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DETAILED SCOPE

INGERSOLL RAND single stage 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 dry type air cleaner. Minimum efficiency at 3 microns is 99.0% (ISO 12103-1 A2 fine dust at a velocity of 15 cm/s).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 air-end 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 air-end 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. The optimized machining process produces extremely precise rotors which consistently deliver high performance. The rotor housings are made of close grain high quality cast iron. After machining the housing is dimensionally checked to ensure accuracy.

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The bearing configuration at discharge end consists of a cylindrical roller bearing, angular contact bearings, and a deep groove ball bearing. The cylindrical roller bearing handles the radial loads while the angular contact bearings support the thrust loads. The deep groove ball bearing protects the air-end under a reverse rotation condition or heavy off-loading.

Cylindrical roller bearings are used to carry the radial loads on the inlet end of the rotors.

All bearings whether thrust or radial, use premium cost vacuum degassed bearings, which provide truer, harder running surfaces for both inner and outer bearing races. This bearing configuration allows for extremely tight control of clearances during operation and reduced power losses for improved efficiency.

To ensure these bearings receive the proper amount of lubricant, specifically located oil passageways deliver a controlled amount of oil to the bearings and ring seals separate the bearings from the compression chamber. This ensures the bearings always receive the correct amount of lubricant which maximizes life and optimizes efficiency.

DRIVE MOTOR (Fixed Speed):

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 enable the motor to develop peak efficiency and power factor at full load of the compressor package. Standard units are supplied with IP55 motors, meeting or exceeding IE3 (IEC60034-30) and NEMA Premium® efficiency rating requirements for totally enclosed fan cooled motors.

- **Frame -** The cast iron IEC frame motor is foot and flange 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 available in 50Hz (230, 400V) and 60Hz (200, 230, 380, 440, 460 and 575V). 400V 50Hz motors are suitable for 380-415V rated supplies

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- **Bearings -** Vacuum degassed bearings provide dependable and reliable service. The motor shaft has the largest possible standard diameter. This means that larger bearings are fitted. The average applied life is approximately five times greater with these oversized bearings than standard bearings. Both bearings are grease lubricated with bearing housings having inlet and relief fittings to simplify the lubrication procedures.

- **Insulation -** The Ingersoll Rand dedicated motor has a major benefit in that the maximum temperature rise the motor actually experiences is much 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 temperature rise up to 109°C (228°F). Design limits the actual temperature rise to not exceed 89°C (192°F) in a 46°C (115°F) ambient.
  This is significant, since the motor life expectancy is doubled with every 10°C reduction in temperature rise. This conservative application leads to better reliability, increased life, and a much more forgiving motor under adverse conditions.
  All windings and leads are copper with triple coats of insulating varnish to add extra margins of protection to the motor.

DRIVE MOTOR (Variable Speed Induction):

Machines with integral variable frequency drive utilize motors specifically designed for the purpose. In addition to all the features for fixed speed induction machines, the windings have a minimum 1600V winding withstand (1800V for 575V). Additional motor protection is included as standard with thermally protected stator windings (one device per phase). Motor speed is controlled using pulse width modulation (PWM) vector type motor control.

INTEGRAL DRIVE ASSEMBLY:

In order to maximize the inherent efficiency advantage of the Ingersoll Rand motor and air-end it was necessary to develop a means of efficiently and reliably transmitting power from the motor to the compressor. The Ingersoll Rand integral gear drive system was engineered to operate without losses or slip and without mechanical complexity of alignment compensating couplings. The reliable and rugged design has been refined and proven over more than a quarter century of use.

Conservatively chosen speed optimizing gears are mounted on the shafts of the air-end and motor. These smooth running helical gears dictate that the air-ends always

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rotate at the selected speed which provides consistent capacity and efficiency. The gear housing is completely sealed against atmospheric contaminants to ensure lifetime trouble-free power transmission. A self-centering PTFE impregnated motor shaft seal provides a positive system against leakage to the motor winding.

