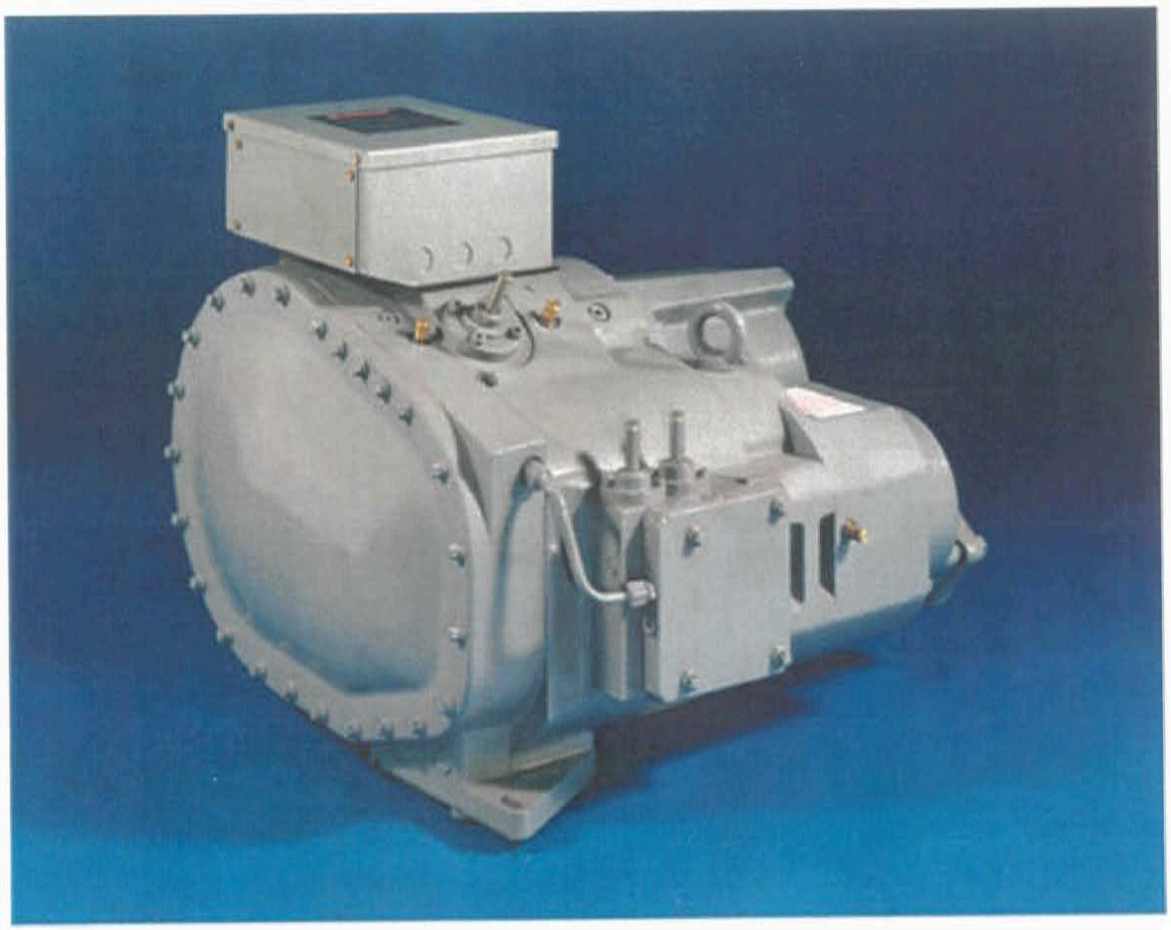
GTS104 Compressor Application Guide



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1. Introduction

The *GTS104* family of **G**eared **T**win **S**crew compressors utilize a common platform, **104**mm diameter drive rotor. The family includes six displacements from 123 cfm to 300 cfm at a 60Hz drive frequency. Nominal capacities range from 33 to 70 tons with R-134a at flooded chiller operating conditions. Optimized models are available for air cooled and water cooled condensers, as well as for economized and non-economized applications. All models are identical externally.

1.1 Scope

This application guide is intended to familiarize system designers with the *GTS104* screw compressor and to provide technical information necessary to assure safe and reliable compressor operation. Contact Carlyle Compressor Engineering for specific performance characteristics, troubleshooting assistance, and detailed service instructions.

1.2 Compressor Offerings

Six carefully selected displacements provide the *GTS104* family of compressors with five equivalent capacities for 50 and 60Hz power systems.

Nominal Capacity Air Cooled Condensing Non-Economized R-134a System			
60 Hz cfm	**Gear Ratio**	**50 Hz (tons)**	**60 Hz (tons)**
123	1.214	Not Available	33
146	1.466	33	40
174	1.782	40	49
209	2.145	49	57
250	2.557	57	70
300	3.094	70	Not Available

Water cooled condensing systems will typically develop 5-6% higher capacity. Systems with economizers will obtain 15% more capacity than a non-economized system. The actual capacity will change based on the system design and operating condition.

1.3 Standard Features

1.3.1 Discharge Check Valve

The discharge check valve is an axial movement type located within the compressor discharge muffler. The check valve is field serviceable by removing the muffler casing.

1.3.2 Discharge Muffler

A discharge muffler is integral to the design of the compressor. The muffler is included to reduce the amplitude of the discharge gas pressure pulsations. The muffler is a passive device which is also field serviceable.

1.3.3 Pressure Relief Valve

All of the *GTS104* screw compressors have an internal relief device which is designed to relieve pressure from the high side of the compressor to the low side when the pressure differential exceeds 27.6 bar (400 psid). The pressure relief valve is not field serviceable.

1.3.4 Oil Filter

The *GTS104* screw compressor has an oil filter integral in the compressor housing. This filter is field replaceable.

1.3.5 Oil Supply Solenoid Valve

An oil supply solenoid valve is standard on the compressor to isolate the compressor from oil flow when the compressor is not operating. The oil solenoid valve has an integral check valve to prevent backflow when replacing the internal oil filter element. The oil solenoid is field replaceable.

1.3.6 Suction & Economizer Screens

To increase the reliability of the compressor, a screen has been incorporated as a standard feature into suction and economizer inlets of the compressor.

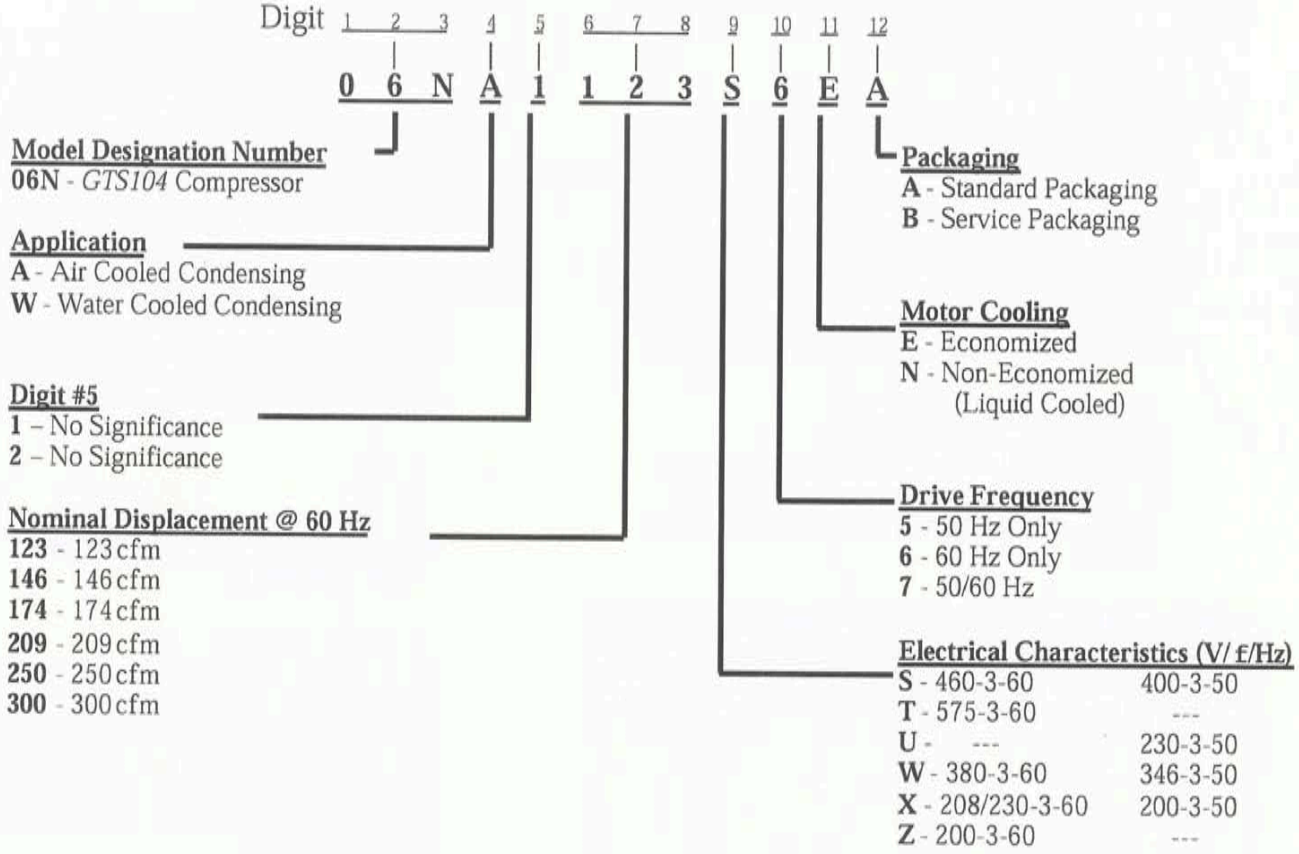
1.3.7 Unloading System

The *GTS104* screw compressor has an unloading system standard on all compressors. The unloading system consists of two steps of unloading that decrease the compressor capacity by rerouting partially compressed gas back to suction.

