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Detailed Scope

INGERSOLL RAND single stage (R4-11), contact cooled, rotary screw packaged air compressor.

GENERAL PACKAGE DESCRIPTION:

The fully packaged contact cooled, rotary screw air compressor is designed for total convenience, it is easy to install, simple to operate and will deliver rated compressed air with reliable efficiency. The enclosure is designed to manage the environment of the internal components and the cooling ventilation system, at the same time as significantly reducing the sound level emitted from the machine into the installation environment. The complete package is designed to be located on an adequate flat floor without any special foundations and will operate without imparting significant vibrations to the installation.

INLET AIR FILTER:

Inlet air filtration is accomplished by a large 99.9% efficient at 3 micron and above, dry type air cleaner. This is more than suitable for the vast majority of applications: however, where high dust and dirt contamination is present, optional enhanced filtration systems are available.

COMPRESSION MODULE / AIR END:

Since the airend is the fundamental component in any rotary screw compressor package, reliability, performance and efficiency are determined for the most part by the design, manufacturing tolerances and assembly of the airend itself. All other elements in the compressor system are essentially support and monitoring devices included to ensure dependable service and performance.

The rotors are manufactured from AISI-1045 steel or EN 10083-2 C45+N steel. The asymmetrical helical profile is developed through a unique two step machining process. The first step in the machining process develops the basic wrap angle profile and is a rough cut. The second and final step is a finish grinding process which ensures a hard, true rotor surface. Rotor shafts are precision ground to tolerances within 0.5mil or 0.0005 of an inch. The rotors are paired prior to assembly into the rotor housing. The rotor housings are made of close grain high quality cast iron. After machining the housing is dimensionally checked to ensure accuracy.

The bearing configuration used is back to back tapered roller bearing. The tapered roller bearing essentially consists of constructing the roller elements, as well as the

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raceways, so that lines drawn coincident with the working surfaces of the rollers and races will all meet at a common point on the axis of bearing. This allows the bearing to handle all loads, radial, thrust or both. With this bearing configuration, the discharge end of the male and female rotors are each equipped with a pair of tapered roller bearings offset at opposing axes for maximum absorption of thrust and radial loads.

High quality cylindrical roller bearings are used to carry the radial loads on the inlet end of the rotors

To ensure these bearings are always lubricated the airend is equipped with unique "coolant dams" which retain a reservoir of coolant in the bearings, providing lubrication at all times, particularly during start up when immediate lubrication is critical.

MAIN DRIVE MOTOR:

The main drive motor is exactly matched to the requirements of the compressor. Torque and shaft load requirements of the compressor were matched to design criteria that enabled the specified motor to develop peak efficiency and power factor at full load of the compressor package. Standard units are supplied with IP55 two pole motors, meeting or exceeding local efficiency rating requirements for totally enclosed fan cooled motors.

- **Frame -** The cast iron frame motor is foot mounted. The frame design is specified to provide maximum strength and rigidity for bearing support, uniform stator/rotor gap and permanent alignment of all mating parts.

- **Electrical Design -** Speed, torque and operating characteristics have been designed to match the load of the compressor. Motor efficiency and power factor have been optimized. Standard motors are wound to cover operation on 400V and 230V 50Hz in Europe, 208 and 230 and 460 and 575V 60Hz in North America and 220 and 380 and 440V 60Hz in South America.

- **Bearings -** Vacuum degassed bearings provide dependable and reliable service.

- **Insulation -** The Ingersoll Rand dedicated motor has a major benefit in that the maximum temperature rise the motor actually experiences is lower than the temperature rise permitted by the design of the motor. The motor has class F insulation as standard, which means it is rated at a continuous duty for a

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temperature rise up to 105°C (221°F). However no motor is ever applied for a temperature rise over 89°C (192°F) in a 46°C (115°F) ambient. This is significant, since the motor life expectancy is doubled with every 10° reduction in temperature rise. The extra conservatism Ingersoll Rand build into the motor means more reliability, increased life, and a much more forgiving motor under adverse conditions. Temperature rise is at the applied load and not the nominal power.

