GARDNER DENVER®

13–10–613 SP
2nd Edition
December, 1995

ELECTRA–SAVER®

STATIONARY BASE–MOUNTED

COMPRESSOR

WITH OPTIONAL ES+ CONTROLLER

MODELS

EAYQ_E
EAYS_E

OPERATING AND SERVICE MANUAL

Gardner Denver

MAINTAIN COMPRESSOR RELIABILITY AND PERFORMANCE WITH GENUINE GARDNER DENVER COMPRESSOR PARTS AND SUPPORT SERVICES

Gardner Denver Compressor genuine parts, engineered to original tolerances, are designed for optimum dependability —— specifically for Gardner Denver compressor systems. Design and material innovations are the result of years of experience with hundreds of different compressor applications. Reliability in materials and quality assurance are incorporated in our genuine replacement parts.

Your authorized Gardner Denver Compressor distributor offers all the backup you'll need. A worldwide network of authorized distributors provides the finest product support in the air compressor industry.Your local authorized distributor maintains a large inventory of genuine parts and he is backed up for emergency parts by direct access to the Gardner Denver Machinery Inc. Master Distribution Center (MDC) in Memphis, Tennessee.

Your authorized distributor can support your Gardner Denver air compressor with these services:

1. Trained parts specialists to assist you in selecting the correct replacement parts.
2. Factory warranted new and remanufactured rotary screw air ends. Most popular model remanufactured air ends are maintained in stock at MDC for purchase on an exchange basis with liberal core credit available for the replacement unit.
3. A full line of factory tested AEON™ compressor lubricants specifically formulated for use in Gardner Denver compressors.
4. Repair and maintenance kits designed with the necessary parts to simplify servicing your compressor.

Authorized distributor service technicians are factory–trained and skilled in compressor maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

For the location of your local authorized Gardner Denver Air Compressor distributor refer to the yellow pages of your phone directory or contact:

Distribution Center:
Gardner Denver Machinery Inc.
Master Distribution Center
5585 East Shelby Drive
Memphis, TN 38141
Phone: (901) 542–6100
(800) 245–4946
Fax: (901) 542–6159

Factory:
Gardner Denver Machinery Inc.
1800 Gardner Expressway
Quincy, IL 62301
Phone: (217) 222–5400
Fax: (217) 223–5897

REMANUFACTURED AIR ENDS

Whenever an air end requires replacement or repair, Gardner Denver offers an industry unique, factory remanufactured air end exchange program. From its modern Remanufacturing Center in Indianapolis, IN, Gardner Denver is committed to supplying you with the highest quality, factory remanufactured air ends that are guaranteed to save you time, aggravation and money.

Immediately Available

Repair downtime costs you money, which is why there are over 200 remanufactured units in inventory at all times, ready for immediate delivery.

Skilled Craftsmen

Our Remanufacturing assembly technicians average over 20 years experience with air compression products.

Precision Remanufacturing

All potentially usable parts are thoroughly cleaned, inspected and analyzed. Only those parts that can be brought back to original factory specifications are remanufactured. Every remanufactured air end receives a new overhaul kit: bearings, gears, seals, sleeves and gaskets.

Extensive Testing

Gardner Denver performs testing that repair houses just don't do. Magnaflux and ultrasonic inspection spot cracked or stressed castings, monochromatic light analysis exposes oil leaks, and coordinate measurement machine inspects to +/– .0001", insuring that all remanufactured air ends meet factory performance specifications.

Warranty

Gardner Denver backs up every remanufactured air end with a new warranty . . . 18 months from purchase, 12 months from service.

Gardner Denver remanufactured air ends deliver *quality without question . . . year in and year out.*

Call Gardner Denver for information on the air end exchange program and the name of your authorized distributor.

Phone Number: 800–245–4946 or
FAX: 901–542–6159

FOREWORD

Gardner Denver Rotary Screw compressors are the result of advanced engineering and skilled manufacturing. To be assured of receiving maximum service from this machine the owner must exercise care in its operation and maintenance. This book is written to give the operator and maintenance department essential information for day–to–day operation, maintenance and adjustment. Careful adherence to these instructions will result in economical operation and minimum downtime.

⚠ DANGER

Danger is used to indicate the presence of a hazard which will cause severe personal injury, death, or substantial property damage if the warning is ignored.

⚠ WARNING

Warning is used to indicate the presence of a hazard which can cause severe personal injury, death, or substantial property damage if the warning is ignored.

⚠ CAUTION

Caution is used to indicate the presence of a hazard which will or can cause minor personal injury or property damage if the warning is ignored.

NOTICE

Notice is used to notify people of installation, operation or maintenance information which is important but not hazard–related.

This book covers the following models:

HP	PSIG	Air Cooled	Water Cooled	Parts List
350	100, 125, 150	EAYQSE	EAYSSE	13–10–510 SP
400	100, 125, 150	EAYQTE	EAYSTE	13–10–510 SP
500	100, 125, 150	EAYQVE	EAYSVE	13–10–510 SP

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INSTRUCTIONS FOR ORDERING REPAIR PARTS

When ordering parts, specify Compressor MODEL, Method of Cooling, HORSEPOWER and SERIAL NUMBER (see nameplate on unit). The Serial Number is also stamped on top of the cylinder flange to the right of the inlet housing.

All orders for Parts should be placed with the nearest authorized distributor.

Where NOT specified, quantity of parts required per compressor or unit is one (1); where more than one is required per unit, quantity is indicated in parenthesis. SPECIFY EXACTLY THE NUMBER OF PARTS REQUIRED.

DO NOT ORDER BY SETS OR GROUPS.

To determine the Right Hand and Left Hand side of a compressor, stand at the motor end and look toward the compressor. Right Hand and Left Hand are indicated in parenthesis following the part name, i.e. (RH) & (LH), when appropriate.

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GENERAL INFORMATION

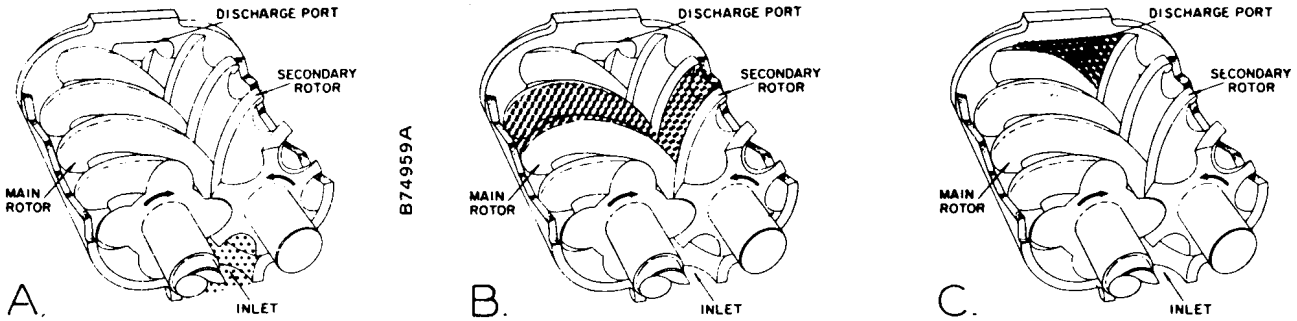


FIGURE 1–1 – COMPRESSION CYCLE

COMPRESSOR – The Gardner Denver Electra–Saver compressor is a single stage, positive displacement rotary machine using meshing helical rotors to effect compression. The input drive shaft and helical drive gear are supported in the gear case by high capacity tapered roller bearings. The drive gear meshes with a driven gear mounted on the main rotor shaft to drive the rotors. Both rotors are supported between large capacity anti–friction bearings located outside the compression chamber. Single width cylindrical roller bearings are used at the inlet end of the rotors. Early models used two (2) heavy–duty, single–row, angular contact ball bearings at the discharge end to locate each rotor axially and carry all thrust loads; later models use tapered roller bearings in this location.

COMPRESSION PRINCIPLE (FIGURE 1–1) – Compression is accomplished by the main and secondary rotors synchronously meshing in a one–piece cylinder. The main rotor has four (4) helical lobes 90° apart. The secondary rotor has five (5) matching helical grooves 72° apart to allow meshing with main rotor lobes.

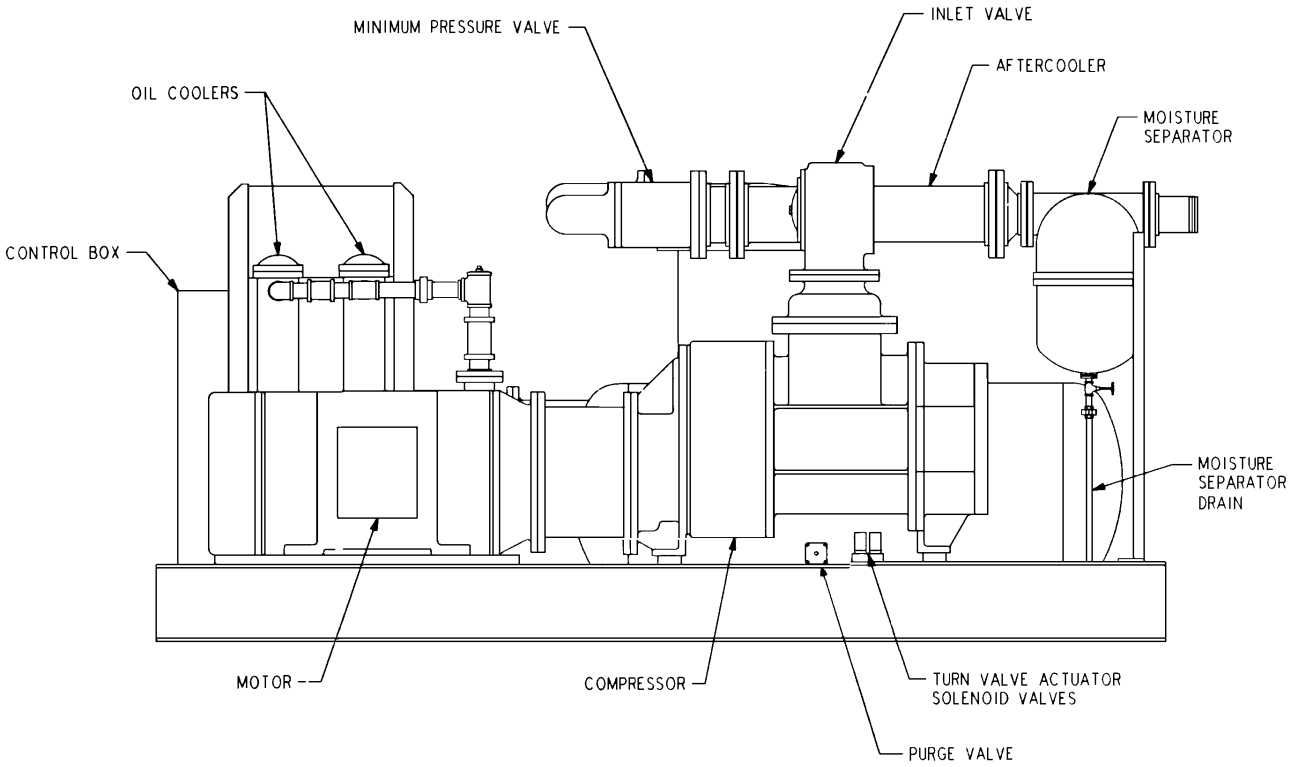
The air inlet port is located on top of the compressor near the center. The discharge port is near the bottom at the opposite end of the compressor cylinder. *Figure 1–1 is an inverted view to show inlet and discharge ports*. The compression cycle begins as rotors unmesh at the inlet port and air is drawn into the cavity between the main rotor lobes and secondary rotor grooves (A). When the rotors pass the inlet port cutoff, air is trapped in the interlobe cavity and flows axially with the meshing rotors (B). As meshing continues, more of the main rotor lobe enters the secondary rotor groove, normal volume is reduced and pressure increases.

Oil is injected into the cylinder to remove the heat of compression and seal internal clearances. Volume reduction and pressure increase continues until the air/oil mixture trapped in the interlobe cavity by the rotors passes the discharge port and is released to the oil reservoir (C). Each rotor cavity follows the same “fill–compress–discharge” cycle in rapid succession to produce a discharge air flow that is continuous, smooth and shock free.

AIR FLOW (FIGURE 5–1, page 40) – Air enters the air filter and passes through the inlet unloader valve to the compressor. After compression, the air/oil mixture passes into the oil reservoir where most of the entrained oil is removed by velocity change and impingement and drops back into the reservoir. The air and remaining oil then passes through the oil separator; the separated oil is returned to the system through tubing connecting the separator and compressor. The air passes through the reservoir discharge manifold, discharge check valve, minimum pressure valve and the customer furnished unit shutoff globe valve to the plant air lines.

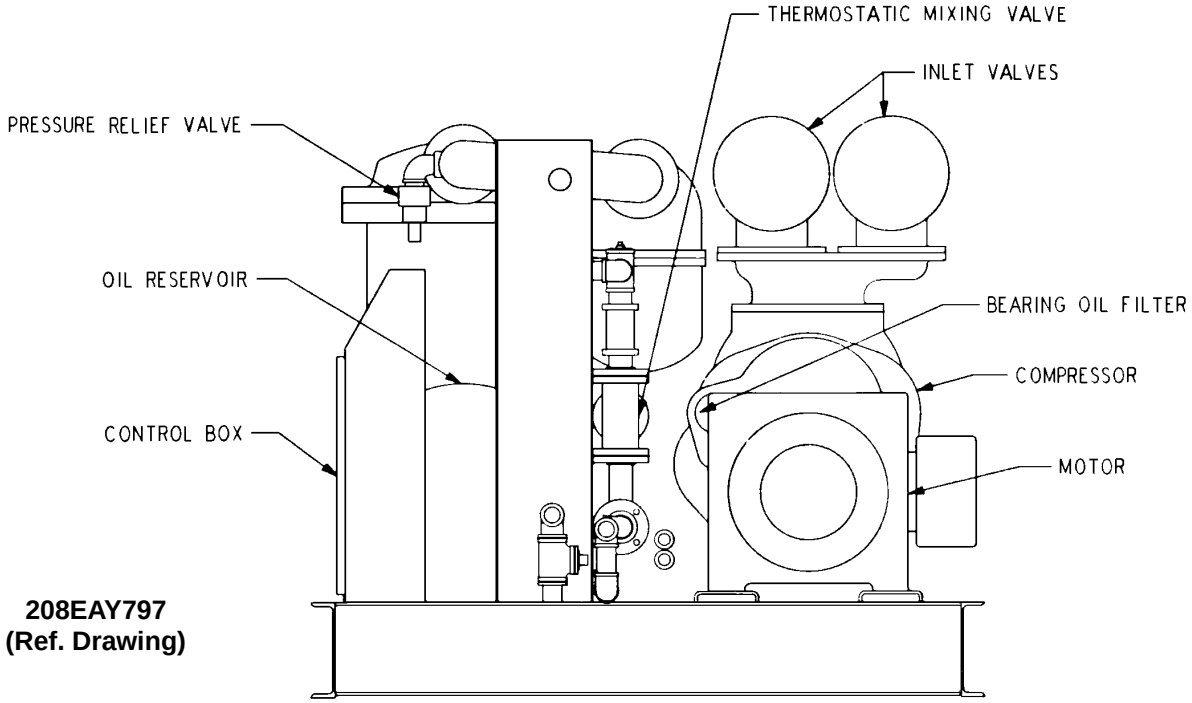
LUBRICATION, COOLING AND SEALING – Oil is forced by air pressure from the oil reservoir through the oil cooler, thermostatic mixing valve, and oil filter and discharges into the compressor main oil gallery. A portion of the oil is directed through internal passages to the bearings, gears and shaft oil seal. The balance of the oil is injected directly into the compression chamber to remove heat of compression, seal internal clearances and lubricate the rotors.

TURN VALVE – The turn valve is a rotary helical valve located on the discharge side of the cylinder toward the inlet end. The valve opens and closes ports in the cylinder which communicates with the inlet passage. This varies the compressor rotor volume to match the demand for air, thus reducing the part–load power requirement.



208EAY797
(Ref. Drawing)

FIGURE 1–2 – VIEW OF WATER COOLED UNIT WITH AFTERCOOLER (LESS ENCLOSURE) COMPRESSOR – MOTOR SIDE



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(Ref. Drawing)

FIGURE 1–3 – VIEW OF WATER COOLED UNIT WITH AFTERCOOLER (LESS ENCLOSURE) – MOTOR END

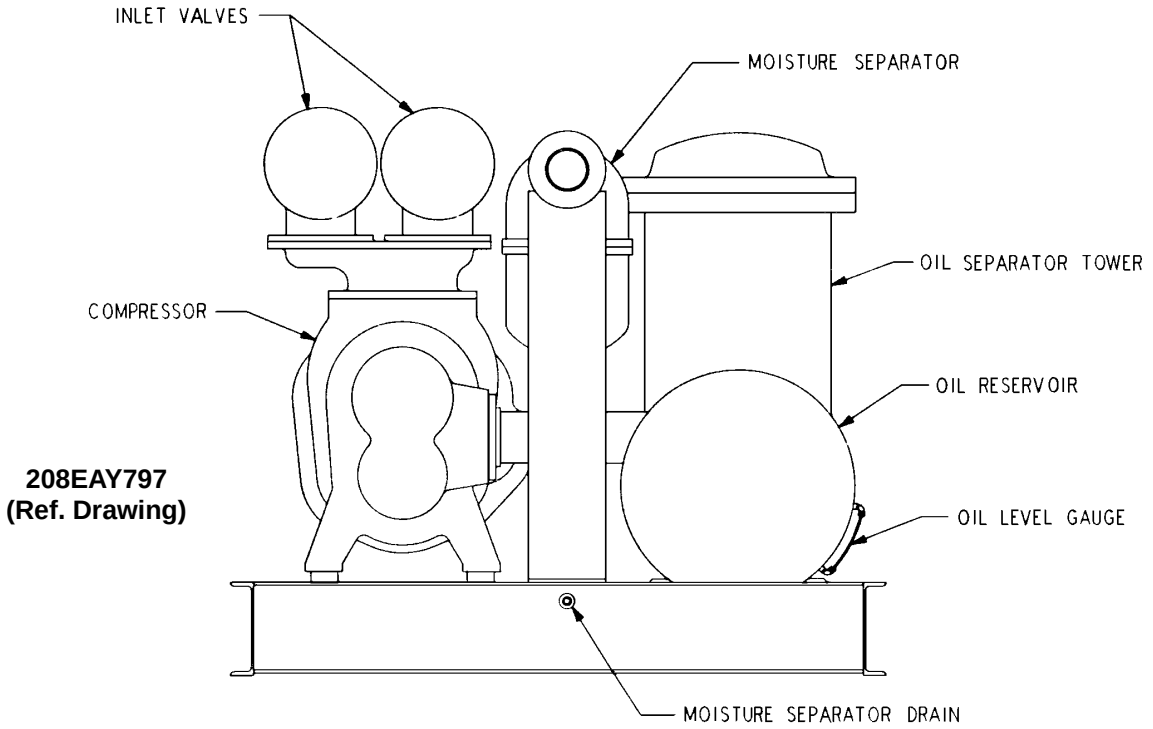

FIGURE 1–4 – VIEW OF WATER COOLED UNIT WITH AFTERCOOLER (LESS ENCLOSURE) COMPRESSOR – RESERVOIR END

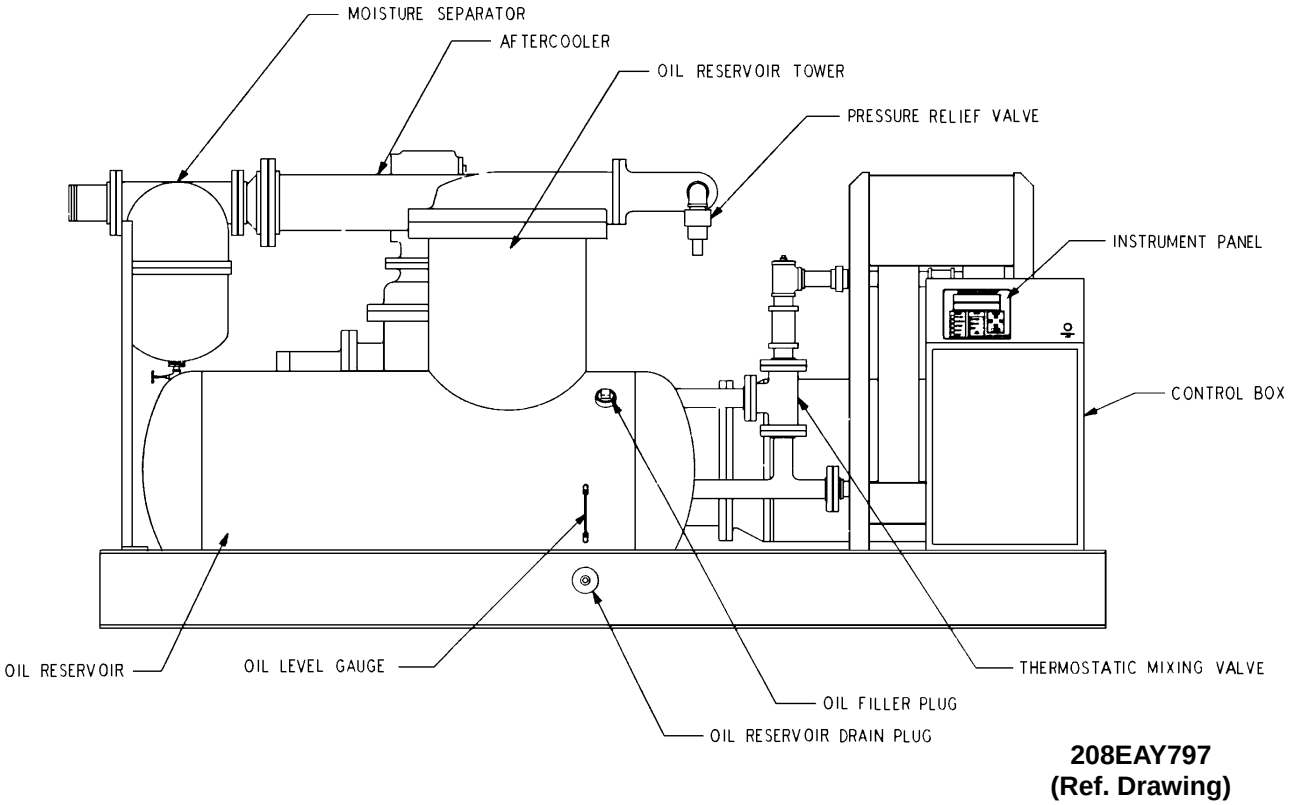

FIGURE 1–5 – VIEW OF WATER COOLED UNIT WITH AFTERCOOLER (LESS ENCLOSURE) RESERVOIR SIDE

SAFETY PRECAUTIONS

Safety is everybody's business and is based on your use of good common sense. All situations or circumstances cannot always be predicted and covered by established rules. Therefore, use your past experience, watch out for safety hazards and be cautious.

Some general safety precautions are given below:

⚠ DANGER

Failure to observe these notices could result in injury to or death of personnel.

- **Keep fingers and clothing away from revolving fan, drive coupling, etc.**
- **Do not use the air discharge from this unit for breathing – not suitable for human consumption.**
- **Do not loosen or remove the oil filler plug, drain plugs, covers, the thermostatic mixing valve or break any connections, etc., in the compressor air or oil system until the unit is shut down and the air pressure has been relieved.**
- **Electrical shock can and may be fatal.**
- **Compressor unit must be grounded in accordance with the National Electrical Code. A ground jumper equal to the size of the equipment ground conductor must be used to connect the compressor motor base to the unit base.**
- **Fan motors must remain grounded to the main base through the starter mounting panel in accordance with the National Electrical Code.**
- **Open main disconnect switch, tag and lockout before working on the control.**
- **Disconnect the compressor unit from its power source, tag and lockout before working on the unit – this machine is automatically controlled and may start at any time.**

⚠ WARNING

Failure to observe these notices could result in damage to equipment.

- **<u>Stop the unit</u> if any repairs or adjustments on or around the compressor are required.**
- **<u>Disconnect the compressor</u> unit from its power source, tag and lockout before working on the unit – this machine is automatically controlled and may start at any time.**
- **<u>An Excess Flow Valve</u> should be on all compressed air supply hoses exceeding 1/2 inch inside diameter. (OSHA Regulation, Section 1926.302)**
- **<u>Do not exceed the rated maximum pressure values</u> shown on the nameplate.**
- **<u>Do not operate unit</u> if safety devices are not operating properly. Check periodically. Never bypass safety devices.**

DECALS

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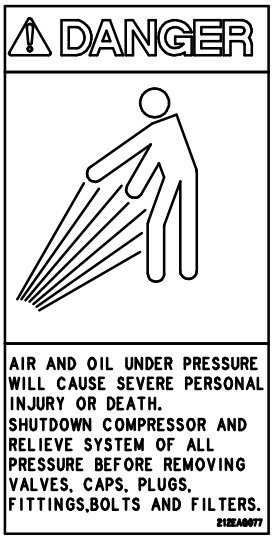

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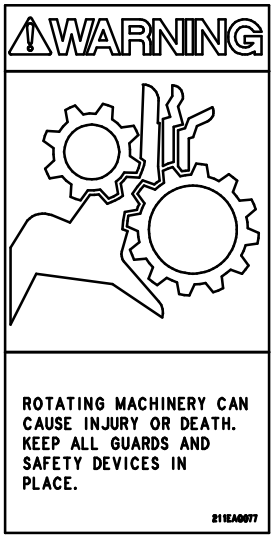

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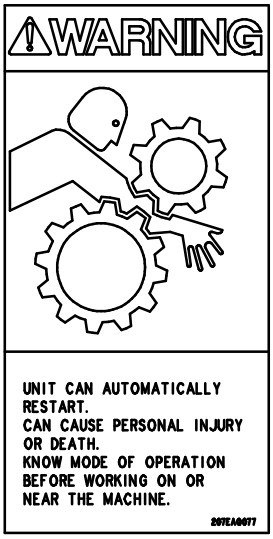

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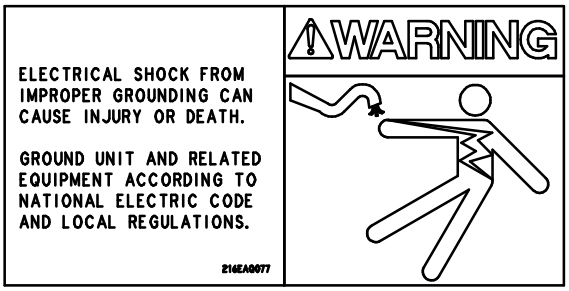
DECALS



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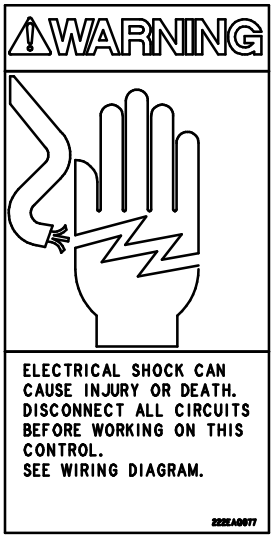

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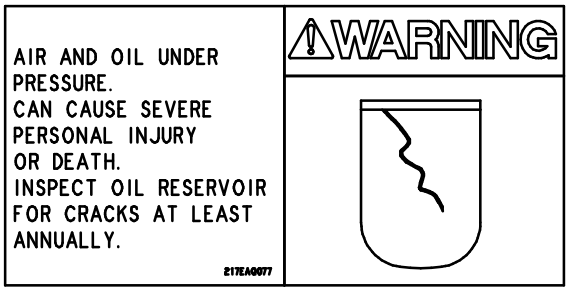

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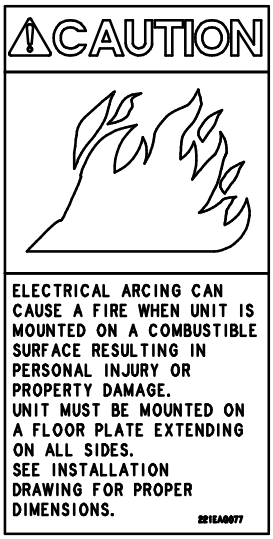

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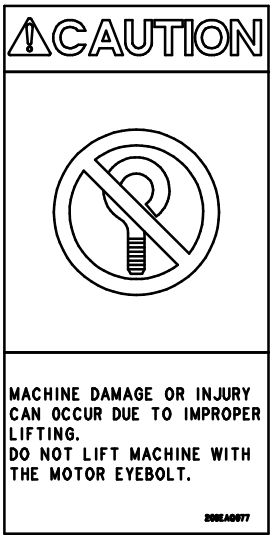

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SECTION 2
INSTALLATION

GENERAL – On receipt of the unit, check for any damage that may have been incurred during transit. Report any damage or missing parts as soon as possible.