1.3.8 Reversible Terminal Box

The terminal box on the *GTS104* compressor is 180° reversible. This allows the power wiring to enter the box from either over the gear cover or over the motor casing. The compressor certified drawings show the standard orientation of the box.

1.4 Model Number Significance Chart



See Section 10.2 for valid model number configurations.

2. Refrigerants and Lubricants

2.1. Approved Refrigerants

The *GTS104* screw compressor is specifically designed for use in R-134a systems only.

2.2. Approved Lubricants

The *GTS104* screw compressor is approved for use with the following lubricants:

Carrier Material Spec	PP47-32
Approved Lubricant	Castrol SW220
Viscosity Grade	ISO 220
Carrier RCD Part #	
1 gallon	P903-1201
5 gallon	P903-1205

On occasion it may be necessary to use an assembly grease to retain an o-ring within its groove. The *GTS104* screw compressor is approved for use with the following assembly grease:

Carrier Material Spec	PP80-29
Approved Lubricant	Castrol Synplex GP2

3. Environmental and Installation Considerations

3.1 Operating Ambient

The screw compressor is designed to operate in the following ambient temperature ranges:

Non-Operating	-40°C(-40.0°F) to 82°C (180°F)
Operating	-32°C(-25.6°F) to 55°C (131°F)

3.2. Salt-Spray Requirements

The compressor and its accessories have been tested through 500 hours of salt-spray in compliance with ASTM specification B-117, (Carrier Engineering Requirement R-203).

4. Operating Limits & Controls

4.1 Operating Envelope

The following R-134a operating envelopes, Figures 4.1-1 and 4.1-2, show where the compressor can be operated in both direct expansion and flooded applications. The envelopes differ for the unique design configuration of the compressor. The fourth digit of the model number dictates the operating envelope.

Figure 4.1-1 06NA Compressor
Air-Cooled Condensing Operating Envelope

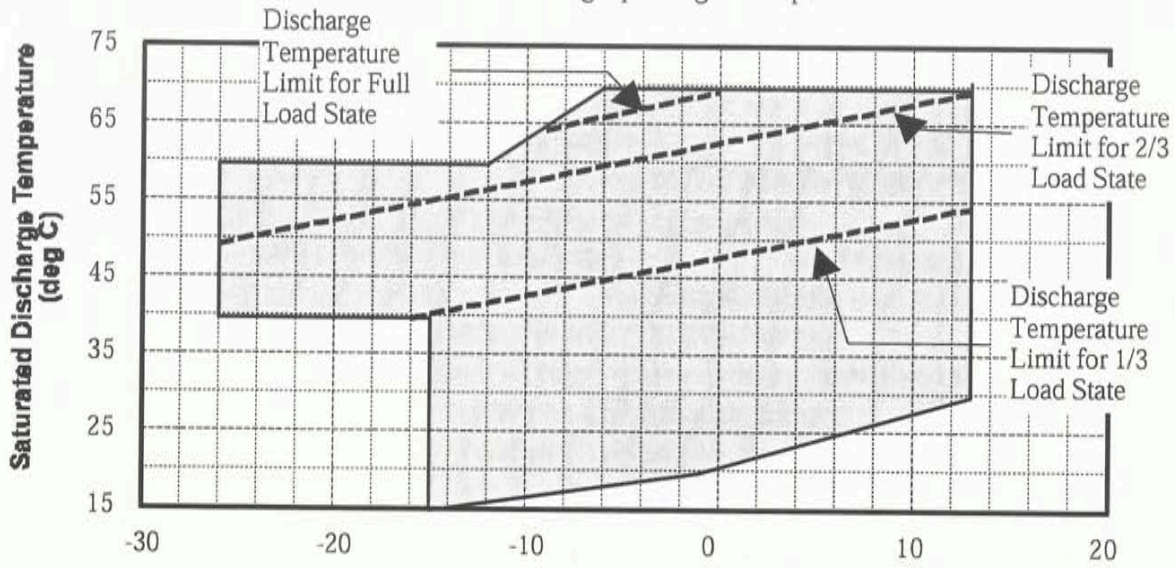
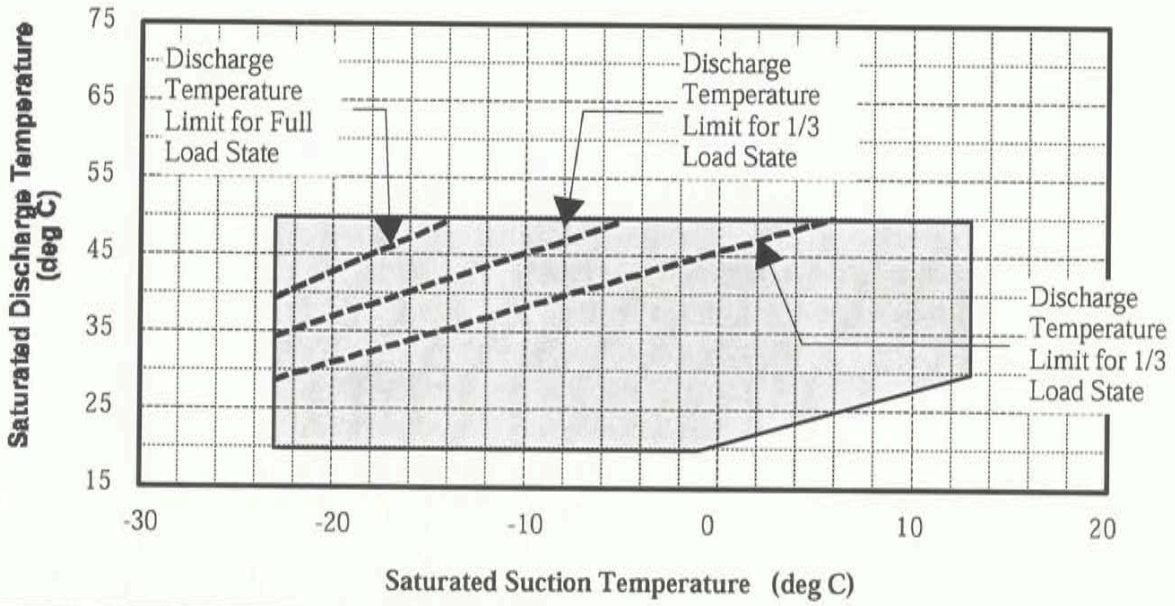


Figure 4.1-2 06NW Compressor
Water-Cooled Condensing Operating Envelope



Pressure limits are described in Section 8.

4.2 Temperature Limits

The following table is intended to show the range of control points allowable for the compressor operating on R-134a and Castrol SW-220 oil.

	Minimum	Maximum
Discharge Gas	11°C (20°F) *superheat*	99°C (210°F)
Economizer Gas	Saturated Liquid	5°C (10°F) *superheat*
Suction Gas	Saturated Vapor	See Section 5.5
Oil Supply at Compressor	See Section 5.7	99°C (210°F)
Motor Windings		
Nominal Running	*No limit*	93°C (200°F)
Must Not Exceed	*No limit*	118°C (244°F)

Section 5 lists different methods to control the operating pressures and temperatures, and Section 11 provides a complete list of the required safety protection.

4.3 Unloader Operation

All *GTS104* compressors come equipped with unloaders for three stages of operation - nominally 1/3, 2/3 and full load. The actual capacity reduction will depend on the system operating condition and rebalance characteristics.

Two solenoid actuated poppet-style unloaders accomplish unloading. These poppet valves either block or allow communication of a portion of the compression chamber with the suction plenum. The poppets are situated to permit gas to escape from the compression chamber just as it begins to decrease in volume and thus minimize any compression work being done on the gas.

The power head of the unloader pistons is at suction pressure in the de-energized, unloaded, state. Discharge pressure is applied to the power head to close the poppet valve when the solenoid is energized.

The compressor will start with minimum power draw in the fully unloaded (1/3 load) state - both solenoids de-energized. There is no minimum or maximum time limit immediately after startup for which the compressor must operate in the unloaded state. However, it is recommended that the compressor be operated at 1/3 load for 30 seconds just prior to shutdown. This will ensure the compressor is fully unloaded on the subsequent start.

If additional capacity is required, one or both of the unloader solenoids can be energized. The compressor is fully loaded when both solenoids are in the energized state. It is more efficient to obtain the 2/3 capacity step by having the high stage solenoid (the one located closer to the discharge end of the compressor) energized, and the low stage solenoid de-energized. If the control solenoids are reversed, the compressor will operate at approximately 1/2 full capacity but nearly full power.

Table 4.3-1 shows the proper control states for the unloader system.

Table 4.3-1
Unloader System Control States

	Full Load	2/3 Step	1/3 Step ***
Typical Capacity	100%	70%	45%
Typical Power	100%	85%	65%
High Stage Solenoid	Energized	Energized	De-Energized
Low Stage Solenoid	Energized	De-Energized	De-Energized

*** This is the required start-up position of the unloaders.

Note: *The solenoid coils used to control the unloaders are specified in Section 7.*

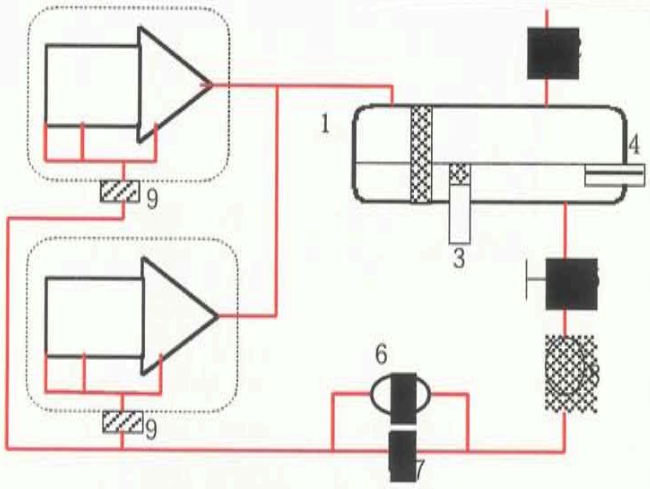
For a given operating condition, compressor discharge temperatures will be higher with the compressor running in an unloaded state than it would be for the fully loaded state. The operating limits described for full load operation must also be considered when operating in an unloaded state. The compressor can operate in the unloaded state over the entire operating envelope. Standard troubleshooting procedures should be followed in the event that a protective limit is exceeded.