- All motors are designed for operation with variable frequency drive.

All windings and leads are copper with triple coats of insulating varnish to add extra margins of protection to the drive.

BELT DRIVE ASSEMBLY:

Power transmission between the motor drive and the airend male rotor is provided by a non-stretching poly-v belt with easy to adjust belt tension control and simple access for maintenance. This setup assures performance integrity and maximum belt life. The entire drive system is shielded by protective guarding for maximum safety.

VIBRATION MOUNTS:

The airend / motor module is mounted to the sub-base on anti-vibration pads. This makes the compressor silent and smooth running.

LUBRICATION SYSTEM:

Elements of the lubrication system include;

- **Coolant Filtration -** The full capacity coolant filter is a 5 micron replaceable element. The system contains an internal pressure relief that bypasses at 2.5 bar (36 psi) in the event that the change warning is not acknowledged.

- **Coolant/Lubricant Temperature Control -** The thermostatic control valve is integrated with the airend casting and includes 3 ports, (1) for the coolant from the pressurized receiver/separator, (2) for the coolant from the valve to the cooler, (3) and for the coolant from the cooler. The way from valve to the coolant filter, is also part of airend casting. The temperature sensitive element controls the quantity of coolant from each source, cooled and un-cooled as

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necessary to provide the proper injection temperature, assuring fast warm-up and avoiding potentially harmful condensation.

- **Coolant Injection -** The coolant is injected through a single large port on the female rotor inlet side. This ensures the best possible pre-sealing of the rotor, plus an optimum mix of coolant with inlet air. Coolant flow is maintained by the differential pressure between the separator tank and the airend inlet.

COOLANT/AIR SEPARATION:

After compression and discharge from the airend, the air heavily laden with coolant travels to the separator tank which is part of the airend block. Entering through separator tank inlet, the air coolant mixture is directed in a circular motion around the inside of the tank. The vortex or the circular motion separates a major portion of the coolant from the air through centrifugal force. .

Separator element is two-stage molded fiberglass structurally reinforced coalescing separator. There is a scavenge line which picks up coolant which has coalesced on the inside of the separator element and feeds it back to the airend inlet. The carryover after the separator element is less than 5 ppm. Due to the conservative sizing of the separator element there is a minimal 3 psi (0.2 bar) pressure drop. This reduces the required power to move the air through the compressor system.

The separator tank is part of the airend module mounted horizontally to airend discharge. The separator vessel is protected by pressure relief safety valve mounted on the top of the tank. There is a coolant drain valve at the bottom of the tank which can be piped out to the sub-base (the pipe is delivered as compressor accessory). Sight level glass is located in front of the separator tank to allow user to check for the correct fill of the compressor with coolant. The air discharge from the separator is regulated by a minimum pressure check valve which ensures, that when the unit is unloaded, sufficient pressure is maintained in the tank to propel the coolant through the system.

Pressure reducing blow down valves on the separator tank allow the pressure in the separator tank to be reduced when the machine is unloaded, when this valve opens and the internal pressure falls to approximately 20 psig (1.4 Barg) which fully reduces the unloaded power requirement.

Ingersoll Rand compressors are factory filled with Ingersoll Rand Premium Compressor Coolant; a PAG advanced synthetic lubricant, providing better cooling

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characteristics, reduced wear through improved lubrication, and has a longer operating life than other synthetic lubricants.

COOLERS:

R4-11 compressors are available as air-cooled units as standard. The compressor has one combo heat exchanger divided into after-cooler to cool the discharge air and a coolant cooler.

In standard air cooled units, the discharge air is cooled to as low as 5-12ºC (9-21.5ºF) (see engineering sheet for CTD by model) of the ambient temperature, basis 46ºC (115ºF) and 40% RH. Cooling air which is drawn into the enclosure passes over the main motor and airend until it exits the package through the after-cooler and coolant cooler. The coolers are of an aluminum finned tube construction and are designed to operate continuously, fully loaded in ambient air up to 46ºC (115°F) without exceeding the normal design coolant injection temperature.

