Overview

This startup procedure provides a step by step guide which should be followed at the initial startup of a 74mm screw compressor job. It can be conducted at the factory if final testing is completed on the system before shipment or can be conducted on-site when the refrigeration system and compressors are initially started up.

The startup procedure is broken down into the following sections:

- ***Installation Checks***
  These items will verify that the correct compressor accessories have been installed,
- ***Pre-Startup Checks***
  Includes items to be checked before the compressors are started,
- ***Compressor Startup Procedure***
  Procedures to be followed and verification checks to be made while each compressor is started for the first time,
- ***Operational Checks***
  Verification checks to be made after all of the compressors on the rack have been started and are operating.

The following tools will be required during startup:

- Voltage meter capable of readings DC volts to hundredth of a volt (10^{th} of a volt minimum).
- Pressure Gauges: (2) high side gauges, (1) low side gauge
- Amp probe

Installation Checks

The compressor motor protection and de-superheating valves (if required) should be checked to make sure that the correct items are installed for each compressor. The results of the tests should be recorded on the startup worksheet.

Motor Protection

Each compressor must be protected by an approved motor protection device. In general, this must consist of either the correct calibrated circuit breaker or the approved Furnas overload. Note that each compressor HP & voltage combination will result in a unique circuit breaker or overload. The most recent Circuit Breaker recommendations are summarized in OEM bulletin 03T-2. If calibrated circuit breakers are used, at a minimum the circuit breaker handle stamping should be checked to make sure it matches the Must Hold Amp rating of the required breaker. If Furnas overloads are used, OEM bulletin 99T-3 should be referenced to make sure that the correct model overload has been installed and that the overload has been set to the appropriate current rating (should be set to specified Must Hold setting as summarized in the bulletin. Both of these bulletins are available on our website, www.carlylecompressor.com.

De-superheating Valve Installation

Most applications of our 06T compressors do not require the use of an oil cooler. When an oil cooler is not used, it is critical that the appropriate de-superheating valve (used to control the compressor discharge temperature) be installed. Failure to apply the appropriate de-superheating valve (***appropriate size valve & temperature set-point***) can lead to possible compressor overheating and failure. The de-superheating valve must be a Sporlan Y1037 190F valve (starts to open at 190F, fully open at 200F) and must be sized according to the information supplied in OEM bulletin 98T-5. Medium temperature R404A/R507 applications do not require de-superheating, while low/med temp R22 and low temp R404A/R507 applications do.

ALL 05T/06T applications require the use of a motor cooling valve which injects liquid into the economizer port located at the motor end of the compressor.

Compressor Oil Screens (located at compressor oil feed connection)

Each compressor should have an oil screen installed at the compressor oil feed connection (installed directly in the 3/8" flare fitting at compressor). Check to insure that this screen is installed on at least one of the compressors on the rack.

Pre-Startup Checks

Before the compressor is started, make sure all of the following items have been completed before the compressor is started:

Module Powered and All Solenoid Valves De-Energized

Before starting the compressors the control circuit power should be switched on. At that point, the LonCEM module should have control power to it and the power light (green light in upper right hand corner) should be on. No other lights should be on as the compressor call from the controller should be de-energized. ***At no point prior to starting the compressor should the module energize the solenoid outputs while the compressor is locked out*** (i.e. circuit breaker tripped) as this could cause the compressor to fail.

LonCEM Module Pressure Transducer Installation

Verify that all of the sensors have been installed in the correct location. This involves removing each of the pressure transducer harnesses from the transducer and verifying that the compressor module records the appropriate sensor failure alarm.

The results of the test should be recorded in the "Verify Compressor Transducers" columns of the startup worksheet.

Also, verify that the Zener Diode (see "Zener Diode Installation Instructions") has been correctly installed on the modules suction pressure transducer input. The diode should be installed between the suction pressure signal (Sig) and ground (Gnd) connections with the cathode band (dark band around diode bead) facing the sensor input. If zener diodes are not installed, contact Carlyle Application Engineering (800-GO-CARLYLE) in order to obtain them.