4.4 Oil Supply Control

The *GTS104* screw contains an integral oil supply solenoid valve. The oil supply solenoid valve, shown in Figure 4.4-1, must open when the compressor is started. The control algorithm for the valve must know if the compressor is actually running. If it is not running, the valve must remain closed to avoid filling the compressor with oil. It is not recommended that the oil supply solenoid be controlled by using the auxiliary contacts of the compressor contactor. At shutdown, the oil supply solenoid must close immediately after power to the compressor is interrupted.

Figure 4.4-1 schematically shows the recommended oil supply system. The main components of the system are listed.

Figure 4.4-1
Oil System Schematic

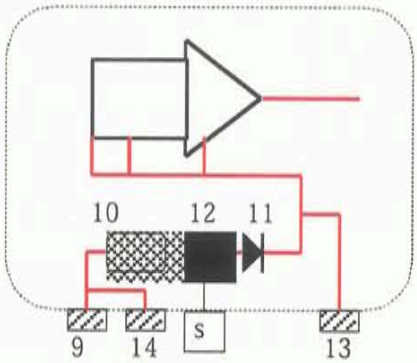


Oil Supply System

1. Oil Separator
2. Back Pressure Valve
3. Oil Level Switch
4. Oil Heater
5. Oil Filter Service Valve
6. Pre-Lube Oil Pump (with Integral Pressure Relief Valve)
7. Bypass Check Valve
8. Oil Filter
9. Oil Supply Fitting at Compressor

Once the oil enters the compressor it passes through a filter to remove any particulate contamination. Closing the service valve can isolate the oil pump, check valve, and filters. The oil filter check valve provides isolation downstream of these components.

Figure 4.4-2
Internal Oil Routing



9 Oil Supply Fitting
10. Oil Filter
11. Oil Filter Check Valve
12. Oil Supply Solenoid Valve
13. Oil Pressure Port
14. Oil Filter Service Port

4.4.1 Oil Pressure Requirements

There are two minimum oil pressure criteria that must be met for the *GTS104* compressor.

The first criteria is that the pressure differential between the oil galley pressure and the economizer pressure must satisfy the appropriate limit:

For 06NA compressors:

$$Poil - Pecon \geq \left\{ \begin{matrix} 0.7\text{bar} \\ 10\text{psid} \end{matrix} \right\} \text{for all Ps}$$

For 06NW compressors:

$$Poil - Pecon \geq \begin{cases} 0.7\text{bar} & \text{for Ps} \leq 2.3\text{ bar} \\ 10\text{psid} & \text{for Ps} \leq 35\text{ psia} \\ 0.1613 \times \text{Ps} + 0.300 & \text{for } 2.3 < \text{Ps} < 4.5\text{ bar} \\ 0.1613 \times \text{Ps} + 4.355 & \text{for } 35 < \text{Ps} < 66\text{ psia} \\ 1.0\text{bar} & \text{for Ps} \geq 4.5\text{ bar} \\ 15\text{psid} & \text{for Ps} \geq 66\text{ psia} \end{cases}$$

At low pressure differential operating conditions special system controls are required to maintain adequate oil supply to the compressor. A backpressure valve is shown in Figure 4.4-1 for this purpose.

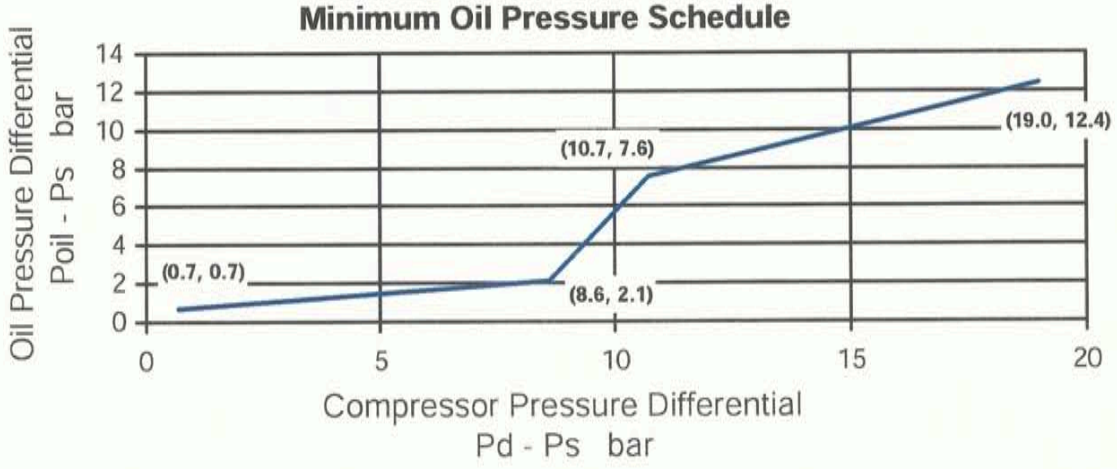
The second criterion is that the oil pressure must satisfy the minimum oil pressure schedule shown in Figure 4.4.1-1. The minimum pressure requirement changes as a function of the operating condition.

The unit control system must monitor oil pressure differential as well as the operating condition and be able to shutdown the compressor if the minimum requirement is not met for any duration exceeding 15 seconds. This time delay has two functions: The first is to avoid nuisance tripping during normal and transient operation. The second is to allow the system sufficient time to develop pressure differential during start-up.

A control override can be implemented to minimize the opportunity of nuisance tripping on low oil pressure safeties. Compressor suction pressure can be throttled to increase the differential between the oil galley pressure and either economizer or suction pressure.

The compressor must be shutdown and prevented from restarting when the low oil pressure safety is tripped. The safety should be a manual reset type that locks out compressor operation until the system is serviced.

Figure 4.4.1-1
Minimum Oil Pressure Schedule



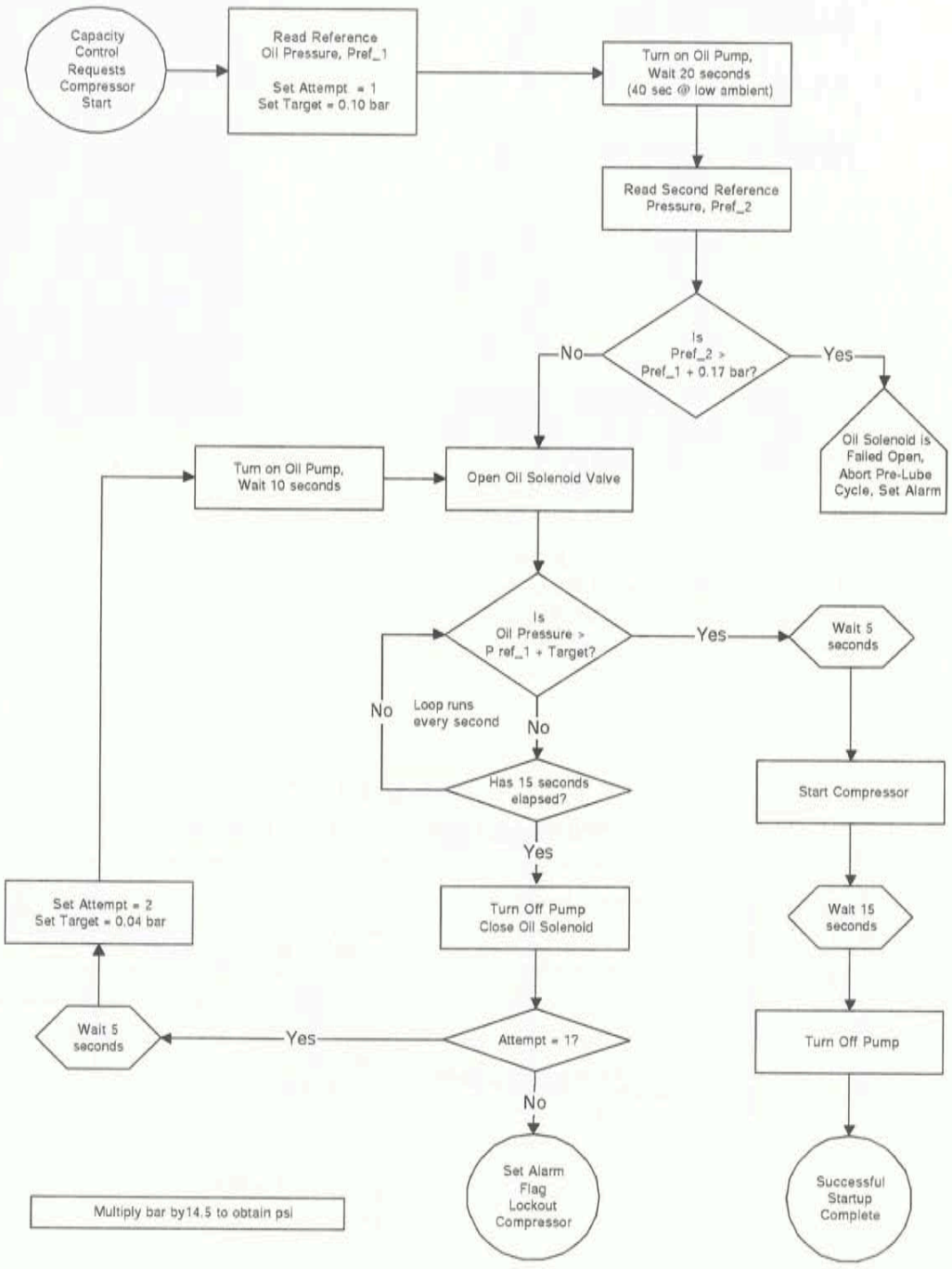
Multiply bar by 14.5 to obtain psi

4.4.2 Pre-Lube Pump & Oil Solenoid Valve Control

A pre-lube oil pump is required in the oil circuit to provide lubrication to the bearings prior to start-up of the compressor.

