

**06TS,TT,TU,TV CARLYLE® PARAGON TWIN SCREW COMPRESSOR
APPLICATION GUIDE**



Contents

Introduction

R-134a, R-513A, R-1234ze Applications	3
R-404A, R-407A, R-407C, R-407F, R-448A, R-449A, and R-507A Applications	3
Scope	3
Certifications	3
Compressor Offerings	3
Compressor Displacement (R-134a, R-513A, R- 1234ZE for air and water cooled models)	3
Compressor Displacement (Low/Medium Temperature Models). R-404A, R-407A, R-407C, R-407F, R-448A, R-449A, and R-507A.	4
Standard Features	4
Model Number Significance Chart	5
Compressor Physical Data and Connections	6
06TS Compressor	6
06TT Compressor	7
06TU Compressor	8
06TV Compressor	9

1.0 Medium/High Temperature System Design Considerations

1.1 Refrigerants and Lubricants	10
1.2 Environmental Considerations	10
1.3 Operating Limits and Controls	10
1.4 Control Points Summary	14

2.0 Medium/High Temperature System Oil Management

2.1 Oil Pressure Requirements	15
2.2 Oil Separator Recommendations	15
2.3 Oil Heater Recommendations for Air-Cooled Models	15
2.4 Oil Level Safety Switch	16
2.5 Oil Filter	16

3.0 Low Temperature System Design Considerations

3.1 Refrigerants and Lubricants	17
3.2 Environmental Considerations	17
3.3 Operating Limits and Controls	17
3.4 Control Points Summary	22

4.0 Low Temperature System Oil Management

4.1 Oil Pressure Requirements	23
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4.2 Oil Separator Recommendations	24
4.3 Oil Heater Recommendations	23
4.4 Oil Level Safety Switch	23
4.5 Oil Filter	24
4.6 Oil Cooling Systems	24
4.7 Oil Cooler Selection	24
4.8 Oil Cooler Sizing	25

5.0 Unloader Operation

5.1 Unloader System Control Points	27
5.2 Approximate Part Load Factors	28

6.0 Software Version 2.0 Schematics

6.1 Compressor Requirements	36
6.2 Design Pressures	36

7.0 Variable Frequency Drive Guidelines

7.1 Scope	37
7.2 Capacity Control	37
7.3 Power Supply	37

8.0 Compressor Electrical Data

8.1 Allowable Voltage Range	39
8.2 Electrical Connection Requirements	39
8.3 Motor Data	41

9.0 Compressor Accessories

9.1 Oil Separators	48
9.2 Vertical Oil Separator Kit	49
9.3 Horizontal Oil Separator Kit	49
9.4 Compressor Components Kit	49
9.5 Compressor Protection and Slide Valve Capacity Control Kits	50
9.6 Service Valves	50
9.7 Motor Protection Devices	50
9.8 Oil Coolers	51

10.0 Packaging and Storage Requirements

10.1 Packaging	52
10.2 Shipping	52
10.3 Storage	52
10.4 Weights and Dimensions	52

Introduction

This manual is for the Carlyle® Paragon screw compressor product line, which is comprised of four unique compressor families (series type TS, TT, TU, and TV). Carlyle offers distinct versions of the Paragon Twin-Screw Compressors for Low/Medium/High Temperature applications. The operational limits, required accessories, and operational guidelines are contained in this manual and must be complied with to stay within the compressor warranty guidelines.

R-134a, R-513A, R-1234ze Applications

The TS series compressors are designed for air-cooled applications only. The TT, TU, and TV series compressors are available in both air-cooled and water-cooled applications. There are 3 different displacement sizes of each of the TS, TT, and TV series compressors, along with 2 displacement sizes of the TU series compressor.

Each Paragon twin-screw compressor is designed to be applied with a dedicated, performance-matched oil separator. Carlyle offers two types of oil separators: high-efficiency (for applications in flooded-type systems) and standard-efficiency (for application in direct expansion-type systems). This compressor / oil separator assembly is then applied in a single-compressor, medium-temperature, or high-temperature refrigeration circuit. Carlyle offers the required oil separators as shown in Section 9.1 of this application guide. See Section 10.5 of this document for Assembly views of the R-134a Paragon models applied with these oil separator designs. Application guidelines for the R-134a compressors that have been approved for VFD applications are covered in this guide.

R-404A, R-407A, R-407C, R-407F, R-448A, R-449A, and R-507A Applications

The low/medium temperature Paragon twin-screw compressor models are designed to be applied in single or multiple compressor circuits. Each circuit requires a properly selected oil separator (contact Carlyle Application Engineering for selection criteria). Carlyle offers 3 models within each of the TS and TT compressor series for low/medium temperature applications.

Scope

This application guide is intended to familiarize system designers with the Paragon screw compressor and to provide technical information necessary to assure safe and reliable compressor operation.

Certifications

UL and CSA approvals have been obtained for specific 06TS, 06TT, 06TU, and 06TV screw compressor models applied with R-134a and for certain 06TS and 06TT screw compressor models applied with R-404A, R-407A,

R-407C, R-407F, and R-507A (compressors that have an R or M in the fifth digit of the model number).

UL File #: SA4936 CSA File #: SA4936

For the UL and CSA approvals it is essential that only Listed, Special-Purpose circuit breakers or Carlyle approved, solid-state motor overloads be used (contact Carlyle Application Engineering for further information). For circuit breakers, the Must Trip Amp settings must not exceed 140% of the compressor rated load amps.

Both UL and CSA approvals have been obtained for all voltage combinations shown in Section 8.3 of this guide. These compressor models also comply with the EC Low Voltage and Machinery Directives.

Compressor Offerings

The four Paragon compressor frame sizes (TS, TT, TU, and TV) are optimized for application in economized refrigeration circuits. Non-economized capacity will decrease by 11 to 16% for water-cooled operation. The following tables show the displacements for each of the compressors at 60 Hz.

Compressor Displacement (R-134a, R-513A, R-1234ze for air and water cooled models)

See Tables 1 and 2.

Table 1 — Air-Cooled Models

MODEL NUMBER	NOMINAL HORSEPOWER	DISPLACEMENT (CFM at 60 Hz)
06TSA137	60	137
06TSA155	75	155
06TSA186	75	186
06TTA266	120	266
06TTA301	150	301
06TTA356	150	356
06TUA483	225	483
06TUA554	225	554
06TVA680	340	680
06TVA753	340	753
06TVA819	340	819

Table 2 — Water-Cooled Models

MODEL NUMBER	NOMINAL HORSEPOWER	DISPLACEMENT (CFM at 60 Hz)
06TTW266	90	266
06TTW301	90	301
06TTW356	120	356
06TUW483	160	483
06TUW554	160	554
06TVW680	225	680
06TVW753	225	753
06TVW819	225	819

NOTE: Carlyle has optimized the Vi (volume index) for the R-134a air-cooled and water-cooled models.

Compressor Displacement (Low/Medium Temperature Models). R-404A, R-407A, R-407C, R-407F, R-448A, R-449A, and R-507A

See Tables 3 and 4.

Table 3 — Low Temperature (Refrigeration) Models

MODEL NUMBER	NOMINAL HORSEPOWER	DISPLACEMENT (CFM at 60 Hz)
06TSR137	60	137
06TSR155	75	155
06TSR186	75	186
06TTR266	120	266
06TTR301	150	301
06TTR356	150	356

Table 4 — Medium Temperature Models

MODEL NUMBER	NOMINAL HORSEPOWER	DISPLACEMENT (CFM at 60 Hz)
06TSM137	75	137
06TSM155	75	155
06TTM266	150	266
06TTM301	150	301

Standard Features

See Fig. 1-4 for physical data and connection information.

Discharge Check Valve

The discharge check valve is an axial movement type located within the compressor. The check valve is field serviceable by removing the oil separator or discharge line to access the valve in the compressor discharge housing.

Pressure Relief Valve

The Paragon screw compressors have an internal relief device which is designed to relieve pressure from the high side to the low side of the compressor.

Suction and Economizer Screens

To increase the reliability of the compressor, a screen has been incorporated as a standard feature into the suction inlet and economizer inlet of the compressor. The suction inlet screen is installed into the suction inlet of each compressor. The economizer inlet screen is supplied in the economizer flange package (which is included in the compressor kit 06TT660093). Refer to the economizer flange Installation Instruction document for more details.

Slide Valve Unloading System

All Paragon screw compressors utilize a continuous slide valve unloading system. The slide valve decreases the compressor's capacity by reducing the amount of compression performed by the screw rotors. It is infinitely variable down to approximately 30% of full load capacity for air-cooled models and approximately 15% of the full load capacity for water-cooled models. These percentages of unloading are based on operation at typical rating conditions and may be different at other operating conditions.

Variable Speed for Capacity Control

The paragon compressor has been qualified to operate with a variable frequency drive (VFD) for all low, medium, and high temperature applications. The VFD speed application range is 30 to 60 Hz. The compressor slide valve should remain in the fully loaded position while the VFD is controlling compressor capacity between 30 to 60 Hz. The slide valve may be used to reduce compressor capacity below 50% (30 Hz) if required. Recommendations and requirements for these applications are provided in Section 7.0.

Model Number Significance Chart

DIGIT	1	2	3	4	5	6	7	8	9	10	11	12
MODEL NO.	0	6	T	T	A	3	5	6	S	S	1	C

1 st & 2 nd	DESIGN FEATURE
06	Semi-Hermetic

3 rd & 4 th	MODEL CODE
TS	Paragon
TT	Paragon
TU	Paragon
TV	Paragon

5 th	DESIGN VARIABLE
A	Air Cooled Vi
R	Refrigeration Vi
W	Water-Cooled Vi
X	Variable-Speed (WC Vi)
M	Medium Temperature Vi

LEGEND
 Vi — Volume Index
 WC — Water-Cooled
 VFD — Variable Frequency Drive

6 th , 7 th & 8 th	
DISPLACEMENT (CFM at 60 Hz)	MODEL REF.
137	TS1
155	TS2
186	TS3
266	TT1
301	TT2
356	TT3
483	TU2
554	TU3
680	TV1
753	TV2
819	TV3

12 th	PACKAGE / ACCS.
A	Not Used
B	Not Used
C	Plate Mounting Feet
D	Bar Mounting Feet

11 th	DESIGN LEVEL
1	Phase 1
3	Product Variant
9	Not Used

10 th	MOTOR SIZE
G	60
J	75
M	90
P	120
S	150
T	160
W	225
X	340

9 th	MOTOR VOLTAGES	
S	400/460-3-50/60	690-3-50 (Wye)
T	575-3-60	
W	380-3-60	690-3-60 (Wye)
X	200/230-3-50/60	
Z	200-3-60	

Compressor Physical Data and Connections

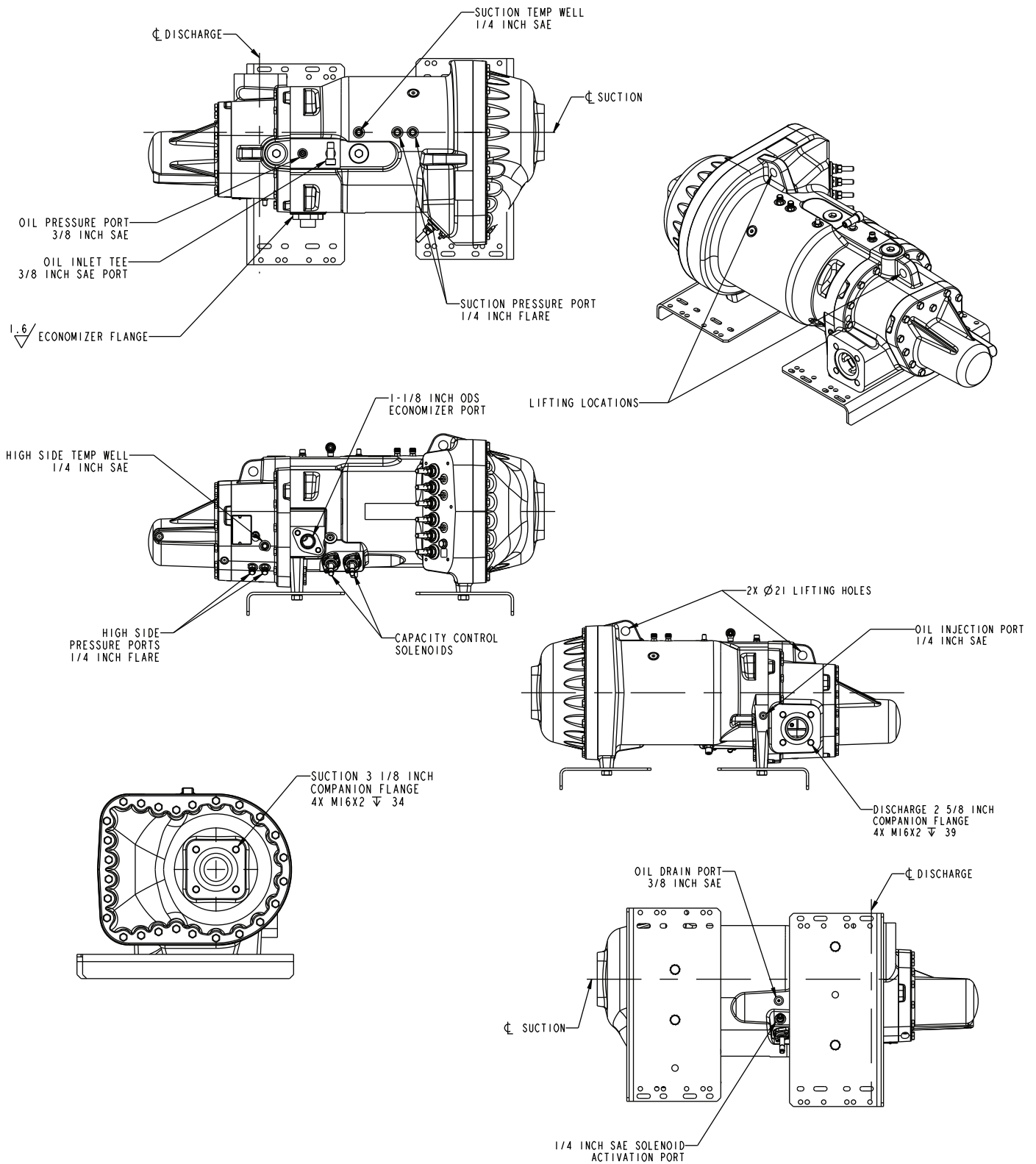


Fig. 1 — 06TS Compressor Physical Data and Connections

Compressor Physical Data and Connections (cont)

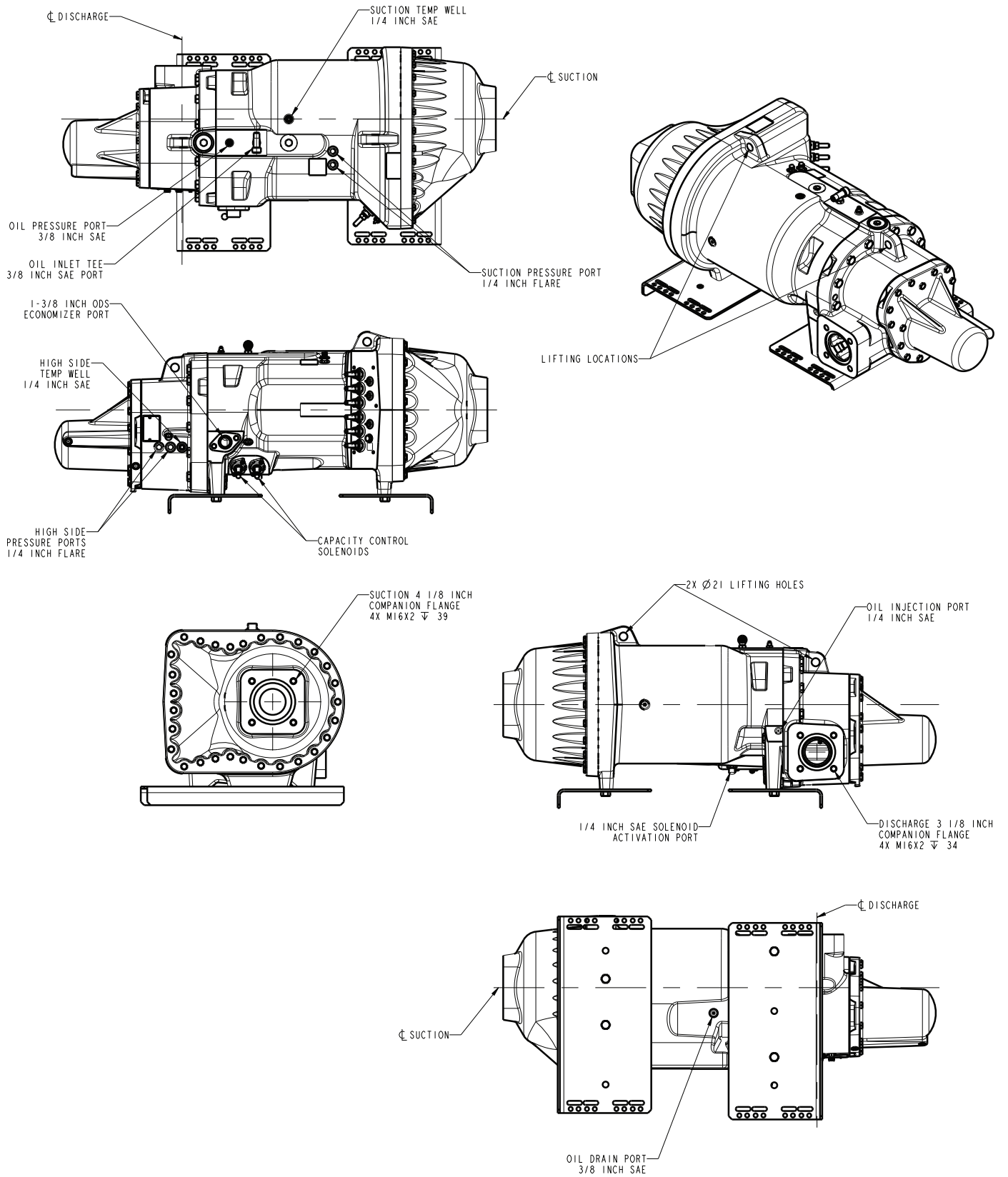


Fig. 2 — 06TT Compressor Physical Data and Connections

Compressor Physical Data and Connections (cont)

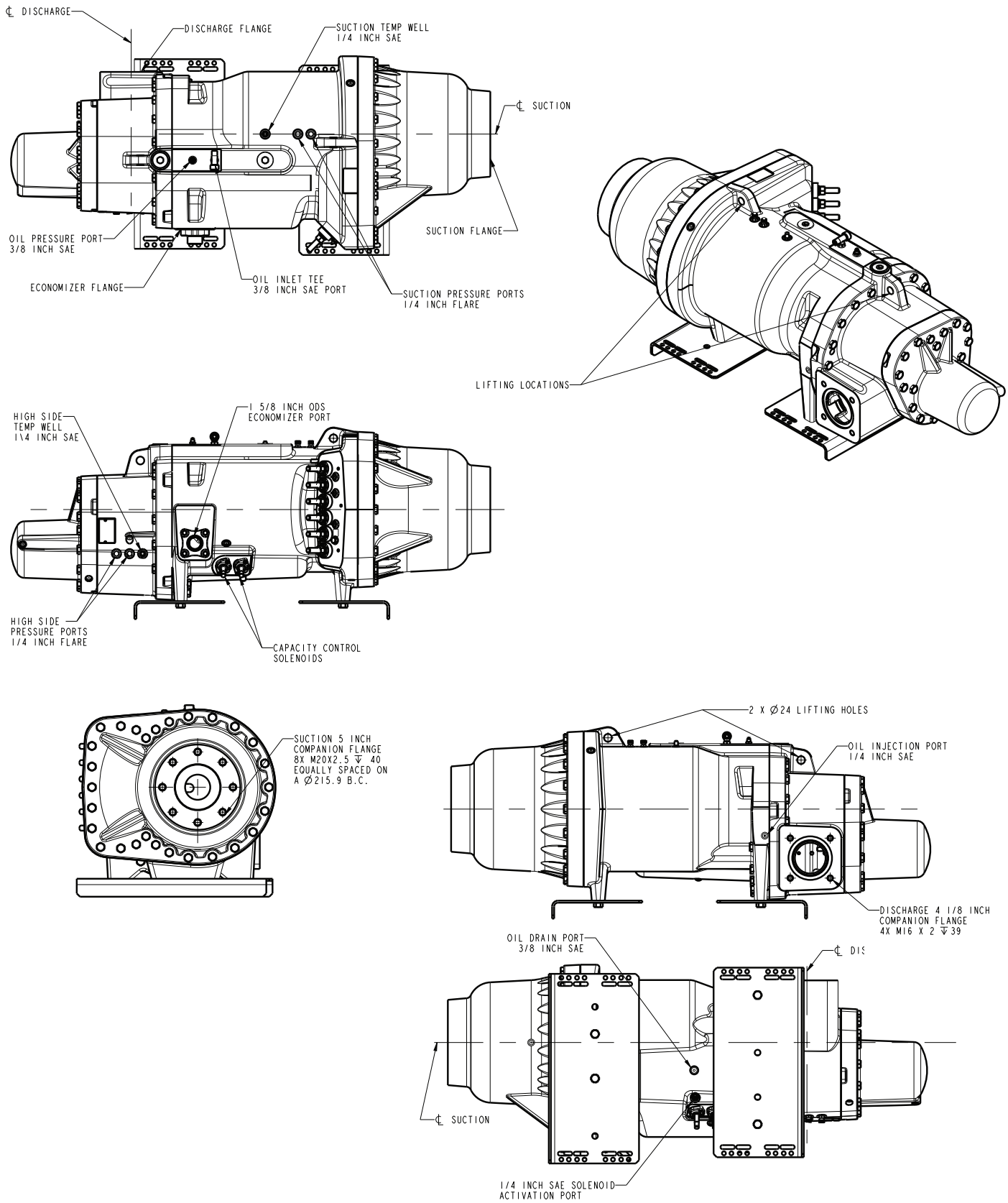


Fig. 3 — 06TU Compressor Physical Data and Connections

Compressor Physical Data and Connections (cont)