VIBRATION MOUNTS:

The air-end / motor module is mounted to the sub-base on anti-vibration pads.

LUBRICATION SYSTEM:

Elements of the lubrication system include;

- **Coolant Filtration -** The full capacity replaceable coolant filter element is 99.5% efficient at 10 micron ($\beta_{10} \geq 200$ – ISO 4572). Filter condition is monitored by the controller which provides a warning when filter differential reaches 1.8 bar (25 psi). 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 with four ports, (1) for the coolant from the pressurized receiver/separator, (2) for the coolant from the valve to the cooler, (3) for the coolant from the cooler, and (4) for the coolant to the coolant filter, is mounted in the piping system. The temperature sensitive element controls the quantity of coolant from each source, cooled and un-cooled as necessary to provide the proper injection temperature, ensuring 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 air-end inlet.

COOLANT/AIR SEPARATION:

After compression and discharge from the air-end, the coolant laden air travels to the receiver/separator. Entering through a tangential 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. The air is then directed through baffles, which further reduces the coolant content. The

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vortex action and impingement on baffles results in a pre-cleaning of the compressed air prior to entering the separator element.

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 air-end inlet. The carryover after the separator element is less than 3 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 mounted vertically in the compressor with the air-end discharge entering near the bottom. The separator vessel is protected by pressure relief safety valve mounted on the side of the tank. There is a coolant drain valve at the bottom of the tank and a coolant filler point which is located so that it is not possible to overfill the compressor with coolant. There is also a coolant sight level glass on the side of the tank. 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 allow the pressure in the separator tank to be reduced when the machine is unloaded, when this valve opens, the internal pressure falls to approximately 20 psig (1.4 barg) which minimizes the unloaded power requirement.

COOLANT:

Ingersoll Rand compressors are factory filled with Ingersoll Rand Premium Coolant; a polyalkylene glycol (PAG) advanced full synthetic lubricant, providing better cooling characteristics, reduced wear through improved lubrication, and has a longer operating life than other synthetic lubricants.

COOLERS:

In standard air cooled units the discharge air is cooled to as low as within 10.5ºC (19ºF) of the ambient temperature, basis 38ºC (115ºF) and 40% RH. In air-cooled units cooling air which is drawn into the enclosure passes over the main motor and air-end and is then forced out 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).

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FAN MOTORS:

In air-cooled machines, the TEFC motor and the low noise, high pressure, centrifugal blower is mounted behind the coolers. This forces a cooling air flow through the cooler prior to exiting the enclosure. A residual pressure is increased due to ducting losses, the maximum ambient temperature decreases accordingly.

Additional Static Pressure (inches H_2O/Pa)	LAT (°F)	LAT (°C)
0.25 / 65	111	44
0.50 / 125	109	43
0.75 / 185	109	43
1.00 / 250	108	42

COMPRESSOR/ CAPACITY CONTROLS (Fixed Speed):

As standard, 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 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.

Automatic stop/start is standard that 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 time at which the compressor is operating most inefficiently is when the compressor is running unloaded. The controller will monitor the compressor's operating cycle and reduce the off load running time to a minimum.

Upper range modulation control is an option on these compressors. Refer to the option section for details.

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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 high turndown range while maintaining a system efficiency of 92% or greater. The compressor will turn itself off at minimum speed (subject to minimum run times) and remain off until system pressure decays below operator set target pressure.

STARTER (Fixed Speed):

The standard compressor has an integrally mounted IP55 (NEMA 4 – North America) 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. An optional electronic soft starter is available. US models have a minimum 10kA SCCR.

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 drive 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. The inverter also provides phase loss and phase reversal protection.

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XE SERIES 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.

