GARDNER DENVER®

13-9-653
Version: 03
July 14, 2004

AUTO SENTRY® - ES+ CONTROLS

OPERATING AND SERVICE MANUAL

GARDNER DENVER

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AUTO SENTRY – ES+ CONTROLLER

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 in the package instruction manual.

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 controller 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 and lock main disconnect and any other circuits before servicing 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 controller to interrupt and restart the unit based on controls by others. When stopped by these controls, the display indicates **"REMOTE HALT"**.

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.

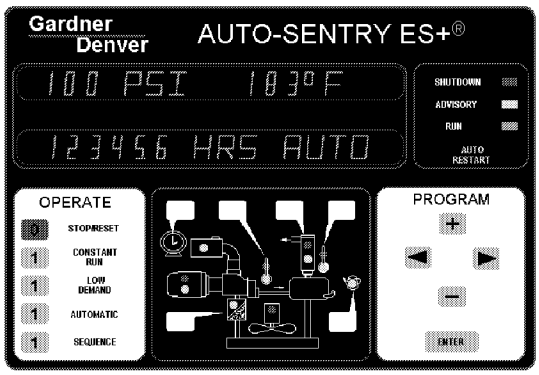


Figure 1-1 – AUTO SENTRY ES+ DISPLAY

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 controller operates the solenoid valves TVO (TurnValve open), TVC (TurnValve 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 TurnValve will control delivery. At lighter demands, the TurnValve 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.

On compressor units without TurnValve, the controller operates valves IVO and IVC to position the inlet valve. This continuously adjusts delivery to match demand.

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 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. It also eliminates the problems of oil foaming and carryover that can occur if the oil reservoir of an oil-flooded compressor is blown down too often. The timer is adjustable from 1 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 1 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.

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. Airend 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 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 controller 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. Overload relays provided in standard units are sensitive to both overload and phase imbalance for improved motor protection. 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. This controller will shut the compressor down if temperature exceeds 225° F (or as set in setup adjustments) or if rapid temperature rise is detected. Reservoir / 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 controller. 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 controller 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. Shutdown 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 sump pressure - The controller will shut down the unit if inadequate oil reservoir 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, water press, and motor overtemp.

Amp sensor failure - The optional current sensor used with the controller is used for operational tuning and advisory purposes only. The only shutdown functions are those when the controller senses improper operation. These may be disabled if no sensor is installed.

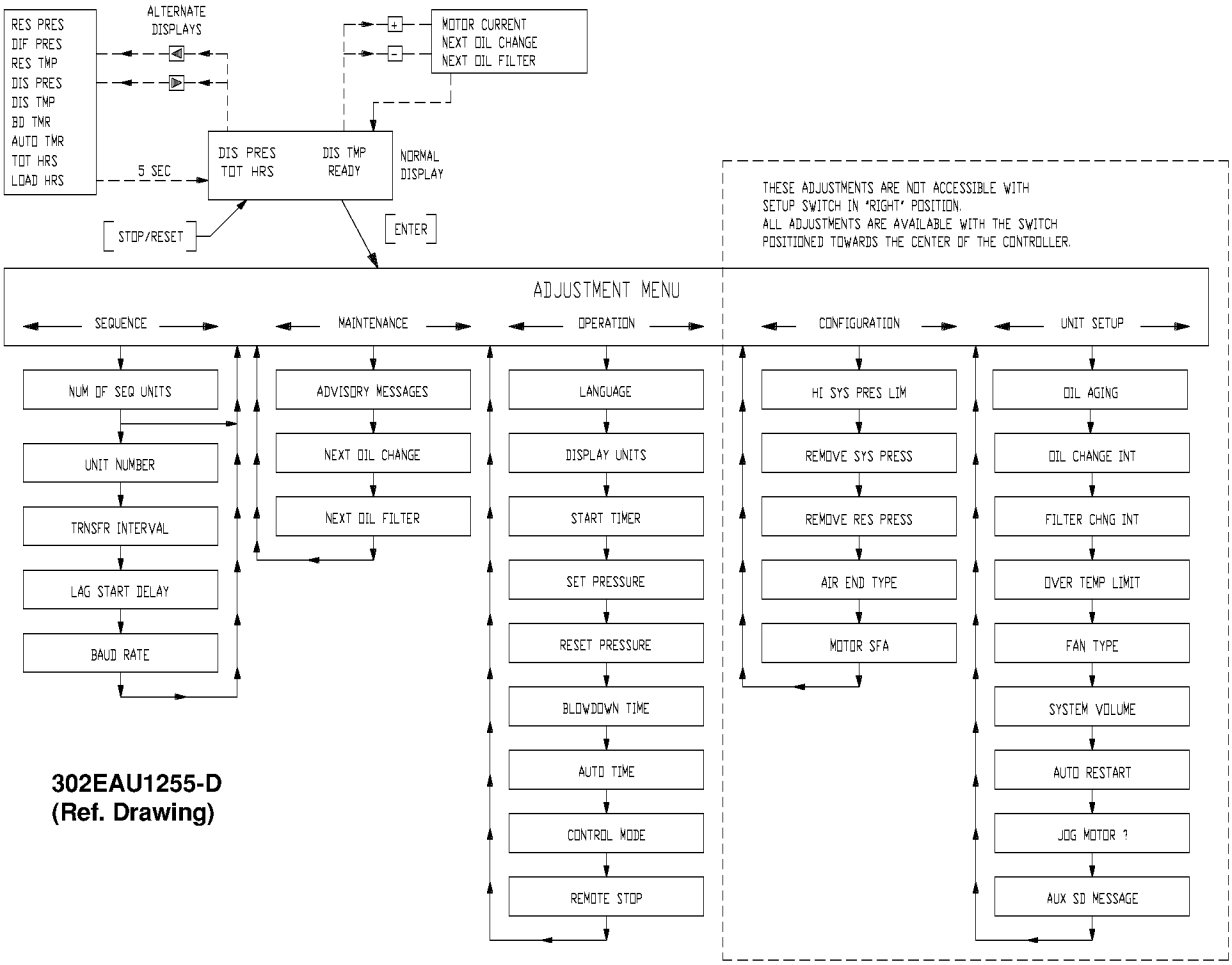
Connection failure - The controller checks input connectors and will shutdown if they become unplugged.