FAN MOTORS:

The fan with integrated TEFC high efficiency motor is mounted in front of the cooler forcing a cooling air to flow through the cooler prior to exiting the enclosure. A residual pressure is increased due to ducting losses, the maximum ambient temperature decreases accordingly. The results of the increased static pressure are shown in the table below.

Additional Static Pressure (inches H_2O)	LAT (°F)	LAT (°C)
0.25	114	45
0.50	112	44
0.75	111	44
1.00	110	43

COMPRESSOR/ CAPACITY CONTROLS (Fixed Speed):

As standard, R4-11 units are provided with on line/off line control. This control strategy allows the compressor to operate at 2 points on the capacity curve. The first is 100% full-flow and the second is zero flow. On line/off line control is a power savings mode

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of operation where the unloaded operation provides for immediate compressor system blow-down to minimize power requirements. The compressor will automatically reload to 100% capacity when the system pressure falls to a predetermined pressure.

Ingersoll Rand R4-11 units are fitted with automatic stop/start as optional. This allows the compressor to run unloaded for a predetermined time, and if there is no demand within that period, the unit shuts down to standby, consuming zero energy and will automatically restart and load if the pressure falls to a preset level.

The compressor is operating most inefficiently when it is running unloaded. The controller will monitor the compressor's operating cycle and reduce the off load running time to a minimum.

COMPRESSOR/ CAPACITY CONTROLS (Variable Speed):

The compressor is controlled by one of the advanced Xe Series machine controllers. These highly automated controls allow for a turndown range of 57-66%.The compressor will turn itself off at minimum speed and remain off until system pressure decays below operator set target pressure.

STARTER (Fixed Speed):

The standard compressor has an integrally mounted IP54 starter box with a hinged door panel. It contains starter contactors, control transformer and all the components of the control circuit. The star-delta starter is used to reduce the current inrush on starting. The control relays operate at 110V AC and the control circuit is protected by miniature circuit breakers or fuses. All electrical equipment is designed to conform to the applicable local electrical codes

INVERTER (Variable Speed):

A standard feature of the variable speed drive compressors is the integral inverter, which has been engineered to perform optimally with the compressors motor. The inverter has a minimum efficiency of 96% throughout its operating range. Integral to the drive module is the control voltage circuit, which provides control power for all control circuits.

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XE SERIES CONTROLLER:

The R4-11 is offering two options of controllers.

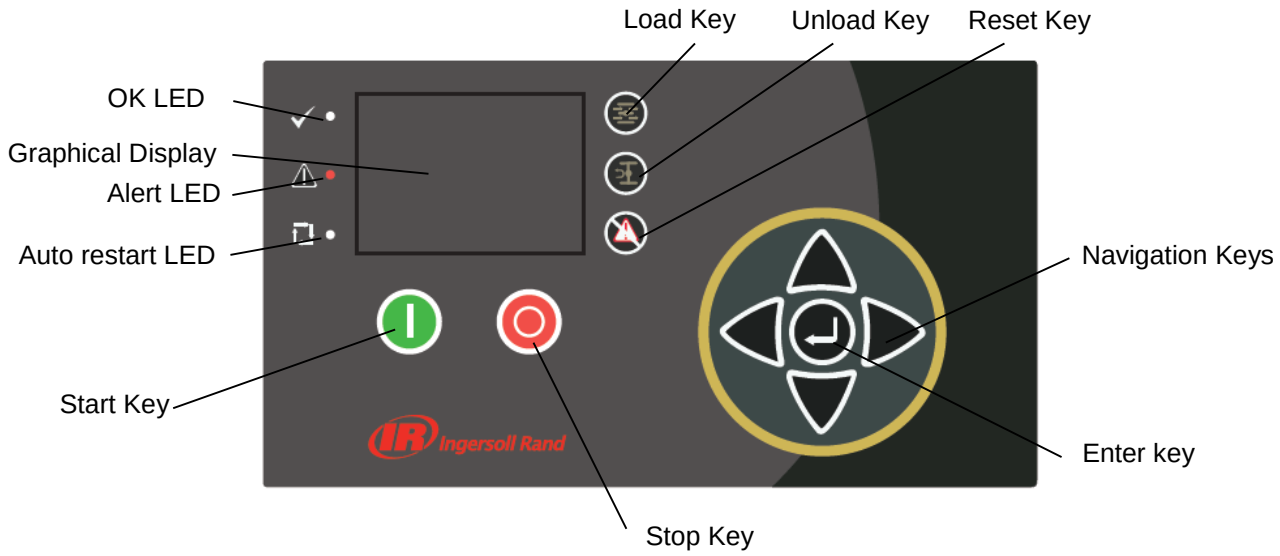
- Xe 50 – for fix speed only
- Xe 70 – For VSD and Fix speed (optional)

