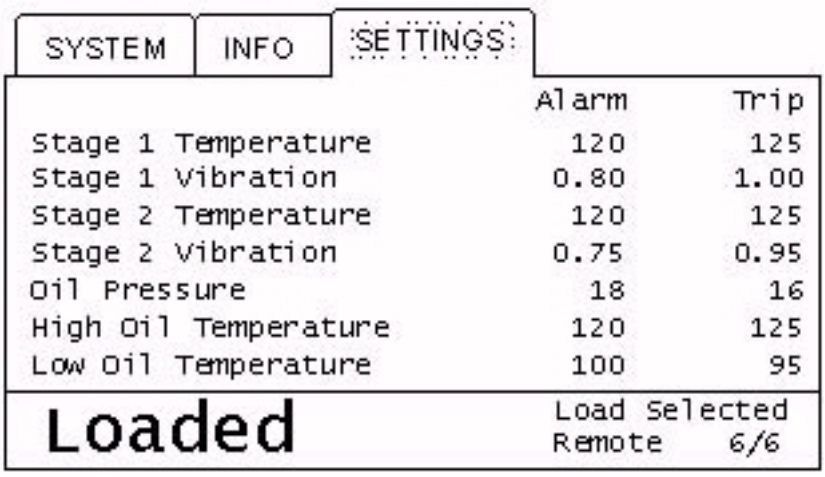


Figure 6.20 Alarm and Trip Settings Page

The Alarm and Trip Settings Page provides the means for changing the analog health monitoring values. The number of inputs varies depending upon the number of compression stages and optional inputs. Additional pages will be added as needed after this page. All line items are changeable for the Alarm and Trip setpoints.

6.6.2 General Sequence of Operation

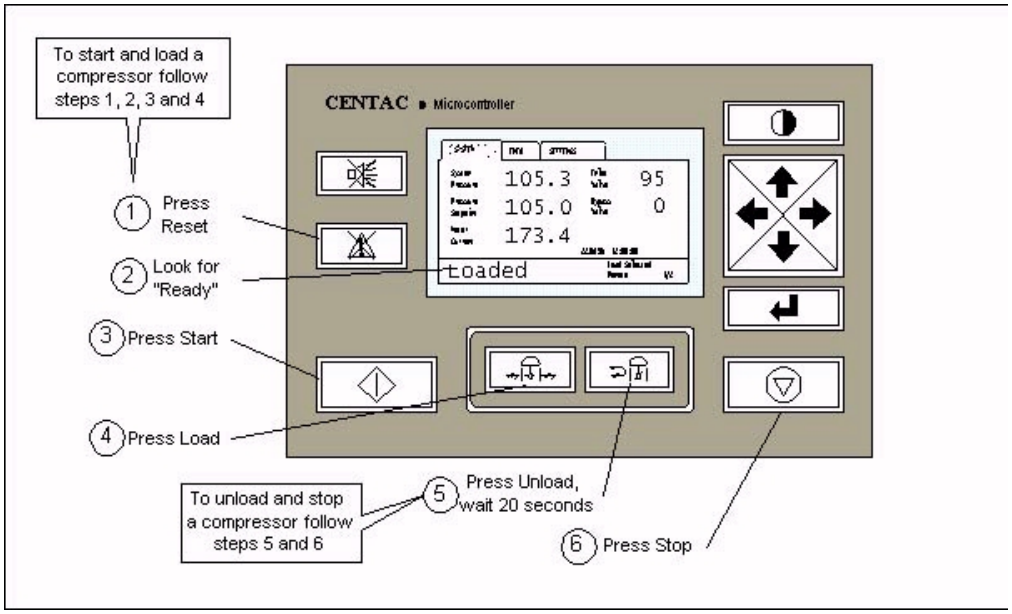


Figure 6.21

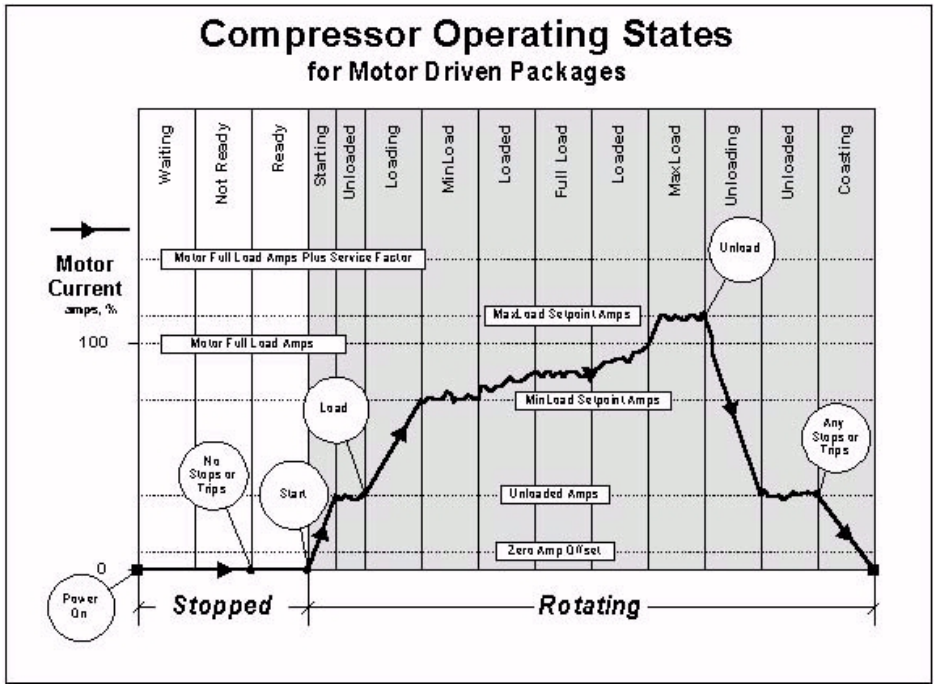


Figure 6.22

6.6.3 Indicator, Switch and Light Layout

In addition to the CMC OUI there may be a variety of indicators, switches, and lights mounted on.

6.6.3.1 Lights

The lights provided are the green CONTROL POWER ON light, which is integral to the CONTROL POWER OFF/ON switch, the amber PRELUBE PUMP RUNNING light and the red TROUBLE INDICATION light.

6.6.3.2 Push Buttons

The red EMERGENCY STOP push button stops the compressor any time that it is pressed. This push button is used to initiate a stop in the case of an emergency.

6.6.3.3 Switches

The CONTROL POWER ON/OFF selector switch turns the panel power on or off. An optional LOCAL/REMOTE selector switch is provided when purchasing an automatic start option.

6.7 CMC Tuning Procedures

When commissioning a new compressor, troubleshooting an existing compressor, or tuning a system, the following procedures may be required. The procedures are performed, and any changes required are made through the CMC OUI. For instructions on how to use the OUI refer to the section titled User Interface. The following figure will be referenced in the procedures.

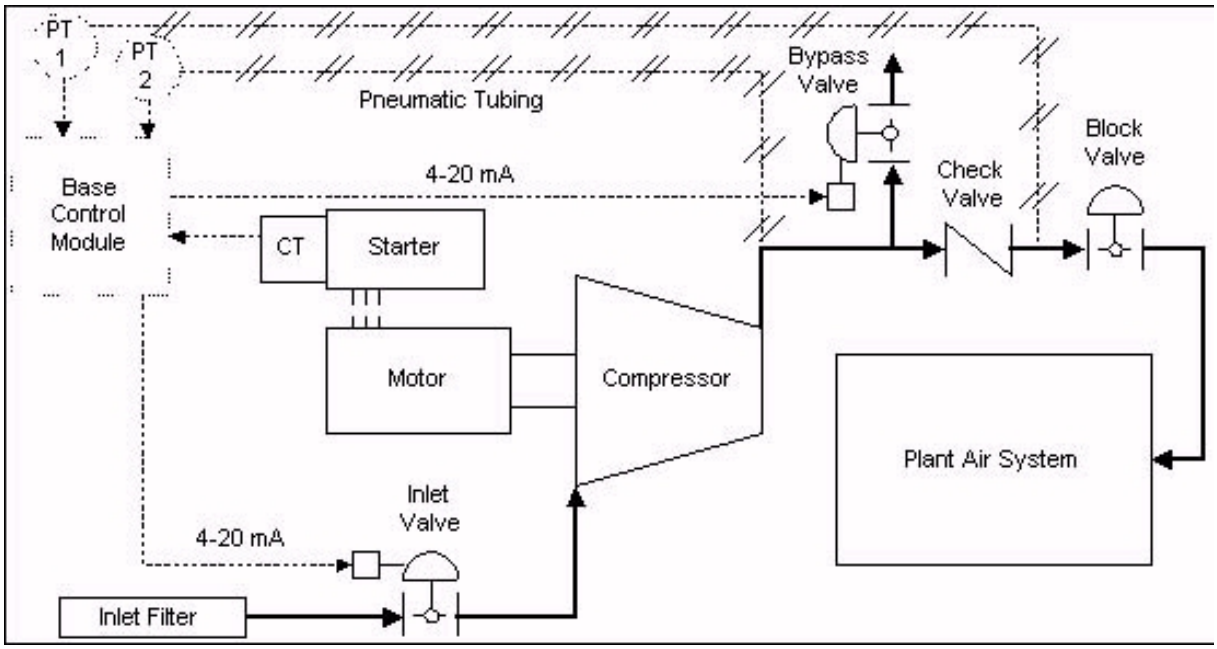


Figure 6.23 Plant Air System

6.7.1 Setting MaxLoad (HLL)

The MaxLoad Setpoint keeps the motor within the allowable current range. To determine the value for MaxLoad, an Adjusted Service Factor (ASF) is multiplied by the motor full load amps (FLA). The (ASF) is found by obtaining the motor service factor from the motor nameplate and selecting the adjustment factor from the table below. The motor full load amps is found on the motor nameplate.

Motor Service Factor	Adjusted Service Factor
1.15	1.05
1.25	1.10

Table 6.9

Example: MaxLoad = FLA X ASF
FLA: 134 Amps
Motor service factor: 1.15
MaxLoad: 140

6.7.2 Setting MinLoad

MinLoad establishes the minimum flow through the machine when loaded, it is the maximum point of inlet valve throttling. If system demand is below this throttle point, the compressor must bypass air or unload. If flow were allowed to go below MinLoad, the machine would eventually hit the surge line and surge. By stopping inlet valve throttling at MinLoad the machine is kept out of surge. To find the MinLoad setting, the machine is run into the surge line, and the value of load (amps, kilowatts, SCFM) at surge is recorded. The recorded value is then incremented by five percent and set as the value for MinLoad.

1. Before continuing this procedure, verify the following:
   - The inlet and bypass control valves have been calibrated.
   - The machine is running unloaded.
   - The block valve at the inlet to the plant air system (Figure 6.23) is closed.
   - The pressure setpoint is set to the pressure at which the machine is going to operate.
2. Set initial MinLoad estimates.
   - In the Settings Folder, select the Edit Data cell for MinLoad.
   - Increment or decrement the value to achieve a value of approximately 95% of full load amps.
3. Preset the manual bypass valve position to 100.
   - On the OUI select the Settings Folder and enable manual valve control by highlighting the manual check box.