⚠ CAUTION

Do not electric weld on the compressor or base; bearings can be damaged by passage of current.

LIFTING UNIT:

⚠ CAUTION

Lift compressor unit by base only. Do not use other places such as motor, compressor or discharge manifold piping as lifting points.

⚠ DANGER

The eyebolts or lugs provided on the motor are for lifting the motor only and should not be used to lift any additional weight. All eyebolts must be securely tightened. When lifting the motor the lifting angle must not exceed 15 degrees. Failure to observe this warning may result in damage to equipment or personal injury.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

LOCATION – The compressor should be installed in a clean, well–lighted, well–ventilated area with ample space all around for maintenance. Select a location that provides a cool, clean, dry source of air. In some cases it may be necessary to install the air filter at some distance from the compressor to obtain proper air supply.

The compressor unit require electric motor cooling air as well as air to the compressor inlet. Proper ventilation MUST be provided (FIGURE 2–2); hot air must be exhausted from the compressor operating area. A typical inlet–outlet air flow arrangement is shown in FIGURE 2–1.

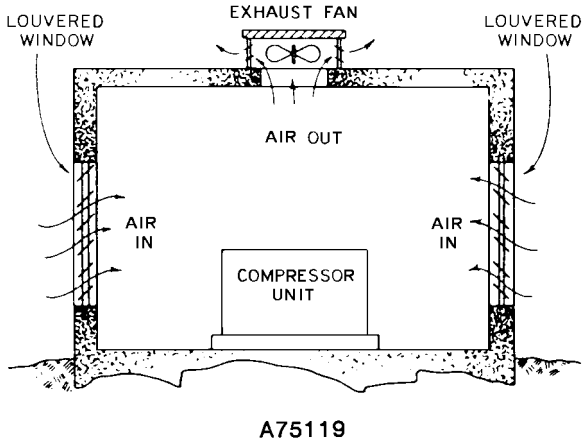


FIGURE 2–1 – TYPICAL COMPRESSOR ROOM

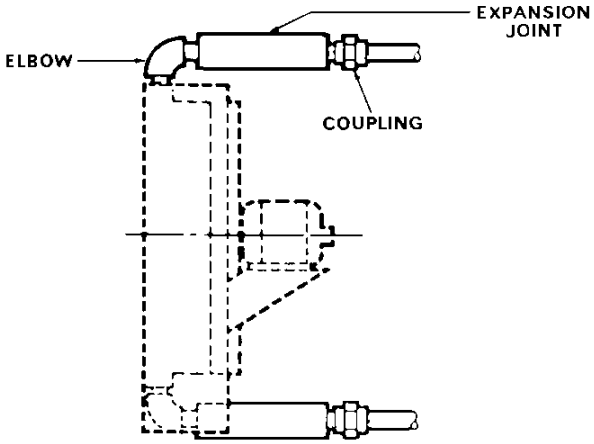
If the air–cooled oil cooler module is to be installed at a location remote from the compressor unit, be sure that adequate ventilation is provided, FIGURE 2–2. Hot air must be exhausted from the oil cooler area.

Do not block the air flow to and from the unit. Allow 3–1/2 feet to the nearest obstruction on the control box side of the unit and 3 feet on all other sides.

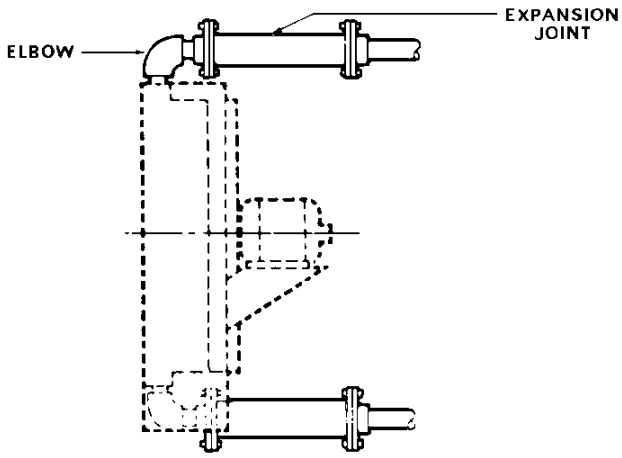
Size	Open Compressor Unit	Aftercooler and Oil Cooler Module	Open Unit With Aftercooler & Oil Cooler Module Discharge in Same Room
350 HP	12,600	43,000	55,600
400 HP	14,400	43,000	57,400
500 HP	18,000	43,000	61,000

* 80° F Inlet Air

FIGURE 2–2 – AIR FLOW CHART



PIPING SCHEMATIC OF COOLER WITH SCREWED CONNECTIONS.



PIPING SCHEMATIC OF COOLER WITH FLANGED CONNECTIONS.

FIGURE 2–3 – PIPING SCHEMATIC

VENTILATION – The unit, whether air– or water–cooled, requires sufficient air flow, FIGURE 2–2, for electric motor cooling. Air is drawn into the back and front of the motor and is discharged out the sides. Do not block air flow to and from the unit.

FOUNDATION – The Electra–Saver® compressor requires no special foundation but should be mounted on a smooth, solid surface of sufficient strength to support the weight of the unit. Whenever possible install the unit near level. Temporary installation may be made at a maximum 10° angle lengthwise or 30° sidewise.

Mounting bolts are not normally required. However, installation conditions such as piping rigidity, angle of tilt, or danger of shifting from outside vibrations or moving vehicles may require the use of mounting bolts to the foundation.

OIL RESERVOIR DRAIN – (FIGURE 1–5, page 3) The oil reservoir drain valve is located near the center of the oil reservoir just below the separator tower. The drain valve is approximately 5 inches from the floor level. If this height is not sufficient to conveniently drain the oil, some other methods of providing oil drain are:

1. Elevate the compressor unit on a suitable structure to obtain the desired drain height.

2. Construct an oil sump or trough below the floor level and pump or bail the drained oil.

3. Pump oil from the reservoir filler opening or drain to a container.

ACOUSTIC ENCLOSURE – The Electra–Saver unit is furnished with an acoustic enclosure over the compressor only, as standard equipment. The enclosure reduces the normal operating sound of the unit to 90 DBA or below in free field conditions.

AIR–COOLED OIL COOLER MODULE – The air–cooled oil cooler is a separate module and may be mounted remote to the compressor unit.

Ventilation – The oil cooler requires adequate cooling air flow. Proper ventilation MUST be provided, with hot air exhausted away from the cooler; take care that hot air is not recirculated form the exhaust to the inlet side of the cooler. Cooling air flow direction is from the motor side through the grille side of the oil cooler. Do not obstruct the air flow to or from the cooler. Allow two (2) feet clearance on all sides of the cooler module. See FIGURE 2–2, page 8, for cooling air flow requirements.

Low Oil Pressure Protection – The standard factory–installed low oil pressure shutdown switch in the control box will prevent start–up or shut the unit down if oil pressure is not established or maintained due to malfunction in the oil cooler system.

Oil Cooler – Location and General Piping – The oil cooler module can be mounted in any of several remote locations; close coupled but not joined to the compressor unit; horizontal remote, located on the same level as the compressor unit, but some distance away; or overhead remote, located above level of the compressor unit, as on a roof.

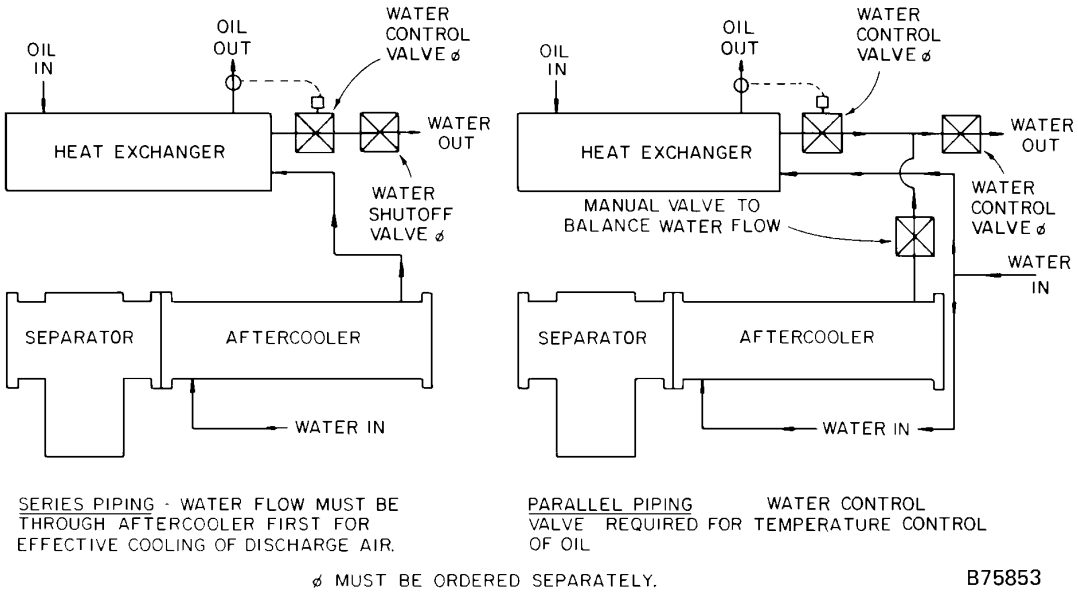


FIGURE 2–4 – PIPING DIAGRAM FOR AFTERCOOLER AND HEAT EXCHANGER

⚠ WARNING

The machine cannot be run blown down with remote overhead oil cooler. These units require special wiring diagram – check with factory. Running the machine blown down with an overhead cooler could result in damage to compressor.

All piping and wiring between the compressor unit and the remote oil cooler is to be supplied by the user. **THE DESIGN OF THE REMOTE OIL COOLER MODULE SYSTEM MUST BE APPROVED BY THE FACTORY BEFORE INSTALLATION.** The design information to be submitted for approval includes:

1. Location of oil cooler module – inside or outdoors.
2. Range of operating ambient temperatures at the oil cooler location.
3. Elevation of the oil cooler above the compressor unit.
4. Pipe type and size(s) to be used to connect the oil cooler and the compressor unit. Minimum pipe size is 2–1/2" NPT.
5. Horizontal and vertical lengths of the pipe run. If more than one pipe size is used, list length of each size and total length.
6. Number and size of elbows, tees, unions, reducers, and valves to be used in the pipe run.
7. A dimensional sketch of the proposed piping system showing location of the compressor unit, oil cooler, pipe, and fittings illustrating design information included in numbers 3 through 6 above.

All remote piping should be of adequate size to insure a minimum pressure loss. Number 4 above lists the minimum pipe size to be used. Long runs of pipe and the use of valves and fittings require larger than the minimum pipe sizes in the system to keep the pressure loss low. All pipe and fittings used in a remote oil cooler system should be galvanized or treated internally to prevent rust, and all valves are to be of a nonferrous construction to prevent corrosion and fouling.

The remote cooler should be placed so that the fan air flow through the cooler (air flow is from the motor side through core) and the prevailing winds are in the same direction. A baffle should be provided on the exhaust side of the cooler for protection against occasional wind shifts.

When the oil cooler is mounted above the compressor unit, a check valve is to be mounted on the compressor unit in the line to the oil cooler; see FIGURE 5–4, page 45. A pneumatic pilot–operated normally–closed valve is to be mounted at the oil filter inlet on the compressor unit line from the oil cooler. The check valve permits oil flow to the oil cooler during operation, but prevents return oil flow from the cooler when the unit is shut down. The pilot valve is held open by air pressure from the unit oil reservoir during operation and closes under spring load when the unit is shut down to prevent return oil flow from the oil cooler.

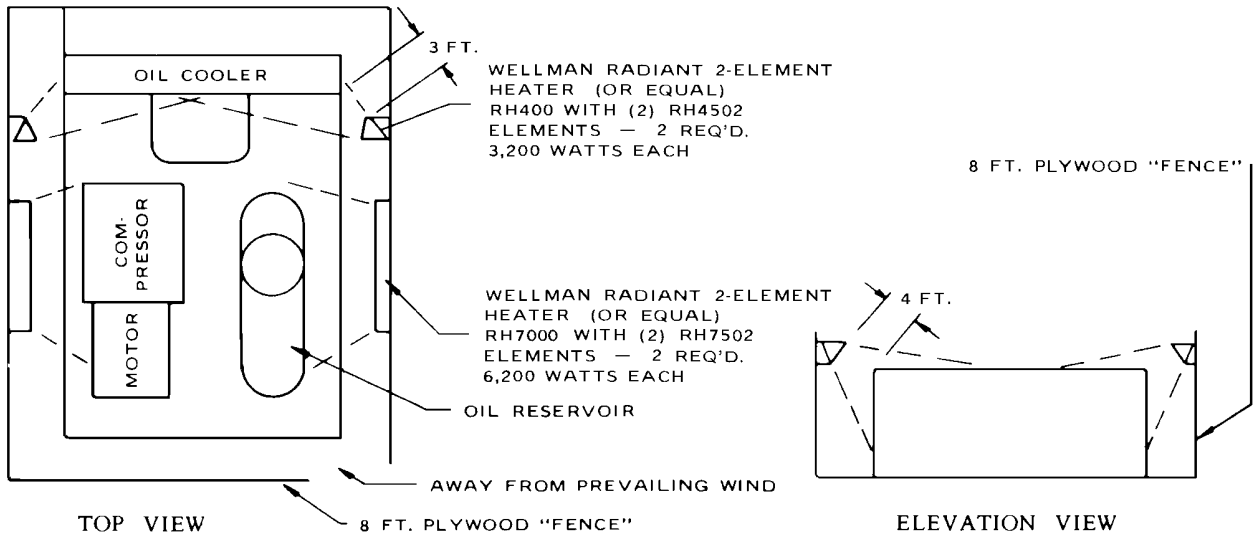


FIGURE 2–5 – COLD WEATHER INSTALLATION

An oil filler stand pipe and plug must be located in the piping on the oil cooler module for ease of filling of a remote oil cooler, see FIGURE 5–4, page 45.

Oil Cooler – Installation – Inspect unit upon arrival. In case of damage, report immediately to transportation company. Before installation, check rating plate on motor to verify that power input and motor specification requirements match available electric power at point of installation.

1. Set the unit level on a firm, solid foundation. The larger oil cooler models have lifting holes to facilitate unit hoisting.
2. Allow for linear expansion and contraction of piping in the direction away from the oil cooler. Use flexible connectors or suitable expansion joints on all oil cooler inlet and outlet piping. See FIGURE 2–3, page 9, for typical schematics.
3. Select properly tensioned and aligned piping support clamps or hangers and position them to relieve any piping stress at the oil cooler inlet and outlet ports. Do not support from flexible connectors.
4. Service – For continuous efficiency, oil cooler cores must be periodically cleaned with either vacuum or compressed air. If wet cleaning is required, shield motor and spray on a mild soap solution and flush with clear water.

AUXILIARY AIR RECEIVER – The unit requires an auxiliary air receiver unless the piping system is large and provides sufficient storage capacity to prevent rapid cycling. When used, an air receiver should be of adequate size, provided with a relief valve of proper setting, a pressure gauge, and a means of draining condensate.

AFTERCOOLER (FIGURE 1–2 and FIGURE 1–5, pages 2 and 3) – An aftercooler will provide control of moisture entering the shop air lines while reducing the normal low discharge temperature of about 180° F at 100 PSIG discharge pressure to near inlet air temperature, or cooling water temperature.

Air–Cooled Machines – When an aftercooler is furnished on an air–cooled machine, the aftercooler is installed on the oil cooler module between the fan and the oil cooler. The moisture separator is furnished by Gardner Denver but must be mounted by the customer between the aftercooler and the auxiliary air receiver with a condensate drain provided at the bottom. All air piping from the compressor discharge to aftercooler to auxiliary air receiver is to be furnished and mounted by customer. **The design of the aftercooler piping must be approved by the factory before installation.** Design information to be submitted for approval includes:

1. Location of aftercooler module – inside or outdoors.
2. Range of operating ambient temperatures at the aftercooler location.
3. Pipe type and size(s) to be used to connect the aftercooler, separator, and compressor unit – minimum pipe size is 5” NPT.
4. Lengths of the pipe run. If more than one pipe size is used, list length of each size and total length.
5. Number and size of elbows, tees, unions, reducers, and valves to be used in the pipe run.
6. A dimensional sketch of the proposed piping system showing location of the compressor unit, aftercooler, separator and auxiliary air receiver, pipe and fittings illustrating design information included in numbers 3 through 5 above.

Water–Cooled Machines (FIGURE 2–4, page 10) – On water–cooled machines with aftercooler, the moisture separator and condensate drain are shipped loose and must be installed by customer. Customer must furnish and install all water piping required.

INSTALLATION FOR COLD WEATHER OPERATION – It is recommended that the unit be installed inside a shelter that will be heated to temperatures above freezing (32°F, 0°C). This will eliminate many of the problems associated with operating units in cold climates where freezing rain, drifting snow, freezing condensate and bitter cold temperatures are encountered.

Refer to Engineering Data Sheet 13–9–411 for the advantages of using the heat recovered from rotary compressors. This heat recovery could easily pay for an adequate shelter for the unit.

When an outside installation must be made, the precautions required will depend on the severity of the environment. The following are general guidelines for outside installations:

Cold Weather (Down To +10°F)

1. Be sure all drains, traps, and control lines, including pressure transducer lines are heated to avoid freezing of condensate. Heat tape with thermostat control is generally satisfactory for this purpose and can be obtained at various local plumbing or hardware outlets at nominal cost.
2. If an air–cooled aftercooler is to be used, provisions to bypass the aftercooler must be made. Since cold air contains very little moisture, successful operation can be achieved without the aftercooler. Successful operation down to +15° F can be accomplished by reversing fan flow, but cooler bypass should still be provided should it be required.
3. Provide at least some simple shelter such as a plywood windbreak to protect against drifting snow.
4. Use only Gardner Denver® AEON™ 9000 SP lubricant.
5. Monitor the unit carefully during start–up and operation to be sure it is functioning normally.
6. Specify NEMA 4 enclosure for electrical devices.

Extreme Cold Weather Operation (Down To –40°F, –40°C**) –** In addition to the above, the following should be provided:

1. A temperature switch to control the fan should be provided for better starting and quicker warm–up. This switch can be provided from the factory and will delay fan start–up until discharge temperature reaches approximately 150–160° F.
2. It will probably be necessary to provide shutters or to block off part of the cooler in some manner since the cooler is greatly oversized for operation in these low temperatures. Shutters are not a factory option.
3. Auto operation should not be used in extreme environments.
4. Coolers should be located as close to the unit as possible. Long lines to and from the cooler only further complicate the circulation of oil flow on cold starts. Heat tape and insulation may be required on oil lines.
5. Some means of providing heat to the oil reservoir and cooler during shutdown should be provided. There are various methods to accomplish this, but since openings are not provided for sump heaters, the use of radiant heaters is recommended. The heaters should be sized to provide at least a +10°F environment for coolers, motor and sump. FIGURE 2–5, page 11, shows how these might be located in a typical installation and sizes required.

Remember unsheltered (outside) installations should be avoided where possible. Installation next to a heated building where enough heat can be used to keep the compressor room above freezing will save many complications in the operation and installation of the unit.

MOISTURE SEPARATOR/TRAP – Since the unit is equipped with a built–in aftercooler, a combination moisture separator and trap is furnished with the unit. A means of draining condensate will need to be provided for.

INLET LINE – Where an inlet line is used between the air filter and the compressor, it must be thoroughly

Length of Inlet Line	Diameter of Pipe Size
0 to 10 Feet	Same as Compressor Inlet Opening
10 to 17 Feet	One Size Larger Than Inlet Opening
17 to 38 Feet	Two Sizes Larger Than Inlet Opening

FIGURE 2–6 – INLET LINE LENGTHS

HEAT EXCHANGER							
Size	Rated Pressure PSIG	Water Temperature to Heat Exchanger Gallons/minute				Maximum Water Flow GPM	Approximate Water Pressure Drop @ Maximum Flow (PSI)
		60° F.	70° F.	80° F.	90° F.		
350 HP	ALL	33	42	56	83	120	21.0
400 HP	ALL	38	48	64	95	120	21.0
500 HP	ALL	48	60	80	119	130	17.0

The maximum water flow shown is allowable through the heat exchanger.

FIGURE 2–7 – HEAT EXCHANGER (OIL COOLER) APPROXIMATE WATER FLOW

AFTERCOOLER							
Size	Rated Pressure PSIG	Water Temperature to Aftercooler Gallons/minute				Maximum Water Flow GPM	Approximate Water Pressure Drop @ Maximum Flow (PSI)
		60° F.	70° F.	80° F.	90° F.		
350 HP	ALL	8.4	10.5	14.0	21.6	100.0	10.0
400 HP	ALL	9.4	11.7	15.6	23.5	100.0	10.0
500 HP	ALL	11.3	14.1	18.8	29.0	100.0	10.0

Water flow rates (gpm) are based on 100° F water temperature out of cooler. Maximum water flow shown is the maximum allowable flow through aftercooler.

FIGURE 2–8 – AFTERCOOLER APPROXIMATE WATER FLOW

cleaned on the inside to prevent dirt or scale from entering the compressor. **If welded construction is used, the line must be shot blasted and cleaned to remove welding scale.** In either case, the inlet line must be coated internally by galvanizing or painting with a moisture and oil–proof sealing lacquer. The inlet line should be the full size of the inlet opening on the compressor. If an extra–long line is necessary, the pipe size should be increased according to Inlet Line Length Chart, FIGURE 2–6, page 12.

Accessibility for inlet air filter servicing must be considered when relocating the filters from the unit to a remote location.

DISCHARGE SERVICE LINE – The discharge service line connection on water–cooled units with aftercooler is made at the moisture separator. On air–cooled units and water–cooled without aftercooler, the connection is made at the pipe nipple located behind the instrument panel. When manifolding two or more Electra–Saver units on the same line, each unit is isolated by the check valve in the unit discharge line.

If an Electra–Saver unit is manifolded to another compressor, be sure the other compressor has a check valve in the line between the machine and the manifold.

If an Electra–Saver and a reciprocating compressor are manifolded together, an air receiver must be located between the two units.

⚠ DANGER

Discharge air used for breathing will cause severe injury or death.

Consult filtration specialists for additional filtration and treatment equipment to meet health and safety standards.

WATER PIPING (Water–Cooled Heat Exchanger Models Only) – On machines equipped with water–cooled heat exchangers, the water inlet and outlet con-

nections are located in the unit base flange on the left side of the unit.

⚠ WARNING

It is mandatory that any water cooled unit be installed in a shelter heated to temperatures above freezing (32° F., 0° C).

The water source should be capable of supplying up to the maximum flow shown in FIGURE 2–6, page 12, and FIGURE 2–7, page 13, at a minimum pressure of 40 PSIG; maximum allowable water pressure is 150 PSIG. The water flow rates shown in FIGURE 2–6, page 12, are approximate and a guide to sizing piping, cooling tower and other water system equipment.

The heat exchanger system is designed to operate with water inlet temperatures from 60° to 90° F and a water outlet temperature not to exceed 110°F. If water cooler than 60° F is used, high water outlet temperatures (over 110° F) will be experienced along with shortened heat exchanger life caused by tube fouling and corrosion. If water warmer than 90° F is used, higher compressor oil inlet temperatures and high water usage will result.

Most water systems will require control of impurities: filtration, softening or other treatment. See "Compressor Oil Cooler – Water–Cooled Heat Exchanger" for more information on the water system.

Aftercooler – Heat Exchanger Water Piping (FIGURE 2–4, page 10, and FIGURE 2–6, page 12, and FIGURE 2–7, page 13) – If an aftercooler is used and piped in series with the heat exchanger, install the water flow control valve and magnetic water shutoff valve, if used, downstream of the exchanger. Pipe the aftercooler water outlet to the heat exchanger water inlet on the compressor unit.

If the aftercooler is piped in parallel with the heat exchanger, provide a manual valve between aftercooler outlet and heat exchanger outlet after the water control valve to adjust aftercooler water flow for discharge temperature required and most economical water use; separate water inlet lines are piped to the aftercooler and heat exchanger.

If the standard factory built–in aftercooler is used, the maximum allowable water flow through the aftercooler is 100 gallons per minute on all 350 – 500 HP units and the maximum water inlet pressure is 150 PSIG. If another aftercooler is used, consult the manufacturer for operating limits.

⚠ CAUTION

When an aftercooler is piped in series with the oil cooler, the maximum allowable flow rate through the oil/aftercooler system is the maximum allowed by the aftercooler. If the oil cooler requires more water flow than the maximum allowed by the aftercooler, a parallel water piping system must be used.

The water control valve MUST be used to maintain discharge temperatures approximately 10° F. over the dew point for expected ambient (FIGURE 5–7, page 47). See Section 5 for adjustment instructions and maximum allowable oil temperature.

ELECTRICAL WIRING – The Electra–Saver® unit is furnished with the compressor motor enclosure as specified by the user. If unit has an air–cooled oil cooler, this fan motor is a totally enclosed "air–over" or "fan–cooled type" and is complete with starter and enclosure as specified by the user. Allow 42" deep and 30" wide clear space to the nearest obstruction in accordance with Article 110–16(a), National Electric Code.

It is necessary to connect the compressor unit (and oil cooler, if used) to a main starter of the correct size, power characteristics, and enclosure for the application. See Section 4 for typical wiring diagrams; however, use only the wiring diagrams supplied with the unit for final connections.

Starter – The main starter is to be mounted at a location selected by the user at the time of installation. The first three feet of line from the motor conduit box to the starter must be of flexible conduit to maintain effective vibration isolation. Electrical connections to other parts of the unit (instrument panel, fan motor, etc.) from the starter do not require flexible conduit since the compressor and motor are already isolated from these parts. See Article 110–16(a) National Electric Code for working clearance.

⚠ WARNING

Electrical shock can cause injury or death. Open main disconnect switch, tag and lockout before working on starter/control box.

GROUNDING – Equipment must be grounded in accordance with Section 250–95 of the National Electrical Code.

⚠ WARNING

Failure to properly ground the compressor package could result in controller malfunction.

MOTOR LUBRICATION – Long time satisfactory operation of an electric motor depends in large measure on proper lubrication of the bearings. The following charts show recommended grease qualities and regreasing intervals for motors supplied with ball bearings. For additional information refer to the motor manufacturer's instructions. The following procedure should be used in regreasing:

1. Stop the unit.
2. Disconnect, tag and lockout the unit from the power supply.
3. Remove the relief plug and free hole of hardened grease.
4. Wipe lubrication fitting clean and add grease with a hand–operated grease gun.

   The amount and type of grease added is very important. Only enough grease should be added to replace the grease used by the bearing. Too much grease can be as harmful as insufficient grease. The grease cavity should be filled 1/3 to 1/2 full.
5. Leave the relief plug temporarily off. Reconnect the unit and run for about 20 minutes to expel the excess grease.
6. Stop the unit. Replace the relief plug.
7. Restart the unit.

