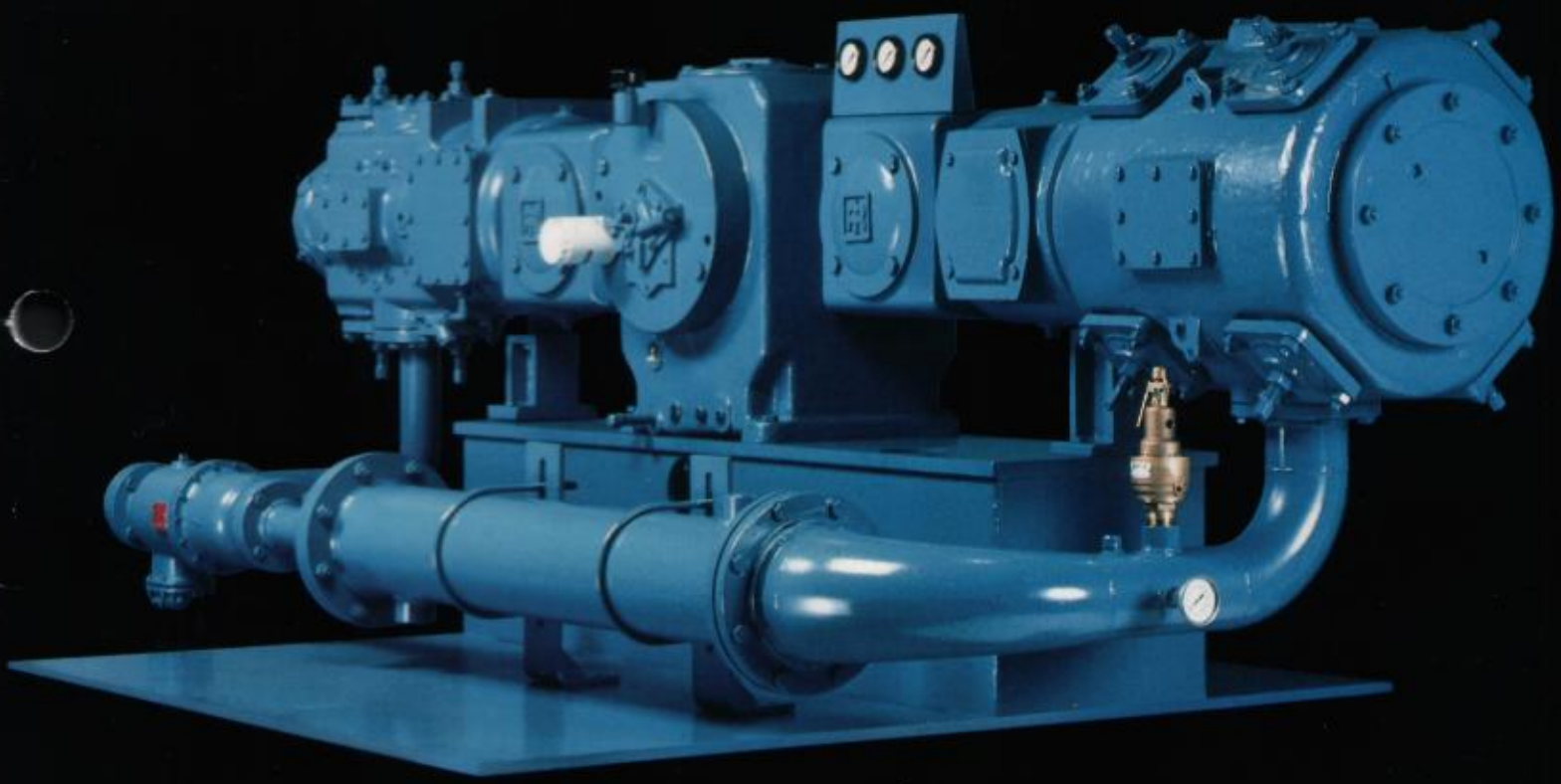
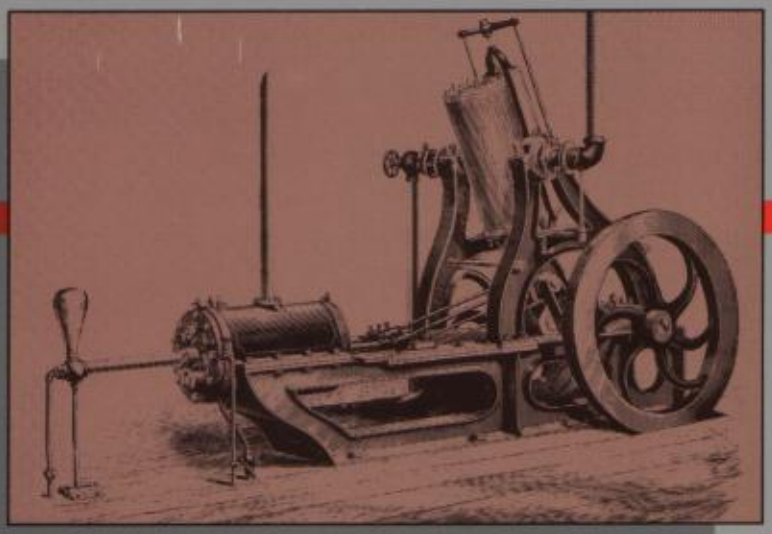
ESV & PHE
Reciprocating Compressors



