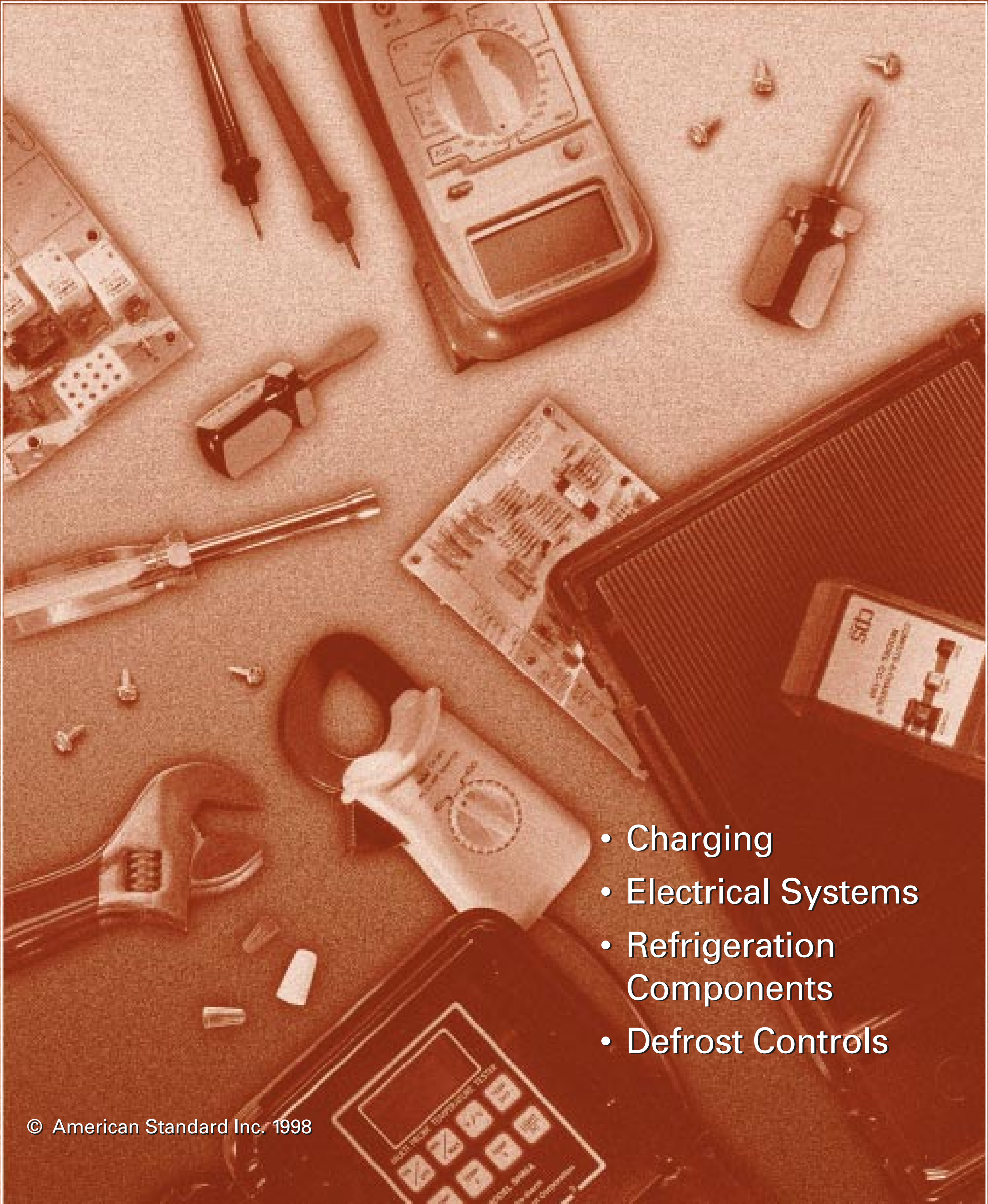
Service Procedures



- Charging
- Electrical Systems
- Refrigeration Components
- Defrost Controls

Service Procedures – Table of Contents

Cooling and Heat Pump Systems

The following general procedures may be used in performing service on the various Cooling and Heat Pump units and their components. In some instances alternate methods are illustrated due to changes in design.

Service Procedures – Index

SP110 – Checking Power Supplies

Supply voltage to air conditioning and heating equipment should be measured at the load side of the contactor, relay or switch that supplies power to the equipment – not at a main or auxiliary disconnect. (See Figure 110-1)

Equipment should be operating at normal load conditions when making voltage measurements.

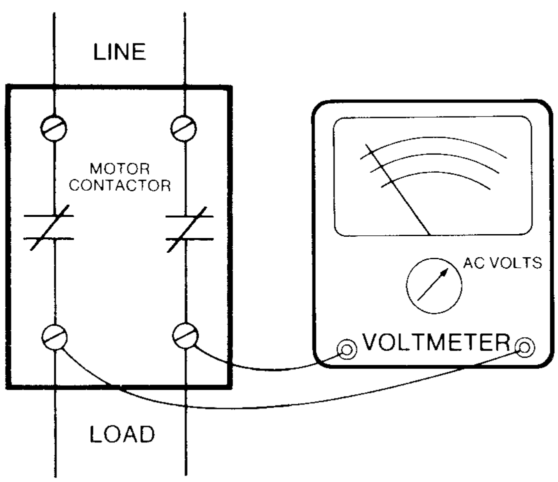
Supply voltage should be within 10% of the equipment nameplate rating. Equipment is not generally limited to 10% of nameplate rating but may require special consideration or application limitations. Consult your distributor for limits.

Three Phase Power Supplies

Phase to phase voltages should be within 2.5% of the average phase to phase voltage.

Measure voltage across each phase. Add the three voltages and divide the total by 3 to obtain average phase to phase voltage.

Example:
Phase 1 = 485 volts
Phase 2 = 477 volts
Phase 3 = 487 volts
Total = 1449
Average = 1449/3 = 483 volts
Allowable deviation from average = 2.5 x 483 = 12 volts.



Checking Power Supply Voltage
Figure 110-1

Troubleshooting Power Supplies

If no voltage is present: check fuses, breakers or other protective device per SP112.

If supply nuisance trips breakers or fuses: check terminals, lugs and fuse holders for loose connections.

Aluminum conducters tend to become loose under terminals and lugs. Discoloration of lugs and terminals or fraying and melting of wire insulation near terminals indicate loose connections.

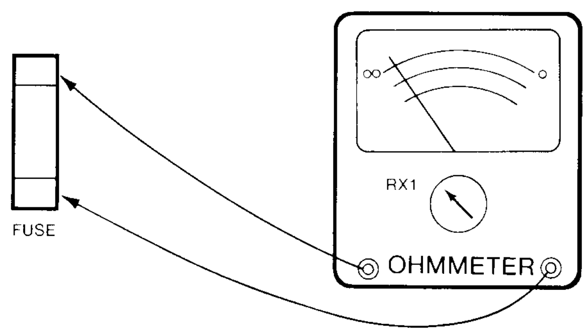
If voltage is more than 10% from rated supply, check voltage at powerhead entry to the building to be sure that distribution equipment is not at fault.

If voltage at the powerhead entry is more than 10% from the rated supply, consult the local electric utility.

SP112 – Checking Fuses, Breakers and Line Starters

Power off checks on fuses and breakers are made by removing the fuse or breaker from the power box. Check resistance across the fuse or breaker with an ohmmeter set at the lowest resistance scale. The resistance should be zero ohms. Any measurable resistance indicates a faulty fuse or breaker. An infinite ohms reading indicates an open fuse or breaker. (See Figure 112-1)

Power on checks (of voltage drop) are preferable since nuisance tripping can be detected easier than with power off checks.



Checking Fuse – Power Off
Figure 112-1

Fuses – measure the voltage across each fuse with the load connected. Applied voltage is measured across an open fuse.

Breakers – measure the voltage across the breaker with the load connected. Applied voltage is measured across an open breaker. Any measurable voltage across a breaker indicates a resistance at the breaker contacts. Breaker should be replaced.

Loose connections to fuse or breakers will cause the device to overheat and result in fuse blowing or breaker tripping at currents below their rating.

Line Starters

Line starters are disconnect devices that have internal protective cut outs that trip out the line starter at currents or horsepowers that exceed their rating. Line starters are normally used with commercial equipment with multi-horsepower ratings.

If line starters trip, check the current or horsepower rating of the line starter. Check the ampere draw of the connected equipment against the nameplate ampere draw. If the ampere draw is less than the rating of the line starter trip out heater, replace the trip out heater. If the ampere draw is greater than the equipment nameplate rating check the equipment for faults.

SP114 – Checking Control Transformers

Control transformers are rated to their volt-ampere (VA) rating. To determine the VA rating see the printed rating on the transformer. The VA rating of a transformer is determined by multiplying the secondary voltage by the secondary current. Example: A 77 VA rated transformer with a 24 volt secondary can operate at 24 volts x 3.2 amps without overloading the transformer's capacity. Currents above 3.2 amps will overload the transformer and trip a protective device or burn out the transformer.

Troubleshooting Control Transformers

If control devices fail to operate: check the voltage to the transformer primary against the primary voltage rating of the transformer.

If primary voltage is present – check all fuses or protective devices in the secondary.

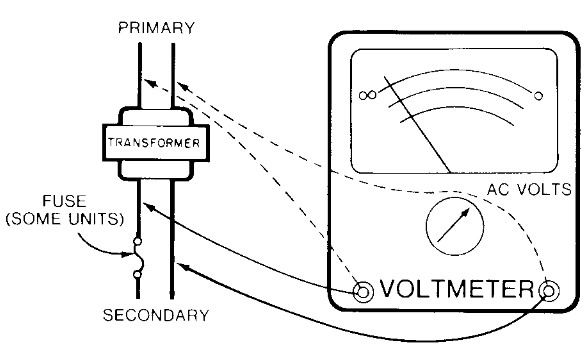
If secondary protective devices are good and no secondary voltage is present, replace the transformer. (See Figure 114-1)

If secondary voltage is present and control devices do not operate; temporarily jumper the transformer protective device. Connect an ammeter in the secondary circuit. Energize the circuit and observe the secondary ampere draw. If ampere draw exceeds the transformer rated current check control circuit components.

Disconnect one control component at a time until secondary current is within the transformer VA rating to isolate the defective component.

CAUTION: Do not operate the transformer more than 10 seconds with the protective device jumperer or the transformer may burn out.

Lightning during a thunderstorm or transient voltages on the supply line can cause the transformer fuse to open when no fault occurs within the equipment.



Checking Control Transformer Voltage
Figure 114-1

SP116 – Checking Control Circuit Field Wiring

Control circuit field wiring must be at least 18 AWG copper or control devices may chatter or fail to operate.

Control wiring circuits longer than 100 feet may require wire larger than 18 AWG wire.

Low primary voltage may cause control devices to chatter or fail to operate due to low voltage output from control transformers. Primary voltage below 10% of equipment nameplate rating can cause erratic operation of control devices.