	**When Manual is enabled, both control valves can be positioned while stopped, while only the Bypass Valve can be positioned when Loaded.**
NOTE	

- Switch to the System Folder Page 1 and press the Enter Key to enable edit mode.
- Use the horizontal navigation keys to select the bypass valve.
- Increment the value to position the valve to 100 percent.

4. Load the compressor by pressing the Load Key.
5. Find the throttled surge point.
   - Slowly decrement the bypass valve position until the last stage discharge pressure equals the pressure setpoint.
   - Allow the system to stabilize at MinLoad. It the system does not stay at MinLoad, slightly decrement the valve position to force the machine to throttle to MinLoad.
   - Decrement (MinLoad) 2%.
   - Verify the last stage pressure equals the pressure setpoint and adjust the bypass valve position if necessary.
   - Repeat 5.2-4 until the compressor surges.
6. Increase MinLoad by five percent.
7. Exit MinLoad editing by pressing the Enter Key.
8. Unload the machine.
9. Disable manual valve control by unchecking the manual check box.

6.7.3 Setting MinLoad Surge Index Increment

When Surge Indexing is enabled (MinLoad Surge Index Increment is greater than zero), the Index Increment value is the amount added to the MinLoad Control Setpoint upon a surge. The MinLoad Control Setpoint will stop being incremented when and if the value reaches MaxLoad.

6.7.4 Setting Surge Sensitivity

The Surge Sensitivity setting should be set sensitive enough to detect a surge, yet not trigger on spurious noise in the system. To set the surge sensor the machine is forced to surge by running the machine at MinLoad and the MinLoad setpoint is dropped until the machine audibly surges. The process is repeated until the correct setting is found.

1. Before continuing this procedure, verify the following:
   - The plant can tolerate a pressure disturbance when the machine surges.
   - Surge Indexing (by placing MinLoad Surge Index Increment to zero) is disabled.
   - Surge Absorber is disabled.
   - The pressure setpoint is set to the pressure at which the machine is going to operate.
   - The machine is running unloaded.
2. Set the initial Surge Sensitivity setting to 9.
   - In the Settings Folder, select the Edit Data cell for Surge Sensitivity.
   - Increment or decrement the value to achieve a setting of 9.
3. Press the Load Key.
4. Run the compressor at MinLoad at pressure. The machine can be forced to MinLoad and pressure by either:
   - Running the plant at a higher pressure than pressure setpoint.
   - Decreasing load in the plant.
   - Verify the compressor is at pressure by observing the last stage pressure on Page 2 of the Settings Folder.
5. Find the throttled surge point.
   - Select the MinLoad cell in the Settings Folder and slowly decrement the value until the machine surges. Typically the machine will make a puffing or popping noise upon surge, this is your indication surge has occurred.
6. Press the Unload Key.
7. Determine if Surge was recorded.
   - Inspect the Status Bar. If the message Surge Unload is displayed surge was recorded, if the message is not displayed surge was not recorded.
8. Check the Surge Sensitivity setting.
   - If the surge was recorded, the setting may be correct or the Surge Sensor may be too sensitive, skip to the too sensitive step, which follows.
   - If the surge was not recorded, the setting is not sensitive enough, skip to the not sensitive enough step which follows.
9. Surge Sensor too sensitive.
   - Select the Surge Sensitivity Setting in the Settings Folder.
   - Decrease the value for Surge Sensitivity by 0.1.
   - Press the Reset Key.

- Skip to step 11.

10. Surge Sensor not sensitive enough.
    - Select the Surge Sensitivity Setting in the Settings Folder.
    - Increase the value for Surge Sensitivity by 0.1.
    - Press the Reset Key.
11. Repeat the procedure until the Surge Sensitivity setting is found which just catches a surge but does not miss a surge.
    - Return to step 3.
12. Restore all values but Surge Sensitivity.

6.7.5 Tuning Stability

The CMC controls stability with four Proportion Integral Derivative (PID) control loops. When the machine is running above the MinLoad point and below the MaxLoad point, pressure is regulated with the Inlet Valve Pressure control loop. When the machine is running at the MinLoad point, pressure is regulated with the Bypass Valve Pressure control loop and motor current is regulated with the Inlet Valve MinLoad control loop. When the machine is running at MaxLoad motor current is regulated with the Inlet Valve MaxLoad control loop. For each PID loop, Proportional, Integral and Derivative parameters are used to stabilize the system. For a definition of the parameters and their effect on stability, refer to the section titled "How does Constant Pressure Modulation Work." The proportional and integral terms are labeled by their respective loops, Inlet Valve, Bypass Valve, MinLoad, and MaxLoad.

6.7.6 Calibrating the Control Valves

The purpose of this procedure is to position the inlet and bypass valves by opening and closing each valve from the CMC analog outputs. The valves should be adjusted to physically correspond with the valve positions displayed on the OUI.

1. Stop the compressor.

	**Performing this procedure while the compressor is operating may cause serious damage.**
NOTE	

2. On the OUI enable Setpoint changes by entering the password on the Settings Folder.
3. Verify the OUI status bar displays "Ready" or "Not Ready".

4. On the OUI select the Settings Folder and enable manual valve control by highlighting the manual check box.

	**When Manual is enabled, both control valves can be positioned while stopped, while only the Bypass Valve can be positioned when Loaded.**
NOTE	

5. Switch to the System Folder Page 1 and press the Enter Key to enable edit mode.
6. Use the horizontal navigation keys to select the valve requiring positioning.
7. Use the vertical arrows to increment and decrement the valve position sent to the valve.

	**For the Inlet and Bypass Valves, the displayed position corresponds to percent open.**
NOTE	

8. Disable manual valve control by blanking the manual check box.

6.7.7 Autodual Control Settings

For a detailed definition of the Autodual control mode refer to the section titled "Control Methodology". The procedure for tuning Autodual requires the setting of the following variables:

6.7.7.1 Unload Point (Bypass Valve % Open)

The Bypass Valve Unload Point is selected to correspond to the check valve closing as shown in Figure 6.23 , since at this point the machine is not supplying the system. This position is found by running the machine at MinLoad and monitoring the System and Discharge pressures. When the System pressure is 5% of setpoint greater than the last stage pressure as shown in the System Folder, the check valve is assumed to be closed.
Example: Given the following conditions the Unload Point would be set at 35.

Variable	Case 1	Case 2
Pressure Setpoint	100	100
PT1 (system pressure)	100	100
PT2 (last stage pressure)	100	94
Bypass Valve Position	13	35
Assumed check valve position	Open	Closed

Table 6.10

1. Run the machine at MinLoad by elevating the system pressure no more than 3% or decrease the pressure setpoint no more than 3%.
2. Monitor the difference between the Discharge and System Pressures by using the System Folder Pages 1 and 2.
3. When the Discharge Pressure is approximately 5% of setpoint less than the System Pressure, record the Bypass Valve Position.
4. Enter the recorded Bypass Valve Position as the Unload Point.

6.7.7.2 Unload Delay Time (seconds)

The Unload Delay Timer should be set to prevent unloading during short excursions through the Unload Point. Typically, when the check valve closes, system demand requires the check valve to open again soon thereafter due to the demand being on the verge of requiring the compressor. If the compressor had unloaded when the check valve first closed, a reload would be immediately required and the machine would go through the automatic unload/load cycle until demand was consistently low enough to keep the check valve closed. For this reason, the timer is used to inhibit Unload until demand has consistently remained low.

1. Run the compressor at MinLoad by either:
   - Running the plant at a higher pressure than pressure setpoint.
   - Shedding load in the plant.
2. Determine delay time.
   - Observe time when bypass valve first hits unload point.
   - Observe time when bypass valve remains below unload point, typically less than 300 seconds.
   - Enter the time difference as the Delay Time.

6.7.7.3 Reload Percent

The Reload Percent determines the System Pressure at which the machine will automatically load into the system. This value should be set according to the customer's minimum acceptable system pressure.

6.7.8 Setting the Start Time

The Start Time is set to the transition time of a built-in reduced voltage starter or the acceleration time of a customer supplied starter. This procedure requires the Inlet Unload Position to have been set.

1. Initially set the Start Time to 25 Seconds. Caution: Damage to the starter contacts could result if starter transition occurs before the compressor is up to full speed.
2. Stop the compressor.
3. On the OUI record the time and press the start button.
4. Wait for the compressor to stop accelerating and again record the time.
5. Calculate the difference between the two values and enter as the Start Time.

6.7.9 Setting the CT Ratio

Locate the CT and find the rating, which is typically printed, on the side of the CT. Divide the primary by the secondary and enter the value as the CT Ratio.
Example: CT is printed with 600:5, the value entered is 120.

6.7.10 Inlet Unload Position

The purpose of this variable is to set the inlet valve position when the machine is running unloaded. For a description of the Unloaded state refer to the section titled "Unload".

1. If the inlet valve is a butterfly type, enter an initial value for Inlet Unload Position of 15. If the inlet valve is a inlet guide vane type, enter an initial value for Inlet Unload Position of 5.
2. Start the machine. If during startup the motor trips on overload, is drawing what is considered excessive amperage or sounds labored, stop the machine and decrease the Unload Position by 2.
3. Run the machine in the Unloaded state and monitor the first stage pressure.
4. Adjust the Unload Position to achieve 1 PSIG on the first stage discharge, or until a positive pressure is felt at the first stage trap bypass.
5. If the inlet air temperature is relatively cold, increase the setting 2%, this will accommodate hot day operation.

6.7.11 Setting Set Point Ramp Rate

Setpoint ramp rate determines the rate at which the machine transitions from unloaded to loaded. The setting should be set as high as possible without creating excessive overshoot when the machine enters the system.

1. Verify the machine is unloaded by the "Unloaded" message in the OUI Status Bar.
2. Determine overshoot.
   - Load the machine.
   - Monitor the pressure overshoot.
3. If overshoot is excessive.
   - Decrease the Setpoint Ramp Rate.
   - Repeat step 2.
4. If overshoot is satisfactory and time to load is excessive.
   - Increase the Setpoint Ramp Rate.
   - Repeat step 2.
5. If overshoot is satisfactory and time to load is satisfactory the Setpoint Ramp Rate is correct.

6.7.12 Alarm and Trip Settings

The values for vibration, temperature, pressure etc. alarm and trip setpoints are located on the electrical schematic. These values determine when the controller will indicate an alarm or trip condition.