INGERSOLL-RAND®
AIR COMPRESSORS



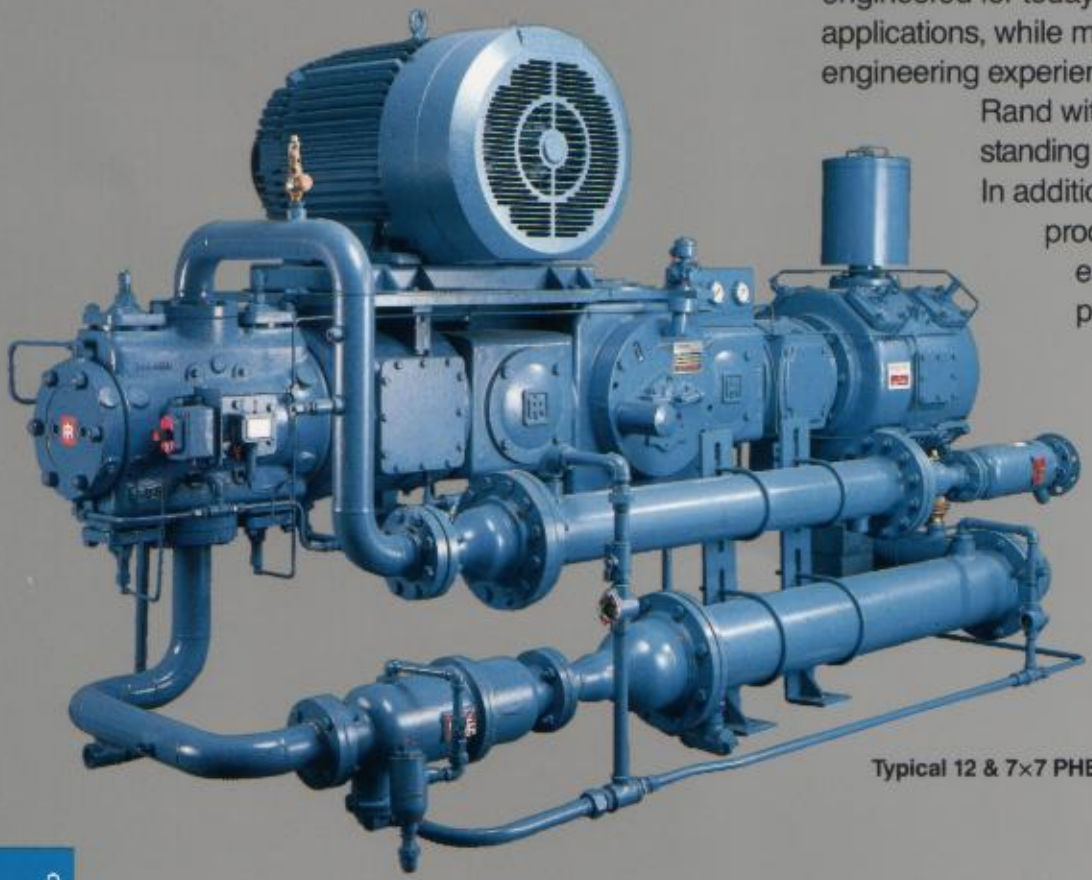
Since 1872, Ingersoll-Rand compressors have served the world's industries. Early products included reciprocating compressors, the forerunners of today's popular ESV and PHE models. Continuous product improvement over the past 120 years has produced a line of compressors that offers exceptional value based on improved operating life, low maintenance, and high efficiency.

Quality

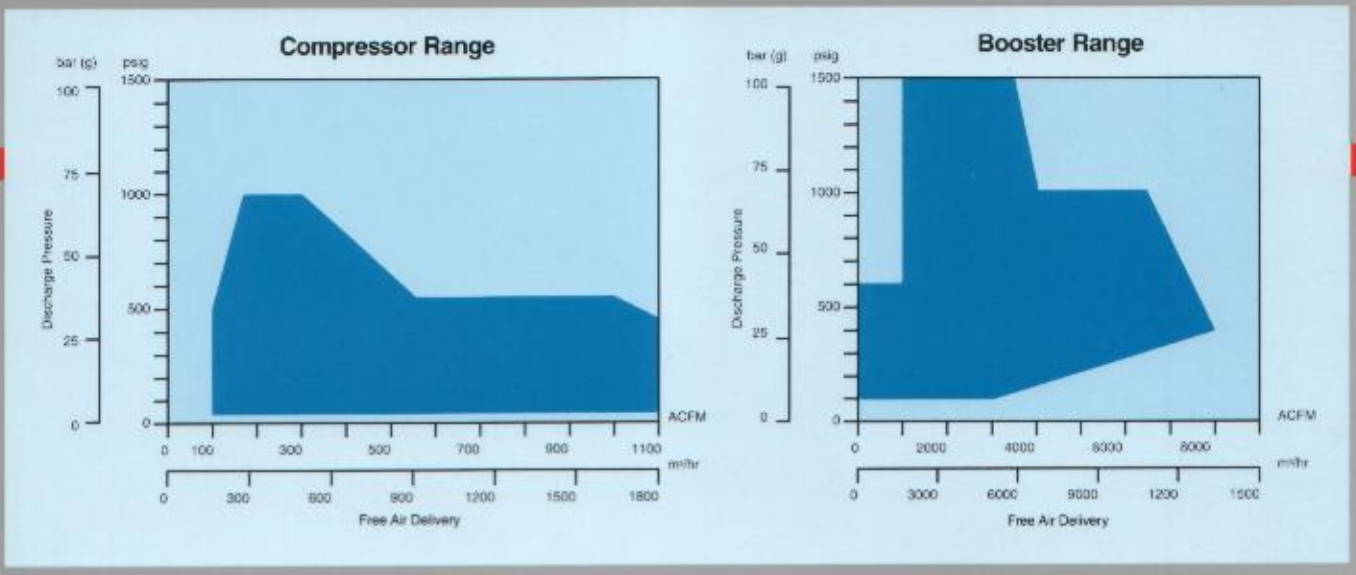
Ingersoll-Rand applies stringent quality standards throughout the engineering and manufacturing cycles to ensure that every product matches customer requirements. Superior components are combined with the highest quality manufacturing processes and testing facilities to produce compressors that last for generations.