Loose connections at terminals and wire nut connectors can cause erratic operation of control devices.

Check control circuit fuses or breakers before checking field wiring.

Checking Field Wiring - Heat Pump

Remove room thermostat from sub-base.

Energize heat pump electrical circuits.

Connect a jumper wire between terminals shown below and observe equipment operation.

Jumper thermostat terminals:

R to G – indoor fan operates

R to Y – outdoor fan and compressor operates

R to 0 – reversing valve operates

R to W – electric heaters operate (if outdoor thermostat closed)

R to X2 – electric heaters operate (if outdoor thermostat closed)

R to B – never jumper – will blow fuse or transformer

R to F – not necessary – clogged filter circuit

R to U – not necessary – utility circuit

R to T – do not jumper – may damage anticipator circuit.

Checking Field Wiring for Short Circuits

Disconnect field wiring from outdoor unit, indoor unit and thermostat.

Measure from each control wire to all other control wires with an ohmmeter set at the highest ohms scale. All control wires should measure infinity (open) to any other control wire.

If continuity of any definite resistance is measured, check for wire insulation missing at terminations, staples or nails through control wiring and damaged insulation at pull through points.

Checking Control Wiring for Open Circuits

Disconnect field wiring from outdoor unit, indoor unit and thermostat.

Tie all control wires between the thermostat and the indoor unit together at the indoor unit. Check continuity between all control wires at the thermostat with an ohmmeter. An open reading to any single wire indicates that an open circuit exists in that particular wire.

Repeat for wiring between the indoor and outdoor units. Tie all control wires together at the outdoor unit and perform ohmmeter continuity test at indoor unit.

SP117 – Checking Factory Wiring

When factory miswiring occurs, the malfunction or failure to operate should be detected at initial start up.

Check field wiring per SP116 before checking factory wiring.

Check power supply against equipment nameplate power rating for correct power supply.

Check terminals and lugs for loose connections.

Check equipment wiring with the wiring diagram attached to the equipment. The wiring diagram shows physical location of electrical components, terminal designations and wire color codes.

SP120 – Heat Pump Thermostats

A. Automatic change over BAY28X138 (See Figure 120-1)

Individual temperature lever controls with a minimum 4°F difference between heating and cooling modes.

Range: Heating 50°F to 90°F. Cooling 50°F to 90°F.

One stage cooling – two stage heating with 1.5°F maximum differential between heating stages.

System switch – off and automatic positions.

Fan switch – automatic and on positions – operates independently of system switch.

Norm-Emerg. heat switch – normal position provides normal compressor and system operation. Emerg. heat position locks out compressor and allows resistance heaters to operate on first stage heat.

Anticipation feature – adjusts thermostat bias heat as outdoor temperature changes, prevents thermostat droop.

Indicator lights

Red – two functions:

1. Indicates emergency heat switch set for resistance heat.
2. Clogged filter indicator when used with low airflow switch.

Blue – second stage heat cycling light.

Electrical Rating

24 volt

1.5 amp mercury switches

2.0 amp slide switches

BAY28X138 sequence of operation:

Cooling Cycle – System and Fan Switches Set on Auto

TSC-1 (Top Mercury Bulb) closes ahead of cooling lever set point, energizing switchover valve coil for cooling operation.

TSC-2 (Bottom Mercury Bulb) closes on call for cooling, energizing the compressor motor starter coil (MS or MSA) and indoor fan relay coil (F or FA).

TSC-2 opens when indoor temperature falls to cooling lever set point.

TSC-1 should remain closed.

Heating Cycle – System and Fan Switches Set on Auto

TSH-1 (Top Mercury Bulb) closes on call for heat at heating lever set point, energizing the compressor motor starter coil (MS or MSA) and indoor fan relay coil (F or FA). TSH-1 opens when thermostat is satisfied (Approx. 2°F swing).

TSH-2 (Bottom Mercury Switch) closes, energizing resistance heater relay coil (AH), if the indoor temperature falls 1.5°F below the heating lever set point with the compressor running.

TSH-2 will cycle as long as the outdoor temperature remains below the system balance point.

Emergency Heat Operation

Emergency Switch in EMERG. position (red light remains on until switch is reset to normal position).

1. "Y" circuit is opened in thermostat. (TSH-1 to Y)
2. X-2 circuit is closed in thermostat. (TSH-1 to X-2)
3. This switching arrangement prevents compressor operation while allowing the resistance heaters to cycle on first stage heat.

B. Manual Changeover BAY28X139 (See Figure 120-2)

Single temperature lever control with a 2°F differential, heating or cooling.

Range: Heating 50°F to 90°F. Cooling 50°F to 90°F.

One stage cooling, two stage heating with 1.5°F differential between heating stages.

System switch – off, heat and cool positions.

Fan switch – automatic and on positions – operates independently of system switch.

Norm/Emergency heat switch.

1. Normal position allows normal system and compressor operation.
2. Emergency heat position locks out compressor and allows resistance heater to operate on first stage heat.

Anticipation feature: Adjusts thermostat bias heat as outdoor temperature changes, preventing thermostat droop.

Indicator lights:

Red – two functions:

1. Indicates system is on emergency heat.
2. Clogged filter indicator when used with low airflow switch.

Blue – second stage heat cycling light.

Electric rating: 24 volts – 1.5 amp. mercury switches – 2.0 amp. switches.

Cooling Cycle – Fan Switch Set on Auto

Set system switch on cool - this energizes switch over valve (SOV).

TS (Top Mercury Bulb – Single Pole Double Throw) closes on call for cooling, energizing the compressor motor starter (MS or MSA) and indoor fan relay (F or FA) – TS opens when thermostat is satisfied, switch over valve coil remains energized.

Heating Cycle – Fan Switch Set on Auto

Set system switch on heat.

TS (Top Mercury Bulb) closes on call for heat energizing the compressor motor starter (MS or MSA) and indoor fan relay (F or FA). TS opens when thermostat is satisfied.

TSH (Bottom Mercury Bulb) closes, energizing resistance heat relay (AH or BH), if the indoor temperature falls 1.5 degrees below the heating set point with the compressor running.

TSH will cycle as long as the outdoor temperature remains below the system balance point.

Emergency Heat Operation

Emergency switch in EMERG. position (red light remains on until switch is reset to normal position).

"Y" circuit is opened in thermostat (T-S to Y)

X-2 circuit is closed in thermostat (T-S to X2)

This switching arrangement prevents compressor operation while allowing the resistance heaters to cycle on first stage heat.

Installation Checkout – BAY28X138 and BAY28X139

Be sure that the thermostat is the correct model number to match the installed system.

Thermostats should not be located where operation will be affected by:

Cold unused rooms on opposite side of partition.

Kitchen range on opposite side of partition.

Air handler with heaters on opposite side of partition.

Subject to direct rays of sunlight.

Subject to radiation from fireplace.

Subject to drafts from stairwells or outside doors.

In direct path of air from supply registers.

Heat from lamps, radios or TV sets.

Where closing doors may jar the thermostat.

Never located on outside walls.

Thermostats must be mounted level for proper operation.

The wire entry hole behind the thermostat must be plugged for proper operation.

Visually inspect mercury bulbs for cracks, wire connections or discolored mercury.

Manually move the mercury bulbs to be sure that the bulbs or bi-metal element is not binding.

Manually move the thermostat temperature selection levers and observe the mercury switches for making electrical contact.

When making operational checks, visually check thermostat switches, temperature selection levers and mercury bulbs for correct setting.

C. Electrical Check – BAY28X138 and BAY28X139

Thermostat Terminal and Control Circuit Identification

Thermostat Terminal B – wire color: blue – low voltage component and circuit common lead, to all low voltage components, from control transformer secondary.

Thermostat Terminal R – wire color: red – switching lead from control transformer secondary.

Thermostat Terminal Y – wire color: yellow – compressor motor starter (MS or MSA).

Thermostat Terminal G – wire color: green – indoor fan relay (F or FA).

Thermostat Terminal O – wire color: orange – switch over valve (SOV).

Thermostat Terminal W – wire color: white – resistance heater relay (AH or BH).

Thermostat Terminal T – wire color: brown – anticipator circuit, to outdoor sensor (ODS).

Thermostat Terminal X-2 – emergency heat circuit – to resistance heater relay or aux. relay.

Thermostat Terminal F – low airflow switch.

Thermostat Terminal U – (not used)

Short Circuit Test (Power On) (Component(s) Will Not De-Energize)

Remove thermostat from sub-base, disconnect field wiring from sub-base.

If component(s) remain energized, check for short in field wiring and component circuit in unit.

If component(s) de-energize, visually inspect thermostat, sub-base and field wire leads for shorts - if o.k.

Replace thermostat.

Open Circuit Check (Power On)

Check thermostat to sub-base mounting screws. All three must be in place and tight.

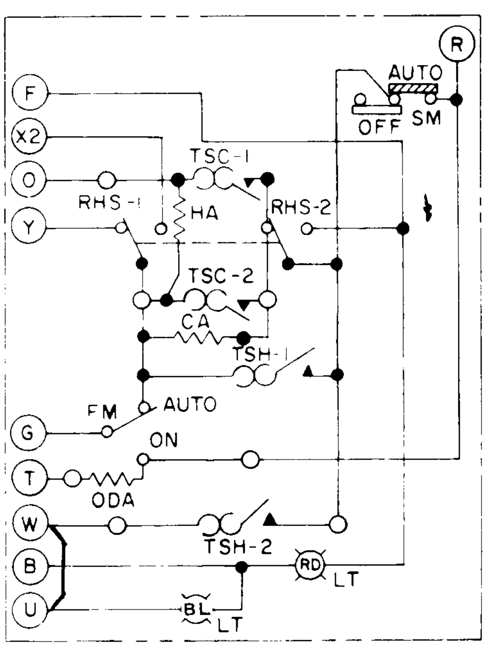
Remove thermostat from sub-base and measure voltage between R and B to check 24 volt supply.

Check thermostat to sub-base pressure contacts (may be bent for better contact). Check all field wiring connections at sub-base terminals.

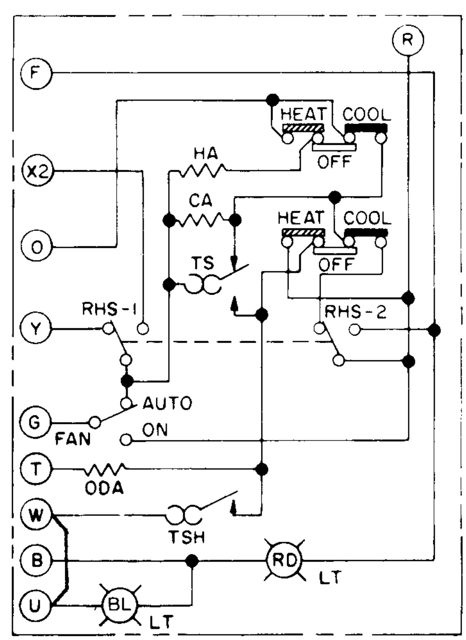
Jumper wire test at sub-base terminals. (power on).