Oil Feed Line Open; Oil Charging & Access Ports

Insure the oil feed line is open so that the compressor can get oil when the compressor is started. The oil separator should be charged with oil above the second sight glass and the oil header and piping should be charged with oil up to the oil solenoid valve. No oil should be added to the compressor prior to starting it. Insure that any other feed lines that may be manually closed (including the suction, discharge and economizer service valves) are also opened before starting the compressor.

Compressor Startup Procedure

This procedure should be followed once you are ready to begin starting the compressors on a given rack.

Reverse Rotation Check

This is probably the single most important startup item that should be conducted before starting the compressor. A high pressure gauge should be installed on the discharge access port of the compressor. It MUST be installed on the discharge access port (all access port locations are called out on the compressor schematic included at the end of this document). The compressor should be "bump started" (i.e. control power de-energized immediately after startup) and the direction of the gauge movement should be checked to insure that the discharge pressure rises upon compressor start. If the compressor rotation is backwards the discharge pressure will be

pulled immediately into a vacuum. If the rotation is backwards, the phasing of the compressor should be corrected (reversing any two leads will change rotation) before attempting to re-start the compressor.

Suction and Oil Pressure Gauges

Before starting the compressor additional gauges should be added to the suction access port and the oil access port so that these parameters can be watched when the compressor starts.

Sensor Voltages Before Compressor Start

Verify Sensor Operation. DC Voltage should be measured at the module input terminals (from Sig to Gnd for Pressure Transducers and Across Thermistor Terminals for Motor and Discharge Temperature) and recorded in the Operational Summary worksheet. Charts are provided at the end of this document to convert voltage measurements to Pressure and Temperature. Compressors operating on the same suction group should show similar operating parameters (i.e. corresponding sensor output voltages should be similar for all compressors on a common suction group).

Compressor Start

The following checks should be made when the compressor is started for the first time:

- Make sure that the compressor does not make an unusually high pitched noise at initial startup and that the oil pressure builds as the compressor operates (oil pressure should be no more than 10-20 psi lower than the operating discharge pressure). Lack of oil can result in a loud pitched noise from the compressor and if heard the compressor should be shut off immediately and the source of the noise investigated.
- If at any point the compressor suction pulls into a deep vacuum, it should be shut off immediately. The compressor should never operate with suction pressure lower than 10" of vacuum. Operation in a deep vacuum will cause the rotors to quickly overheat. This can lead to contact between the rotors and rotor housing resulting in damage to or failure of the compressor.
- Check to make sure that the following solenoid valves **turn ON** when the compressors starts: oil solenoid valve, economizer solenoid valve, de-superheating solenoid valve. Each of the coils to these solenoid valves should be tested to make sure they are energized when the compressor is operating.
- Insure that the motor cooling valve is energized and feeds when called by the module.
- Insure that the de-superheating valve (if applicable) feeds when the discharge temperature is above 190F (should be fully open when discharge is at 200F).
- Unloader & VI Solenoids – will remain de-energized at startup and will be activated after 30 seconds of compressor runtime: Unloader will energize depending on call from controller, module will energize Vi based on pressure ratio (energized Pr> 5:1, de-energized Pr<5:1). Only 06TR compressors will have a Vi valve.
- The Sensor Voltages should be recorded with the compressor operating following the same procedure outline above. The temperature inputs should be examined to make sure that both the motor and discharge temperatures rise when the compressors starts. This will confirm that the sensors are installed and are operating correctly. The sensor voltage will drop when the temperatures rises as the thermistors have a negative temperature coefficient (NTC). Compressors operating on the same suction group should show similar operating parameters.
- The Low Pressure Switch (all compressors are required to have a LPS) and the High Pressure switch should all be tested to insure they are operational. The LPS cut-out should not be set lower than 10" vacuum. The compressor has a built in relief valve which is set to open at differential pressures (discharge – suction) above 400 psi. Under no circumstances (i.e. while testing/setting the high pressure switch) should the compressor be subject to differential pressures which might cause the relief valve to open as servicing the relief valve can be difficult.

- Insure that the following solenoids **turn OFF** when the compressor shuts down: oil solenoid valve, economizer solenoid valve, de-superheating solenoid valve.