Engineering

Reciprocating compressors have withstood the test of time because of inherent design advantages, including rugged construction, slow operating speed, high efficiency, and simple maintenance. Through use of advanced technology, ESV and PHE compressors are engineered for today's demanding industrial applications, while more than a century of engineering experience provides Ingersoll-Rand with a thorough understanding of customer requirements. In addition, Ingersoll-Rand produces completely engineered ESV and PHE packages and systems.



Typical 12 & 7×7 PHE Installation



High Efficiency

Inherent in the design of the ESV and PHE reciprocating product lines is a high efficiency of compression relative to other types of compressors. This efficiency results in immediate energy cost savings, providing faster payback and continued savings over the life of the machine.

Valves

ESV and PHE compressors incorporate highly efficient Ingersoll-Rand channel valves. These valves offer distinct advantages:

- Reversible stainless steel seat plates yielding twice the life of ordinary valve seats
- Quiet operation
- High durability
- Thousands of hours of life proven over 60 years of experience
- Stainless steel channels and springs are designed using precise tolerancing to provide an air cushion, prolonging valve life
- Requires no remachining or special tools to rebuild

Gases

Designs can be readily adapted to compress a variety of gas mixtures including air, nitrogen, helium and other non-hydrocarbon gases.

Performance

ESV and PHE compressors are designed to handle a broad range of pressures and flows. Atmospheric inlet and booster compressors are available through the following ranges:

- 20 to 400 BHP (15 to 300 kw)
- 30 to 1500 PSIG (2 to 102 bar (g))
- 100 to 1000 CFM (atmospheric inlet) (170 to 1700 m^3/hr)
- 100 to 8000 CFM (booster) (170 to 13,600 m^3/hr)

Applications

In addition to plant and control air service, ESV and PHE compressors are well suited for high pressure applications including:

- Booster Service
- Bottle Blowing
- Engine Starting
- Air Drilling
- Wind Speed Simulation
- Off-Shore Platforms
- Wet Air Oxidation
- Air Separation
- Pollution Control
- Soot Blowing

Intellisys®

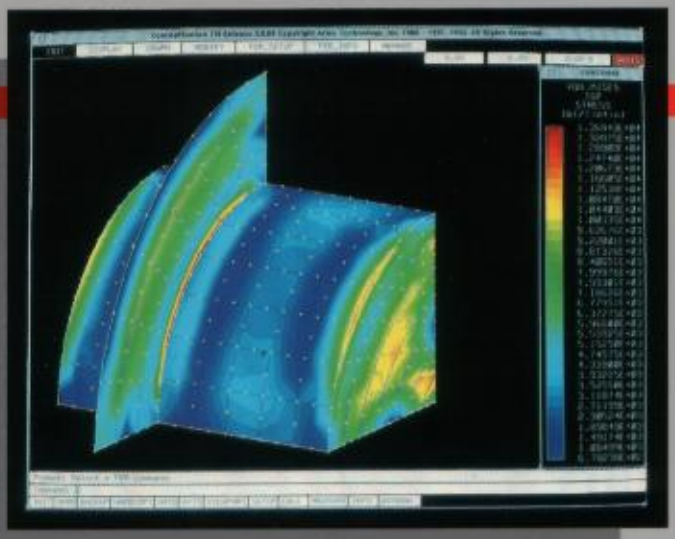
Intellisys® is an Ingersoll-Rand designed and built electronic, microprocessor-based controller. Every quarter-second, it monitors all system parameters as well as the compressor's operating conditions. This real-time accurate monitoring allows the compressor to be operated with the assurance of maximum reliability.

The Intellisys controller comes factory-tested. It is housed in a NEMA 4 (IP65) enclosure. All monitored pressures and temperatures have adjustable set points and most have both an alarm and shutdown function.

Intellisys can be adjusted easily from the membrane panel. Since mechanical control adjustments on the compressor have been eliminated, special tools are no longer required. Intellisys will warn operators when a programmed limit is being approached and will shut down if a predetermined limit is exceeded.

Features

- DIGITAL DISPLAY
  - Two 20 character alpha-numeric displays
  - Precise, complete information
- MEMBRANE TOUCH PANEL
  - Easy to understand control panel
  - Finger touch panel eliminates manual adjustments
- MAXIMIZED COMPRESSOR EFFICIENCY
  - Multi-step constant speed control
  - Auto Dual Control
- FIRST OUT ANNUNCIATION
  - Warning is displayed as parameters approach setpoints
  - Alarm/Shutdown occurs if parameters reach setpoints
  - If shutdown occurs, operating conditions are recorded for ease in troubleshooting
- SOLENOID VALVES
  - Condensate traps replaced with simple, low maintenance solenoid valves
  - Eliminate frequent, time consuming regulator adjustments
- OPERATIONAL HISTORY OF ALL LOAD CONDITIONS



Finite Element Analysis

Technologies, such as finite element analysis, are being utilized to evaluate the strength and durability not only of complete compressors but also of individual parts. Stresses resulting from various loads are studied on an incremental basis. The different colors (as shown in the photo above) signify, on a three-dimensional graphic, the magnitude of the load throughout the part. Areas of highest stress are further investigated to enhance the design. The result of finite element analysis is that optimum design and maximum component life are achieved, allowing Ingersoll-Rand to provide the highest quality compressors available.