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 FOR THE "AUTO SENTRY®-ES+" CONTROLLER

Programming and setup is accomplished with the PROGRAM keys. See Figure 1-1. 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 controller. Remember, between each step, it is necessary to press the [ENTER] key to store the new value and advance to the next step.



302EAU1255-D
(Ref. Drawing)

Figure 1-2 – FLOW CHART

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.

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

3. Press the [ENTER] key to begin programming. This enters the adjustments menu. The adjustments are broken into five groups as shown in Figure 1-2. 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.

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, **"LANGUAGE"** is indicated. The bottom line will indicate **"ENGLISH"** or an alternate language for display messages. Select the desired display language and press [ENTER] to proceed.

   If a controller is set for another language, press the [STOP/RESET] key, press [ENTER] twice, and press the [+] or [-] key to select ENGLISH at this step. Then press [ENTER] to select the language.

2. 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.

3. 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.

4. 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.

5. 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.

6. In the top line, **"BLOWDOWN TIME"** is displayed. The bottom line will indicate a time between 1 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.

7. In the top line, **"AUTO TIME"** is displayed. The bottom line will indicate a time between 1 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.

8. **"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.

9. In the top line, **"REMOTE HALT"** 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.

10. 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 controller 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 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.

   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+" 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 controllers. It should be noted that all controllers 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 controller. The adjustments will continue with step 5

2. In the top line, **"UNIT NUMBER"** is displayed. The bottom line will again indicate a number of one through eight and be factory set at "1". Enter a different number for each controller 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. All units in the system must be set the same. 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 the nameplate. 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 pressure 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 system pressure is, in fact, zero psig. Remove the pressure line to the system pressure transducer. Pressing [ENTER] will now cause the controller 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 step 2 above.

4. In the top line, **"AIREND 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. If current monitoring is not installed, set this to zero (0) to disable current monitoring.

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

Unit Setup Adjustments

1. On the top line, **"Oil Aging"** is displayed. Select between **"Standard"** or **"High Temp"** on the second line. This will change how fast the oil change timer will increment when using high temperature oil such as AEON 9000TH.

2. In the top line, **"OIL CHANGE INTERVAL"** is displayed. The bottom line will indicate a time interval of 1000 to 12000 hours. After the machine has run for the programmed setting, an advisory will be displayed, requesting an oil change. Adjust as appropriate and press [ENTER] to proceed.

3. 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.

4. In the top line, **"OVER TEMP LIMIT"** is displayed. The bottom line will indicate 225° F. This is the proper setting for compressor operation with conventional coolant. It may be set higher for high temperature oils, per the manufacturer's instructions. It may be temporarily lowered to verify the function of the temperature shutdown system.

5. **"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.

6. 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.

7. 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.

8. 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.

9. 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.

10. 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.

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

OTHER CONTROL FEATURES

Modulating - Load / Unload - The 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 TurnValves 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 a controller is used on a compressor unit with TurnValve control and has current monitoring installed. This is based on the motor service factor amps programmed above.

On units with TurnValves, 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 controller, 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 controller 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 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 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 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 controllers will then resume the same sequence numbers which they had prior to the interruption. The 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 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 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 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.

NOTICE
Though similar in operation and installation, this sequencing system is designed to take advantage of all the internal features of the controller. Communication cables should not be connected to compressor units with controller parts numbers 201EAP1173 OR 202EAP1173. Multiple compressors with each type controller may be operated as independent groups piped to the same plant demand.

Auto Sentry ES+ and RS2000 Controllers may be combined into a system. In the ES+ adjustments, adjust set pressure and reset pressure equal to the load and unload pressures of the RS2000. Adjust the IV control mode to Load-Unload.

The 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, part number 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.

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+ controlled 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 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 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 part number 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, located on the top of the controller case. 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 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 controller sequencing system: control is always executed locally by each member controller. So while controllers count 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.

"AUTO SENTRY®-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 **"DIS 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 DIS 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 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 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 - A controller will be the lead compressor for the time programmed as TRANSFER INTERVAL. Then it 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 controller sequencing system is designed to tolerate minor variations. The controller 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 TurnValve 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 "AUTO SENTRY®-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 also 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 controller offers interconnection points for external controls and indicators. This allows simple connection to remote controls and indicators, or integration into any plant-wide 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, and the remote is not capable of starting a unit after the [STOP/RESET] key has been pressed to place the controller in the READY state. 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 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.