⚠ WARNING

Rotating machinery can cause injury or death. Open main disconnect, tag and lockout power supply to the starter before working on the electric motor.

ELECTRIC MOTOR GREASE RECOMMENDATIONS (–30° to 50° C)

MANUFACTURER	TRADE NAME
CHEVRON	SRI #2
SHELL	DOLIUM R
EXXON	UNIREX #2
EXXON	POLYREX

ELECTRIC MOTOR REGREASING INTERVAL

Type of Service	Typical Examples	Rating	Relubrication Interval
Standard	One– or Two–Shift Operation	Above 150 HP	12 Months
Severe	Continuous Operation	Above 150 HP	6 Months
Very Severe	Dirty Locations, High Ambient Temperature	Above 150 HP	2 Months

SECTION 3
STARTING & OPERATING PROCEDURES

PRESTART–UP INSTRUCTIONS – A new unit as received from the factory has been tested and then prepared for shipping only. Do not attempt to operate the unit until checked and serviced as follows:

1. **Compressor Oil** – Check the oil level in the reservoir. Add oil only if the oil level gauge reads in the red "ADD OIL" range. Do not mix different type oils. The unit is shipped filled with Gardner Denver AEON™ 4000 SP Lubricating Coolant which is suitable for the first 6000 hours under normal operating conditions.

   REPLACE OIL FILTER EVERY 1000 HOURS.

   Initial fill, or filling after a complete draining of the system, may show the oil level in the yellow "EXCESS OIL" range. After start–up, the oil will fall into the green operating range as system components are filled. If necessary, add oil to bring the level to the top of the green range as read when the unit is operating at full load and normal pressure. See FIGURE 5–2, page 42.

NOTICE

Regular maintenance and replacement at required intervals of the oil filter, air filter and air–oil separator is necessary to achieve maximum service and extended drain intervals of AEON™ 9000 SP synthetic lubricant. Use only genuine Gardner Denver filters designed and specified for this compressor.

⚠ DANGER

Always stop the unit and release air pressure before removing the oil filler plug. Failure to release pressure may result in personal injury or death.

During unloaded operation and after shutdown, the system will partially drain back into the oil reservoir and the oil level may read higher than when operating on load. DO NOT DRAIN OIL TO CORRECT; on the next loaded cycle or start, oil will again fill the system and the gauge will indicate the operating level.

2. **Air Filter** – Inspect the air filter to be sure it is clean and tightly assembled. Refer to Section 6, "Air Filter," page 51, for complete servicing instructions. Be sure the inlet line, if used, is tight and clean.
3. **Coupling** – Check all bolts and cap screws for tightness. See Section 7, page 53.
4. **Piping** – Refer to Section 2, "Installation," page 10, and make sure piping meets all recommendations.
5. **Electrical** – Check the wiring diagrams furnished with the unit to be sure it is properly wired. See Section 4, "Controls and Instruments," for general wiring diagrams and Section 2, page 8 for installation instructions.
6. **Grounding** – Equipment must be properly grounded according to Section 250–95 of the National Electrical Code.

⚠ WARNING

Failure to properly ground the compressor package could result in controller malfunction.

7. **Rotation** – Check for correct motor rotation using "JOG MODE." Compressor drive shaft rotation must be clockwise standing facing the compressor coupling.

⚠ WARNING

Operation with incorrect motor rotation can damage equipment and cause oil eruption from the compressor inlet. When checking motor rotation, induce minimum rotation (less than one revolution if possible). Never allow motor to reach full speed.

8. **System Pressure** – Set the controls to the desired load pressure. DO NOT EXCEED THE MAXIMUM OPERATING PRESSURE ON THE COMPRESSOR NAMEPLATE. See Section 4, “Controls and Instrumentation” for procedure.

⚠ WARNING

Operation at excessive discharge air pressure can cause personal injury or damage to equipment. Do not adjust the full discharge air pressure above the maximum stamped on the unit nameplate.

9. **Operating Mode** – Refer to Section 4 for detailed information on the control system.

10. **Enclosure** – Check for damaged panels or doors. Check all screws and latches for tightness. Be sure doors are closed and latched.

STARTING THE UNIT – OBSERVE UNIT COLD OR HOT STARTING PROCEDURES.

Unit Cold – If the unit is a water–cooled heat exchanger model, open any manual water inlet valves wide open. Start the unit by pushing either the “CONSTANT RUN” button or one of the “AUTO” buttons. Since the unit is equipped with a minimum (65 psig) pressure discharge valve, no special procedure to maintain unit reservoir pressure is required.

Unit Hot – No warm–up period is required. If the unit is a water–cooled heat exchanger model, open any manual water inlet valves wide open. Start the unit by pushing either the “CONSTANT RUN” button or one of the “AUTO” buttons.

DAILY CHECK – Refer to Section 8, “Maintenance Schedule,” page 54.

STOPPING THE UNIT – Press “STOP–RESET” button. The oil reservoir will automatically blow down as the motor stops. If the unit is a water–cooled heat exchanger type, close any manual water inlet valves.

SECTION 4
CONTROLS & INSTRUMENTATION

GENERAL DESCRIPTION – The Gardner Denver rotary screw compressor is prewired with all controls, motor, and starter for the voltage and horsepower at the time of ordering. It is necessary only to connect the compressor unit to the correct power supply and to the shop air line (and to the appropriate water supply if water cooled). A standard compressor unit consists of the compressor, oil reservoir, oil cooling system and filter, motor type as specified, NEMA 12 starter / control box, and control components as described below.

This compressor unit features the "AUTO SENTRY®–ES+" controller, which integrates all the control functions under microprocessor control. Its functions include safety and shutdown, compressor regulation, operator control, and advisory / maintenance indicators. The keypad and display provide the operator with a logical and easily operated control of the compressor and indication of its condition.

AUTO SENTRY®–ES+ OPERATION

Operation of the "Auto Sentry®–ES+" is dependent on selection of an operating mode (described below) from the controller keypad. Prior to starting, the STOP/RESET key must be pressed to place the controller into its READY state (as indicated on the display). Compressor operation may then be started by pressing an operating mode key. Once operating, the mode may be changed at any time by pressing a key, and the selected mode will be displayed in the lower right corner of the message window. Press the STOP/RESET key at any time to stop the compressor under normal conditions. If the compressor has been running, the reservoir will first be relieved of pressure before stopping the motor. The display will count down to zero during the normal stop.

⚠ WARNING

Automatic restarting or electrical shock can cause injury or death. Open, tag and lockout main disconnect and any other circuits before servicing the unit.

If any alternate display is on, press the operating mode key to return to the "normal" display. While operating and running, the unit may be manually unloaded by pressing and holding the operating mode key. This unloads a running compressor after several seconds, and will prevent loading while the key is held down. When the key is released, the control will resume its normal operation as required.

An optional control may be wired into the "Auto Sentry® ES+ controller to interrupt and restart the unit based on controls by others. When stopped by these controls, the display indicates remote stop.

In any mode, the compressor will start only if reservoir pressure is below 5 psig. The display will indicate if the control is waiting for a reservoir blowdown, along with the remaining pressure. The controls also delay initial loading of the compressor until a startup delay has been completed.

Constant Run Mode Operation – This mode is best used in applications where there are no long periods of unloaded operation, or for minimum response time to sudden demands. The compressor unit will start and run continuously, using its modulation controls to match delivery to demand.

As demand falls below the compressor capacity, the pressure will rise to the setpoint of the control. When the pressure reaches the setpoint, the "Auto Sentry®–ES+ controller operates the solenoid valves TVO (turn valve open), TVC (turn valve close), IVO (inlet valve open) and IVC (inlet valve close) to control the CFM of the compressor to match the CFM demand of the air system. As the demand changes, the controller will continue adjustment for the best compressor operation. At moderate to heavy demand, the inlet will be held open, and the turn valve will control delivery. At lighter demands, the turn valve will be fully open, and the inlet valve will control capacity. At very light demand, the compressor will unload, but will not blow down the reservoir. It will reload just below the set pressure. The controller will thus maintain the pressure within a few psi of the set pressure.

If the controller is programmed for "load–unload" operation, the controller will deliver full capacity until the system pressure reaches the set pressure. It will then unload (but not blow down) and will not deliver any air to the system. When the system pressure falls to halfway between the set and reset pressure, the ES+ controller again fully loads the compressor.

When first starting, the controller will keep the compressor fully unloaded and blown down until the system pressure drops below the reset pressure. Once loaded, the reservoir will remain fully charged, regardless of demand. Responses to demand are thus immediate, as soon as system pressure drops below the setpoint.

Low Demand Mode Operation – The low demand mode reduces power consumption by relieving pressure in the reservoir during unloaded operation. This mode is best used where there is moderate air storage and there are unloaded periods during the day, but frequent motor starting and stopping is undesirable. During periods of moderate to high demands, this mode is identical to the constant–run mode described above.

During low demand periods, the controller will open the blowdown valve and fully close the inlet valve to minimize the motor load. A timer is reset when this occurs. While in this state, control air pressure is supplied from the plant air system (as are any plant loads). When the system air pressure drops to the reset pressure due to increased demand, the blowdown valve recloses and the controls resume their normal modulation to maintain the system pressure near the set pressure.

Subsequent blowdown periods are not allowed until the timer has completed its cycle. This cycle eliminates frequent blowdowns during moderate loads, and the energy required to repressurize the reservoir. The timer is adjustable from 5 to 20 minutes.

Automatic Mode Operation – This mode provides automatic start and timed stop, and is best used in applications with long unloaded periods (e.g. idle shifts or weekends) and adequate storage to allow the compressor to be stopped for periods of light demands. Operation during periods of moderate to heavy demands are identical to the low demand mode.

The automatic time delay is adjustable from 5 to 20 minutes. If the controller operates unloaded for this period with no demand, the compressor drive motor is halted to eliminate its power consumption. The controls will remain in this state until demand is again indicated by a drop in pressure.

This is the most common selected mode of operation, as it automatically will operate the compressor unit in the most efficient manner for the demand of the air system.

Sequence Mode Operation – This mode provides for communication between controllers, operating only as many as are required for economical operation. This is best used on applications with large storage capacity and diverse loads. The lead unit will operate identically to the automatic mode; operation will be automatically staged for each lag unit (up to 8 total). For more information, refer to the sequencing instructions later in this chapter.

FIGURE 4–1 – AUTO SENTRY® –ES+ DISPLAY

Communication between controllers is achieved by interconnection of a communications cable to circuit board connectors. A “unit number” must be assigned to each unit in this mode, but the display will indicate the unit’s actual operating ranking.

AUTO–SENTRY®–ES+ CONTROL DISPLAY

The display above the keypad is used to provide operating information to the user. If a shutdown has occurred, the display will indicate the cause.

During normal operation, the display will show the system (plant) pressure, compressor discharge temperature, total running hours, and operation mode. Alternate displays are available by pressing the keys on the diagram or the [<][>] keypad keys, and will be identified on the display. These include:

1. Air/oil reservoir pressure
2. Separator differential pressure
3. Air/oil reservoir & separator temperature
4. System discharge pressure
5. Air end discharge temperature
6. Remaining blowdown time
7. Remaining auto time
8. Total running hourmeter
9. Loaded operation hourmeter

Remaining blowdown and auto times are only available in Low Demand, Automatic, and Sequence modes, as appropriate.

Service information may also be displayed while the compressor is running. Press the [+][–] keys to display the following:

1. Main motor current (optional)
2. Est. hours till next recommended oil change
3. Hours till next recommended oil filter change
4. List of any active advisory messages

If no keys are pressed for 5 seconds, the display will revert to its normal mode.

The display is also used as a service reminder for normal maintenance items. If service is recommended, the yellow advisory light will be on, and a message will alternate with the normal lower line display. Yellow lights on the diagram also indicate the area needing service. These messages are intended to advise of conditions which may lead to a shutdown.

If a protective shutdown occurs, the red shutdown light will be on and the top line of the display will indicate “SHUTDOWN.” The lower line will indicate the cause of the shutdown. A red indicator on the diagram indicates the area needing service.

SERVICE ADVISORIES

The ES+ controller turns on an advisory when it detects operation which needs service attention, but does not warrant shutting down the compressor. Some of these are normal maintenance procedures, and are intended to serve as a reminder to perform routine service. Others are conditions which can reduce the maximum compressor performance. It will remain in effect until reset. Check the display during routine inspections, and perform maintenance as suggested. Refer to the troubleshooting section for detailed information about each advisory.

Temperature advisories may be cleared while the unit is running by simply pressing the ENTER key. To reset the service advisories, press the STOP/RESET key to stop operation of the compressor. After it has stopped, disconnect power and service as required. After servicing, restore power and reset the board as indicated in the programming / maintenance section below.

PROTECTIVE SHUTDOWNS

The “AUTO SENTRY®–ES+” will shut down the unit following any fault detected in the following devices. Long–term problems will have a brief blowdown period before fully shutting down. Following a shutdown, a message will be displayed, with the top line indicating “SHUTDOWN” and the lower line indicating the cause. The shutdown light will be steadily lit if the cause still exists, or will flash if the cause has been cleared. Refer to the troubleshooting section for detailed information about each shutdown. To resume operation, the cause of the shutdown must be corrected and the controller reset by pressing the “STOP/RESET” key.

Motor Protective Devices – Overload heaters are furnished for the starter in the voltage range specified. There are three (3) overloads in the starter of proper size for the starter and its enclosure. Note that motor nameplate current must be multiplied by 0.577 for wye–delta starters. The display will indicate that an overload relay has tripped. The overload relay is reset by pressing the button on the relay itself, then the controller may be reset. Motor current (amps) and voltage must be measured in the affected motor wiring to locate the cause for high current. Proper starter coil and contact action is also monitored and errors in operation will cause a shutdown with the cause displayed as a starter or starter contact error.

High Temperature – The compressor is protected from high discharge temperature by a thermistor probe located in the compressor discharge elbow. The “AUTO SENTRY–ES+” will shut the compressor down if temperature exceeds 225° F (or lower per user adjustment) or if rapid temperature rise is detected. Res-

ervoir / separator temperature is also monitored, and will provide high temp shutdowns. The location of the temperature fault will be displayed. Thermistor probes are also checked for open or shorted circuits, and the display will indicate the location of the defective probe.

⚠ CAUTION

Machine damage will occur if compressor is repeatedly restarted after high temperature stops operation. Find and correct the malfunction before resuming operation.

Separator Differential Pressure – The pressure drop across the separator is continually monitored by the "AUTO SENTRY®–ES+". The unit will be shut down at a differential pressure of approximately 15 psid.

The pressure drop can be monitored at any time by pressing the separator key on the diagram twice. This should be checked while the compressor is delivering at full capacity. A service advisory comes on to recommend maintenance prior to this shutdown.

High Pressure – The "AUTO SENTRY®–ES+" will first attempt to unload and blow down the unit if excessive pressures are detected in the reservoir or the plant system. If unsuccessful, a shutdown will occur. Shut down will also occur if a defective transducer is detected, or improper zero adjustments are detected. The display will indicate the location of the high sensed pressure or transducer (xducer) error. Check that all adjustments have been properly made, and all connections are secure.

Low Oil Pressure – The "AUTO SENTRY®–ES+" will shutdown the unit if inadequate oil pressure is detected after loading the compressor. If this occurs, check the wiring and piping to the solenoid valves.

Emergency Stop – Press the emergency stop button to shut down the unit and the controller. To restart, pull the button out to its normal position and reset the controller. This should be used for emergency purposes only – use the keypad "STOP/RESET" for normal controlled stopping.

Power Failure – Following power interruptions, the controller will remain in a shutdown state (unless programmed for auto restart).

External Device – This input is provided for user– or dealer– installed devices needed by specific applications. Other shutdown field selectable messages include: high vibration, phase relay, low voltage relay, and water press.

Amp Sensor Failure – The optional current sensor used with the ES+ controller is used for operational tuning and advisory purposes only. The only shutdown functions are those when the controller senses improper operation.

Connection Failure – The ES+ controller checks input connectors and will shutdown if they become unplugged.

Other Shutdowns – The controller runs continuous diagnostic checks of its own operation and the sensors to which it is connected. Refer to the service section for a complete listing of shutdowns and remedial actions.

PROGRAMMING AND SETUP INSTRUCTIONS FOR THE AUTO SENTRY®–ES CONTROLLER

Programming and setup is accomplished with the PROGRAM keys. See FIGURE 4–1, page 19. In all steps, the [ENTER] key enters the displayed value into memory and advances to the next programming function. The plus [+] and minus [–] keys will increase and decrease displayed numeric values, or step through menu selections. During numeric adjustments, the left [<] and right [>] arrow keys, move the cursor (flashing digit) to the position desired. Use the [+] and [–] keys to change the number at the cursor. At any point in the programming and setup routine, the [STOP–RESET] key can be pressed to exit the adjustment mode without altering the adjustment. In all steps of the programming routine, the top line of the display will give a description of the parameter to be programmed, while the bottom line shows the variable that may be altered or stored.

The following is a step–by–step guide to programming the "Auto Sentry–ES+". Remember, between each step, it is necessary to press the "ENTER" key to store the new value and advance to the next step.

Main Adjustments Menu

1. The compressor must be stopped prior to making any adjustments. If the unit is running, press the [STOP/RESET] key to place the control in the "READY" state.

   Adjustments can also be performed from the "SHUTDOWN" state. After adjustments are completed, the ES+ controller returns to the this state until the cause is repaired and the controller is manually reset.

2. Press the [ENTER] key to begin programming. This enters the adjustments menu. The adjustments are broken into five groups as shown in FIGURE 4–2, page 22. To select a group, press [+] or [–] until the desired group is shown on the bottom line of the display. Press [ENTER] to proceed to the group adjustments detailed below.

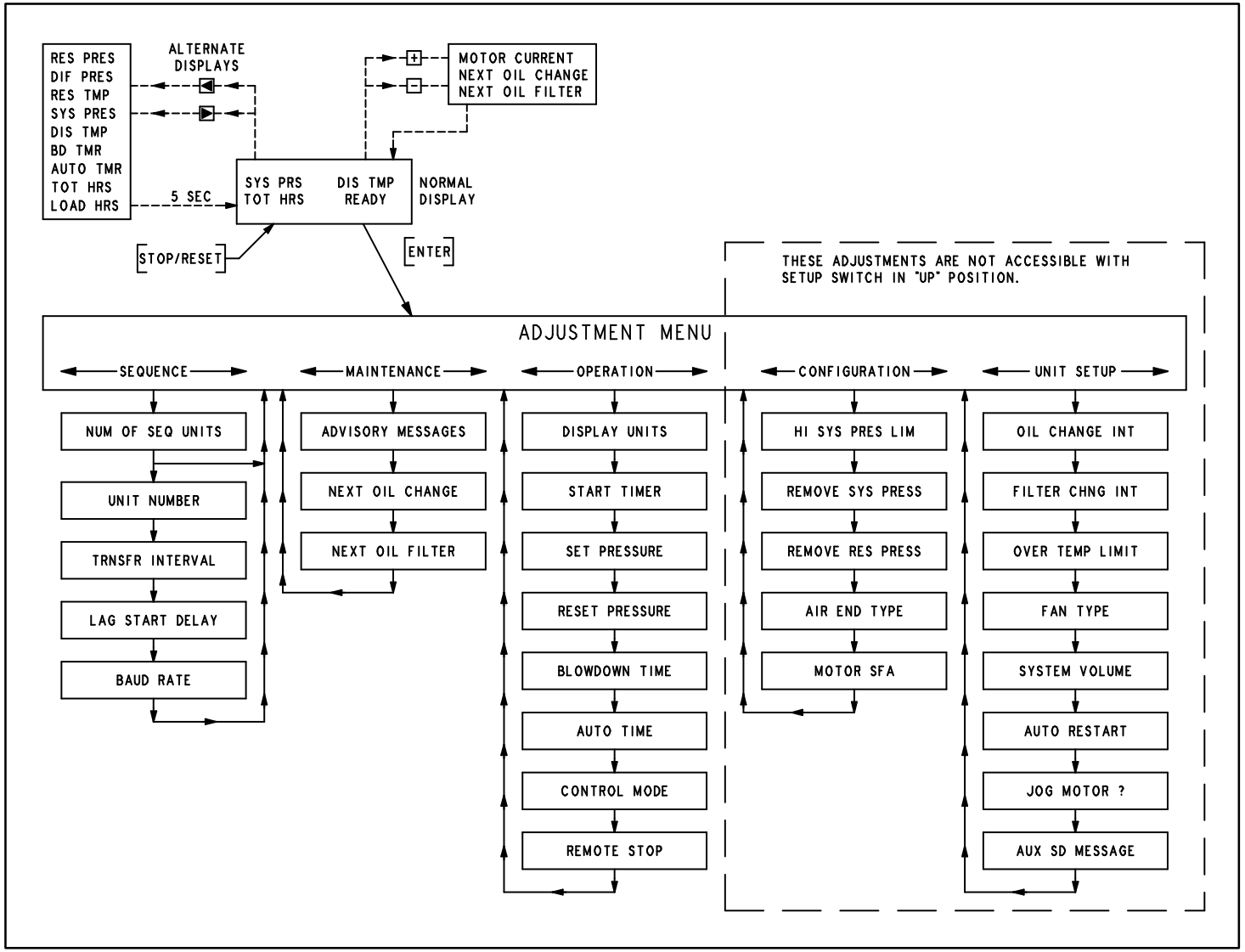


FIGURE 4–2 – FLOW CHART FOR SET–UP PROGRAMMING

Note: Configuration adjustments are normally required only at the time of assembly or after parts have been replaced. Unit setup adjustments are normally required only at the time of unit installation. To prevent accidental access, these will not be available if the "SET" switch is in the position closest to the corner. The "SET" switch is located on the bottom of the controller chassis, on the side behind the program keypad area. If the switch is towards the center of the controller, all five adjustment sections are accessible.

Operation Adjustments

1. In the top line, "**DISPLAY UNITS**" is indicated. The bottom line will indicate "ENGLISH" (PSIG, Fahrenheit) or "METRIC" (Bars, Celsius) units of measurement. Select the desired display units and press [ENTER] to proceed.

2. In the top line, "**START TIMER**" is displayed. The bottom line will indicate a time between 3 and 10 seconds. This is the time that the controller spends in the unloaded 'start' mode. This also controls the operation of package–mounted wye–delta starters, if so equipped. Set this adjustment for the amount of time needed for the motor to reach its highest speed while starting. This is typically 3 seconds for full–voltage starters, 7–9 seconds for wye–delta starters.

   If a remote–mounted, reduced voltage starter is used, set this adjustment 1–2 seconds longer than the starter's internal timer.

3. In the top line, "**SET PRESSURE**" is displayed. The bottom line will indicate a pressure value. It is to be set at the nameplate rating of the compressor for normal operation. Under NO circumstances, is this adjustment to be set in excess of the compressor nameplate pressure. It may be set lower, if desired, to reduce pressure and power consumption.

4. In the top line, "**RESET PRESSURE**" is displayed. The bottom line will indicate a pressure value. This setting determines the point at which machine startup occurs in AUTO and SEQUENCE modes and when the compressor will load up from the blown down condition. Note that RESET PRESSURE can be set up to 5 PSI below SET PRESSURE. Set this lower to reduce compressor cycling. All sequenced machines must have the same SET and RESET PRESSURE setpoints.

5. In the top line, "**BLOWDOWN TIME**" is displayed. The bottom line will indicate a time between 5 and 20 minutes. It is factory set at 10 minutes. This is the minimum time interval between blowdowns. A longer blowdown time minimizes wasteful dumping of compressed air when loading is likely to occur in a short time.

6. In the top line, "**AUTO TIME**" is displayed. The bottom line will indicate a time between 5 and 20 minutes. It too, is factory set at 10 minutes. Its function is to prevent too frequent motor starting, and to allow the motor a 'cool–down' period before stopping.

7. "**IV CONTROL MODE**" is displayed on the top line. Select "MODULATING" for standard operation. "LOAD–UNLOAD" may be selected for systems with large storage and wide pressure differential.

8. In the top line, "**REMOTE STOP**" is displayed. The bottom line indicates either "TIMED" or "IMMEDIATE". Refer to the description of "Remote On / Off" later in this section for additional details. Select the desired response to the remote input and press [ENTER] to proceed.

9. This completes the operational adjustments. The controller will return to the main adjustments menu.

Maintenance Adjustments

1. If any service advisories are in effect (yellow ADVISORY indicator is on), they will be displayed on the top line. The bottom line indicates "**LEAVE ADVISORY**" (do not reset) or "**CLEAR ADVISORY**" (turn it off). Select the desired action and press [ENTER] to proceed.

   Note that both the "CHANGE OIL" and "CHANGE OIL FILTER" advisories are based on operating time. These timers are not automatically reset on the ES+ when the advisory is turned off, and the advisory will come back on shortly after the unit starts running. If the oil or filter has been changed, clear the advisory as noted above, then proceed to the following steps to reset the appropriate timer back to its full value.

2. The top line displays "**NEXT OIL CHANGE**" and the estimated hours remaining are displayed on the bottom line. The actual time will be affected by operating conditions which affect oil life. Press the [+] or [–] keys to switch to the oil change interval (see UNIT SETUP) if service was performed early. Press again to change back to remaining time. When the desired value is shown, press [ENTER] to save and proceed to the next step.

   If the advisory message is on, it must be cleared as noted in step 1.

3. The top line displays "**NEXT OIL FILTER**" and the hours remaining are displayed on the bottom line. Press the [+] or [–] keys to switch to the oil filter in-

terval (see UNIT SETUP) if service was performed early. Press again to change back to remaining time. When the desired value is shown, press [ENTER] to save and proceed.

If the advisory message is on, it must be cleared as noted in step 1.

4. This completes the maintenance adjustments. The controller will return to the main adjustments menu.

Sequence Adjustments

See "SEQUENCING COMPRESSORS WITH THE AUTO SENTRY–ES+", page 26, for more details on setting up and optimizing a sequenced compressor installation.

1. In the top line, "**NUM OF SEQ UNITS**" is displayed. The bottom line will indicate a number in the range of one through eight. This will be factory set at "1". This should be set to a number corresponding to the number of compressors that are currently installed on this air system that also have AUTO SENTRY–ES+ controllers. It should be noted that all AUTO SENTRY–ES+ compressors on the system must have the same number programmed here to operate correctly in SEQUENCE mode. Adjust as required, and press [ENTER] to proceed.

NOTICE

Setting the value in step 1 to one indicates that no sequencing is to take place. Consequently, steps 2, 3, and 4, which relate to sequencing, are skipped by the "AUTO SENTRY®–ES+"; the controller will return to the main adjustments menu.

2. In the top line, "**UNIT NUMBER**" is displayed. The bottom line will again indicate a number of one through eight and is factory set at "1". Enter a different number for each "AUTO SENTRY–ES+" in a sequenced system. The sequence mode will not function properly if two or more compressors have the same UNIT NUMBER. Example: 1, 2, and 3 for a three compressor installation.

   This is the only setting which must be different for each member of a sequenced system. All other settings should normally be the same for all members.

3. In the top line, "**TRANSFER INTERVAL**" is displayed. The bottom line will indicate a number of hours in the range of 1 to 5000. It is factory set at 24. This is the number of hours that this machine will stay in the role of "lead" compressor.

   Normally it is desirable to set this to the same value on all sequenced units to equalize running hours. Different values may be programmed, if desired, to help equalize hours.

4. In the top line, "**LAG START DELAY**" is displayed. The bottom line will indicate a number in the range of 1 to 600 seconds. It is factory set at 30. This is the length of time this machine will wait before starting when the pressure drops below the reset point. This delay period begins when a previous member of the system is loaded. This should be set to the same value for all sequenced units. Its setting will depend on the amount of air storage volume in the system. Too small a number will result in more compressors being started than is necessary to satisfy demand.