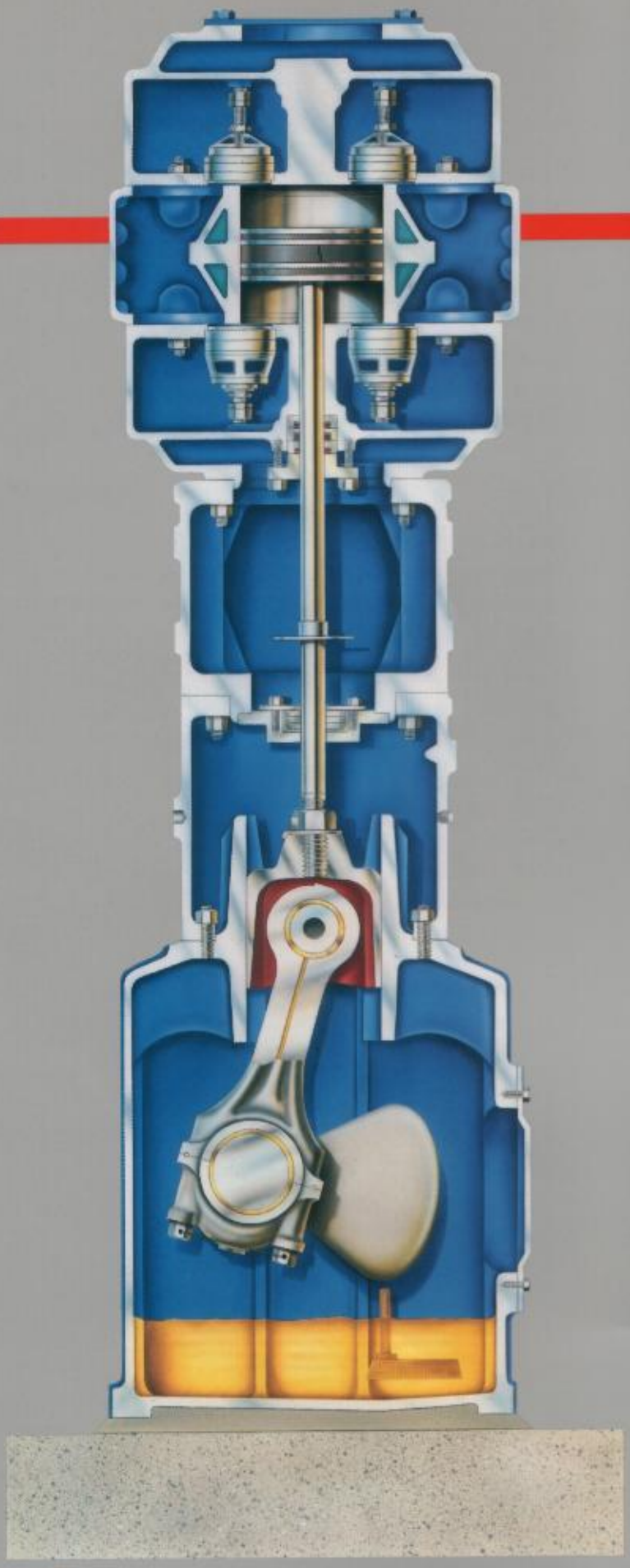
Advanced Materials

Ingersoll-Rand engineers are constantly evaluating advances in new materials to complement the efficiency and versatility of the reciprocating compressor design.

A variety of specifically engineered materials are utilized in non-lubricated valves, piston rings and packing. These materials are designed to match the component to the application and to facilitate long life and reliability.

Compressed graphite and other gasket materials ensure trouble-free sealing through wide pressure and temperature ranges.

The material of choice for Ingersoll-Rand channels and springs continues to be 410 Stainless Steel while forged steel remains the choice for crankshafts and connecting rods. These materials, over time, have proven to be unsurpassed for strength and service.



10×7 ESV

ESV Compressors

Ingersoll-Rand's ESV is a crosshead design, double-acting, single stage, reciprocating compressor.

Non-Lubricated (NL) Construction

For applications where lubrication cannot be tolerated, Ingersoll-Rand's non-lubricated construction ensures that the air or gas system will be oil-free. NL features include:

- Piston rings constructed of the highest grade of self-lubricating TFE material
- Pistons fitted with TFE rider bands
- Piston rod packing composed of TFE material
- Moving valve parts which contact only TFE at points of sliding contact

The ESV is also available as a lubricated compressor.

Frame

Components are designed and built for years of trouble-free service:

- Frame—Rugged, yet simple one-piece cast iron construction
- Main and connecting rod bearings—full floating for long-life
- Crankshaft—High-strength single piece, heat-treated steel forging with integral counterweights
- Connecting rod—forged steel, superior in strength to ductile cast iron
- Crosshead—heavy duty, one-piece, requiring no adjustment
- Crosshead pin bushing—full floating design, bronze construction

Distance Pieces

ESV construction features durable cast iron distance pieces:

- Gasketed access covers seal out contaminants
- Allow easy access to scrapers and packing for inspection and service
- Extra distance piece ensures frame lubricant does not reach cylinder

Frame Lubrication System

The ESV is equipped with a self-contained pressurized lubrication system featuring:

- Gear-type oil pump
- Dedicated oil sump
- Non-bypassing cartridge-type oil filter provides 100% filtered lubrication
- Pressurized lubricant supplied to all bearing surfaces through rifle-drilled crankshaft, connecting rod, and crosshead

Cylinders

Three cast iron components comprise the ESV airend: cylinders, frame heads, and outer heads.

- Large, cast-in water jackets for dimensional stability under continuous operation
- Generous air flow passages minimize pulsations and reduce pressure drops
- No cylinder liners which can leak cooling water into the air stream

Piston Rod Packing

The piston rod passage through the ESV frame head is sealed by multi-cup packing.

- Water cooled for high pressure applications
- Ground piston rod to ensure superior sealing and long packing life
- Customized materials for specific applications

Regulation

Electro-pneumatic constant speed control with inlet valve unloading is standard in ESV compressors. This provides instantaneous response and very low unloaded horsepower.

ESV Operational Data

Model	psig	bar (g)	ACFM*	m³/hr	Nominal HP	Nominal kw
7×5	125	8.6	94	160	25	18.7
10×7	125	8.6	128	212	30	22.4
10×7	125	8.6	167	284	40	29.9
10×7	125	8.6	213	362	50	37.3
11×7	100	6.9	275	467	60	44.8

**ACFM and m³/hr at maximum pressure.*

Forged Steel Connecting Rods

Full Floating Bearings

PHE Compressors

Ingersoll-Rand's PHE compressor is a balanced-opposed, double-acting reciprocating compressor available in single- or multi-stage designs.