This startup procedure should be followed for each compressor as it is started for the first time. The results of the startup and the startup data should be recorded in the Startup Worksheet.

Compressor Operating Checks

After all compressors have been started on the rack, the following checks should be made once the rack has been charged with refrigerant and the rack begins to operate with some stability. The voltages from the module inputs can be used in order to obtain much of the data required for the operational checks. The results should be recorded in the Startup Worksheet.

Oil Pressure Check:

A. Discharge Pressure (psi) _____- taken at Discharge Access Port
B. Oil Pressure (psi) _____- taken at Oil Pressure Access Port
C. Suction Pressure (psi) _____- taken at the Suction Pressure Access Port (below suction service valve)
D. Oil Filter Inlet (psi) _____ E. Oil Filter Outlet (psi) _____

- Oil Pressure (B – C) should be greater than 45 psi (module will cut-out at less than 45 psi)
- Oil Pressure Drop (A – B) should be less than 45 psi (module will alarm above 35 psid and cut-out at 50 psid)
- Oil Pressure Drop across the filter (D – E) should be less than 25 psi (must replace if greater than 45 psi)

Economizer Check:

If an economizer is used, set the superheat leaving the economizer to 10F to 20F.

Economizer Vapor Pressure (psi) _____
Saturation Temperature (F) _____
Superheat (F) _____
Subcooler Hold Back Valve setting (psi) _____
Liquid Temp - Outlet of Subcooler (F) _____

The subcooler hold back pressure should be set based on the design liquid temperature for the rack. Typically it is set such that the saturated temperature is 10F below the design liquid temperature.

Discharge Temperature:

Discharge temperature (measured within 6" of discharge service valve) should be less than 210F, module will cut-out at 230F. DC voltages measured on the discharge thermistor input lower than 0.70V indicate temperatures in excess of 230F.

Compressor Amp Draw:

The operating amperage of the compressor should be compared to the expected amp draw for the particular model/refrigerant/operating condition. The expected amp draw can be obtained from our compressor selection software (available at www.carlylecompressor.com) or from the tabular performance data available in the product catalog.

Oil Temperature (when an Oil Cooler is applied):

If an oil cooler is applied*, check the oil temperature entering the compressor and ensure that it is less than 150F (should be maintained between 90F – 140F).

*** Most current applications do not require the use of an oil cooler. This check is only required for those applications where an oil cooler has been applied.**

Oil Separator – Oil Level:
Once the rack has operated for a few days and has begun to stabilize, the oil level in the oil separator should be checked to make sure that it is between the second and third sight glasses (our recommended operating level). If it is not, oil should be added or removed in order to get the correct oil level charged in the separator. Only one of Carlyle's approved refrigerant oils (POE oil with viscosity rating between 100 – 170 cSt; 170 cSt required with R22 applications without an oil cooler) should be applied with our 74mm screw compressors. Using another oil can lead to premature compressor failure and may void the compressor warranty. See the compressor application guide, available on our website www.carlylecompressor.com, for a complete list of approved oils.