A pre-lube cycle must be initiated each time a compressor is started. Figure 4.4.2-1 shows the recommended pre-lube cycle control sequence to be followed when starting a compressor.

Figure 4.4.2-1
Pre-Lube Cycle Flowchart



4.5 Compressor Rotation Control

Correct compressor rotation is one of the most critical application considerations. Powered reverse rotation, even for a very short duration, can seriously affect the reliability of the compressor.

The reverse rotation protection scheme must be capable of determining the direction of rotation and stopping the compressor within 300 milliseconds.

Reverse rotation is most likely to occur whenever the wiring to the compressor terminals is disturbed.

To minimize the opportunity for reverse rotation, Carlyle recommends the following procedures:

1) During factory run test of the chiller, a low-pressure switch should be temporarily installed as a hard safety on the high-pressure port of the compressor. The purpose of this switch is to protect the compressor against any wiring errors at the compressor terminal pins. The electrical contacts of the switch should be wired between the CPM and the compressor high-pressure switch. This switch should remain in place for the duration of the run test. At the end of the run test the switch should be removed so that it could be used on the next chiller/compressor to be tested.

2) For service replacement compressors, a similar protection system is recommended. All service compressors should have a low-pressure switch included with the compressor. The chiller service literature should make reference to this switch and provide instructions on how to temporarily install the low-pressure switch into the safety chain for the compressor. Each service compressor should be supplied with Installation Instructions documenting the procedure for installing and using the switch. The switch should remain in place until the compressor has been started and direction of rotation has been verified, at this point the switch should be removed and discarded.

The switch that has been selected for detecting reverse rotation is specified on Carrier Purchased Part Specification HK01CB001. This switch opens the contacts when the pressure falls below 50.8mm (2 inches) of vacuum. The switch is a manual reset type that can be reset after the pressure has once again risen above 1.7 bar (25 psia). It is critical that the switch be a manual reset type to preclude the compressor from short cycling in the reverse direction. This switch is also used on the GTS74 screw compressor to detect reverse rotation.

5. Recommended Control Strategies

This section describes the methods of system control currently approved by Carlyle Application Engineering for use with the *GTS104* screw compressor. Customers wishing to use alternate methods not described here should contact Carlyle Engineering. Additional methods of control will be included as they are evaluated and approved.

THE USE OF UNAPPROVED CONTROL PRACTICES COULD INVALIDATE THE COMPRESSOR WARRANTY.

5.1 Head Pressure Control

Head pressure control is not required with the *GTS104* screw compressor as long as the minimum oil pressure requirements are satisfied.

5.2 Suction Pressure Control

The saturated suction temperature is limited to a maximum of 12.8°C (55°F). Maximum Operating Pressure controls (MOP) must limit the suction pressure to avoid overloading the motor.

The most desirable means of limiting suction pressure is to throttle the amount of refrigerant fed to the low side of the system when the pressure approaches the limit. The flow can be throttled with an active expansion device. Throttling the liquid refrigerant flow can allow the compressor to remain operating at full load.

When the compressor is applied in a system without an active refrigerant expansion device able to perform MOP control, the compressor should be unloaded, using the poppet unloaders, to keep the compressor on-line during high suction pressure operation.

5.3 Economizer Pressure / Flow Control

The economizer pressure will be allowed to float with the system/compressor operating conditions and the motor winding temperature control. The compressor does not require any active control for the economizer pressure.

In multiplexed applications, the system controls and piping must be designed such that any compressor can be isolated from economizer flow when it is not operating. This will prevent any logging of oil or refrigerant in the motor casing during off cycles.

5.4 Discharge Gas Temperature Control

Discharge gas temperature control is required on applications where the temperature can exceed 99°C (210°F). The discharge temperature limit is necessary for both oil temperature control and to limit the thermal growth of the internal components of the compressor.

The operating envelopes in Figures 4.1-1 and 4.1-2 show approximately where discharge temperature control will be required for all loading states of the air and water-cooled compressors. These values are based on zero degrees of suction superheat. Higher superheat will result in a more restricted operating range. These values are included to provide an indication as to whether or not liquid injection algorithms may be required. *System testing must be performed to verify whether or not discharge temperature control is required.*

The recommended method of providing discharge gas temperature control is to inject liquid refrigerant into the economizer port. By using this control scheme, one valve can be used to inject liquid refrigerant either for motor cooling or for discharge temperature suppression. Figures 5.8-1 and 5.8-2 show the system schematic for motor cooling and discharge temperature control.

A protective limit of 104°C (220°F) is the shutdown limit for discharge temperature.

5.5 Suction Gas Temperature Control

Control of the return gas temperature for the *GTS104* screw compressor is no different than other compressors, screw or reciprocating. The application of screw compressors is much more forgiving in the area of liquid floodback to the compressor.

As specified in the temperature limits in Section 4.2, continuous floodback to the compressor should be avoided since it can lead to mechanical damage. The return gas temperature can be allowed to float over a wide range as long as the discharge gas temperature limit is not exceeded.

The conventional means of suction gas temperature control, thermostatic and electronic expansion devices for example, are approved by Carlyle Engineering as acceptable methods of control.

In flooded applications, liquid level in the cooler will determine the return gas temperature. Float actuated valves are acceptable means of cooler level control.

5.6 Economizer Return Gas Control

The economizer gas is used to cool the compressor motor. The temperature/quality of the economizer return gas must be controlled in order to maintain the proper motor winding temperature as described in Section 5.8.

5.7 Oil Temperature Control

Oil temperature control is critical in order to maintain adequate lubricant viscosity. The rolling element bearings in the *GTS104* screw compressor require a minimum oil viscosity of 6 cSt. An oil cooler is required on applications where the oil viscosity falls below this limit. Section 7.3 describes the requirements for oil coolers.

5.7.1 On-cycle Control

Systems that use the recommended oil and satisfy the discharge gas temperature limits will not require oil temperature control.

5.7.2 Off-cycle Control

During periods when the compressor is not running, system design precautions should preclude the possibility of liquid refrigerant accumulating in the oil separator. This can be accomplished by heating the oil reservoir to drive refrigerant out of the oil, and by piping the refrigerant lines such that liquid cannot freely drain from the condenser back to the oil separator. In applications where refrigerant can freely drain back to the oil reservoir, the minimum oil temperature should be maintained 17°C (30°F) above ambient temperature.

5.8 Motor Winding Temperature Control

The maximum continuous operating motor winding temperature is 93°C (200°F). Economizer return gas with low superheat [approximately 5°C (10°F)] should provide sufficient cooling for most compressors at most operating conditions. At more severe operating conditions, the refrigerant entering the motor will have to run "wet", either saturated or a two-phase quality.

Figure 5.8-1 shows a refrigerant flow schematic for a single compressor system with an economizer and supplemental liquid injection. Figure 5.8-2 shows the recommended motor cooling scheme for non-economized systems.

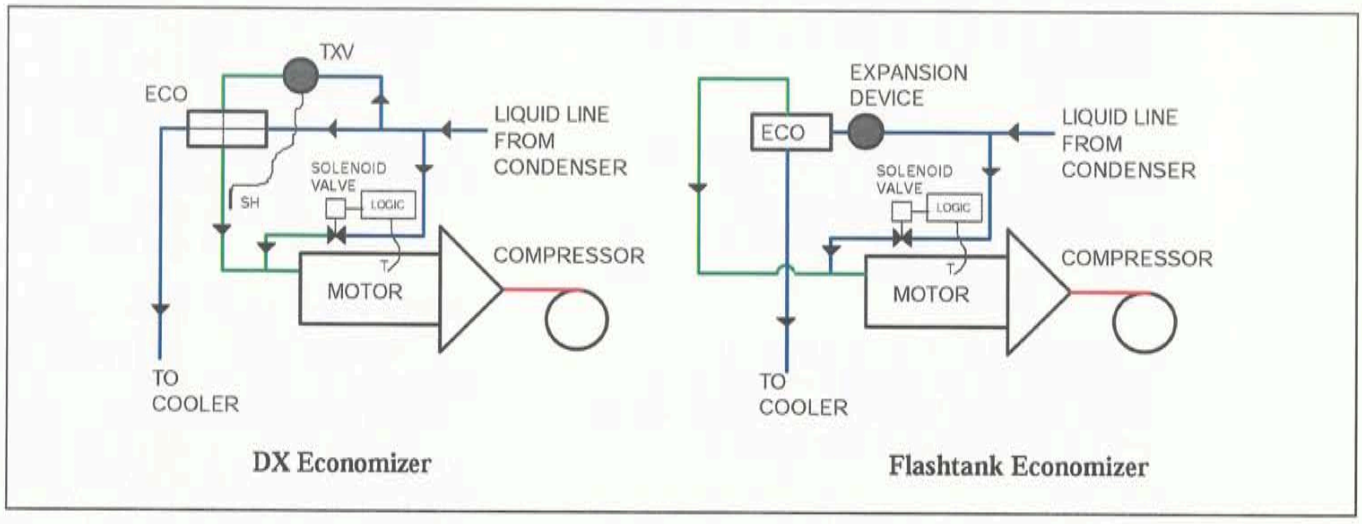
The unit control system should contain a control algorithm that monitors the motor winding temperature, and modulates the liquid refrigerant flow as necessary to maintain acceptable motor temperatures.