CAUTION: Do not use jumper wire test on terminals.

R to B – will short out transformer.



BAY28X138
Figure 120-1



BAY28X139
Figure 120-2

R to T – will damage outdoor sensor in anticipator circuit.

To energize:

Indoor fan – jumper R to G

Compressor – jumper R to Y

Switch over valve – jumper R to 0

**Resistance heat – jumper R to W and *G

**Emergency heat – jumper R to X-2 and *G

**Indoor fan *relay must be closed for this test

If all components operate with jumper, replace thermostat.

If component(s) do not operate with jumper, problem is not in thermostat. Check field wiring and component(s) circuit in unit.

Calibration – BAY28X138 and BAY28X139

Prior to thermostat calibration test. Check the following.

Installation: thermostat must be mounted level on a flat wall surface. All holes in wall behind thermostat must be sealed to prevent wall drafts from affecting thermostat calibration. The thermostat must not be exposed to radiant heat or excessive drafts.

Bias heaters and sensors: voltage must be applied at least 30 minutes before normal thermostat operation will occur.

Anticipator System

Measure voltage in anticipator circuit as follows:

OUTDOOR TEMP.	TEST POINT LV. TERM. BOARD	EXPECTED READING FOR NORMAL OPERATION
70°F or above	R to T	22 volts
70°F or above	B to T	2 volts
30°F	R to T	19 volts
30°F	B to T	5 volts
0°F	R to T	15 volts
0°F	B to T	9 volts

NOTE: If anticipator circuit is open thermostat will be 6 degrees to 8 degrees out of calibration.

Thermostat Calibration Test

Allow indoor temperature to remain at thermostat off point temperature at least one hour prior to test.

Place thermometer at thermostat location. Allow time for thermometer to stabilize.

Record temperature reading.

If thermostat is out of calibration replace thermostat.

Adjustments

Cover thermometer – screw adjustment on back of cover.

Heat/cool anticipators – voltage type non-adjustable.

Mercury calibration – adjustments not recommended.

SP126 – Outdoor Thermostat – AY28X125

The AY28X125 full range outdoor thermostat is adjustable from 40°F to -10°F.

The AY28X125 is a single pole, single throw temperature operated device that closes on a temperature drop.

The temperature dial should be set at the temperature desired to energize the electric heater stage to be controlled.

Checking outdoor thermostat operation.

Connect an ohmmeter to the outdoor thermostat terminals.

Set the ODT temperature dial at 40°F. Place the ODT sensing element in a solution of 1 pint water, ice and a teaspoon of table salt.

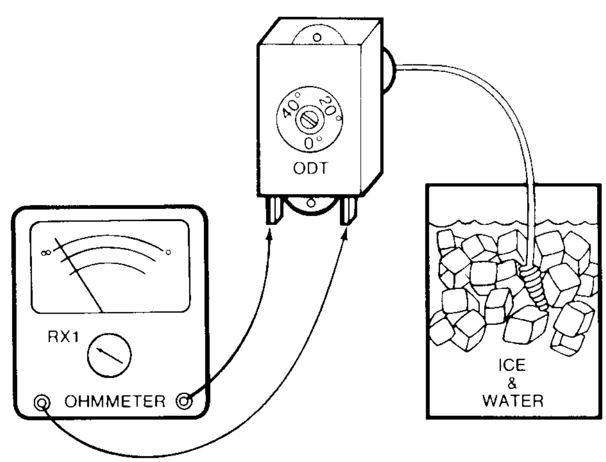
Ohmmeter should read zero ohms when the sensing element is sufficiently chilled.

Warm the sensing element, contacts should be open outdoor thermostat calibration.

Connect an ohmmeter to the outdoor thermostat terminals. (See Figure 126-1)

Immerse the outdoor thermostat sensing element in ice water.

Measure the ice water temperature. Stir the ice water until 32°F is indicated by the thermometer.



Check Outdoor Thermostat Calibration
Figure 126-1

Slowly rotate the outdoor thermostat temperature dial until the ohmmeter indicates closing of the outdoor thermostat contacts.

Outdoor thermostat dial should indicate 32°F + or –5°F.

If more than 5°F error in dial reading exists at 32°F ice water, replace the outdoor thermostat.

If the outdoor thermostat is within 5°F dial indication at 32°F ice water, set the dial to the desired electric heater energizing temperature.

SP130 – Checking Relays, Contactors, Solenoid Coils

Magnetic relays, coils, and solenoids may have coils rated at any AC or DC voltage. The device will have its coil voltage rating stamped or printed on the device.

Be sure that the voltage applied to the coil is within 10% of the voltage rating.

Power Off Checks on Magnetic Coil and Contacts

Disconnect the magnetic coil from the power source.

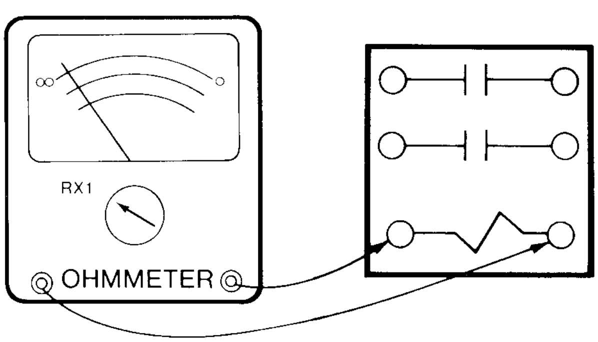
Check the coil for continuity with an ohmmeter. (See Figure 130-1)

If the coil is open or shorted, replace the coil or relay.

Visually inspect the coil for discoloration or loose terminals.

Inspect the contacts for excessive burning or foreign materials.

Inspect the return spring for rust or disfiguration.



Checking Relay or Contactor Coil
Figure 130-1

Manually close the relay or contactor and measure the contacts for resistance with an ohmmeter. Resistance across the contacts should be zero ohms.

Power On Checks for Coils and Contacts

With power on and the load connected to the relay or contactor, measure the voltage supply to the magnetic coil. Voltage to the coil should be within 10% of the coil rating. Voltages lower than 10% of coil rating may cause failure of the device to operate or cause the device to chatter.

Measure the voltage across the closed contacts of the relay or contactor. Voltage across closed contacts with the load connected should be zero volts. Any voltage measured across closed contacts indicates excessive contact resistance. The contacts or device should be replaced.

Excessive humming noise produced by a magnetic relay or contactor may be caused by mechanical misalignment, binding, rust, excessive spring tension or low voltage to the coil.

Never adjust the relay or contactor return spring tension. Contact closing time is determined by return spring tension. Any adjustment will cause premature failure of the contacts.

If contacts indicate excessive burning, check the circuit current draw against the contact rating of the device.

Solenoid Coils

Solenoid coils operating reversing valves, shut off valves or clutches must be fully inserted on the coil core or the coil will draw excessive current and burn out.

Any spacers or washers that locate solenoid coils on their core must be in the proper position or the device may fail to operate.

For power off test on solenoid coils, measure coil for continuity with an ohmmeter.

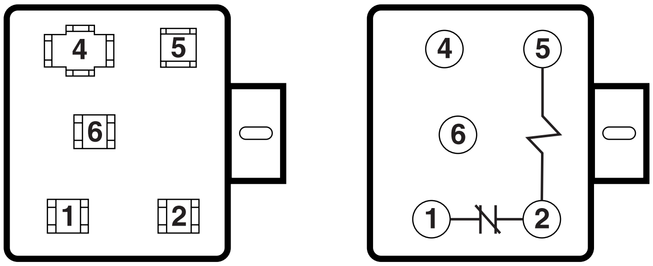
For power on test on solenoid coils; energize the coil. Removed the retainer that holds the coil in place on its core. Move the coil back and forth along its core. If the coil is good, a definite magnetic pull will be felt.

Operating voltage to the solenoid coil should be within 10% of the coil rating for proper operation.

SP135 – Capacitor Switching Relay

Original or replacement relay should be part RLY1097. This is the only relay which will function properly with reciprocating compressors in single compressor systems. Dual compressor models use capacitor switching relay RLY1869. Scroll compressor models use capacitor switching relay RLY02227. These relays may be mounted in any position. However, the relays are calibrated in the position shown. The pick up and drop out voltage will be slightly different when mounted in other positions.

Reciprocating (Part No. RLY1097)

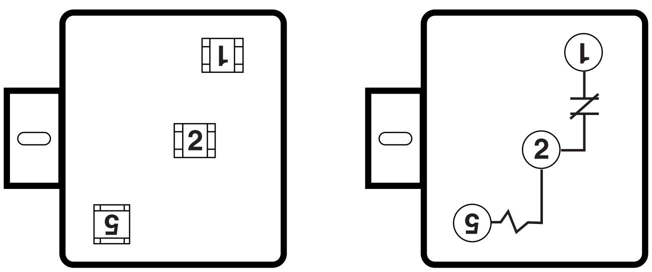


MAX. ST WINDING AMPS. @ 230 V	VOLTAGE RATING	HOT (40°C) PICK UP VOLTS	COLD PICK UP VOLTS	DROP OUT VOLTS	CONTINOUS COIL RATING (40°C)
35 A	230 V 60 1 0	260 – 280	239 – 268	60 – 135	502

Reciprocating – Dual Compressor Model Units (Part No. RLY1869)

MAX. ST WINDING AMPS. @ 230 V	VOLTAGE RATING	HOT (40°C) PICK UP VOLTS	COLD PICK UP VOLTS	DROP OUT VOLTS	CONTINOUS COIL RATING (40°C)
50 A	230 V 60 1 0	260 – 280	239 – 268	60 – 135	502

Mounting shown below.



Scroll Compressor (Part No. RLY02227)

MAX. ST WINDING AMPS. @ 230 V	VOLTAGE RATING	HOT (40°C) PICK UP VOLTS	COLD PICK UP VOLTS	DROP OUT VOLTS	CONTINOUS COIL RATING (40°C)
50 A	230 V 60 1 0	190 – 200	150 – 175	60 – 110	420

Mounting shown above.

Figure 135-1

Relay Coil Checkout (See Figure 135-1)

Disconnect power to unit.

Remove wires from terminals #2 and #5.

Check for continuity between terminals #2 and #5. If open circuit – replace relay. If closed circuit – check contacts.

Relay Contacts Checkout

Disconnect power to unit.

Remove wires from terminals #1 and #2.

Check for continuity between terminals #1 and #2. If open circuit - replace relay. If closed circuit - check relay visually.

Visual Checkout

If coil and contacts check out O.K. remove relay cover and visually inspect contacts and coil for signs of pitted or burned contacts and for burned or charred wiring. If any of these are found replace relay.

SP140 – Fan and Blower Motor

Instruments necessary for properly diagnosing problems:

Voltmeter, ampmeter, ohmmeter and test light.