5. The controller displays "**BAUD RATE**" on the top line, and a selection between "1200" or "9600" on the lower line. The controller can operate at either speed. Select the desired value, and press [ENTER].

6. This completes the sequence adjustments. The controller will return to the main adjustments menu.

Configuration Adjustments

1. In the top line, "**HI SYS PRES LIM**" is displayed. The bottom line will indicate a value that is factory set 20 – 25 PSI above name plate. This is the pressure that will cause a shutdown if exceeded due to a malfunction such as a stuck inlet valve or broken control line. This should be set at or slightly below the rating of the pressure relief valve. The controller will attempt a number of actions as it approaches to prevent the pressure from reaching this limit.

NOTICE

The controller will automatically adjust the set and reset pressures as required if this limit is lowered.

2. In the top line, "**REMOVE SYS PRESS**" is displayed. The bottom line displays the current pressure being sensed at the package discharge. At this point steps must be taken to ensure that sys-

tem pressure is, in fact, zero psig. Remove the pressure line to the system pressure transducer. Pressing [ENTER] will now cause the "AUTO SENTRY–ES+" to calibrate the transducer output to zero PSIG. Obviously, pressure measurement errors will be encountered if 'zeroing' is done with pressure at the transducer. If large errors are detected, the controller will demand that the transducer be checked.

3. In the top line, "**REMOVE RES PRESS**" is displayed. The bottom line displays the current pressure being sensed in the reservoir. The reservoir pressure transducer may now be 'zeroed' by following the steps outlined in 2 above.

4. In the top line, "**AIR END TYPE**" is displayed. The bottom line displays the current selection. Set as appropriate for the compressor.

5. "**MOTOR SFA**" is displayed on the top line. This should normally be set for either the motor nameplate service factor amps (SFA, if given) or for the motor nameplate full load amps (FLA) times the motor nameplate service factor (SF). It may be set lower, if desired. Refer to other features, later in this section, for additional details.

   On units built without current monitoring, this is set to zero to disable the current monitoring functions.

6. This completes the configuration adjustments. The controller will return to the main adjustments menu.

Unit Setup Adjustments

1. In the top line, "**OIL CHANGE INTERVAL**" is displayed. The bottom line will indicate a time interval of 1000 to 8000 hours. After the machine has run for the programmed setting, an advisory will be displayed, requesting an oil change. Adjust as desired and press [ENTER] to proceed.

2. In the top line, "**FILTER CHNG INTERVAL**" is displayed. The bottom line will indicate a time interval of 500 to 1000 hours. After the machine has run for the programmed setting, an advisory will be displayed, requesting an oil filter change. Adjust as desired and press [ENTER] to proceed.

3. In the top line, "**HI TEMP LIMIT**" is displayed. The bottom line will indicate 225 degrees F. This is the maximum (and proper) setting for compressor operation. It may be temporarily lowered to verify the function of the temperature shutdown system.

4. "**FAN TYPE**" is displayed next on the top line. Select "AIR COOLED" for units with package–mounted air coolers only. This will delay fan startup until the oil has warmed up in the package. Select "WATER COOLED" for water cooled units or any unit with a remote cooler. This will run the fan whenever the compressor motor runs.

5. In the top line, "**SYSTEM VOLUME**" is displayed. The bottom line may be selected as "SMALL", "MEDIUM", or "LARGE". This tunes the response of the modulation control loops to optimize loop stability. It is factory set to MEDIUM. Set as follows:

   SMALL if estimated volume is less than .25 gallon per CFM.

   MEDIUM if estimated volume is between .25 and 1.0 gallon per CFM.

   LARGE if estimated volume is greater than 1.0 gallon per CFM.

NOTICE

The setting of this parameter is not critical. When set to the most appropriate value, the controller will maintain the discharge pressure with minimized modulation changes.

6. In the top line, "**AUTO RESTART**" is displayed. The bottom line will indicate either "OFF" or "ON". The factory setting is "OFF", and the controller will display a power failure shutdown after power has been restored.

   Set this feature to ON when it is necessary to have the compressor automatically restart after a power interruption. There will be a brief delay, then the control resumes the mode it was in prior to the interruption. This feature shall only be enabled when the owner determines that it is safe to do so. It is recommended that compressor access be limited to only trained service personnel when this feature is used.

7. This step is only encountered if the AUTO RESTART function was set to ON in the previous step. In the top line, "**RESTART TIME**" is displayed. The bottom line will indicate a time between 5 and 60 seconds. It is factory set at 10 seconds. This is the amount of delay introduced before restarting after power has been restored. Set it as desired to allow time for power to stabilize before starting compressors.

8. The display now reads "**JOG MOTOR?**" and indicates the amount of time to energize the starter. Adjust with the [+] or [–] key to the smallest value needed to bump the motor and check rotation. 0.1

to 0.2 seconds is normally adequate for factory–furnished full–voltage starters; wye–delta or remote starters may require a little more time. Set back to zero to proceed to the next step.

9. In the top line, "**AUX SD MESSAGE**" is displayed. The bottom line will display the message which will appear if power is removed from terminal 7. Select the most appropriate message for user–furnished shutdown devices, and press [ENTER] to proceed.

10. This completes the unit setup adjustments. The controller will return to the main adjustments menu.

OTHER CONTROL FEATURES

Modulating – Load / Unload – The ES+ controller offers two control modes, to suit the needs of different applications with different storage capacity.

When set for "**MODULATING**", the controller will start and load whenever the pressure drops below the reset pressure. Continuous modulation by the turn–valve (if so equipped) and the inlet valve will maintain the discharge pressure near the set pressure for any CFM demand from full capacity to very light demand. The inlet and turn valves are coordinated to always use the most efficient and appropriate control. At very light or zero demand, the compressor will completely unload, blowdown, and stop as appropriate for the selected operating mode. This is the normal control mode for the compressor, and is preferred for almost all applications.

When set for "**LOAD–UNLOAD**", the controller will start and load whenever the pressure drops below the reset pressure. When the pressure rises to the set pressure, it completely unloads. If the blowdown timer has not timed out, the compressor will reload when the system pressure drops below the midpoint between set and reset pressure. If the blowdown timer has timed out, the reservoir will blow down, and reload will not occur until the pressure drops below the reset pressure. Use a large receiver volume or wide difference between set and reset pressure to prevent rapid cycling.

Current Limiting – Current limiting is available when an ES+ controller is used on a compressor unit with turn valve control and has current monitoring installed. This is based on the motor service factor amps programmed above.

On units with turn valves, the controller will unload as required to prevent operation above the programmed service factor amps. This continues operation of the compressor at reduced delivery, but within the programmed limit. This limiting will occur in either the modulating or the load–unload mode of operation.

This feature takes control only if operating conditions are outside of the compressor unit's design range. Low operating voltage, in particular, can cause high amp draw. This will heat the motor beyond its design, and will normally trip the overload relay to prevent motor failure. The ES+, however, will automatically reduce the delivery to continue operation within design limits. If severe conditions persist, The controller will display "**HIGH MOTOR AMPS**."

This feature is also coordinated with the ES+ sequencing controls. During low voltage conditions, lead units will operate only up to their limits. If necessary, another compressor will start to meet the air demand.

Auto Restart After Power Failure – The ES+ controller normally displays "**SHUTDOWN – POWER FAILURE**" after power has been interrupted and restored. Press the STOP / RESET key and select an operating mode to restart the compressor.

If programmed for automatic restart, The ES+ controller pauses and begins counting down when power is restored. This time is adjustable in the programming steps noted above. This must be at least several seconds, but may be set longer to allow other plant loads to start up first. After the countdown is complete, the ES+ controller resumes the mode of operation prior to the power interruption.

If this is enabled in a sequenced system, set all of the timers to the same value. All ES+ controllers will the resume the same sequence numbers which they had prior to the interruption. The ES+ sequence controls will start the lead unit after the start timer countdown, and add units individually as required, based on the lag start delay.

SEQUENCING COMPRESSORS WITH THE AUTO SENTRY–ES+

General – The sequencing mode is used to operate multiple compressors in a common plant air system. The individual units operate similarly to operation in the automatic mode, except that the setpoints are under control of the sequencing system. This system is actually distributed among the individual ES+ controllers and compressor units, with communications between them to keep the system coordinated. Sequencing is intended to start, run, unload, blowdown, and stop compressors in response to changes in demand during the day or week.

The ES+ controller is designed for systems of two through eight compressors piped into a common air receiver for distribution to the plant. In any such system, the receiver is an important part of the application; it supplies air to the plant and allows compressor units to be unloaded and stopped. This stored reserve eliminates the need to operate "spinning reserve" of unloaded compressors. This storage may be an air receiver, or may be the volume of air in a large distribution system. In either case, the compressors must be piped to this volume with a minimum of restriction. The ES+

control system will operate only as many compressors as are needed to supply the CFM demand of the plant, and to maintain the compressor system pressure between the SET and RESET pressures programmed into the controllers.

The ES+ controllers are completely set up to operate this system. The only required additional part is the cable which runs from controller to controller. A kit, 200EAP752, is available which contains all material needed to sequence up to five compressors. This kit contains 500 feet of cable, eight modular connectors, and a crimping tool to install the connectors.

NOTICE

Though similar in operation and installation, this sequencing system is designed to take advantage of all of the internal features of the ES+ controller. Communications cables should not be connected to compressor units with ES controllers part number 201EAP1173 or 202EAP1173. Multiple compressors with each type controller may be operated as independent groups piped to the same plant demand.

In spite of the fact that it is a standard feature and its inherent installation simplicity, the sequencing function of a multi–compressor "AUTO SENTRY–ES+" system is the most fully–featured, functionally–complete available today.

Compressor System – A proper sequencing installation requires two or more Gardner–Denver rotary air compressors complete with "AUTO SENTRY–ES+" controllers, piped into a common air system, interconnected as described above. For best performance, connect the units directly to a common header and receiver, without any intervening dryers, filters, or other restrictions. If any equipment must be installed on individual compressors, select equipment with minimum pressure drop. If filters are installed, establish a maintenance procedure to prevent clogging filters from upsetting the system. There should be no check valves or other devices which isolate a member from the air system. During operation, be sure that any unit is taken out of the sequence mode before closing its service valve.

The receiver should also be sized to prevent excessive drops or rapid rises in pressures during the operation as described below. Note that "receiver" really applies to the entire storage volume of a physical receiver and the volume of the air distribution throughout the plant. Modulating systems work best when the receiver is at least one gallon for the rated CFM of a member compressor in the system (the largest if they differ). If the system is operated load–unload, larger volume or wider differential may be needed to prevent unnecessary starts or rapid compressor cycles. Note that when demand exceeds the capacity of the running unit(s), there will be a delay until the next unit starts and delivers additional air. The stored air serves the plant during this period. With a properly sized receiver, pressure changes on a receiver gauge should be very slow and gradual.

All standard practices common to sound air compressor installations such as proper sizing of piping, proper electrical supply and conductor sizing, and grounding are to be observed. Run the compressors in the system in Automatic mode for at least one week to evaluate system performance.

Sequencing Installation – Once the compressor system is set up, sequencing compressors with the AUTO SENTRY–ES+ controller is as simple as plugging in a telephone to a wall jack. The only item required to make the system functional is a cable similar to a phone cable. The cable and connectors used in kit 200EAP752 have been specially selected to meet the needs of an industrial application. One less cable than the number of compressors to be sequenced is required. For example, to sequence four compressors, three cables are required.

The serial communications interface meets RS–485 standards, the most widely used interface in harsh, industrial environments today. However, the communications cables should be routed through metallic conduit to provide them with both mechanical protection and electromagnetic shielding. Do not run the communications cable in a conduit with other wiring.

Each controller has two modular jacks which accept RJ–12 telephone plugs. One jack is vacant, the other has a short pigtail plugged into it. To interconnect two compressors, plug the cable into the vacant jack on each controller. For installations of more than two units, the pigtail plug must be disconnected on all controllers except the two at each end of the communications line. The order of interconnection has no effect on the system operation. The following conditions are necessary and sufficient for proper operation:

1. Every compressor must have a cable connecting it to another compressor. One less cable than the number of units sequenced must be used.

2. Each board that has only one cable connected to it must have its pigtail plugged into the unused jack. All installations will have two such units.

Program all members of the system, as described in the programming procedure on previous pages. All adjustments should be identical for each member, except for unit number. The sequencing system will make any necessary adjustments to the setpoints to properly run the compressed air system.

Operation – Press the SEQUENCE key on each of the compressors to start operation of the sequenced system. Once this is done, the member controllers will operate the compressor units as required to maintain the plant pressure between the programmed Set and Reset Pressures, for demands from 0 CFM up to the capacity of the system.

While operating, each controller will display a sequence number. As demand requires, the units will start and load in order, starting with sequence number 1 (lead unit). As demand falls, the higher sequence number units (lag units) will modulate, unload, and stop.

If any member of the system is taken out of sequence mode for any reason, other units with higher sequence numbers will automatically promote as required. Sequence numbers will start with 1, and will be assigned on other units up to the number of compressors in the system. This feature makes the system completely tolerant of any manual or protective stopping of any member.

ESTABLISHING THE INITIAL SEQUENCE

The first member compressor placed into sequence mode will become the lead unit. However, since any controller first placed into sequence has no way of knowing whether or not other members already exist, it will first assume the highest rotation number available. For example if the number of units to be sequenced is programmed at four, any compressor will start out in position four when placed in sequence mode. It will then listen for other units on the communications line.

If there is no member with the next lower sequence number, the controller will automatically promote itself. This movement is fairly rapid with the ES+ controller, and the number will advance to the lowest vacant position in several seconds.

To establish a desired order of units, press STOP/RESET or select any mode other than sequence (if already in sequence, put into auto mode if you wish to continue operation while doing this selection). Then put the desired lead unit back into sequence. Wait until it promotes one step (or longer), then put the desired #2 unit into sequence mode and wait until it promotes one step, and so forth until all units are back into the sequence mode.

During this procedure, the system is not deprived of air. This is due to one of the outstanding features of the "AUTO SENTRY–ES+" sequencing system: control is always executed locally by each member controller. So while a controller (or controllers) is/are counting down towards the final order, they are also capable operating their compressor and will deliver air. Once the sequence order is finally established, setpoints will continue to be adjusted in each member to provide operation in the preferred order. This may take several minutes after a manual change of sequence numbers.

ES+ SEQUENCE SYSTEM OPERATION

Each member compressor in the system operates similarly to the Automatic mode of operation. It will start, load, modulate, unload, blowdown, and automatically stop as necessary to meet system demand for air. There are several differences, however, when running in the Sequence mode.

The pressure shown on the top line of the display is the average system pressure of all the members. Each member communicates its local pressure through the communications cable, for use by others in the system for display and control. The system responds to this average. This number will be the same for all units in the system. To obtain the local package discharge pressure, select the "SYS PRESS" alternate display on the lower line.

Pressure setpoints are continuously adjusted, depending on the operation of the members. The last lag unit which is loaded will control its modulation to keep the system pressure near the programmed Set Pressure, and serves as the trim machine. Any running lead unit will be adjusted for slightly higher pressures, and will run at or near capacity. The first unloaded lag unit will have its reset pressure adjusted so it will come on line if the system pressure drops to the programmed Reset Pressure. The system is continuously adjusted to maintain the system pressure between the programmed Set and Reset Pressures.

If any lag unit is loaded, any preceding lead unit will be loaded. Its blowdown timer will reset and hold at full value. This ensures that the last lag unit will always be the first to unload and blow down, and lead units will be prepared to handle the demand.

When demand exceeds the capacity of the loaded lead compressor(s), the pressure will drop. If a lag unit is stopped, its restart will be delayed. This delay is the adjustable "Lag Start Delay". This allows time for lead units and stored air to serve intermittent demands, without starting another compressor. The next available member accumulates any time spent below Reset Pressure, and will start whether there are repeated brief demands or a sustained demand. The Lag Start Delay timer does not begin timing until the preceding member of the system is loaded.

SEQUENCED SYSTEM CHECKOUT

One of the best indicators of the stability of the system is to compare the local system pressure of a running unit with the system average pressure. To do this, simply press the [<] or [>] cursor keys until the lower line of the display shows SYS PRES and the local pressure. In a properly operating system, this value will be within 1–2 psi of the top line value, and will change slowly as demand and delivery are changing. Rapid and large changes in local pressure indicate system problems. Ensure that all compressor units are piped to a common system pressure with adequate storage to handle the plant demands. Select other operating modes if rapid response to large demand changes is needed.

The system is redundant, and will tolerate any breakdown in communications. If any unit is taken out of the Sequence mode, other members will “fill the gap” to keep the system operating. If a break should occur in the communications cable, the compressors will continue to function as two systems, one on each side of the break. Each will have its own lead unit (Seq 1) and may have lag units (depending on how many ES+ controllers are on that side of the break). Look for a cable break if there are multiple units with the same Sequence number displayed.

Each ES+ controller also monitors the communications data for errors. If these occur, the yellow advisory will come on, and the controller displays a message to check the communications port. If this message comes on, and one member changes to “AUTO” operation, then it has been mistakenly programmed with the same Unit Number as another member. Refer to programming instructions above for instructions on programming.

Automatic Rotation – After the lead compressor has served for the duration programmed (TRANSFER INTERVAL), it relinquishes control and assigns itself the highest available rotation number. The lag compressors detect the loss of the lead unit and decrement their rotation numbers. Number 2 becomes number 1, the new lead unit, number 3 becomes number 2, etc. The former lead unit will become the last lag unit.

The transfer interval timer operates whenever a member is the lead (Seq 1) unit of the system. It will continue to time out regardless of other units in the system. The remaining time is retained during power interruptions. It is reset back to full value if the controller is in any mode other than Seq 1.

Other Sequencing Features – Any air system will exhibit pressure differences from one point to the next. Even a well designed multi–compressor installation will show ’minor’ pressure variations between one compressor’s discharge point and another compressor’s discharge. These points will also vary from the actual system storage (normally the air storage receiver). The “AUTO SENTRY–ES+” sequencing system is designed to tolerate minor variations. The “AUTO SENTRY–ES+” sequencing system will automatically adjust the system setpoint to maintain the average system pressure. Overpressures within any member compressor are prevented locally, and other members will load up to meet the demand. When a turn valve compressor is provided with current monitoring, the controller will also shed some load on any overloaded unit, and lag units will load as required to service the demand. The dynamic setpoint control is completely automatic and is continuously adjusted.

If airflow is restricted between the compressor units and the common storage, the ’minor’ variations described above become more significant. The pressure in the receiver will always be lower than that sensed by the compressor system. The ES+ system will tolerate this, and will still maintain the average pressure within limits. These restrictions will spread modulation over several units, rather than showing the strong preference to unload the last loaded lag unit.

The Lag Start Delay timer of any member does not begin timing until the preceding member of the system is loaded. This is particularly useful when starting up the system, as compressors will be started one at a time. This sequenced starting happens if the members are controlled by their remote inputs. If programmed for automatic restart after power failure, the lead unit will be delayed by the automatic restart delay, then each additional unit will be delayed by the lag start delay.

CONNECTION TO EXTERNAL CONTROLS

The ES+ controller offers interconnection points for external controls and indicators. This allows simple connection to remote controls and indicators, or integration into any plantwide controls system.

Remote On / Off – Remote on–off control of the system requires only a simple two–wire control, with an isolated contact suitable for 120 volts, 1 amp. This may be a switch, a timer contact, a relay contact, or a PLC output. To connect, simply run the two wires to the control enclosure, remove the jumper between terminal 6 and terminal 9 on the terminal strip, and connect the two wires to terminal 6 and terminal 9.

The air compressor will operate normally in its selected mode whenever this contact is closed (turned on). Note that the keypad is always the master control; the operating mode must be selected at the keypad. When the contact is opened (turned off), operation depends on how the controller has been programmed and what it is doing prior to opening the contact.

If the compressor was already stopped in automatic or sequence modes, it will remain stopped and will not restart until the contact is closed. The display will flash

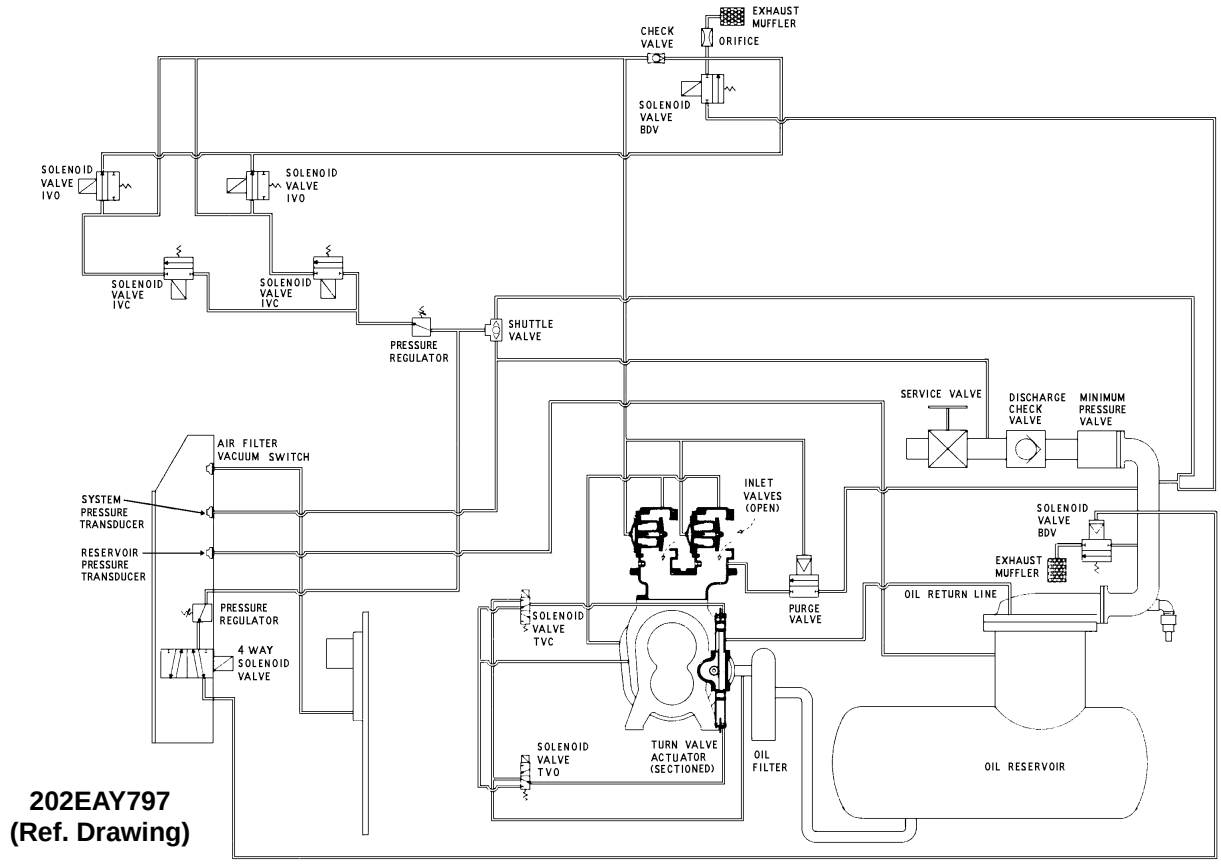


FIGURE 4–3 – SCHEMATIC TUBING DIAGRAM

the message “REMOTE HALT” to indicate that it is waiting for the remote signal.

If the compressor was running in any mode when the contact was opened, and the remote response is programmed for “IMMEDIATE”, the compressor will immediately unload, and will run only until the reservoir is blown down. Then the motors stop, and the unit will be in the “REMOTE HALT” mode as indicated above.

If the compressor was running in any mode when the contact was opened, and the remote response is programmed for “TIMED UNLOAD”, the compressor will immediately unload and blowdown. It will then continue to run unloaded for whatever period has been programmed for “AUTO TIME” (or will complete the remaining auto time if already blown down). The controller displays “REMOTE UNLOAD” during this period. After completion, the motors will stop, and the unit will be in the “REMOTE HALT” mode as indicated above.

When the remote is turned back on, the unit will start immediately in the CONSTANT or LOW DEMAND modes. Loading in these modes, or starting in AUTO or SEQUENCE modes will occur when the pressure drops below the set pressure.

The remote is not capable of restarting following a SHUTDOWN. The unit must be serviced and reset locally.

Alarm Relay – The ES+ controller is provided with an alarm relay which may be connected to a remote mounted indicator light, horn, or into a PLC input of a plantwide control system. The contact is commercial rated 2 amps at 120 volts. The relay is turned on whenever there is a SHUTDOWN condition requiring service at the compressor, and remains off during normal operation, stopping, or power off conditions. The external connections from the controller are from an isolated form C (single–pole, double–throw) contact. This allows control of either a “compressor okay” or a “compressor shutdown” remote indicator.

To use this relay, connect the supply wire for the remote circuit to terminal 21 (relay common) on the terminal strip. Connect a wire to the indicator from either terminal 19 (normally open) or from terminal 20 (normally closed). Connect the other side of the indicator to its neutral.

Serial Communications – The RS–232 port is available for serial communications of compressor data to external monitoring systems at any time. If units are NOT connected in sequence, the RS–485 port may be used for multi–drop communications of compressor

data to external monitoring systems. Data available include all pressures and temperatures, and a reports of internal service data. This is accessible with a PC or PLC with an appropriate communications port. For protocol information, request drawing 201EAU1255.

OTHER CONTROL DEVICES

Besides the electronic controller noted above, the following components are also used to control operation of the compressor unit.

Relief Valve – A pressure relief valve(s) is (are) installed in the final discharge line and set to approximately 120–125% of the unit's full load operating pressure for protection against over pressure. Periodic checks should be made to ensure its (their) operation.

The relief valve should be tested for proper operation at least once every year. To test the relief valve, raise the system operating pressure to 75% of the relief valve set pressure and manually open the valve with the hand lever. Hold the valve open for a few seconds and allow it to snap shut.

⚠ WARNING

When the relief valve opens, a stream of high velocity air is released, resulting in a high noise level and possible discharge of accumulated dirt or other debris. Always wear eye and ear protection and stand clear of the discharge port when testing the relief valve to prevent injury.

⚠ CAUTION

Never paint, lubricate or alter a relief valve. Do not plug vent or restrict discharge.

⚠ WARNING

Operation of unit with improper relief valve setting can result in severe personal injury or machine damage.

Insure properly set valves are installed and maintained.

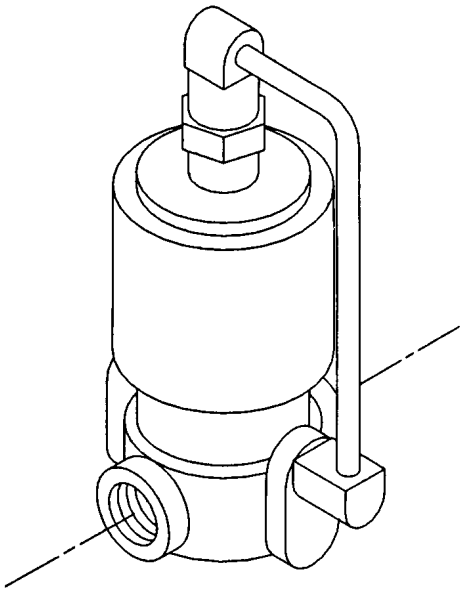


FIGURE 4–4 – BLOWDOWN VALVE

Blowdown Valve (FIGURE 4–4) – This valve normally is used for control functions, but also serves to relieve reservoir pressure following a shutdown. The blowdown valve is a two–way solenoid valve which is piped into the oil reservoir outlet ahead of the minimum pressure valve. When the solenoid is de–energized, the valve opens and the coolant system is blown down. When the solenoid is energized, the valve closes to allow the coolant system to pressurize. A control air check valve is provided to ensure that the inlet valve is closed during blowdown.