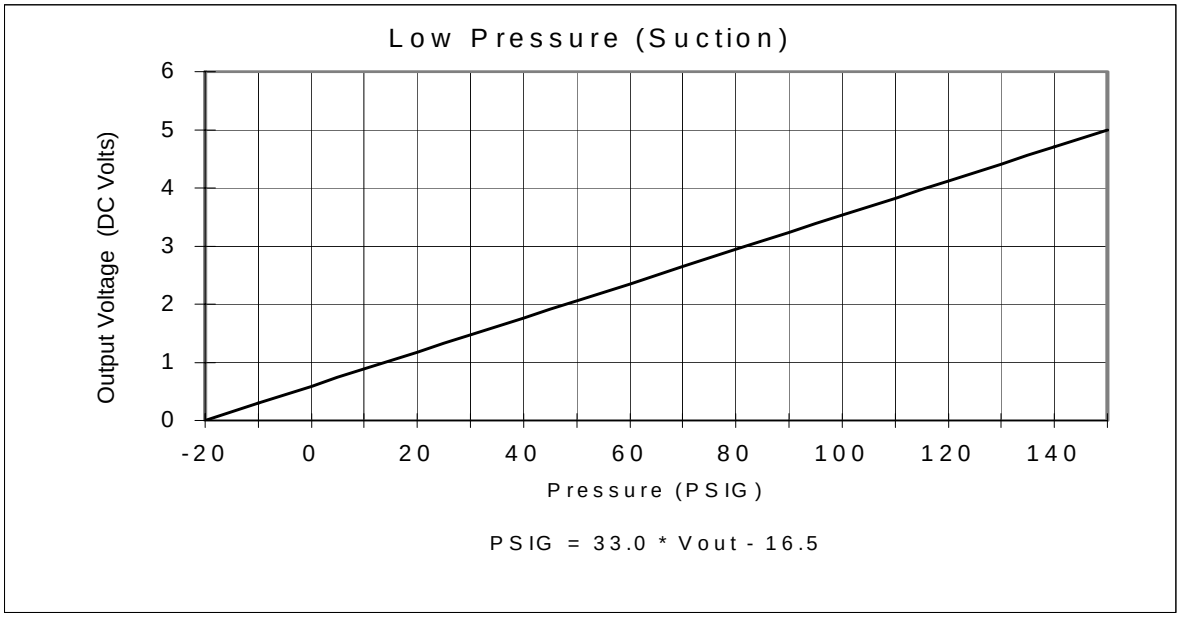
Oil Separator - Oil Level Float Switch:
The oil level switch installed at the bottom of the oil separator must be wired such that it shuts down all of the compressors on the rack when it opens. The float switch closes when satisfied and opens upon a loss of oil. The switch should be tested (i.e. remove one of the wires from the switch or at the terminal block) to verify that all of the compressors are taken off-line. In order to avoid nuisance tripping, the rack should be wired / controlled such that a lockout occurs only after a 30 second time delay has expired. After a lock out, the controller should not begin to bring compressors back on-line until after the float switch has been satisfied for at least 2 minutes.

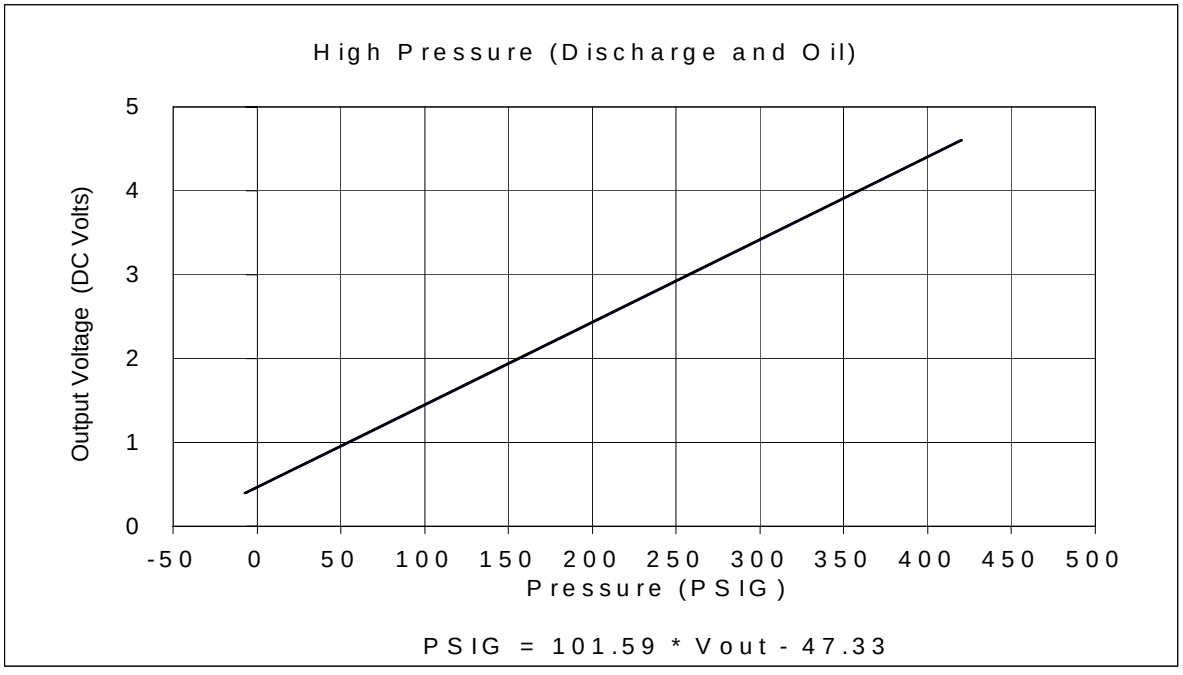
Rack Controller Set-points:
In order to avoid over cycling* of the compressors, it is important that the rack controller is programmed with the correct compressor set-points. These parameters include:
Compressor Capacity / HP – HP should be available on the rack legend or our application guide; compressor capacity is available from our software or tabular performance data.
Compressor Unloading % - Section 2.7 of our application guide (available on our website) contains tables showing the unloading % for each compressor model.
Unloading Solenoid Control – Our 74mm screw compressors are loaded when the unloading coil is energized and unloaded when de-energized. This is the opposite of our 06D/E compressors and may not match the default of the rack controller. The state of the unloading coil should be checked to make sure it matches the intent of the rack controller load state.
* In general, the compressors should not average more than 6 starts per hour over a 24 hour period.