Xe-70 Controller

The compressor is monitored, controlled and protected by an intuitive Xe Series controller. The controller continuously monitors the status of the compressor and takes immediate action if an abnormal operating condition occurs. The controller also has several features which make operating the compressor easier and more efficient.

- **User Interface –** The controller consists of the membrane and the LCD display. The membrane consists of five command keys (Start, Stop, Load, Unload, and Reset), four navigation keys (Up, Right, Left and Down), and an Edit mode selection key (Enter). These keys, in conjunction with the graphics display and the LED icons, make up the user interface to the compressor.

Xe 70 controller



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- **Event and Logs (Optional - with ECO module only) –** Xe 70 model provides a record of 30 days' worth of trips, events and logs.

- **Event Tracking -** The Event Log details the last 250 "events" in the order that they happened. This enables an operator or technician to view and quickly diagnose the sequence of events that caused an occurrence to be logged. An "event" is defined as any alarm, trip, set-point change or command key input from the operator user interface. Each "event" has an associated time and date stamp to enable precise tracking.

- **Selectable Languages –** Thanks to the graphic display and extensive memory, the Xe controller comes pre-configured with 30 selectable languages.

Bulgarian	Chinese	Croatian	Czech
Danish	Dutch	English	Estonian
Finnish	French	German	Greek
Hungarian	Indonesian	Italian	Korean
Latvian	Lithuanian	Maltese	Norwegian
Polish	Portuguese	Romanian	Russian
Slovak	Slovenian	Spanish	Swedish
Thai	Turkish		

Xe-50M Controller

- **User Interface Xe 50–** The controller consists of the membrane and the LCD display. The membrane consists of three command keys (Start, Stop and Reset), two navigation keys (Up and Down), and an Edit mode selection key (Enter). These keys, in conjunction with the graphics display, make up the user interface to the compressor.

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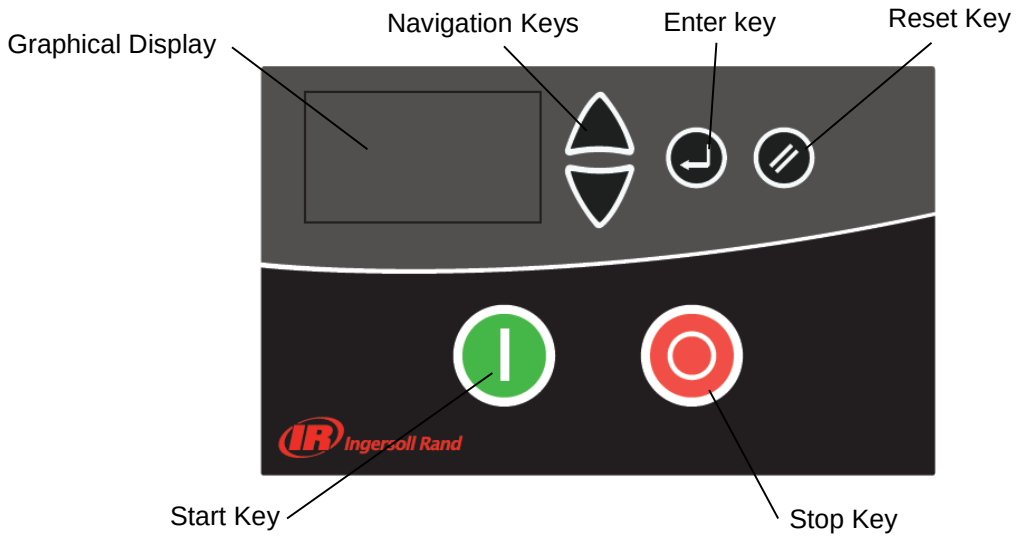