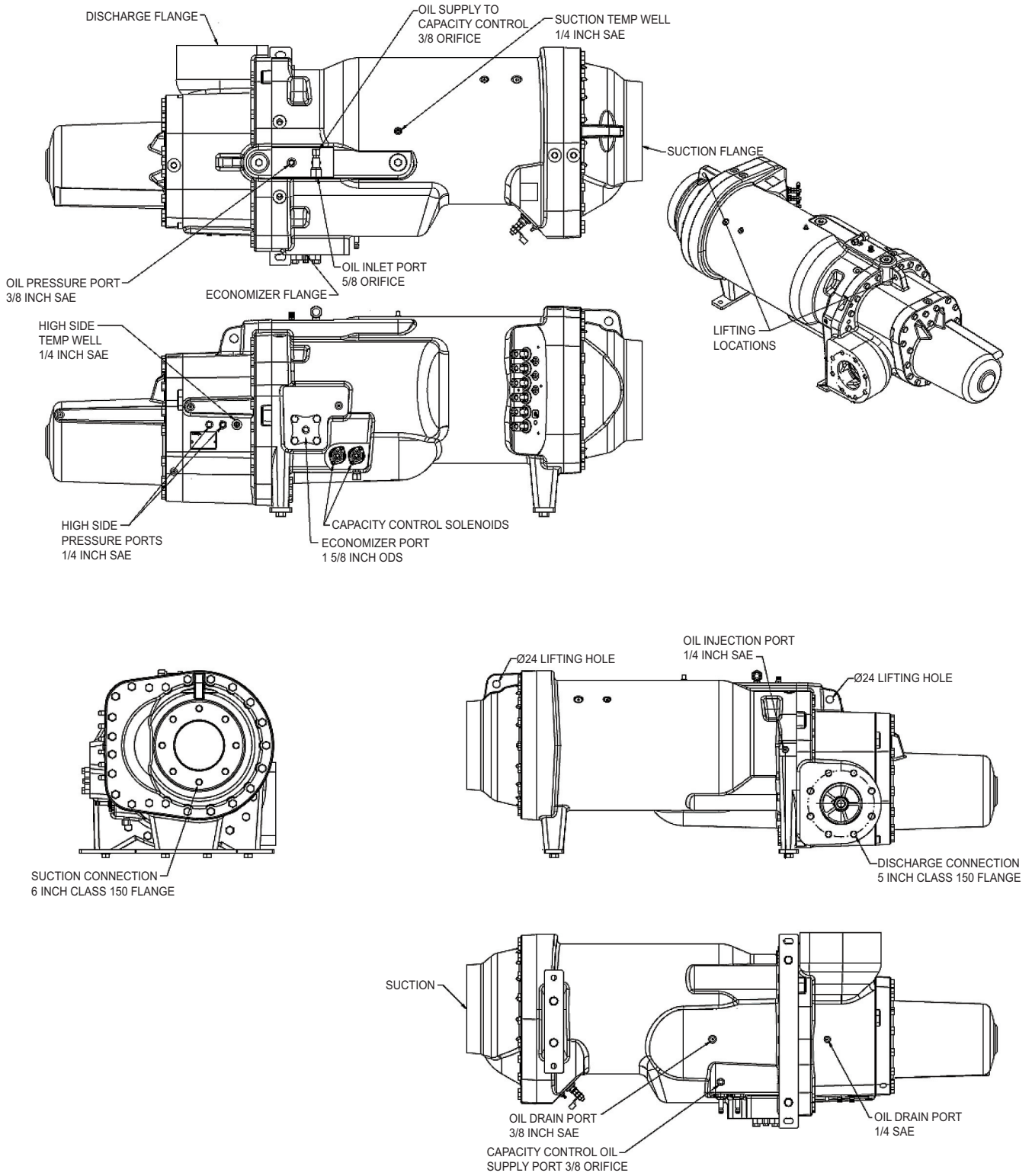


Fig. 4 — 6TV Compressor Physical Data and Connections

1.0 Medium/High Temperature System Design Considerations (R-134a, R-513A, R-1234ze)

1.1 Refrigerants and Lubricants

Approved Refrigerants

The Paragon medium-temperature screw compressor is specifically designed for use in R-134a systems.

Approved Lubricants

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

Approved Lubricant — Emkarate RL 220H
Viscosity Grade — ISO 220

or

Approved Lubricant — Emkarate RL 220HC
Viscosity Grade — ISO 220

Carrier Part Number — 1 gallon: P903-2301
5 gallon: P903-2305

Assembly Grease

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

Approved Lubricant — Castrol Synplex GP2
or

Approved Lubricant — Parker Super-O-Lube

Carrier Part Number — 19XL680001

Terminal Pin Dielectric Grease

Carlyle recommends that compressor motor terminal pins are coated with dielectric grease (P/N 06TT660050) to reduce the effects of condensation that may form on the terminal pins.

1.2 Environmental Considerations

Operating Ambient Temperature

The screw compressor is designed for the following ambient temperature ranges:

Non-Operating: -40°F to 176°F (-40°C to 80°C)

Operating: -31°F to 131°F (-35°C to 55°C)

Salt-Spray Requirements

The compressor has been tested through 500 hours of salt-spray in compliance with ASTM specification B-117.

1.3 Operating Limits and Controls

R-134a, R-513A, R-1234ze Operating Envelope

The following operating envelopes show where the compressor can be operated in both direct expansion and flooded applications. See Fig. 5-7. The envelopes differ for the unique design configuration of the compressor. The fifth digit of the model number indicates the operating envelope. The load line percentages refer to the capacity relative to full load at the same saturated suction temperature (SST) and saturated discharge temperature (SDT).

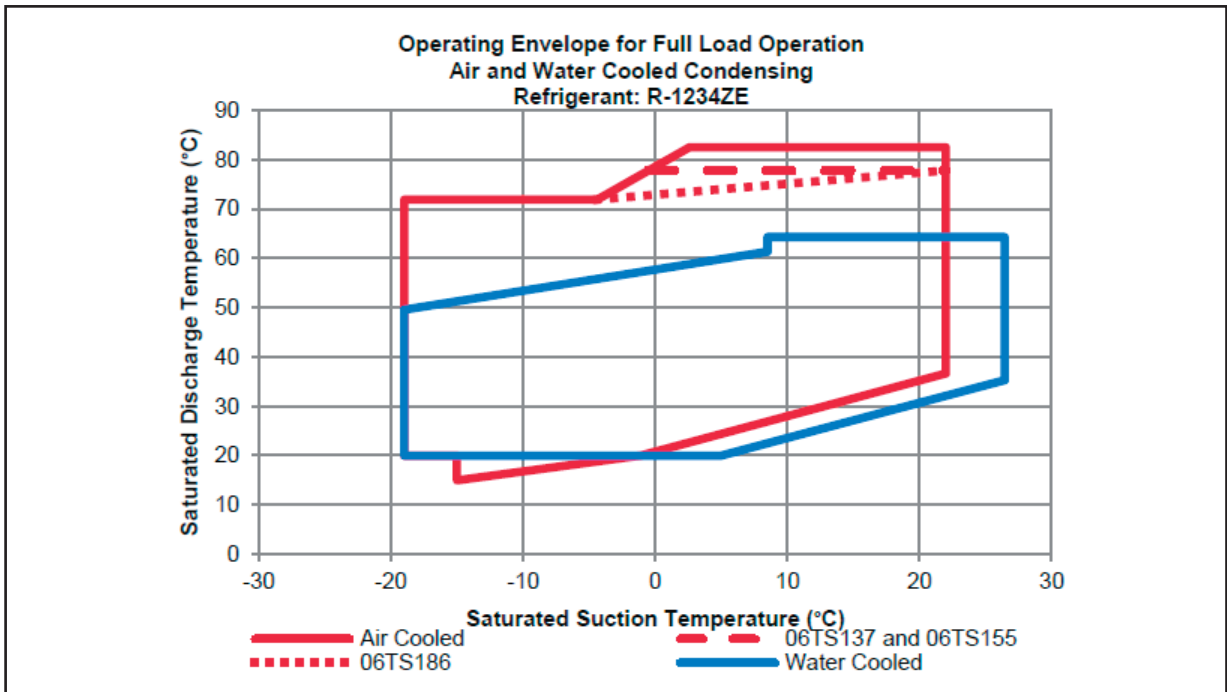


Fig. 5 — Operating Limits for Full Load Operation

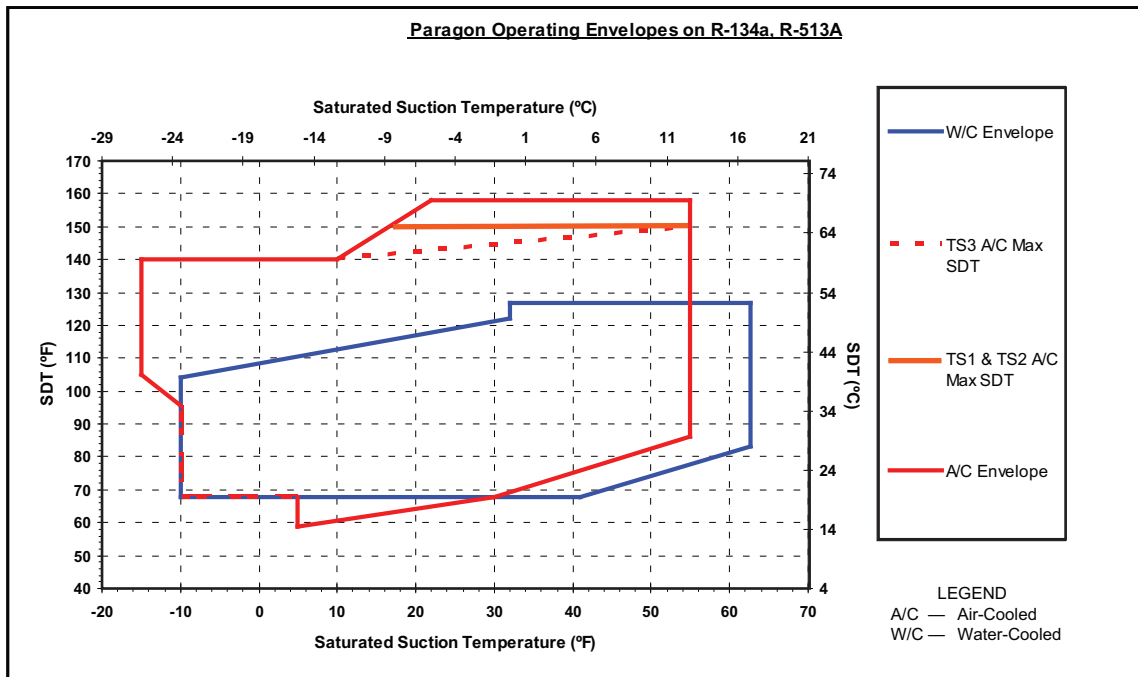
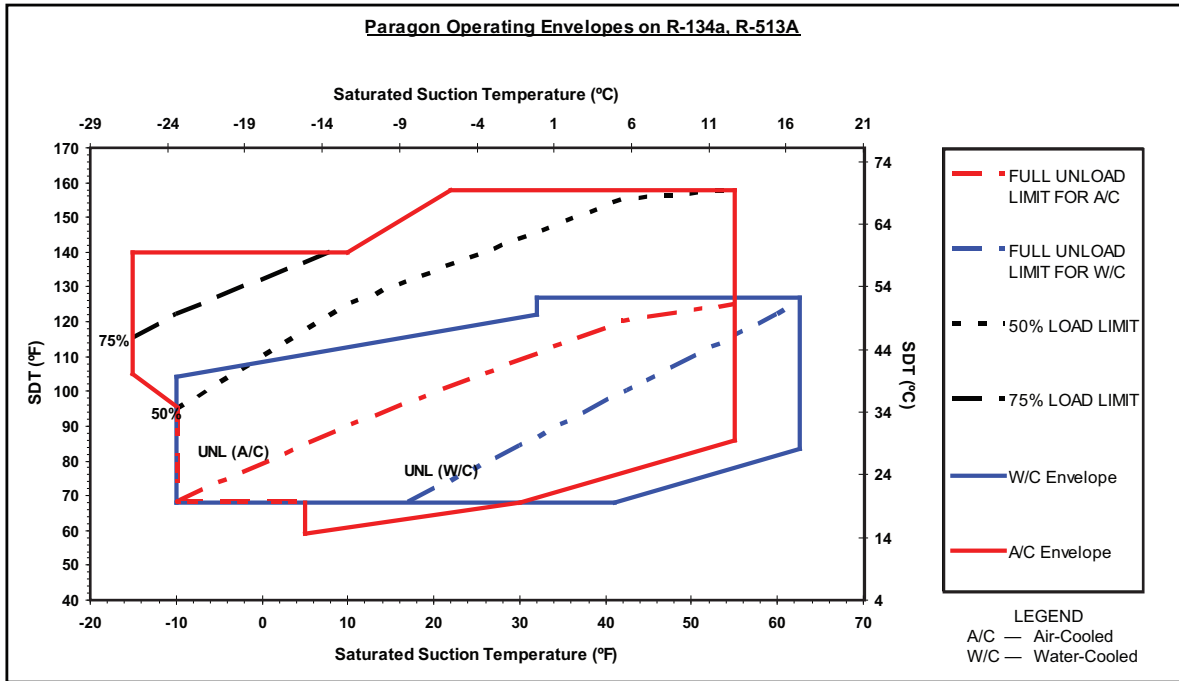


Fig. 6 — Operating Limits for Full Load Operation



NOTE: Liquid injection may be required when operating fully unloaded. Contact Carlyle Applications Engineering for valve sizing requirements.

Fig. 7 — Operating Limits for Unloaded Operation

Start-Up and Suction Pressure Transients

Operating a screw compressor without refrigerant flow through the compressor can be harmful. When this occurs, the evaporator typically will go into a vacuum, leading to very high pressure ratios and little mass flow to carry the heat away from the screw rotors. This situation most often occurs during start-up when the refrigerant may be in another part of the system. This is tolerable for short periods of time. The Paragon screw compressor should not be allowed to operate with a suction pressure less than 0 psig (vacuum) for more than 1 minute after a “cold” start. (Contact Carlyle Application Engineering for more information on cold starts.) If a compressor is allowed to operate for longer periods of time without refrigerant flow, catastrophic damage to the screw rotors, rotor housing, and discharge housing may occur, requiring compressor replacement.

Air-Cooled Oil Supply at Compressor

To reduce the possibility of liquid refrigerant becoming entrained in the oil, it is recommended that the temperature of the oil entering the compressor is kept above the outdoor ambient as shown in Fig. 8.

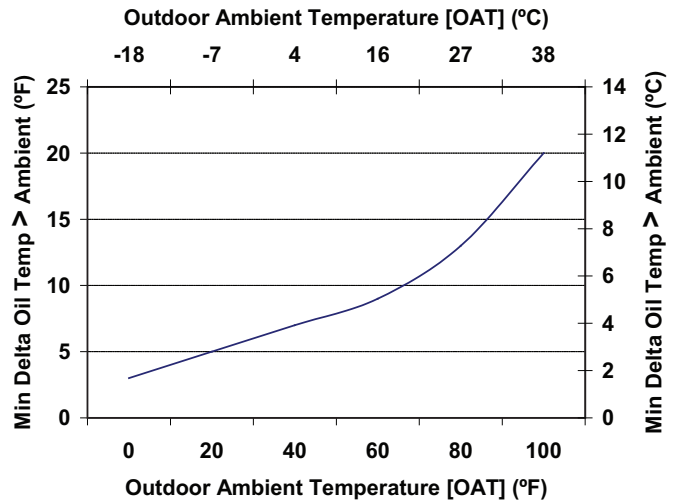


Fig. 8 — Oil Temperature

Temperature Limits

Table 5 shows the temperature range of control points allowable for the compressor using the approved lubricants listed in Section 1.1, Refrigerants and Lubricants.

Table 5 — Allowable Temperature Ranges

CONTROL POINT	MINIMUM	MAXIMUM
Discharge Gas	20°F (11°C) superheat	210°F (99°C)
Economizer Gas	Saturated Liquid	9°F (5°C) superheat
Suction Gas	Saturated Vapor	Can float if motor and discharge maximum temps are met
Oil Supply at Compressor	Refer to Fig. 8	210°F (99°C)
Motor Windings	No limit	275°F (135°C)

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 1 second.

Reverse rotation is most likely to occur at initial start-up or whenever the wiring to the compressor terminals is disturbed.

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

1. During initial run test of the unit, a suitable low-pressure switch should be temporarily installed on the high-pressure port of the compressor and be wired to open the compressor control circuit. 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 must be wired in the control circuit of the compressor start components to shut off the compressor in the event it is operating in reverse rotation. This switch would remain in place for the duration of the run test. At the end of the run test the switch would be removed so that it could be used on the next unit or compressor to be tested.

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

The low-pressure switch must be suitable for the pressures consistent with R-134a systems, and the switch must be manually resettable and open when the pressure falls below 50 mm (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.

If a switch is not available, a manifold gage connected to the discharge housing of the compressor BEFORE THE DISCHARGE CHECK VALVE can be used. If the compressor can be “bumped” or “jogged” very quickly (< 1 second) while someone is watching the gage, compressor rotation can be determined without damage to the compressor. If the pressure drops, the compressor is rotating backwards and will have to be rewired. If the pressure goes up, the compressor is spinning in the correct direction.

Refrigeration System Design Considerations

In order to eliminate the possibility of refrigerant migrating into the oil separator and compressor, Carlyle requires the application of a positive-seal, discharge check valve (or a similar functioning device) to be installed in the discharge line after the oil separator.

Carlyle recommends the application of our qualified Safety Control Module package (P/N 6BSB000472) which provides the following safety control functionality:

- Discharge Temperature Monitoring
- Oil Level Monitoring (Optional)
- Reverse Rotation Monitoring
- Oil Flow-Rate/Supply Monitoring

Technical documentation for this Safety Control Module package (P/N 6BSB000472) is provided on the Carlyle Website at www.carlylecompressor.com

1.4 Control Points Summary

<p>Reverse Rotation / Operation with Suction Pressure in Vacuum</p> <ul style="list-style-type: none"> Control must detect and prevent reverse rotation of the compressor within 1 second of compressor start-up. Compressor must not operate in a vacuum, as measured at the suction pressure port, for greater than 1 minute.
<p>Oil Pressure Confirmation / Safety</p> <ul style="list-style-type: none"> Three pressures must be observed to ensure that the oil pressure is suitable for compressor operation: suction, discharge and oil. Oil pressure safety control must be manually reset. Oil pressure must be maintained as follows: <ol style="list-style-type: none"> $P_{OIL} > [0.7 \times (P_{DISCHARGE} - P_{SUCTION}) + P_{SUCTION}]$ $P_{OIL} > [P_{SUCTION} + 0.5 \text{ bar}]$ 15 seconds after start (Air-Cooled models; <i>A</i> in 5th digit of model numbers) $[P_{SUCTION} + 1.0 \text{ bar}]$ 45 seconds after start (Refrigeration models; <i>R</i> in 5th digit of model numbers) $[P_{SUCTION} + 1.0 \text{ bar}]$ 75 seconds after start (Water-Cooled models: <i>W</i> in 5th digit of model numbers)
<p>Oil Supply Confirmation / Oil Level Switch</p> <ul style="list-style-type: none"> Oil supply to the compressor must be maintained during operation at all times. Compressor operation must be stopped if the required oil level switch is open for 5 continuous seconds. Oil supply solenoid valve must be closed during OFF cycles.
<p>Oil Filter Differential Pressure</p> <ul style="list-style-type: none"> Compressor operation must be stopped if the pressure differential measured between the entering and leaving oil filter locations exceeds 2 bars. The oil filter supply tubing design should apply valves to allow for the isolation and replacement of the filter without removing the system refrigerant charge.
<p>Motor Temperature Limitation</p> <ul style="list-style-type: none"> Motor temperatures must be continuously monitored during compressor operation. Motor temperatures must not exceed 275°F (135°C).
<p>Compressor Short Cycling</p> <ul style="list-style-type: none"> Control must provide for a minimum of 10 minutes time delay before restarting the Paragon compressor. The maximum number of compressor START cycles per hour is 6.
<p>Maximum Discharge Gas Temperature</p> <ul style="list-style-type: none"> Discharge gas temperatures must not exceed 210°F (99°C). Control must prevent compressor operation when discharge gas temperatures exceed this maximum.
<p>Maximum Oil Temperature</p> <ul style="list-style-type: none"> Oil temperatures must not exceed 210°F (99°C). Control must prevent compressor operation when oil temperatures exceed this maximum.
<p>Run-Proof</p> <ul style="list-style-type: none"> Current must be monitored to detect welded contacts on a contactor or single-phase condition. Oil flow must be resumed if a contactor is determined to be welded shut. Compressor must be shut down if a single-phase condition is detected.
<p>Liquid Line Solenoid / Economizer</p> <ul style="list-style-type: none"> A liquid line solenoid valve is required to shut off liquid flow to the compressor during OFF cycles. Controlling this valve allows for additional capacity reduction during low load conditions.
<p>Unloading Control</p> <ul style="list-style-type: none"> Control must be provided to the two unloader coils. These coils position the slide valve mechanism within the compressor and allow for infinite unloading valve positioning.
<p>Unloaded Shutdown</p> <ul style="list-style-type: none"> It is recommended that the compressor operate for 30 seconds fully unloaded prior to shut down. This ensures fully unloaded re-start will occur.