Non-Lubricated (NL) Construction

In applications specifying oil-free air, PHE non-lubricated models successfully fill the requirements. NL features include:

- Piston rings constructed of self-lubricating TFE material
- Pistons fitted with TFE rider bands
- TFE at points of sliding contact with moving valve parts

The PHE compressor is also available for lubricated applications.

Frame

Components are designed and built for years of trouble-free service:

- Frame—Rugged, yet simple one-piece cast iron construction
- Main and connecting rod bearings—full floating for long-life
- Crankshaft—high-strength, single piece heat-treated steel forging with opposed journals for optimum balance
- Connecting rod—forged steel, superior in strength to ductile cast iron
- Crosshead—one-piece, heavy duty, requiring no adjustment
- Crosshead pin bushing—full floating design, bronze construction

Cylinders

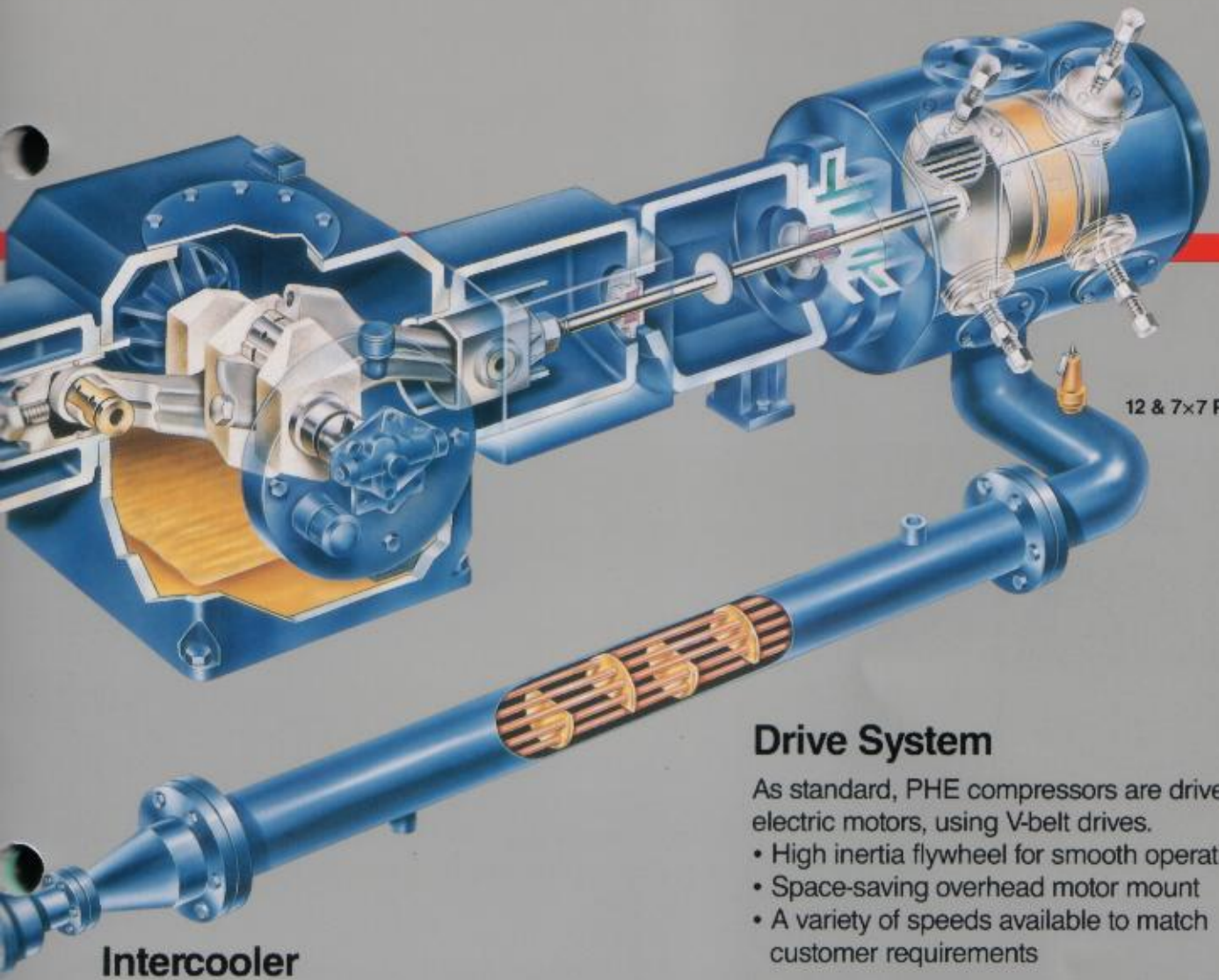
Three cast iron components comprise the PHE airend: cylinders, frame heads, and outer heads.

- Large, cast-in water jackets for dimensional stability under continuous operation
- Generous air flow passages minimize pulsations and reduce pressure drops
- No cylinder liners which can leak cooling water into the air stream

Piston Rod Packing

The piston rod passage through the frame head is sealed by a multi-cup packing.

- Customized materials selected for specific applications
- Water cooled for high pressure applications
- Ground piston rod to ensure superior sealing and long packing life



12 & 7×7 PHE

Intercooler

PHE multi-stage compressors are equipped with intercoolers selected for a 15°F (8°C) approach temperature.

- Water-in-the-shell, air-in-the-tube design
- Interstage piping designed in accordance with ANSI B31.1
- Equipped with safety valve
- Designed with centrifugal-type separator and condensate trap
- All components constructed in accordance with ASME code and stamped as applicable (constructed with other codes upon request)

Regulation

Electro-pneumatic constant speed control with inlet valve unloading is standard in PHE compressors.