Converting Sensor Inputs to Engineering Units

Pressure Transducers

The following graphs show the sensor output voltage, as measured across the **Sig** and **Gnd** terminals, versus the operating pressure. Separate graphs are shown for the low side (suction) and high side (discharge and oil) transducers. The equations shown in the graphs give approximate values as they assume a perfect +5 power supply.





Motor and Discharge Thermistors

The following table shows conversion of module voltage (as measured across the modules input terminals) and thermistor resistance (as measured across the thermistor leads when not connected to the module) to temperature.

LonCEM 5K Thermistor Output Conversion to Temperature

Voltage[1] (VDC)	Resistance[2] (ohms)	Temp (C)	Temp (F)	Voltage[1] (VDC)	Resistance[2] (ohms)	Temp (C)	Temp (F)
4	6480.0	19.2	66.5	2.1	1173.1	61.6	142.9
3.9	5743.6	21.9	71.4	2	1080.0	64.0	147.1
3.8	5130.0	24.4	75.9	1.9	992.9	66.4	151.4
3.7	4610.8	26.9	80.3	1.8	911.2	68.8	155.9
3.6	4165.7	29.2	84.6	1.7	834.5	71.4	160.6
3.5	3780.0	31.5	88.7	1.6	762.4	74.1	165.4
3.4	3442.5	33.7	92.7	1.5	694.3	76.9	170.5
3.3	3144.7	35.9	96.6	1.4	630.0	79.9	175.8
3.2	2880.0	38.1	100.5	1.3	569.2	83.1	181.5
3.1	2643.2	40.2	104.3	1.2	511.6	86.4	187.6
3	2430.0	42.3	108.1	1.1	456.9	90.1	194.1
2.9	2237.1	44.4	111.9	1	405.0	94.0	201.3
2.8	2061.8	46.5	115.6	0.9	355.6	98.4	209.1
2.7	1901.7	48.6	119.4	0.8	308.6	103.3	217.9
2.6	1755.0	50.7	123.2	0.7	263.7	108.8	227.8
2.5	1620.0	52.8	127.0	0.6	220.9	115.2	239.4
2.4	1495.4	54.9	130.9	0.5	180.0	122.9	253.2
2.3	1380.0	57.1	134.8	0.4	140.9	132.5	270.4
2.2	1272.9	59.4	138.8	0.3	103.4	145.2	293.3

Notes

1. Voltage measured between thermistor input pins on module sensor terminal block.
2. Resistance measured across the Thermistor Leads when **not** connected to module.