NOTE: Carlyle offers Compressor Protection Module package, P/N 6BSB000472, which protects against reverse rotation, low oil flow and maximum discharge gas temperature. See Marketing Bulletin 14M-01 at www.carlylecompressor.com.

2.0 Medium/High Temperature System Oil Management (R-134a, R-513A, R-1234ze)

Oil supply system components are shown in Fig. 9.

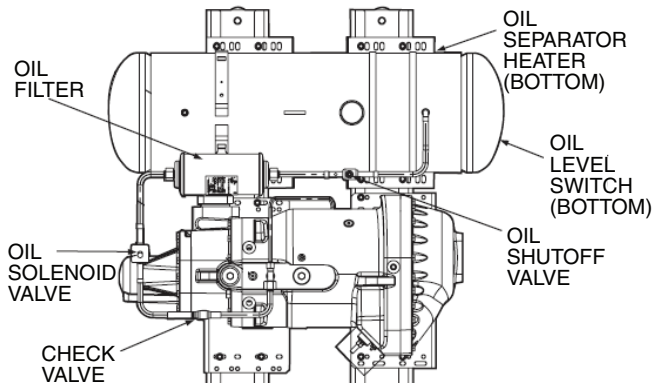


Fig. 9 — Oil Supply System Components

2.1 Oil Pressure Requirements

System pressure is used to generate the oil pressure required to lubricate bearings and provide the oil that acts as a seal between the screw rotors and the bores. Oil pressure is monitored continuously during compressor operation. The oil pressure must meet the following criteria, based on $P_{DISCHARGE}$, $P_{SUCTION}$ and P_{OIL} :

1. $P_{OIL} > [0.7 \times (P_{DISCHARGE} - P_{SUCTION}) + P_{SUCTION}]$
2. $P_{OIL} > [P_{SUCTION} + 0.5 \text{ bar}]$ 15 seconds after start
 $[P_{SUCTION} + 1.0 \text{ bar}]$ 45 seconds after start
 (Air-Cooled models; A in fifth digit of model number)
 $[P_{SUCTION} + 1.0 \text{ bar}]$ 75 seconds after start
 (Water-cooled models; W in 5th digit of model number)

The unit control system must monitor the oil pressure differential, as well as the operating condition, so the compressor can be shut down if the minimum requirements are not met for any duration exceeding 15 seconds.

This time delay has two functions: first, to avoid nuisance tripping during normal and transient operation, and second, to allow the system sufficient time to develop pressure differential during start-up.

The compressor must be shut down 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.

Carlyle offers a Compressor Protection Module package to provide protection against loss of oil flow, reverse-rotation and elevated discharge gas temperature.

2.2 Oil Separator Recommendations

The Paragon compressor requires an oil separator. The combined oil capacity of the oil separator sump, the oil reservoir, and the oil cooler, should be greater than the values shown in Table 6.

The separator should be selected to provide a maximum oil carryover leaving the separator required by that system/application. Approximate oil flow versus compressor pressure differential (Discharge Pressure - Suction Pressure) is shown in Fig. 10. Additional oil charge may be required for systems that have longer tubing sets. See Sections 9.1.1, 9.1.2, and 10.5 for additional information.

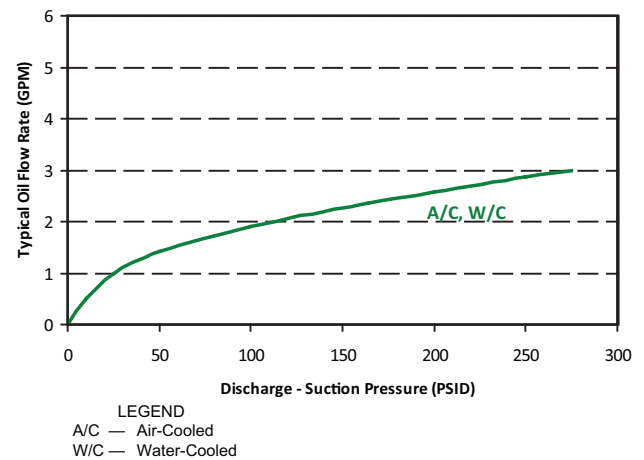


Fig. 10 — Oil Supply at Compressor

2.3 Oil Heater Recommendations for Air-Cooled Models

For the typical oil separators used with the Paragon compressor (see Table 6), a 500-watt flexible strip heater is recommended. The heater should be wired to operate when the compressor is OFF. This minimizes the migration of refrigerant to the oil stored in the sump. Figure 8 shows the minimum oil temperatures that must be maintained when the compressor is not operating based on the outdoor ambient temperature (OAT). If the application will allow refrigerant to collect in the compressor, then a heater must be installed on the compressor. Running unit water that is at least 20°F (11°C) below OAT, if possible, can be used to prevent refrigerant from collecting in the compressor. Carlyle recommends that the oil temperature be monitored in warm climate applications and that the oil separator heater be cycled off if oil temperatures reach 190°F (88°C).

Table 6 — Oil Separators

	PART NUMBER	MINIMUM OIL CHARGE	DISCHARGE CFM
SIDE-MOUNT HORIZONTAL OIL SEPARATORS	8BSB000704	4.5 gal. (17.0 L)	17-150
	8BTB000705	4.5 gal. (17.0 L)	17-170
	8BVB000787	4.5 gal. (17.0 L)	15-150
COMPACT OVER / UNDER OIL SEPARATORS	8BSB000643	4.5 gal. (17.0 L)	17-170
	8BTB000644	4.5 gal. (17.0 L)	17-170
VERTICAL OIL SEPARATORS	KH31ZZ212	10.0 gal. (38.0 L)	30-60

2.4 Oil Level Safety Switch

An oil level safety switch must be installed in the sump of the oil separator or the oil reservoir, depending on the system design. Carlyle recommends an oil level safety switch that interrupts compressor operation if oil levels are below adequate levels. Enough oil should remain in the sump when the switch is opened for the compressor to operate for at least one minute before completely running out of oil.

To reduce the possibility of false oil level alarms, Carlyle recommends that the oil level safety switch should be open continuously for 5 seconds prior to initiating compressor shutdown.

2.5 Oil Filter

Provisions should be made to isolate the oil filter using some combination of shutoff valves and/or check valves. This will allow for the filter element to be replaced without removing or isolating the charge in the unit.

Because of the long bearing life requirements, filtration for this compressor is very stringent. The Beta Ratio for this filter is greater than or equal to 200 for a five micron particle size evaluated using ISO 16889 ($\beta_{(5)} \geq 200$). Filter areas must also be sufficient to avoid premature clogging of the filter during normal operation. The Carlyle supplied filters have a filtration area of $> 5000 \text{ cm}^2$. An alarm in the controls should be signaled any time the pressure drop across the filter ($P_{\text{DISCHARGE}} - P_{\text{OIL}}$) exceeds 2 bar (29 psid) indicating the filter needs to be replaced.

3.0 Low/Medium Temperature System Design Considerations (R-404A, R-407A, R-407C, R-407F, R-507A, R-448A, R-449A)

3.1 Refrigerants and Lubricants

Approved Refrigerants

The Paragon low/medium temperature duty screw compressor is specifically designed for use in single or parallel compressor systems.

Approved Lubricants

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

Approved Lubricant - Solest 170

Viscosity Grade - ISO 170

Assembly Grease

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

Approved Grease - Castrol Synplex GP2

Or

Approved Grease - Parker Super-O-Lube

Carrier Part Number - 19XL680001

Terminal Pin Dielectric Grease

Carlyle recommends that compressor motor terminal pins are coated with dielectric grease, P/N 06TT660050,

to reduce the effects of condensation which may form on the terminal pins.

3.2 Environmental Considerations

Operating Ambient Temperature

The screw compressor is designed for the following ambient temperature ranges:

Non-Operating: -40°F to 176°F (-40°C to 80°C)

Operating: -31°F to 131°F (-35°C to 55°C)

Salt-Spray Requirements

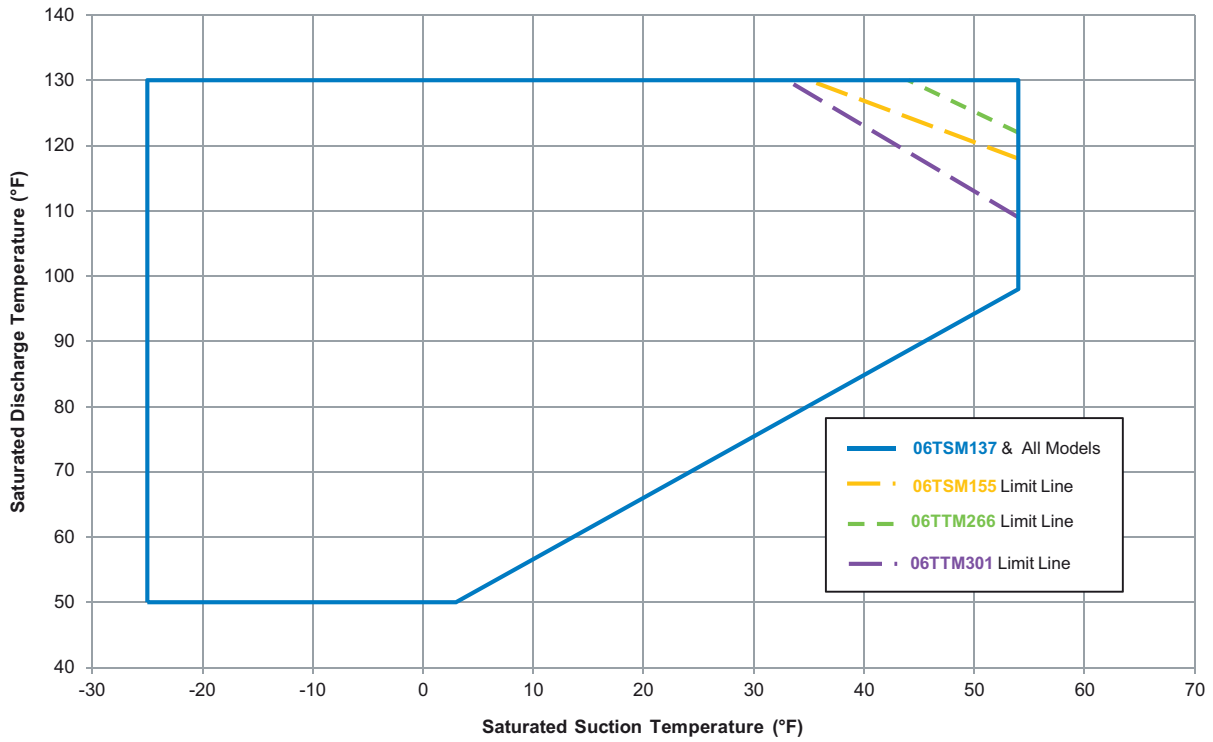
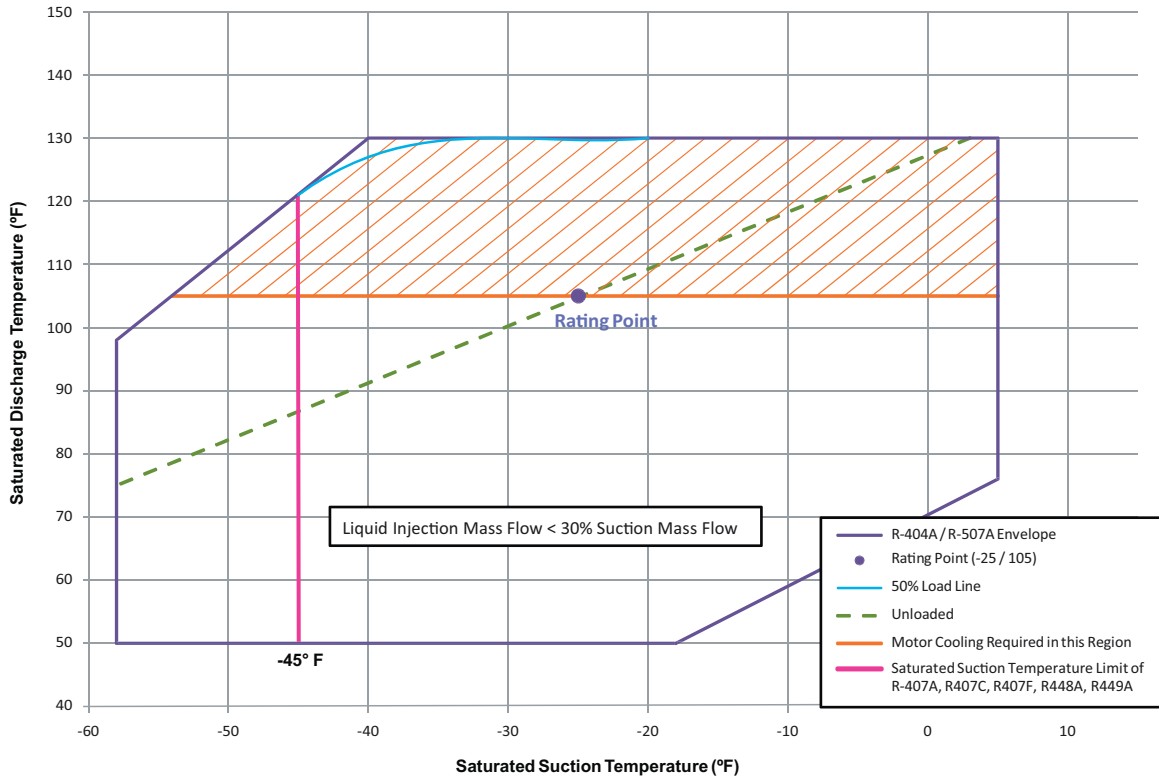
The compressor has been tested through 500 hours of salt-spray in compliance with ASTM specification B-117.

3.3 Operating Limits and Controls

Low and Medium Temperature Operating Envelopes

The following low and medium temperature operating envelopes show where the compressor can be operated in both water-cooled and air-cooled direct expansion applications. See Fig. 11 and 12.

The Motor Cooling and Discharge Gas De-Superheating lines are added to the envelopes to provide guidance for OEM customers.



Start-Up and Suction Pressure Transients

Operating a screw compressor without refrigerant flow through the compressor can be harmful. When this occurs, the evaporator typically will go into a vacuum, leading to very high pressure ratios and little mass flow to carry the heat away from the screw rotors. This situation most often occurs during start-up when the refrigerant may be in another part of the system. This is tolerable for short periods of time. The Paragon screw compressor should not be allowed to operate with a suction pressure less than 0 psig (vacuum) for more than 1 minute after a “cold” start. (Contact Carlyle Application Engineering for more information on cold starts.)

If a compressor is allowed to operate for longer periods of time without refrigerant flow, catastrophic damage may occur to the screw rotors, rotor housing, and discharge housing, requiring compressor replacement.

Oil Supply at Compressor

To reduce the possibility of liquid refrigerant becoming entrained in the oil during an OFF cycle, it is recommended that the temperature of the oil entering the compressor is kept above the outdoor ambient as shown in Fig. 13. See Section 4.0 for additional information.

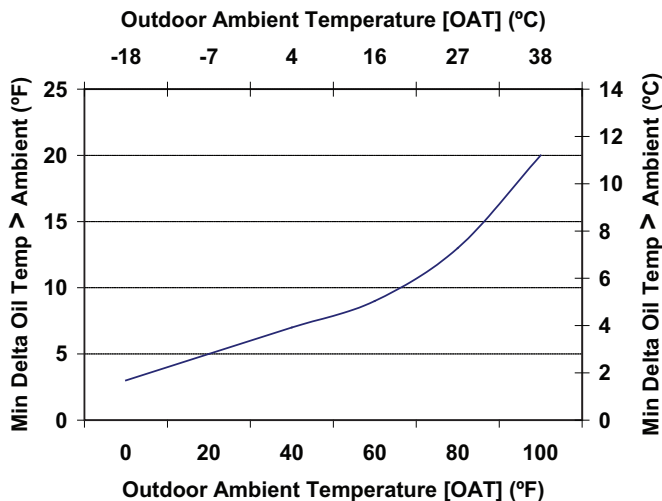


Fig. 13 — Oil Temperature

Allowable Temperature Ranges

See Table 7 for allowable temperature ranges.

Table 7 — Allowable Temperature Ranges

CONTROL POINT	MINIMUM	MAXIMUM
Discharge Gas	20°F (11°C) superheat	210°F (99°C)
Economizer Gas	Saturated Liquid	9°F (5°C) superheat
Suction Gas	Saturated Vapor	Can float if motor and discharge maximum temps are met
Oil Supply at Compressor	Refer to Fig. 13	140°F (60°C)
Motor Windings	No limit	275°F (135°C)

Unloader System Control Points

Table 8 shows the proper control states for the slide valve solenoids. See Fig. 14 for solenoid locations.

Table 8 — Solenoid Control States

	INCREASE CAPACITY	DECREASE CAPACITY	PARTIAL*
SOLENOID #1	Energized	De-Energized	De-Energized
SOLENOID #2	Energized	De-Energized	Energized

* Maintain capacity: Solenoid activation after proper slide valve position has been attained.

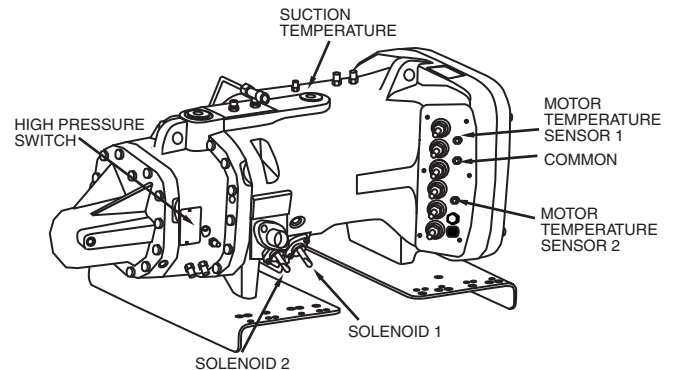


Fig. 14 — Solenoid Locations

The compressor will start with minimum power draw in the fully unloaded state. There is no minimum or maximum time limit immediately after start-up for which the compressor must operate in the unloaded state.

However, it is recommended that the compressor operates unloaded for a minimum load for 30 seconds just prior to shut down. This will ensure the compressor is fully unloaded on the subsequent start, and means that the compressor is drawing the minimum current when the contactors open to shut down the compressor.

Certain fully unloaded operating conditions may result in discharge gas temperatures which exceed the recommended operating parameters. Carlyle requires that some form of liquid injection be applied to control/reduce discharge gas temperatures to be within recommended guidelines. Common methods to accomplish this may include increased flow through the economizer circuit or direct liquid injection into the economizer port/tubing. Please refer to Refrigeration System Design Considerations at the end of this section. Also see Fig. 15 and Section 9.9.3 for additional information.

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 1 second.

Reverse rotation is most likely to occur at initial start-up or whenever the wiring to the compressor terminals is disturbed. To minimize the possibility for reverse rotation operation, Carlyle recommends the following procedures:

1. During initial run test of the unit, a suitable low-pressure switch should be temporarily installed on the high-pressure port of the compressor and be wired to open the compressor control circuit. 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 must be wired in the control circuit of the compressor start components to shut off the compressor in the event it is operating in reverse rotation. This switch would remain in place for the duration of the run test. At the end of the run test the switch would be removed for use on the next unit or compressor to be tested.
2. For service replacement compressors, a similar protection system is recommended. The unit service literature will make reference to this switch and provide instructions on how to temporarily install the low pressure switch into the safety circuit for the compressor. Each service compressor will be supplied with Installation Instructions documenting the procedure for installing and using the switch.

The switch will remain in place until the compressor has been started and direction of rotation has been verified, at this point the switch will be removed.

The low pressure switch must be suitable for the pressures consistent with R-404A systems, and the switch must be manually resettable and open when the pressure falls below 50 mm (2 inches) of vacuum. The switch is a "Manual Reset" type that can be reset only after the pressure has 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.

If a switch is not available, a manifold gage can be used so long as it is connected to the discharge housing of the compressor BEFORE THE DISCHARGE CHECK VALVE. If the compressor can be "bumped" or "jogged" very quickly (< 1 second) while someone is watching the gage, compressor rotation can be determined without damage to the compressor. If the pressure drops, the compressor is rotating backwards and will have to be rewired. If the pressure rises, the compressor is spinning in the correct direction.

Refrigeration System Design Considerations

In order to eliminate the possibility of refrigerant migrating into the oil separator and compressor, Carlyle requires the application of a positive-seal, discharge check valve (or a similar functioning device) to be installed in the discharge line after the oil separator. See Fig. 15.

Certain operating conditions may result in motor temperatures and/or discharge gas temperatures which exceed the recommended operating parameters.

Carlyle's solutions software can be used to estimate the discharge temperature for a given application. The oil cooler does offer some help in keeping the discharge and motor temperatures within their required limits. However, oil cooling alone is not sufficient to adequately control motor and discharge gas temperatures within their respective acceptable ranges.