- Standard two-step control
- Three-step unloading available as an option
- Intellisys control optional
- Very low unloaded horsepower

Drive System

As standard, PHE compressors are driven by electric motors, using V-belt drives.

- High inertia flywheel for smooth operation
- Space-saving overhead motor mount
- A variety of speeds available to match customer requirements

PHE Operational Data

Model	psig	bar (g)	ACFM*	m³/hr	Nominal HP	Nominal kw
10 & 5×7	500	34.5	320	544	125	93.3
12 & 5×7	500	34.5	383	651	150	111.9
12 & 7×7	250	17.2	511	868	150	111.9
12 & 5 & 4×7	750	51.7	350	595	150	111.9
12 & 7 & 5×7	400	27.6	528	897	200	149.3
14 & 6×9	500	34.5	560	952	200	149.3
17 & 9×9	350	24.1	830	1411	250	186.4
17 & 9 & 4.5×9	650	44.8	920	1563	350	261

**ACFM and m³/hr at maximum pressure.*

Boosters

The number of industrial applications involving high pressure air and gases continues to increase. High pressure air is being used for such diverse duties as plastic bottle blowing and autoclaves. Booster compressors are frequently the most cost effective choice for handling these applications.

Often, when a plant air system already exists, high pressure requirements can be fulfilled by adding a booster compressor. For example, when an application calls for 500 scfm (850 m^3/hr) of air at 500 psi (34 bar), the compressor required to deliver the air from atmosphere would be approximately 200 bhp (150 kw). If, on the other hand, 500 scfm (850 m^3/hr) was available from the plant system at 125 psi (8.5 bar), the compressor required to boost this plant air to 500 psi (34 bar) would be only about 70 bhp (52 kw).

Booster compressors are often utilized together with a dedicated primary compressor. By using a booster compressor in series with a low pressure compressor, the total job of compression can be divided into multiple stages. This operation improves efficiency and extends compressor life by maintaining lower operating temperatures.

Booster compressors have been applied for many years to compressed gas service, such as nitrogen product compression from air separation. Boosters are ideal for providing higher pressures for many process applications.

ESV and PHE compressors are uniquely suited for booster service. Their rugged cast-iron cylinder design accommodates very high operating pressures. Due to a wide variety of available cylinder sizes and pressure ratings, correct compressor combinations can be made to fit many applications.

Ingersoll-Rand ESV and PHE booster compressors provide coverage of applications in the 20 to 400 HP (15 to 300 kw) range. Discharge pressures as high as 1500 psig (102 bar (g)) and flows as high as 8000 acfm (13,600 m^3/hr) can be achieved.

5×7 ESV Booster Package for Refinery Service

9 & 6×9 PHE Booster Package

Whatever the high pressure needs may be, Ingersoll-Rand's commitment to total quality is reflected in the manufacture of every ESV and PHE compressor.

Applications

- Plastic Bottle Blowing
- Air Separation
- Air Brake Testing
- Wet Air Oxidation
- Soot Blowing
- Metal Forming
- Down Hole Air Drilling
- Nitrogen Boosting
- Engine Starting
- Blow Molding
- High Pressure Instrument Air
- Autoclaving Processes

Booster Operational Data

Single Stage Operational Data				
			Nominal	
Model	psig	bar (g)	HP	kw
4×7	1000	69.0	70	52.2
5×7	500	34.5	85	63.4
7×7	335	23.1	85	63.4
4 & 4×7	1000	69.0	200	149.3
5 & 5×7	500	34.5	200	149.3
7 & 7×7	335	23.1	200	149.3
4.5 & 4.5×9	1500	103.4	400	298.5
7 & 7×9	500	34.5	400	298.5

Two Stage Operational Data				
			Nominal	
Model	psig	bar (g)	HP	kw
5 & 4×7	1000	69.0	200	149.3
7 & 4×7	1000	69.0	200	149.3
7 & 5×7	500	34.5	200	149.3
7 & 4.5×9	1500	103.4	400	298.5
9 & 6×9	1000	69.0	400	298.5

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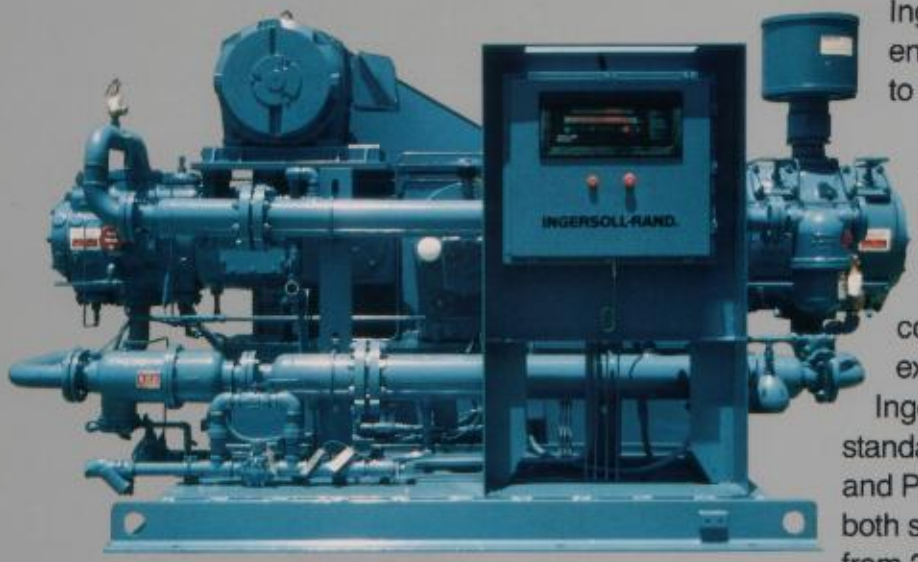
Packaging Capabilities