HARDWARE:

Xe-70 Display Communication Unit (DCU)

- 2.6” 240 x 160 pixel Monochrome
- 3 - LED Status Indicators (Green – OK, Red – Fault, Blue – Automatic Start)
- Tabbed folders for ease of navigation
- Multiple screens of compressor information and setup data
- Status Bar with compressor state and 4 Status Icons
- Left/Right/Up/Down/Enter push buttons
- Acknowledge/Reset push buttons
- Start/Stop push buttons
- Load/Unload push buttons

Xe-50M Display Communication Unit (DCU)

- 2.1” Monochrome display
- Tabbed folders for ease of navigation
- Multiple screens of compressor information and setup data
- Up/Down/Enter push buttons
- Acknowledge/Reset push buttons
- Start/Stop push buttons

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EVENT LOG (Xe 70 only):

The Event Log is a comprehensive listing of the most recent occurrences with name, time, date and value. The Event Log contains details on the last 250 "events" in order of occurrence.

Logged events

- Power ON
- Power OFF
- Press the Start Key
- Press the Stop Key
- Press the Load Key
- Press the Unload Key
- Starting the compressor remotely
- Stopping the compressor remotely
- Loading the compressor remotely
- Unloading the compressor remotely
- Warning
- Trip
- Start Inhibit

Both controllers have maintenance timers to help you optimize your maintenance scheduling and maintain optimal performance.

COMMUNICATIONS:

The Xe 70 controller can be accessed through the following access points.

- Serial - RS485
  - Modbus RTU
  - Field Service Tool Remote access
- Ethernet (optional – with ECO module only)

- Hard Wired Communication
  - Trouble Indication Contacts (Warning and Trip, Running Unloaded Contact)

The Xe-50 does not have communication functionality

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TOTAL AIR SYSTEM / TAS – (Factory Option Only):

A TAS option is available consisting of a refrigerated dryer with a General Purpose (GP) filter mounted in-line before the dryer and a High Efficiency (HE) filter mounted in-line after the dryer. The dryer has its own power supply and runs independently to the compressor operation. Delivered air quality of the package with the TAS module installed is to meet ISO 8573.1 class 1-5-1 (Dirt – 1 micron, Dew Point 7 degree C, Oil 0.01 mg/m3) air quality requirements at 25°C (77 °F), 60% RH. The dryer is designed such that it will operate and provide dew point suppression across the normal operating conditions of the compressor (2°C-46°C/37°F -115°F ambient).

The system consists of a refrigerant compressor, condenser, condenser fan, expansion valve, refrigerant filter, sight glass, evaporator, moisture drain, and hot gas bypass valve. The hot gas bypass is used to assist with Variable Speed operation across the flow range. R134A refrigerant is used to ensure optimum performance.

In order to prevent the dryer from starting against an excessive head pressure, the dryer must remain off for 90 seconds before it can restart. If the dryer has been off for greater than 90 seconds when it receives the run command, it will start immediately. If the dryer has been off for less than 90 seconds, the dryer will remain off until the total off time reached 90 seconds. At that point, the dryer will start.

In order to prevent the dryer from exceeding the maximum number of starts per hour, the dryer may remain on for a period of time after the compressor shuts off. The dryer can be set to constant run via the controller for those applications where these limits are creating issues with the customer's air quality.