The motor winding temperature is measured via a thermistor embedded directly in the motor windings. Section 10 provides details of the thermistor.

A protective limit of 118°C (245°F) is the shutdown limit for the motor winding temperature.

Figure 5.8-1

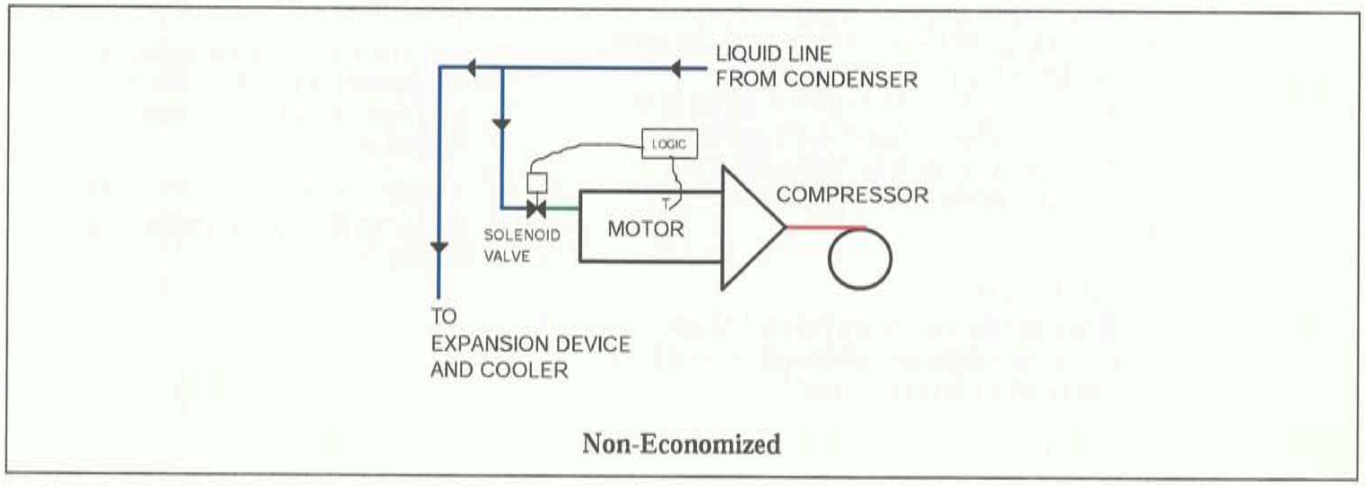
Motor Cooling Control Schematic
for Economized Systems



In the DX economizer schematic, the expansion device is configured to provide economizer gas to the motor with 2-5°C (5-10°F) superheat. In the flashtank economizer system, the economizer will provide saturated vapor to the motor. In either case, supplemental liquid refrigerant may be required to provide additional cooling as dictated by the motor winding temperature.

Figure 5.8-2

Motor Cooling Control Schematic
for Non-Economized Systems



In the non-economized schematic, a solenoid valve is used to inject liquid refrigerant into the motor casing to provide motor cooling. The solenoid valve is cycled as necessary to maintain nominal motor winding temperatures.

6. Vortex Oil Separators

6.1 Discharge Line Sizing

The inlet piping to the 8" vortex separator should be sized to maintain sufficient velocity at minimum load conditions of the circuit. The gas velocity at minimum load should be maintained at 6.1 meters per second (20 fps). With this line size, a check should be made at the full load condition; velocities at full load should be limited to 22.9 meters per second (75 fps) to avoid excessive pressure drop across the separator. If the application will operate outside of these limits, consult Carlyle Application Engineering for additional recommendations.

6.2 System Oil Charge

Oil separator performance can be significantly impacted by system induced transients. There are several minor adjustments that can be made to the oil system to make it more robust in terms of handling these transient conditions.

Provided that the separator is installed with properly sized lines, the most likely causes of poor oil separation are excessive liquid carry-over through the discharge of the compressor or excessive oil charge in the system. Either transient will manifest itself in a similar manner.

The oil separator contains a baffle plate that divides the separation chamber from the oil storage sump area. If the oil in the sump area rises above the level of the baffle plate the separator will no longer be able to separate effectively because the separated oil has nowhere to drain. Excessive liquid carry-over from the compressor(s) can cause this since the liquid refrigerant will also be separated and drained into the sump area. It will be absorbed into the oil causing the volume of oil to expand. Likewise, if the system is over charged with oil, the volume of oil alone can cause the level to rise past the baffle plate.

It is recommended that all systems using the vortex style separators install an external oil sump in conjunction with the separator.

6.3 External Oil Sump

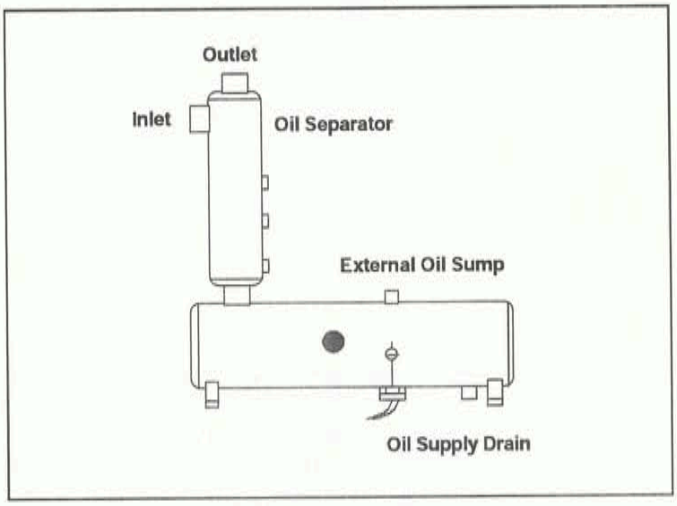
Applying the external oil sump is rather simple at normal design and operating conditions, but requires some caution to avoid problems. During transients, any outgassed refrigerant should free-vent back to the separator.

The external sump, conceptually shown below, will provide over 14 gallons of oil storage capacity. However, filling the reservoir to this level would leave any free surface for refrigerant to outgas from the oil. The sump should not be filled more than 50% which leaves room for the oil level to grow during outgassing transients.

The large connection between the separator and sump allow any outgassed refrigerant in the sump to be directly vented back to the oil separator. Figure 6.3-1 shows the separator/sump configuration.

Figure 6.3-1

Oil Separator & Sump Schematic



6.4 Vortex Oil Separator Hardware

The oil separation hardware discussed throughout this section is available as Carlyle part numbers KH 31YA 347 and KH 31MZ 150 for the separator and sump, respectively.

7. Compressor Accessories

7.1 Oil Level Switch

The recommended oil level switch is a float style switch. This switch is normally open when no oil level exists. An adequate oil level is required to raise the float along the stem and close the contacts.

Additional details on this switch are available on the Carrier purchased part specifications HK13ZB001 and HK13ZB002.

Fluctuations in discharge pressure of the machine can cause outgassing of refrigerant within the oil sump that creates foam in the oil sump. Depending on the severity of the transient, the foam can cause a nuisance trip on low oil level. Control system design should take this into consideration and delay compressor shutdown until the low oil level reading can be verified. The verification time should not exceed ten seconds.

7.2 Oil Sump Heater

An oil sump heater is recommended to prevent oil dilution during times when the refrigerant circuit is not in operation. The oil heater must be sized to maintain the minimum oil temperature in the lowest allowable starting ambient. However, the watt density of the heater must not be so high that the local oil heating around the element raises the oil temperature above the specified maximum. See Section 4 for temperature limits.

7.3 Oil Cooler

An oil cooler is required where the oil viscosity will be less than 6 centistokes. The oil cooler should be sized to provide sufficient heat rejection to meet this viscosity requirement. Compressor oil flow rates depend on the operating condition, but can be estimated as 0.25 liters/second (4.0 gpm) for the purpose of sizing an oil cooler.

7.4 Integral Oil Filter

The integral oil filter in the *GTS104* screw compressors is specified to provide a high level of filtration required for long bearing life. System cleanliness is critical to reliable system operation, however, the integral oil filter should not be counted on as the device which cleans out manufacturing debris.

The replacement filter element part number is:

Carlyle part number:	8TB0320
Parker part number:	932777Q

An alternate filter element is:

Carrier part number:	KH 39MG 001
Parker part number:	931984

Both elements provide similar filtration, rated as $\beta_3 < 20$. However, it may be more difficult to remove the KH 39MG 001 element from the compressor since it does not have a removal ring.

It is recommended to change the o-ring on the cover plug any time that the filter cavity is opened. The replacement part numbers for the o-ring are:

Carrier part number:	8TB0847

The oil filter will require replacement if it becomes plugged with dirt and other contaminants from the system. Including a coarser filter in the oil line upstream of the integral filter can extend the service life of the integral oil filter. This filter should be sized based on the individual system requirements.

7.4.1 Filter Change-Out Schedule

The filter should be checked after the first 1000 hours of operation, and every subsequent 4000 hours. **The filter should be replaced at any time when the pressure differential across the filter exceeds 2.1 bar, (30 psid).**

The pressure drop across the filter can be determined by measuring the pressure at the filter service port and the oil pressure port. The difference in these two pressures will be the pressure drop across the filter, check valve, and solenoid valve. The pressure drop across the check valve and solenoid valve is approximately 0.6 bar (8 psid), which should be subtracted from the two oil pressure measurements to give the oil filter pressure drop. The oil filter pressure drop should be checked after any occasion that the compressor is shutdown due to low oil pressure safety.

7.4.2 Filter Change-Out Procedure

The following steps outline the proper method of changing the integral oil filter.