6.8 Communication (When provided)

In case Communication is required please contact your closest Ingersool-Rand service representative. He will provide a detailed technical reference manual for the communication.
Customers may want to communicate to the CMC control systems for remote compressor control and monitoring. This communication capability provides for flexibility in the customer's compressed air operation through remote start and stop, data gathering for preventative maintenance, and incorporation into plant-wide control system.
The major avenue for communicating with the CMC is via MODBUS protocol over an RS422/485 hardware link. This requires hardware for the control panel, and a communications device with the appropriate driver software to perform the desired panel functions. The RS422/485 interface can communicate with any serial device that has an RS422 or RS485 port. The customer or his representative must write system software to suit his individual needs for remote control and monitoring. Since the customer writes this interface, the system can be as flexible as the customer desires.

6.8.1 Human Machine Interface (HMI) Systems

Air System Controller (ASC) and Air System Manager (ASM) are software packages available for compressors with CMC panels.
ASC and ASM are graphical integration software specifically developed for air compressor systems. Both provide energy management through load sharing and reduction of air bypass by using a minimum amount of energy to meet the system demand. The primary goal of both systems is to

maintain stable system pressure, to integrate, monitor and control the compressed air system.
ASM is the integration of compressor control software in an off-the-shelf Supervisor Control and Data Acquisition (SCADA) package that is available from various manufacturers. The ASM provides more custom features than does ASC.
Both ASC and ASM provide a window into the compressor room by making the raw data from compressors and other equipment available to plant operators and managers in formats that are easy to understand.
Implementing the CMC in any HMI system may require additional hardware and/or software upgrade.

6.8.2 Direct CMC Communications with RS422/485

For the descriptions that follow, a serial device can be a Personal Computer (PC), Programmable Logic Controller (PLC), Distributed Control System (DCS) or any other device that can transmit, receive and interpret an RS422/485 formatted signal over a hardware link. In the descriptions that follow, the PC and PLC serial devices are not specific to manufacturers or operating systems.
There are many ways of interfacing to CMC control systems through an RS422/485 port. Most of the following methodologies are currently available; but please be aware, other possible configurations can exist.
All RS422/485 interfaces require custom interface software and custom application software. The interface software allows a specific serial device and operating system to transmit, receive and interpret data from a CMC control system. The application software tells the CMC control system what to do; for example, start compressor when ready, stop compressor after midnight and retrieve the current data and save to a disk file.
Currently there are hundreds of different serial devices using different operating systems and languages in the industrial equipment world. Therefore, the practicality of having an interface for many systems is limited. Custom interfaces must be written as required by the hardware and operating system used.
The capabilities of the hardware and the imagination of the developer only limit the application software. For example, one developer may have two compressors. In this application the developer wants a screen to display the compressor interstage pressure and temperatures for both machines with various other compressor data. A second developer has five compressors. He also wants to display the same data, but this time for all five machines. The only way this is done is through changing the application software (custom modification).
The developer may write functions to read and display data, log that data to some magnetic media for storage, change compressor set points, sequence the compressors for efficient operation and network additional devices, such as pumps, dryers, etc., into the system. All of these functions require specially written application software for the intended use.

6.8.3 The CMC-MODBUS Interface

6.8.3.1 Introduction

The CMC can communicate with other devices over a variety of communications standards. Supported standards, or protocols, include RS-232, IRBUS (Ingersoll-Rand Proprietary), and Modicon's MODBUS. The built-in ports on the CMC's optional Universal Communication Adapters access communications. The CMC-MODBUS Interface defines the message structure that a CMC uses to exist on a MODBUS network. This interface will allow the MODBUS network to gather information and control the compressor.

In order to communicate over other types of networks, a network adapter must be used. The information presented in the following sections does not include MODBUS protocol details like framing messages and calculating checksums. This detailed information can be obtained from Snyder Automation's MODBUS PROTOCOL Manual, Chapters 1 through 6. This can be obtained through the Internet at "www.modicon.com".

NOTE	**Unless specified otherwise, numerical values (such as addresses, codes, or data) are expressed as decimal values in the text of this section. They are expressed as hexadecimal values in the message fields of the examples.**

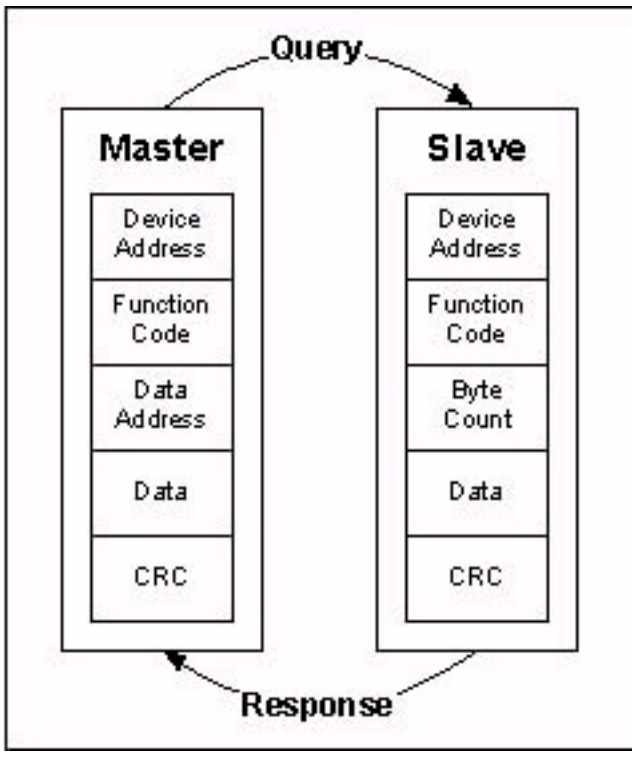


Figure 6.24 MODBUS Messages

6.8.3.2 Serial Modes

MODBUS Controllers can be setup to communicate on MODBUS networks using either of two transmission modes: ASCII or RTU. The CMC supports only the RTU mode. The user must specify the serial port communication parameters (baud rate, parity mode, etc.) during configuration of each CMC. The mode and serial parameters must be the same for all devices on a MODBUS network.

7 Pre-start check list

7.1 General

All systems on the CENTAC should be checked prior to initial start-up. This check-out must be accomplished under the direction of an INGERSOLL-RAND Customer Service Representative. The following check list is to prevent oversights which could delay start-up of the unit and additional expense in correcting oversights.

	**THE COMPRESSOR BULLGEAR IS LOCKED TO THE CASING TO PREVENT ROTATION DURING SHIPMENT. LOCKING BOLT MUST BE REMOVED PRIOR TO COUPLING THE MOTOR TO THE COMPRESSOR OR SERIOUS DAMAGE WILL RESULT.**
CAUTION	

	**THE DRIVER ROTATION MUST BE CHECKED BEFORE MAKING UP COUPLING. DAMAGE TO THE EQUIPMENT AND PERSONAL INJURY COULD RESULT FROM OPERATING THE UNIT WITH WRONG ROTATION.**
CAUTION	

	**VERIFY THAT ALL THE INSTRUCTION AND SAFETY LABELS ARE IN PLACE AND READABLE. THESE ARE AS IMPORTANT AS ANY OTHER EQUIPMENT ON THE COMPRESSOR.**
NOTE	

	**THE PREPARATION FOR AND THE INITIAL START-UP OF THE CENTAC COMPRESSOR MUST BE DONE UNDER SUPERVISION OF AN INGERSOLL-RAND OR CERTIFIED INGERSOLL-RAND DISTRIBUTOR SERVICE SUPERVISOR. POWER MUST NOT BE APPLIED TO THE MOTOR OR PANEL FOR THE FIRST TIME WITHOUT INGERSOLL-RAND SERVICE SUPERVISOR.**
NOTE	

Prior to starting, the operator should become familiar with the operation of the Main Electric Driver. Refer to the Driver Manufacturer's instructions. The operator should also be familiar with all the

accessory equipment contained on the unit. Personnel unfamiliar with the compressor package should not start, operate or tamper with the equipment. Only fully trained personnel should be allowed to start and operate this compressor. The following procedure is a guideline for the fully trained operator.

7.2 Impeller to diffuser clearance

Impeller to diffuser clearance are factory set, and no adjustments are required before start-up.

	**IMPELLER TO DIFFUSER CLEARANCE MAY BE ADJUSTED ONLY BY INGERSOLL-RAND QUALIFIED PERSONNEL.**
CAUTION	

7.3 1st stage rotor preparation (only for 5CII units)

The 1st stage rotor (only for 5CII model compressors) are shipped with a device which keeps locked the rotor during transport. Remove such device before start up. The locking device must be removed only by Ingersoll-Rand qualified personnel.

	**5CII COMPRESSORS ARE SHIPPED WITH THE 1ST STAGE ROTOR LOCKED. RELEASE THE ROTOR BEFORE START UP. PLEASE REFER TO INGERSOLL-RAND CUSTOMER SERVICE.**
CAUTION	

7.4 Coupling alignment

The CENTAC is equipped with coupling joint between compressor and driver, aligned by the manufacturer. Compressors with motor directly flanged to the compressor does not need alignment.
If further on site alignment is needed before start up, please refer to Ingersoll-Rand customer service.

	**THE ALIGNMENT BETWEEN COMPRESSOR AND DRIVER MUST BE CARRIED OUT IN THE PRESENCE OF INGERSOLL-RAND QUALIFIED PERSONNEL.**
CAUTION	

7.5 Main driver preparation

If the driver is an electric motor, the preparation shall include but not be limited to:

1. CHECK THE BOLTED JOINTS FOR SIGNS OF LOOSENESS.
2. MAKE SURE THAT BEARINGS HAVE BEEN PROPERLY LUBRICATED ACCORDING TO MOTOR MANUFACTURER INSTRUCTIONS.
3. ROTATE THE SHAFT BY HAND TO INSURE THERE IS FREEDOM OF MOVEMENT.
4. CHECK THE MOTOR NAMEPLATE FOR VOLTAGE, PHASE AND FREQUENCY AND INSURE THAT THEY AGREE WITH SUPPLY.
5. CHECK THAT MOTOR, STARTER, AND CONTROL DEVICE CONNECTIONS AGREE WITH WIRING DIAGRAMS.
6. MEASURE THE INSULATION RESISTANCE OF THE WINDINGS.
7. BUMP THE UNCOUPLED MOTOR TO CHECK PROPER ROTATION OF CLOCKWISE AS VIEWED FROM NON-DRIVE END.
8. REFER TO THE MANUFACTURER'S INSTRUCTIONS FOR DETAILED INITIAL START INSTRUCTIONS AND STOPPING INSTRUCTIONS.

	**FOR MORE DETAILED INFORMATION, PLEASE REFER TO THE DRIVER SECTION (IF INCLUDED IN IR SUPPLY).**
NOTE	

	**ON LARGER UNITS, EQUIPPED WITH FLANGED MOTOR, ADDITIONAL MOTOR SUPPORTS UNDER NON-DRIVE END IS PROVIDED, PRE-LOAD SHIMS MUST BE MAINTAINED FOR PROPER MOTOR SUPPORT. OVERHUNG FLANGE LOADING WITHOUT THIS SUPPORT CAN RESULT IN SEVERE INJURY OR DAMAGE.**
CAUTION	

If the compressor is driven by a turbine, please refer to the manufacturer manual for all necessary information necessary for start up preparation.