Carlyle requires that some form of liquid injection be applied to control/reduce motor and discharge gas temperatures to be within recommended guidelines.

Motor cooling valves are available through Carlyle and they should be applied to inject liquid into the compressor suction line (see Fig. 15). For Paragon screw compressor applications, this injection is accomplished using a motor-cooling valve that injects liquid into the suction line entering the compressor.

Carlyle also offers de-superheating valves. These valves inject liquid at the economizer line or economizer port to assist in controlling discharge gas temperatures (see Fig. 15). For Paragon screw compressor applications, discharge gas temperature control is accomplished using a de-superheating valve that injects liquid into the economizer port or the economizer line (after the liquid refrigerant subcooler).

Because refrigerant injection for discharge gas cooling eventually flows into the screw rotor chamber after the suction gas is trapped, compressor capacity is not significantly affected.

Carlyle recommends a Sporlan Y-1037 de-superheating valve (or an equivalent) for operating conditions that require additional discharge gas de-superheating. The selected valve should be selected to start opening at a discharge temperature of 190°F (88°C) and be fully open at 200°F (93°C). The bulb should be located on the discharge line within 6 in. of the compressor discharge service valve. A properly sized solenoid valve should be located upstream to ensure positive shutoff when the compressor is off.

Please see Section 9.9.3 for de-superheating valve sizes and part number information.

Carlyle recommends the application of our qualified Safety Control Module package (Carlyle P/N 6BSB000929 [R-134a] and 6BSB000930 [R-404A, R-407A, R-407C, R-407F, and R-507A]), which provides the following safety control functionality:

- Discharge Temperature Monitoring
- Oil Level Monitoring (Optional)
- Reverse Rotation Monitoring
- Oil Flow-Rate/Supply Monitoring
- Capacity Control/Slide Valve Control

Technical documentation for this Safety Control Module package (P/N 6BSB000603) is provided on the Carlyle Website at www.carlylecompressor.com

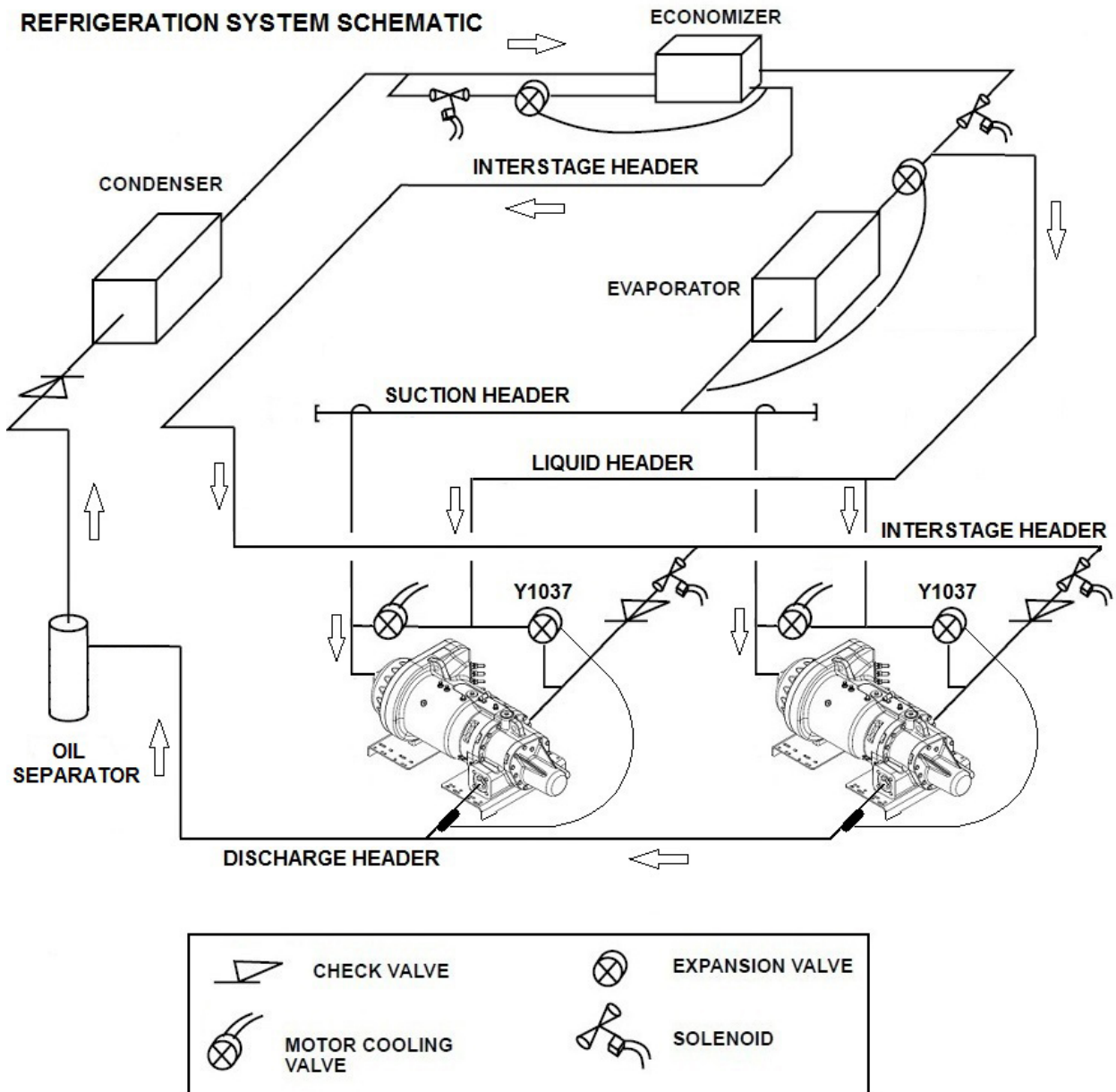


Fig. 15 — Refrigeration System Schematic

3.4 Control Points Summary

<p>Reverse Rotation / Operation with Suction Pressure in Vacuum</p> <ul style="list-style-type: none"> Control must detect and prevent reverse rotation of the compressor within 1 second of compressor start-up. Compressor must not operate in a vacuum, as measured at the suction pressure port, for greater than 1 minute.
<p>Oil Pressure Confirmation / Safety</p> <ul style="list-style-type: none"> Three pressures must be observed to ensure that the oil pressure is suitable for compressor operation: suction, discharge and oil. Oil pressure safety control must be manually reset. Oil pressure must be maintained as follows: <ol style="list-style-type: none"> $P_{OIL} > [0.7 \times (P_{DISCHARGE} - P_{SUCTION}) + P_{SUCTION}]$ $P_{OIL} > [P_{SUCTION} + 0.5 \text{ bar}]$ 15 seconds after start (Air-Cooled models; <i>A</i> in 5th digit of model numbers) $[P_{SUCTION} + 1.0 \text{ bar}]$ 45 seconds after start (Refrigeration models; <i>R</i> in 5th digit of model numbers) $[P_{SUCTION} + 1.0 \text{ bar}]$ 75 seconds after start (Water-Cooled models: <i>W</i> in 5th digit of model numbers)
<p>Oil Supply Confirmation / Oil Level Switch</p> <ul style="list-style-type: none"> Oil supply to the compressor must be maintained during operation at all times. Compressor operation must be stopped if the required oil level switch is open for 5 continuous seconds. Oil supply solenoid valve must be closed during OFF cycles.
<p>Oil Filter Differential Pressure</p> <ul style="list-style-type: none"> Compressor operation must be stopped if the pressure differential measured between the entering and leaving oil filter locations exceeds 2 bars. The oil filter supply tubing design should apply valves to allow for the isolation and replacement of the filter without removing the system refrigerant charge.
<p>Motor Temperature Limitation</p> <ul style="list-style-type: none"> Motor temperatures must be continuously monitored during compressor operation. Motor temperatures must not exceed 275°F (135°C). Liquid injection into the suction line may be required.
<p>Compressor Short Cycling</p> <ul style="list-style-type: none"> Control must provide for a minimum of 10 minutes time delay before restarting the Paragon compressor. The maximum number of compressor START cycles per hour is 6.
<p>Maximum Discharge Gas Temperature</p> <ul style="list-style-type: none"> Discharge gas temperatures must not exceed 210°F (99°C). Liquid injection into economizer inlet port may be required. Control must prevent compressor operation when discharge gas temperatures exceed this maximum.
<p>Maximum Oil Temperature</p> <ul style="list-style-type: none"> Oil temperatures must not exceed 115°F (46°C). Oil cooling will be required for most applications. Control must prevent compressor operation when oil temperatures exceed this maximum.
<p>Run-Proof</p> <ul style="list-style-type: none"> Current must be monitored to detect welded contacts on a contactor or single-phase condition. Oil flow must be resumed if a contactor is determined to be welded shut. Compressor must be shut down if a single-phase condition is detected.
<p>Liquid Line Solenoid / Economizer</p> <ul style="list-style-type: none"> A liquid line solenoid valve is required to shut off liquid flow to the compressor during OFF cycles. Controlling this valve allows for additional capacity reduction during low load conditions.
<p>Unloading Control</p> <ul style="list-style-type: none"> Control must be provided to the two unloader coils. These coils position the slide valve mechanism within the compressor and allow for infinite unloading valve positioning.
<p>Unloaded Shutdown</p> <ul style="list-style-type: none"> It is recommended that the compressor operate for 30 seconds fully unloaded prior to shut down. This ensures fully unloaded re-start will occur.

NOTE: Carlyle offers Compressor Protection Module package, PN 6BSB000603, which protects against reverse rotation, low oil flow and maximum discharge gas temperature. See Marketing Bulletin 14M-01 at www.carlylecompressor.com.

4.0 Low/Medium Temperature System Oil Management (R-404A, R-407A, R-407C, R-407F, R-507A, R-448A, R-449A)

Oil supply system components are shown in Fig. 16.

4.1 Oil Pressure Requirements

System pressure is used to generate the oil pressure required to lubricate bearings and provide the oil that acts as a seal between the screw rotors and the bores. Oil pressure is monitored continuously during compressor operation. The oil pressure must meet the following criteria, based on $P_{DISCHARGE}$, $P_{SUCTION}$ and P_{OIL} , as shown in Fig. 18, Oil System Schematic:

1. $P_{OIL} > [0.7 \times (P_{DISCHARGE} - P_{SUCTION}) + P_{SUCTION}]$
2. $P_{OIL} > [P_{SUCTION} + 0.5 \text{ bar}]$ 15 seconds after start (Air-Cooled C models; A in 5th digit of model numbers)
 $[P_{SUCTION} + 1.0 \text{ bar}]$ 45 seconds after start (Refrigeration models; R in 5th digit of model numbers)
 $[P_{SUCTION} + 1.0 \text{ bar}]$ 75 seconds after start (Water-Cooled models: W in 5th digit of model numbers)

The unit control system must monitor the oil pressure differential, as well as the operating condition, so the compressor can be shut down if the minimum requirements are not met for any duration exceeding 15 seconds.

This time delay has two functions: first, to avoid nuisance tripping during normal and transient operation, and second, to allow the system sufficient time to develop pressure differential during start-up.

The compressor must be shut down 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.

Carlyle offers a Compressor Protection Module package to provide protection against loss of oil flow, reverse-rotation, and elevated discharge gas temperature. Application of this package provides equal alternate protection to the method described above. The Carlyle R-404A Compressor Protection Module package part number is 6BSB000603.

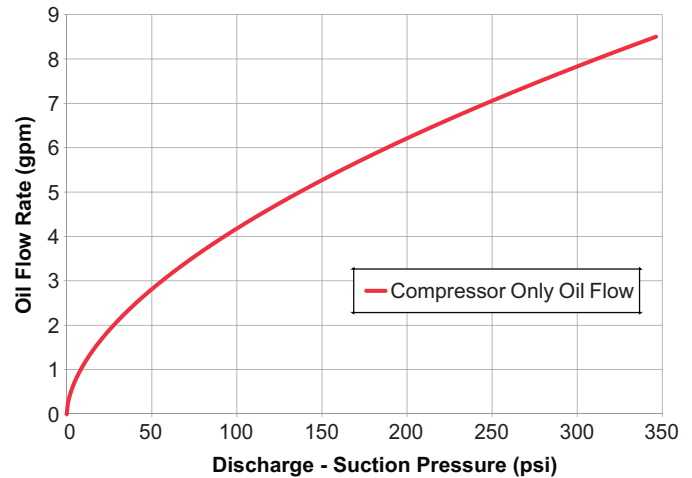


Fig. 16 — Oil Supply at Compressor

4.2 Oil Separator Recommendations

The low/medium temperature Paragon compressor will require an oil separator. The combined oil capacity of the oil separator sump, the oil reservoir, and the oil cooler will vary greatly depending on system design and the number of compressors applied. Carlyle recommends that the oil reservoir of the system is large enough to hold 4 gallons of oil for each compressor applied.

Contact Carlyle Application Engineering for additional oil separator information.

4.3 Oil Heater Recommendations

For the typical oil separators used with the Paragon compressor, a 500-watt flexible-band heater is recommended. The heater should be wired to operate when the compressor is OFF. This minimizes the migration of refrigerant to the oil stored in the oil separator reservoir. Carlyle recommends monitoring the temperature of the oil in the oil separator reservoir. If oil temperatures climb above 190°F (88°C), the heater element should be de-energized to prevent oil overheating.

Figure 13 shows the minimum oil temperatures that must be maintained when the compressor is not operating based on the outdoor ambient temperature (OAT).

4.4 Oil Level Safety Switch

An oil level safety switch must be installed in the sump of the oil separator or the oil reservoir, depending on the system design. Carlyle recommends a float style switch which opens if the oil level falls below a safe point.

Enough oil should remain in the sump when the switch is opened for the compressor to operate for at least one minute before completely running out of oil.

To reduce the possibility of false oil level alarms, Carlyle recommends that the oil level safety switch should be open continuously for five seconds prior to initiating a compressor shutdown.

4.5 Oil Filter

Provisions should be made to isolate the oil filter using some combination of shutoff valves and/or check valves. See Fig. 19.

This will allow for the filter element to be replaced without removing or isolating the charge in the unit. The oil filter must be installed after the oil cooler and as close to the compressor as feasible.

Because of the long bearing life requirements, filtration for this compressor is very stringent. The Beta Ratio for this filter is greater than or equal to 200 for a five micron particle size evaluated using ISO 16889.

Filter areas must also be sufficient to avoid premature clogging of the filter during normal operation. The Carlyle supplied filters have a filtration area of > 5000 cm². Carlyle recommends monitoring the pressure differential across the oil filter. An alarm should be activated if the differential pressure exceeds 2 bar (29 psig) and the oil filter should be replaced.

4.6 Oil Cooling Systems

Carlyle's 06TSR/TTR refrigeration-duty and 06TSM/TTM medium-temperature-duty compressor models require oil cooling for all operating points in the application envelope. The oil temperature entering the compressor is to be maintained at 115°F (46.1°C) at all times over the range of operation.

Be aware that air-cooled oil coolers may not be suitable for applications that have very high design saturated discharge temperatures. The maximum oil temperature entering the compressor is 115°F (46.1°C). If the design outdoor ambient air temperature for the application is greater than 115°F (46.1°C), an alternate oil cooling method should be selected.

Carlyle offers a complete line of air-cooled oil coolers to assist systems designers. Please see Section 9.9.1. A mixing valve is recommended for all oil coolers circuited through a remote air-cooled condenser.

4.7 Oil Cooler Selection

An oil cooler is required for all Paragon low/medium temperature screw compressor applications. As noted in Section 4.6, the maximum oil temperature entering the compressor may not exceed 115°F (46.1°C).

Carlyle's Solutions software calculates the oil cooler load based on the operating parameters and compressor models selected. The oil cooler must maintain the oil temperature entering the compressor at 115°F (46.1°C) maximum over the range of operation.

Several methods exist to control oil temperature, including:

- Oil cooler fan cycling based on oil outlet temperature (measured at the outlet of the oil cooler, controlled to 10 F Δ T)
- Oil cooler bypass, via a solenoid valve, controlled by the temperature of the oil entering the oil cooler.
- Use of a mixing valve to maintain a constant oil temperature entering the compressor.
- Some combination of the three methods listed above.

The oil may be cooled by means of air-cooled, refrigerant-cooled, or water-cooled oil coolers. Following are selection criteria for the various models, along with dimensional information.

If using a refrigerant-cooled oil cooler, the oil cooling load will need to be subtracted from either the compressor's evaporator capacity or the subcooling capacity, depending on where the oil cooler's suction gas flow enters the compressor. The superheated gas from refrigerant-cooled oil coolers may be connected to the economizer port or the suction line of the compressor.

Using a compressor suction port will lead to a reduction in system capacity since some of the compressor suction mass flow will now come from the oil cooler.

Using the compressor interstage port for oil cooling will not reduce the compressor suction pumping capacity, but will indirectly reduce system capacity by decreasing the compressor's ability to perform liquid subcooling.

The additional mass flow from the oil cooler to the interstage will increase the interstage pressure. This method will marginally raise the economizer pressure, which may increase the liquid temperature of the liquid refrigerant subcooler.

Both methods will require holdback valves to prevent the oil temperature from dropping below 80°F (27°C).

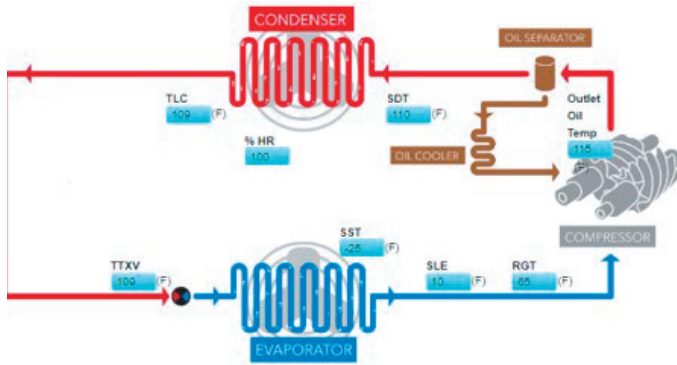
The heat rejected from the oil cooler may be used for heat reclaim processes, such as water heating. Since the oil cooler rejects some discharge heat, the heat rejection from the oil cooler must be considered when sizing the system condenser (unless a refrigerant-cooled oil cooler is used). This may allow the application of a smaller condenser.

Condenser circuiting may also be used for oil cooling; however, pressure drops must be taken into account for minimum oil pressure differential to the compressors.

4.8 Oil Cooler Sizing

An oil cooler is required for all LT and MT applications using R-404A, R-407A, R-407C, R-407F, and R-507A, and may be required for R-134a, depending on the

operating condition. Size the oil cooler by using Oil Cooling Load featured in the Carwin software (see Fig. 17 and Table 9 below).



Oil Cooling		Discharge Temperature	
Oil flow (gpm)	5.50	Td w/o Oil Cooling (F)	276
Oil Cooling Load(BTU/Hr)	93927.00	Td w/ Oil Cooling(F)	198
		Td Max (F)	190
Oil Separator		De-Superheating Load	
Oil Separator DCFM (cfm)	14.5	After Oil cooling(tons)	0.7

Fig. 17 — Carwin Software Interface Display

Table 9 — Available Oil Cooler Models

FAN SPEED	PART NUMBERS	OIL COOLING CAPACITY AT AMBIENT AIR TEMPERATURE			
		95°F (35°C)	100°F (38°C)	105°F (41°C)	110°F (43°C)
50 Hz	KH51ZZ181 (2 Compressors Max)*	32,200 Btu/Hr (9,405 W/Hr)	28,800 Btu/Hr (9,435 W/Hr)	27,300 Btu/Hr (8,438 W/Hr)	25,900 Btu/Hr (7,999 W/Hr)
	KH51ZZ182 (3 Compressors Max)*	63,700 Btu/Hr (18,664 W/Hr)	60,600 Btu/Hr (17,756 W/Hr)	57,600 Btu/Hr (16,877 W/Hr)	54,600 Btu/Hr (15,998 W/Hr)
	KH51ZZ183 (4 Compressors Max)*	94,900 Btu/Hr (27,805 W/Hr)	90,400 Btu/Hr (26,487 W/Hr)	85,900 Btu/Hr (25,168 W/Hr)	81,400 Btu/Hr (23,850 W/Hr)
	KH51ZZ184 (5 Compressors Max)*	123,400 Btu/Hr (26,156 W/Hr)	117,500 Btu/Hr (34,427 W/Hr)	111,600 Btu/Hr (32,699 W/Hr)	105,800 Btu/Hr (30,999 W/Hr)
60 Hz	KH51ZZ181 (2 Compressors Max)*	32,100 Btu/Hr (9,405 W/Hr)	30,600 Btu/Hr (8,966 W/Hr)	29,000 Btu/Hr (8,497 W/Hr)	27,600 Btu/Hr (8,087 W/Hr)
	KH51ZZ182 (3 Compressors Max)*	69,100 Btu/Hr (20,246 W/Hr)	65,700 Btu/Hr (19,250 W/Hr)	62,400 Btu/Hr (18,283 W/Hr)	59,100 Btu/Hr (17,316 W/Hr)
	KH51ZZ183 (4 Compressors Max)*	102,600 Btu/Hr (30,061 W/Hr)	97,700 Btu/Hr (28,626 W/Hr)	92,800 Btu/Hr (27,190 W/Hr)	87,900 Btu/Hr (25,755 W/Hr)
	KH51ZZ184 (5 Compressors Max)*	134,100 Btu/Hr (39,291 W/Hr)	127,700 Btu/Hr (37,416 W/Hr)	121,300 Btu/Hr (35,541 W/Hr)	114,900 Btu/Hr (33,665 W/Hr)

* Maximum number of compressors based on oil cooler pressure drop of less than 6 PSID (0.41 bar).