Oil Level Gauge (FIGURE 1–5, Section 1, page 3) – This gauge is located on the oil reservoir and indicates the oil level. See section 5 for information on how to correctly read the gauge and proper lubrication.

Minimum Discharge Pressure/Check Valve (FIGURE 4–5, page 32) – An internal spring–loaded minimum pressure valve is used in the final discharge line to provide a positive pressure on the coolant system of the compressor even if the air service valve is fully open to atmospheric pressure. This valve also functions as a check valve to prevent back flow of air from the shop air line when the unit stops, unloads, or is shut down.

The valve incorporates a spring–loaded piston which maintains approximately 65 psig in the oil reservoir. When the air pressure on the upstream (reservoir) side of the valve rises above 65 psig, the spring is overridden and the valve opens to full porting.

The valve does not require maintenance or adjustment. If the valve fails to function, check the valve stem O–

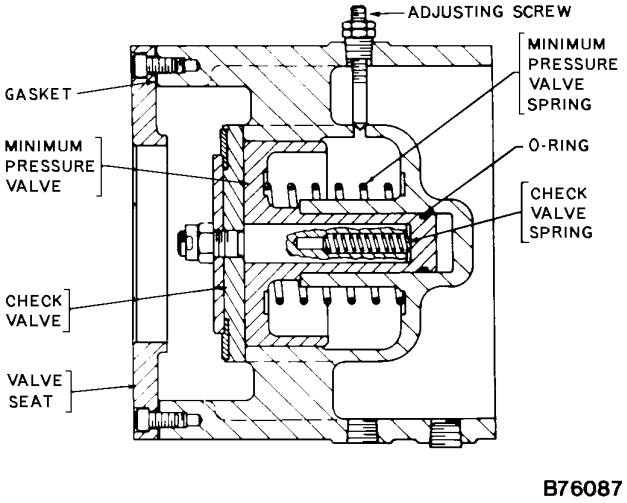


FIGURE 4–5 – MINIMUM DISCHARGE PRESSURE / CHECK VALVE

ring for sealing, valve orifices for restriction, or valve and valve seat for burrs and dirt.

The valve is adjustable within a small range. It is adjusted by a screw on the side of the valve. By turning the screw, the minimum pressure to open the valve increases. Conversely, backing it out decreases the minimum pressure required to open the valve.

To service the valve, unscrew the valve cap from the body. The internal parts will come out after the cap has been removed. Repair kits are available from your local authorized Gardner Denver Machinery distributor.

Inlet Valve (FIGURE 1–4, page 3, and FIGURE 4–6) – The Inlet valve restricts the inlet to control delivery and closes to unload the compressor. At shutdown, the inlet valve closes to prevent the back flow of air.

The inlet valve position is controlled by air pressure in its piston cylinder, which is controlled by the "Auto Sentry–ES+" through solenoid valves IVC and IVO. As Pressure to the piston is increased, the valve closes to restrict air flow and compressor delivery.

Solenoid Valves IVC and IVO – These valves control position of the inlet valve in response to signals from the "Auto Sentry®–ES+". With both valves de–energized, the normally open IVC valve allows control pressure to the inlet piston to close the valve. If IVC only is energized, the inlet valve is held in its current posi-

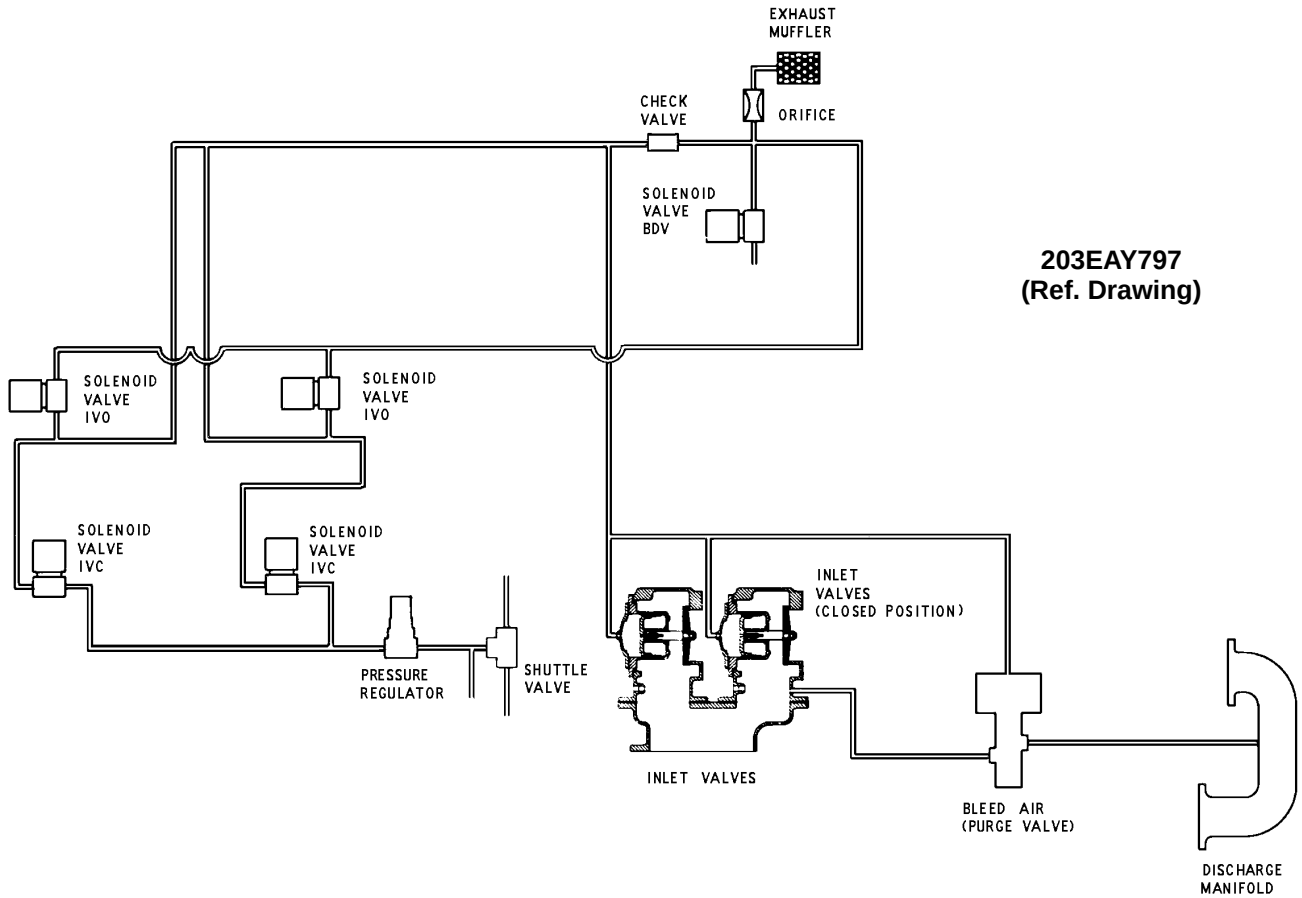


FIGURE 4–6 – INLET VALVE

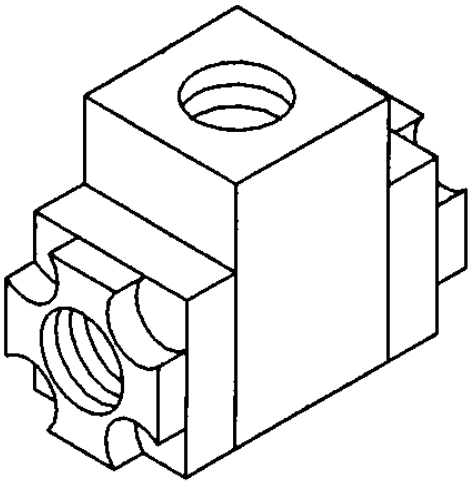


FIGURE 4–7 – SHUTTLE VALVE

tion. If both valves are energized, control pressure is relieved from the inlet piston to allow the valve to open.

Pressure Regulator – The pressure regulator is used to supply a constant and low control pressure to prevent damage to the inlet valve from "slamming." The regulator should be set for 25–30 psig.

Shuttle Valve (FIGURE 4–7) – Also known as a double check valve, the shuttle valve is a device which will take two (2) supply signals and allow the one with the highest pressure to pass through. The shuttle valve is used to provide control air pressure from either the reservoir or plant air system, as required during different operating conditions.

Purge Air Valve – The purge valve is a normally closed two–way air actuated valve that admits purge air from the final discharge manifold to the compressor to counteract the oil knock that occurs in oil–flooded rotary screw compressors when they are completely unloaded with pressure in the oil reservoir. This valve is controlled by the same control pressure which controls the inlet valve.

Turn Valve (Electra–Saver only) (FIGURE 4–8)– The turn valve is a helical valve which, when rotated, opens and closes a series of ports cast into the compressor cylinder. When these ports are open, they direct some of the air which would otherwise be compressed back to the inlet, reducing both capacity and power consumption.

Turn Valve Actuator (Electra–Saver only) (FIGURE 4–9, page 34) – The turn valve actuator is a rotary rack and pinion device which positions the turn valve according to system demand. Filtered oil from the compressor sump is directed to the outboard end of the two actuating cylinders to move the rack and rotate the valve. Located on the ends of the cylinders are adjusting screws which limit the travel of the actuator. The adjusting screw on the top adjusts the open position of the turn valve; the bottom adjusting screw adjusts the full closed (full load) position of the valve. The full load position of the actuator may be checked by removing the adjusting screw at the unloaded end of the actuator (top of the compressor) and using a rod to push the pistons to the full load position. The rod must be clean and free of burrs and scale. Take care not to scrape the cylinder walls when moving the pistons.

Solenoid Valves TVC and TVO (Electra–Saver only) – These valves control the position of the turn valve in response to signals from the "AUTO SENTRY–ES+" controller. With both valves de–energized, equal pressure is applied to both ends of the actuator to hold it in its present position. If TVC only is energized, the bottom of the turn valve actuator is exhausted to the compressor inlet cavity, causing the turn valve to move towards the full load position. If TVO only is energized, the top of the turn valve actuator is exhausted to the compressor inlet cavity, causing the turn valve to move towards the unload position. See "AUTO SENTRY–ES+ OPERATION" in this section for a description of

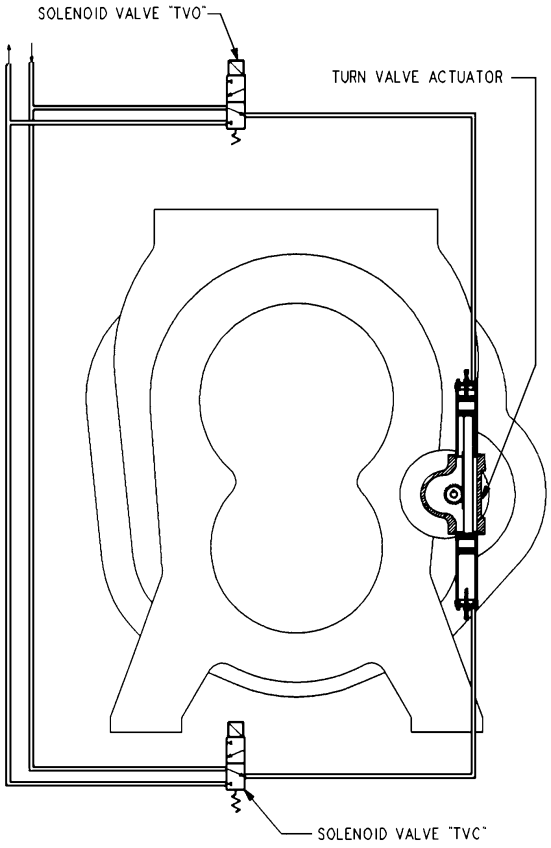


FIGURE 4–8 – TURN VALVE CONTROL

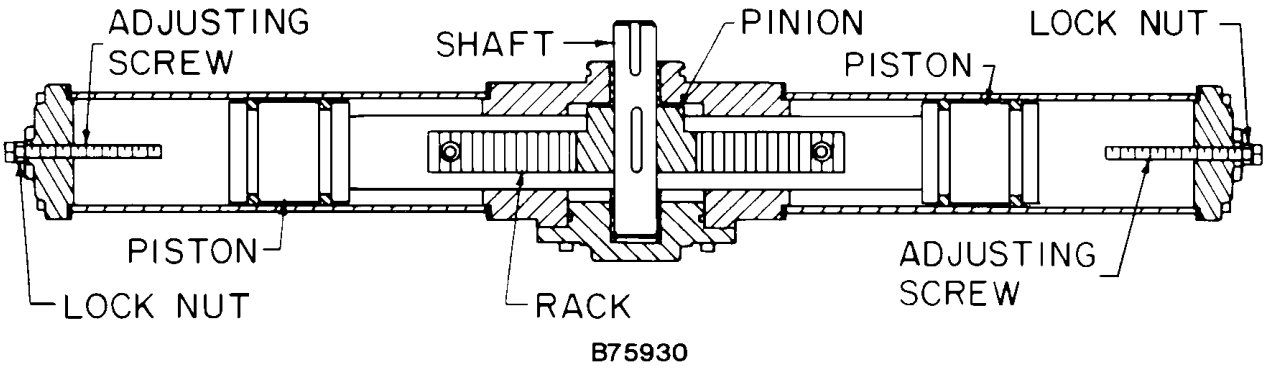


FIGURE 4–9 – TURN VALVE ACTUATOR

how the turn valve position is controlled during normal operation.

System Pressure Transducer – This transducer is connected after the minimum pressure valve. It converts the pressure in the plant air system into an electrical signal for use by the "Auto Sentry–ES+" controller for modulation and control.

Reservoir Pressure Transducer – This transducer is connected to the coolant system. Its signal is used to prevent loaded starts, monitor reservoir pressure, and monitor the condition of the air/oil separator.

Air Filter Vacuum Switch – This switch is used to monitor air filter condition and alert the user if the filter requires service or replacement.

Discharge Thermistor – This sensor is located directly in the compressor discharge. Its signal is used to monitor compressor temperature and shut down the compressor if a coolant problem is detected.

Reservoir Thermistor – This sensor is located near the separator and is used to monitor temperature and shut down the compressor if high temperatures are detected.

Emergency Stop Push–Button – This is a maintained push–button, and removes power from the controller outputs regardless of controller status. It is located on the upper section of the panel, next to the keypad. This should be used for emergency purposes only – use the keypad "STOP/RESET" for normal controlled stopping.

⚠ WARNING

Automatic restarting or electrical shock can cause injury or death. Open, tag and lockout main disconnect and any other circuits before servicing the unit.

Vibration Switch – The "Auto Sentry–ES+" controller has one additional input available for dealer or user installed optional shutdown switches. The switch is simply wired in place of the jumper between terminals 7 and 9 of the terminal strip. If the contact is opened, the compressor will be shut down, and will display "SHUTDOWN – HIGH VIBRATION".

The vibration shutdown switch is to be mounted on the compressor coupling cover, and detects an increase in vibration that could be an indication of impending damage to the unit. The switch actuates when the selected level of vibration is exceeded.

The switch must be adjusted when the unit is first installed. Refer to the switch manufacturer's instruction manual for complete details.

Optional Switches – The "Auto Sentry–ES+" controller has one additional input available for dealer or user installed optional shutdown switches. If the contact is opened, the compressor will be shut down, and will display a user selectable message (refer to unit setup adjustments for list of messages).

Control Transformer – This control device changes the incoming power voltage to 110–120 volts for use by all unit control devices. The transformers employed are usually connectable for several input voltages, re-

fer to the transformer label for connection prior to energizing. Two primary and one secondary fuse are provided. Refer to adjacent labeling for replacement information.

Terminal Strip – This provides connections for all 110–120 volt devices not contained within the enclosure.

Fan Starter – The starter is used to provide control and overload protection for the cooling fan or the ventilation fan of water–cooled units with enclosure. Overload heaters should be selected and adjusted based on the motor nameplate amps and the instructions located inside the cover of the electrical enclosure. Three fuses are provided. Refer to adjacent labeling for replacement information.

Main Starter – This starter is used to provide control and overload protection for the main drive motor. Full voltage starters employ a single contactor, overload heaters should be selected and adjusted based on the motor nameplate amps and the instructions located inside the cover of the enclosure. Wye–delta starters employ three contactors which are controlled sequentially to provide low current starting. For wye–delta starters, the motor nameplate amps must be first multiplied by 0.577 before using the heater table.

COMPRESSOR CAPACITY CONTROL – TURN VALVE UNITS ONLY

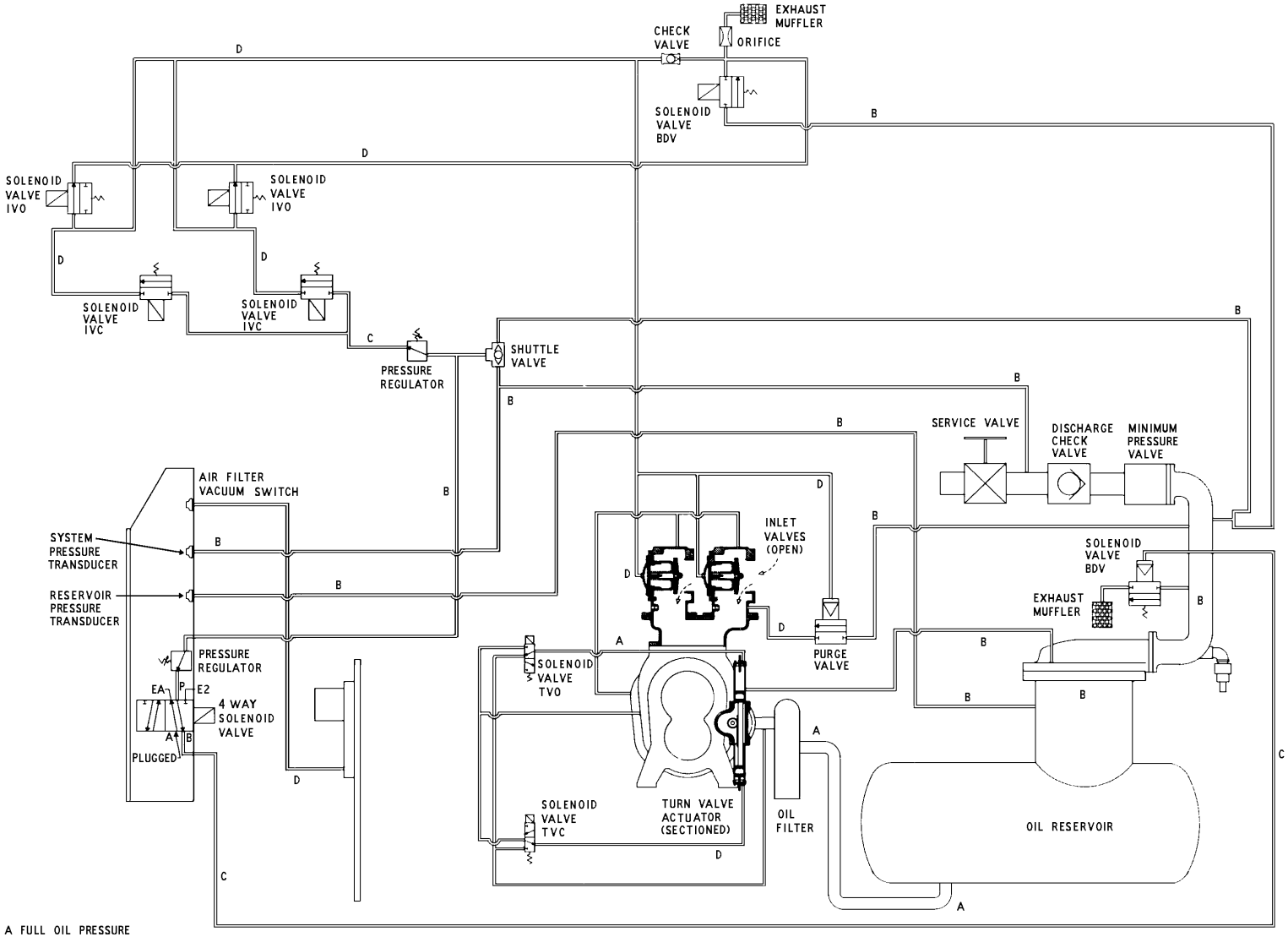
The capacity of the compressor is controlled by the action of the Turn Valve and the Compressor Inlet Valve. The turn valve controls compressor delivery to match demands of 40% to 100% of the compressor's maximum capacity. The inlet valve throttles to control compressor delivery to match demands of 0% to 40% of the compressors maximum capacity.

Example with normal setting of 100 PSIG:

Compressor Delivery	Inlet Valve	Turn Valve	Discharge Manifold Pressure
Full Capacity	Open	Closed	100
70% Capacity	Open	50% Open	100
40% Capacity	Open	Full Open	100
30% Capacity	Closing	Full Open	103
20% Capacity	Closing	Full Open	103
0% Capacity	Closed	Full Open	103

CONTROL SCHEMATICS – FIGURE 4–10 through FIGURE 4–12, pages 36 through 38, illustrate valve positions during common operating conditions.

WIRING DIAGRAMS – FIGURE 4–13, page 39, illustrates the most common package configuration. If current monitoring is not installed, there is no connection to connector CN–4 on the controller. Refer to the wiring diagram furnished with the compressor package for specific connections and wiring.



204EAY797
(Ref. Drawing)

FIGURE 4–10 – CONTROL SCHEMATIC – COMPRESSOR AT FULL LOAD

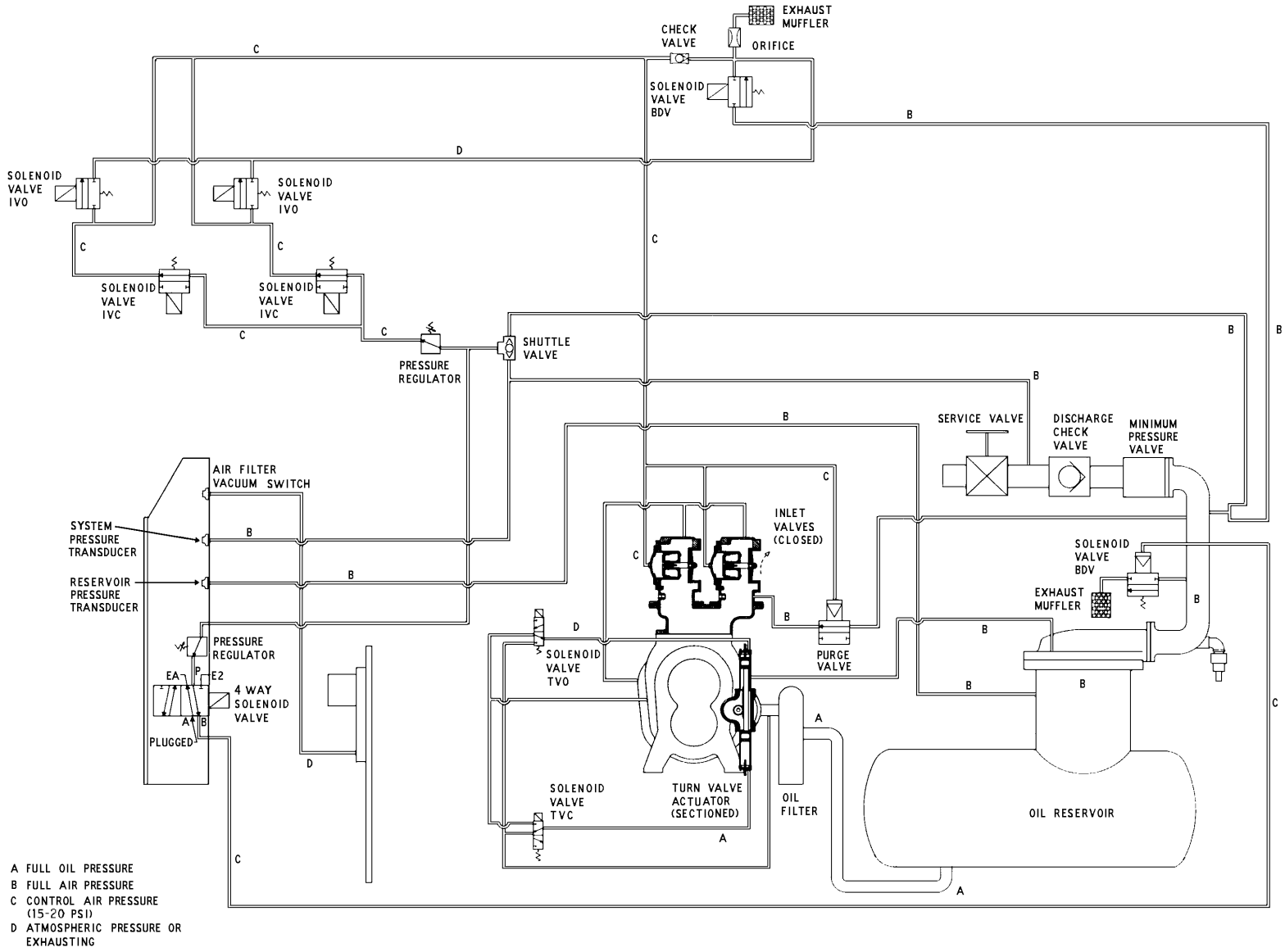


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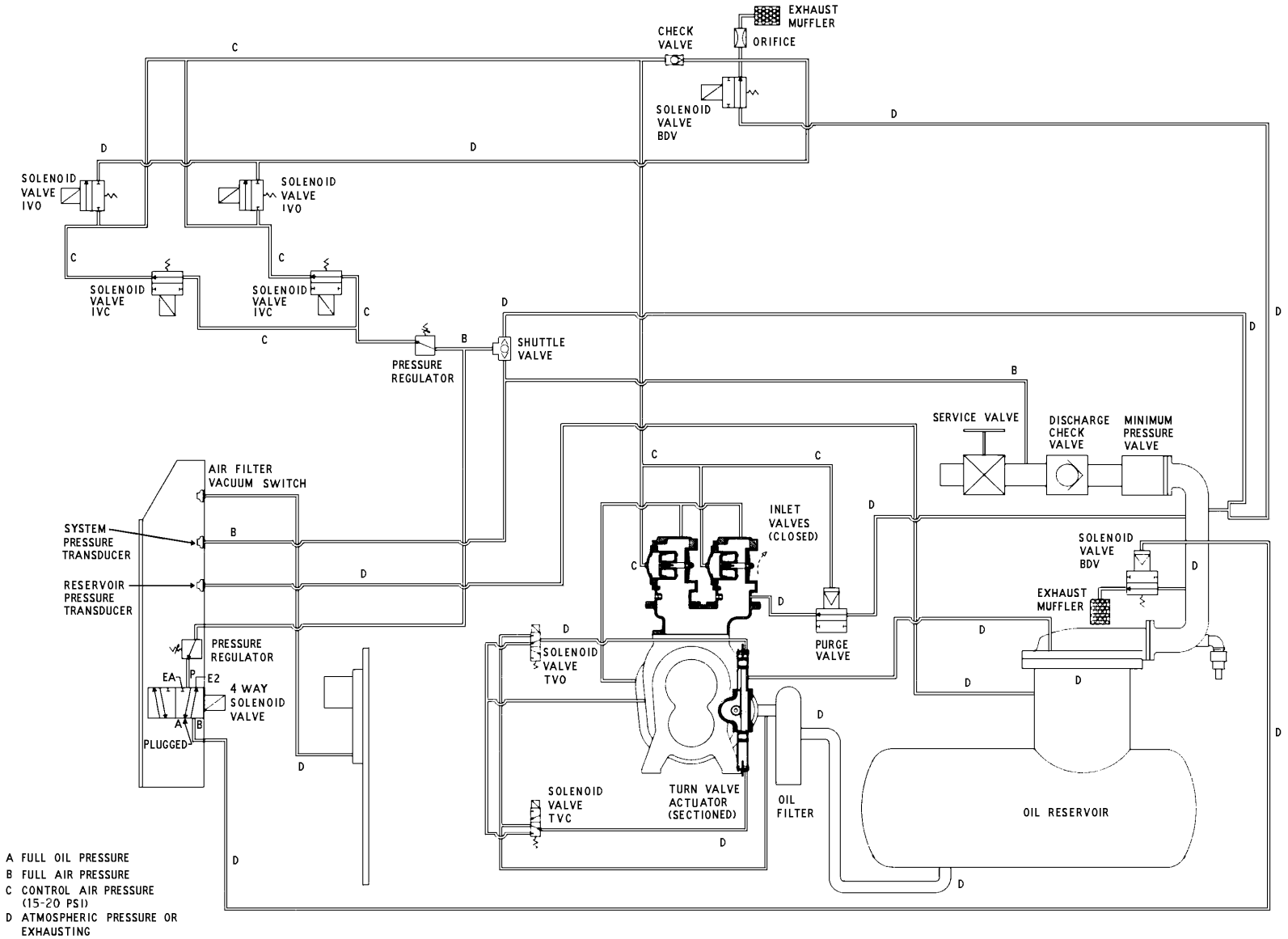
FIGURE 4–11 – CONTROL SCHEMATIC – COMPRESSOR FULLY UNLOADED – CONSTANT SPEED MODE