7.6 Basic control system set-up

The Modulate and Auto-Dual control components for the CENTAC compressor are set-up and adjusted for operation settings before leaving the manufacturer.

INLET AND BYPASS VALVES ADJUSTMENT

- Inlet Throttle valve
  Connect a 400 to 700 kPa(g) instrument air supply to the supply port on the valve positioner.
  Connect a 4-20 MA signal simulator to the positioner power supply. Send a 4 mA signal and check that the valve is completely closed, and the cam indicator is approximately at 90°, as shown in Figure 7.1 . Then send a 20 mA signal and check that the valve is completely open, and the cam indicator is at 0°, as shown in Figure 7.2

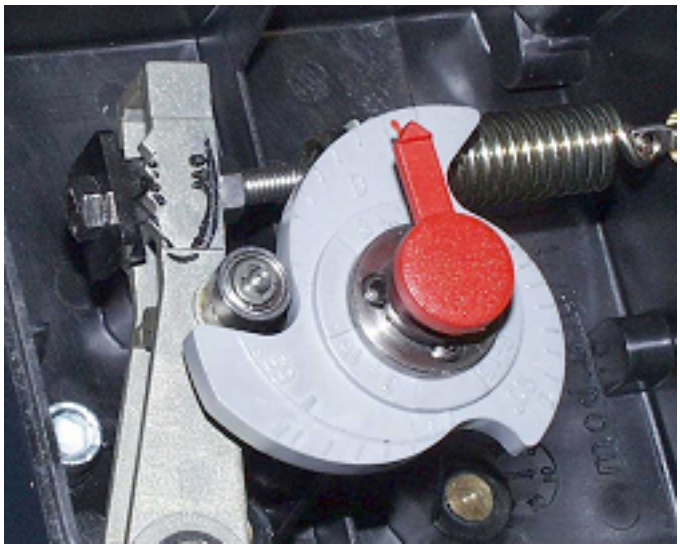


Figure 7.1

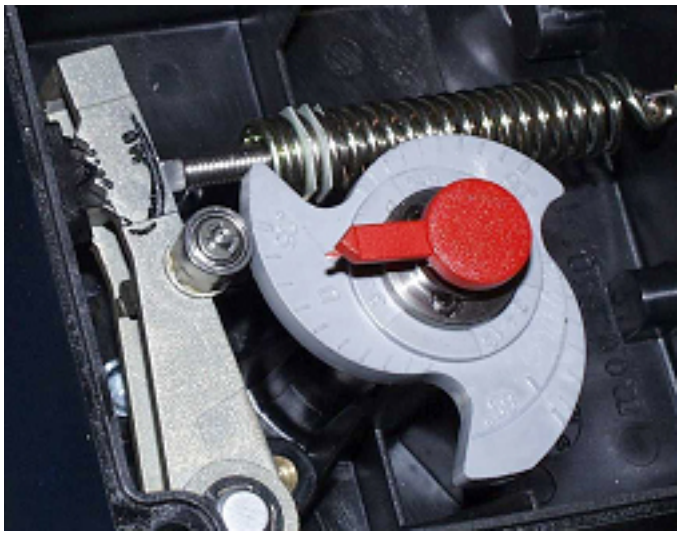


Figure 7.2

Otherwise rotate the spring manually Figure 7.3 , until reaching the above mentioned positions.

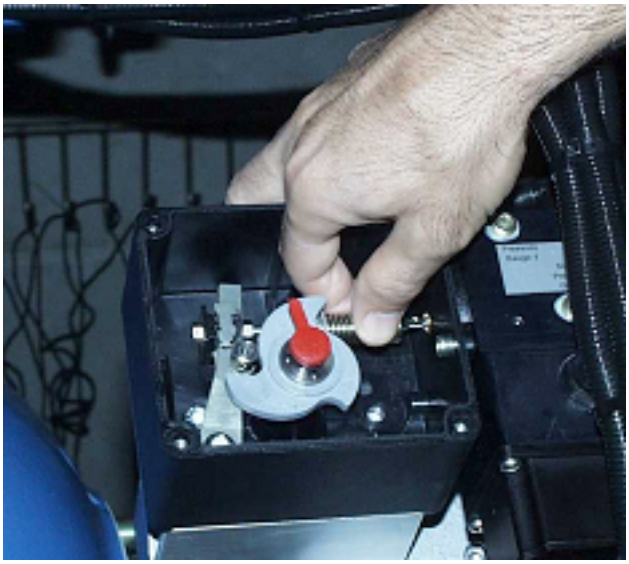


Figure 7.3

If the valves are supplied already installed and the compressor is equipped with CMC panel, is not necessary to connect any external 4-20 mA signal simulator, because adjustment may be carried out from the signal generated by the panel.

page, set #manual#, go to the #system# menu until the valves #set point# page Figure 7.4

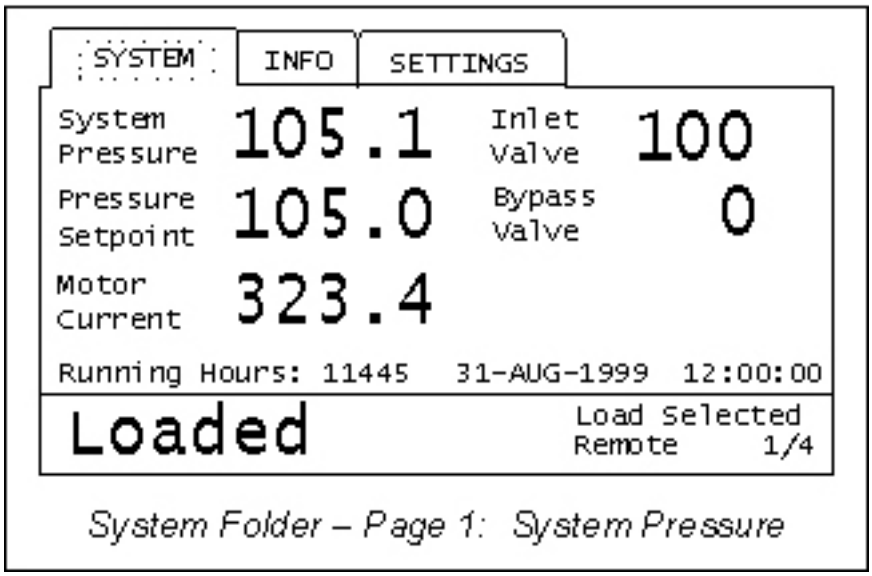


Figure 7.4

At this stage set 0 as inlet valve value and verify that the valve is completely closed Figure 7.1 , and set 100, verifying that the valve is completely closed Figure 7.2

- By-pass valve
  The by-pass valve adjustment procedure is analogous to the inlet valve procedure, except for the fact that for a 4Ma signal the valve is completely open, and for a 20mA signal the valve must be completely closed. Also the positioner cam indicator position is reversed Figure 7.5 compared to the inlet valve configuration.

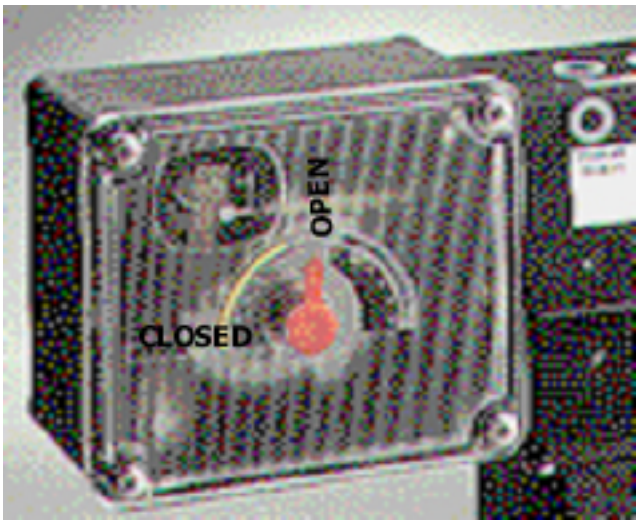


Figure 7.5

7.7 Lube oil system adjustment

Cleanliness of the lubricating system is of paramount importance to the CENTAC. Although the system is flushed and fully tested at the factory, the following steps should be taken prior to initial start-up.

CLEANING

1. Remove the sump access cover. Thoroughly clean of any shipping oil and dry with lint free rags.
2. Fill the reservoir with recommended oil (please refer to #lubrication# section in #Operation# chapter, for oil characteristics, and to the Data Sheet section for oil quantities, according to the compressor model) through the refilling points arranged on the baseplate Figure 7.6 After refilling, check the level, making sure that the oil have reached the indicator upper mark Figure 7.7

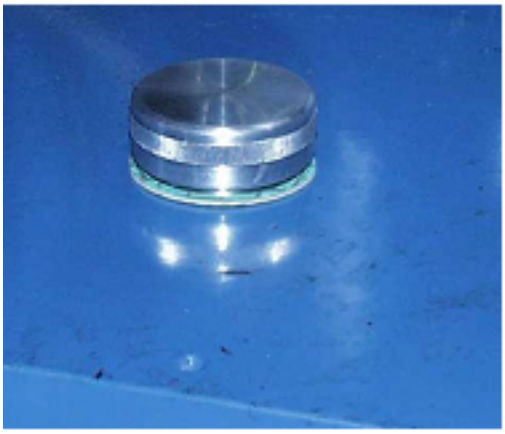


Figure 7.6

Figure 7.7

3. Remove the oil filter element and inspect element and housing for cleanliness.
   Reassemble the oil filter element (for instructions, please refer to the Oil Filter enclosure of this manual).

NOTE	**THE ABOVE REQUIRED PRECAUTIONS SHALL HAVE TO BE CARRIED OUT WEARING THE REQUIRED AND SUITABLE PROTECTIVE GLOVES TO AVOID ANY POSSIBLE INJURY. ALL THE CONSUMABLE AND REPLACED PARTS SHALL HAVE TO BE DISPOSED IN ACCORDANCE WITH THE GOVERNING LOCAL RULES AND REGULATIONS.**

PRESSURE SETTING

The CENTAC lube system is designed to operate between 140 and 210 kPa(g) (1.4 and 2.1 Bar g). When setting the system oil pressure, attention must be given to the pressure sensing valve mounted in the lube system piping. This valve is factory set, but final adjustment may be required prior to start-up.