OIL SYSTEM SCHEMATIC

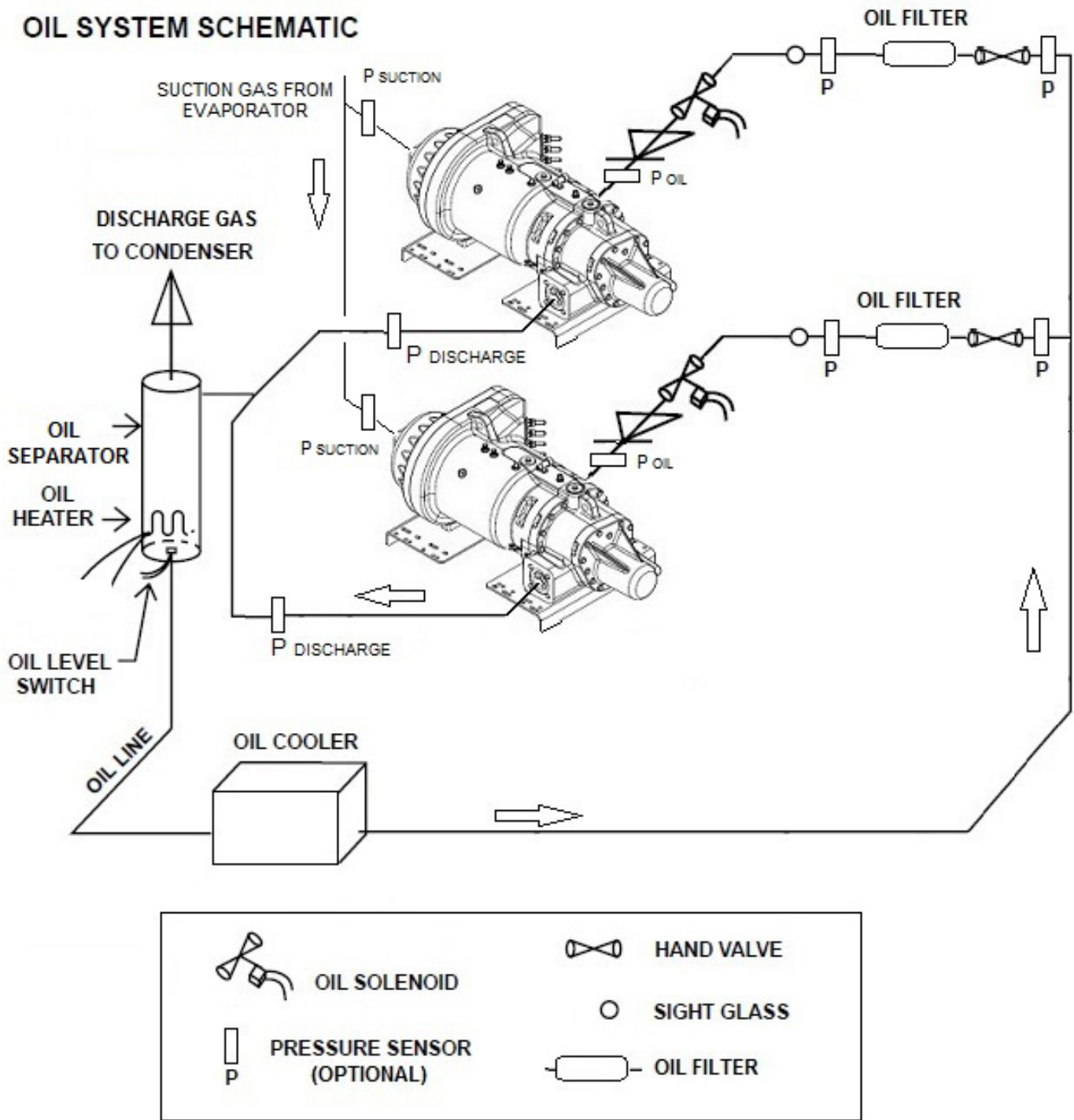


Fig. 18 — Oil System Schematic

5.0 Unloader Operation

All Paragon compressors come equipped with an infinitely adjustable slide valve unloading system. The actual capacity reduction will depend on the system operating conditions and the rebalance characteristics.

Two solenoids control the slide valve by allowing communication between the unloader piston chamber and either high pressure oil or low pressure suction.

- To fully load the compressor, both solenoid #1 and #2 are energized (see Fig. 19). This allows high-pressure oil to enter the unloader piston chamber, moving the slide valve and providing more engagement under the screw rotors. Both solenoids should remain energized to maintain the full load position.

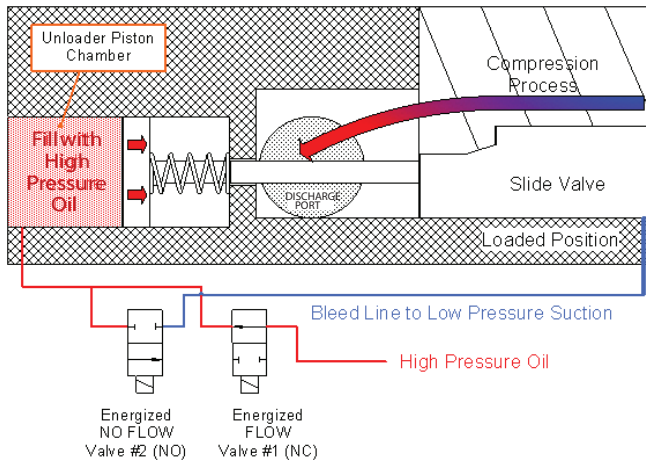


Fig. 19 — Fully Loaded Operation

- To unload the compressor, both solenoids are de-energized (Fig. 20). This exposes the unloader piston chamber to suction pressure, pulling the slide valve out from under the screw rotors and reducing the amount of compression being performed.

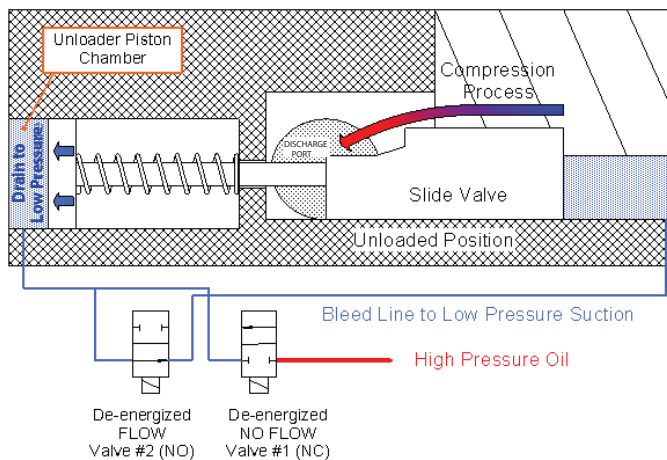


Fig. 20 — Configuration for Unloading

- Part load is achieved by stopping the load or unload process previously described at an intermediate slide valve position. Stopping the valve at an intermediate position is accomplished by de-energizing valve #1 and energizing valve #2 (Fig. 21). When this happens, both valves are closed and the piston is not allowed to move. Cycling of the solenoids may be required to compensate for leakages around the piston seal, etc.

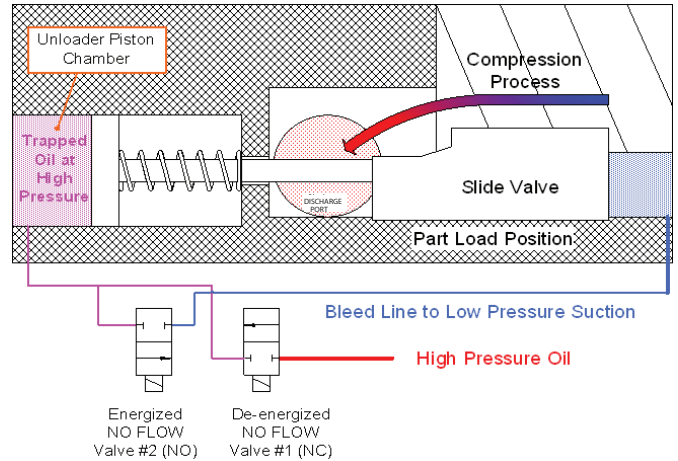


Fig. 21 — Configuration for Maintaining Part Load

The TU and TV water-cooled models have a hot gas bypass port on the slide valve. This feature allows discharge gas to leak back to suction through the slide valve when the slide valve is in the fully unloaded position. The hole is closed at all other load states. The purpose of this feature is to allow the compressor to unload to 15% of the full load capacity.

The compressor will start with minimum power draw in the fully unloaded state. There is no minimum or maximum time limit immediately after start-up for which the compressor must operate in the unloaded state. However, it is recommended that the compressor operates unloaded for a minimum load for 30 seconds just prior to shutdown. This will ensure the compressor is fully unloaded on the subsequent start, and means that the compressor is drawing the minimum current when the contactors open to shut down the compressor.

5.1 Unloader System Control Points

Table 10 shows the proper control states for the slide valve solenoids. See Fig. 22 for solenoid locations.

Table 10 — Proper Control States for Slide Valve Solenoids

	INCREASE CAPACITY	DECREASE CAPACITY	PARTIAL*
SOLENOID #1	Energized	De-Energized	De-Energized
SOLENOID #2	Energized	De-Energized	Energized

* Maintain capacity: Solenoid activation after proper slide valve position has been attained.

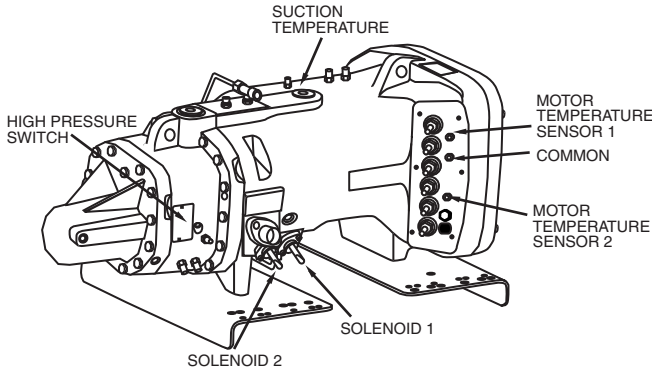


Fig. 22 — Solenoid Locations

5.2 Approximate Part Load Factors

Table 11 shows the typical relation of part load capacity and power at their respective rating conditions. Contact Carlyle Application Engineering for further information.

Table 11 — Typical Relation of Part Load Capacity

% FULL LOAD CAPACITY	AIR-COOLED (R-134a)	WATER-COOLED (R-134a)
	% FULL LOAD POWER	% FULL LOAD POWER
100	100	100
75	78	78
50	58	58
34	50	50
15	—	50

Certain fully unloaded operating conditions may result in discharge gas temperatures which exceed the recommended operating parameters. Carlyle requires that some form of liquid injection be applied to control/reduce discharge gas temperatures to be within recommended guidelines. Common methods to accomplish this may include increased flow through the economizer circuit or direct liquid injection into the economizer port/tubing.

5.3 Slide Valve Capacity Controller and Protection

5.3.1 General Description

The Carlyle Control Module (CCM) will function to control compressor capacity by operating the compressor's slide valve to maintain the system's control set point (suction pressure or temperature). This process control point is an input to the CCM. In addition, the CCM will have function-

ality to protect the compressor and provide LED fault status indication for:

- Oil Level Protection
- Oil Flow Protection
- Motor Cooling Protection
- Discharge Temperature Protection
- Transducer Sensor Failure
- Temperature Thermistor Failure

The following Paragon capacity and protection kits 6BSB000929 and 6BSB000930 are available through Carlyle. See Table 12. Detailed information regarding the Paragon Slide Valve controller may be found at www.carlylecompressor.com, Application Guide 575-012.

5.3.2 CCM Configuration

The CCM can be configured to function in the following 3 modes of operation:

1. Slide Valve Control and Compressor Protection (Default Setting).
2. Slide Valve Control only.
3. Compressor Protection only.

Configuring the CCM for options 2 or 3 can be accomplished through:

- Using the BACview¹ hand-held display unit.
- Downloading BACview software to a laptop.
- Setting up a communication port between the CCM and System Controller.

To allow easier transmission of data across a network between the CCM and the System Controller, the CCM is pre-configured with the following protocol networks:

- BACnet²
- Modbus³
- N2 Open
- LonWorks⁴ (requires optional card)
- RS485 Communication Port

1. BACview is a registered trademark of Automated Logic Corporation.
2. BACnet is a registered trademark of ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers).
3. Modbus is a registered trademark of Schneider Electric.
4. LonWorks is a registered trademark of Echelon Corporation.

Table 12 — Paragon Capacity and Protection Kits

CARLYLE P/N	DESCRIPTION	APPLICATION
6BSB000929	High Temperature Paragon Controller Kit	R-134a, R513A, R1234ze
6BSB000930	Low/Medium Temperature Paragon Controller Kit	R404A, R-407A, R-407C, R-407F, R-448A, R-449A, R-507A
USB-L	CCM Interface Cable	Cable interface between controller and laptop