The dryer has own incoming power supply for European version only. The refrigerant compressor and condenser fan starters will be located in a separate electrical box in the dryer module. 230 volt control power will be used to operate dryer functions within the separate electrical box.

The dryer moisture drain will mirror the compressor option (NLD or timed solenoid) and is accessible from the same side as pressure ports and other service items. High pressure safety switch and fan pressure switch are also easily accessible from this common side.

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Dryer design allows for modular removal of the dryer system to accommodate major component replacements such as refrigerant compressor or condenser. Dryer by-pass will not be offered.

For TAS packages, the max pressure of the package will be derated by 7.5 psi (0.5 bar). For example, the max pressure setting on a VSD TAS package will be 138 psi (9.5 barg). This will allow an incremental 16 psi pressure drop (combination of separator element and TAS filter). This would match the summation of the max Δp ratings of the elements.

TAS will NOT be available with Low Ambient or Outdoor Mod Options.

RECEIVER:

The machines are available with receiver mounted version with receiver sizes 272l, 500l (EU); 200l (Brazil); 80gal and 120gal (North America). The compressor is mounted to the top of the receiver for reducing of the foot space increasing.

COOLANT:

Ingersoll Rand R4-11 machines are supplied with a factory fill of Ingersoll Rand Premium Compressor Coolant as standard. Optionally they may be supplied from the factory with H-1F food grade coolant. Food Grade coolant requirements must be specified on the order.

SEQUENCE CONTROL:

The control fitted to the R4-11 compressor is suitable for use with Ingersoll Rand approved energy management controllers.

In addition, the Xe-70M controller on the fixed speed unit can automatically sequence up to four compressors fitted with the same controller via the RS485 serial communication interface; sharing running hours, operating on a common pressure range and changing running order in accordance with a pre-programmed schedule.

When controlling an air system with an Ingersoll Rand Air System Controller, which sequencers multiple compressors and accessories, connect directly to the compressors via the RS485 serial communication interface (Xe-70M only).

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PORO, AUDIBLE RESTART WARNING KIT:

For the “real time clock” timed operation function which is available within the controller, or for customers who anticipate interruptions in their incoming power supplied to their compressors, but need to maintain their supply of compressed air, the Power Outage Restart Option allows the compressor to restart automatically within an adjustable time period after incoming power is restored following power interruption. The option is a factory and field fit modification kit, which consists of an audible warning device and full fitting instructions. The siren, which sounds when power is restored to the compressor, warning people in the vicinity that the unit is about to start. The option is only available in combination with the Xe 70 controller.

HIGH DUST FILTER (Fixed Speed Only):

This is a heavy duty filter, enclosed in a plastic shroud, for use in dirty, dusty environments. The filter has two stages of separation; a centrifugal primary stage is employed to mechanically separate larger dust particles which are ejected, followed by a high capacity dry type filter element. Together these give a high filtration capacity with an efficiency of 99.9% at 3 microns and above.

LOW AMBIENT FREEZE PROTECTION (Europe Only, Fixed Speed, Non-TAS, Non-Receiver, Xe-70M Controller Only):

Starting a compressor with viscous coolant, condensation within the electrical components or frozen condensate drainage systems can all result in damage. To protect against such an event the controller will warn if freezing conditions occur at start-up, and if heaters are fitted will execute a warm-up cycle prior to loading. For units to be installed in conditions with temperatures down to -10ºC (14ºF), Ingersoll Rand offers a combination of heating elements in the starter panel, trace heating and motor heaters or fan assisted space heaters to prevent moisture or freezing of condensate when the unit is shut down. The heaters can be wired directly to a suitable customers’ supply voltage or through the starter so they can switch on when the units shut down.

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OUTDOOR INSTALLATION RAIN INGRESS PROTECTION (Fixed Speed Non TAS Only):

Intended for operation between temperatures of 35ºF (2ºC) through 115ºF (46ºC) in installations which may be exposed to rain ingress this option will ensure that sensitive electrical areas are ingress protected and any water penetration into general machine is channeled out of the enclosure appropriately.