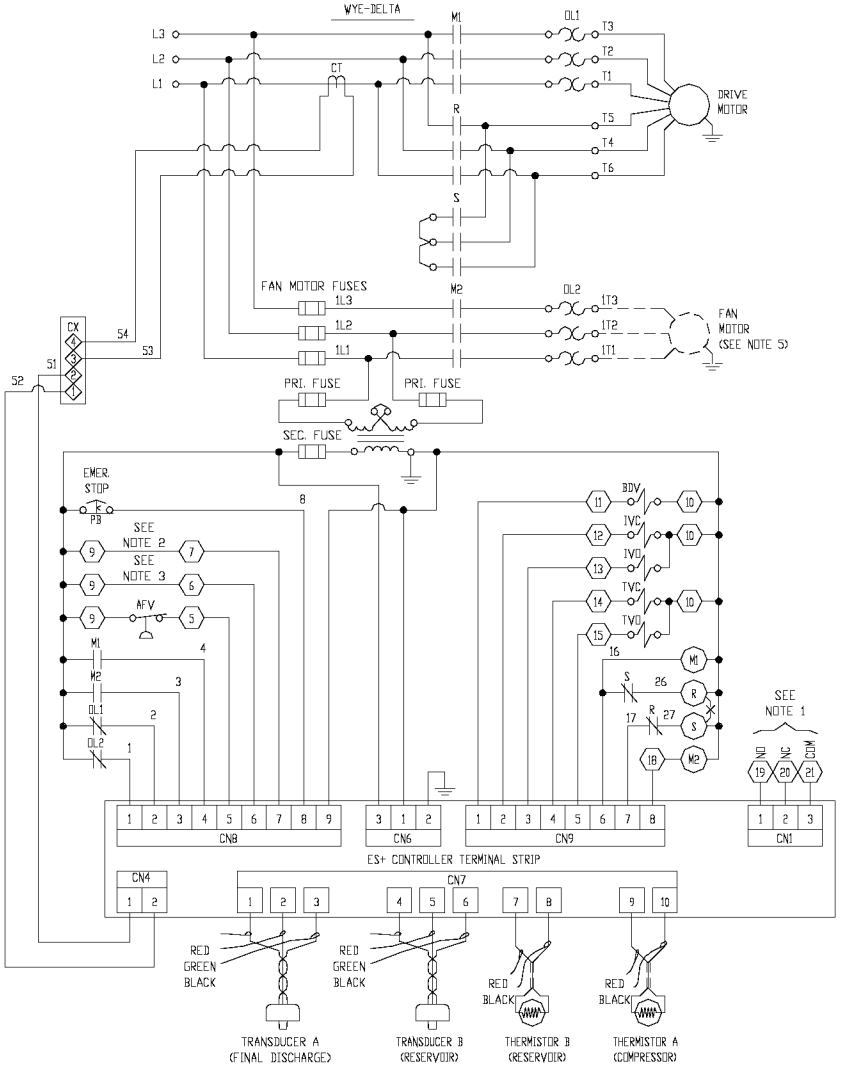
When the remote is turned back on, the unit will start immediately in the CONSTANT or LOW DEMAND modes. Loading in these modes, or starting in AUTO or SEQUENCE modes will occur when the pressure drops below the set pressure.

Alarm Relay - The 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 report of internal service data. This is accessible with a PC or PLC with an appropriate communications port. For protocol information, request drawing 305EAU1255.

Wiring Diagrams - The following wiring diagrams show connections in typical units. Refer to the wiring diagram shipped with the compressor unit for actual connections.



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. 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: FAN MOTOR IS NOT USED ON WATERCOOLED UNITS WITHOUT ENCLOSURE. UNITS WITHOUT FAN HAVE NO CONNECTION TO 1T1, 1T2 & 1T3.
NOTE 6: WHEN A MAGNETIC WATER VALVE IS USED, CONNECT TO TERMINALS 18 & 10. VALVE COIL IS 120 VOLTS, NOT TO EXCEED 90VA.

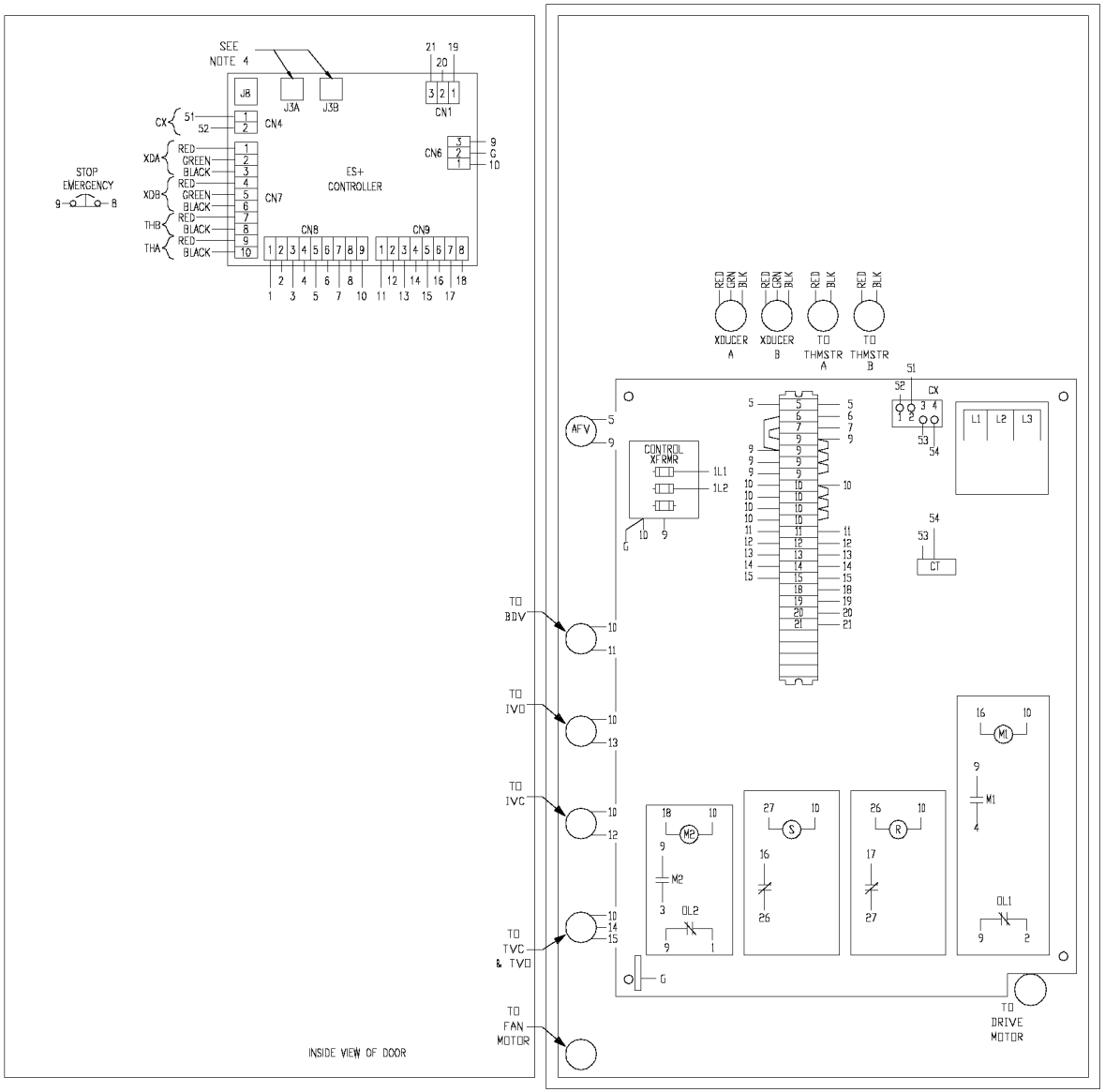
LEGEND:
AFV - AIR FILTER VACUUM SWITCH
BDV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID VALVE
IVO - INLET VALVE OPEN SOLENOID VALVE
TVC - TURN VALVE CLOSE SOLENOID VALVE
TVO - TURN VALVE OPEN SOLENOID VALVE
THA - THERMISTOR A (COMPRESSOR)
THB - THERMISTOR B (RESERVOIR)
XDA - TRANSDUCER A (FINAL DISCHARGE)
XDB - TRANSDUCER B (RESERVOIR)
CT - CURRENT TRANSFORMER
CX - CURRENT TRANSDUCER
= CONNECTION TO CONTROL BOARD.
= PANEL TERMINAL BLOCKS
= CURRENT TRANSDUCER TERMINAL