5.3.3 CCM Inputs/Outputs

Software Version 1.5 Schematics

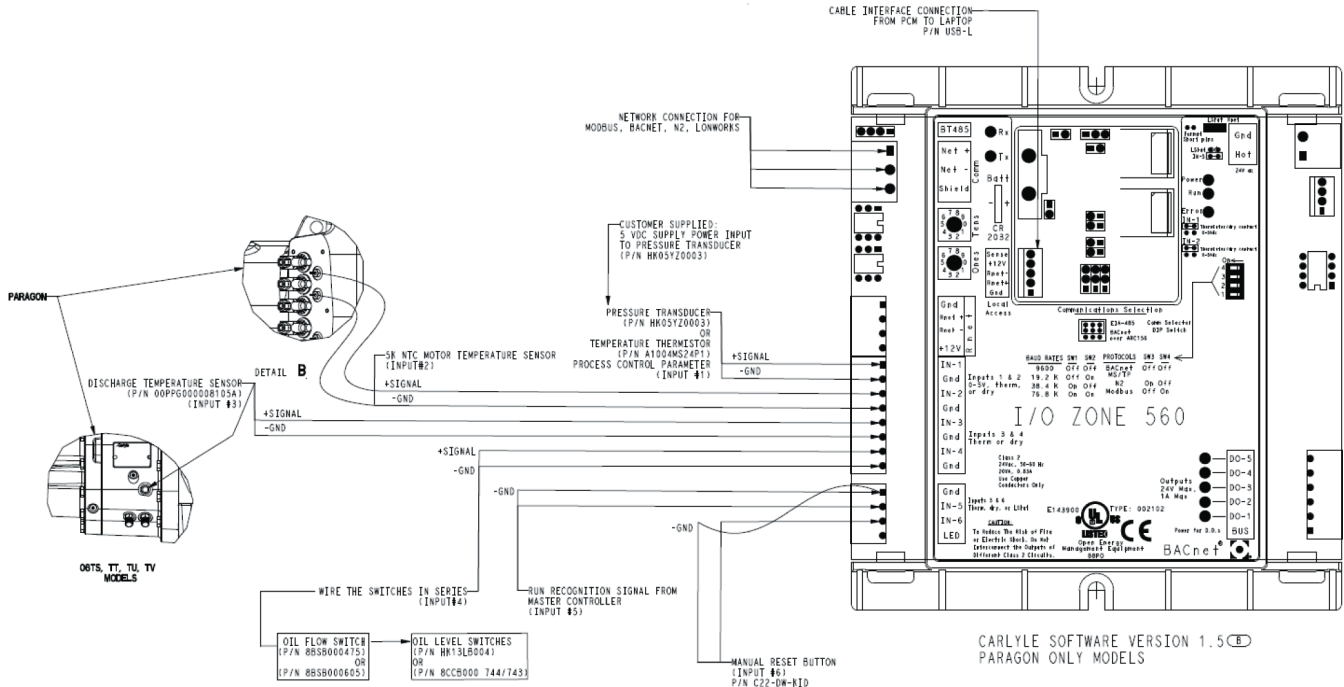


Fig. 23 — CCM Inputs, Version 1.5

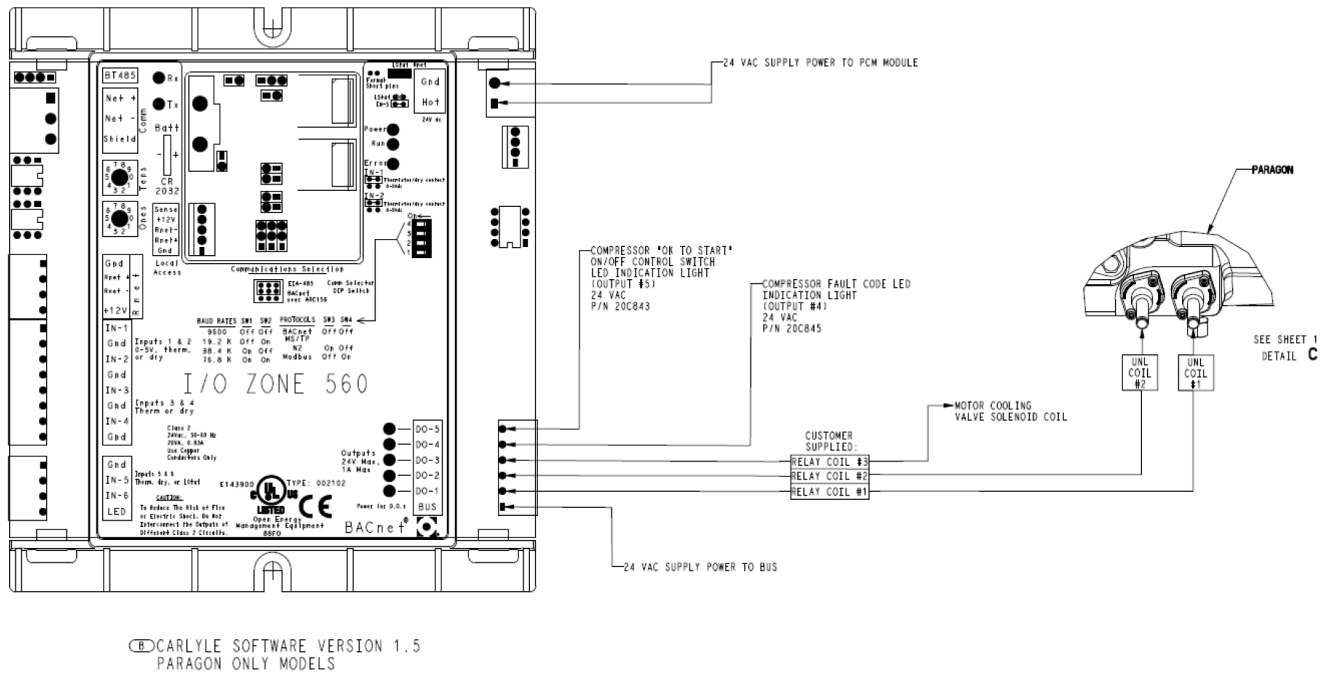


Fig. 24 — CCM Outputs, Version 1.5

5.3.4 CCM Inputs/Outputs

Software Version 2.0 Schematics

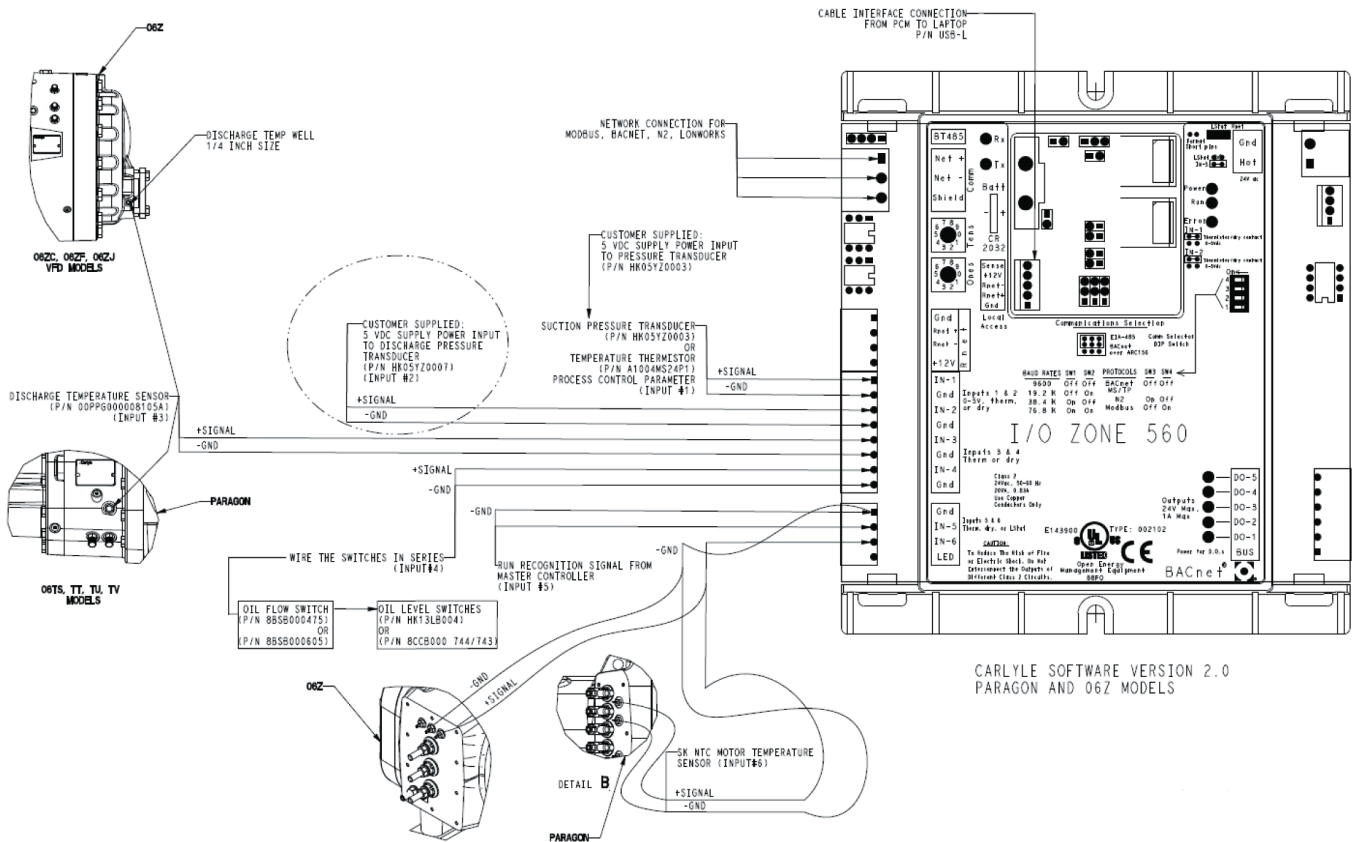


Fig. 25 — CCM Inputs, Version 2.0

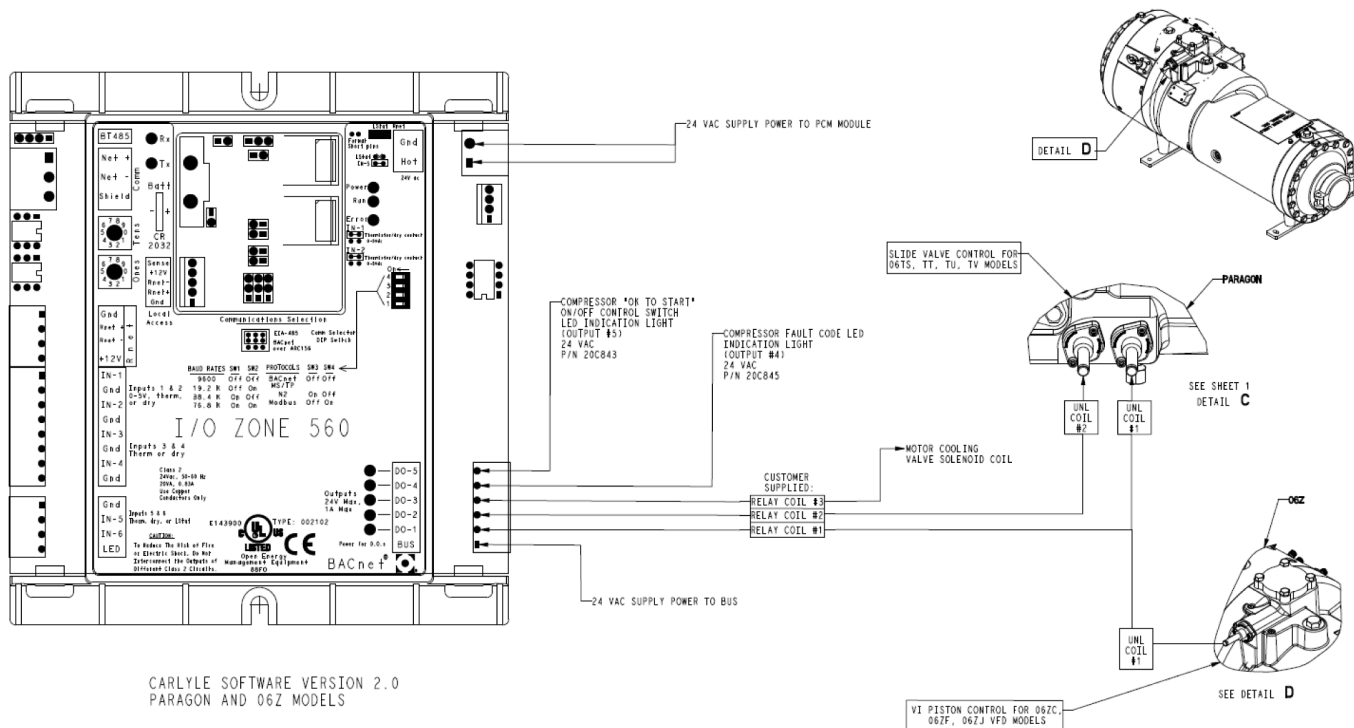


Fig. 26 — CCM Outputs, Version 2.0

5.3.4 Slide Valve Capacity Control

The CCM will have the ability to control the compressor slide valve for capacity control by loading/unloading the compressor to maintain the refrigeration system's process control set point. The set point can be defined in one of two ways: refrigerant suction pressure (psig) or a leaving water temperature (deg. F). The end user will have to configure the CCM in the following way:

1. Select Pressure or Temperature for the process control variable (default is Pressure).
2. Select Physical Input or Network Input (Network Input means the process control variable is not physically wired to the CCM, but the value is being passed via the network to the CCM as an input).
3. Input the process control set point value.
 - Allowable pressure range is -1.5 psig to 70 psig (-0.1 bar to 4.8 bar).
 - Allowable temperature range is -60°F to 80°F (-51°C to 27°C).
4. Steps 1, 2, 3 can be accomplished through:
 - Using the BACview hand-held display unit.
 - Downloading BACview software to a laptop.
 - Setting up a communication port between the CCM and System Controller.
5. The CCM slide valve control logic works with two upper and two lower dead-bands. The lower and upper dead-bands are adjustable control inputs to customize the capacity control algorithm per the application.

CCM Slide Valve Control Logic

The CCM slide valve control logic works with two upper and two lower deadbands. The lower and upper deadbands are adjustable control inputs to customize the capacity control algorithm per the application. The numbered phases below correspond with those that appear in Fig. 27.

1. On Process Point rise above the Upper DB-1 deadband, the CCM will energize both unloader coils to load the compressor and increase capacity until the process point falls below Upper DB-2.

Slide Valve Coil #1-Energized

Slide Valve Coil #2 -Energized

2. If the Process Point decreases to the Upper DB-2 deadband limit, the CCM will stop the compressor from loading by de-energizing coil #1, fixing the slide valve position and keeping the compressor capacity constant.

Slide Valve Coil #1-De-energized

Slide Valve Coil #2 -Energized

NOTE: As long as the Process Point remains between the Upper DB-2 and Lower DB-3 deadband

limits, the slide valve will not move, but remain fixed, keeping the compressor capacity constant.

Slide Valve Coil #1-De-energized

Slide Valve Coil #2 -Energized

3. If the Process Point continues to fall and reaches the Lower DB-4 deadband limit, the CCM will de-energize both unloader coils to unload the compressor and decrease compressor capacity.

Slide Valve Coil #1-De-energized

Slide Valve Coil #2 -De-energized

4. Both unloader coils will remain De-energized until the suction pressure rises to the Lower DB-3 deadband limit. This will stop compressor unloading, stopping the slide valve from moving and keeping the compressor capacity constant.

Slide Valve Coil #1-De-energized

Slide Valve Coil #2 -Energized

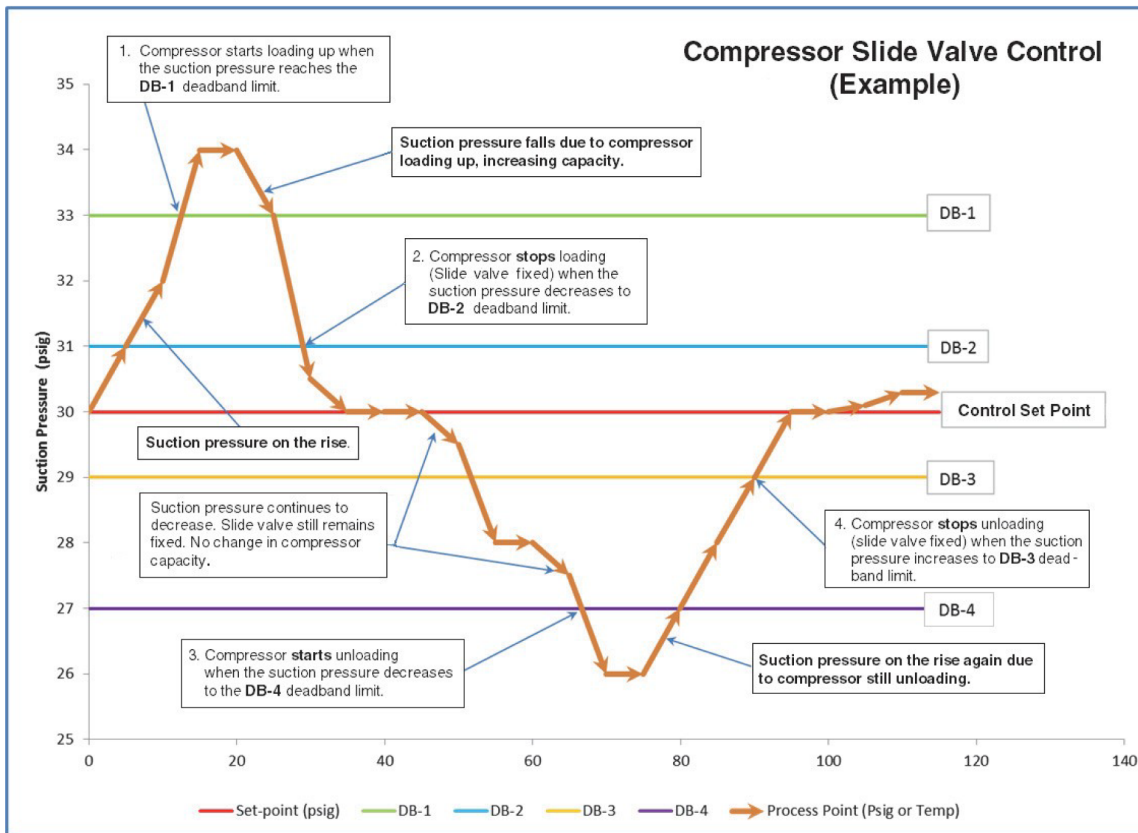


Fig. 27 — Paragon Slide Valve Control Illustration

5.3.5 Compressor Protection

Motor and discharge temperature control for a screw compressor is critical. Excessive motor and discharge gas temperatures can cause premature compressor failure; therefore, control of these temperatures is very important. The CCM monitors these temperatures through the use of the factory-installed 5K thermistor in the motor windings and a field-installed 5K thermistor in the compressor discharge temperature thermo-well. When the thermistors indicate an overheated condition, the CCM will perform the following:

- Energize a liquid injection valve, sending cool liquid into the motor compartment.
- Override the Slide Valve and restrict the compressor from unloading and or force the compressor to fully load to reduce motor and or discharge temperature.
- Trip the compressor off.

Motor Temperature (T_m) will have the following functions:

- Control a motor cooling valve to provide liquid injection to the motor compartment.

- Override the compressor slide valve to reduce motor temperature.
- Turn the compressor off on an overheated motor temperature condition.
- See Table 13: Motor and Discharge Temperature Control Points and Table 14: Slide Valve Override Control Points for T_m control points.

Motor Temperature (T_d) will have the following functions:

- Override the compressor slide valve to reduce discharge temperature.
- Turn the compressor off on a high discharge temperature condition.
- See Table 13: Motor and Discharge Temperature Control Points and Table 14: Slide Valve Override Control Points for T_d control points.

5.3.6 LED Fault Indication

The CCM will provide an LED alarm output signal to the System Controller when a compressor fault condition arises. See Tables 15 and 16.

Table 13 — Motor and Discharge Temperature Control Points

ALC CONTROLLER	INJECTION ON (°F)	INJECTION OFF (°F)	SHUTDOWN COMPRESSOR (°F)	MANUALLY RESET COMPRESSOR (°F)	TIME DELAY REQUIRED BEFORE MANUAL RESET (SEC)
Discharge Temperature (Td)	N/A	N/A	Td > 225	Td < 175	30
Motor Cooling Temperature (Tm)	Tm > 240	Tm < 225	Tm > 270	Tm < 225	30

Table 14 — Slide Valve Override Control Points

ALC CONTROLLER	RESTRICT FURTHER COMPRESSOR UNLOADING Energize SV Coil #2 Continuously (°F)	FULLY LOAD COMPRESSOR AND RESTRICT UNLOADING BELOW 100% Energize SV Coil #1 and Coil #2 Continuously (°F)
SV - Discharge Temperature (Td)	200 < Td < 215 (discontinue SV override when Td < 198)	Td > 215 (discontinue SV override when Td < 213)
SV - Motor Cooling Temperature (Tm)	245 < Tm < 260 (discontinue SV override when Tm < 243)	Tm > 260 (discontinue SV override when Tm < 258)

LEGEND

SV— Slide Valve

Table 15 — Fault Codes for Software Version 1.5

FAULT DESCRIPTION	LED INDICATION (OUTPUT#4)	OUTPUT #5	COMPRESSOR	MANUAL RESET REQUIRED
High Discharge Temperature Trip	Solid red	Opens/De-energized	OFF	Yes
High Motor Temperature Trip	Constant blinking	Opens/De-energized	OFF	Yes
Compressor Oil Trip	One blink and 2-second pause	Opens/De-energized	OFF	Yes
Faulty Transducer/ Thermistor Slide Valve Sensor	One blink and 2-second pause	Opens/De-energized	OFF	Yes
Faulty Motor Temperature Thermistor	Three blinks and 2-second pause	Opens/De-energized	OFF	Yes
Faulty Discharge Temperature Thermistor	Four blinks and 2-second pause	Opens/De-energized	OFF	Yes

Table 16 — Fault Codes for Software Version 2.0

FAULT DESCRIPTION	LED INDICATION (OUTPUT#4)	OUTPUT #5	COMPRESSOR	MANUAL RESET REQUIRED
High Discharge Temperature Trip	Solid red	Opens/De-energized	OFF	Yes
High Motor Temperature Trip	Constant blinking	Opens/De-energized	OFF	Yes
Compressor Oil Trip	One blink and 2-second pause	Opens/De-energized	OFF	Yes
Faulty Transducer/ Thermistor Slide Valve Sensor	One blink and 2-second pause	Opens/De-energized	OFF	Yes
Faulty Motor Temperature Thermistor	Three blinks and 2-second pause	Opens/De-energized	OFF	Yes
Faulty Discharge Temperature Thermistor	Four blinks and 2-second pause	Opens/De-energized	OFF	Yes
Faulty Discharge Pressure Transducer	Five blinks and 2-second pause	Opens/De-energized	OFF	Yes

5.3.7 CCM Controller Display Features

The CCM controller requires the user to install the Virtual BACview6 software to their laptop. This software can be obtained at www.carlylecompressor.com under software. Once installed, using the USB-L interface cable, the user can configure and setup the controller, view inputs, outputs, status, and fault codes.

BACview6 Virtual Display

The virtual BACview software (see Fig. 28) simulates the BACview6 Handheld keypad and display. It has all the

same functionality as the BACview6 device except that it is a software-based application that is easily displayed on any laptop.

Once the BACview6 software is installed, the user will use the 12-ft interface cable (Carlyle Part# USB-L) to communicate between the laptop and the CCM. Drivers are supplied with the USB-L cable. Install the drivers to the laptop. See Fig. 29. This is also covered in the BACview User Guide.

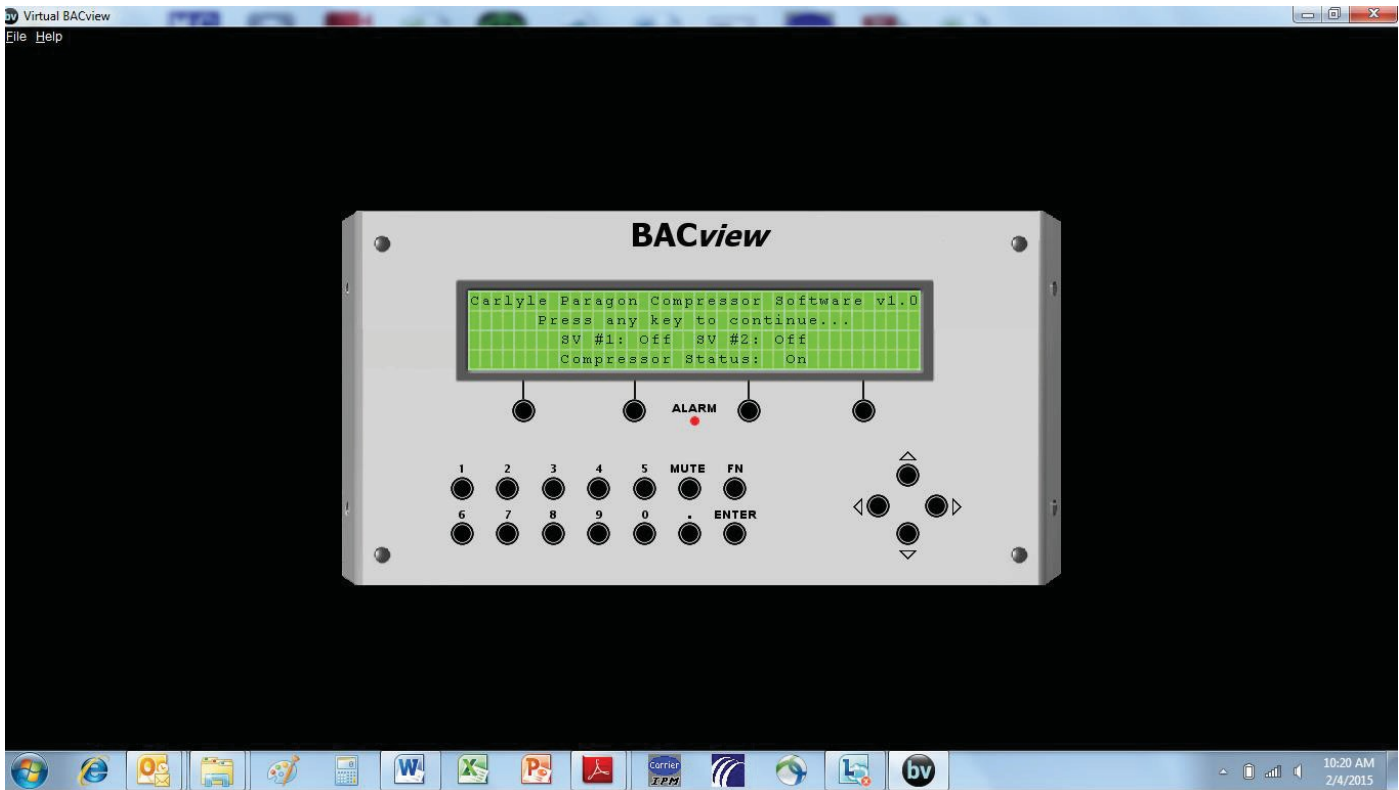


Fig. 28 — BACview6 Laptop Display

Connect the USB-Link to the computer and to the controller's **Local Access** port.

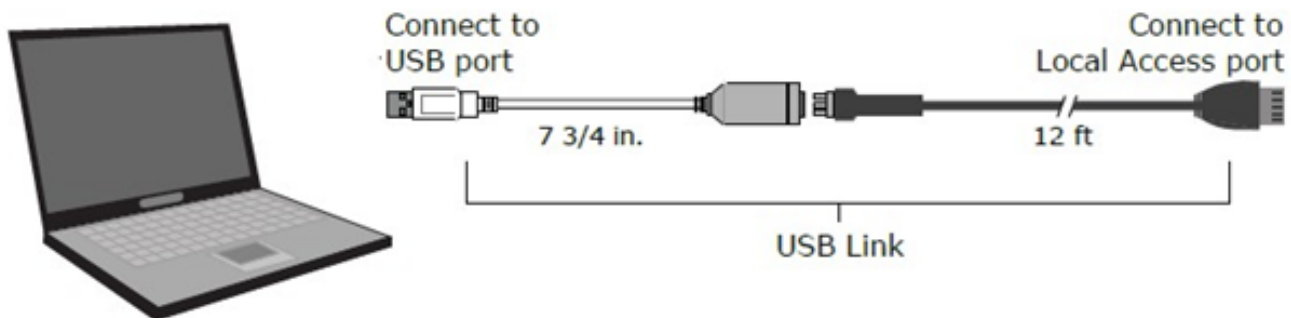


Fig. 29 — Laptop-to-BACview6 Connection Schematic

5.1.1 General Installation

The CCM can mount directly inside the compressor's electrical box as shown in Fig. 30.

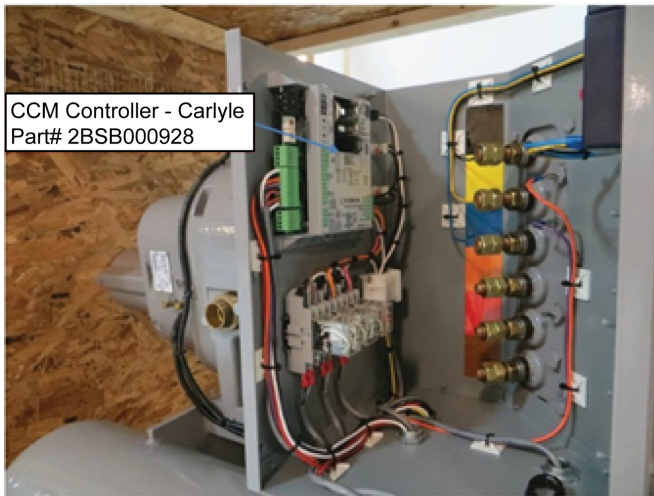


Fig. 30 — CCM Mounted inside Compressor Box

6.1 Compressor Requirements

The compressor is designed to meet the UL and ASHRAE safety code for refrigeration compressors. The manufacturing facilities for the compressor conduct pressure burst tests in accordance with ASHRAE-15, UL safety codes and the Pressure Equipment 97/23/CEE directive.