1) Shutdown and lockout the compressor.
2) Close the oil filter service valve. Bleed pressure from the filter cavity through the filter service port.
3) Remove the oil filter plug. Remove the old oil filter using only a pulling motion; *the filter is never to be turned in a counter-clockwise rotation.* If twisting is necessary, it must be done in the *clockwise* direction. This, along with the Service Instructions for oil filter replacement, provided in the 30GX/HX service literature, must be followed for safe filter replacement.
4) Replace the o-ring on the filter plug by sliding it over the backside of the plug.
5) Prior to installing the new oil filter, "wet" the o-ring with oil. Install the filter and replace the plug.
6) Evacuate the filter cavity through the filter service port. Open the filter service valve. Remove any compressor lockout devices. The compressor is ready to return to operation.

7.5 Flanges, O-Rings, & Inlet Screens

Table 7.5-1 shows the flange, o-ring, and inlet screen specifications for the compressor connections.

7.6 Solenoid Coils

Solenoid coils are used to actuate the unloader and oil supply solenoid valves. These coils are shown below in Table 7.6-1 according to coil voltage.

Table 7.5-1
Flange, O-Ring & Inlet Screen Part Numbers

	Suction	Discharge		Motor Cooling
	Flanges			
Carrier P/N	Custom	EP 29ZC 570	EP 29VC 601	DK 24CA 727
Vendor	Design for	Henry		Mueller
Vendor P/N	Application	M583A-19-2	R491-10	F-34742
	O-Rings			
Carrier P/N	8TB0677	8TB0285		8TB0415
Vendor	Parker	Parker		Parker
Vendor P/N	2-354	2-234		2-223
	Inlet Screen			
Carrier P/N	2TB0773	---		8TB0676

Table 7.6-1
Solenoid Coil Part Number Specifications

Part Number	Electrical Characteristics		Watts	Inrush VA	Termination
06DA401834	24V	DC	15	---	With Leads
EF 19ZE 024	24V	50/60	12	28.8/24.0	With Leads
EF 19ZE 120	120V	50/60	12	30.0/22.8	With Leads
EF 19ZE 240	240V	50/60	12	38.4/31.2	With Leads

Other coils that meet the form and function of these coils may also be used.

7.7 Mating Electrical Connections

The terminal pin connections for the *GTS104* compressor are M12 metric thread. Electrical hardware for making the power connections is standard with each compressor in the Jumper Bar Accessory Kit, part number 0TB0673. Refer to the Compressor Application Drawing, 0TB0410, for torque specifications, and the proper installation of the power terminal hardware for both the Delta start-Delta run configuration (Across the Line), and the Wye start-Delta Run configuration.

The motor winding thermistor connections are 1/4" spade terminals.

7.8 Oil Supply Solenoid Valve

The oil supply solenoid valve is required to isolate the compressor from oil flow when the compressor is not operating. The oil supply solenoid valve is field replaceable; the replacement part number is 8TB0884.

7.9 Unloader Solenoid Valves

The unloader solenoid valves are required to actuate the poppet unloaders of the compressor. The unloader solenoid valves are field replaceable; the replacement part number is 8TA0049D.

7.10 Compressor Protection Module

The compressor protection modules (CPM) are set-up in the Carrier Purchased Parts system as part numbers HN 67LM 100 and HN 67LM 101.

7.11 External Muffler

An external muffler is available, Carlyle part number 2TB0646, and can be piped into the discharge line of the compressor that will further reduce the discharge gas pressure pulsations leaving the compressor. The addition of the external muffler will reduce radiated noise levels from other system components that can be excited by the gas pulsations. Sound treatment is recommended on the discharge line between the compressor and the muffler.

The muffler can be included into horizontal and vertically flowing pipes, without respect to any particular orientation. The sound reduction material in the muffler will absorb approximately 2 liters (0.5 gallon) of oil that should be taken into account when the system oil charge is calculated. The maximum working pressure for the muffler is 31 bar (450 psig).

8. Code Agency Certification

The *GTS104* compressor is recognized under UL File SA4936 and the CE low Voltage Directive 73/23/CEE Test Reports 06N-S-1, 06N-T-1, 06N-U-1, 06N-W-1, 06N-X-1, and 06Z-S-1.

8.1 Electrical Connection Requirements

8.1.1 Power Connections

The compressor terminal pins are copper pins with 12mm metric threads. Power wires are connected to the terminal pins using ring terminals, jam nuts, and jumper bars in some applications. The power connection system is designed for nominal line voltages up to 575 volts. A wiring schematic is provided on the label inside each terminal box cover. The *GTS104* compressor is approved for use with Across-the-Line, and Open and Closed Transition Wye-Delta applications. Tables 8.1.1-1 and 8.1.1-2 describe the wiring configurations for Across-the-Line and Wye-Delta applications.

The motor temperature thermistors and a separate 6mm grounding lug connection are located in the terminal pin area.

Table 8.1.1-1

Wiring Connections
Delta Connected Start

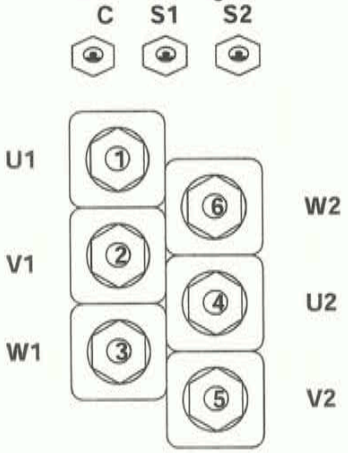
XL-Connected Start, D-Connected Run				
Connection	L1	L2	L3	Tie Together
Start (Δ)	1, 6 (U1,W2)	2, 4 (V1,U2)	3, 5 (W1,V2)	---
Run (Δ) *(same as Start)*	1, 6 (U1,W2)	2, 4 (V1,U2)	3, 5 (W1,V2)	---

Table 8.1.1-2

Wiring Connections
Open Transition Y-D Start

Y-Connected Start, D-Connected Run				
Connection	L1	L2	L3	Tie Together
Start (Y) *(5 second duration)*	1 (U1)	2 (V1)	3 (W1)	4, 5, 6 (U2,V2,W2)
Run (Δ)	1, 6 (U1,W2)	2, 4 (V1,U2)	3, 5 (W1,V2)	---

Figure 8.1.1-1
Terminal Pin Layout



8.1.2 Wye-Delta Starting

There are two critical timing parameters associated with starting the GTS104 compressor with an open transition Wye-Delta starter. The first is the maximum duration of running in the wye connection. It is recommended that the duration of the wye connection be 5 seconds. The duration of the wye connection can be longer but in any case should not exceed 10 seconds. This is necessary to limit the potential for excessive heating of the motor.
The second critical timing parameter is the duration of the power interruption from when the wye connection is broken to when the delta connection is made. It is recommended that the duration of this interruption not exceed 49 milliseconds. Starter selections should be made such that this limit is not exceeded. Longer interruption times could lead to excessive deceleration during the power interruption. Low running speed at transition will result in inrush currents similar to the delta locked rotor current.

8.1.3 Terminal Box

The terminal box is designed in accordance with UL 984, UL 1995, CSA, for the North American market, IEC 529, and EN 60204; IP 43, and IP 54 for the European market.

8.2 Pressure Requirements

8.2.1 Hydrostatic Design Pressures

The design pressure for the compressor castings is listed in Table 8.2.1-1.

Table 8.2.1-1

	Discharge	Economizer	Suction
Hydrostatic Burst Test Pressure (BURST)	17.3 MPa 2500 psig	6.9 MPa 986 psig	6.9 MPa 986 psig
Proof Test Pressure (TP)	3.3 MPa 460 psig		
Maximum Operating Pressure (MOP)	2.1 MPa 292 psig	1.3 MPa 176 psig	0.45 MPa 52 psig
Leak Test Pressure (AP)	2.2 MPa 310 psig		
Design Pressure (DP)	2.1 MPa 292 psig	1.3 MPa 176 psig	1.3 MPa 176 psig

The pressure data reported in the table are gage pressures in psig and absolute pressures in MPa.

8.2.2 Pressure Relief Valve

All compressors have an internal relief valve (from discharge to suction) designed to the ASME and UL pressure safety codes.

The internal relief valve is designed to open when the pressure differential between suction and discharge pressure is greater than 27.6 bar, (400 psid). The valve will close and seal again after the pressure difference falls below the set value.

9. Packaging and Storage Requirements

9.1. Packaging

Packaging for the *GTS104* screw compressor consists of a returnable plastic container and a plastic wood insert to position the compressor inside the container. The compressor is attached to the insert by two bolts. One bolt attaches the compressor through a hole in the suction blank-off plate, and another bolt fastens the compressor at the end of the motor casing through a bracket that is attached to the motor casing.

The bracket is a permanent part of the compressor installed on the compressor prior to the painting process. **THIS BRACKET MUST REMAIN ATTACHED TO THE COMPRESSOR.** Failure to do so could jeopardize the corrosion resistance of the compressor.

9.2. Shipping

All compressors that are shipped within the U.S. will be unstacked (single layer). Compressors that are intended for international shipment may be stacked depending upon the mode of shipment. Any compressors that will be stacked during shipping will require special packaging consideration. Consult Carlyle Compressor for these requirements.

The stacking limit for shipping is two high.

Compressor weights are shown in Table 9.2-1.

9.3. Storage

The compressor packaging allows for stacking of the compressors during storage.

The stacking limit for storage is three high.

Although the *GTS104* compressors are painted in order to meet the 500 hours salt spray requirements, it is preferable to store the compressors indoors where they are shielded from the weather. Outdoor storage is also permissible.