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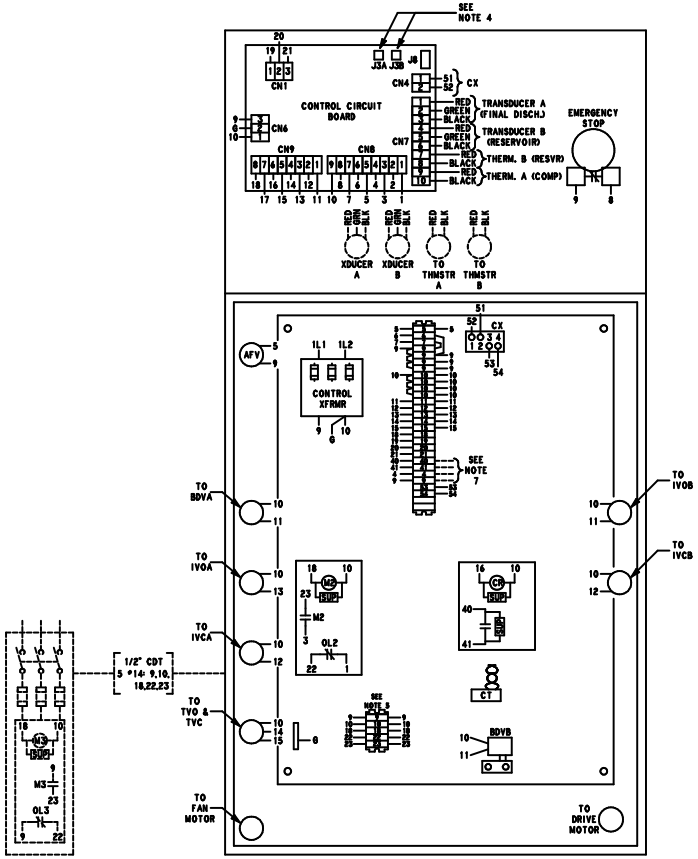
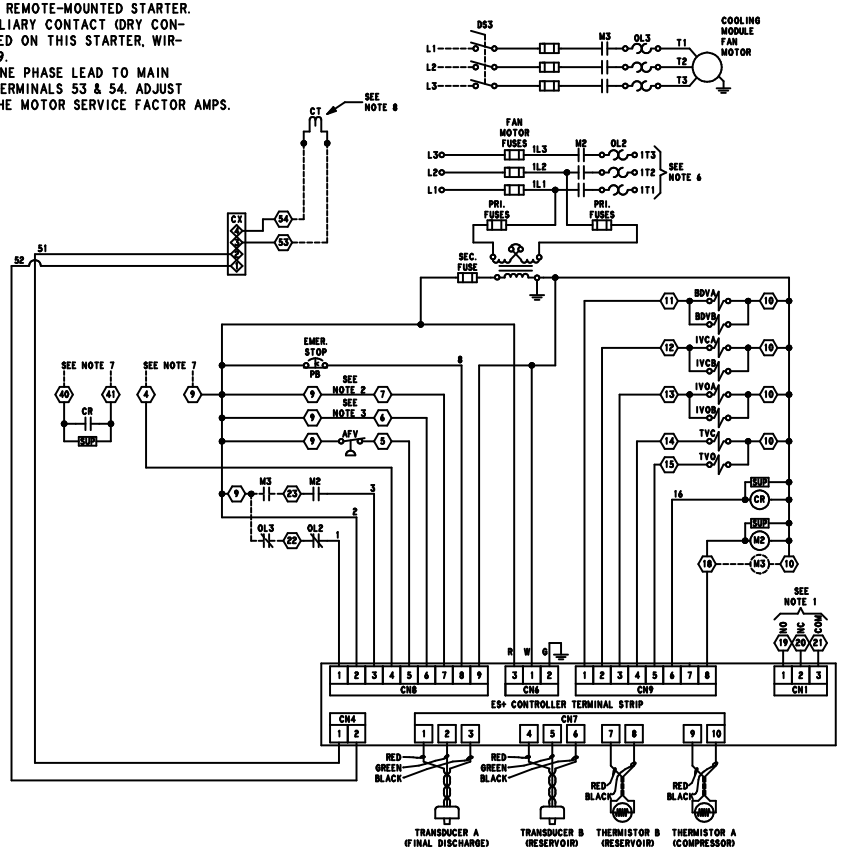
(Ref. Drawing)

FIGURE 4–12 – CONTROL SCHEMATIC – COMPRESSOR FULLY UNLOADED – LOW DEMAND MODE

NOTE 1: FORM C CONTACT FOR USE BY OTHERS. CONTACT OPERATES FOLLOWING COMPRESSOR SHUTDOWN. RATING: 120VAC, 2 AMP.
NOTE 2: FOR USE WITH OPTIONAL SHUTDOWN SWITCH, REMOVE JUMPER BETWEEN TERMINALS 7 & 9. CONNECT N.C. VIBRATION SWITCH CONTACT TO TERMINALS 7 & 9.
NOTE 3: FOR CONTROL BY REMOTE CONTACT, REMOVE JUMPER BETWEEN TERMINALS 6 & 9. CONNECT CONTACT TO TERMINALS 6 & 9.
NOTE 4: J3A & J3B ARE FOR USE OF OPTIONAL COMMUNICATIONS CABLE.
NOTE 5: MOUNT THE COOLING MODULE COMBINATION STARTER AND REMOVE ALL CONTROL WIRES INSIDE THE STARTER. INSTALL CONTROL CONDUIT WITH 5 WIRES. CONNECT WIRES 18 & 10 TO COIL, WIRES 9 & 23 TO AUXILIARY CONTACT, WIRES 9 & 22 TO OVERLOAD CONTACT. CONNECT 5 WIRES TO TERMINALS IN CONTROL BOX. ADJUST CONTROLLER FOR "WATERCOOLED" FAN MODE.
NOTE 6: NO CONNECTION TO 1T1, 1T2 & 1T3.
NOTE 7: TERMINALS 40 & 41 ARE TO BE USED FOR TWO WIRE CONTROL OF REMOTE-MOUNTED STARTER. AN ISOLATED N.O. AUXILIARY CONTACT (DRY CONTACT) MUST BE PROVIDED ON THIS STARTER, WIRED TO TERMINALS 4 & 9.
NOTE 8: INSTALL CT ON ONE PHASE LEAD TO MAIN MOTOR, AND WIRE TO TERMINALS 53 & 54. ADJUST CONTROLLER SFA TO THE MOTOR SERVICE FACTOR AMPS.





LEGEND:
BDVA – BLOWDOWN SOLENOID VALVE
BDVA – 4 WAY BLOWDOWN CONTROL VALVE
IVCA – INLET VALVE CLOSE SOLENOID VALVE
IVCB – INLET VALVE CLOSE SOLENOID VALVE
IVOA – INLET VALVE OPEN SOLENOID VALVE
IVOB – INLET VALVE OPEN SOLENOID VALVE
AFV – AIR FILTER VACUUM SWITCH
TVC – TURN VALVE CLOSE SOLENOID VALVE
TVO – TURN VALVE OPEN SOLENOID VALVE
SUP – SUPRESSOR
THA – THERMISTOR A (COMPRESSOR)
THB – THERMISTOR B (RESERVOIR)
XDA – TRANSDUCER A (FINAL DISCHARGE)
XDB – TRANSDUCER B (RESERVOIR)
CT – CURRENT TRANSFORMER
CX – CURRENT TRANSDUCER
□ – CONNECTION TO CONTROL BOARD.
⬡ – PANEL TERMINAL BLOCKS
◇ – CURRENT TRANSDUCER TERMINAL

202EAY546
(Ref. Drawing)

FIGURE 4–13 – WIRING DIAGRAM

SECTION 5
LUBRICATION
OIL COOLER, OIL FILTER & SEPARATOR

A – Compressor
B – Oil Reservoir
C – Oil Separator
D – Oil Cooler
E – Thermal Mixing Valve
F – Oil Filter
G – Separator to Cylinder Oil Return Line
H. – Pressure Relief Valve
J – Discharge Check Valve
K – Minimum Discharge Pressure Valve
L – Purge Valve
M – Pneumatic Blowdown Valve
N – Orifice
P – Blowdown Muffler
R – Shuttle Valve
S – Pressure Regulator
T – Solenoid Valve “IVC”
U – Solenoid Valve “IVO”
W – Check Valve
X – Air Filter Vacuum Switch
Y – System Pressure Transducer
Z – Discharge Pressure Transducer
AA – Fan & Motor
BB – Water Flow Control Valve
CC – Magnetic Water Shutoff Valve
DD – Oil LIne Check Valve (Remote Overhead Oil Cooler Only)
EE – Oil Stop Valve (Remote Overhead Oil Cooler Only)

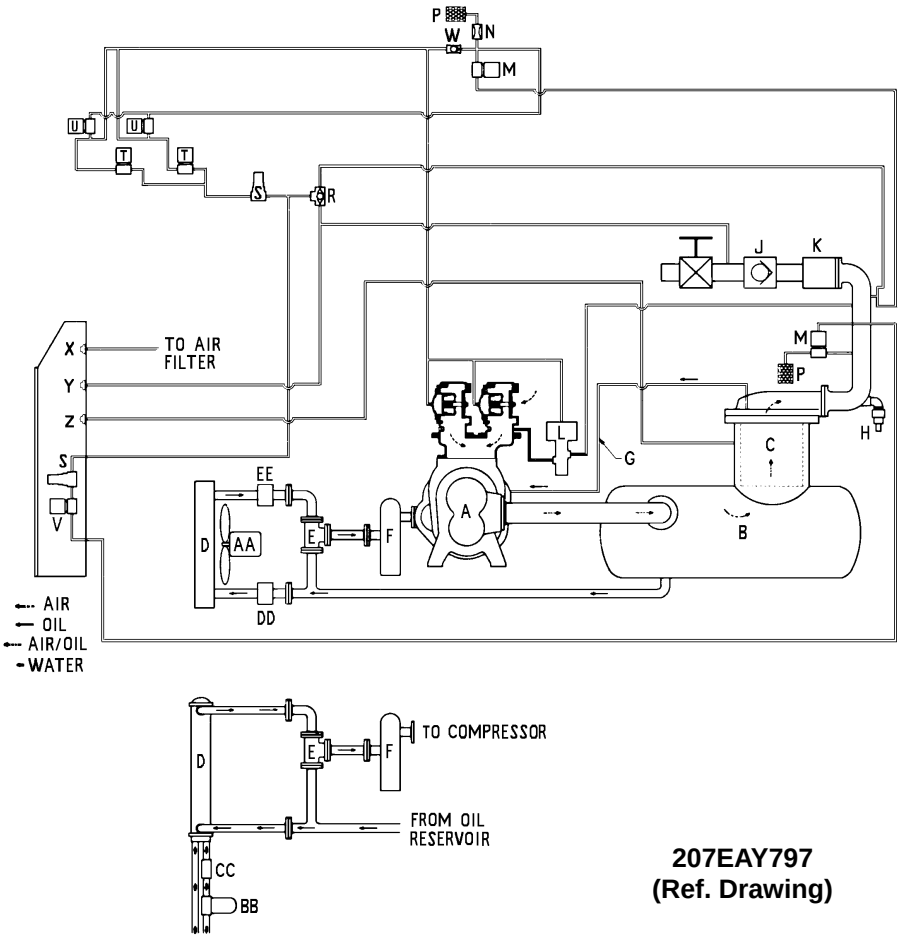


FIGURE 5–1 – FLOW DIAGRAM – AIR/OIL SYSTEMS

COMPRESSOR OIL SYSTEM (FIGURE 5–1) cools the compressor, lubricates moving parts and seals internal clearances in the compression chamber.

The oil inlet line is connected at the bottom of the oil reservoir. Air pressure in the oil reservoir forces oil through the oil cooler, thermostatic mixing valve, oil filter and into the compressor main oil gallery.

The oil passes through internal passages for lubrication, cooling and sealing. The air–oil mixture is then discharged to the oil reservoir where a large part of the entrained oil drops out of the air stream; the air then passes through the final oil separator where most of the remaining oil is removed. The separated oil is returned to the compressor and the air passes to the final discharge line.

RECOMMENDED LUBRICANT – Gardner Denver compressors are factory filled with AEON lubricants. These lubricants are formulated to the highest quality standards and are factory authorized, tested and approved for use in rotary screw compressors. AEON lubricants are available through your authorized Gardner Denver compressor distributor.

OIL SPECIFICATIONS – The recommended compressor lubricant is Gardner Denver AEON™ 4000 Lubricating Coolant which can be used for year–round operation except as noted in the “High Temperature Operation” paragraph below, or low temperature, see “Installation for Cold Weather”, Section 2, page 12. AEON™ 4000 Lubricating Coolant is a superior petroleum base lubricant formulated and containing additives for use in Gardner Denver compressors.

⚠ CAUTION

Use of improper lubricants will cause damage to equipment. Do not mix different types of lubricants or use inferior lubricants.

HIGH TEMPERATURE OPERATION – If the discharge temperature is sustained between 200–210° F for a period of more than four (4) hours due to continuing high ambient air temperature, use Gardner Denver® AEON 9000 SP Lubricating Coolant which is a superior synthetic lubricant. Short periods of up to four (4) hours of sustained discharge temperatures up to 210° F do not require a change from the recommended year–round lubricant AEON™ 4000.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

LUBRICANT CHANGE PROCEDURE – Upgrading to a longer life lubricant is essentially a very worthwhile practice. Following are the primary steps to be completed when upgrading or changing the type of lubricant.

1. Thoroughly drain system:
   - – Drain oil from air end and cooler while hot.
   - – Break low point connections and drain oil from pipe runs.
   - – Dump oil from the filter and reinstall used filter.
2. Fill the system with a 50 percent charge of the new lubricant:
   - – Start the machine and stay there to observe.
   - – Allow the machine to run about five minutes at temperature, or until temperature stabilizes, then shut down.
3. Thoroughly drain the machine.
4. Change to a new filter and separator.
5. Fill the system with a full charge of the new lubricant.
6. Replace the drain plug before restoring power.
7. Machine should then be run normally, however, total run time after the initial changeout should be 50 percent of normal anticipated service life of the new lubricant.
   - – Drain all lubricant from the system, change the filter and separator, and replace with a full charge of the new lubricant.
8. Subsequent lubricant changeouts should be at normal intervals. (See (FIGURE 5–3, page 43.)

⚠ CAUTION

Improper equipment maintenance with use of synthetic lubricants will damage equipment. Oil filter and oil separator change intervals remain the same as for AEON™ 4000 –– See Maintenance Schedule, page 54.

⚠ WARNING

High temperature operation can cause damage to equipment or personal injury. Do not repeatedly restart after high temperature stops operation. Find and correct the malfunction before resuming operation.

⚠ WARNING

All materials used in Gardner Denver® compressor units are compatible with AEON™ 9000 SP Lubricating Coolant. Use caution when selecting downstream components such as air line lubricating bowls, gaskets and valve trim.

AEON™ 9000 SP Synthetic Lubricant is not compatible with low nitrile Buna N or acrylic paints. AEON™ 9000 SP is compatible with most air system downstream components.

Material Safety Data Sheets (MSDS) are available for all AEON lubricants from your authorized Gardner Denver distributor or by calling 217–222–5400.

COLD AMBIENT OPERATION – See “Installation for Cold Weather Operation,” page 12.

ADDITION OF OIL BETWEEN CHANGES must be made when the oil level is in the red range on the gauge as read while the unit is on. To add oil, follow these steps:

1. Be sure the unit is completely off and that no air pressure is in the oil reservoir.
2. Disconnect, tag and lockout the power supply to the starter.
3. Wipe away all dirt around the oil filler plug.
4. Remove the oil filler plug and add oil as required to return the oil level to the center of the green range on the gauge.
5. Replace the oil filter plug BEFORE restoring power to the unit.

DO NOT OVERFILL. The quantity required to raise the oil level from the red range center of the green range is shown in FIGURE 5–2. Repeated addition of oil between oil changes may indicate excessive oil carry–over and should be investigated.

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

Size	Approximate System Capacity (Initial Fill)	Oil Reservoir Capacity** (Refill)	Qty. – Top of ADD to Centerline of RUN
350 HP	Air Cld* – 61 Water Cld – 59	55 55	11 11
400 HP	Air Cld* – 61 Water Cld – 59	55 55	11 11
500 HP	Air Cld* – 61 Water Cld – 59	55 55	11 11

* System capacity shown is for the initial fill of the compressor unit oil cooler module ONLY – remotely mounted oil coolers will require additional oil to fill the piping between the compressor unit and the cooler.

** The oil reservoir refill quantity shown is measured at the centerline of the oil level gauge RUN range or approximately 3.5 inches below the centerline of the oil reservoir.

FIGURE 5–2 – OIL SYSTEM CAPACITIES (APPROXIMATE) – U. S. GALLONS

⚠ CAUTION

Excessive oil carry–over can damage equipment. Never fill oil reservoir above the “FULL” marker.

OIL LEVEL GAUGE (FIGURE 1–5, page 3) indicates the amount of oil in the oil reservoir. When the unit is stopped, the oil level will be higher in the RUN range than when operating on load. When the unit is operating, the oil level should be near the center of the RUN range. In normal operation, the oil level will fluctuate slightly as the compressor loads and unloads. Add oil only when the oil level gauge indicated in the ADD OIL range when the compressor is loaded. Drain oil only when the oil level gauge indicates EXCESS OIL when the compressor is loaded.

MOISTURE IN THE OIL SYSTEM – In normal humidity and with normal operating temperatures and pressures, the thermal mixing valve controls the oil temperature and prevents moisture contamination of the oil. Unusual cooling of the oil reservoir, short loaded cycle in high humidity or malfunctions of the thermal valve may result in moisture in the oil system which is detrimental to compressor lubrication and could cause oil carryover. If moisture is observed in the oil reservoir,

drain the moisture and correct the condition causing the accumulation. See “Compressor Oil System Check,” page 50 and “Thermal Control (Thermostatic Mixing) Valve,” page 46.

OIL CHANGE INTERVAL – Recommended oil change intervals are based on oil temperature (see FIGURE 5–3).

When operating conditions are severe (very dusty, high humidity, etc.), it will be necessary to change the oil more frequently. Operating conditions and the appearance of the drained oil must be surveyed and the oil change intervals planned accordingly by the user. A good lubricant analysis program is helpful in planning the change interval.

⚠ CAUTION

Change the oil filter every 1000 hours.

DRAINING AND CLEANING OIL SYSTEM

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

Always drain the complete system. Draining when the oil is hot will help to prevent varnish deposits and carry away impurities.

To drain the system, use one of the following methods:

1. If the unit is not elevated high enough to use the oil reservoir drain line to drain oil, a small hand, electric or air operated pump should be used to drain reservoir through the oil filler opening or from the drain valve.

2. If the unit is elevated so that the oil reservoir drain can be used, empty the oil reservoir through the drain valve to a suitable container or sump.

3. If the drained oil and/or the oil filter element are contaminated with dirt, flush the entire system: reservoir, oil cooler, mixing valve and lines.

4. Inspect the oil separator elements for dirt accumulation; replace if necessary. If a varnish deposit exists, contact the factory for recommendations for removal of the deposit and prevention of varnish.

Discharge Temperature	AEON 4000 Change Interval	AEON 9000 SP Change Interval
Up to 180°F (82°C)	6000 hrs.	8000 hrs.
180° to 190°F (82° to 88°C)	4500 hrs.	6000 hrs.
190° to 200°F (88° to 93°C)	3000 hrs.	4000 hrs.
200°F+ (93°C)	1500 hrs.	2000 hrs.

FIGURE 5–3 – OIL CHANGE INTERVAL

FILLING OIL RESERVOIR

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

1. Be sure the unit is completely off and that no air pressure is in the oil reservoir.
2. Disconnect, tag and lockout the power supply to the starter.
3. Wipe away all dirt around the oil filler plug.
4. Remove the oil filler plug and add oil as required to return the oil level to the center of the green range on the gauge.
5. Install the oil filler plug and operate the unit for about a minute allowing oil to fill all areas of the system. Check for leaks.
6. Shut down unit, allowing the oil to settle, and be certain all pressure is relieved.
7. Add oil, if necessary, to bring level to the center of the green range on the gauge.

On unloaded operation and after shutdown some oil will drain back into the oil reservoir and the oil level gauge may read in EXCESS OIL range. DO NOT DRAIN OIL TO CORRECT. On the next start, oil will again fill the system and the gauge will indicate the operating level.

COMPRESSOR OIL FILTER (FIGURE 5–4, page 45) – This replaceable element oil filter is a vital part in maintaining a trouble–free compressor, since it removes dirt and abrasives from the circulated oil. The oil filter relief valve is located in the oil filter head. The relief valve opens in the event the element becomes dirty enough to block the flow of oil.

⚠ CAUTION

Element must be replaced every 1000 hours or sooner, or when top of the indicator on the filter is in the red CHANGE FILTER half of the window. Unit must be running and warmed up for indicator to read accurately. Check with light to be certain of indicator position – some lubricants will obscure the indicator.

Use only the replacement element shown on the filter tag or refer to the parts list for the part number. Use the following procedure to replace the filter element. Do not disturb the piping.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

Compressor Main Oil Filter Instructions (Refer to FIGURE 5–4, page 45)

1. Stop the unit and be sure no air pressure is in the oil reservoir. Disconnect, tag and lockout power supply to the starter.
2. To remove head assembly, rotate tee handle (9) counterclockwise until head assembly (1) is free of housing (3).
3. Holding baffle (12) down, push down on indicator assembly (5) to insure that it moves up and down freely within the baffle. Remove baffle (12) and

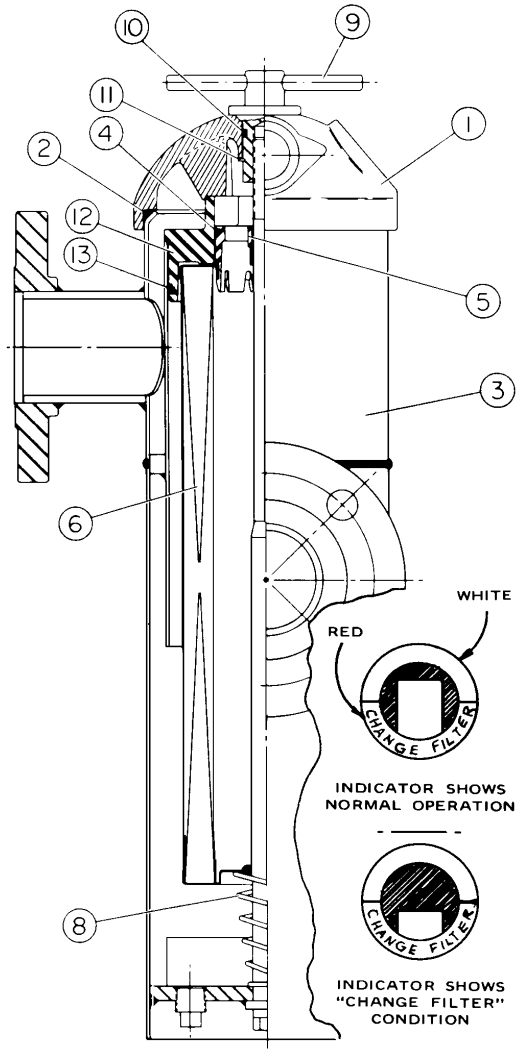


FIGURE 5–4 – COMPRESSOR OIL FILTER

check its inside bore for burrs or deep scratches and carefully smooth out if required. Check seal (13) for cuts and excess wear.

4. Remove element (6) from housing assembly (3). Remove indicator assembly (5) from element (6) by inserting screwdriver between indicator assembly and element cap and carefully prying downward. Inspect indicator O–ring (4) for cuts or excessive wear and discard element (6).

5. Remove O–ring from head assembly (1) and inspect for cuts or excessive wear. Wipe O–ring area of head (1) with clean cloth and after covering O–ring (2) with oil, reinstall in head assembly.

6. Reinstall indicator assembly (5) into new element (6). Place element into cannister (3), making sure that large diameter of spring (8) contacts the new element, and install baffle (12).

7. Place head assembly (1) onto housing assembly (3) and rotate tee handle (9) clockwise until hand tight; do not exceed 20 foot–pound torque if tools are used.

8. Reconnect starter to power source.

9. If leakage appears around tee handle (9) remove snap ring (11) and remove tee handle (9) from head assembly (1). Remove O–ring (10) and inspect for nicks or cuts and replace if necessary. Wipe tee handle (9) and O–ring groove. Then oil and replace O–ring (10), insert tee handle (9) into head assembly (1) and replace snap ring (11).

BEARING OIL FILTER – An oil filter of the spin–on type is used. This filter is a vital part in maintaining a trouble–free compressor, since it removes dirt and abrasives from the circulated oil before it reaches the bearings. The filter is the disposable type and is equipped with a relief valve that opens in the event the element becomes dirty enough to block the flow of oil. **The filter must be replaced each time the main oil filter element is replaced.** When changing this filter between oil changes, add one (1) quart of lubricant to the system to replace that retained in the old filter. Use only the replacement filter shown in the parts list, as others may not have sufficient burst pressure strength.

To replace filter, stop the unit and be sure no air pressure is in the oil reservoir. Disconnect, tag and lockout power supply to the starter. Spin off the old filter and discard, then spin on the new filter by hand, tightening firmly enough to prevent leaks.

COMPRESSOR OIL COOLER – RADIATOR TYPE (FIGURE 5–5) – The air–cooled oil cooler module is remote mounted. The oil cooler requires pipe and electri-

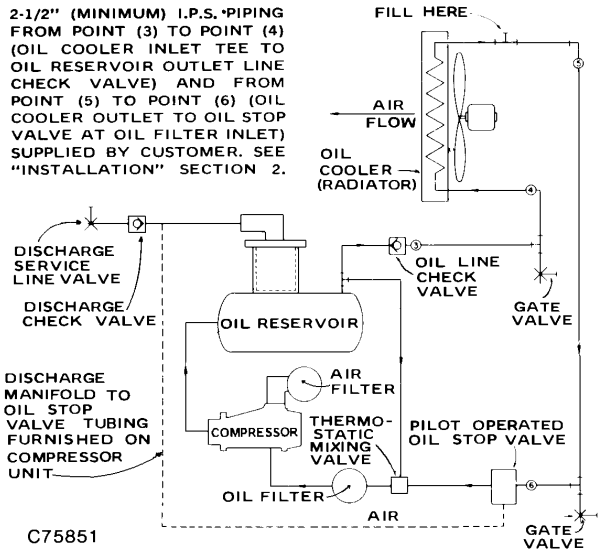


FIGURE 5–5 – OIL FLOW DIAGRAM – REMOTE OVERHEAD MOUNTED OIL COOLER

cal connection to the main compressor unit. Connecting piping and wiring are furnished by the user. See “Installation”, Section 2, page 8.