300EAM546-A
(Ref. Drawing)

MAIN MOTOR	Y-D STARTER
FAN MOTOR	AIR/WATER COOLED
CONTROLLER	ES+
ACCESSORY	CURRENT MONITOR

Figure 1-3 – WIRING DIAGRAM

60-100 HP, WYE DELTA WITH CURRENT MONITOR WITH TURN VALVE



300EAM546-A
(Ref. Drawing)
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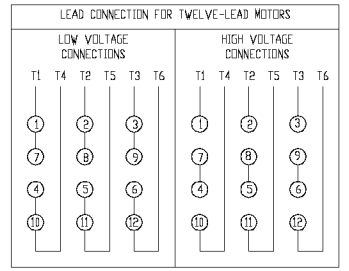
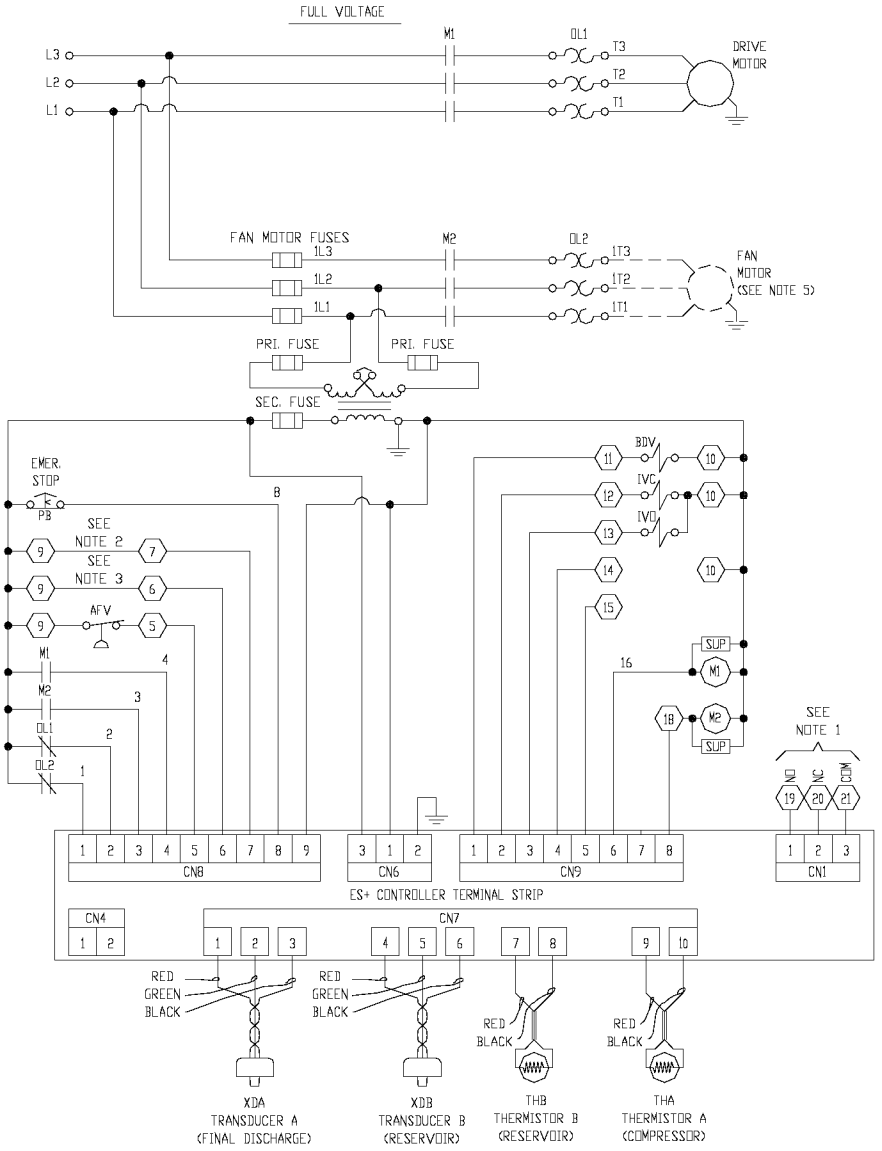


CONNECTIONS SHOWN ARE FOR A TYPICAL 12 LEAD, DUAL-VOLTAGE MOTOR. CONNECTIONS FOR LARGE MOTORS AND SINGLE-VOLTAGE MOTORS DIFFER. REFER TO MOTOR NAMEPLATE TO VERIFY ACTUAL CONNECTION.

316EBH546-A
(Ref. Drawing)



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. 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: FAN MOTOR IS NOT USED ON WATERCOOLED UNITS WITHOUT ENCLOSURE. UNITS WITHOUT FAN HAVE NO CONNECTION TO 1T1, 1T2 & 1T3.
NOTE 6: WHEN A MAGNETIC WATER VALVE IS USED, CONNECT TO TERMINALS 18 & 10. VALVE COIL IS 120 VOLTS, NOT TO EXCEED 90VA.