6.2 Design Pressures

Pressure Relief Valve

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) for R-134a and greater than 30 bar (435 psid) for R-404A. The valve will close and seal again after the pressure difference falls below the set value.

Hydrostatic Design Pressures

The design pressures for the compressor castings are listed in Table 17.

Table 17 — Compressor Design Pressures

PRESSURE TYPE	APPLICATION	DISCHARGE	ECONOMIZER	SUCTION
Hydrostatic Burst Test Pressure (BURST)	R-134a Water-Cooled	950 psig (6.6 MPa)	540 psig (3.7 MPa)	440 psig (3.0 MPa)
	R-134a Air-Cooled	1470 psig (10.1 MPa)	610 psig (4.2 MPa)	440 psig (3.0 MPa)
	R-404A LT Ref	1770 psig (12.2 MPa)	1040 psig (7.2 MPa)	870 psig (6.0 MPa)
Proof Test Pressure (TP)	R-134a Water-Cooled	465 psig (3.2 MPa)		
	R-134a Air-Cooled			
	R-404A LT Ref			
Maximum Operating Pressure (MOP)	R-134a Water-Cooled	190 psig (1.3 MPa)	108 psig (0.7 MPa)	61 psig (0.4 MPa)
	R-134a Air-Cooled	294 psig (2.0 MPa)	122 psig (0.8 MPa)	51 psig (0.4 MPa)
	R-404A LT Ref	354 psig (2.4 MPa)	116 psig (0.8 MPa)	38 psig (0.3 MPa)
Leak Test Pressure (AP)	R-134a Water-Cooled	310 psig (2.1 MPa)		
	R-134a Air-Cooled			
	R-404A LT Ref			
UL60335-2-34 Design Pressure (DP)	R-134a Water-Cooled	190 psig (1.3 MPa)	108 psig (0.7 MPa)	88 psig (0.6 MPa)
	R-134a Air-Cooled	294 psig (2.0 MPa)	122 psig (0.8 MPa)	88 psig (0.6 MPa)
	R-404A LT Ref	354 psig (2.4 MPa)	116 psig (0.8 MPa)	176 psig (1.2 MPa)

LEGEND

LT — Low Temperature Refrigeration

NOTE: All pressures listed are gage pressures. Add 14.7 psi (0.1 MPa) to obtain absolute pressure, if necessary.

7.0 Variable Frequency Drive Guidelines

7.1 Scope

Carlyle has conducted an extensive qualification program for our R-134a compressors and has approved most compressors for VFD applications. A summary of the qualified models is presented in Table 18.

Table 18 —Variable Speed Model Summary

MODEL NUMBER	APPROVED FOR VARIABLE SPEED	
	AIR-COOLED	WATER-COOLED ³
06TS-137	Note 1 and 2	N/A
06TS-155	YES	N/A
06TS-186	YES	N/A
06TT-266	YES	Note 1
06TT-301	YES	Note 1
06TT-356	YES	Note 1
06TU-483	YES	YES, Note 3
06TU-554	YES	YES, Note 3
06TV-680	YES	YES, Note 3
06TV-753	Note 2	YES, Note 3
06TV-819	YES	Note 2 and 3

NOTES:

1. See Application Engineering as approval is limited to certain applications.
2. See Application Engineering as compressor has been approved but limited performance data is available.
3. Standard model cannot be used for VFD applications. The “VS” model must be ordered, which is identified by an “X” in the 5th digit of the model number.
4. Variable speed operation is approved for all low/medium temperature R-404A, R-407A, R-407C, R407F, R-448A, R-449A, and R-507A.

It may be possible to have the drive provide the compressor motor protection, replacing the compressor overloads. Carlyle Application Engineering should be contacted to verify that the overcurrent protection meets Carlyle's requirements for UL-rated motor overload protection and to verify the required overload settings.

It is important to work with the drive manufacturer to select a drive appropriate for the application. Refrigeration screw compressors provide a constant torque loading to the drive and also have unique starting torque requirements. The drive should not be sized on the nominal HP rating of the compressor, but based on the nominal electrical data, including RLA and LRA (available in Section 8.3), along with the operating power and amperage at the max load design condition. It is important that the appropriate criteria are taken into consideration when selecting the type and size of the drive.

It is also important to review items associated with the wiring of the compressor and associated control system wiring, as special precautions may be required to avoid interference between the drive and other control wiring. There may also be restrictions on the length and routing of the wires from the drive to the compressor. These items should be reviewed with the drive manufacturer to

ensure all application guidelines are followed when installing the drive.

7.2 Capacity Control

The compressors have been approved with an allowable speed range from 30 to 60 Hz. The capacity at 30 Hz will be approximately 50% of the full load capacity and will vary linearly in direct proportion to the speed.

It is possible to operate the compressors with a combination of slide valve and VFD control. The compressor can be operated at minimum speed of 30 Hz and the slide valve used for further unloading as long as appropriate discharge and motor temperature limits are observed. The compressor slide valve should remain in the fully loaded position while the VFD is controlling compressor capacity between 30 to 60 Hz. The slide valve may be used to reduce compressor capacity below 50% (30hz) if required.

Discharge Temperature

1. Compressor must be forced to 100% load if discharge temperature $\geq 200^{\circ}\text{F}$ (93.3°C).
2. Unloading control must limit further unloading if discharge temperature $\geq 190^{\circ}\text{F}$ (87.8°C)

Motor Temperature

1. Compressor must be forced to 100% load if motor temperature $\geq 265^{\circ}\text{F}$ (129.4°C).
2. Unloading control must limit further unloading if motor temperature $\geq 260^{\circ}\text{F}$ (126.7°C)

NOTE: Different temperature limits may be required depending on the accuracy and response time of the sensors and control system that is used as well as the overall stability of the system and desired safety factor.

7.3 Power Supply

The variable speed drive should fix the output voltage based on a constant Volts-per-Hz curve running through the nominal voltage (380V/60Hz, 460V/60Hz) regardless of the nominal voltage supplied to the drive. The drive should maintain a constant V-Hz over the range of operation and should limit the speed of the drive if the appropriate voltage cannot be maintained. Over voltage should be limited to +10% and under voltage limited to -15%. Under voltage should limit the speed (Hz) until the constant V-Hz curve is reached. Over voltage should limit operation at the maximum speed, 60 Hz. The VFD should also limit the amperage of the compressor to $\geq 90\%$ of the MCC (maximum continuous current) value (lower amperage limits may be applied depending on the application). It may be necessary to limit the speed of the

compressor at high load conditions, especially if operating below the nominal voltage.

Figure 31 shows two sample voltage curves showing compressor motor voltage (V) versus operating speed

(Hz). As shown in the graph, the motor voltage is lowered at lower operating speeds while maintaining a fixed Volts/Hz value.

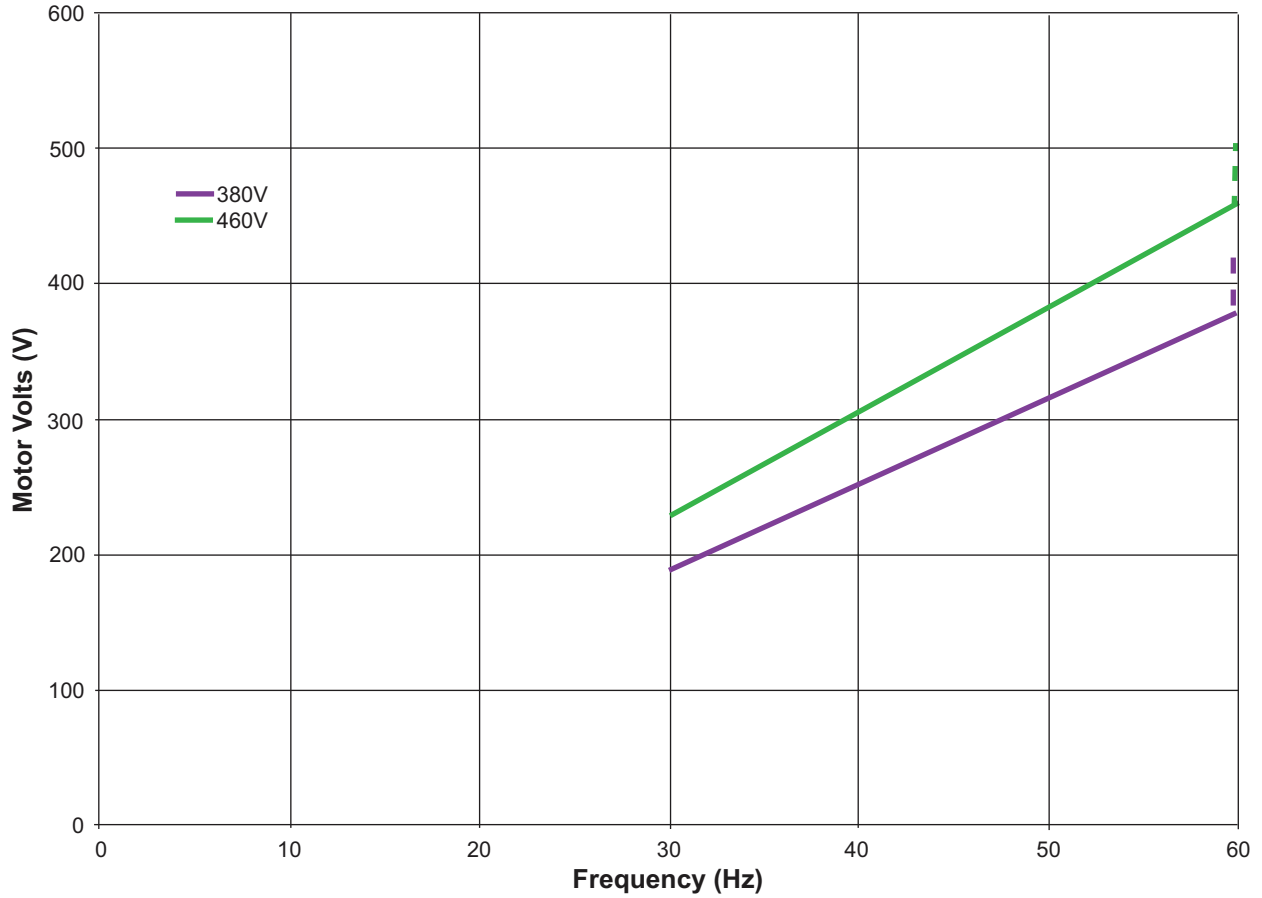


Fig. 31 — Sample Compressor Motor Voltage Curves

8.0 Compressor Electrical Data

8.1 Allowable Voltage Range

The motors for the Paragon compressor are designed to function in the voltage ranges listed in Table 19.

Table 19 — Compressor Motor Voltage Range

VOLTAGE CODE	60 Hz			50 Hz		
	NOMINAL	MIN	MAX	NOMINAL	MIN	MAX
S	460	396	506	400	342	440
				690*	592	762
T	575	518	633	—	—	—
W	380	342	418	—	—	—
	690*	592	762			
X	230	198	253	200	180	220
Z	200	180	220	—	—	—

* For Wye connected motors only.

8.2 Electrical Connection Requirements

Power Connections

The compressor terminals are copper feed-through pins with M12 metric threads for all models (except for low-voltage versions of the 06TU and 06TV model types, which have M16 metric threads).

Torque specifications are as follows:

- 15 to 20 lb-ft (20-27 Nm) on the TS, TT, TU and TV compressors with 12 mm pins
- 20 to 25 lb-ft (27-34 Nm) on low voltage (< 375 V) TU and TV compressors with 16 mm pins

Power wires are connected to the terminal pins using ring terminals and jam nuts. The power connection system is designed for nominal line voltages up to 575 volts. The motor temperature thermistors and a separate 12 mm grounding lug connection are located in the terminal pin area. Terminal and sensor pin layout on the compressor is shown in Fig. 32 and 33.

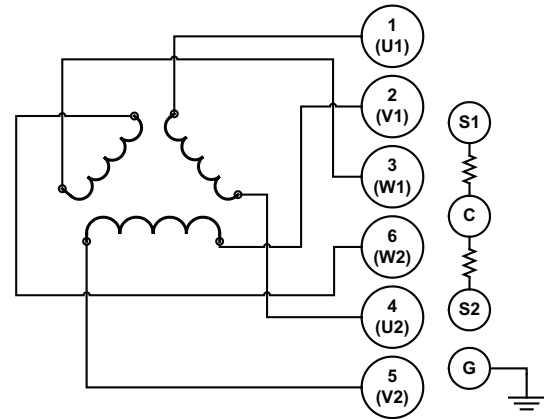


Fig. 32 — Terminal and Sensor Pin Layout

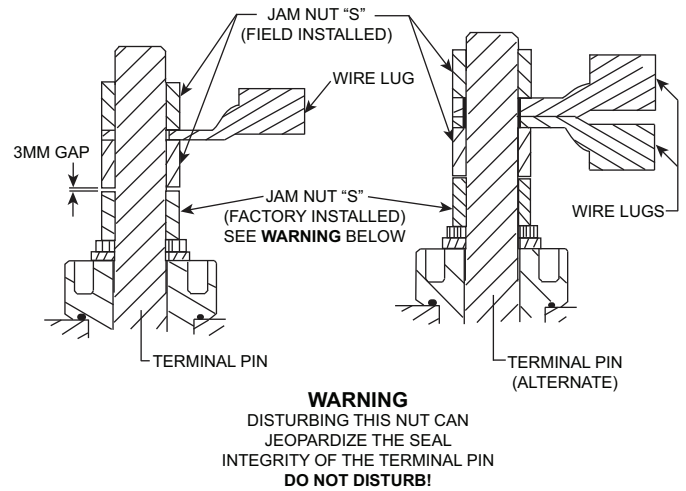


Fig. 33 — Terminal Pin Cross Section

The Paragon compressor is approved for use with across-the-line, open, and closed transition Wye-delta applications.

Across-the-Line Starting

Table 20 shows the wiring configuration for an across-the-line (XL), delta configuration.

Table 20 — Across-the-Line, Delta Configuration Wiring

CONNECTION	L1	L2	L3	TIE TOGETHER
Start (delta)	1, 6 (U1, W2)	2, 4 (V1, U2)	3, 5 (W1, V2)	—
Run (delta) (same as start)	1, 6 (U1, W2)	2, 4 (V1, U2)	3, 5 (W1, V2)	—

Wye-Delta Starting (Open Transition)

There are two critical timing parameters associated with starting the Paragon 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 no case should 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 the values given in Table 21 for single compressor circuits. A shorter duration may be required if compressor must start against head pressure. 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.

Table 21 — Maximum Transition Time

MODEL	MAXIMUM TRANSITION TIME
TS	0.035 seconds
TT	0.055 seconds
TU	0.060 seconds
TV	0.060 seconds

Table 22 shows the wiring configuration for an open transition wye-delta start configuration.

Table 22 — Wye-Delta Start Configuration Wiring

CONNECTION	L1	L2	L3	TIE TOGETHER
Start (wye) (5 seconds)	1 (U1)	2 (V1)	3 (W1)	4, 5, 6 (U1, V2, W2)
Run (delta)	1, 6 (U1, W2)	2, 4 (V1, U2)	3, 5 (W1, V2)	—

Motor Windings 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 5000 ohms at 77°F (25°C). All Paragon compressor motors are supplied with a spare thermistor to be used if the primary thermistor fails. Table 23 lists the resistance versus temperature characteristics. Additional information regarding this sensor can be obtained from Carlyle Application Engineering.

Table 23 — Resistance vs Temperature

TEMPERATURE			RESISTANCE
C	±C	F	ohms
-30	.35	-22	88480.0
-25	.33	-13	65205.0
-20	.30	-4	48536.0
-15	.28	5	36476.0
-10	.20	14	27663.0
-5	.20	23	16325.0
5	.20	41	12696.0
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

8.3 Motor Data

See Tables 24-27 for motor data.

Table 24 — Air-Cooled Motor Data R-134a, R-1234ZE & R-513A

COMPRESSOR BASE MODELS	MOTOR SIZE (HP AT 60 Hz)	MOTOR VOLTAGE (VOLTS-PH-FREQ)	RLA	LRA	
				WYE	DELTA
06TSA137	60	460-3-60	89	162	505
		400-3-50	86	160	500
		690-3-50	50	289	NOTE 2
		575-3-60	68	130	404
		380-3-60	103	196	611
		690-3-60	59	353	NOTE 2
		230-3-60	178	324	1010
		200-3-50	163	320	1000
06TSA155	75	460-3-60	100	174	545
		400-3-50	96	170	530
		690-3-50	58	306	NOTE 2
		575-3-60	76	139	436
		380-3-60	116	211	660
		690-3-60	67	381	NOTE 2
		230-3-60	200	348	1090
		200-3-50	183	340	1060
06TSA186	75	460-3-60	116	174	545
		400-3-50	112	170	530
		690-3-50	65	306	NOTE 2
		575-3-60	89	139	436
		380-3-60	135	211	660
		690-3-60	78	381	NOTE 2
		230-3-60	233	348	1090
		200-3-50	213	340	1060
06TTA266	120	460-3-60	165	298	930
		400-3-50	159	303	945
		690-3-50	92	546	NOTE 2
		575-3-60	126	238	744
		380-3-60	191	361	1126
		690-3-60	105	650	NOTE 2
		230-3-60	330	596	1860
		200-3-50	303	606	1890
06TTA301	150	460-3-60	187	382	1190
		400-3-50	181	388	1210
		690-3-50	105	699	NOTE 2
		575-3-60	143	306	952
		380-3-60	217	462	1441
		690-3-60	120	832	NOTE 2
		230-3-60	375	764	2380
		200-3-50	344	776	2420
		200-3-60	412	879	2737

Table 24 — Air-Cooled Motor Data R-134a, R-1234ZE & R-513A (cont)

COMPRESSOR BASE MODELS	MOTOR SIZE (HP AT 60 Hz)	MOTOR VOLTAGE (VOLTS-PH-FREQ)	RLA	LRA	
				WYE	DELTA
06TTA356	150	460-3-60	226	382	1190
		400-3-50	218	388	1210
		690-3-50	126	699	NOTE 2
		575-3-60	173	306	952
		380-3-60	262	462	1441
		690-3-60	144	832	NOTE 2
		230-3-60	452	764	2380
		200-3-50	414	776	2420
		200-3-60	497	879	2737
06TUA483	225	460-3-60	314	578	1800
		400-3-50	303	587	1828
		690-3-50	175	1055	NOTE 2
		575-3-60	240	462	1440
		380-3-60	363	700	2179
		690-3-60	200	1258	NOTE 2
		230-3-60	628	1156	3600
		200-3-50	576	1174	3656
		200-3-60	691	1329	4140
06TUA554	225	460-3-60	360	578	1800
		400-3-50	347	587	1828
		690-3-50	201	1055	NOTE 2
		575-3-60	275	462	1440
		380-3-60	417	700	2179
		690-3-60	230	1258	NOTE 2
		230-3-60	720	1156	3600
		200-3-50	660	1174	3656
		200-3-60	792	1329	4140
06TVA680	340	460-3-60	462	623	1900
		400-3-50	438	629	1919
		690-3-50	555	1108	NOTE 2
06TVA753	340	460-3-60	506	623	1900
		400-3-50	487	629	1919
		690-3-50	579	1108	NOTE 2
06TVA819	340	460-3-60	517	623	1900
		400-3-50	504	629	1919
		690-3-50	571	1108	NOTE 2

LEGEND

- FREQ** — Frequency
- HP** — Horsepower
- LRA** — Locked Rotor Amps
- PH** — Phase
- RLA** — Rated Load Amps

NOTES:

1. Please contact Carlyle Application Engineering for proper motor protection device.
2. Delta wiring is not applicable for the selected voltage.