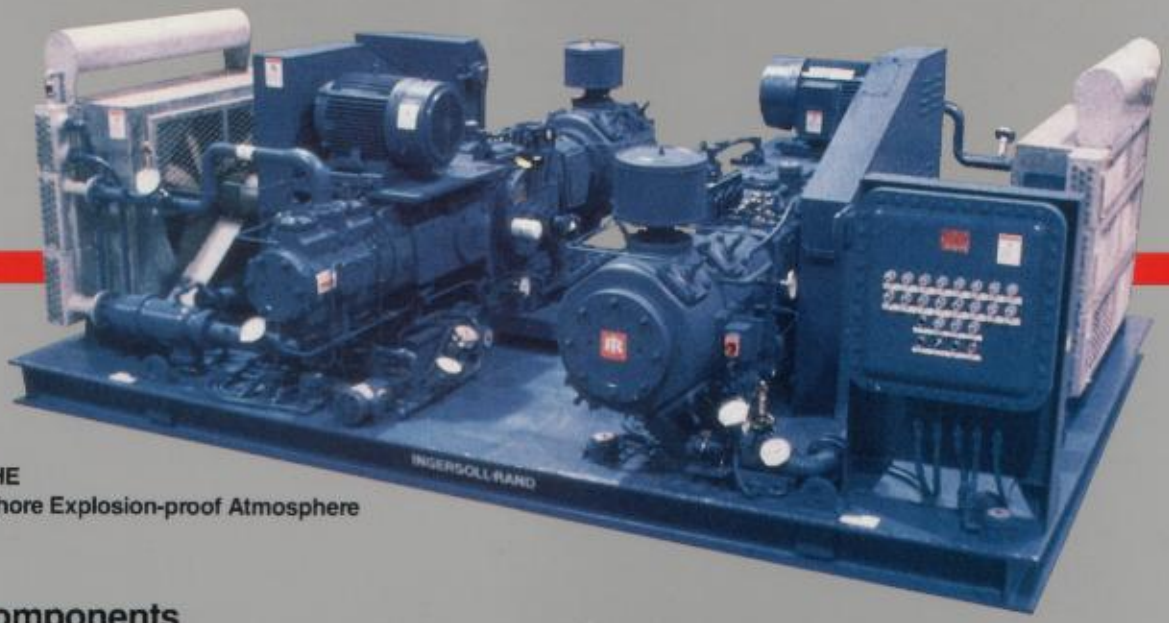


12 & 5×7 PHE Package with Intellisys Control

Ingersoll-Rand has the expertise to engineer and build packages that conform to specialized customer application requirements. Decades of compressor and package design, a wealth of assembly experience and state of the art technology unite to provide customers with the peace of mind that comes from dealing with the world's most experienced compressor manufacturer.

Ingersoll-Rand offers a complete line of standard reciprocating compressors. The ESV and PHE product lines include units providing both single- and multi-stage compression from 20 to 400 HP (15 to 300 kw). Factory packages, manufactured to meet customer requirements, are our specialty. These packages come completely assembled, tested, and ready for service.