Do not obstruct the air flow to and from the oil cooler. Allow two (2) feet clearance on all sides of the oil cooler. See FIGURE 2–2, Section 2, page 8, for cooling air flow requirements. Keep both faces of the oil cooler core clean for efficient cooling of the compressor oil. Oil cooler malfunctions may be traced by checking oil pressure drop through the cooler; check by installing pressure gauges at fittings in the inlet and outlet oil piping near the end of the cooler. At normal operating air service pressures (65 to 150 psig), with the unit warm, a pressure drop of 2 to 25 psig can be expected between the inlet and outlet side of the cooler. The controller will show the reservoir temperature which is the air temperature in the reservoir and the approximate oil temperature into the thermal mixing valve.

An oil filler stand pipe and plug must be located in the piping on the oil cooler module for ease of filling the oil cooler when it is mounted at a distance from the compressor unit. When filling a remotely mounted oil cooler, be sure all lines to and from the compressor unit are also filled to prevent excessive drawdown of the oil supply in the oil reservoir. A vent line should be installed between the oil cooler and compressor oil reservoir as an aid in filling and to prevent siphoning.

HEAT EXCHANGER (OIL) PIPING – All remote elevated cooler applications must be sent through Engineering for approval and for recommending the pipe size. A special control group will be mounted on the package at the factory. This group controls the oil stop valve as well as not allowing the machine to run unloaded.Kit number EAU68133 includes the oil stop valve, check valve and flanges and must be installed on all remote elevated coolers per FIGURE 5–5, page 45, and the following instructions.

NOTICE

Remote mounted elevated coolers have a maximum pipe length of 30 feet (each way) and a maximum height of 20 feet with a minimum of fittings. Engineering will review all remote elevated cooler applications and recommend pipe size on an individual basis. Customer Service should include the engineering recommendation in the special order sent to Engineering.

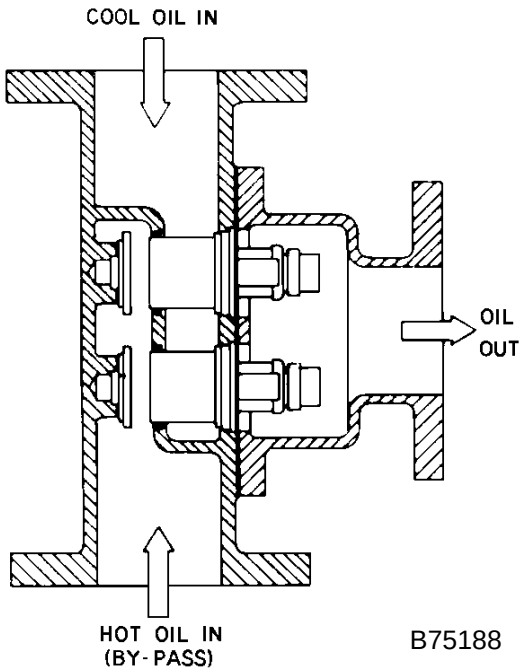


FIGURE 5–6 – THERMOSTATIC MIXING VALVE ELEMENT

1. Mount the check valve (90J113).
2. Mount the drain valves in the lowest section of the pipe on each side of the cooler connections.
3. Mount the oil stop valve (90AR243) in the line after the thermal mixing valve as shown.

Modifications to the control lines will be made at the factory to control the oil stop valve. Air to the oil stop valve must come from the dry side of the reservoir cover, then through the 3–way pneumatic valve. Control air to the valve must come from the line between the tee and the orifice in the blowdown muffler line. When the machine blows down, it will activate the pneumatic valve which will shut off the air and vent the line between the pneumatic control valve and the oil stop valve to the atmosphere. This will shut the oil stop valve and prevent excessive oil from running into the reservoir. Failure to install these parts could result in high oil carryover and cause the machine to shutdown on high discharge temperature.

THERMAL CONTROL (THERMOSTATIC MIXING) VALVE (FIGURE 5–6) on current units is installed in the system as shown in FIGURE 5–1, page 40. This valve is used to control temperature of the oil in both air–cooled radiator and water–cooled heat exchanger type oil cooler systems. The element is so designed that a portion of the oil can flow through the oil cooler at all times. On start–up with unit cold, element is open to bypass, allowing oil to pass directly from the reservoir to compressor during warm–up. As oil warms, element gradually closes to the bypass allowing more of

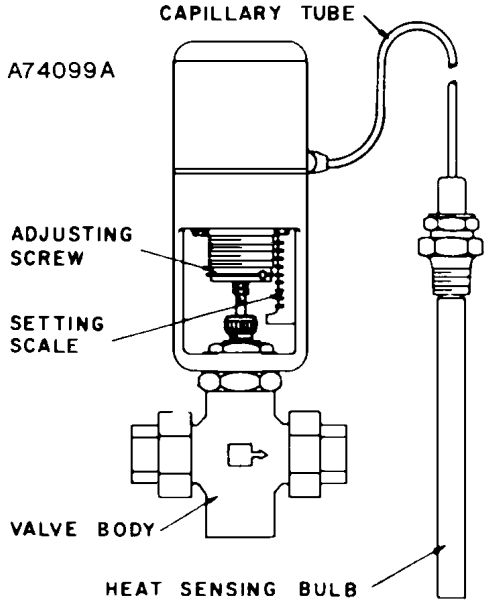


FIGURE 5–7 – WATER CONTROL VALVE

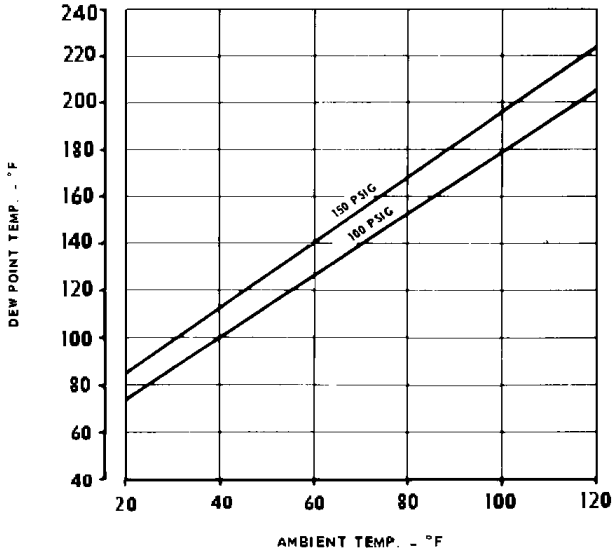


FIGURE 5–8 – DEW POINT TEMPERATURE VS. AMBIENT TEMPERATURE (100% RELATIVE HUMIDITY)

the oil from the cooler to mix with oil from the bypass. After the unit is warmed up, the mixing valve maintains oil injection temperature into the compressor at a minimum of 150° F (66° C). This system provides proper compressor warm–up and helps prevent moisture contamination of oil.

To check element, heat in oil – it should be fully extended at 150° F (66° C). If unit shuts down due to high air discharge temperature, the cause may be that the element is stuck open to the bypass, in which case lines 1 and 2 (FIGURE 5–1, page 40) will be hot to touch and lines 3 and 4 much cooler. When flushing the oil system, remove mixing valve and clean all parts thoroughly.

COMPRESSOR OIL COOLER – WATER–COOLED HEAT EXCHANGER (FIGURE 1–2, page 2) – The heat exchanger oil cooler is a multiple pass type, with water in the tubes and oil in the shell. The oil temperature is controlled by the thermal (thermostatic mixing) valve. The optional water control valve may be used to conserve water.

⚠ WARNING

It is mandatory that any water cooled unit be installed in a shelter heated to temperatures above freezing (32° F., 0° C).

Oil cooler malfunction may be traced by checking pressure at oil inlet and outlet. At normal operating air service pressure (65 to 150 psig) with the unit warm, a pressure drop of 3 to 15 psi can be expected between the oil inlet and the oil outlet.

Water pressure drop from water inlet to outlet will vary with the inlet pressure and amount of water flowing. A normal pressure drop may range from 5 to 10 psi. Any change in the pressure drop from that normally held may indicate tube leakage or fouling and should be investigated.

In many instances, the cooling water supply for the heat exchanger will contain impurities in solution and/or suspension. These substances can cause scale formation, corrosion and plugging of any water–cooled heat exchanger equipment. Disregarding the possibility that one or more of these conditions exist may result in increased maintenance and operation expense, reduced equipment life and emergency shutdown. It is strongly recommended that a reputable, local water treatment concern be engaged to establish the corrosion, scale forming and fouling tendency of the cooling water and take steps necessary to remedy the situation if a problem does exist. The need for water treatment may involve only filtration (screening) to remove debris, sand and/or salt in the cooling water supply. However, chemical treatment methods may be necessary in certain instances to inhibit corrosion and/or remove dissolved solids, to alter the water's tendency to form scale deposits, or prevent the growth of microorganisms. The normal maintenance program for the unit should also include periodic cleaning of the tubes (wa-

ter side) of the heat exchanger to remove deposits which enhance fouling and corrosion.

Hex head zinc anodes are used in the return bonnet (opposite end to the water pipe connections) of heat exchangers to provide internal water system corrosion protection. These anodes should be inspected periodically and replaced when the zinc has been reduced to about 1/2 inch in length.

WATER FLOW CONTROL VALVE FOR HEAT EXCHANGER (Optional Equipment) (FIGURE 5–7, page 47) – The water flow control valve is adjustable to compensate for varying water inlet temperatures and pressures (thermal control valve prevents settings below approximate 180° F.) Use the discharge air temperature gauge on the instrument panel in setting flow control valve for minimum water usage to maintain discharge temperature at a minimum of 10° F above dew point at the maximum anticipated ambient; refer to FIGURE 5–8, page 47, for the dew point temperature at the operating pressure and ambient temperatures.

To decrease water flow (increase compressor discharge air temperature) turn the adjusting screw from left to right, increasing spring tension. **To increase water flow** (decrease compressor discharge air temperature) turn the adjusting screw in the opposite direction. The groove at the lower edge of the adjusting screw is an index line for use with the index scale 0 to 8 in obtaining a desired setting.

These valves must be handled with care and proper tools and techniques must be used when working on the valve.

Care must be used when handling the capillary tube; a kink or break in the tubing or connections will make the valve inoperative. Never attempt to change capillary length. Excess capillary tube should be carefully coiled and placed so that damage will not occur in normal maintenance or traffic past the unit.

If a leak develops through the packing, tighten the packing gland nut firmly with a wrench to reseat the packing around the valve stem, then back off the nut until loose, and finally retighten the nut finger tight. Tightening the packing nut too tight may cause erratic operation. An occasional drop of oil on the valve stem at the packing nut will prolong packing life.

If valve malfunctions, check for bent or binding, paint or corrosion on valve stem, foreign material in valve, erosion, or thermal system (capillary) failure. If foreign material or scale is likely, the use of a strainer in the inlet water line is recommended.

WATER SHUTOFF VALVE – WATER–COOLED HEAT EXCHANGER (Optional Equipment) (FIGURE 5–1, page 40) – A magnetic solenoid–operated water shutoff valve rated at 150 psig water pressure should be mounted in the water outlet line after the oil cooler. The valve should be wired into the compressor control circuit in such a manner that the valve opens to allow water to flow any time the ON–OFF push button is ON and the compressor is running. When the compressor stops under automatic control, or is shut off manually, the valve should close, stopping water flow through the system.

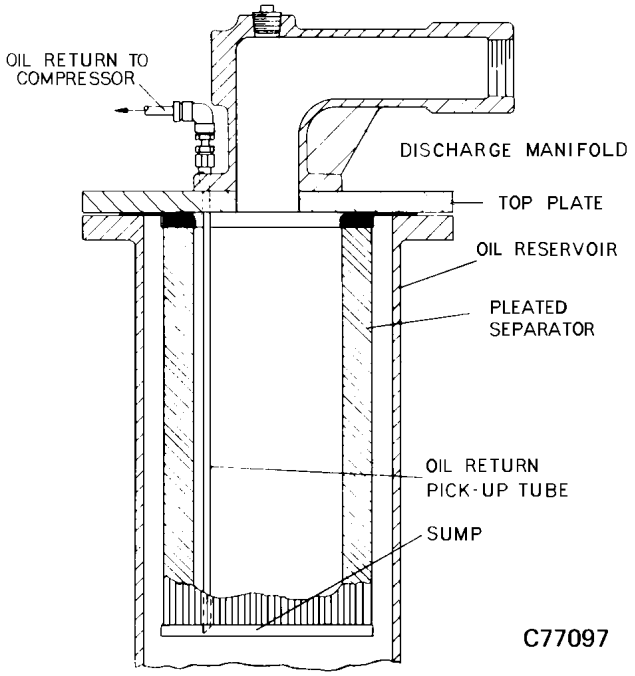


FIGURE 5–9 – SINGLE ELEMENT OIL SEPARATOR

OIL RESERVOIR – The oil reservoir–separator combines multiple functions into one vessel. The lower half is the oil reservoir, providing oil storage capacity for the system and the top portion, a primary oil separation means. The reservoir also provides limited air storage for control and gauge actuation.

COMPRESSOR OIL SEPARATOR located in a separate housing, consists of a renewable cartridge–type separator element and provides the final removal of oil from the air stream. Oil from inside the separator elements is returned through tubing to the compressor cylinder. (FIGURE 5–9).

Oil carryover through the service lines may be caused by a faulty oil separator, faulty minimum pressure valve, over–filling of the oil reservoir, oil that foams, oil return line malfunction or water condensate in the oil. If oil carryover occurs, inspect the separator only after it is determined that the oil level is not too high, the oil

is not foaming excessively, the oil return line from the separator housing to the compressor cylinder is not clogged or pinched off, the check valve in the oil return line is functioning properly, and there is not water or an oil/water emulsion in the oil.

Oil carryover malfunctions of the oil separator are usually due to using elements too long, heavy dirt or varnish deposits caused by inadequate air filter service, use of improper oil or using oil too long for existing conditions. A ruptured or collapsed separator element is usually due to heavy dirt or varnish buildup in the filtering material. Excessive tilt angle of the unit will also hamper separation and cause oil carryover.

Oil separator element life cannot be predicted; it will vary greatly depending on the conditions of operation, the quality of the oil used and the maintenance of the oil and air filters. The condition of the separator can be determined by pressure differential gauging or by inspection.

Pressure Differential Gauging – The "CHANGE SEPARATOR" advisory will flash when the pressure differential across the oil separator reaches approximately 8 PSI. Replace the oil separator element at this time. If ignored, the unit will shut down and the advisory will illuminate steadily when the pressure differential reaches 15 PSI.

⚠ CAUTION

Using an oil separator element at excessive pressure differential can cause damage to equipment. Replace the separator when the "Change Separator" advisory appears.

NOTICE

A sudden drop of zero pressure differential or sudden heavy oil carryover may indicate a ruptured element.

Inspection – After removal of separator element, shine a light inside the element to reveal areas of heavy dirt or varnish deposits or breaks (ruptures) in the element media.

Removal Of Oil Separator For Inspection Or Replacement:

⚠ DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

⚠ DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

1. Be certain unit is completely off and that no air pressure is in the oil reservoir.
2. Disconnect, tag and lockout power supply to the starter.
3. Disconnect oil return to compressor tubing at tube elbow near the discharge manifold flange on the top plate.
4. Loosen the nut on fitting at manifold flange and completely withdraw the tubing through the fitting.
5. Disconnect all other tubing from discharge manifold.
6. Disconnect discharge manifold pipe union.
7. Remove screws holding the top plate to the oil reservoir. Lift the top plate form the oil reservoir.
8. Lift the separator from the separator housing.
9. Inspect and/or replace the separator as necessary. Before installing (or reinstalling) any separator be sure gaskets bonded to the separator flanges are not damaged. Remove the gasket material adhering to the top plate or reservoir flange from the old separator.
10. Lower the separator into the oil reservoir.
11. Seat the top plate to the oil reservoir flange; install and tighten all cap screws.
12. Reconnect the discharge manifold pipe union and all tubing.

13. Install original oil return by slipping tube through the fitting at the discharge manifold flange until ferrule bottoms in the fitting. If a new fitting and return tube are used, slip the tube through the fitting until it touches the bottom of the separator, then raise the tube about 1/4 inch off the bottom and tighten the fitting nut securely. Connect the other end of the tube to the compressor oil return tube elbow. Do not bend tube or raise tube further than 1/4"–1/2" from the bottom of the separator.

14. Reconnect compressor oil return tube to tube elbow.

COMPRESSOR OIL SYSTEM CHECK – The compressor should be at operating temperature at the time of the checks. On–half hour of loaded operation is usually sufficient to reach level–out operating temperatures. The data shown below is for an oil–system in good condition.

If the unit will operate at discharge temperatures over 200° F for more than 4 consecutive hours, refer to the "High Temperature Operation" paragraph and select a lubricant for this service. Regardless of level of sustained discharge temperature, the high discharge air temperature switch must never be set higher than 225° F shutdown temperature.

Air and Oil Discharge Temperature – Check with a thermometer in the tapped opening on top of the compressor discharge pipe to the oil reservoir.

For **Air Cooled Oil Systems**, FIGURE 5–10 shows the normal upper limit of discharge temperatures for varying ambient temperatures beginning at the system design point of 80° F. At ambient temperatures below 80° F, the mixing valve will hold the discharge temperature at the 80° F ambient temperature point. Above 80° F, the oil cooler is fully used and the discharge temperature varies degree for degree with the ambient temperature.

For **Water Cooled Oil Systems**, the water flows at various temperatures outlined in Section 2 will hold the discharge temperature below the 80° F ambient temperature level of FIGURE 5–10. Small variations in specific water flows or temperatures will not be noted in the discharge temperature since the water control valve will tend to hold a constant oil temperature. A significant change in the discharge temperature is cause to check for a change in water flow or temperature.

Oil Inlet Pressure – Check at the fitting in the line near the compressor oil inlet. With air receiver pressure at 100 psi, oil inlet pressure should be 75–85 psig.

Oil Cooler Oil Pressure Differential (Air–Cooled Radiator) – 2 to 25 psi (65 to 150 PSIG Receiver Pressure) – Check at the fitting in the inlet and outlet lines of the oil cooler.

Oil Cooler Oil Pressure Differential (Water–Cooled Heat Exchanger) – 2 to 25 PSI (65 to 150 PSIG Receiver Pressure) – Check at the heat exchanger oil inlet and outlet fittings.

Oil Cooler Temperature Differential (Air–Cooled Radiator) – The oil temperature differential depends on the temperature of the air at the oil cooler fan and cleanliness of core faces. As ambient temperatures and core restrictions increase, the oil cooler outlet temperature will increase. The inlet oil temperature may be checked at the fittings in the oil inlet line on the oil cooler module. The outlet oil temperature may be checked at the fitting in the oil outlet line.

Oil Cooler Temperature Differential (Water–Cooled Heat Exchanger) – The oil temperature differential depends on the inlet water temperature and the water flow rate permitted by the water flow control valve setting. The oil inlet temperature is approximately the same as the air discharge temperature – see the gauge on the instrument panel. The oil outlet temperature may be checked at the compressor oil inlet line fitting.

Oil Cooler Water Pressure Differential (Water–Cooled Heat Exchanger) – The water pressure differential through the heat exchanger will depend on the supply pressure, flow rate, cooler tube cleanliness and outlet pressure. The inlet and outlet water pressure may be checked at the pipe fittings supplied by the customer.

Ambient Temperature (°F.)		80	90	100
350 HP	Discharge	171	181	191
400 HP	Temperature	175	185	195
500 HP	° F	184	194	204*

* For temperatures above 200 F see "High Temperature Operation".

FIGURE 5–10 – AMBIENT TEMPERATURES

SECTION 6
AIR FILTERS

AIR FILTER – The air filter furnished as standard equipment is a panel type washable filter. The air filter must receive proper maintenance if maximum service is to be obtained from the unit. Establishing adequate and timely filter service is MOST IMPORTANT. With wide variation of dust conditions encountered, only experience can determine the proper time element for servicing filters. Although a paper filter element is normally considered expendable, proper and careful cleaning can extend its original life several times.

Filter Element – Service the air filter element when the "CHANGE AIR FILTER" LED is illuminated. Clean every 50 to 150 operating hours depending on dust conditions.

To service:

Remove louvered filter cover and filter element by removing the six (6) cover to enclosure screws.

Two methods of cleaning are recommended. Use of compressed air is effective when the major contaminant is dust. Washing is effective on carbon, soot, and oil laden elements.

DO NOT ATTEMPT TO CLEAN ELEMENTS BY BEATING OR RAPPING.

When air is used, direct a jet of air (100 PSI maximum) against the clean air side of the element in the opposite direction of normal air flow. Move the air jet up and down the pleat, slowly moving across the face of the element. The nozzle must be kept at least one inch away from the element. Take care that the paper is not ruptured by the nozzle or air jet.

When cleaning by washing, use a good non–sudsing detergent and water. Soak the element in a solution of two (2) ounces of detergent per gallon of water (140° F maximum) for at least 15 minutes. Swish the element around in the solution (2 minutes) to help remove dirt. Warm solution gives best results. Rinse the element with a stream of water (40 PSI maximum) opposite to normal air flow until rinse water is clear. DRY THE ELEMENT THOROUGHLY BEFORE USING. DO NOT USE LIGHT BULBS FOR DRYING. Warm air (160° F or less) must be circulated as high surface temperatures can burn or scorch the filter paper.

After cleaning, thoroughly inspect the element for dirt on the clean air side, holes or damage, by looking through the element toward a bright light. Do not reuse damaged elements.

Filter Element Life – The element should be replaced after six (6) cleanings or if:

1. Visual inspection indicates a rupture, crack or pin hole in the pleated media. Inspection should be done by placing a bright light inside the element.
2. Pressure drop through a filter with a freshly cleaned element is below three (3) inches of water with the compressor running at full load – this would indicate a rupture or crack.

NOTICE

Use only genuine Gardner Denver air filter elements on Gardner Denver compressor units. Genuine parts are available through your authorized Gardner Denver distributor.

⚠ WARNING

Do not oil this element. Do not wash in inflammable cleaning fluids. Do not use solvents other than water. Improper cleaning may damage the element.

NOTICE

Never operate the unit without the element. Never use elements that are damaged, ruptured or wet. Never use gaskets that won't seal. Keep spare elements and gaskets on hand to reduce downtime. Store elements in a protected area free from damage, dirt and moisture. Handle all parts with care.

HEAVY–DUTY AIR FILTER – 350 & 400 HP UNITS (FIGURE 6–1, page 52) – When heavy–duty air filters are specified for the 350 & 400 HP units, they will be a

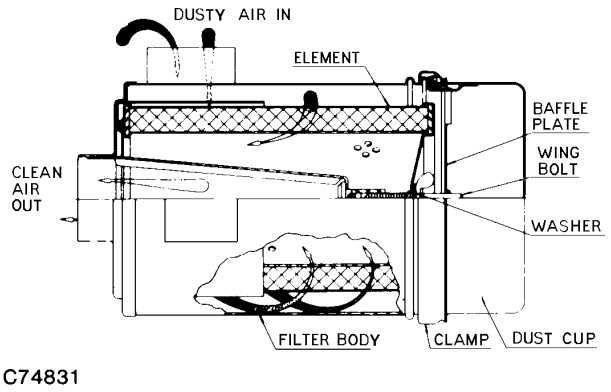


FIGURE 6–1 – HEAVY DUTY AIR FILTER

two–stage dry type. When the unit has been so equipped, service the filters as follows:

Dust Cup – Service every 4 to 120 hours depending on dust conditions. To service, loosen the retaining band clamp and remove the dust cup. Do not wash the dust cup – wipe clean with a clean dry cloth. Do not bend the edge of the cup by striking on a hard surface. When installing the dust cup, make sure the clamp is securely tightened to prevent leakage.

Filter Element – Service the air filter element when the "CHANGE AIR FILTER" LED is illuminated. Clean every 50 to 150 operating hours depending on dust conditions.

To service:

1. Loosen the retaining band clamp and remove the dust cup from the body of the filter.
2. Visually inspect the element in place. If cleaning is not necessary, reinstall the dust cup on the filter. If the element requires cleaning, unscrew the wing bolt and withdraw the element from the body.
3. Wash the element by soaking about 15 minutes in warm water with a mild detergent. Rinse the element thoroughly with clean water; a hose may be used if the water pressure does not exceed 40 psig.
4. Inspect the element for ruptures or cracks in the pleated media; replace the element if any are found. Inspect the gasket on the bottom (outlet end) of the element; replace the entire element if the gasket is damaged.
5. Allow the element to air dry COMPLETELY. Do not expose the element to heat over 150° F. Install the element in the filter body and fasten securely with the wing bolt. Reinstall the dust cup and retaining band clamp. Make sure the clamp is tightened securely to prevent leakage.

Filter Element Life – The element should be replaced after six (6) cleanings or if:

1. Visual inspection indicates a rupture, crack or pin hole in the pleated media. Inspection should be done by placing a bright light inside the element.
2. Pressure drop through a filter with a freshly cleaned element is below three (3) inches of water with the compressor running at full load – this would indicate a rupture or crack.

Inlet Tube – Inspect the inlet screen and tube for dirt accumulation each time the filter is serviced. Clean the tube when required by ramming a clean dry cloth through the tube. Wipe the inside of the filter body to remove any dirt falling from the inlet tube before reinstalling the element.

Causes of short element life include: severe dust conditions, infrequent servicing, improper cleaning, or contamination by oil or chemical fumes.

NOTICE

Use only genuine Gardner Denver air filter elements on Gardner Denver compressor units. Genuine parts are available through your authorized Gardner Denver distributor.

⚠ WARNING

Do not oil this element. Do not wash in inflammable cleaning fluids. Do not use solvents other than water. Improper cleaning may damage the element.

NOTICE

Never operate the unit without the element. Never use elements that are damaged, ruptured or wet. Never use gaskets that won't seal. Keep spare elements and gaskets on hand to reduce downtime. Store elements in a protected area free from damage, dirt and moisture. Handle all parts with care.

SECTION 7
COUPLING

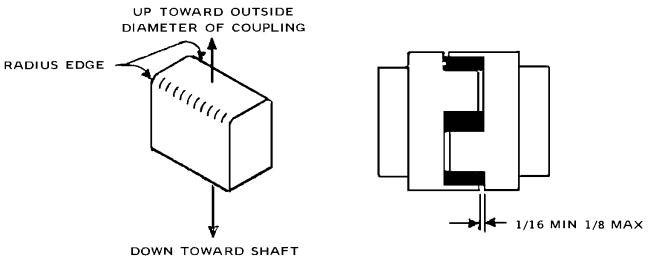


FIGURE 7–1 – INSTALLATION OF COUPLING – STYLE "A"

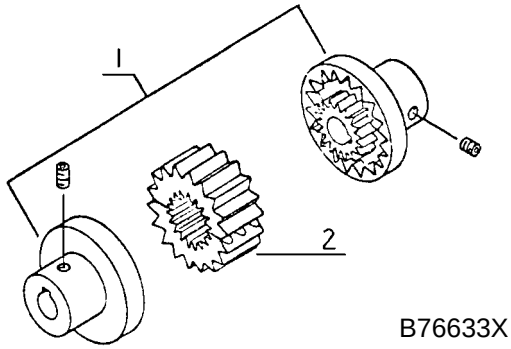


FIGURE 7–2 – INSTALLATION OF COUPLING – STYLE "B"

COUPLING – The motor and compressor are direct connected by a flexible coupling. Style "A" coupling has several individual cushions, (FIGURE 7–1). Style "B" has a two piece split sleeve, (FIGURE 7–2).