	Xe-70M	Xe-90M	Xe-145M
Display	2.6" 240 x 160 Monochrome	3.5" QVGA Color	5.7" VGA Color
Total I/O's	23	44	44
Modbus RS-485	2	4	4
Ethernet Port	(Optional ECO)	Yes	Yes
USB Port	No	Yes	Yes
Data Collection (SD Card)	7 days (Optional ECO)	30 days	30 days
Language	30 Languages text	31 Languages text	31 Languages text

LANGUAGES:

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

*Xe-90M/Xe-145M only

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HARDWARE:

Display Communication Unit (DCU)

- LCD graphic display window w LED back light
- 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

CONTROLLER EVENT LOG:

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

- Start inhibit
- Warnings
- Trips
- Command key press (local and remote)
- E-Stop pressed
- Module control power up and down
- Analog input failed
- Set point change (local and remote)
- Automatic start and stop
- Compressor Started

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COMMUNICATIONS:

The controller can be accessed through the following standard access points.

- Serial - RS485
  - Modbus RTU
  - System Controller / Integral sequencing
- Ethernet (Xe-70M only with ECO option)
  - Modbus TCP
  - Field Service Tool Remote access
- USB (Service Port) – Excluding Xe-70M
  - PC direct connection for Field Service Tool.
- Hard Wired Communication
  - Trouble Indication Contacts (Warning and Trip, Running Unloaded Contact)

SEQUENCE CONTROL:

The controller is suitable for use with Ingersoll Rand approved energy management controllers. In addition, the 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.

ECO MODULE (Xe-70 only):

Available only as a factory installed option, this feature adds additional hardware interfaces via Ethernet port and integrated SD card for data collection. With the option this adds remote web access, remote control via web page, Modbus/TCP and email notification of events and warnings

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

A TAS option is be available consisting of a refrigerated dryer and a high efficiency (HE) filter mounted in-line before the dryer. In standard configuration the dryer will run continuously even when the compressor is off but energized. The constant run mode will be the default mode; however, an optional energy saving mode can be selected where the dryer will start when the compressor starts and will stop when the compressor stops. This can be used in applications where there is a relatively stable demand and the compressor will be on/off for longer periods of time.

RS30-37ie-TAS air quality meets ISO 8573.1 class 1-4-2 air quality requirements at 25°C (77 °F), 60% RH (particulate 1-5 µm ≤ 10, liquid water ≤ 3 °C, Oil ≤ 0.1 mg/m3).

RS30-37i-TAS air quality meets ISO 8573.1 class 1-5-2 air quality requirements at 25°C (77 °F), 60% RH (particulate 1-5 µm ≤ 10, liquid water ≤ 7 °C, Oil ≤ 0.1 mg/m3).

The dryer is designed so 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 will consist 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 will be used to assist with Variable Speed operation across the flow range.

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 less than 90 seconds, the dryer will remain off until the total off time reaches 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 receives all power within the package and no separate power supply to the package is required. The refrigerant compressor and condenser fan starters will be located in a separate electrical box in the dryer module. 24 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 will allow for modular removal of the dryer system to accommodate major component change out such as refrigerant compressor or condenser. Dryer by-pass will not be offered. The dryer design will allow for modular dryer removal in less than 1 hour; a “bypass pipe” can then be installed in the machine to allow the unit to operate without the dryer installed.

For TAS packages, the max pressure of the package will be de-rated by 7.5 psi (0.5 bar). For example, the max pressure setting on a variable speed 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) before the PAC protection kicks in. 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.

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OPTIONS

POWER OUTAGE RESTART (PORO):

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 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. This is mounted into the instrument panel.

HIGH DUST FILTER (Fixed Speed Only):

This is a heavy duty and high capacity 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. Minimum efficiency at 3 microns is 99.0% (ISO 12103-1 A2 fine dust at a velocity of 15 cm/s).

CONTAINMENT BASE:

This variation of the standard rugged base frame has a welded and sealed tray to provide a full containment of lubricant in the event of spillage during maintenance and can contain the full sump capacity of lubricant.