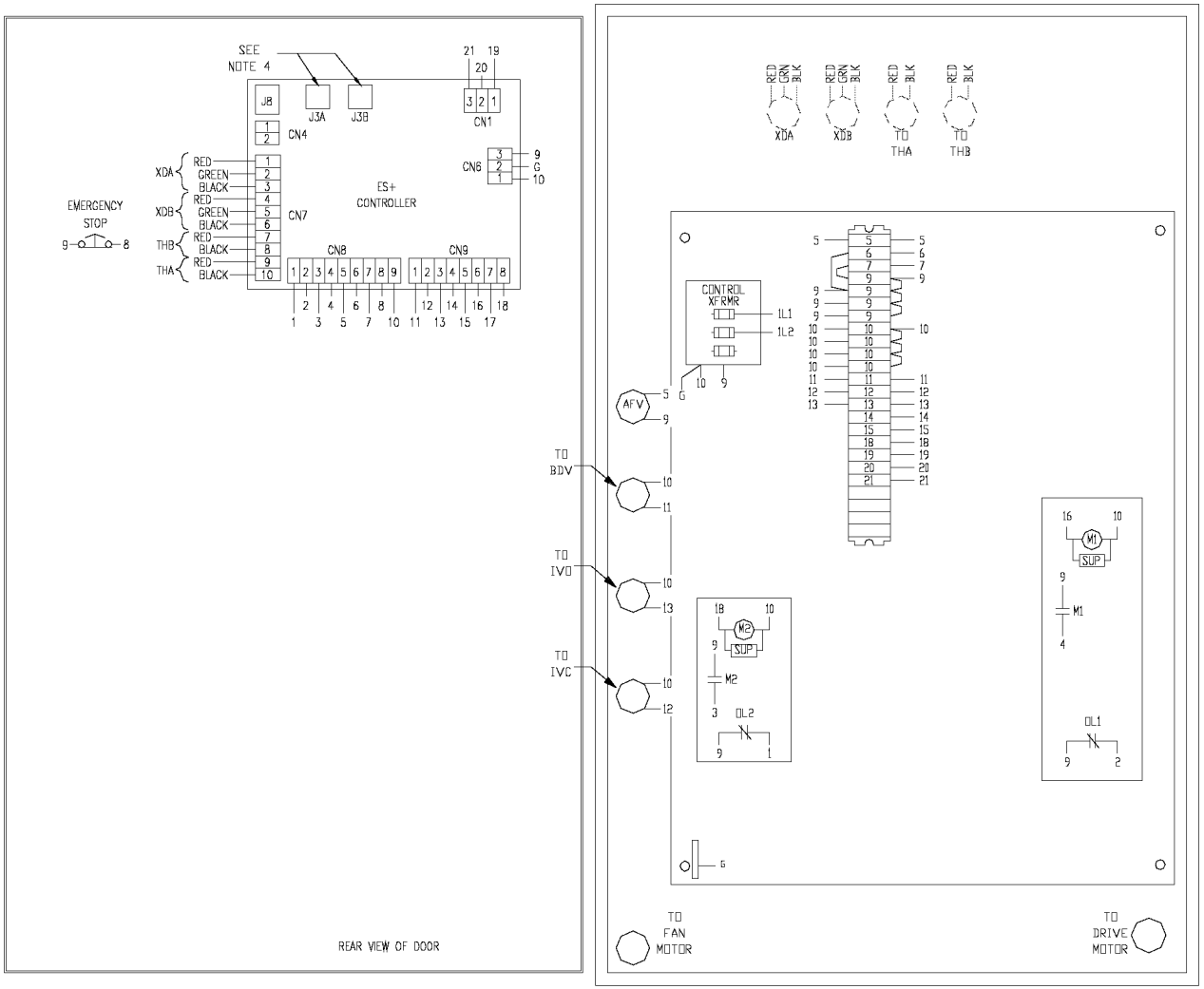
LEGEND:
AFV - AIR FILTER VACUUM SWITCH
BDV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID VALVE
IVO - INLET VALVE OPEN SOLENOID VALVE
THA - THERMISTOR A (COMPRESSOR)
THB - THERMISTOR B (RESERVOIR)
XDA - TRANSDUCER A (FINAL DISCHARGE)
XDB - TRANSDUCER B (RESERVOIR)