A. Outdoor Fan Motor Won't Run

Visually check disconnect, circuit breaker or fuses.

Determine if there is proper voltage at the motor. (See Figure 140-1)

If no voltage, check supply source, broken or loose wires, bad relay or relay coil.

Check motor shaft for binding or dragging or excessive end play.

Disconnect motor leads and check for winding continuity. If open, replace motor.

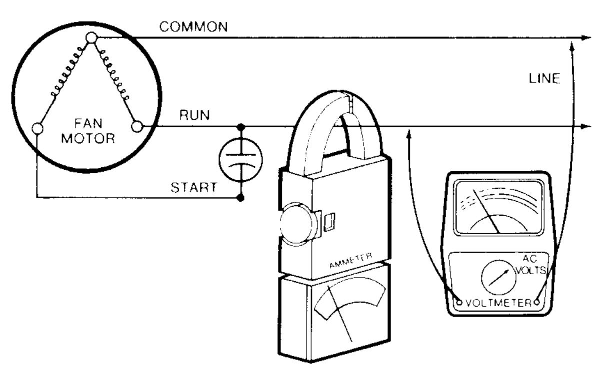
With ohmmeter, check for grounded motor. If grounded replace.

Check fan position on shaft – too low or too high could bind on mountings.

Check defrost relay. (Could be stuck in defrost cycle which opens circuit to outdoor motor.)

Visually check run capacitor for swelled or ruptured end.

Check fan relay coil, determine if proper voltage at coil. If voltage present and relay doesn't pick up, replace relay.



Checking Fan Motor Current and Voltage
Figure 140-1

If relay energizes, with voltmeter, check line voltage across contacts – voltage present, contacts are open. Replace relay.

If no voltage indicated, contacts are closed, relay good.

Outdoor Fan Motor Cycles on Internal Overload

Determine if proper voltage to motor is present.

Check motor shaft for drag.

With disconnect switch off, pull motor leads and check for grounding.

Check fan position on motor shaft.

Check fan capacitor.

Check capacitor for proper mfd. for motor.

Check for proper horsepower of motor from label or nameplate.

Check for proper size fan.

Check amp draw on motor (determine proper full load amps from motor nameplate). (See Figure 140- 1)

Check for excessive end play in motor.

Check lubrication.

B. Indoor Fan Motor Won't Run

Visually check disconnect, circuit breaker and/or fuses.

Determine if there is proper voltage at motor.

If no voltage, check voltage supply source, broken or loose wires, bad relay, or relay coil.

Check motor shaft for binding or dragging.

Disconnect motor leads and check motor windings for continuity. If open, replace.

Check for grounding with ohmmeter.

Visually check run capacitor. If end is bulged or ruptured, replace.

Check for correct voltage at motor.

Check run capacitor for proper size for motor.

See if motor shaft is binding or dragging.

Check full load amps (motor running with all panels in place).

With motor leads and power disconnected, use ohmmeter to check for continuity through motor windings.

With motor leads disconnected, use ohmmeter to check for grounded motor. Use meter probes, one to motor shell and one to motor leads.

Check motor lubrication.

Check blower for binding, or heavily coated with sediment, etc.

Check start capacitor. (KC type belt drive motors only)

Check run capacitor. (SP150)

With disconnect pulled, rotate fan on blower and visually note if there is an untrue turn (wobble). If present, replace.

With squirrel cage blower, place screwdriver near edge of blower while rotating to measure true rotation, and to determine extent of damage or unbalance.

If clicking or metallic sounds, possible break in, vane or vanes, or foreign matter lodged in blower.

Check for loose anchor bolt or set screw.

SP150 – Checking Run Capacitors

Run capacitors should be replaced with a capacitor of equal microfarad rating. The replacement capacitor working voltage must be equal to or higher than the original capacitor.

The best test on a suspected bad capacitor is substitution with a known good capacitor of equal microfarad and voltage rating.

Visually check suspected bad capacitors for oil leaks, loose terminals and bulging or disfiguration of the capacitor case. Replace the capacitor without further tests if any of these symptoms exist.

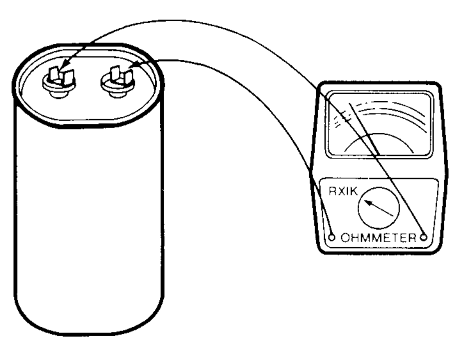
Check the equipment wiring diagram for the correct capacitor mfd, and voltage rating. This information is provided on some diagrams.

Ohmmeter Test – continuous duty oil filled capacitors.

Disconnect capacitor from power circuits.

Set ohmmeter to R X 1000 or higher scale.

Zero adjust ohmmeter.



Ohmmeter Test Continuous Duty Oil Filled Capacitors
Figure 150-1

If capacitor has a discharge resistor connected between terminals, disconnect resistor from one terminal.

Observe meter scale and touch meter leads to capacitor terminals. (See Figure 150-1 below)

Good capacitor – meter pointer will deflect upscale toward zero ohms reading and slowly return downscale to infinity ohms reading.

Open capacitor – meter pointer does not move from infinity ohms reading.

Shorted capacitor – meter pointer will indicate a definite ohms reading less than infinity.

Metal-Cased Round Dual Capacitors

The round metal-cased dual capacitors with stamped marking of "C", "HERM" and "FAN" on the top surface, are generally used in an air conditioner in a conventional circuit using "C" to "HERM" in the compressor circuit with "C" to "FAN" in the fan motor circuit. The fan portion of the capacitor is usually not larger than 15 MFD in capacity.

Power Test – Continuous Duty Oil Filled Capacitors (See Figure 150-2)

CAUTION: Do not perform this test on start capacitors.

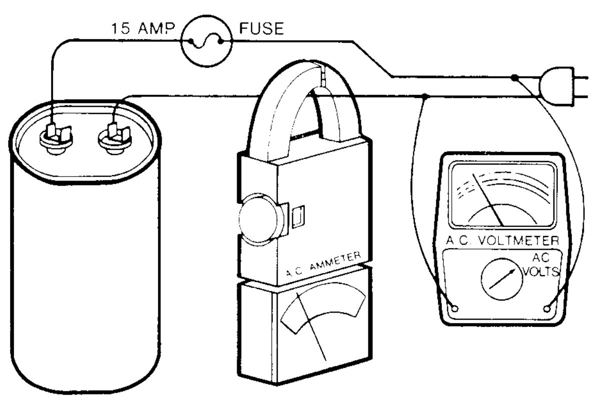
CAUTION: Check capacitor with ohmmeter for short circuit between terminals and between terminals and capacitor case before performing power test.

Connect capacitor to AC supply that does not exceed the capacitor voltage rating.

Measure and record the applied AC voltage.

Measure and record amp draw of the capacitor.

$$\text{MFD} = \frac{\text{amp draw x 2650}}{\text{applied AC volts}}$$



Power Test Continuous Duty Oil Filled Capacitors
Figure 150-2

Example: capacitor draws 3 amps at 230 volts. Indicator capacitor value is:

$$\frac{3 \text{ x } 2650}{230} = 33 \text{ MFD}$$

MFD calculated value should be within 10% of value stamped on capacitor.

SP152 – Checking Start Capacitors

Start capacitors should be replaced with a capacitor of equal microfarad rating. The replacement capacitor working voltage must be equal to or greater than the original capacitor.

The best test for suspected bad capacitors is substitution with a known good capacitor of equal microfarad and voltage rating.

Visually check suspected bad start capacitors for cracked casing, loose terminals or broken rupture disc in the capacitor top. Replace the capacitor without further tests if these symptoms exist.

Always check the capacitor start relay for defects per SP135. A defective start relay will cause premature failure of the start capacitor.

Never connect a start capacitor in a continuous duty circuit. Start capacitors are designed for intermittent duty only.

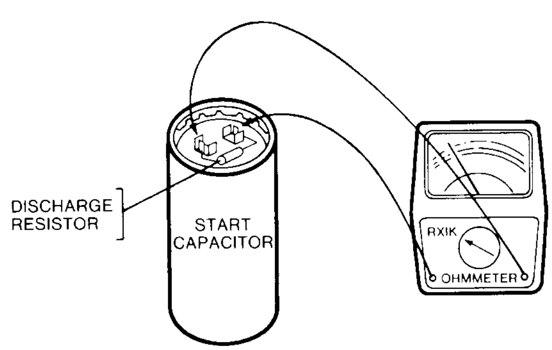
Checking a Start Capacitor with an Ohmmeter

Set ohmmeter to R X 1000 scale.

Zero adjust ohmmeter.

Good capacitor - meter pointer will deflect upscale toward zero ohms reading and slowly return downscale toward infinity ohms reading. Pointer will stop at the ohms value of the discharge resistor. (See Figure 152-1)

Open capacitor - meter pointer will not swing upscale near zero ohms reading. Pointer will indicate ohms value of the discharge resistor.



Checking A Start Capacitor with an Ohmmeter
Figure 152-1

Shorted capacitor - pointer will indicate a definite ohms reading between zero ohms and less than the ohms value of the discharge resistor.

CAUTION: Do not perform power on tests on start capacitors.

SP160 – Checking External Overloads (XOL and XOLS)

Due to the position of the external overload in the unit circuit, testing is usually done with the power removed.

The external overload is made up of a heater and a set of contacts.

There are two types of external overloads which function the same but are constructed differently.

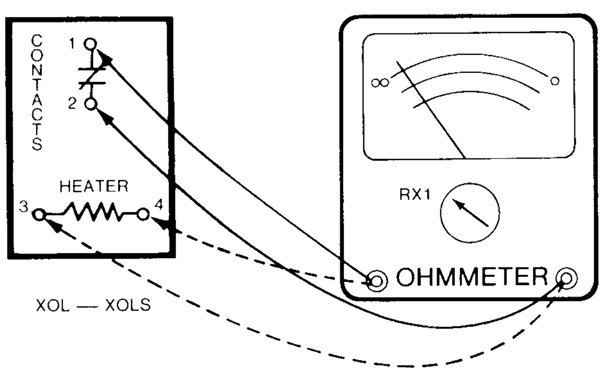
1. 3 terminal – use a common terminal between the heater and one side of the contacts.
2. 4 terminal – has two separate circuits.

Check Out Procedure (See Figure 160-1)

With the power off and the leads to the overloads removed use an ohmmeter to read the heater circuit. A small amount of resistance will be found.

With the power off, read the resistance of the contact circuit. No resistance should be found.

An open circuit in either heater or contact circuit indicates a defective overload. Replace the overload.



Checking External Overload Protectors
Figure 160-1

SP165 – Compressor Internal Thermostat (TM)

The compressor internal thermostat is a temperature sensing device used to break the control circuit when the internal temperature of the compressor exceeds a pre-selected limit.