Table 9.2-1
Compressor Weights

Compressor Model Number	Compressor Weight lb.	Compressor Weight kg.	Shipping Weight lb.	Shipping Weight kg.
Economized				
06NA-123--E-	835	380	955	435
06NA-146--E-	855	390	975	445
06NA-174--E-	880	400	1000	455
06NA-209--E-	895	405	1015	460
06NA-250--E-	910	415	1030	470
06NA-300--E-	920	415	1040	475
06NW-146--E-	805	365	925	420
06NW-174--E-	825	375	945	430
06NW-209--E-	835	380	955	435
06NW-250--E-	855	390	975	445
06NW-300--E-	880	400	1000	455
Non-Economized				
06NA-123--N-	825	375	945	430
06NA-146--N-	835	380	955	435
06NA-174--N-	855	390	975	445
06NA-209--N-	880	400	1000	455
06NA-250--N-	895	405	1015	460
06NA-300--N-	910	415	1030	470
06NW-123--N-	795	360	915	415
06NW-146--N-	795	360	915	415
06NW-174--N-	805	365	925	420
06NW-209--N-	825	375	945	430
06NW-250--N-	835	380	955	435
06NW-300--N-	855	390	975	445

The compressor weight is without packaging. The shipping weight includes the weight of the compressor, returnable packaging, and cover plates.

10. Compressor Electrical Data

10.1 Allowable Voltage Ranges

The motors for the *GTS104* compressors are designed to be applied within voltage range listed on the table below. Operation outside these ranges is not permitted.

Table 10.1-1
Allowable Voltage Range

Model # 9th Digit	60 Hz Voltages Nominal	Min	Max	50 Hz Voltages Nominal	Min	Max
S	460	396	528	400	342	456
T	575	495	660			
U				230	196	264
W	380	324	483	346	288	396
X	208/230	187	264	200	180	230
Z	200	180	230			

10.2 Electrical Data

Table 10.2-1
06NA Compressor Motor Data
Air-Cooled Condensing, Economized

Compressor Model Number	Compressor Electrical Data Nominal Voltage/Freq.	RLA	PF	Locked Rotor Amps LRA (Y)	LRA (D)
123 cfm, Air-Cooled Vi, Economized					
06NA*123S6EA	460-60	85.9	.84	183	580
06NA*123T6EA	575-60	68.8	.84	147	484
06NA*123W6EA	380-60	104.0	.84	203	641
06NA*123X6EA	208/230-60	180.5	.84	367	1160
06NA*123Z6EA	200-60	197.7	.84	422	1334
146 cfm, Air-Cooled Vi, Economized					
06NA*146S7EA	460-60 400-50	103.4 101.7	.85 .82	216 226	685 715
06NA*146T6EA	575-60	82.7	.85	173	548
06NA*146U5EA	230-50	176.8	.82	361	1142
06NA*146W7EA	380-60 346-50	125.2 117.5	.85 .82	239 248	757 786
06NA*146X7EA	208/230-60 200-50	217.2 203.3	.85 .82	433 452	1370 1430
06NA*146Z6EA	200-60	237.8	.85	498	1576

Compressor Model Number	Nominal Voltage/Freq.	RLA	PF	Locked Rotor Amps LRA (Y)	LRA (D)
174 cfm, Air-Cooled Vi, Economized					
06NA*174S7EA	460-60 400-50	125.0 123.1	.86 .83	259 270	820 856
06NA*174T6EA	575-60	100.0	.86	207	656
06NA*174U5EA	230-50	214.1	.83	432	1367
06NA*174W7EA	380-60 346-50	151.3 142.3	.86 .83	286 297	906 941
06NA*174X7EA	208/230-60 200-50	262.6 246.2	.86 .83	518 541	1640 1711
06NA*174Z6EA	200-60	287.5	.86	596	1886
209 cfm, Air-Cooled Vi, Economized					
06NA*209S7EA	460-60 400-50	152.0 147.4	.87 .84	291 303	920 960
06NA*209T6EA	575-60	121.6	.87	233	736
06NA*209U5EA	230-50	256.4	.84	485	1533
06NA*209W7EA	380-60 346-50	184.0 170.4	.87 .84	321 334	1017 1056
06NA*209X7EA	208/230-60 200-50	319.2 294.8	.87 .84	581 607	1840 1920
06NA*209Z6EA	200-60	349.6	.87	669	2116
250 cfm, Air-Cooled Vi, Economized					
06NA*250S7EA	460-60 400-50	185.3 178.8	.85 .82	371 387	1175 1226
06NA*250T6EA	575-60	148.3	.85	297	940
06NA*250U5EA	230-50	310.9	.82	619	1958
06NA*250W7EA	380-60 346-50	224.3 206.7	.85 .82	410 426	1299 1348
06NA*250X7EA	208/230-60 200-50	389.3 357.5	.85 .82	743 775	2350 2452
06NA*250Z6EA	200-60	426.3	.85	854	2703
300 cfm, Air-Cooled Vi, Economized					
06NA*300S5EA	400-50	221.8	.86	400	1265
06NA*300U5EA	230-50	385.8	.86	638	2020
06NA*300W5EA	346-50	256.4	.86	439	1391
06NA*300X5EA	200-50	443.7	.86	799	2529

Table 10.2-2
06NW Compressor Motor Data
Water-Cooled Condensing, Economized

Compressor Model Number	Compressor Electrical Data Nominal Voltage/Freq.	RLA	PF	Locked Rotor Amps LRA (Y)	LRA (D)
123 cfm, Water-Cooled Vi, Economized					
Model Not Available Use as Equal Alternate 06NW*123*6NA 123 cfm, Water-Cooled Vi, Non-Economized					
146 cfm, Water-Cooled Vi, Economized					
06NW*146S7EA	460-60 400-50	68.2 67.1	.86 .84	128 134	405 423
06NW*146T6EA	575-60	54.6	.86	102	324
06NW*146U5EA	230-50	116.7	.84	213	675
06NW*146W7EA	380-60 346-50	82.6 77.6	.86 .84	141 147	448 465
06NW*146X7EA	208/230-60 200-50	143.3 134.2	.86 .84	256 267	810 845
06NW*146Z6EA	200-60	156.9	.86	294	932
174 cfm, Water-Cooled Vi, Economized					
06NW*174S7EA	460-60 400-50	83.4 81.5	.87 .85	153 160	485 506
06NW*174T6EA	575-60	66.7	.87	123	388
06NW*174U5EA	230-50	141.7	.85	255	808
06NW*174W7EA	380-60 346-50	100.9 94.2	.87 .85	169 176	536 556
06NW*174X7EA	208/230-60 200-50	175.1 162.9	.87 .85	307 320	970 1012
06NW*174Z6EA	200-60	191.8	.87	352	1116

Compressor Model Number	Nominal Voltage/Freq.	RLA	PF	Locked Rotor Amps LRA (Y)	LRA (D)
209 cfm, Water-Cooled Vi, Economized					
06NW*209S7EA	460-60 400-50	100.8 98.2	.88 .86	183 191	580 605
06NW*209T6EA	575-60	80.6	.88	147	484
06NW*209U5EA	230-50	170.9	.86	305	967
06NW209W7EA	380-60 346-50	122.0 113.6	.88 .86	203 210	641 665
06NW*209X7EA	208/230-60 200-50	211.8 196.5	.88 .86	367 382	1160 1210
06NW*209Z6EA	200-60	231.9	.88	422	1334
250 cfm, Water-Cooled Vi, Economized					
06NW*250S7EA	460-60 400-50	120.7 117.9	.88 .86	216 226	685 715
06NW*250T6EA	575-60	96.6	.88	173	548
06NW*250U5EA	230-50	205.0	.86	361	1142
06NW*250W7EA	380-60 346-50	146.1 136.6	.88 .86	239 248	757 786
06NW*250X7EA	208/230-60 200-50	253.6 235.7	.88 .86	433 452	1370 1430
06NW*250Z6EA	200-60	277.7	.88	498	1576
300 cfm, Water-Cooled Vi, Economized					
06NW*300S5EA	400-50	143.3	.87	270	856
06NW*300U5EA	230-50	249.2	.87	432	1367
06NW*300W5EA	346-50	165.7	.87	297	941
06NW*300X5EA	200-50	286.6	.87	541	1711

Table 10.2-3
06NA Compressor Motor Data
Air-Cooled Condensing, Non-Economized

Compressor Model Number	Compressor Electrical Data Nominal Voltage/Freq.	RLA	PF	Locked Rotor Amps LRA (Y)	LRA (D)
123 cfm, Air-Cooled Vi, Non-Economized					
06NA*123S6NA	460-60	76.5	.87	153	485
06NA*123T6NA	575-60	61.2	.87	123	388
06NA*123W6NA	380-60	92.6	.87	169	536
06NA*123X6NA	208/230-60	160.7	.87	307	970
06NA*123Z6NA	200-60	176.0	.87	352	1116
146 cfm, Air-Cooled Vi, Non-Economized					
06NA*146S7NA	460-60 400-50	91.9 90.1	.87 .85	183 191	580 605
06NA*146T6NA	575-60	73.5	.87	147	484
06NA*146U5NA	230-50	156.8	.85	305	967
06NA*146W7NA	380-60 346-50	111.2 104.2	.87 .85	203 210	641 665
06NA*146X7NA	208/230-60 200-50	192.9 180.3	.87 .85	367 382	1160 1210
06NA*146Z6NA	200-60	211.3	.87	422	1334
174 cfm, Air-Cooled Vi, Non-Economized					
06NA*174S7NA	460-60 400-50	112.2 109.7	.85 .82	216 226	685 715
06NA*174T6NA	575-60	89.7	.85	173	548
06NA*174U5NA	230-50	190.7	.82	361	1142
06NA*174W7NA	380-60 346-50	135.8 126.8	.85 .85	239 248	757 786
06NA*174X7NA	208/230-60 200-50	235.6 219.3	.85 .82	433 452	1370 1430
06NA*174Z6NA	200-60	257.9	.85	498	1576