= CONNECTION TO CONTROL BOARD.
= PANEL TERMINAL BLOCKS

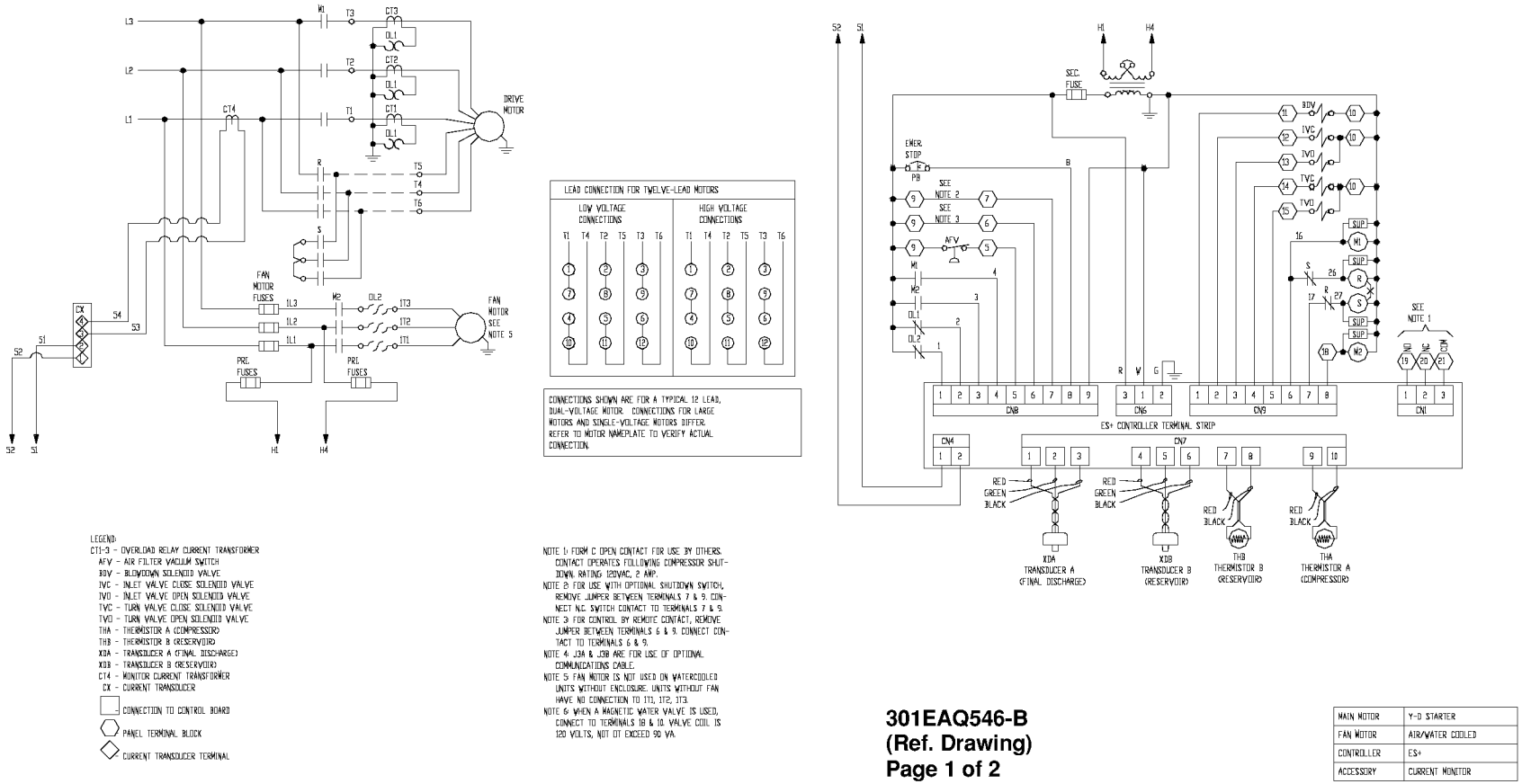
Figure 1-4 – WIRING DIAGRAM

40-50 HP WYE DELTA LESS CURRENT MONITOR LESS TURN VALVE

316EBH546-A
(Ref. Drawing)



MAIN MOTOR	FV STARTER
FAN MOTOR	AIR/WATER COOLED
CONTROLLER	ES+
ACCESSORY	NONE



LEGEND:
CT1-3 - OVERLOAD RELAY CURRENT TRANSFORMER
AFV - AIR FILTER VACUUM SWITCH
BDV - BLOWDOWN SOLENOID VALVE
IVC - INLET VALVE CLOSE SOLENOID VALVE
IVO - INLET VALVE OPEN SOLENOID VALVE
TVC - TURN VALVE CLOSE SOLENOID VALVE
TVO - TURN VALVE OPEN SOLENOID VALVE
THA - THERMISTOR A (COMPRESSOR)
THB - THERMISTOR B (RESERVOIR)
XDA - TRANSDUCER A (FINAL DISCHARGE)
XDB - TRANSDUCER B (RESERVOIR)
CT4 - MONITOR CURRENT TRANSFORMER
CX - CURRENT TRANSDUCER

CONNECTION TO CONTROL BOARD

PANEL TERMINAL BLOCK

CURRENT TRANSDUCER TERMINAL

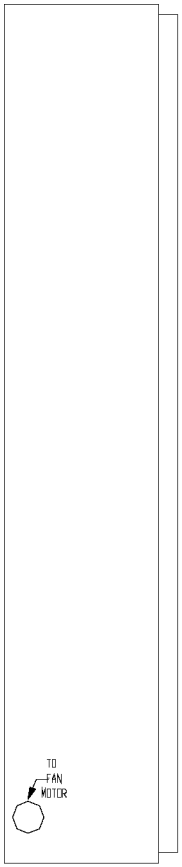
NOTE 1: FORM C OPEN CONTACT FOR USE BY OTHERS. CONTACT OPERATES FOLLOWING COMPRESSOR SHUTDOWN. RATING 120VAC, 2 AMP.
NOTE 2: FOR USE WITH OPTIONAL SHUTDOWN SWITCH, REMOVE JUMPER BETWEEN TERMINALS 7 & 9. CONNECT N.C. SWITCH CONTACT TO TERMINALS 7 & 9.
NOTE 3: FOR CONTROL BY REMOTE CONTACT, REMOVE JUMPER BETWEEN TERMINALS 6 & 9. CONNECT CONTACT TO TERMINALS 6 & 9.
NOTE 4: J3A & J3B ARE FOR USE OF OPTIONAL COMMUNICATIONS CABLE.
NOTE 5: FAN MOTOR IS NOT USED ON WATERCOOLED UNITS WITHOUT ENCLOSURE. UNITS WITHOUT FAN HAVE NO CONNECTION TO 1T3, 1T2, 1T3.
NOTE 6: WHEN A MAGNETIC WATER VALVE IS USED, CONNECT TO TERMINALS 18 & 10. VALVE COIL IS 120 VOLTS, NOT DT EXCEED 90 VA.