It will reset automatically when the compressor cools but it may require two hours or more to do so.

Check Out Procedure – Unit

Remove all power and check the internal thermostat with an ohmmeter for continuity. (See Figure 165- 1)

1. If closed, proceed to next step.
2. If open, wait the required time for the compressor to cool if there is no reset, replace the compressor.

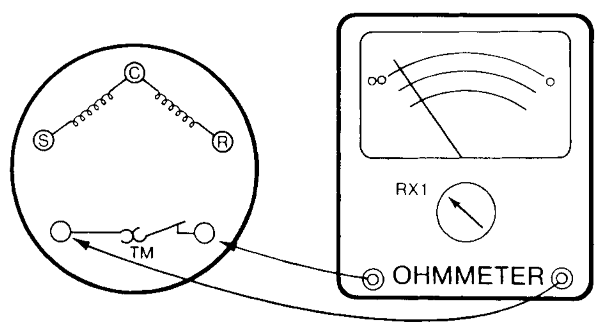
Check the unit charge. Low charge causes the internal thermostat to trip.

Check the flow control device, expansion valve or capillary tube. Normal system refrigerant flow is necessary.

Check for other obstructions in the system; plugged drier or crimped tubing.

Check the return gas flow temperature for excessive loading caused by high ambient temperatures near the suction line. For example, the liquid line may be in contact with the suction line.

Check main contactor for burnt or corroded contacts.



Checking Compressor Internal Thermostat (TM)
Figure 165-1

Replacement Procedure

If all the following are checked and found correct: charge is correct, system is circulating refrigerant in adequate quantities, power supply is correct but the unit still is tripping on the internal thermostat the compressor must be replaced, since the internal thermostat is not a replaceable part.

SP167 – Overload Protectors – Line Duty – (IOL)

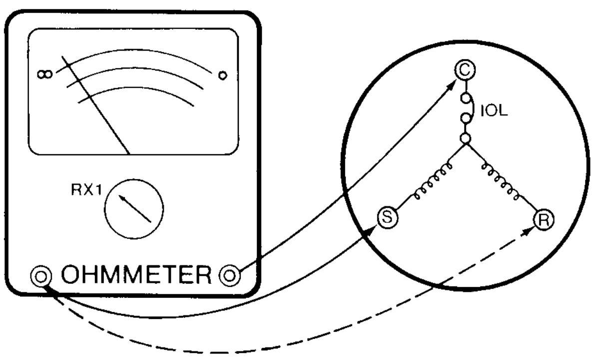
Line break internal overload protectors are buried in the compressor motor winding. They measure the temperature of the winding and the current flow in the common line that feeds both the start and run windings. Internal overload tripout is caused by a combination of current and temperature.

Low refrigerant charge or low refrigerant flow rates caused by other refrigerant circuit faults can cause the internal overload to trip on temperature, even at low operating currents.

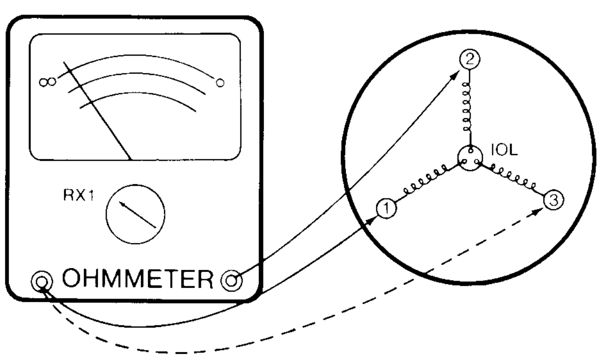
Excessive current due to excessive head pressure, low line voltage, or electrical faults in the motor circuits cause tripout even when the motor temperature is relatively low.

Checking Internal Overload – Single Phase Compressors (See Figure 167-1)

With power off and compressor leads disconnected, measure from the run to start terminal with an ohmmeter. An infinite (open) reading indicates open windings in the motor. Replace the compressor. If continuity (a definite resistance) is measured, then measure from the common terminal to the run terminal, then from common to start. An infinite (open) resistance from common to both run and start terminals indicates a tripped or open IOL. Allow adequate time for the IOL to re-set before condemning the compressor. Up to 2 hours may be required if the compressor is extremely hot.



Checking Internal Overload Protector 1 Phase
Figure 167-1



Checking Internal Overload Protector 3 Phase
Figure 167-2

3 Phase Compressors (See Figure 167-2)

On 3 phase compressors equipped with an internal overload, a continuity measurement between any two compressor terminals and an open measurement to the remaining terminal indicates an open motor winding. Replace the compressor.

Internal overload protectors are identified by IOL designation on the equipment wiring diagram.

SP168 – Compressor Motor Protection (Robertshaw)

This system of motor protection is made up of six parts – transformer, solid state control board, two sensors buried in the compressor windings and two fuses to protect the sensors.

This solid state motor protector system may take two hours or more to reset after a trip.

All testing in this circuit should be done with an ohmmeter, having no more than 6 volts at the probes. Test lights, etc., should not be used as the voltage may damage the sensors.

Diagnosis

With compressor off, MS relay not energized, power applied, momentarily jumper the two contacts labeled "control circuit". They are on the end of the control board which has only two terminals. (See Figure 168-1)

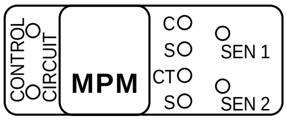
1. If the MS relay does not close, check the thermostat and control circuit wiring, including the fuse in the "Y" circuit (if present).
2. If the MS relay closes and the compressor fails to start, check the power source and compressor circuit.
3. If the MS relay closes and the compressor starts, the fault is in the control circuit. Proceed to the next step.

With power still applied, check the output voltage of the centertapped transformer. From S to CT and from the second S to CT, the voltage should be equal. Any measurable difference indicates a bad transformer. Replace it.

Remove all power. With an ohmmeter, read the resistance from C to Sensor 1 and from C to Sensor 2, after removing the leads from the control. Both sensors should read 90 ohms or less but not 0. (See Figures 168-2 and 168-3)

If an open circuit is found, check the sensor lead fuses for continuity. Only fuses of the AGC series, 8 through

CT100HS AND CT125HU SERVICE CHECK LIST

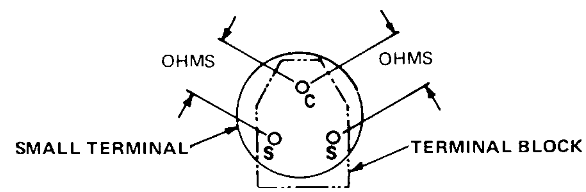


NOTE: THIS COMPRESSOR IS EQUIPPED WITH SOLID STATE MOTOR PROTECTION SYSTEM. IF EQUIPMENT DOES NOT OPERATE, PROCEED AS FOLLOWS:

1. Jumper control circuit contacts and energize unit for a **maximum of five seconds.**
   a. If contactor (MS) does not pick up, problem is in the controls external to compressor terminalbox.
   b. If (MS) picks up but compressor does not run, **de-energize immediately.**
      1. Check all terminals in power and control circuits. Repair loose connections and re-energize **(5 sec. Max.)**. If compressor fails to run, de-energize.
      2. Remove and isolate power leads at compressor. Energize and check 3 phase voltage. If voltage is correct on all phases, compressor has internal problem and must be replaced.
2. If compressor operates with jumper, check each component of solid state protection system for possible malfunction as follows:

TRANSFORMER (MPT)
1. Primary side must be connected to line side of contactor.
2. Remove secondary leads (S, CT, S) from module and measure voltage between each S and CT. The two voltages should be the same, approximately 12 volts. If not, MPT is defective and must be replaced.

Preliminary Control Check MPM Protector
Figure 168-1



SENSORS – Remove sensor leads (C, Sensor 1, Sensor 2) from module. Measure resistance between C and each sensor using a **battery powered volt-ohm meter.***

***WARNING: DO NOT USE A VOLT-OHM METER WHICH APPLIES MORE THAN 3 V DC TO CHECK SENSORS OR SENSOR FUSES. BOTH ARE EASILY DAMAGED AND NO ATTEMPT SHOULD BE MADE TO CHECK CONTINUITY BY ANY OTHER MEANS.**

a. Resistance should measure between 60 and 150 ohms. If resistance is greater than 90 ohms, motor is too hot to permit operation. Allow to cool until sensor resistance is less than 90 ohms.
b. If sensor resistance is greater than 150 ohms:
   1. Check sensor fuses. Only fuses of the AGC series, 8 through 30 amps, or MDA series, 8 through 20 amps, should be used as replacements..
   2. If fuses are okay, remove terminal block from small terminal and check sensors **according to diagram below**. If either sensor has a resistance greater than 150 ohms, compressor must be replaced.

MODULE (MPM) – If sensor fuses, sensors and transformer are not defective, module must be replaced.

Sensor Check – MPM Protector
Figure 168-2

30 amps, or MDA series, 8 through 20 amps, should be used as replacements

If an open still exists, remove the cover on the compressor which protects the sensor leads and read the sensors directly to C the common terminal. If the open exists at this point, the compressor must be changed.

If a short (0 ohms) is found, check at the compressor terminals as in the step above. If the short or ground still exists at this point, the compressor must be replaced.

If the open or short is found in the compressor itself, recheck all wiring to the circuit.

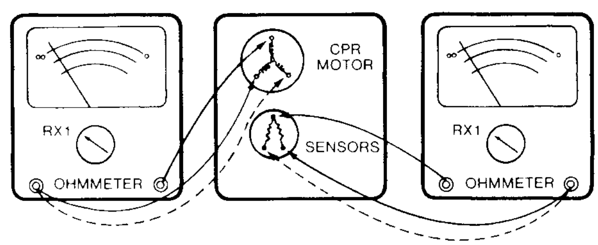
After checking the sensor resistance and finding it correct but still not closing the circuit through the contacts of the solid state control board, the control is bad. Replace it.

Control Operates Properly but Compressor Still Trips

After compressor cools and control allows a restart, check refrigerant charge.

Check voltage supply under load.

Check for abnormal current draw. See nameplate for correct amp reading.



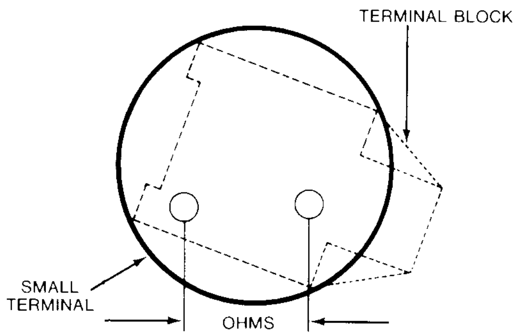
Testing 3 Phase Compressors with Solid State Motor Protection System (MPM)
Ohmmeter Hook-up MPM Sensor and Motor Checks
Figure 168-3

SP169 – Compressor Protection – Texas Instrument Electronic Protection Module 15AA203D

This compressor overload system consists of a solid state module located in the compressor terminal box and solid state sensors buried in the compressor motor windings.