⚠ DANGER

Rotating machinery can cause personal injury or death. Turn the unit completely off, open the main disconnect, tag and lockout before servicing the coupling.

If maintenance on mating parts is requires, reassemble coupling as follows:

1. Slide coupling halves over shaft extensions. Be sure the collar is installed on the shaft behind one coupling body.
2. Assemble the motor to the compressor.

FOR STYLE "A" COUPLING:

a. Working through the cover plate opening, center coupling halves over the gap between the shafts, maintaining the gap as shown in FIGURE 7–1 between the ends of the jaws on one coupling body and the flange on the opposite coupling body. Tighten set screws in each coupling body.

b. Insert individual cushions as shown in FIGURE 7–1 and slide the collar over the cushions and secure with cap screws. Reinstall the cover plate.

FOR STYLE "B" COUPLING:

⚠ DANGER

Rotating machinery can cause personal injury or death. Do not operate unit with either the coupling guard or the collar removed. All bolts and screws must be properly tightened.

a. Working through coverplate, center coupling halves over the gap in the shafts. Secure short hub half of the coupling to the shaft by tightening the set screws over the shaft key and 90° to the key.

b. Assemble halves of split sleeve into the teeth of the short hub half of the coupling.

c. Slide the long hub over the split sleeve teeth until the sleeve is bottomed in both hubs; back long hub off 1/16 inch.

d. Secure the long hub in position by tightening the socket head cap screw through the split section of the hub; tighten the set screw over the shaft key.

Alignment – The coupling is permanently aligned by the flanges on the compressor and motor.

SECTION 8
MAINTENANCE SCHEDULE

SERVICE CHECK LIST –

Air Filter – Operating conditions determine frequency of service. If the "CHANGE AIR FILTER" message is displayed, air filter requires servicing or changing. See "Air Filter," Section 6, page 51.

Oil Separator – Operating conditions determine frequency of service. If the "CHANGE SEPARATOR" message is displayed, the oil separator element requires changing. See "Compressor Oil Separator" in Section 5, page 48, for further details.

Motor Lubrication – Refer to Section 2, page 15, and Maintenance Schedule Chart below.

Every 8 Hours Operation

1. Check the reservoir oil level – add oil if required. See Section 5, page 42. If oil consumption is high, refer to "Excessive Oil consumption, page 56. DO NOT MIX LUBRICANTS.
2. Observe if the unit loads and unloads properly.
3. Check discharge pressure and temperature.
4. Drain the moisture trap in the control system.
5. Check Panel LED's for advisories.

Every 125 Hours Operation

1. Check for dirt accumulation on oil/aftercooler core faces and the cooling fan. If cleaning is required, clean the exterior fin surfaces of the cores by blowing compressed air carrying a nonflammable safety solvent in a direction opposite that of the cooling fan air flow. This cleaning operation will keep the exterior cooling surfaces clean and ensure effective heat dissipation.

Every 1000 Hours Operation

1. Change the oil filter element.

Every 6000 Hours Operation

1. Change the compressor lubricant. UNDER ADVERSE CONDITIONS, CHANGE MORE FREQUENTLY (refer to "Oil Change Interval", page 43). Flush system if required.

Every Year

1. Check the relief valve for proper operation. See Section 4, page 31.

MAINTENANCE SCHEDULE (See detail notes above)

Maintenance Action	As Indicated By Auto–Sentry–ES	Every 8 Hours	Every 125 Hours	Every 1000 Hours	Every 6000* Hours	Every Year
Change Air Filter	●					
Change Oil Separator	●					
Check Reservoir Oil Level		●				
Check For Proper Load/Unload		●				
Check Discharge Pressure/Temp		●				
Check Dirt Accumulation on Cooler			●			
Change Oil Filter Element	●			●		
Change Compressor Lubricant (AEON 4000)	●				●	
Check Relief Valve						●

* See Oil Change Interval Chart, FIGURE 5–3, Page 43, for specific lubricant life.

SECTION 9
TROUBLE SHOOTING

SYMPTOM	POSSIBLE CAUSE	REMEDY
Compressor fails to start.	1. Wrong lead connections.	1. Change leads.
	2. Blown fuses in control box.	2. Replace fuse.
	3. Motor starter overload heaters tripped.	3. Reset and investigate cause of overload.
	4. Pressure in reservoir.	4. Inspect blowdown valve. and muffler.
	5. Read error message on control panel.	5. Take appropriate action. See Section 4.
	6. Remote Contact is open (terminals 6 & 9).	6. Replace switch or jumper.
Compressor starts but stops after a short time.	1. High discharge temperature.	1. See “High Discharge Air Temperature,” this section, page 56.
	2. High discharge temperature switch malfunction.	2. Replace switch.
	3. Blown fuse in starter/ control box.	3. Replace fuse (investigate if fuses continue to blow).
	4. Motor starter overload heaters trip.	4. Reset and investigate cause of overload.
Compressor does not unload (or load).	1. Improperly adjusted control.	1. Refer to Section 4 and adjust control.
	2. Air leak in control lines.	2. Determine source of leak and correct.
	3. Restricted control line.	3. Clean control lines.
	4. Blowdown valve malfunction.	4. Repair, clean or replace valve.
Compressor cycles from load to unload excessively.	1. Insufficient receiver capacity.	1. Increase receiver size.
	2. Restriction in control tubing.	2. Inspect and clean control tubing.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Compressor is low on delivery and pressure.	1. Restricted air filter.	1. Clean or replace filter.
	2. Sticking inlet valve.	2. Inspect and clean inlet valve.
	3. Unload pressure adjusted too low.	3. Adjust the unload pressure. See Section 4, page 33.
	4. Minimum pressure valve stuck closed.	4. Disassemble and clean valve.
	5. Turn valve adjustment or malfunction.	5. Adjust turn valve per Section 4, page 33.
High discharge air temperature.	1. Thermostatic mixing valve stuck open.	1. Repair or replace valve.
	2. Dirty or clogged cooler face.	2. Clean cooler.
	3. Insufficient cooling air flow.	3. Provide unrestricted supply of cooling air.
	4. Clogged oil filter or cooler (interior).	4. Replace filter or clean cooler.
	5. Low compressor oil.	5. Add oil to proper level.
Excessive Oil Consumption	1. Oil carryover through lines.	1. See “Oil Carryover”, below.
	2. Oil leaks at all fittings and gaskets.	2. Tighten or replace fittings or gasket.
Oil Carry–Over	1. Overfilling the reservoir.	1. Drain excess oil from system.

DANGER

Air/oil under pressure will cause severe personal injury or death. Shut down compressor, relieve system of all pressure, disconnect, tag and lockout power supply to the starter before removing valves, caps, plugs, fittings, bolts, and filters.

DANGER

Compressor, air/oil reservoir, separation chamber and all piping and tubing may be at high temperature during and after operation.

SYMPTOM	POSSIBLE CAUSE	REMEDY
Oil Carry–Over (Continued)	2. Clogged, broken or loose oil return lines	2. Tighten or replace faulty lines.
	3. Ruptured oil separator element.	3. Replace element.
	4. Loose assembly.	4. Tighten all fittings and gaskets.
	5. Foam caused by use of incorrect oil.	5. Use Gardner Denver® AEON™ 9000 SP Lubricating Coolant.
	6. Inoperative minimum pressure valve, causing low operating pressure.	6. Clean out or replace valve.
	7. Operation at elevated discharge temperatures.	7. Reduce temperature. See High Discharge Air Temperature, page 56, this section.
	8. Scavenge line check valve failure.	8. Replace check valve.
	9. Water condensate in oil.	9. Check oil reservoir tempera–ture and if low, change thermal mixing valve element to higher temperature.

NOTICE

Gardner Denver factory remanufactured replacement compressor air end units are available from your authorized distributor, on an exchange basis, for all rotary screw compressor units.

SECTION 10
TROUBLE SHOOTING CONTROLS

AUTO SENTRY® ES+ CONTROLLER

DISPLAY MODES

The normal display indicates the package service pressure, the airend discharge, the total running hours, and one of the following operating modes. The green light will be on for any operating mode, whether the compressor is running or not.

READY	The compressor has been stopped by pressing the [STOP/RESET] key.
CON	The compressor is operating in the Constant Run mode.
LDM	The compressor is operating in the Low Demand mode.
AUTO	The compressor is operating in the Automatic mode.
SEQ n	The compressor is operating in the Sequence mode.

The following alternate displays may be called by pressing a cursor [<] or [>] key

RES PRES	The pressure in the oil reservoir
DIF PRES	The pressure drop across the separator
RES TMP	The temperature at the separator
SYS PRES	The pressure at the service connection
DIS TMP	The temperature at the airend discharge
BD TMR	The time remaining before a blowdown will be allowed
AUTO TMR	The time remaining of unloaded motor operation
TOT HRS	The total hours of compressor running
LOAD HRS	The hours of compressor delivery

The following alternate displays may be called by pressing the [+] or [–] key

MOTOR CURRENT	The main motor current in amps (Optional)
NEXT OIL CHANGE	The estimated remaining time until the next recommended change
NEXT OIL FILTER	The remaining time until the next recommended filter change

The compressor schematic area keys may be used to select alternate displays.

CLOCK KEY	First press shows the total run hourmeter.
CLOCK KEY	Second press shows the loaded hourmeter.
CLOCK KEY	Third press shows the remaining blowdown time.
CLOCK KEY	Fourth press shows the remaining auto time.
DISCH THERM KEY	Shows temperature at the compressor discharge.
SEPARATOR KEY	First press shows the pressure in the reservoir.
SEPARATOR KEY	Second press shows the separator pressure drop.
SEPAR THERM KEY	Shows temperature at the reservoir / separator.
OIL CAN KEY	Shows estimated remaining time until next recommended oil change.
OIL FILTER KEY	Shows remaining time until next recommended oil filter change.

The compressor schematic area has red shutdown and yellow service advisory indicator lights.

AIR FILTER	yellow indicates that the filter needs to be changed
DISCH THERM	yellow indicates high temperature operation
DISCH THERM	red indicates a high temperature shutdown
SEPARATOR	yellow indicates the separator needs to be changed
SEPARATOR	red indicates a change separator shutdown
SEPAR THERM	yellow indicates high temperature operation
SEPAR THERM	red indicates a high temperature shutdown
OIL CAN SYMBOL	yellow indicates that the oil needs to be changed
FAN MOTOR	red indicates a fan motor overload or starter shutdown
OIL FILTER	yellow indicates that the filter needs to be changed
DRIVE MOTOR	yellow indicates operation with high motor amps
DRIVE MOTOR	red indicates a main motor overload or starter shutdown

ADVISORY TROUBLESHOOTING GUIDE

All advisories are indicated on the keypad by a yellow indicator in the Status area, and one of the following messages alternating with the normal lower line display. Perform service or maintenance as indicated, then clear the advisory as instructed in Section 4.

Message	**Action Needed**
CHECK COMM PORT	The controller has detected a communications problem while running in Sequence mode. Check for proper cable installation. If the controller switches from Sequence to Auto mode, reprogram a different unit number.
CHNG AIR FILTER	Excessive vacuum has been detected after the air filter, indicating it has become full. Change the air filter to ensure maximum air delivery.
CHNG SEPARATOR	The differential pressure across the separator has risen to over 8 psid. Change the separator to ensure peak compressor performance.
CHNG OIL FILTER	The unit has been operated for the programmed number of hours since the last filter replacement. Change the filter to ensure an adequate flow of lubricant.
CHANGE OIL	The unit has been operated for the programmed number of hours since the last oil change. Change the oil to ensure lubricant quality.
HIGH DISCH TEMP	The temperature was greater than 210 degrees F (99 degrees C) at the airend discharge. Ensure that the compressor receives adequate cooling air or water, and that the coolers are not plugged.
HIGH MOTOR AMPS	The unit has been operated with motor current in excess of the programmed service factor amps. Turn valve units will unload during moderate overcurrent to prevent sustained operation.
HIGH RES TEMP	The temperature was greater than 210 degrees F (99 degrees C) at the separator. Ensure that the compressor receives adequate cooling air or water, and that the coolers are not plugged.
LOW AMB TEMP	The temperature was less than 40 degrees F (4 degrees C) at: (A) the airend discharge, (B) the separator. Ensure that the compressor is located in a room kept above freezing.

SHUTDOWN TROUBLESHOOTING GUIDE

All shutdowns are indicated on the keypad by the word “SHUTDOWN” on the top line of the display, and one of the following messages on the lower line of the display. The red indicator in the Status area will be steadily lit while the conditions exist, and will flash after the condition has been corrected. Perform service as indicated. Press the [STOP/RESET] key to clear the shutdown.

Message	Action Needed
CHANGE SEPARATOR	The differential pressure across the air / oil separator has risen to over 15 psid. Change the separator to ensure maximum compressor performance.
CHECK CN7	All inputs at connector 7 of the controller are off. The most common cause for this is that the connector plug has been pulled out. Plug the connector back in firmly.
CHECK CN8	120 volts has been removed from ALL inputs to connector 8 of the controller. The most common cause for this is that the connector plug has been pulled out. Plug the connector back in firmly.
CONTROLLER ERROR	The ES+ controller performs several internal diagnostic checks of its own operation. Follow instructions on lower line, or replace if the controller indicates “REPAIR REQUIRED.”
EMERGENCY STOP	The Emergency Stop button has been pressed. Pull it back out to its normal position. If the button has not been pressed, check that the contact block is firmly mounted in the right or left (not center) position of the operator. Check for loose connections which would remove 120 volts from connector 8–8 of the controller.
EXTERNAL DEVICE	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
FAN OVERLOAD	The motor overload relay for the fan motor, located within the electrical control box, has tripped. This indicates high motor shaft load, low voltage, or excessive imbalance in the incoming power (such as a blown fuse). Disconnect and lock out power, open the box, and press the reset button – it will click when reset. Measure motor amps, and take corrective actions to get all currents within the motor nameplate rating. If the overload relay has not tripped, check for the cause that 120 volts was removed from connector 8–1 of the controller.
FAN STARTER	The controller has attempted to start the fan, but did not receive a return signal from the starter’s auxiliary contact. If the starter does not pick up when attempting to start, check that connector 9 of the controller is plugged in firmly, and check the starter coil. If the starter does pick up, but this message appears, check that the auxiliary contact block is properly installed on the starter and wired to connector 8, terminal 3.
FAN STRT CONTACT	The controller has attempted to turn off the fan, but is still receiving a return signal from the starter’s auxiliary contact. Check that the starter operates freely and that the contact block is properly installed on the starter.
HI SYSTEM PRESS	Pressure in excess of the programmed high pressure limit has been detected. The most likely cause is other, higher pressure compressors on the same air system; separate these from this compressor unit. Other possible causes are loose connections to the transducer, electrical noise and transients, or improper setting of the high pressure limit.
HIGH AMP SENSOR	The controller is sensing current to the main motor when it is turned off. Check that the main starter is operating properly. Check for proper installation of the current transformer and current transducer.

SHUTDOWN TROUBLESHOOTING GUIDE (Continued)

Message	Action Needed
HIGH DISCH TEMP	This indicates that the controller has detected temperature in excess of the programmed high temperature limit at the airend discharge. The most common cause for this is inadequate package cooling. Ensure proper air flow for air-cooled units, or adequate cooling water for water cooled units. Check for proper oil level, and fill as required. Monitor the temperature carefully during restarts after servicing.
HIGH DISCH TEMR	This indicates that the controller has detected a rapid temperature rise in the airend discharge. This normally would indicate a loss of coolant injection into the airend. Check oil level, and fill if required. Completely check all oil piping, the filter, and flow controls for blockage or freezing. This may also be caused by a loose connection at connector 7 of the controller. Monitor the temperature carefully during restarts after servicing.
HIGH RESVR PRESS	Pressure in excess of the programmed high pressure limit has been detected. This shutdown will occur if a loss of pneumatic controls occurs. Check the inlet valve, all control piping, solenoid valves, and all other control devices to find the cause for the inlet valve not closing. Other possible causes are loose connections to the transducer, electrical noise and transients, or improper setting of the high pressure limit.
HIGH RESVR TEMP	This indicates that the controller has detected temperature in excess of the programmed high temperature limit at the air / oil separator. The most common cause for this is inadequate package cooling. Ensure proper air flow for air-cooled units, or adequate cooling water for water cooled units. Check separator element, replace non–standard separators with recommended separator. Monitor the temperature carefully during restarts after servicing.
HIGH RESVR TEMR	This indicates that the controller has detected a rapid temperature rise in the air / oil separator. Use only recommended separators; replace non–standard separators. This may also be caused by a loose connection at connector 7 of the controller. Monitor the temperature carefully during restarts after servicing.
HIGH VIBRATION	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
LOW OIL PRESS	The controller has attempted to start and load the compressor, but pressure is not building up in the oil reservoir. This may indicate either a failure of the motor to turn the compressor, or a failure of the inlet valve to open. If the latter, check also the wiring and piping to solenoid valves IVO and IVC; these are both turned on to load up the compressor.
LV RELAY	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
MAIN OVERLOAD	The overload relay for the main compressor drive motor, located within the electrical control box, has tripped. This indicates high motor shaft load, low voltage, or excessive imbalance in the incoming power (such as a blown fuse). Disconnect and lock out power, open the box, and press the reset button – it will click when reset. Measure motor amps, and take corrective actions to get all currents within the motor nameplate rating. Check that the programmed Set Pressure is at or below the compressor nameplate rating. If the overload relay has not tripped, check for the cause that 120 volts was removed from connector 8 –2 of the controller.

Message	Action Needed
MAIN STARTER	The controller has attempted to start the compressor, but did not receive a return signal from the starter's auxiliary contact. If the starter does not pick up when attempting to start, check that connector 9 of the controller is plugged in firmly, and check the starter coil. If the starter does pick up, but this message appears, check that the auxiliary contact block is properly installed on the starter and wired to connector 8, terminal 4.
MAIN STRT CONTCT	The controller has attempted to turn off the compressor, but is still receiving a return signal from the starter's auxiliary contact. Check that the starter operates freely and that the contact block is properly installed on the starter.
OPEN AMP SENSOR	The controller is not sensing current to the main motor when it is turned on. Check that the main starter is operating properly. Check for a loose or broken connection at connector 4. Check wiring and proper installation of the current transformer and current transducer. If not installed, set the "MOTOR SFA" to zero amps in the configuration adjustments.
OPEN THERM	The controller has detected an open connection to thermistor: (A) airend discharge or (B) separator. This normally indicates a loose or broken connection at the controller connector 7; check and correct the connection. This could also be indicating a broken wire or thermistor probe, or exposure to excessively low temperatures.
OPEN XDUCER	Signal voltage has fallen too low at transducer: (A) Final discharge or (B) Reservoir. This probably indicates a loose connection of the red or green wire to the transducer or an unplugged transducer. It connections are good, this is indicating a defective transducer. Check connections, or replace transducer if necessary.
PHASE RELAY	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
POWER FAILURE	The power to the compressor unit has been turned off and back on. Press [STOP/RESET] and select an operating mode.
SHORTED THERM	The controller has detected a shorted connection to thermistor: (A) airend discharge or (B) separator. This normally indicates a faulty connection (e.g. wire strands touching) at the controller connector 7; check and correct the connection. This could also be indicating a damaged wire or thermistor probe.
SHORTED XDUCER	Signal voltage has exceeded approximately 4.6 volts at transducer: (A) Final discharge or (B) Reservoir. This may indicate a loose connection of the black wire to the transducer or a defective transducer. Check connections, or replace transducer if necessary.
WATER PRESS	120 volts has been removed from terminal 7 of the terminal strip. This is normally shipped jumpered directly to terminal 9, but the jumper may be removed to add a field installed shutdown switch. Reset the external switch.
ZERO XDUCER	Signal voltage has fallen too low at transducer: (A) Final discharge or (B) Reservoir. This error is usually the result of the transducers being improperly zeroed. Disconnect the air lines to the transducers and follow the procedure indicated in the adjustment instructions. This shutdown for transducer B may also be the result of reverse compressor rotation. Check connections, or replace transducer if necessary.

CONTROLS TROUBLESHOOTING GUIDE

The following are recommended service actions. Observe all instructions noted elsewhere in this manual. All electrical service is to be performed only by a qualified electrician.

Symptom	Recommended Action
No display, compressor stopped	Check incoming power to the compressor unit. Ensure that the disconnect is on and that fuses have not blown (or circuit beaker tripped). If power is being properly supplied to the control box, check the fuses located at the fan starter, the control transformer fuses, and the wiring to connector CN–6.
Compressor will not start.	To operate, the controller must be placed into an operating mode (e.g. “AUTO); press the [STOP]RESET] key to put the control into the READY state, then select a mode with the operating mode keys. In AUTOMATIC and SEQUENCE modes, compressors will not start until the pressure drops below the reset pressures.
Display indicates “NOT BLOWN DOWN”	The controller prevents attempts to start the main motor if the reservoir pressure is over 5 psig. Pressure continues to be relieved from the reservoir while this message is on, and the compressor will start automatically after the pressure has dropped. If this message remains with NO pressure in the reservoir, follow the transducer zeroing procedure found in the controls adjustment section.
Display indicates “REMOTE STOP”	The controller is provided with an input for user–furnished remote controls. This display indicates that 120 volt is removed from terminal 6 of the terminal strip. Check all connections of the factory installed jumper, or the customer–provided controls, if applicable.
Display indicates “SHUTDOWN”	If the display indicates “SHUTDOWN”, refer to the shutdown troubleshooting section for assistance. In addition to the messages shown, there are several internal and system diagnostics performed by the controller. Consult the factory for additional assistance.
Compressor runs, but does not load	In the CONSTANT RUN and LOW DEMAND modes, the compressor will not load until the pressure drops below reset pressure. Refer to the operating instructions for further information. If pressure is below the reset pressure,check that the inlet valve operates freely. Check that the TVO, TVC, IVO and IVC valves are wired and operating properly.
Compressor runs, unloads at low pressure	If the inlet valve closes at low pressure, check the wiring to the blowdown valve and the piping and check valves in its discharge line.
Compressor does not modulate	On units with turn valve control, the turn valve will control delivery for moderate to heavy demands to maintain the system near the programmed set pressure, with the inlet valve held open. At light demands, the inlet valve controls the compressor delivery to maintain pressure approximately 3 psi above the programmed set pressure, with the turn valve held open. If the pressure continues to rise above these pressures, check that the turn valve and inlet valve operate freely, and check wiring and piping to control valves TVO, TVC, IVO and IVC. If normal modulation does occur, the inlet valve will be closed during a blowdown as pressure approaches the high pressure limit.
Compressor cycles between load and unload	The external air receiver should be sized appropriately to prevent rapid rapidly cycles. The rapid response time in the CONSTANT RUN mode will operate with small receivers, but any plant air system will operate more efficiently with adequately sized storage. Refer to the operating instructions for further information.

Symptom	Recommended Action
Low reservoir pressure in CONSTANT mode other modes before blowdown	The ES+ controller will maintain a minimum pressure in the oil reservoir while in CONSTANT or in other modes while the blowdown valve is closed. This or occurs only after initially loading the compressor unit. If reservoir pressure drops while the blowdown valve is closed, check for leaks between at the reservoir, separator, and connected piping.
Erratic pressures in SEQUENCE only	The sequencing system transmits low–level signal between units to commun–icate pressures. Units must be properly grounded to a good ground system, the communications cable should use only appropriate quality cable, and the cable should be run in its own conduit.
Compressor cycles rapidly in SEQUENCE mode only	In the sequence mode, the operating system requires all compressors be piped directly to receiver, such that all transducers sense the same pressure. Check valves or restrictions between compressors and the storage will cause system instability. Run units in AUTOMATIC mode until the system is corrected.
Error in displayed pressure or “CHECK XDUCER” while zeroing	Pressure measurement errors are almost always the result of poor zero adjust–ment. This must be done after replacement of a controller or a transducer. The proper display with all pressure removed is 0 +/–1 psig. The adjustment procedure will prevent large zeroing errors, and recommend that the transduc-ers be checked.

Gardner Denver

WARRANTY

ROTARY SCREW COMPRESSORS

OIL INJECTED • OIL FREE

GENERAL PROVISIONS AND LIMITATIONS

Gardner Denver Machinery Inc. (the "Company") warrants to each original retail purchaser ("Purchaser") of its new products from the Company or its authorized distributor that such products are, at the time of delivery to the Purchaser, made with good material and workmanship. No warranty is made with respect to:

1. Any product which has been repaired or altered in such a way, in the Company's judgment, as to affect the product adversely.
2. Any product which has, in the Company's judgment been subject to negligence, accident, improper storage, or improper installation or application.
3. Any product which has not been operated or maintained in accordance with the recommendations of the Company.
4. Components or accessories manufactured, warranted and serviced by others.
5. Any reconditioned or prior owned product.

Claims for items described in (4) above should be submitted directly to the manufacturer.

WARRANTY PERIOD

The Company's obligation under this warranty is limited to repairing or, at its option, replacing, during normal business hours at an authorized service facility of the Company, any part which in its judgment proved not to be as warranted within the applicable Warranty Period as follows.

COMPRESSOR AIR ENDS

Compressor air ends, consisting of all parts within and including the compressor cylinder and gear housing, are warranted for 24 months from date of initial use or 27 months from date of shipment to the first purchaser, whichever occurs first.

Any disassembly or partial disassembly of the air end, or failure to return the "unopened" air end per Company instructions, will be cause for denial of warranty.

OTHER COMPONENTS

All other components are warranted for 12 months from date of initial use or 15 months from date of shipment to first purchaser, whichever occurs first.

LABOR TRANSPORTATION AND INSPECTION

The Company will provide labor, by Company representative or authorized service personnel, for repair or replacement of any product or part thereof which in the Company's judgment is proved not to be as warranted. Labor shall be limited to the amount specified in the Company's labor rate schedule.

Labor costs in excess of the Company rate schedule amounts or labor provided by unauthorized service personnel is not provided for by this warranty.

All costs of transportation of product, labor or parts claimed not to be as warranted and, of repaired or replacement parts to or from such service facilities shall be borne by the Purchaser. The Company may require the return of any part claimed not to be as warranted to one of its facilities as designated by Company, transportation prepaid by Purchaser, to establish a claim under this warranty.

Replacement parts provided under the terms of the warranty are warranted for the remainder of the Warranty Period of the product upon which installed to the same extent as if such parts were original components.

DISCLAIMER

THE FOREGOING WARRANTY IS EXCLUSIVE AND IT IS EXPRESSLY AGREED THAT, EXCEPT AS TO TITLE, THE COMPANY MAKES NO OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY.

THE REMEDY PROVIDED UNDER THIS WARRANTY SHALL BE THE SOLE, EXCLUSIVE AND ONLY REMEDY AVAILABLE TO PURCHASER AND IN NO CASE SHALL THE COMPANY BE SUBJECT TO ANY OTHER OBLIGATIONS OR LIABILITIES. UNDER NO CIRCUMSTANCES SHALL THE COMPANY BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOSSES OR DELAYS HOWSOEVER CAUSED.

No statement, representation, agreement, or understanding, oral or written, made by any agent, distributor, representative, or employee of the Company which is not contained in this Warranty will be binding upon the Company unless made in writing and executed by an officer of the Company.

This warranty shall not be effective as to any claim which is not presented within 30 days after the date upon which the product is claimed not to have been as warranted. Any action for breach of this warranty must be commenced within one year after the date upon which the cause of action occurred.

Any adjustment made pursuant to this warranty shall not be construed as an admission by the Company that any product was not as warranted.

Gardner Denver

For additional information contact your local representative or
Gardner Denver Machinery Inc., Customer Service Department,
1800 Gardner Expressway, Quincy, Illinois 62301
Telephone: (800) 682-9868 FAX: (217) 224-7814

Sales and Service in all major cities.

For parts information, contact Gardner Denver,
Master Distribution Center, Memphis, TN
Telephone: (800) 245-4946 FAX: (901) 542-6159

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