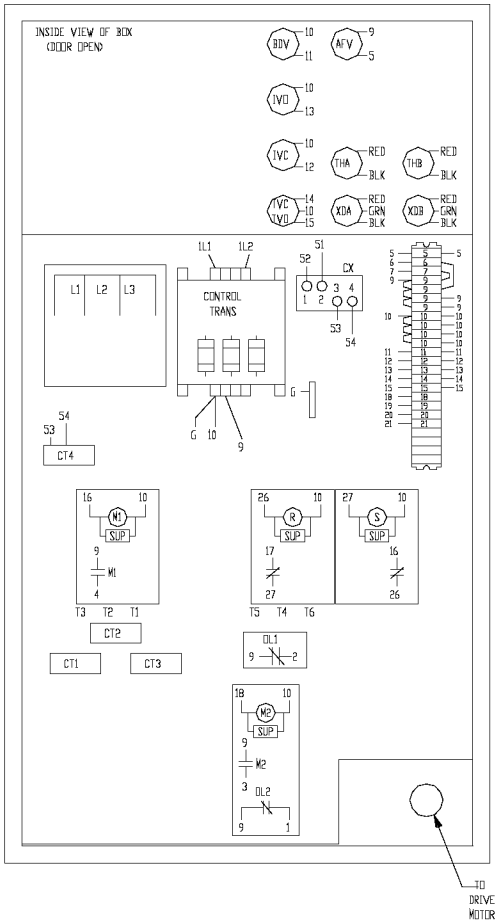
301EAQ546-B
(Ref. Drawing)
Page 1 of 2

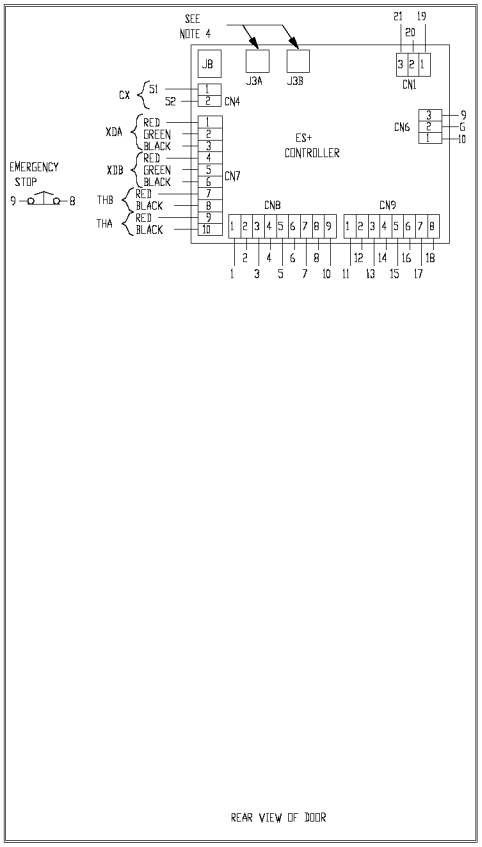
MAIN MOTOR	Y-D STARTER
FAN MOTOR	AIR/WATER COOLED
CONTROLLER	ES+
ACCESSORY	CURRENT MONITOR

Figure 1-5 – WIRING DIAGRAM

125-200 HP WYE DELTA WITH CURRENT MONITOR WITH TURN VALVE







301EAQ546-B
(Ref. Drawing)
Page 2 of 2

DISPLAY MODES

The normal display indicates the package service pressure, the airend discharge temperature, the total running hours, and one of the following operating modes. The green run 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
DIS 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
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 the operating instructions.

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.
CHANGE 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	High temperature was sensed 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. TurnValve units will unload during moderate over-current to prevent sustained operation.
HIGH RESRVR TEMP	High temperature was sensed 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. This shutdown may also occur during brief power interruptions.
CONTROLLER ERROR	The 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.

Message	Action needed
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.
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 RESRVR 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 RESRVR 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 SUMP 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.

Message	Action needed
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.
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.
MOTOR OVERTEMP	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.
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.
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.

Message	Action needed
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 HALT"**	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.

Symptom	Recommended action
Compressor does not modulate	On units with TurnValve control, the TurnValve 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 TurnValve held open. If the pressure continues to rise above these pressures, check that the TurnValve 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 rapidly between load and unload	The external air receiver should be sized appropriately to prevent 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.
Low reservoir pressure in CONSTANT mode or other modes before blowdown	The controller will maintain a minimum pressure in the oil reservoir while in CONSTANT or in other modes while the blowdown valve is closed. This 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 communicate 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 adjustment. This must be done after replacement of a controller or a transducer. The proper display with all pressure removed is 0 $\pm$1 psig. The adjustment procedure will prevent large zeroing erros, and recommend that the transducers be checked.

SECTION 2
REMOTE – MOUNTED MAIN MOTOR STARTERS

CONNECTION OF REMOTE-MOUNTED MAIN MOTOR STARTERS TO ES+ CONTROL SYSTEMS

The majority of our rotary screw compressor packages feature starters completely wired and tested at the factory. Some special applications and large units, however, do not have the main motor starter mounted on the package. The following information describes special requirements for applications with a remote-mounted main starter.

Starter

Regardless of starter type or brand, the following are required:

- The starter must have its own fused control circuit (and control transformer, if required for the starter).
- The starter must have provision for connection to a two-wire control circuit.
- The starter must have an isolated (dry contact) normally-open auxiliary contact.

Installation and wiring

The starter should be mounted and wired in accordance with the National Electrical Code and the manufacturers instructions. Wiring from the load terminals of the starter to the motor should include flexible conduit to the motor junction box to allow for normal movement of the motor in the package.

The compressor package control box must have its own disconnect and overcurrent protection. If the package has a fan, the wiring should be sized for the fan horsepower and voltage. If the package does not include a fan, the only package load is the control transformer.

Install a separate conduit from the starter to the package control box for control wiring. Label and pull four control wires through this conduit. Since two separate supplies are involved, run one pair of red wires and one pair of yellow wires for identification.

Controls connections

Disconnect and remove any manual starter controls which may be mounted on the starter or elsewhere. The starter must be controller by the compressor controls for proper operation. The following is general information; refer to the unit wiring diagram for detailed connection.

Connect the control relay contact in the control box to the starter terminals for two-wire control. The terminals are identified in the control box as 40 & 41 on standard packages. Refer to the starter instructions for identification of the control terminals for two-wire control. Use the pair of yellow wires to indicate that this circuit is from a different source.

Connect the starter auxiliary contact to the compressor control box. When connecting this contact, make sure that no other wires are connected to it in the starter - it has to be an isolated contact. These two wire connect to terminals 4 & 9 on standard packages. Use the pair of red wires; this is powered from the compressor control panel control transformer.

Controls checkout

Lock the disconnect switch for the starter in the open position. Energize the compressor package control panel. If the display indicates "SHUTDOWN - MAIN STRT CONTCT", the starter auxiliary contact is misconnected. Remove all power and correctly wire as indicated above.