The sensors are connected to the two small terminals located at the lower part of the compressor terminal box. (See Figure 169-1)

If the sensors in the motor windings sense a motor temperature that is too high for safe motor operation they will cause the electronic protection module to open a normally closed switch circuit between terminal M1 and M2 of the module. When this switch circuit opens, power to the compressor motor starter coil is interrupted, de-energizing the motor starter.

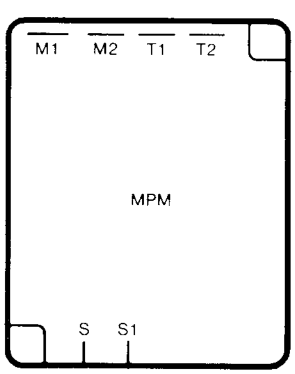


Sensor Terminals in Compressor Terminal Box
Figure 169-1

Troubleshooting The T1 Protection Circuit (See Figure 169-2)

If the compressor contactor fails to energize; jumper terminals M1 and M2 of the module. **Do not jumper for more than 5 seconds.** If compressor contactor fails to energize, the problem is in controls external to the compressor terminal box. If the compressor contactor energizes when module terminals MI and M2 are jumpered, check voltage at terminals T1 and T2 on the module. Voltage should be between 21 and 30 volts A.C.

If T1 and T2 voltage is present, disconnect the motor sensor leads from module terminals S and S1. Measure resistance of the motor sensors with a battery powered ohmmeter. Sensors will be damaged if exposed to high voltage. Resistance should be between 2,000 and 45,000 ohms. If resistance is above 10,000 ohms the motor is too hot to permit operation. Allow motor to cool until sensor resistance is below 10,500 ohms before operating the compressor.



Terminal Location – Protection Module
Figure 169-2

If sensor resistance is above 45,000 ohms sensors are damaged and the compressor must be replaced.

If sensor resistance and supply voltage are correct and the motor contactor will not energize, the module is defective.

Compressor motor overheating can be caused by:

a. Shorted or grounded motor windings
b. Defective run capacitors
c. Defective start capacitors or start relay
d. Low line voltage
e. Low refrigerant charge
f. Dirty condenser or excessive head pressure due to refrigerant overcharge.

SP210 – Checking Electric Heaters

Electric resistance heaters used with heat pump equipment, air conditioning equipment and electric furnaces utilize low voltage control circuits to operate magnetic relays or time delay sequencers.

Magnetic relays energize the heating circuit instantaneously upon a call for heat.

Sequencers are time delay control devices that delay operation of the heater up to 60 seconds after a call for heat by the control circuits. On a call for heat, 24 volts is supplied to the operator terminals of the sequencer. A bi-metallic element is heated causing the bi-metal to bend and operate the sequence load contacts that energize the electric heater. At the same time pilot duty contacts are energized supplying 24 volts to the next sequencer operator. Each stage of the heater is delayed by subsequent sequencers until all stages are energized. Outdoor thermostats may be used to lockout stages of sequenced heaters.

When a call for heat is terminated by the control circuit, the heater remains energized until the sequencer operator cools, de-energizing the heater. The off cycle delay may be up to 90 seconds.

Sequencers are frequently called "hot wire" relays, "warp" relays or "warp" switches.

When magnetic relays are used to control electric heaters, the indoor fan cycles on and off instantaneously with the room thermostat unless the system is set for continuous fan operation.

When sequencers are used to control electric heaters, the indoor fan cycles on instantaneously with a call for heat. When the call for heat is terminated by the room thermostat, the indoor fan will continue to operate until the last sequencer in the heater circuit de-energizes. This delay can be several minutes depending upon the number of sequencers used in the heater.

In a typical electric heater control circuit, each heater control relay coil or sequencer operator is electrically in series with a thermal cut out located in the heater, a set of heater interlock contacts located on the indoor fan relay, and the room thermostat contacts. On multi-stage heaters, an outdoor thermostat may also be in the series circuit. All switches and contacts in the series circuit must be closed before the heater control will energize.

In a typical electric heater primary power circuit, each stage of the heater is composed of one or more heating elements. Each element is electrically in series with a control relay load contact and a fuse link, both located in the heater. Fuses or circuit breakers for each supply wire may be located in the heater or outside the equipment cabinet

Electric Heater Does Not Heat

Be sure indoor thermostat is calling for heat.

Check primary power supply to heater circuit.

Check fuses, circuit breakers and terminal connections.

If heater control relay or sequencer fails to energize, check for 24 volts at the relay coil or sequencer operator. If 24 volts is present and the relay or sequencer fails to operate - change the relay or sequencer. Allow at least 5 minutes after 24 volts has been applied to a sequencer before condemning the sequencer.

If heater control relay or sequencer fails to energize, check for 24 volts at the relay coil or sequencer operator. If no 24 volts present, check room thermostat for heat call. Check 24 volt supply. Check outdoor thermostat(s) for setting and operation. Check heater thermal cut out for closed circuit. Check indoor fan relay heater interlock contacts for closed circuit.

If heater control relay or sequencer energizes and the heater does not heat; check relay or sequencer load contacts for closed circuit. Check heater fuse links for closed circuit. Check heating elements for continuity. Check primary power supply to heater.

Heater Trips Thermal Cut Out or Blows Fuse Links

Airflow too low. Check for dirty filters, dirty blower wheels, blocked or closed registers and grilles. Check fan motor speed setting or pulley setting. Check for loose pulleys and belts where used. Check fan motor and blower bearings, fan clearance for binding causing fan motor to run at low shaft speed. Check for proper blower rotation.

Primary supply voltage too high causing excessive current and heat output. Electric heaters should not operate at voltages more than 10% above the heater nameplate voltage rating.

Heater connected to wrong voltage or phase. Supply must agree with the heater nameplate rating. Check supply against nameplate rating.

Heater KW too high for air handling equipment air supply capability. Electric heater and air handler combination must be approved match. Consult manufacturer's listing of approved combinations.

Heater element grounded to heater frame or duct will blow fuse links. Check for grounded heater element.

Heater must be installed in the correct position. If heater is installed with air entering the wrong side, thermal cut outs and fuse links will blow.

Not Enough Heat Output from Heater

Check control circuits to all heater stages to be sure all stages are operational.

If all control circuits are operational, check for line voltage at all control relay or sequencer load terminals.

If voltage is present at all terminals, check the current draw to each heater element. Make current measurements in the wire that feeds each fuse link.

If current is present in all fuse link feed wires, all heater elements are operating.

Absence of current flow in any fuse link feed wire indicates an open fuse link or open heater element. Check fuse link and heater element for continuity.

If all heater elements are operating and the heat output is too low, check the supply voltage to the heater. If the supply voltage is lower than the heater nameplate voltage rating, heat output will be lower than the heater rated KW.

Determining Operating KW – Single Phase Heaters

Measure supply voltage at the heater with the heater operating.

Measure heater amp draw in each supply circuit.

To obtain circuit watts, multiply measured circuit volts by measured circuit amps.

Example: 206 volts x 23 amps = 4738 watts = 4.738 KW

If the heater has more than one supply circuit, measure each supply circuit. Total KW = circuit 1 KW + circuit 2 KW, etc.

If the fan motor is operating on one of the heater supply circuits, measure the fan motor amp draw. Subtract fan motor amps from circuit amps before making heater KW calculation for that circuit.

Heater KW rating, voltage rating and amp draw is shown on the heater wiring diagram. If heater supply voltage is lower than heater rated voltage, the input KW and amp draw will be less than rated values shown on the diagram.

Determining Operating KW-3 Phase Heaters

Measure phase to phase supply voltage at the heater with the heater operating. Add the phase to phase voltages and divide by 3 to obtain average voltage.

Example:

Phase 1 volts = 214

Phase 2 volts = 209

Phase 3 volts = 212

Average volts = 635 ÷ 3 = 211.6

Measure amp draw in each supply line.

To obtain circuit watts:

Add:

Line 1 amps x avg. volts

Line 2 amps x avg. volts

Line 3 amps x avg. volts

Total watts = subtotal ÷ 1.73

Example:

20 amps x 211 volts = 4220

15 amps x 211 volts = 3165

12 amps x 211 volts = 2532

Total circuit watts = 9917 ÷ 1.73 = 57.32 = 5.732 KW

(1.73 is a constant used in determining 3 phase power)

If the heater has more than one supply circuit, measure each supply circuit. Total KW = circuit 1 KW + circuit 2 KW, etc. 2 KW, etc.

If the fan motor is operating on one of the heater supply circuits, measure fan motor amp draw. Subtract fan motor amps from total circuit amps before making heater KW calculation for that circuit.

Heater KW rating, voltage rating and amp draw is shown on the heater wiring diagram. If heater supply voltage is lower than heater rated voltage, the input KW and amp draw will be less than values shown on the diagram.

When the fan motor is located in the air stream, heat generated by the motor is added to the heater output for total heat output. For service purposes the motor heat generated by a fractional horsepower motor is generally a small part of the total heat and causes a small error in total heat calculations when it is not calculated. Multi-horsepower motors must be considered in total heat calculations since they may add, considerable heat to the airstream. Motor heat generated by motors in the airstream can be calculated.

$$\text{Watts} = \frac{\text{motor horsepower x 745}}{\text{motor efficiency}}$$

SP335 – Checking Compressor Electrical Circuits

Checking compressor electrical circuits requires the use of the equipment wiring diagram to locate and troubleshoot components in the circuits.

Wiring diagrams are attached to control box covers or power cover panels on all equipment.

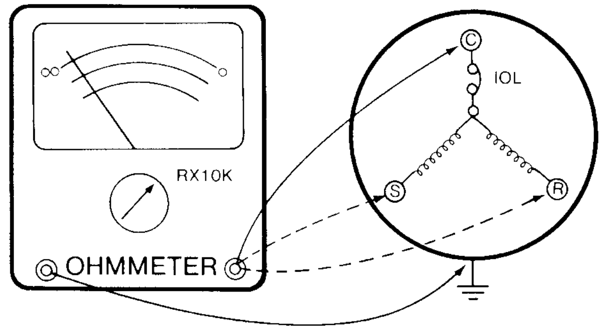
The wiring diagram shows physical location of components, terminal connections, and physical wiring layout.

The schematic portion of the diagram shows electrical connections to components necessary to operate each electrical circuit in the system.

When a component fails to operate, the schematic should be used to identify all other components that completes the circuit. The wiring diagram should be used to physically locate the components.

Wire color codes are shown on wiring diagrams and schematics to assist in circuit tracing.

The wiring diagram identifies compressor terminals and internal overload protector terminals.



Testing Compressor For Motor Grounding All Single and Three Phase Compressors Figure 335-1

Before condemning a compressor for internal electrical failure, measure resistance between all terminals and measure each terminal to ground. (See Figure 335-1)

Compressor Fails to Start – Control Circuit

Check compressor contactor for energized position.