- Remove the sensing valve cap, by using the special spanner Figure 7.8

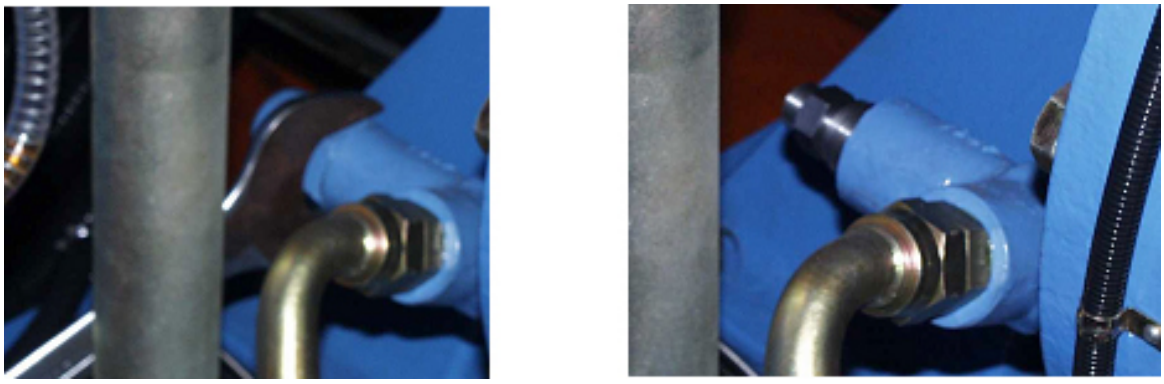


Figure 7.8

- With seal air on and oil reservoir filled to the proper level, start the prelube pump by energizing the control panel. If the oil pressure does not increase immediately, it means that the pump may be rotating in the wrong direction. Disconnect the power supply and check pump terminal board connections.
  By using the special screwdriver
- , start to set the screw Figure 7.9 closing or opening the pressure sensing valve, until an oil pressure of 210 kPa(g) (2.1 Bar g) (please refer also to Data Sheet section) and then, lock pressure sensing valve adjusting screw Figure 7.10 , by tightening the lock nut

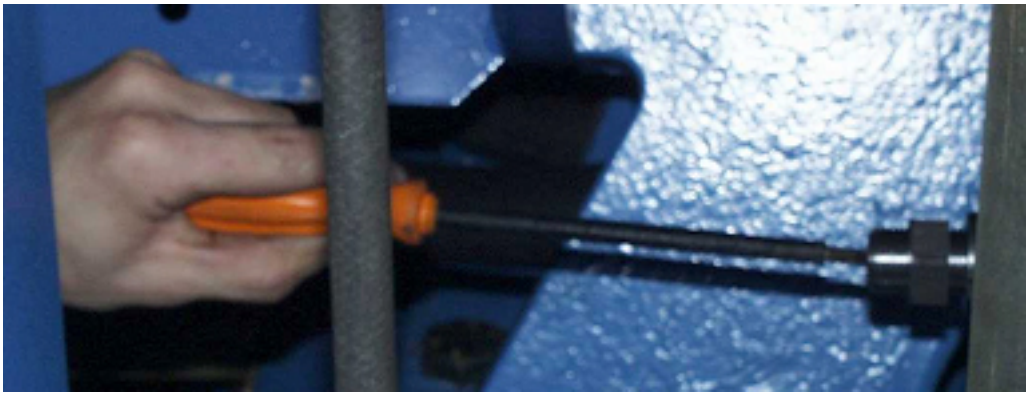


Figure 7.9

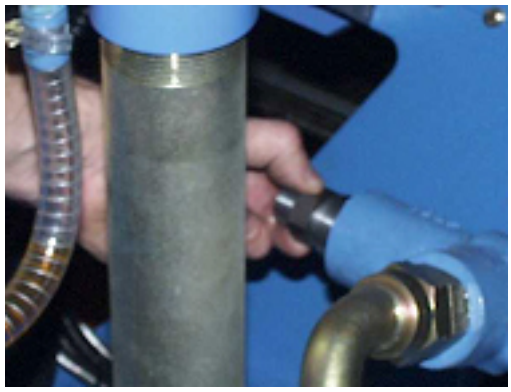


Figure 7.10

, once the unit is operating and up to temperature, final adjustment may be needed.

CAUTION	**HOT OIL CAN CAUSE SERIOUS INJURY TO PERSONNEL. PRECAUTION MUST BE TAKEN TO PREVENT CONTACT WITH HOT OIL.**

CAUTION	**OPERATION OF THE UNIT WITHOUT PROPER LUBRICATION CAN RESULT IN OVERHEATING OF THE BEARINGS, BEARING FAILURES, PUMP SEIZURES AND EQUIPMENT FAILURE EXPOSING OPERATING PERSONNEL TO PERSONAL INJURY.**

WARNING	**THE CENTAC DOES NOT REQUIRED A CONSTANT CONTINUOUS PRESENCE OF THE OPERATOR. HOWEVER, DURING THE REQUIRED SCHEDULED INSPECTION, THE OPERATOR MUST HAVE THE APPROPRIATE NOISE PRECAUTION LIKE EARS PROTECTION, GLOVES, GLASSES, ETC.**

7.8 Check out summary

The following check list includes all checks to be carried out during commissioning, before starting up the unit.

1. The following shall be inspected for corrosion and cleanliness just prior to start-up:
   - Oil Reservoir.
   - Inlet Air Filter.
   - Inlet Air Piping.
   - Discharge Piping.
   - By-pass Piping
   - Water Piping.
2. Check inlet air filter location and installation.
3. If the Inlet Air Filter is mounted at a REMOTE LOCATION, check the following on the inlet air piping:
   - Material
   - Minimum Size.
   - Distance to first elbow (minimum of 4 pipe diameters) from inlet valve.
   - Facilities for moisture removal on any horizontal run of pipe.
   - Piping supports/strain.
   - Manometer or differential pressure switch on inlet air filter.
   - Maximum pressure drop of 2.5 kPa (25mBar). for inlet air system.

	**THE IMPORTANCE OF STARTING AND OPERATING THE COMPRESSOR WITH CLEAN INLET PIPING CANNOT BE OVER-EMPHASIZED. LOSS OF PERFORMANCE OR PHYSICAL DAMAGE COULD RESULT FORM THE INTAKE OF FOREIGN MATERIAL.**
WARNING	

4. Check the following on the discharge piping:
   - Minimum Size.
   - Distance to first elbow (minimum of 3 pipe diameters) from discharge check valve.
   - Piping supports/strain.

- Attachment of control air (minimum of 10 pipe diameters) from discharge check valve.
- Facilities for moisture removal on any horizontal run of pipe.
- Safety valve (located between block valve and compressor) if required.

5. If the Atmospheric by-pass silencer is mounted at a REMOTE LOCATION, check the following on the bypass piping:
   - Minimum Size.
   - Distance to first elbow (minimum of 8 pipe diameters) from by pass valve.
   - Piping supports/strain.
   - Location of by-pass silencer.
   - Facilities for moisture removal on any horizontal run of pipe.
6. Check the following on the control air piping (when foreseen):
   - Material.
   - Minimum Size.
   - Water and dirt line filter (adequately filtered and dried).
   - Attached to Control Panel at bulkhead fitting #CA#.
   - Attached to discharge air piping at top of pipe a minimum of 10 pipe diameters from check valve.
7. Check the following on the instrument air piping:
   - Material.
   - Minimum Size.
   - Attached to Control panel at bulkhead fitting #IA#.
   - Attached to dry clean air source 400-700 kPa(g), (4 - 7 bar g) with capacity of 0,5 m^3/min.
   - Make sure that the system includes a shut-off valve.
8. Check the following on the water piping:
   - Minimum Size.
   - Proper connection to compressor.
   - Maximum of 550 kPa (5.5 bar) water pressure.
   - Differential pressure between inlet and outlet flanges on manifold (normally 80 kPa(g) (0.8 bar).
   - Check for water leaks (leave condensate trap by-pass valves open).
   - If not supplied, check that the system includes at least a manual valve for cooling system outlet adjustment.

- Casing vents open.

9. Check piping on condensate traps.
10. Check compressor lubricant for conformance to specifications.
11. Drain and clean oil reservoir.
12. Fill oil reservoir to shown level.
13. Check anchor bolts and grouting (if required).
14. Check levelness of unit.
15. Check electrical power supply to unit.
16. Check all Control Panel / junction box connections per applicable schematics.
17. Ensure seal air is on the compressor
18. Check driver per manufacturer's instructions found in the driver instruction manual.
19. Remove bullgear(s) (red coloured) lock bolt. Manually rotate compressor and driver shafts, checking for free rotation with prelube pump running
20. Check driver electrical connections. See plate on driver.
21. Check to see that driver bearings are properly lubricated.
22. Check direction of rotation of main motor prior to coupling to compressor.
23. Couple compressor to motor, if applicable.
24. Check rotation of prelube pump.
25. Check lubrication system for oil leaks.
26. Check, if necessary, the calibration of inlet and bypass valves, plus other control and protective devices.
27. Check the calibration of all temperature and pressure switches.
28. Check operation of emergency pushbutton.
29. Start and run compressor.

8 Routine start-up/stop

8.1 Lubrication

	**FOR LUBRICATION SPECIFIC DATA (RESERVOIR CAPACITY, PRESSURE,..) OF YOUR COMPRESSOR, PLEASE REFER TO SECTION 1 "DATA SHEET" OF THIS MANUAL.**
NOTE	

Lubrication is vitally important for CENTAC compressor operation and maintenance. The lubrication oil suggested by Ingersool-Rand for all CENTAC models, except for CVO and X-FLO, is Techtrol Gold synthetic fluid, manufactured and supplied by Ingersoll-Rand. This lube oil ensures adequate cooling and lubrication quality levels for rotating parts.
Techtrol Gold characteristics are shown in the following table.

Techtrol Gold synthetic lube oil chemical/physical characteristics

Property	Test Method	Performance
ISO Viscosity Classification	ASTM D2422	32
Viscosity Index	ASTM D2270	139
Viscosity, cST(SUS)		
@ 0°F/-17.8°C	ASTM D445	895 (4195)
@ 100°F/37.8°C	ASTM D445	30 (142)
@ 104°F/40°C	ASTM D445	28 (133)
@ 210°F/98.9°C	ASTM D445	5.6 (45)
@ 212°F/100°C	ASTM D445	5.4 (44)
Pour Point, °F (°C)	ASTM D97-87	-40 (-40)
Flash Point, COC °F (°C)	ASTM D92	450 (232)
Flash Point, PMCC °F (°C)	ASTM D93-85	390 (199)
Copper Strip Corrosion, 3 hrs. @ 212°F/100°C	ASTM D130	1
Specific Gravity	ASTM D941	0.99
Ferrous Metal Corrosion (Rust Test)	ASTM D665A	Pass
Foam Tendency (Sequence I, II,III)	ASTM D892	0 (Nil)
Density (Grams per cc @ 77°F/25°C)	ASTM D941	0.988
Total Acid Number	ASTM D664	0.10

pH	ASTM D664	8

Table 8.1

Instead of Techtrogold, as an alternative, it is possible to use a mineral based lubricant which shall be a premium-quality, highly filtered fluid with maximum metal wetting ability and rust-preventative properties.