10×7 ESV Compressor Package

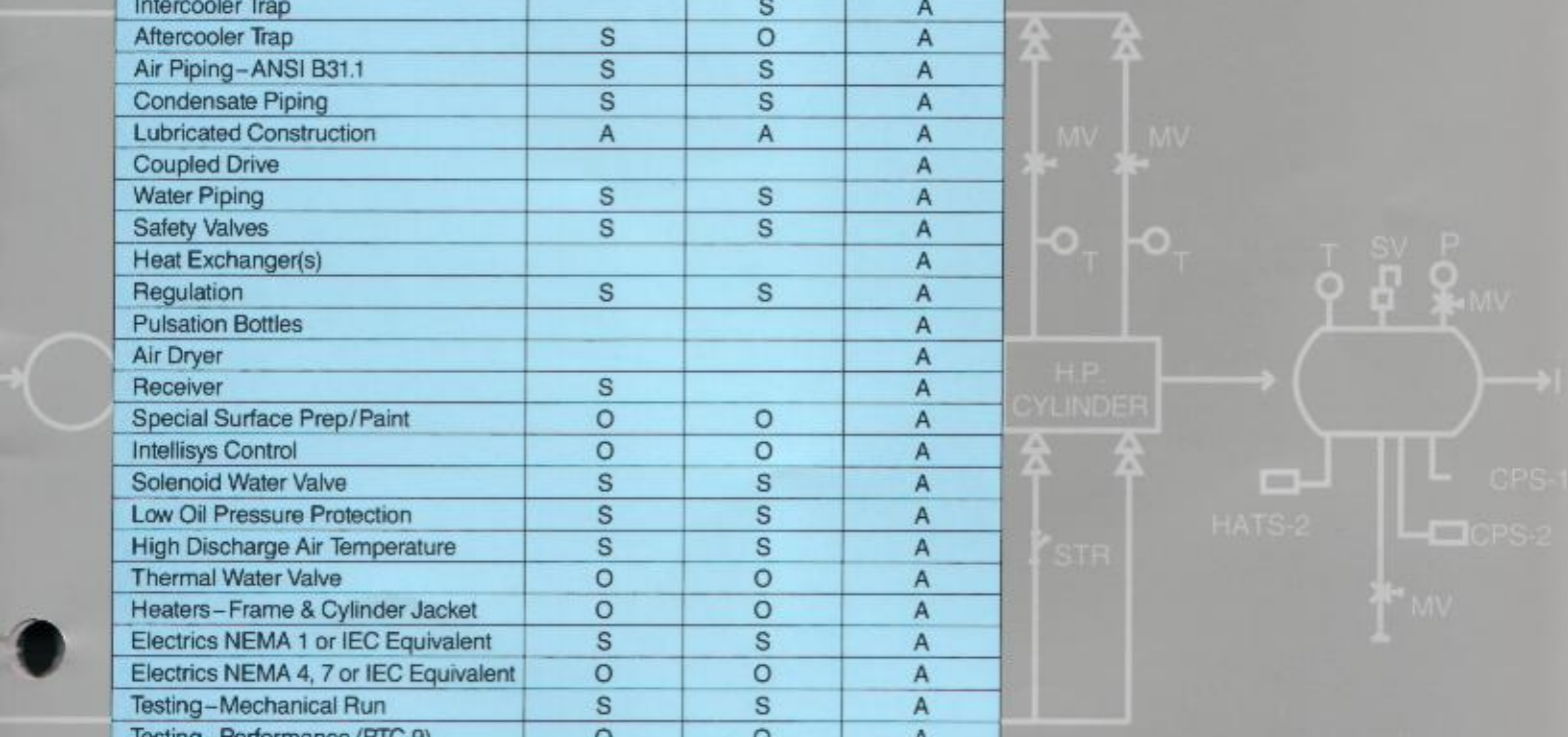


Dual 12 & 7×7 PHE
Package for Offshore Explosion-proof Atmosphere

Package Components

	Pre-Engineered		Special Packages
	ESV Pkg	PHE Pkg	
Inlet Filter–98% at 5 microns	S	S	A
Starter	S	O	A
Control Panel–Auto Dual Control	S	S	A
V-belt Drive	S	S	A
Belt Guard	S	S	A
Motor	S	S	A
Slide Base	S	S	A
Engine Drive			A
Intercooler		S	A
Aftercooler	S	O	A
Intercooler Separator		S	A
Aftercooler Separator		O	A
Intercooler Trap		S	A
Aftercooler Trap	S	O	A
Air Piping–ANSI B31.1	S	S	A
Condensate Piping	S	S	A
Lubricated Construction	A	A	A
Coupled Drive			A
Water Piping	S	S	A
Safety Valves	S	S	A
Heat Exchanger(s)			A
Regulation	S	S	A
Pulsation Bottles			A
Air Dryer			A
Receiver	S		A
Special Surface Prep/Paint	O	O	A
Intellisys Control	O	O	A
Solenoid Water Valve	S	S	A
Low Oil Pressure Protection	S	S	A
High Discharge Air Temperature	S	S	A
Thermal Water Valve	O	O	A
Heaters–Frame & Cylinder Jacket	O	O	A
Electrics NEMA 1 or IEC Equivalent	S	S	A
Electrics NEMA 4, 7 or IEC Equivalent	O	O	A
Testing–Mechanical Run	S	S	A
Testing–Performance (PTC-9)	O	O	A

S=Standard O=Optional A=Available
Other Options Available Upon Request.



Worldwide Support

When customers choose an Ingersoll-Rand compressed air system, they become part of the most extensive and powerful compressor resource in the world. It includes not only the machinery, but the people and the company behind it. This resource encompasses engineering and technical support, service support, and aftersales support.

Worldwide Service Support

Ingersoll-Rand maintains a staff of certified field service technicians to provide preventive maintenance or meet any need that may arise. Each ESV and PHE reciprocating compressor offers excellent value and is backed by a worldwide service organization that is second to none. There are Ingersoll-Rand manufacturing facilities, offices, and distributors in over 130 countries around the globe. Around the clock, around the world, support is available to ensure the continuing performance of Ingersoll-Rand reciprocating compressors.

Worldwide Aftersales Support

Genuine Ingersoll-Rand parts are readily available for your equipment enabling customers to avoid possible costly delays or substitution with inferior parts. As a result, I-R compressors can be kept in good-as-new condition. These proven components deliver a level of reliability and performance that is unsurpassed. Ingersoll-Rand renewal parts are made to the same exacting tolerances and metallurgical specifications designed into the original compressor. Each part is solidly backed by the Ingersoll-Rand warranty.

Worldwide Quality

Ingersoll-Rand has been manufacturing reciprocating compressors longer than any other manufacturer and has always been known for reliability. This experience results in a level of quality and performance which is unsurpassed and recognized throughout the world.

Exclusive Reciprocating Compressor Warranty

All Ingersoll-Rand Double Acting, Reciprocating Compressors and Boosters are now covered by our exclusive two year operating warranty. The warranty is applicable to all compressors and boosters regardless of operating pressure in both lubricated and non-lubricated configurations.

The Tradition Continues

INGERSOLL-RAND®
AIR COMPRESSORS

Rotary-Reciprocating Compressor Division
Ingersoll-Rand Company
Davidson, North Carolina 28036

Statement Concerning the Use of This Equipment for Breathing Air and / or Aqua Lung Service: If the model number on this air compressor contains the letters "BAP", the compressor is suitable for use in breathing air services. In the absence of such a designation, the compressor is *not* considered as capable of producing air of breathing quality. For the compressor to be capable for use in breathing air services, it must be fitted with additional equipment to properly filter and / or purify the air to meet all applicable federal, state and local laws, rules, regulations and codes, such as, but not limited to, OSHA 29 CFR1910, 134. Compressed Gas Association Commodity G-7, I-1989, Grade D Breathing Air, and Canadian Standards Association. Should the purchaser and / or user fail to add such specialized equipment and proceeds to use the compressor for breathing air service, the purchaser / user assumes all liability resulting therefrom without any responsibility or liability assumed by Ingersoll-Rand Company.

The Purchaser is urged to include the above provision in any agreement for any resale of the compressor.

Disclaimer: Nothing contained within this brochure is intended to extend any warranty or representation, expressed or implied, regarding the products described herein. Any such warranties or other terms or conditions of products shall be in accordance with Ingersoll-Rand Standard Terms and Conditions of Sale for such products, which are available upon request.

Product improvement is a continuing goal at Ingersoll-Rand. Designs and specifications are subject to change without notice or obligation.

Form 3986
Printed in USA