If compressor contactor is not energized, check voltage across contactor coil.

If voltage is present, check contactor per SP130.

If no coil voltage is present, check control transformer and control fuse per SP114.

If transformer and fuse check good, jumper R to Y low voltage terminals or wires in the outdoor unit. If the contactor energizes, the problem is in the room thermostat or connecting wiring.

If the contactor fails to energize when R to Y is jumpered, check all components connected in series with the compressor contactor coil. Identify components from the schematic diagram.

Single Phase Compressors Only – Compressor Fails to Start – Compressor Motor Hums

Turn room thermostat to off position.

Disconnect outdoor fan motor(s).

Measure supply voltage at the line side of the compressor contactor. Supply voltage should be within 10% of equipment nameplate rating.

Connect a voltmeter to the load side of the contactor per SP110.

Observe the voltmeter. Manually engage the contactor momentarily. Voltage should not drop more than 10% below no-load voltage. If the voltage drops more than 10%, check circuit wire size, length, and terminals for loose connections per SP 110.

If the motor hums but fails to start, check run capacitor(s) per SP150. Check start capacitor(s) if used per SP152. Check start relay if used per SP135. Check start winding fuse if used per SP112.

If the equipment does not use a start capacitor and relay, be sure head and suction pressures are equalized. Equipment utilizing expansion valves may require a long time period to equalize. Single phase compressors without start capacitors will not start against a pressure differential.

If the equipment does not use a start capacitor and relay, temporarily connect a start capacitor (WW20X8 or equivalent) in parallel with the run capacitor. Manually engage the compressor contactor momentarily.

CAUTION: Do not apply power for more than 5 seconds. Start capacitors are designed for intermittent duty only and could rupture if power is applied for extended time periods. If the compressor starts, remove power immediately. Disconnect the start capacitor. Try to restart the compressor. If the compressor starts, restore equipment to operating condition. Operate the equipment until normal operating pressures are reached. Measure the compressor current draw in the compressor common line. If the current draw is equal to or less than equipment nameplate amps, the servicer must use their experience and judgement to determine whether the equipment will continue to start or a start kit is required.

If the compressor draws excessive current at operating conditions, condemn the compressor.

If the compressor failed to start with the start capacitor connected, condemn the compressor.

Single Phase Compressors – Compressor Fails to Start – Compressor Motor Doesn't Hum

Turn room thermostat to off position.

Disconnect outdoor fan motor(s).

Connect a voltmeter to the load side of the compressor contactor.

Manually engage the contactor momentarily.

If adequate supply voltage is present and the compressor motor does not hum when power is applied, disconnect all power.

Determine from the wiring diagram what type of overload protection system is used.

If the compressor utilizes an internal line break protector, it will be identified on the wiring diagram as IOL. Check IOL per SP167. (See Figure 335-2)

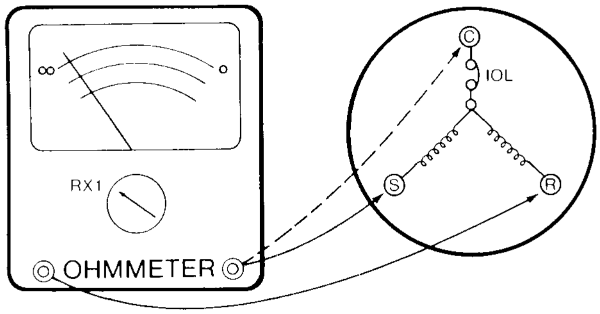
If the compressor utilizes an internal pilot duty protector, it will be identified on the wiring diagram as TM. Check TM per SP165. (See Figure 335-3)

If the compressor utilizes external line break protector(s) they will be identified on the wiring diagram as XOL and XOLS. Check XOL and XOLS per SP160.

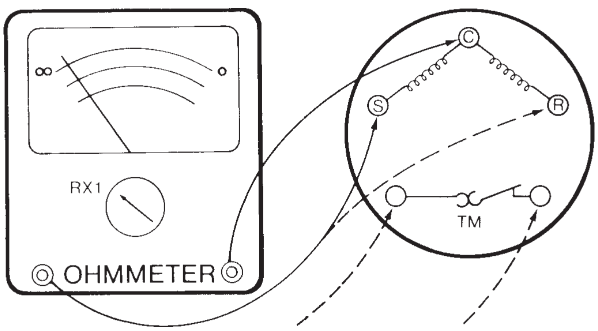
Compressors utilizing TM also utilize XOL and XOLS.

If protectors check good, measure compressor resistance at the compressor terminals.

If compressor has 5 terminals, measure for continuity between the 3 top terminals. An open reading between any of these terminals indicates an open winding. Condemn the compressor. The 2 lower terminals are



**Testing Compressors For Open Windings
Single Phase Compressors With
Internal Line Break Overload Protectors (IOL)
Figure 335-2**



**Testing Compressors For Open Windings
Single Phase Compressors With
Internal Pilot Duty Thermostats (TM)
Figure 335-3**

connected to the internal pilot duty overload (TM) and will not measure continuity to the top 3 terminals. (See Figure 335-3)

Measure from all top 3 terminals to the suction line or discharge line for grounds. If the ohmmeter indicates less than 50,000 ohms, condemn the compressor. (See Figure 335-1)

If compressor has 3 terminals, measure for continuity between the 2 bottom terminals (start to run). If an open circuit is measured, an open winding is indicated. Condemn the compressor. If continuity is measured between the start and run terminals measure from the start terminal to the top terminal (common), and from the run terminal to common. If both start and run terminals are open to the common terminal, the internal overload (IOL) is open. Allow adequate time for the IOL to reset before condemning the compressor per SP167.

If either run to common or start to common measures an open circuit and the other winding measures continuity, condemn the compressor for open winding.

Measure from all 3 terminals to the suction line or discharge line for grounds. If the ohmmeter indicates less than 50,000 ohms, condemn the compressor. (See Figure 335-1)

3 Phase Compressors Only – Compressor Fails to Start – Compressor Motor Hums

Turn room thermostat to off position.

Disconnect outdoor fan motor(s).

Measure phase to phase voltage at the line side of the compressor contactor. Supply voltage should be within 10% of equipment nameplate rating.

Connect a voltmeter across 1 phase on the load side of the contactor.

Observe the voltmeter. Manually engage the contactor momentarily. Voltage should not drop more than 10% below no-load voltage. If the voltage drops more than 10% below no-load voltage, check circuit wire size and length and check terminals for loose connections per SP 110.

Check all phases.

Determine from the wiring diagram what type overload protection system is used.

If the compressor utilizes external protectors they will be identified on the wiring diagram as XOL. Check XOL per SP160.

If the compressor motor hums when power is applied, line voltage on all 3 phases check good, all XOL protectors check good and voltage is present at all 3 compressor winding terminals, then condemn the compressor.

3 Phase Compressors Only – Compressor Fails to Start – Compressor Motor Doesn't Hum

Turn room thermostat to off position.

Disconnect outdoor fan(s).

Manually engage the compressor contactor and measure phase to phase voltage at the load side of the compressor contactor. Phase to phase voltage should be within 10 of equipment nameplate rating.

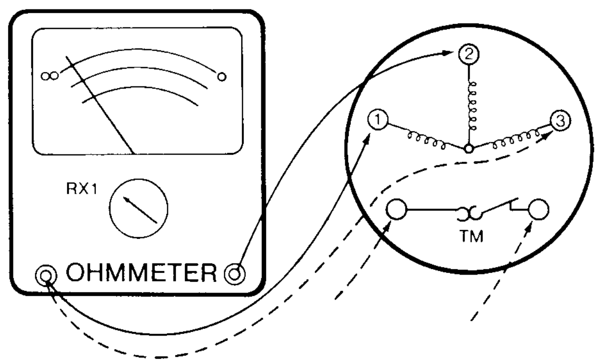
If the supply voltage checks good and the compressor does not hum when power is applied, determine from the wiring diagram what type overload protection system is used.

If the compressor has 5 terminals and the protectors are identified as XOL, check the XOL protectors per SP160.

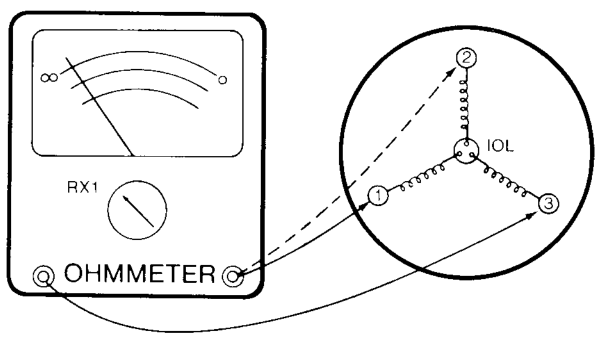
If the XOL protectors check good, phase to phase voltage checks good, supply voltage is present at the top 3 compressor terminals and the compressor fails to hum, an open winding is indicated.

Disconnect power and remove wiring from compressor terminals. Verify open winding by measuring continuity between the top 3 compressor terminals. If an open circuit is measured between any of the top 3 compressor terminals, condemn the compressor. The lower 2 terminals are connected to the internal pilot duty protector and will not measure continuity to the top 3 terminals. (See Figure 335-4)

If the compressor has 3 terminals and the overload protector is identified as IOL on the wiring diagram, the protection system is an internal line break system. (See Figure 335-5)



**Testing Compressors For Open Windings
3 Phase Compressors With
Internal Pilot Duty Thermostats (TM)
Figure 335-4**



**Testing Compressors For Open Windings
3 Phase Compressors With
Internal Line Break Overload Protectors (IOL)
Figure 335-5**

If the compressor fails to hum when power is applied to an IOL protected compressor, the IOL is open. Allow adequate time for the IOL to reset before condemning the compressor per SP167.

To verify an open winding or defective IOL permit at least 1 hour for the compressor to cool. If the IOL is open an open circuit between all three compressor terminals will be measured with an ohmmeter. An open circuit measurement with an ohmmeter between any 2 or the 3 compressor terminals indicate an open winding. Condemn the compressor.

If the compressor has 3 power terminals and 3 protector terminals, the compressor is protected by a solid state protection system.

When power is applied manually engaging the contactor, and the compressor fails to hum, an open winding is indicated.

Remove the leads from the upper 3 compressor terminals and verify open windings. An open circuit measured with an ohmmeter between any 2 of the 3 upper terminals verify an open winding. Condemn the compressor.

The solid state protector can be checked per SP168.

Compressor Draws Excessive Current – 1 or 3 Phase

Check power supply per SP110. Voltages above or below 10% of equipment nameplate rating can cause excessive current draw.

Check normal operating pressures per SP710, 715, 730, 735. Pressures above normal operating pressures or excessive evaporator loads can cause excessive current draw.

If operating pressures are above normal check for dirty condenser per SP820, non-condensables per SP614, refrigerant charge per SP720, 725, 730, 735.