	**TO REPLACE THE MINERAL OIL USED FOR COMPRESSOR OPERATION WITH SYNTHETIC TECHTRO GOLD, IT IS NECESSARY TO FOLLOW A SPECIFIC PROCEDURE. ORDINARE OIL REPLACEMENT, WITHOUT FOLLOWING SPECIFIC PRESCRIPTIONS MAY COMPROMIZE SIGNIFICANTLY THE CENTAC COMPRESSOR PERFORMANCES.**
CAUTION	

The fluid shall have superior oxidation stability, defoaming characteristic and be free of inorganic acids or alkali.
There shall be no tendency toward permanent emulsification and a minimum tendency to oxidize or form a sludge when agitated at operating temperatures and mixed with air and water. Major oil Companies are able to supply a lubricant suitable for CENTAC compressor.
INGERSOLL-RAND does not endorse the product of any individual oil Company.
Fluid should be obtained from your local lubrication specialist to meet the following specifications

Mineral lube oil chemical/physical characteristics

Property	Test Method	Performance
ISO Viscosity Classification	ASTM D2422	32
Viscosity Index	ASTM D2270	100
Viscosity, cST (SUS) @ 104°F/40°C	ASTM D445	28.8 - 35.2
Pour Point, °F (°C)	ASTM D97	41 (5)
Flash Point, °F (°C)	ASTM D92	392 (200)
Copper Strip Corrosion, 3 hrs. @ 212°F/100°C	ASTM D130	1
Oxidation stability		
TOST, Hours to neut. No. 2.0, min	ASTM D943	7000
RBOT, Minutes to 175 kPa drop, min.	ASTM D2272	1000
Emulsion, minutes @ 129	ASTM D1401	20

°F/54 °C to drop to 3mL, max.		
Ferrous Metal Corrosion (Rust Test)	ASTM D665A	Pass
Sludge and corrosion control, mg	ASTM D4310	50
Foam (Sequence I, II,III) Tendency/stability, mL Max.	ASTM D892	30/0/30
Total Acid Number mg KOH/g, Max. (a)	ASTM D664	0.1
Particle count (b)	ISO 4406	16/13
Water (c)	Karl Fisher	100 ppm

Table 8.2

 **CAUTION**	**The premium mineral base fluid used to formulate covered under this specification shall satisfy the requirements of API Group II Specifications. Consult your supplier for more base oil information. While presence of oxidation,corrosion,foam and metal deactivator additives is permitted, only minor quantities of other additives may be used as required for satisfactory performance in turbo compressors. Additives must contain no more than trace of sulfur, zinc, calcium, barium or other metallic elements which may lead to deposits, varnish or corrosion under high temperature and stress conditions at bearings and seals. No sulfur or sulfur-phosphorous anti-wear or extreme pressure additives are to be used. Since lubricant manufacturers do not usually guarantee cleanliness levels of finished products the lubricant should be filtered to this level as it is changed to the compressor. Recommended storage is indoors to prevent water contamination.**

We recommend that you discuss these specifications with your supplier to insure that he can and will furnish the proper fluid.

 **CAUTION**	**FLUID OBTAINED BY THE USER FOR OPERATION OF THIS EQUIPMENT MUST COMPLY WITH THE FOLLOWING SPECIFICATION AND PERFORM SATISFACTORILY IN THE COMPRESSOR.**

	**THE INGERSOLL-RAND COMPANY ASSUMES NO RESPONSIBILITY FOR DAMAGES CAUSED BY NON-COMPLIANCE TO THIS SPECIFICATION WITHIN THE PERIOD OF THIS STANDARD EQUIPMENT GUARANTEE OR THEREAFTER.**
CAUTION	

	**ON SUBSEQUENT PURCHASES OF FLUID FOR USE WITH THIS EQUIPMENT, THE USER IS CAUTIONED TO BE ON THE ALERT FOR ANY CHANGES IN THE FLUID THAT MAY DEVIATE FROM THIS SPECIFICATION THEREBY CAUSING EQUIPMENT DAMAGE. SOME FLUID MIXTURES ARE INCOMPATIBLE WITH EACH OTHER AND RESULT IN THE FORMATION OF VARNISHES, SHELLACS, OR LACQUERS WHICH MAY BE INSOLUBLE. SUCH DEPOSITS CAN CAUSE SERIOUS TROUBLE, INCLUDING CLOGGING OF THE OIL FILTER. WHERE POSSIBLE, TRY TO AVOID MIXING FLUIDS OF THE SAME TYPE BUT DIFFERENT BRANDS. A BRAND CHANGE IS BEST MADE AT THE TIME OF A COMPLETE FLUID CHANGE. INGERSOLL-RAND CANNOT BE HELD RESPONSIBLE FOR EVENTUAL DAMAGES CAUSED TO THE COMPRESSOR BY USING A LUBRICANT NOT CONFORM TO SPECIFICATIONS, BOTH DURING AND AFTER GUARANTEE PERIOD.**
CAUTION	

8.2 Routine start-up/stop

	**DO NOT OPERATE THE MACHINE WITHOUT THE COVER OR GUARD BEING FITTED. FAILURE TO OBSERVE THIS WARNING COULD RESULT IN PERSONAL INJURY TO OPERATING PERSONNEL.**
CAUTION	

The operator must be familiar with all the accessory equipment and optional equipment contained on the unit. Personnel unfamiliar with the compressor package should not start, operate or tamper with the equipment.

	**ONLY FULLY TRAINED PERSONNEL SHOULD BE ALLOWED TO START AND OPERATE THIS COMPRESSOR.**
NOTE	

The following procedure must be carried out by fully trained operator.

Starting

	**THE COMPRESSOR MUST ALWAYS BE STARTED IN "UN-LOAD" MODE.**
NOTE	

1. Check the oil level in the reservoir (please refer to section 7, "Commissioning and first start up").
2. Turn on the cooling fluid to the oil cooler, and air coolers.
3. Supply the control panel with instrumentation air, at a pressure between 400-700 kPa g (4-7 bar g).
4. Adjust, if necessary, the seal air regulator to maintain a minimum of approximately 40 kPa(g) (0.4 bar g) seal air pressure.
5. Turn on the electrical power to the system and start the pre/post lube oil pump. (If your compressor is equipped with CMC control panel, the pump starts automatically when supplying the panel).
6. Check to see that oil pressure in the compressor casing is above minimum starting pressure (see section Data Sheet of this manual).
7. Check to see that oil is above minimum starting temperature (see section Data Sheet of this manual).
8. Check to see that the inlet valve is closed and the bypass valve is open.
9. Open the block valve in the discharge line.
10. Adjust the discharge pressure set point to the desired setting.
11. Start the compressor when "ready to start":

	**NEVER ATTEMPT A RESTART UNTIL THE COMPRESSOR HAS COMPLETELY COME TO REST.**
WARNING	

- Oil pressure should increase to approx. 170 kPa(g) (1.7 bar g).

- Prelube oil pump should automatically stop after start up transitory (approximately 15 seconds for star-delta start ups).
- If the compressor was started in "UNLOAD" mode it will continue to run not making pressure until another control mode is selected.
- If the compressor was started in an operating mode other than "UNLOAD", it will start loading only after the start up time is elapsed.

12. Observe the oil pressure to the unit. Adjust the oil pressure relief valve (see section "Commissioning and first start up") at the sump return until the oil pressure is within the recommended operating range.
13. Observe vibration levels.
14. Observe the inlet oil temperature to the compressor casing. An oil temperature control valve has been installed for oil temperature automatic regulation.
15. Adjust the manifold water flow rates.
    The water flow should be adjusted to obtain the value shown in Data Sheet section of this manual. At this setting, the air temperature leaving the air coolers should be within approximately 8°C to 15°C higher than the inlet water temperature.

The CENTAC is automatic in operation and contains the following minimum protective devices:

1. Low oil pressure shutdown.
2. Oil temperature (high and low) shutdown.
3. High air temperature shutdown.
4. High pinion shaft vibration shutdown.
5. Surge alarm with compressor unload.
6. Pre lubrication pump interlock and compressor stop in case of low seal air pressure.

Refer to the electrical schematic contained in this manual, for additional protective devices.
The pre/post lube oil pump will come on to supplement the main oil pump flow whenever a shutdown occurs.
The prelube pump will continue to run until power is turned off to the control panel and to instrumentation air.

STOPPING

	**UNLOAD THE COMPRESSOR BEFORE SHUTDOWN.**
NOTE	

Refer to the main driver manufacturer's instruction for any special instructions for stopping the main driver.
The compressor may be stopped simply by pushing the "compressor stop" on panel display or by pressing the emergency pushbutton. The prelube oil pump will start immediately after compressor shutdown, if instrumentation air supply is foreseen.
The prelube oil pump should be permitted to operate twenty (20) to thirty (30) minutes after the compressor has stopped.

	**IN CASE OF LACK OF INSTRUMENTATION AIR SUPPLY, THE PRE/POST LUBRICATION PUMP DOES NOT START. DURING COMPRESSOR STOPPING, THE INSTRUMENTATION AIR MUST BE SUPPLIED UNTIL THE PUMP ROTATION HAS STOPPED. STOPPING THE COMPRESSOR WHEN THE PUMP IS STILL ROTATING MAY CAUSE SERIOUS DAMAGES TO THE COMPRESSOR.**
CAUTION	

The power to the control panel may then be turned off and, if the compressor is equipped with CMC panel, the pre-lubrication pump is automatically stopped. Otherwise stop such pump manually.
The above procedure is recommended to allow internal heat to be carried away by the circulating oil.

9 Maintenance

	**IMPROPER MAINTENANCE CAN BE HAZARDOUS. UNDERSTAND MAINTENANCE SAFETY PRIOR TO WORKING. CONSULT THE OPERATING AND MAINTENANCE MANUAL OR INGERSOLL-RAND SERVICE DEPT. BEFORE COMMENCING ANY MAINTENANCE.**
CAUTION	

9.1 Maintenance schedule

Scheduled preventive maintenance and inspection are essential for continued optimum performance and long service life of the compressor and its components. The following are general requirements and schedules for periodical inspection and preventive maintenance. Since unusual service conditions and environment affect equipment reliability, these items and schedules should be adjusted in frequency and contents as necessary to suit your specific requirements.

	**ALL THE FOLLOWING MAINTENANCE OPERATION AND INSPECTION SHALL HAVE TO BE CARRIED OUT WEARING THE REQUIRED PROTECTIVE CLOTHES TO AVOID ANY POSSIBLE PERSONNEL INJURY. ALL THE CONSUMABLE AND REPLACED PARTS MUST BE DISPOSED IN ACCORDANCE WITH THE GOVERNING LOCAL RULES AND REGULATIONS.**
NOTE	

DAILY AND AT EACH START-UP

1. Check and record the oil temperature to the compressor casing.
2. Check and record the compressor oil pressure.
3. Check and record the vibration levels on each stage of the compressor.
4. Check and record the interstage air pressure.
5. Check and record the interstage air temperature.
6. Check and record the inlet air temperature.
7. Check and record the cooling water temperature, both to and from compressor manifold.
8. Check and verify condensate traps operation.
9. Vent the air coolers if they are not continuously vented. Vent valves are located on top of the casing or outside the sound enclosure.