UPPER RANGE MODULATION CONTROL (Fixed Speed Only):

Modulating inlet control automatically matches air capacity to demand. This control method reduces the delivered air volume by causing a pressure reduction in the intake port. When modulation is fitted and selected, partial closure of the intake valve in direct relation to fall and rise of pressure will cause variable air volume delivery. Modulation is available as an option. Modulation control is particularly useful where air demands vary between 60 & 100% (which is most common situation) and where there is some reasonable amount of system storage capacity.

Modulation avoids the frequent cycling which is sometimes associated with on-line/off-line control when insufficient system capacity is available, in which case modulation reduces the thrust loads on bearings and cycling of solenoid valves.

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LOW AMBIENT FREEZE PROTECTION (Fixed Speed Non TAS 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) (-23°C, -10°F for North America), Ingersoll Rand offer 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. Through a VFD on the blower, the controller maintains proper compressor temperatures even in the cold environment. NOTE: Outdoor Modification is a separate option and can be ordered in conjunction with freeze protection.

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.

ELECTRONIC SOFT STARTER (Fixed Speed Only):

The optional soft start facilitates reducing starting current to the lowest value achievable, compatible with positive starting of the drive motor. This system is offered to overcome issues where local equipment is sensitive to, or expected to be effected by disturbances in power supplies caused by relatively high starting currents and transient spikes caused by traditional contactor switching motor starters.

PHASE MONITOR (Fixed Speed Only):

An optional phase monitor can be specified that detects phase loss, phase reversal, low voltage (brown out) and phase imbalance.

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COOLANTS:

Optional longer life Ultra EL or Ultra FG (H-1F food grade) may be used with this compressor.

Ultra Extended Life (EL) advanced synthetic lubricant performs up to twice as long as other rotary lubricants, minimizing downtime and lowering lifecycle costs. Ultra EL is expected to last 16,000 hours in the typical applications, offers superior wear protection, better corrosion protection and improved performance in the presence of air and water.

Ultra FG is an H-1F and NSF certified food grade lubricant designed specifically to help customers in the food and beverage industries meet their production quality standards. Ultra FG offers longer life compared to commercial food grade compressor lubricants (6000 hours +). Ultra FG also has outstanding anti-wear protection and exhibits resistance to formulation of foam, sludge, varnish, and corrosive acids.

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XE CONTROLLER FEATURE COMPARISON:

	Xe-70M	Xe-90M	Xe-145M
Start/Stop Control	X	X	X
Manual Load/Unload	X	X	X
Auto-Restart	X	X	X
Modulation (FS)	X	X	X
Mod/ACS (FS)	X	X	X
Lead/Lag(FS)	X	X	X
Power Out Restart	OPT	OPT	OPT
Progressive Adaptive Control (PAC)	X	X	X
Integrated Dryer Control	X	X	X
Remote Pressure		X	X
Remote Start/Stop	X	X	X
Remote Load/Unload	X	X	X
Monitoring			
Coolant filter monitoring		X	X
Inlet filter monitoring		X	X
Dryer monitoring	X	X	X
Independent main motor and fan motor overload		X	X
Independent warning and trip fault outputs		X	X

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XE CONTROLLER FEATURE COMPARISON (CONTINUED):

	Xe-70M	Xe-90M	Xe-145M
Sequencing (Xe units only)			
# compressors	4	4	4
Use local compressor pressure transducer	X	X	X
Programmable on Elapsed Time	X	X	X
FILO (First in - Last out)	X	X	X
Controller Failure, Revert to local	X	X	X
Prioritized Compressor Selection	X	X	X
Interface			
Energy savings calculator		VS Only	VS Only
Graphing and trending			X
Standard web pages	OPT	X	X
Remote control via web pages	OPT	X	X
Automated reporting			X
Web-based graphing/trending			X
Email notification	OPT	X	X