Single phase only – check run capacitor(s) for correct MFD rating. Check run capcitor(s) operation per SP150, check start capacitor(s) per SP152, check start relay per SP135.

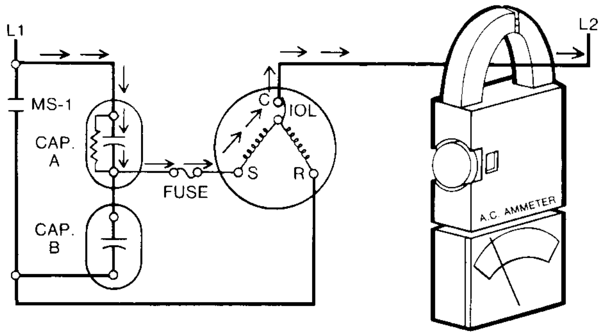
3 phase only – check phase to phase voltage tolerance per SP110. Check fuses and overload protectors for single phasing by measuring current draw in each phase. Current in each phase should be within 2%.

SP350 – Checking Trickle Circuits

The trickle circuit serves the same purpose as a crankcase heater; to prevent accumulation of refrigerant in the compressor crankcase during the compressor off cycle.

The trickle circuit permits a small amount of current to flow through the compressor run capacitor and the compressor start winding when the compressor contactor is de-energized. Power to the compressor run winding is interrupted by the contactor.

The capacitor used in the trickle circuit has a resistor connected across its terminals. The only purpose of the resistor is to serve as a capacitor discharge path when power to the unit is turned off.



Checking Trickle Circuit Current Draw
Figure 350-1

Replacement capacitors in units utilizing trickle circuits must be the same microfarad rating or circuit malfunction may occur. Nuisance tripping of compressor overload protectors is likely.

Only factory supplied start kits should be used with trickle circuit units. Field wired start kits may cause start circuit malfunctions.

Checking Trickle Circuits

Turn the unit off at the room thermostat. Leave power supply to outdoor unit energized.

Connect a clamp on ammeter to one of the lines supplying the outdoor unit. The ammeter should indicate 2 to 4 amps with the outdoor unit off. (See Figure 350-1)

The current draw of the trickle circuit is not indicative of power consumed or dissipated by the circuit. Actual power consumed by the circuit is 45 to 65 watts.

CAUTION: Always disconnect power to the unit before removing unit power panel covers. Only one line from the power supply is interrupted by the compressor contactor on trickle circuit units.

If trickle circuit units nuisance trips compressor internal motor protector during the off cycle - check the microfarad rating of the trickle capacitor against proper rating shown on the unit wiring diagram. The microfarad rating shown on the wiring diagram must be used. Check for miswiring if field wired start kit has been installed.

SP360 – Compressor Condemnation Procedure

Before changing a compressor, checks on all electrical components in the compressor circuit should be performed.

When a compressor is condemned, an acid test per SP932 should be performed to determine if the system requires installation of a permanent suction line clean-up drier with the replacement compressor.

Compressor Will Not Start – Pulls Locked Rotor Amps

Check supply voltage per SP110.

Check run capacitor(s) per SP150.

Check start capacitor(s) per SP152.

Check start relay per SP135.

Check compressor electrical circuits per SP335.

If supply voltage is within 10% of the equipment nameplate rating, capacitors and start relay (if used) check good, compressor wiring is good and the compressor draws locked rotor amps, change the compressor per SP365.

Take an oil sample from the failed compressor and perform acid test per SP932.

Compressor Will Not Start – Pulls Little or No Amps

Check voltage at the compressor per SP335.

If voltage is present at the compressor, check compressor internal overload per SP167.

Check compressor electrical circuit per SP335.

If resistance measurements per SP335 indicate an open overload protector, permit adequate time to reset before condemning the compressor.

If tests indicate an open winding or an internal overload protector that will not reset, change compressor per SP365.

Take an oil sample from the failed compressor and perform acid test per SP932.

Compressor Runs – Little or No Pumping

Check operating pressures per charts attached to the equipment.

Heat pump – check the check valves per SP520.

Heat pump – check reversing valve per SP510.

Check expansion valve(s) if used per SP545.

Check mechanical performance per SP370.

If system components above check good, change the compressor per SP365.

Compressor Runs – Pulls Excessive Amps

Check supply voltage per SP110.

Check operating pressures per charts attached to the equipment.

Check run capacitor(s) per SP150.

If start capacitor and start relay is used, disconnect start components and recheck compressor amps.

Check compressor for grounds per SP335

If pressures are normal, capacitors are good and supply voltage good, change the compressor per SP365.

Take an oil sample from the failed compressor and perform acid test per SP932.

Noisy Compressor – Running Noise

Check equipment for level installation.

Disable outdoor fan(s), observe compressor noise without fan(s) to be sure noise is in the compressor.

Check operating pressures per charts attached to the equipment - (fans operating). Excessive pressures increase running noise.

If noise is isolated to the compressor, change the compressor per SP365.

Noisy Compressor – Starting and/or Stopping

Check equipment for level installation.

Check compressor for level installation in equipment base pan.

Check refrigerant tubing clearance to equipment cabinet, to adjacent tubing, fan motor(s).

Check operating pressures per charts attached to the equipment. Excessive head pressure can cause stopping noise.

Be sure the noise is in the compressor. Noise caused by reversing valve operation or rapid pressure balancing expansion valved can appear as compressor noise.

If noise level is unacceptable, change the compressor per SP365.

SP365 – Compressor Replacement Procedure

Before changing the compressor, a thorough check of the suspect compressor should be performed per SP360, compressor condemnation procedure.

If the following replacement procedure is performed step by step, minimum time will be required for change out.

Recover refrigerant charge per SP928.

While charge is being recovered, remove panels and components necessary for compressor access. Remove compressor cover (if used) and compressor hold down bolts. Remove wiring from compressor terminals. Uncrate replacement compressor. Set up and start vacuum pump on self pull down. Check indoor unit air filters.

When high and low side pressures reach 0 PSIG, loosen compressor Rotolock fittings per SP630. Remove the failed compressor from the equipment. Take oil sample from failed compressor and perform acid test per SP932. Remove existing liquid line drier(s). Replace with new drier(s). See SP935 for brazing. Set replacement compressor in place. Tighten Rotolocks per SP630. Install permanent suction line drier if acid test indicates acid system. Connect vacuum pump to equipment and begin evacuation procedure per SP930.

While evacuating system, install compressor hold down bolts. Connect wiring to compressor terminals. Replace compressor cover (if used). Replace components and panels removed for compressor access. Cap off failed compressor and pack in crate. Locate charging chart attached to equipment.

When acceptable vacuum is reached per SP930, shut off charging manifold valve. Remove vacuum pump. Connect the center manifold hose to a charging cylinder. Purge the hose using a minimum amount of refrigerant. Open the high side manifold valve and charge liquid refrigerant into the high side. Do not charge liquid into the low side. Leave low side manifold valve closed. Permit liquid refrigerant to charge into the high side for 2 to 3 minutes. Close the high side manifold valve. Allow time for high and low side gauges to indicate equalized pressure. Start the equipment and observe pressure readings for proper system operation, balance the refrigerant charge by charging refrigerant vapor into the system low side. Do not charge liquid into the low side. Compressor damage will result.

Use the correct charging method for the type flow control used in the system:

- Charging cap tube systems – cooling – SP720
- Charging cap tube systems – heating – SP725
- Charging expansion valve systems – cooling – SP730
- Charging expansion valve systems – heating – SP735
- Charging by weight – SP740

When the correct charge has been established. Check the system performance with the charts attached to the equipment or see:

- Normal operating pressures —
  cap tube – cooling – SP710
- Normal operating pressures —
  cap tube – heating – SP715
- Normal operating pressures —
  TEV – cooling – SP730

Normal operating pressures —
TEV – heating – SP735

SP370 – Checking Compressor – Mechanical

Compressor mechanical failures are caused by broken valves, stuck bearings, broken springs or broken internal tubing. Each type of failure can usually be attributed to specific system faults that caused the failure. When a compressor fails, the system should be examined to determine whether a system fault contributed to the compressor failure, and may cause the replacement compressor to fail.

The primary cause for broken compressor valves is liquid slugging the compressor at start up. Liquid slugging can also cause compressor internal tubing to break. Slugging can be attributed to excessive refrigerant charge. Excessive operating charge can be the result of long refrigerant lines, oversized liquid lines, oversized refrigerant driers, or an improper refrigerant charge.

Defective expansion valves can also cause liquid slugging. If the thermal element is not in good thermal contact with the suction line, the valve will react slowly on start up and cause slugging.

The primary cause for stuck compressor bearings is refrigerant flooding from the evaporator into the compressor. The main cause for flooding is an overcharge of refrigerant.

Flooding is also caused by dirty air filters, dirty blower wheels, low fan speed, inadequate ductwork, closed registers or grilles or any other cause for low indoor airflow.

Flooding is normally associated with capillary tube systems but is also prevalent in expansion valve systems where the expansion valve thermal element has poor or no contact with the suction line.

Another major cause for stuck bearings is long vertical suction lines where the evaporator is located below the condenser preventing oil return to the compressor. Oversized suction lines in vertical suction lift applications can cause as many oil return problems as long suction lifts. Long horizontal suction lines can cause oil return problems where the line is not tilted downward toward the compressor. Oversized suction lines add to oil return problems. Oversized suction lines should not be used. Refrigerant line lengths should not exceed recommended maximum lengths.

Another major cause for stuck bearings is failure of the compressor crankcase heater. Without a crankcase heater in operation, liquid refrigerant will accumulate in the crankcase, reducing the lubricating qualities of the oil by dilution and cause the oil to foam and leave the compressor at start up. The crankcase heater should always be checked when replacing a compressor.

Some single phase equipment utilizes a trickle circuit through the run capacitor and compressor winding during the off cycle in lieu of a resistance type heater.

Broken compressor internal mounting springs can be a result of high head pressure that results in excessive torque kickback at compressor shut down. Unlevel mounting of the equipment can also contribute to spring breakage. High torque kickback at shutdown can contribute to internal tube breakage.

Mechanical Problems – Compressor Stuck – Will Not Start

Be sure power supply is adequate per SP110.

Check compressor electrical circuits per SP335.

If supply voltage is adequate and electrical components in the compressor circuit check good, replace the compressor.

Mechanical Problems – Compressor Runs – Little or No Pumping

High suction pressure and low head pressure are symptoms of a poor pumping compressor but can also be symptoms of the other system component failure.

Heat pump – check check valves per SP520.

Heat pump – check reversing valve per SP510.

Check expansion valve(s) per SP545.

Check internal pressure relief valve per SP555.

If equipment has service valves, perform pump down test per SP937.

If system components check good and compressor will not pull suction pressure down, condemn the compressor.

Compressor Noise

If compressor running noise is excessive or has starting and/or stopping noise, see SP360.

SP410 – Ranco Timed Defrost Control

The motor on the Ranco defrost control is either 240V or 24 volts (used on 480V models).