10. Drain the condensate from the inlet air line, the discharge header and from the bypass air line, drip leg.
11. Drain the drip legs on any other horizontal run of air piping.
12. Check the compressor reservoir oil level, maintain required level.
13. Check for eventual oil leaks.
14. Check for eventual water leaks.
15. Check for eventual instrumentat air system leaks.
16. Check the control air line filter (if installed). Drain any moisture which may have collected and replace the filter element if necessary.
17. Check the instrument air line filter (if installed). Drain any moisture which may have collected and replace the filter element if necessary.
18. Check and adjust instrument air supply pressure.
19. Check lubrication oil level.
20. Check seal air pressure.
21. Check inlet air filter drop of pressure.

CHECKS TO BE CARRIES OUT EVERY 90 DAYS

1. Check the inlet and bypass valve calibration (please refer to "Commissioning/first start up" section).
2. Visually inspect the inlet air filter element. Clean (if filters can be cleaned) or replace as necessary.
3. Visually inspect the oil mist arrestor and refill the U pipe, if necessary. Clean the housing and replace the element if saturated (please refer to the mist arrestor enclosure).
4. Drain and clean the instrument air filter by replacing the cartridge, if necessary.
5. Inspect air filter internal parts, verifying the absence of cracks and ensuring correct seal.

SEMIANNUAL CHECKS

1. Visually inspect the discharge check valve.
2. Check the condensate traps. (please refer to condensate traps enclosure). Not applicable for nitrogen compressors.
3. Lubricate the motor coupling if necessary.
4. Replace the oil filter element. If not using Techtro-Gold oil, this operation must be carried out

every three months.

ANNUAL CHECKS

	**THESE CHECKS AND OPERATIONS MUST BE CARRIED OUT BY INGERSOLL-RAND PERSONNEL OR QUALIFIED PERSONNEL UNDER INGERSOLL-RAND SUPERVISION.**
CAUTION	

- Inspect the main driver per the manufacturer's instructions found in this instruction manual.
- Check the bullgear bearings for roughness by hand turning the main shaft.
- Inspect and clean the oil reservoir suction screens. Visually inspect the oil cooler tubes. Clean the shell and tube sides of the oil cooler if necessary.
- Calibrate the control and protective devices.
- Visually inspect the inlet throttle valve.
- Visually inspect the bypass valve.
- Check the Physical and Chemical characteristics of the lubricant oil; if the results are not in accordance to required values, change the oil.
- If using mineral oil, change the oil.

	**TO REPLACE THE MINERAL OIL USED FOR COMPRESSOR OPERATION WITH SYNTHETIC TECHTRO GOLD, IT IS NECESSARY TO FOLLOW A SPECIFIC PROCEDURE. ORDINARY OIL REPLACEMENT, WITHOUT FOLLOWING SPECIFIC PRESCRIPTIONS MAY COMPROMISE SIGNIFICANTLY THE CENTAC COMPRESSOR PERFORMANCES.**
CAUTION	

- Carry out vibration analysis on stages rotors.
- Carry out compressor sucked air analysis.

	**THE OIL WASTE DISPOSAL SHALL BE DONE IN ACCORDANCE TO THE LOCAL NATIONAL RULES.**
NOTE	

	**SERVICING OF THE INTERNAL PARTS IS RECOMMENDED WITH THE PRESENCE OF INGERSOLL-RAND SERVICE SUPERVISOR.**
WARNING	

	**DEVELOP AND USE A "RED TAG" PROCEDURE OR SIMILAR SYSTEM UNDER WHICH MAINTENANCE PERSONNEL CAN "LOCK" THE POWER SWITCH OFF DURING MAINTENANCE.**
CAUTION	

MAINTENANCE PROCEDURES

The following procedures are added to supplement the information presented earlier in this manual in the section under the heading Initial Start Preparation.

MAIN DRIVER

Consult the driver manufacturer's literature provided in this manual to insure proper lubrication and maintenance procedures.

OIL CHANGE, FROM MINERAL OIL TO TECHTRO-GOLD SYNTHETIC OIL

1. Empty the oil reservoir, the cooler and remove the oil filter.
2. Remove oi lsuction filters, clean and reassemble them.
3. Dry carefully the reservoir with a clean rag not grinded. Any previous lubricant residual may reduce synthetic lubricant performances.

4. Install new cartridges in the oil filter.
5. Refill the reservoir with Techtrol Gold
6. Let the Techtrol Gold circulate for four hours at normal operation temperature by using the pre-lubrication pump and the oil heater.
7. Replace again the oil filters.
8. Start the compressor. Check all pressures, temperatures, vibrations and oil level.

INTAKE FILTER

All filtration systems have a maximum recommended pressure drop at which the filter element should be cleaned or replaced. Because of the many types of atmospheric conditions that exist it is difficult to accurately determine the life of a given filter element.
It is therefore advisable and highly recommended that a weekly pressure drop measurement be recorded for stage filter element to determine the useful element life. Filter maintenance is a necessary and important part of the entire air system. A properly maintained inlet air filter will result in optimum air compressor operation. An increase in filter differential pressure is an indication that the inlet air filter is performing as intended. The maximum pressure differential levels depend on the filter.
When indicated by the above differential pressure data, the filter elements should be removed for either cleaning or replacement.

	**WHEN FILTER CARTRIDGE ELEMENT SHOULD BE CLEANED OR REPLACED, THE COMPRESSOR MUST BE STOPPED TO AVOID POSSIBLE DAMAGE OR INJURY TO MAINTENANCE PERSONNEL.**
WARNING	

	**DAMAGES MAY BE CAUSED BY: 1) AN AIR FLOW INCREASE OVER 10% THAN THE RATED ONE. 2) EXCESSIVE BACK PRESSURE PULSATION IN CASE OF UNEVEN RUNNING OF COMPRESSOR. 3) OPERATION OF FILTER WITH PRESSURE DROP VALUES HIGHER THAN THOSE INDICATED.**
WARNING	

	**SHOULD A SUDDEN DECREASE OF PRESSURE BE RECORDED OR OBSERVED THE FILTER MUST BE REPLACED IMMEDIATELY. LONGER LIFE OF THE FILTER IS ACHIEVABLE BY PERIODIC CLEANING OF THE INLET LOUVER. THIS CAN EASILY BE DONE USING A VACUUM CLEANER EQUIPPED WITH A FLAT SUCTION PIPE.**
NOTE	

Filtering elements life time will be increased by cleaning periodically the air inlet grids, if installed. Such operation will be eased by using a vacuum cleaner equipped with brush intake. While replacing the elements, ensure there is no dirt around. Furthermore take care not to damage the new filters as even a small breakage may be detrimental to the filtering efficiency of the unit.

	**FOR FILTERING ELEMENTS INFORMATION AND REPLACEMENT PROCEDURES, PLEASE REFER TO THE AIR FILTER ENCLOSURE OF THIS MANUAL.**
NOTE	

	**DURING FILTERS REPLACEMENT, LOCK THE ACCESS DOOR (IF INSTALLED) IN OPEN POSITION, FOR EXAMPLE WITH NEW FILTER CASING.**
CAUTION	

INLET VALVE

Periodically stroke the inlet valve to aid in optimum performance of the compressor: See "Suction and by-pass valves adjustment" in Commissioning and first start up section of this manual for guidelines on stroking the inlet valve.

	**OBSERVE FOR FREEDOM MOVEMENT ON THE INLET VALVE DURING THE STROKING PROCEDURE.**
WARNING	

BYPASS VALVE

Periodically stroke the bypass valve to aid in optimum performance of the compressor: see "Suction and by-pass valves adjustment" in Commissioning and first start up section of this manual for guidelines on stroking the by-pass valve.
In addition to stroking, the bypass valve should be removed from the air piping system annually to inspect the seals for damage. Replace damaged seals as required and reinstall valve.

DISCHARGE CHECK VALVE

The discharge check valve must be removed from the piping system for inspection. When inspecting the check valve, look for:

- RUST
- BROKEN SPRINGS
- DAMAGED SEALS
- FREEDOM OF MOVEMENT

Repair or replace as necessary and reinstall valve. When check valve is mounted in a horizontal run of pipe, the valve should be oriented so that the stem is vertical.

OIL SUCTION SCREENS FILTER

Each time oil reservoir is drained, this suction screens should be removed and cleaned. The screen is submersed in the reservoir and situated in suction piping, upstream of each pump.

OIL FILTER

A single or double line type oil filter is supplied with the CENTAC.

	**FOR FILTERING ELEMENTS INFORMATION AND REPLACEMENT PROCEDURES, PLEASE REFER TO THE AIR FILTER ENCLOSURE OF THIS MANUAL.**
NOTE	

	**LUBE SYSTEM PRESSURE MAY REACH 600 kPa(g) (6 bar) AND TEMPERATURE OF 70°C OR MORE. DO NOT PENETRATE LUBE SYSTEM WHILE MACHINERY IS OPERATING.**
CAUTION	

OIL COOLER

The shell side of the oil cooler generally will not need to be cleaned.
The tube side of the cooler may be cleaned by flushing.
For more stubborn deposits, wire brushes or rods can be used.
After maintenance inspection or cleaning, both shell and tube side should be carefully vented and full of liquid.

	**FOR INFORMATION AND MAINTENANCE PROCEDURES, PLEASE REFER TO THE OIL COOLER ENCLOSURE OF THIS MANUAL.**
NOTE	

MIST ARRESTOR

A reservoir mist arrestor is furnished as standard equipment on the CENTAC. This unit has a replaceable cartridge, which requires periodical replacement.

	**FOR INFORMATION AND MAINTENANCE PROCEDURES, PLEASE REFER TO THE MIST ARRESTOR ENCLOSURE OF THIS MANUAL.**
NOTE	

CONDENSATE TRAP

The condensate trap requires frequent inspection and cleaning. Traps may be of different types, according to contractual requirements.

	**SHUT OFF COMPRESSOR BEFORE PERFORMING ANY MAINTENANCE ON THE CONDENSATE SYSTEM.**
CAUTION	

During normal operation the trap should have an intermittent discharge, a dribble or semi-continuous discharge, or a constant discharge flow of liquid. Any of these conditions are indications of proper trap operation.

	**FOR INFORMATION AND MAINTENANCE PROCEDURES, PLEASE REFER TO THE CONDENSATE TRAP ENCLOSURE OF THIS MANUAL.**
NOTE	

	**CONDENSATE BYPASS VALVES SHOULD BE OPENED SLOWLY AS CONDENSATE MAY BE DISCHARGED AT PRESSURE EXCEEDING 850 kPa(g) (8.5 BARG) HEATING PROTECTION MUST BE WORN WHEN BYPASS VALVES ARE OPEN.**
WARNING	

10 Troubleshooting

The following list of possible troubles concerns compressor operation only, assuming that the motor or driving equipment and starter have been inspected and deemed fit for operation.