Enter the adjustments menu and perform a jog to check for proper fan rotation. If it is incorrect, disconnect power and switch two of the three wires to the fan motor. Restore power to the control box when done.

With the main motor power still disconnected, press the [CONSTANT RUN] key. After a brief delay, The control should stop and display "SHUTDOWN - MAIN STARTER". This properly indicates that the starter did not function because it is turned off by the disconnect switch.

Unlock and close the disconnect switch for the main motor. Enter the adjustments menu to jog the compressor and check rotation. If it is incorrect, disconnect and lockout all power, reverse two of the three power phases at the starter. Restore power when done.

Press the [CONSTANT RUN] key. If the controller displays "SHUTDOWN - MAIN STARTER" and stops the unit, the starter auxiliary contact is misconnected. Remove all power and correctly wire as indicated above.

Press the [STOP/RESET] key to stop the compressor. The control should perform and orderly stop of the compressor unit and motor.

SECTION 3
REMOTE COOLING MODULE STARTERS

Connection of remote cooling module starters to ES+ control systems

The majority of our rotary screw compressor packages feature starters completely wired and tested at the factory. Some applications and large units, however, will have the air cooled cooling module mounted remotely from the compressor package. Standard practice is to provide a combination starter (with fused disconnect) for the cooling module. The following information describes connection requirements for these applications.

Starter

Regardless of starter type or brand, the following are required:

- The starter must have an isolated 120 volt coil.
- The starter must have an isolated (dry contact) normally closed overload relay contact.
- The starter must have an isolated (dry contact) normally-open auxiliary contact.

Standard starters are generally provided by the manufacturer with interconnecting wires between the coil, overload relay contact, and auxiliary contact. Remove all of these to isolate the three control components.

Installation and wiring

The starter should be mounted and wired in accordance with the National Electrical Code and the manufacturers instructions. Wiring from the load terminals of the starter to the motor should include flexible conduit to the motor junction box to allow for normal movement of the motor in the package. Use time-delay fuses in the disconnect, to allow for motor starting. Follow instructions in the starter for proper sizing and application of overload heaters.

Install a separate conduit from the starter to the package control box for control wiring. Label five control wires: 9 , 10 , 18 , 22 , 23 ; pull through this conduit.

Controls connections

Disconnect and remove any manual starter controls or other control wires which may be mounted on the starter or elsewhere. The starter must be controller by the compressor controls for proper operation. The following is general information; refer to the unit wiring diagram for detailed connection.

Connect the five control wires to terminals 9 , 10 , 18 , 22 , 23 in the compressor control box.

At the cooling module starter, connect wire 10 to one terminal of the starter coil, wire 18 to the other coil terminal. Connect wire 9 to one terminal of the aux contact and to one terminal of the overload relay contact terminal. Connect wire 23 to the other aux relay contact. Connect wire 22 to the other overload relay contact terminal.

Controls checkout

After installation is complete, energize both the module and the compressor package. In the controller adjustments, select **"WATER COOLED"** fan type. This operates the fan whenever the compressor operates, and must be used with remote-cooled units as well as water cooled units. This ensures that the oil piping does not accumulate a large quantity of hot oil before the fan starts. This setting also starts the enclosure vent fan (if so equipped) whenever the compressor runs to cool the main drive motor. Check rotation of both the compressor and the cooling fan during the jog motor test.

Start the compressor unit by pressing the [CONSTANT RUN] key. The compressor and cooling module should both start. Run for approximately one minute. Stop the compressor by pressing [STOP/RESET]. The compressor and cooling module should both stop.

If the controller shuts down before a start is attempted and displays "FAN STRT CONTACT", check and correct wiring to the auxiliary contact.

If the cooling module fan does not start, and the controller shuts down and displays "FAN STARTER", check and correct the wiring to the starter coil.

If the cooling module fan does not start, check the fuses in the combination starter and ensure that the disconnect switch is closed.

If the cooling module fan starts, but the controller then shuts down and displays "FAN STARTER", check and correct the wiring to the auxiliary contact.

If the controller shuts down and displays "FAN OVERLOAD", check both the cooling fan and the package fan (if applicable) motors for overload or misconnection.

SECTION 4
SERVICE AND FIELD MODIFICATION

CONTROLLER REPLACEMENT

The controller is mounted into the starter enclosure with fourteen nuts and lockwashers. In most slope-top enclosures (40-100 HP models), these are visible when an access panel on the back of the box is removed. Drape cloths over the starters and other components in these boxes to prevent loose parts from falling into the electrical devices.

To maintain the environmental integrity of the enclosure, all lockwashers and nuts must be used when installing the replacement controller.

CONTROLLER UPGRADES

The controllers share all mounting dimensions and are field interchangeable. To upgrade from Auto Sentry ES to ES+ controller, order Kit Part Number 204EAU6003. This contains all parts and instructions needed for retro fit of the controller into older units.

PC SOFTWARE

25-1-620 contains instructions and PC software for field revisions of AUTO SENTRY ES+ operating software. This requires a PC with approximately 4MB free disk space, a CD-ROM disk drive, and an available RS232 port. An RS232 cable is also needed, connected to the PC's port and the ES+ RS232 port. The PC software provides selection of any current ES+ operating software in English only, English-Spanish, English-French, English-German, English-Dutch, or English-Italian.

ACCESSORIES FOR AUTOSENTRY ES+

The following kits contain all electrical parts and instructions for field installation of accessory inputs for units with AutoSentry ES+ controllers.

Kit Number 203EAU6003 provides a current monitor for units built without the monitor.

Kit Number 205EAQ4014 provides a water pressure switch for installation on the water supply line.

Kit Number 207EAQ4014 provides a voltage/phase monitor for 200-208 volt units.

Kit Number 208EAQ4014 provides a voltage/phase monitor for 230-240 volt units.

Kit Number 209EAQ4014 provides a voltage/phase monitor for 460-480 volt units.

Kit Number 210EAQ4014 provides a voltage/phase monitor for 575-600 volt units.

Gardner Denver

Specifications subject to change without notice.

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Sales and Service in all major cities.

For parts information, contact Gardner Denver,
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