Compressor Model Number	Nominal Voltage/Freq.	RLA	PF	Locked Rotor Amps LRA (Y)	LRA (D)
209 cfm, Air-Cooled Vi, Non-Economized					
06NA*209S7NA	460-60 400-50	136.4 132.5	.86 .83	259 270	820 856
06NA*209T6NA	575-60	109.2	.86	207	656
06NA*209U5NA	230-50	230.5	.83	432	1367
06NA*209W7NA	380-60 346-50	165.2 163.2	.86 .83	286 297	906 941
06NA*209X7NA	208/230-60 200-50	286.6 265.1	.86 .83	518 541	1640 1711
06NA*209Z6NA	200-60	313.8	.86	596	1886
250 cfm, Air-Cooled Vi, Non-Economized					
06NA*250S7NA	460-60 400-50	166.1 160.7	.87 .84	291 303	920 960
06NA*250T6NA	575-60	132.9	.87	233	736
06NA*250U5NA	230-50	279.4	.84	485	1533
06NA*250W7NA	380-60 346-50	201.0 185.7	.87 .84	321 334	1017 1056
06NA*250X7NA	208/230-60 200-50	348.9 321.3	.87 .84	581 607	1840 1920
06NA*250Z6NA	200-60	382.0	.87	669	2116
300 cfm, Air-Cooled Vi, Non-Economized					
06NA*300S5NA	400-50	197.5	.82	387	1226
06NA*300U5NA	230-50	343.5	.82	619	1958
06NA*300W5NA	346-50	228.4	.82	426	1348
06NA*300X5NA	200-50	395.1	.82	775	2452

Table 10.2-4
06NW Compressor Motor Data
Water-Cooled Condensing, Non-Economized

Compressor Model Number	Compressor Electrical Data Nominal Voltage/Freq.	RLA	PF	Locked Rotor Amps LRA (Y)	LRA (D)
123 cfm, Water-Cooled Vi, Non-Economized					
06NW*123S6NA	460-60	51.8	.86	104	330
06NW*123T6NA	575-60	41.5	.86	83	264
06NW*123W6NA	380-60	62.7	.86	115	365
06NW*123X6NA	208/230-60	108.9	.86	209	660
06NW*123Z6NA	200-60	119.2	.86	240	759
146 cfm, Water-Cooled Vi, Non-Economized					
06NW*146S7NA	460-60 400-50	62.6 61.6	.86 .83	104 109	330 344
06NW*146T6NA	575-60	50.1	.86	83	264
06NW*146U5NA	230-50	107.2	.83	174	550
06NW*146W7NA	380-60 346-50	75.8 71.3	.86 .83	115 120	365 379
06NW*146X7NA	208/230-60 200-50	131.5 123.3	.86 .83	209 218	660 689
06NW*146Z6NA	200-60	144.0	.86	240	759
174 cfm, Water-Cooled Vi, Non-Economized					
06NW*174S7NA	460-60 400-50	76.4 74.8	.86 .84	128 134	405 423
06NW*174T6NA	575-60	61.1	.86	102	324
06NW*174U5NA	230-50	130.1	.84	213	675
06NW*174W7NA	380-60 346-50	92.5 86.5	.86 .84	141 147	448 465
06NW*174X7NA	208/230-60 200-50	160.5 149.6	.86 .84	256 267	810 845
06NW*174Z6NA	200-60	175.8	.86	294	932

Compressor Model Number	Nominal Voltage/Freq.	RLA	PF	Locked Rotor Amps LRA (Y)	LRA (D)
209 cfm, Water-Cooled Vi, Non-Economized					
06NW*209S7NA	460-60 400-50	92.5 90.2	.87 .85	153 160	485 506
06NW*209T6NA	575-60	74.0	.87	123	388
06NW*209U5NA	230-50	156.9	.85	255	808
06NW*209W7NA	380-60 346-50	112.0 104.3	.87 .85	169 176	536 556
06NW*209X7NA	208/230-60 200-50	194.3 180.5	.87 .85	307 320	970 1012
06NW*209Z6NA	200-60	212.8	.87	352	1116
250 cfm, Water-Cooled Vi, Non-Economized					
06NW*250S7NA	460-60 400-50	110.8 108.1	.88 .86	183 191	580 605
06NW*250T6NA	575-60	88.7	.88	147	484
06NW*250U5NA	230-50	188.1	.86	305	967
06NW*250W7NA	380-60 346-50	134.1 125.0	.88 .86	203 210	641 665
06NW*250X7NA	208/230-60 200-50	232.8 216.3	.88 .86	367 382	1160 1210
06NW*250Z6NA	200-60	254.9	.88	422	1334
300 cfm, Water-Cooled Vi, Non-Economized					
06NW*300S5NA	400-50	131.3	.86	226	715
06NW*300U5NA	230-50	228.4	.86	361	1142
06NW*300W5NA	346-50	151.8	.86	248	786
06NW*300X5NA	200-50	262.6	.86	452	1430

RLA Rated Load Amps is determined based on the Must Hold (MHA) and Must Trip Amp (MTA) values for the compressor. Each of these relationships are shown in the following equations:

$$RLA = MTA \div 1.40$$

$$MTA = 1.15 \times MHA$$

$$MHA = I_{\substack{Max\ Load \\ -15\%\ Voltage}}$$

PF Power Factor is listed for the nominal load condition.

The maximum load condition for the compressors are:

SST / SDT / SUPH / SUBC

06NA: 12.8 / 70 / 8 / 10
(55 / 158 / 14 / 18)

06NW: 12.8 / 50 / 8 / 3
(55 / 122 / 14 / 5)

The nominal load conditions are:

06NA: 4.7 / 53 / 0 / 14
(40.5 / 128 / 0 / 25)

06NW: 4.7 / 41 / 0 / 3
(40.5 / 105 / 0 / 5)

10.3 Motor Winding Thermistor

The motor winding thermistor is embedded directly into the windings of the motor. The thermistor is an NTC type with a standard resistance of 5000Ω at 25°C. Table 10.3-1 lists the resistance versus temperature characteristics.

Additional information regarding this sensor can be obtained from Carrier drawing 32MP500354.

Table 10.3-1

Motor Temperature Thermistor Temperature vs Resistance Characteristics

TEMPERATURE			RESISTANCE
C	– C	F	W (ohms)
-30	.35	-22	88480
-25	.33	-13	65205
-20	.30	-4	48536
-15	.28	5	36476
-10	.25	14	27663
-5	.23	23	21163
0	.20	32	16325
5	.20	41	12696
10	.20	50	9949.5
15	.20	59	7855.5
20	.20	68	6246.0
25	.20	77	5000.0
30	.20	86	4028.4
35	.20	95	3265.7
40	.20	104	2663.2
45	.20	113	2184.2
50	.20	122	1801.2
55	.20	131	1493.1
60	.20	140	1243.9
65	.20	149	1041.4
70	.20	158	875.8
75	.23	167	739.7
80	.26	176	627.6
85	.29	185	534.9
90	.32	194	457.7
95	.35	203	393.3
100	.38	212	339.3
105	.41	221	293.8
110	.44	230	255.3
115	.47	239	222.6
120	.50	248	194.8

11. Required Safety Protection

Pre-Start Safety Checklist

The following section was included with the intention that any new application should check each of the items listed to verify that the required compressor protection is in place. All safety devices are required unless marked as optional.

Safety Device	Threshold	Application Requirements	Action Required
High Pressure Switch	21 Bar (290 psig) Maximum	Located upstream (on the compressor side) of the discharge service valve. Required only when applied with a discharge service valve.	Shutdown
Low Pressure Switch	1 Bar (0 psig) Minimum	Located downstream (on the compressor side) of the suction service valve. Required only when applied with a suction service valve.	Shutdown
High Suction Pressure (Full Load)	4.5 Bar (51 psig) Maximum	Maximum Operating Pressure control is required above this limit in order to avoid overloading the motor.	Initiate MOP Control
Low Oil Pressure	Per Figure 4.5.1-1	Pressure differential is measured as oil galley pressure (downstream of the filter, check valve, and solenoid valve) minus compressor economizer pressure.	Shutdown
High Discharge/ Oil Temperature (Add Cooling)	99°C (210°F)	Temperature measurement to be made at the compressor outlet. Measurements made further downstream must account for the temperature drop between the compressor outlet and measurement location.	Add Liquid Refrigerant Injection Thru Motor Cooling
High Discharge/ Oil Temperature (Add Cooling)	104°C (220°F) Maximum	Shutdown Limit.	Shutdown
Hot Motor Winding Temperature (Add Cooling)	93°C (200°F)	This is the maximum recommended operating temperature for the motor windings. Additional cooling should be injected if this limit is exceeded.	Add Liquid Refrigerant Injection Thru Motor Cooling
High Motor Winding Temperature (Shutdown)	118°C (245°F) Maximum	Compressor shutdown is required when the motor temperature reaches this limit.	Shutdown
Reverse Rotation	na	After the power wiring to the compressor is disturbed, a low pressure switch must be installed at the high pressure port of the compressor and the contacts installed in series with the compressor contactor. Electronic measurement is adequate for any subsequent starts. Response time of the detection system must be within 300 milliseconds.	Shutdown
Low Oil Level	na	Oil level should be measured in the oil sump (external sump when possible)	Shutdown
Oil Filter Change-out Alert	First 1000 hours, each additional 4000 hours OR when the filter $\Delta P > 2.1$ bar (30psid)	This is the recommended filter change-out schedule. At a minimum, service literature should communicate this requirement.	Service Alert No shutdown.
High Oil Filter Pressure Drop Alarm	6.89 bar (100 psid)	Pressure differential is measured as the difference between the compressor discharge pressure and the oil galley pressure.	Shutdown

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