SYMPTOM	POSSIBLE CAUSE	CORRECTIVE ACTION
FAILURE TO START	• Failure to reset trip and interlock systems. • No voltage to compressor control panel or starter (not provided for turbine-driven compressors). • Loosen or corroded power cable. • Motor starter or starting system malfunctioning. • No seal air.	• Remove trip or interlock conditions. • Check voltage to panel/starter. Check transformer. • Check cables. Clean, tighten and replace as necessary. • Troubleshoot motor starter (contact Ingersoll-Rand Customer Service should the starter be supplied by Intersoll-Rand) • Supply seal air.
PRE-LUBE OIL PUMP MALFUNCTIONING	• Pump not running. • Improper setting of prelube oil pump overflow valve. • Broken motor. • Defective pump.	• Troubleshoot pump contactor and thermal protection. Check for proper supply voltage. • Adjust the overflow valve in order to obtain desired pressure value. • Repair or replace motor or motor pump. • Repair or replace pump.
HIGH OIL TEMPERATURE	• No water flow or insufficient cooling water flow to oil cooler. • Excessively high water temperature. • Improper temperature pick up setting. • Dirty or clogged oil cooler on water side.	• Restore correct water flow to oil cooler. • Lower water temperature. • Provide correct instrument setting • Clean cooler tubes. Provide water strainers as necessary (contact INGERSOLL-RAND Customer Service for more details).
LOW OIL PRESSURE	• Improper setting of oil control valve • Oil circuit leakage or narrowing. • Dirty oil filter. • Defective main oil pump. • Low oil level inside the tank	• Adjust the valve set screw for correct pressure setting • Repair or replace the oil pipe. • Replace oil filter cartridge. • Repair or replace the main oil pump. • Add oil.
HIGH AIR TEMPERATURE	• No or insufficient water flow to air cooler • Improper temperature pick up setting • Dirty or clogged air cooler on water side	• Restore correct water flow to the cooler • Carry out correct instrument calibration • Clean cooler water passes. Provide water strainers as necessary (contact INGERSOLL-RAND Customer Service).

SYMPTOM	POSSIBLE CAUSE	CORRECTIVE ACTION
LOW SEAL AIR PRESSURE	• Low instrument air pressure • Improper setting of seal air pressure regulator • Defective seals	• See “Low instrument air pressure” described below • Adjust regulator to obtain correct seal air pressure • Replace seals (contact INGERSOLL-RAND Customer Service).
LOW INSTRUMENT AIR PRESSURE	• No supply pressure • Cut-off or leaking air lines • Improper air regulator setting.	• Establish instrument air supply pressure • Repair or replace air lines • Adjust regulator to obtain correct instrument air pressure.
HIGH VIBRATION	• Low oil temperature. • Defective coupling / insufficient coupling greasing. • Rotor unbalance. • Induced vibration from the electric motor.	• Allow warm up period for oil. • Grease coupling / replace coupling. • Contact INGERSOLL-RAND Customer service . • Contact INGERSOLL-RAND Customer Service.
COMPRESSOR UNABLE TO REACH FULL LOAD CONDITIONS	• The operating mode selector is on the UNLOAD position. • Pressure controller too low set point. • Bypass valve not completely closed or inlet valve not open.	• Turn selector to desired operating mode. • Set controller correct pressure value. • Check for air leaks or valve supply system (electric signals and instrument air).
SYSTEM DISCHARGE PRESSURE LOW	• Compressor not loaded. • Dirty or clogged inlet air filter. • Compressor surge with too low pressure values. • Compressed air request higher than compressor flow rate or line air leakage.	• See above. • Replace filter cartridge or clean it (for cleanable filters). • See “Continuous Surging“ below • Repair ALL system leaks, if any. Turn off unnecessary utilities.
CONTINUOUS SURGE	• Shut-off valve on discharge line closed. • Dirty or clogged air filter. • Improper setting of chocking point. • High interstage air temperature. • Cooling water temperature higher than expected. • Damaged streamlined parts.	• Open shut-off valve. • Replace filtering element. • Adjust the chocking limit point. • Check water flow to coolers. • Lower water temperature. • Contact INGERSOLL-RAND Customer Service.
EXCESSIVE POWER CONSUMPTION	• Very low ambient temperature.	• Reduce compressor load. Contact INGERSOLL-RAND Customer Service.

SYMPTOM	POSSIBLE CAUSE	CORRECTIVE ACTION
	• Too low supply voltage. • Reduction in motor efficiency.	• Check power grid voltage, at the supply cabin. • Contact motor manufacturer.

Table 10.1

11 Parts & Service

11.1 Parts & Service

	**THE CENTAC IS A HIGH TECHNOLOGY PRODUCT. SERVICE OR INSPECTION BEYOND THE PROCEDURES GIVEN IN THIS MANUAL SHOULD NOT BE ATTEMPTED BY OPERATING PERSONNEL.**
CAUTION	

If you require information, service or parts, for the correct operation of your CENTAC, Ingersoll-Rand Customer Service Departments are present all over the world to supply on-site support and assistance. The Ingersoll-Rand Factory in VIGNATE (MILAN) ITALY, supports your spare parts requirements. When you need support for your CENTAC, contact your local Ingersoll-Rand office.
The main Ingersoll-Rand customer service departments are listed below. For further information on Irgersoll customer departments and distributors consult the site **"www.air.irco.com/asg/sales_service_locations".**

Main customer service departments in the world

1. **INGERSOLL-RAND ITALY**
   20060 VIGNATE (MI), ITALY
   Tel.: 39-2-95056650 -651 -652
   Telefax: 39-2-95360222

2. **INGERSOLL-RAND FRANCE**
   5-7 Avenue A. Einstein
   B.P. 113
   LES CLAYES SOUS BOIS
   FRANCE
   Tel.: 33-1-30076834 / 838 / 839
   Telefax: 33-1-30076851

3. **INGERSOLL-RAND SALES CO. Ltd.**
   Horwich, Bolton
   GREATER MANCHESTER BL6 6JN
   U.K.
   Tel.: 44-204-690690
   Telefax: 44-204-690388

4. **INGERSOLL-RAND SPAGNA**
   MADRID
   SPAIN

Tel.: 902 404081
Telefax: 916 277 404

5. **COMINGERSOLL PORTUGAL**
   CARNAXIDE PORTUGAL
   SPAIN
   Tel.: +351 (0) 214 244 400
   Telefax: +351 (0) 214 181 367

6. **INGERSOLL RAND RUSSIA**
   MOSCOW
   RUSSIA
   Tel.: +70 95 9330321
   Telefax: +70 95 7370148

7. **INGERSOLL RAND INDIA**
   MOMBAI
   INDIA
   Tel: +91 22-4936-765
   Fax: +91 22-4950-516

8. **INGERSOLL-RAND NETHERLANDS**
   2380 AA ZOETERWOUDE
   Tel.: 31-(0) 71-5823456
   Telefax: 31-(0) 71-5823400

9. **INGERSOLL-RAND GERMANY**
   45409 MULHEIM/RUHR
   GERMANY
   Tel.: 49-208-99940 / 208-9994227-233
   Telefax: 49-208-9994375

10. **INGERSOLL-RAND SCANDINAVIA**
    STOCKHOLM
    SWEDEN
    Tel: +46 8 50 63 63 48
    Telefax: +46 8 50 63 63 68

11. **INGERSOLL-RAND CO. SOUTH AFRICA**
    ALRODE 1451
    SOUTH AFRICA
    Tel.: 27-11-8643930
    Telefax: 27-11-8643954

12. **INGERSOLL-RAND AUSTRALIA**
    FRANKSTONE VICTORIA
    AUSTRALIA
    Tel: 61 3-8781 1600

Fax: 61 3-8781-1740

13. **INGERSOLL RAND CHINA**
    SHANGAI 200030
    CHINA
    Tel: 86-21-6438-4310
    Fax::86-21-6426-7836

14. **INGERSOLL RAND USA**
    Davidson, NC 28036
    Tel: 001 800-247-8640

For different areas, consult the site: **"www.air.irco.com/asg/sales_service_locations".**

11.2 Goods Return

No material may be returned to the VIGNATE Plant without authorization from either the Aftermarket Department or Customer Service Department.
The authorization medium is a “Return Authorization Number” (R.A.N.) released by C.S.D./Spare Parts Dept (“R.A.N.”-Return Authorization Number). A R.A.N. number will be issued to control the returned material.
The R.A.N. number will be indicated on all containers, in order to preclude possible material loss or processing delay at the factory.

11.3 Spare Parts

Ingersoll-Rand Centrifugal Compressor Division ESA supports a 24 hours emergency parts service call your local Ingersoll-Rand office or qualified Ingersoll-Rand Distributor or the factory direct at +39 335 7746428.
When ordering renewal parts, the information listed below should be given:

1. Type and Machine Serial Number from the compressor nameplate.
2. The quantity required and Part description.
3. Part Number or tag number, indicated on compressors drawings and on wiring and/or pneumatic diagrams.

The following list indicates the minimum store of spares that should be available for CENTAC safe operation at least during the first months. Contact the nearest Ingersoll-Rand Customer Service Department for the supply and quotation of specific spare parts lists, according to years of operation and specific plant requirements.

- (2) Air filter cartridges;
- (2) oil fumes separator cartridges ;
- (2) Vibration probe and relevant cable;
- (2) Oil filter cartridges.

	**USE ONLY GENUINE INGERSOLL-RAND SPARE PARTS**
NOTE	

12 Drawings and Part Lists

Drawings

Title	Number
General Assembly Drawing	N/A
Flow Sheet ISA (P&I) Drawing	N/A
Instruments List Drawing	N/A
Inlet Air Filter Drawing	N/A
By-Pass Silencer Drawing	N/A
Electrical Schematic Drawing	N/A
Air System Drawing	N/A
Lube System Drawing	N/A
Instrument Air System and Eletrical Connections Drawing	N/A
Water Piping System Drawing	N/A
Condensate Piping System Drawing	N/A
Assembly Detail Drawing	N/A
Compressor Sectional Drawing	N/A
Motor Drawing	N/A
Coupling Drawing	N/A
Oil Cooler Drawing	N/A
Oil Filter Drawing	N/A
Oil Mist Arrestor Drawing	N/A

Material part list

Title	Number
Air System Drawing Part List	N/A
Lube System Drawing Part List	N/A
Instrument Air System and Electrical Connections Drawing Part List	N/A
Water Piping System Drawing Part List	N/A
Condensate Piping System Drawing Part List	N/A
Assembly Detail Drawing Part List	N/A
Compressor Sectional Drawing Part List	N/A

Annex A Main Driver

Not applicable for this configuration

Annex B Air Filter

Not applicable for this configuration

Annex C Oil Filter

Not applicable for this configuration

Annex D Condensate Traps

Not applicable for this configuration

Annex E Pre/Post Lubrication Pump

Not applicable for this configuration

Annex F Oil Cooler

Not applicable for this configuration

Annex G Oil Vapor Separator

Not applicable for this configuration

Annex H Power Kit Seal Air

Not applicable for this configuration

Annex I Coupling

Not applicable for this configuration

Annex L External Air Coolers

Not applicable for this configuration