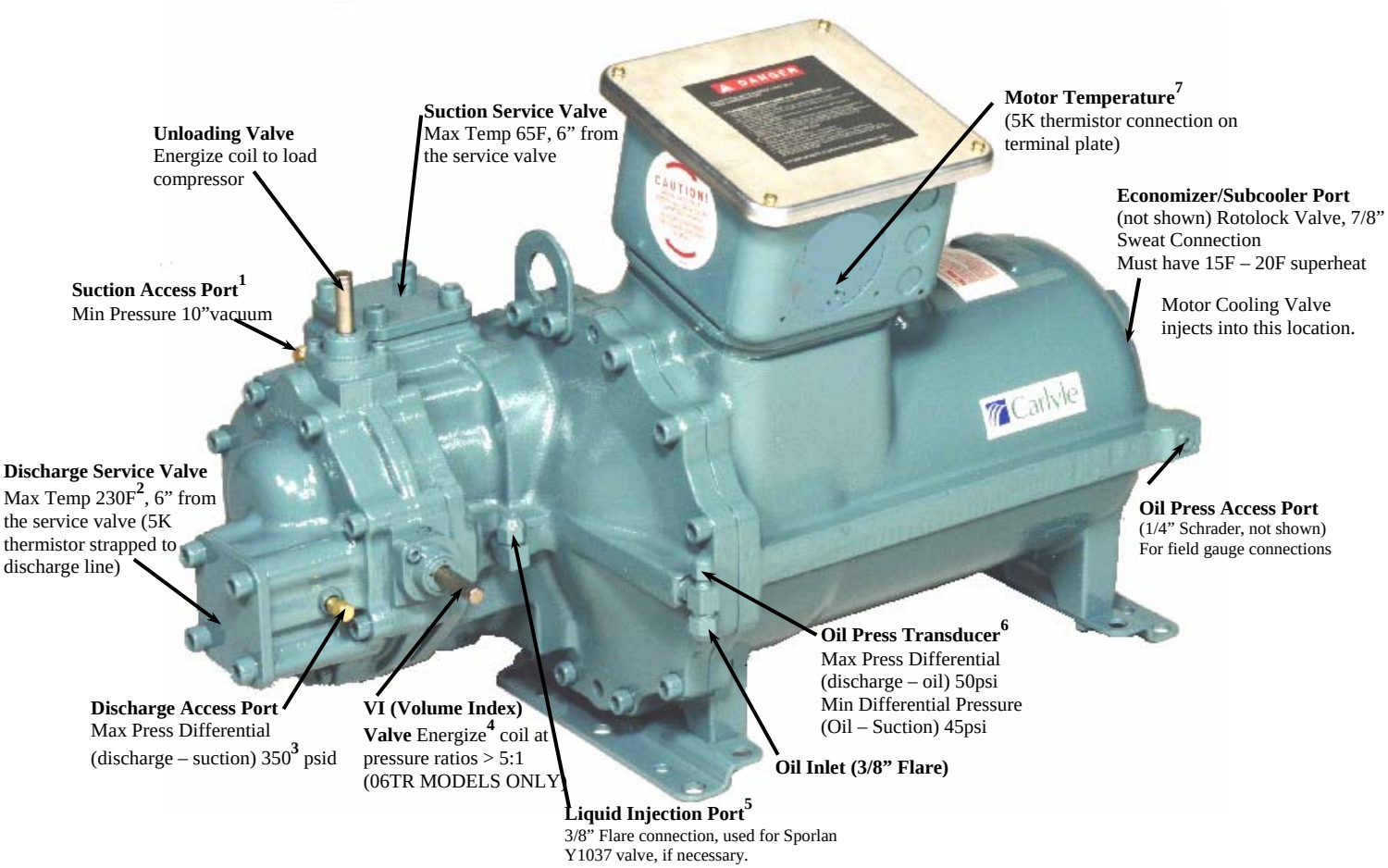


Figure 1. Compressor Connections / Operating Limits

05T/06T Compressor - Operating Limits	
Item	*Notes*
1 – Suction Press	A Low pressure Switch must be installed for each compressor and set no lower than 10" Hg
2 – Disch Temp	LonCEM module will control discharge temp between 190F (injection OFF) – 205F (Injection ON) LonCEM module will shut compressor down at 230F (restart when temp reaches 200F)
3 – Disch Press	Internal relief valve will open if the differential pressure (discharge-suction) exceeds 400psid +/-3%
4 – VI Control	LonCEM control module will control the VI valve based on monitored pressure ratio (energized: Pratio >= 5:1, deenergized: Pratio < 5:1)
5 – Liquid Inj	Y1037 Desuperheating valve (see application guide for usage) injects liquid based on discharge temperature (starts to open at 190F, fully open at 200F); valve must be supplied 100% liquid to be effective
6 – Oil Pressure	LonCEM module simultaneously monitors: Oil Pressure Drop (disch press – oil press): Alarms at 35psi; Locks the compressor out at 50 psi Oil Pressure Differential (oil press – suction press): Lock out at 45psi
7 – Motor Temp	LonCEM module monitors 5k thermistor buried in the motor windings. Motor temperature used to control motor cooling valve: (starts injection at 180F, OFF at 165F). LonCEM module also provides over-temperature protection (Unloads compressor at 220F, Lockout at 240F, resets at 200F)

COMPRESSOR INSTALLATION WORKSHEET

Comp	Design SST Temp (F)	Model	Serial No.	Correct Motor Protection (Y/N)	Correct De-Superheating Valve (Y/N)	Oil Screens Installed (Y/N)	Comp Capacity Correctly Programmed	Oil Level Switch Checked	Oil Filter Alarm Checked

Notes

1 Record the compressor number and staturated suction temperature for the suction group.
2 Record the compressor model number and serial number.
3 Based on the instructions in the Startup Procedures, determine if the correct Motor Protection (Calibrated Circuit Breaker or Furnas Overload), De-Superheating Valve (Sporlan Y1037 valve) and whether oil screens have been installed in the compressors.
4 Insure that the rack controller has been properly programmed with the compressor size (HP or Btu) and that the unloading (% and unloading state) have been properly programmed into the rack controller.

Rack Start-Up Check Sheet

Rack	Job Number

TO BE FILLED OUT WHEN COMPRESSORS ARE STARTED FOR THE FIRST TIME

Compressor Sensors

With the module powered up disconnect each pressure transducer, the module should identify the corresponding sensor failure. This also verifies connections to the correct module.

Before and after starting the compressors, record the DC voltage at the module input terminals (Sig to Grd) for pressure transducers and across the motor and discharge temperature thermister terminals. First take the reading with the compressor off and then running to verify thermister connection to the correct module.

Corresponding sensor output voltages should be similar for all compressors in a common suction group

	Verify Compressor Transducers				**Transducer Operation Reading Vdc**			**Thermister Reading Vdc**	
Compressor	Discharge	Oil	Suction	Comp	Discharge	Oil	Suction	Discharge	Motor
				OFF					
				ON					
				OFF					
				ON					
				OFF					
				ON					
				OFF					
				ON					
				OFF					
				ON					
				OFF					
				ON					
				OFF					
				ON					

Verify operation of all Compressor Solenoids

Compressor	Oil	Econ	De-Super	Motor Clg	Unloader	VI

*Oil, Economizer & Desuperheating Solenoid Valves - energized during compressor run; De-Energized with compressor OFF

*Motor Cooling - energized by module on call for motor or discharge temperature cooling

*Unloader and VI solenoids activated 30 seconds after start up then unloader is operated by controller and VI is controled by module.

Rack Operational Check Sheet

Rack:
Job Number:

TO BE FILLED OUT WHEN RACK OPERATION BEGINS TO STABALIZE

Compressor Transducer Readings (DCV)						
Compressor	Discharge	Oil	Suction	Motor Temperature	Discharge Temperature	
						After rack has stabalized, record the DC voltage at the module input terminals (Sig to Grd) for pressure transducers and across the motor and discharge temperature thermister terminals. Use the Engineering Unit conversion tables to convert voltages to pressures and temperatures and record below.

Compressor Operating Pressures and Temperatures (CONVERT TO ENGINEERING UNITS)						
Compressor	Discharge	Oil	Suction	Motor Temperature	Discharge Temperature	
						Discharge minus oil should be less than 45 psi. Module will alarm at 35 psi and cut out at 50 psi Oil minus suction should be greater than 45 psi. Module will cut out at at less than 45.

	OK
Oil Separator Charged to Proper Level (between 2nd & 3rd sight glass)	
High Pressure Switch (operation & setpoint)	
Low Pressure Swith (operation & setpoint)	