Table 25 — Water-Cooled Motor Data R-134a, R-1234ZE & R-513A

COMPRESSOR BASE MODELS	MOTOR SIZE (HP AT 60 Hz)	MOTOR VOLTAGE (VOLTS-PH-FREQ)	RLA	LRA	
				WYE	DELTA
06TTW266	90	460-3-60	124	229	715
		400-3-50	120	233	726
		690-3-50	69	419	NOTE 2
		575-3-60	95	183	572
		380-3-60	144	277	866
		690-3-60	83	500	NOTE 2
		230-3-60	249	458	1430
		200-3-50	228	466	1452
		200-3-60	274	527	1645
06TTW301	90	460-3-60	139	229	715
		400-3-50	134	233	726
		690-3-50	77	419	NOTE 2
		575-3-60	106	183	572
		380-3-60	161	277	866
		690-3-60	89	500	NOTE 2
		230-3-60	278	458	1430
		200-3-50	255	466	1452
		200-3-60	306	527	1645
06TTW356	120	460-3-60	161	298	930
		400-3-50	155	303	945
		690-3-50	90	546	NOTE 2
		575-3-60	123	238	744
		380-3-60	186	361	1126
		690-3-60	107	650	NOTE 2
		230-3-60	322	596	1860
		200-3-50	295	606	1890
		200-3-60	354	685	2139
06TUW483	160	460-3-60	199	408	1270
		400-3-50	186	414	1290
		690-3-50	108	745	NOTE 2
		575-3-60	159	326	1016
		380-3-60	240	494	1537
		690-3-60	132	888	NOTE 2
		230-3-60	397	816	2540
		200-3-50	371	828	2580
		200-3-60	457	938	2921

Table 25 — Water-Cooled Motor Data R-134a, R-1234ZE & R-513A (cont)

COMPRESSOR BASE MODELS	MOTOR SIZE (HP AT 60 Hz)	MOTOR VOLTAGE (VOLTS-PH-FREQ)	RLA	LRA	
				WYE	DELTA
06TUW554	160	460-3-60	223	408	1270
		400-3-50	209	414	1290
		690-3-50	121	745	NOTE 2
		575-3-60	179	326	1016
		380-3-60	270	494	1537
		690-3-60	149	888	NOTE 2
		230-3-60	447	816	2540
		200-3-50	417	828	2580
		200-3-60	514	938	2921
06TVW680	225	460-3-60	280	578	1800
		400-3-50	261	587	1828
		690-3-50	151	1055	NOTE 2
		575-3-60	224	462	1440
		380-3-60	338	700	2179
		690-3-60	186	1258	NOTE 2
		230-3-60	559	1156	3600
		200-3-50	522	1174	3656
		200-3-60	643	1329	4140
06TVW753	225	460-3-60	310	578	1800
		400-3-50	289	587	1828
		690-3-50	168	1055	NOTE 2
		575-3-60	248	462	1440
		380-3-60	375	700	2179
		690-3-60	206	1258	NOTE 2
		230-3-60	619	1156	3600
		200-3-50	579	1174	3656
		200-3-60	712	1329	4140
06TVW819	225	460-3-60	330	578	1800
		400-3-50	308	587	1828
		690-3-50	179	1055	NOTE 2
		575-3-60	264	462	1440
		380-3-60	400	700	2179
		690-3-60	220	1258	NOTE 2
		230-3-60	660	1156	3600
		200-3-50	617	1174	3656
		200-3-60	759	1329	4140

LEGEND

- FREQ** — Frequency
- HP** — Horsepower
- LRA** — Locked Rotor Amps
- PH** — Phase
- RLA** — Rated Load Amps

NOTES:

1. Please contact Carlyle Application Engineering for proper motor protection device.
2. Delta wiring is not applicable for the selected voltage.

Table 26 — Low Temperature Motor Data

COMPRESSOR BASE MODELS	MOTOR SIZE (HP AT 60 Hz)	MOTOR VOLTAGE (VOLTS-PH-FREQ)	RLA							LRA	
			404A	407A	407C	407F	507A	448A	449A	WYE	DELTA
06TSR137	60	460-3-60	101	90	85	87	106	93	83	162	505
		400-3-50	98	80	76	123	100	90	74	160	500
		690-3-50	57	46	44	50	58	52	42	289	NOTE 1
		575-3-60	78	72	68	99	85	72	66	130	404
		380-3-60	117	109	103	149	128	108	100	196	611
		690-3-60	67	60	57	82	71	62	55	353	NOTE 1
		230-3-60	203	159	153	174	200	171	146	324	1010
		200-3-50	186	180	171	247	212	187	166	320	1000
		200-3-60	223	206	196	284	244	205	190	373	1162
06TSR155	75	460-3-60	108	97	93	118	113	99	89	174	545
		400-3-50	119	87	84	146	108	109	80	170	530
		690-3-50	72	51	49	69	63	66	47	306	NOTE 1
		575-3-60	82	77	74	117	90	75	71	139	436
		380-3-60	126	117	112	176	137	116	108	211	660
		690-3-60	73	65	62	97	75	67	60	381	NOTE 1
		230-3-60	217	175	168	237	216	209	161	348	1090
		200-3-50	227	194	185	291	226	200	178	340	1060
		200-3-60	239	223	213	355	260	220	205	400	1254
06TSR186	75	460-3-60	124	113	107	151	129	114	104	174	545
		400-3-50	120	102	96	176	122	110	94	170	530
		690-3-50	69	59	49	87	71	63	54	306	NOTE 1
		575-3-60	95	90	74	140	103	87	83	139	436
		380-3-60	144	136	112	213	156	132	125	211	660
		690-3-60	73	75	62	117	86	67	69	381	NOTE 1
		230-3-60	249	204	168	301	244	209	188	348	1090
		200-3-50	227	225	185	351	258	229	207	340	1060
		200-3-60	273	259	213	404	297	251	238	400	1254
06TTR266	120	460-3-60	190	179	171	213	195	175	165	298	930
		400-3-50	183	165	159	239	185	168	152	303	945
		690-3-50	106	95	92	123	107	98	87	546	NOTE 1
		575-3-60	145	143	137	191	156	133	132	238	744
		380-3-60	220	216	207	289	236	202	199	361	1126
		690-3-60	121	119	114	159	130	111	109	650	NOTE 1
		230-3-60	380	329	317	426	370	321	303	596	1860
		200-3-50	349	357	342	477	390	350	328	606	1890
200-3-60	418	411	393	549	449	385	378	685	2139		

Table 26 — Low Temperature Motor Data (cont)

COMPRESSOR BASE MODELS	MOTOR SIZE (HP AT 60 Hz)	MOTOR VOLTAGE (VOLTS-PH-FREQ)	RLA							LRA	
			404A	407A	407C	407F	507A	448A	449A	WYE	DELTA
06TTR301	150	460-3-60	210	199	193	249	215	193	183	382	1190
		400-3-50	203	185	180	218	205	187	170	388	1210
		690-3-50	118	107	104	127	119	109	98	699	NOTE
		575-3-60	160	159	154	199	172	147	146	306	952
		380-3-60	243	240	233	301	260	224	221	462	1441
		690-3-60	135	132	129	166	143	124	121	832	NOTE
		230-3-60	421	369	360	437	410	355	339	764	2380
		200-3-50	386	397	386	497	430	387	365	776	2420
		200-3-60	462	457	443	572	495	425	420	879	2737
06TTR356	150	460-3-60	238	227	218	284	243	219	209	382	1190
		400-3-50	229	211	203	260	231	211	194	388	1210
		690-3-50	132	122	118	151	134	121	112	699	NOTE
		575-3-60	182	181	174	227	194	167	167	306	952
		380-3-60	275	274	263	344	294	253	252	462	1441
		690-3-60	151	151	145	189	162	139	139	832	NOTE
		230-3-60	475	422	407	521	462	400	388	764	2380
		200-3-50	435	453	435	568	486	437	417	776	2420
		200-3-60	523	521	500	653	559	481	479	879	2737

LEGEND

- FREQ** — Frequency
- HP** — Horsepower
- LRA** — Locked Rotor Amps
- PH** — Phase
- RLA** — Rated Load Amps

NOTES:

1. Please contact Carlyle Application Engineering for proper motor protection device.
2. Delta wiring is not applicable for the selected voltage.

Table 27 — Medium Temperature Motor Data

COMPRESSOR BASE MODELS	MOTOR SIZE (HP AT 60 Hz)	MOTOR VOLTAGE (VOLTS-PH-FREQ)	RLA							LRA	
			404A	407A	407C	407F	507A	448A	449A	WYE	DELTA
06TSM137	75	460-3-60	123	110	104	150	129	113	101	174	545
		400-3-50	111	91	86	99	113	102	84	170	530
		690-3-50	65	52	50	57	66	60	48	306	NOTE 1
		575-3-60	99	91	86	126	108	91	84	139	436
		380-3-60	149	139	131	190	163	137	128	211	660
		690-3-60	82	73	70	100	87	75	67	381	NOTE 1
		230-3-60	223	191	183	209	240	205	176	340	1060
		200-3-50	246	218	207	299	257	226	201	348	1090
		200-3-60	283	261	249	360	310	260	240	400	1254
06TSM155	75	460-3-60	126	103	98	155	120	116	89	174	545
		400-3-50	118	95	92	129	118	109	80	170	530
		690-3-50	68	48	46	65	60	63	47	306	NOTE 1
		575-3-60	101	95	91	144	111	93	71	139	436
		380-3-60	152	141	135	212	165	140	108	211	660
		690-3-60	84	75	71	112	86	77	60	381	NOTE 1
		230-3-60	235	181	174	245	224	216	161	340	1060
		200-3-50	252	225	215	338	262	232	178	348	1090
		200-3-60	290	271	258	406	315	267	205	400	1254
06TTM266	150	460-3-60	228	215	205	287	234	210	198	382	1190
		400-3-50	216	195	188	251	218	199	179	388	1210
		690-3-50	125	112	108	145	126	115	103	699	NOTE 1
		575-3-60	183	180	173	241	197	168	166	306	952
		380-3-60	276	271	260	363	296	254	249	462	1441
		690-3-60	152	149	143	200	163	140	137	832	NOTE 1
		230-3-60	433	408	393	529	459	398	375	776	2420
		200-3-50	456	428	410	572	468	420	394	764	2380
		200-3-60	525	516	494	690	564	483	475	879	2737
06TTM301	150	460-3-60	228	216	210	270	233	210	183	382	1190
		400-3-50	217	198	192	233	219	200	170	388	1210
		690-3-50	126	114	111	136	127	116	98	699	NOTE 1
		575-3-60	183	182	176	228	197	168	146	306	952
		380-3-60	276	273	265	342	295	254	221	462	1441
		690-3-60	152	149	145	187	161	140	121	832	NOTE 1
		230-3-60	434	415	405	491	461	399	339	776	2420
		200-3-50	456	430	418	538	466	420	365	764	2380
		200-3-60	525	519	503	650	563	483	420	879	2737

LEGEND

FREQ — Frequency
HP — Horsepower
LRA — Locked Rotor Amps
PH — Phase
RLA — Rated Load Amps

NOTES:

1. Please contact Carlyle Application Engineering for proper motor protection device.
2. Delta wiring is not applicable for the selected voltage.

9.0 Compressor Accessories

See Table 28 for universal accessory kit part numbers.

Table 28 — Universal Accessory Kit (for all Paragon models)

CARLYLE PART NUMBER	COMPRESSOR USAGE			
	TS	TT	TU	TV
06TT660093	X	X	X	X

NOTE: One kit required for each compressor ordered.

9.1 Oil Separators

9.1.1 Horizontal Oil Separators/Accessories

Compact Over/Under

CARLYLE PART NUMBER	COMPRESSOR USAGE							
	06TS*137	06TS*155	06TS*186	06TT*266	06TT*301	06TT*356	06TU*483	06TU*554
8BSB000643	X	X	X	X	X			
8BTB000644						X	X	X

Side-Mount

CARLYLE PART NUMBER	COMPRESSOR USAGE							
	06TS*137	06TS*155	06TS*186	06TT*266	06TT*301	06TT*356	06TU*483	06TU*554
8BSB000704	X	X	X	X	X			
8BTB000705						X	X	X

Side-Mount

CARLYLE PART NUMBER	COMPRESSOR USAGE		
	06TV*680	06TV*713	06TV*819
8BVB000787	X	X	X

9.2 Vertical Oil Separator Kit (for TS and TT models only)

CARLYLE PART NUMBER	COMPRESSOR USAGE			
	TS	TT	TU	TV
06TT660094	X	X	N/A	N/A

NOTE: One kit required for each compressor ordered.

P/N 06TT660094	Vertical Oil Separator Kit	QTY
HK13LB004	Oil Level Float	1
5H40-391	Oil Separator Heater insert, 230V	1
KH31ZZ212	Vertical Oil Separator	1

9.3 Horizontal Oil Separator Kit (for all Paragon models)

CARLYLE PART NUMBER	COMPRESSOR USAGE			
	TS	TT	TU	TV
06TT660095	X	X	X	X

NOTE: One kit required for each compressor ordered.

P/N 06TT660095	Horizontal Oil Separator Kit	QTY
HT38KN007	Oil Separator Heater wrap, 230V	1
8CCB000742	Oil Level Sensor	1
8CCB000744	Oil Level Electronic unit (230 V)	1

9.4 Compressor Components Kit

CARLYLE PART NUMBER	COMPRESSOR USAGE			
	TS	TT	TU	TV
6BSA000320	X			
6BTA000321		X		
6BUA000322			X	
6BVA000804				X

NOTE: One kit required for each compressor ordered.

9.5 Compressor Protection and Slide Valve Capacity Control Kits

PART NUMBER	DESCRIPTION	WEIGHT (LBS)	APPLICATION
6BSB000929	High Temperature Controller Kit	5	R-134a, R-513A, R-1234ze
6BSB000930	Low/Medium Temperature Controller	5	R-404A, R-407A, R-407C, R-407F, R-507A, R-448A, R-449A
USB-L	Interface Cable	1	All

NOTES:

- One Compressor Protection Module package required per compressor.
- The interface cable is required to connect/configure the included module to a PC. The cable is also required for Field Service to read information from the module.

9.6 Service Valves

9.6.1 Suction/Discharge Service Valve Package

Flanged Union, Solder Type, Cast Iron Valve Body

CARLYLE PART NUMBER	NOMINAL TUBE SIZE (in.)	COMPRESSOR USAGE		
		TS	TT	TU
06TT660064	2 ⁵ / ₈	D		
06TT660065	3 ¹ / ₈	S	D	
06TT660066	4 ¹ / ₈		S	D

LEGEND

- D** — Discharge
S — Suction

9.7 Motor Protection Devices

PART NUMBER	QUANTITY/PACKAGE	WEIGHT (lb)	CURRENT (AMPS)
06EA907185	1	2	10-40
06EA907186	1	2	25-100
06EA907187	1	2	50-200

One motor overload is required per compressor. The overload follows a 958-trip curve
 Installation instructions are provided with the overload part.

9.8 Oil Coolers

9.8.1 Air-Cooled Oil Coolers

CARLYLE PART NUMBER	COMPRESSOR USAGE			
	TS	TT	TU	TV
KH51ZZ181	X	X	X	X
KH51ZZ182	X	X	X	X
KH51ZZ183	X	X	X	X
KH51ZZ184	X	X	X	X

NOTE: All low temperature duty Paragon compressors require oil cooling. Contact Carlyle Application Engineering for sizing information.

Oils

PART NUMBER	USAGE	QUANTITY
SOLEST170-1G	Low/Medium Temperature — 06TSR, 06TTR	1-Gallon Container
SOLEST170-5G	Low/Medium Temperature — 06TSR, 06TTR	5-Gallon Container
P903-2301*	Medium/High Temperature — 06TSA, 06TTA, 06TUA, 06TVA	1-Gallon Container
P903-2305	Medium/High Temperature — 06TSA, 06TTA, 06TUA, 06TVA	5-Gallon Container

* Minimum order is quantity of 4, 1-gallon container.

10.0 Packaging and Storage Requirements

10.1 Packaging

Packaging for the Paragon screw compressor utilizes a wooden pallet and shrink-wrap plastic.

10.2 Shipping

All compressors that are shipped within the U.S. or internationally will be unstacked (single layer).

10.3 Storage

Although the Paragon compressors are painted to meet the 500 hours salt spray requirement, it is preferable to store the compressors indoors where they are shielded from the weather. Outdoor storage is permissible as long as temperatures stay within a temperature range of 40°F to 176°F (40°C to 80°C).

10.4 Weights and Dimensions

Compressor weights and dimensions are shown in Table 29. See also Fig. 34.

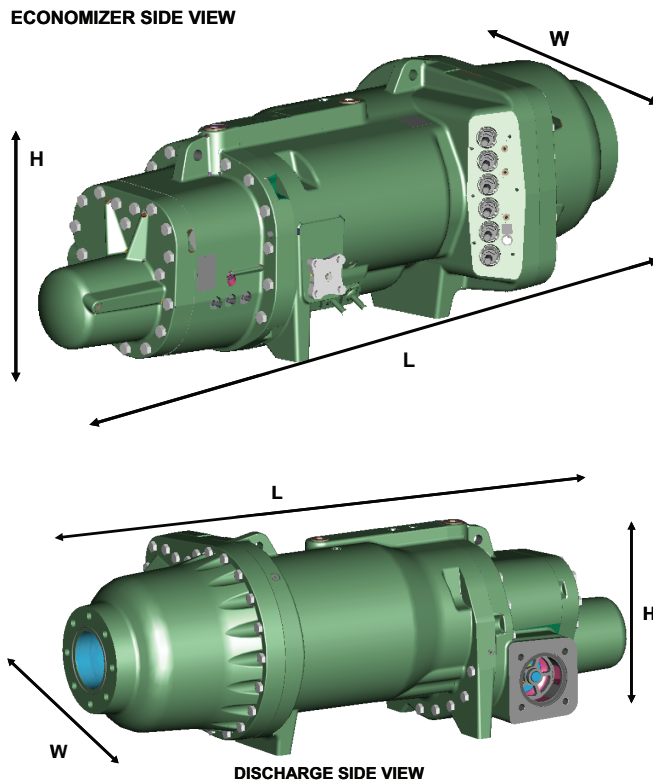


Fig. 34 — Compressor Dimensions

Table 29 — Basic Compressor Weight and Dimensions (Without Electrical Box and Oil Separator)

BASIC COMPRESSOR WEIGHT AND DIMENSIONS (WITHOUT ELECTRICAL BOX AND OIL SEPARATOR)								
MODEL	WEIGHT		DIMENSIONS					
			HEIGHT 'H'		WIDTH 'W'		LENGTH 'L'	
	lb	kg	in.	mm	in.	mm	in.	mm
06TS-137---	814	369	16	412	19	480	41	1029
06TS-155---	830	376	16	412	19	480	41	1047
06TS-186---	867	393	16	412	19	480	43	1091
06TT-266---	1352	613	19	481	21	536	50	1276
06TT-301---	1389	630	19	481	21	536	51	1299
06TT-356---	1460	662	19	481	21	536	53	1347
06TU-483---	2018	915	21	531	23	591	58	1466
06TU-554---	2108	956	21	531	23	591	60	1514
06TV-680---	2585	1173	23	583	24	608	68	1731
06TV-753---	2608	1183	23	583	24	608	68	1731
06TV-819---	2626	1191	23	583	24	608	68	1731

10.0 Packaging and Storage Requirements

10.5 Compressor/Compact Oil Separator Assembly

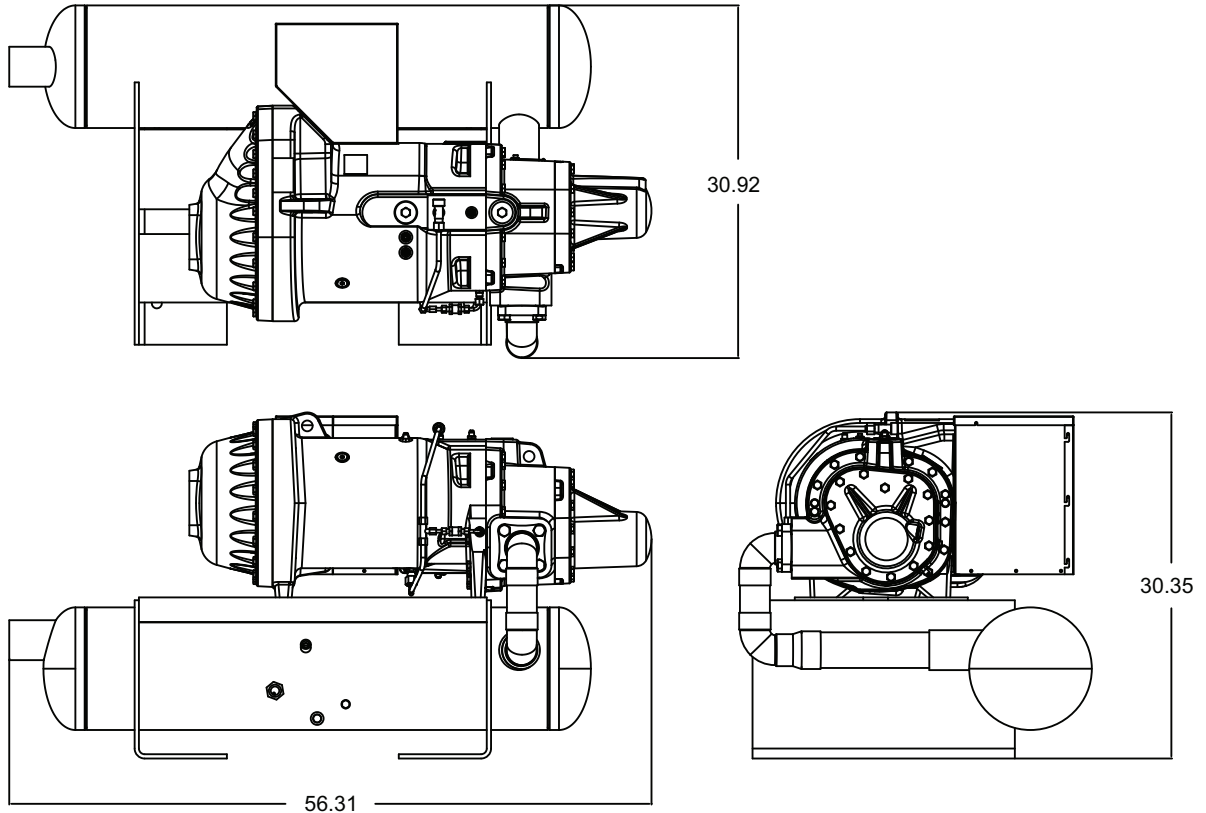


Fig. 35 — 06TSA137 Assembly Drawing

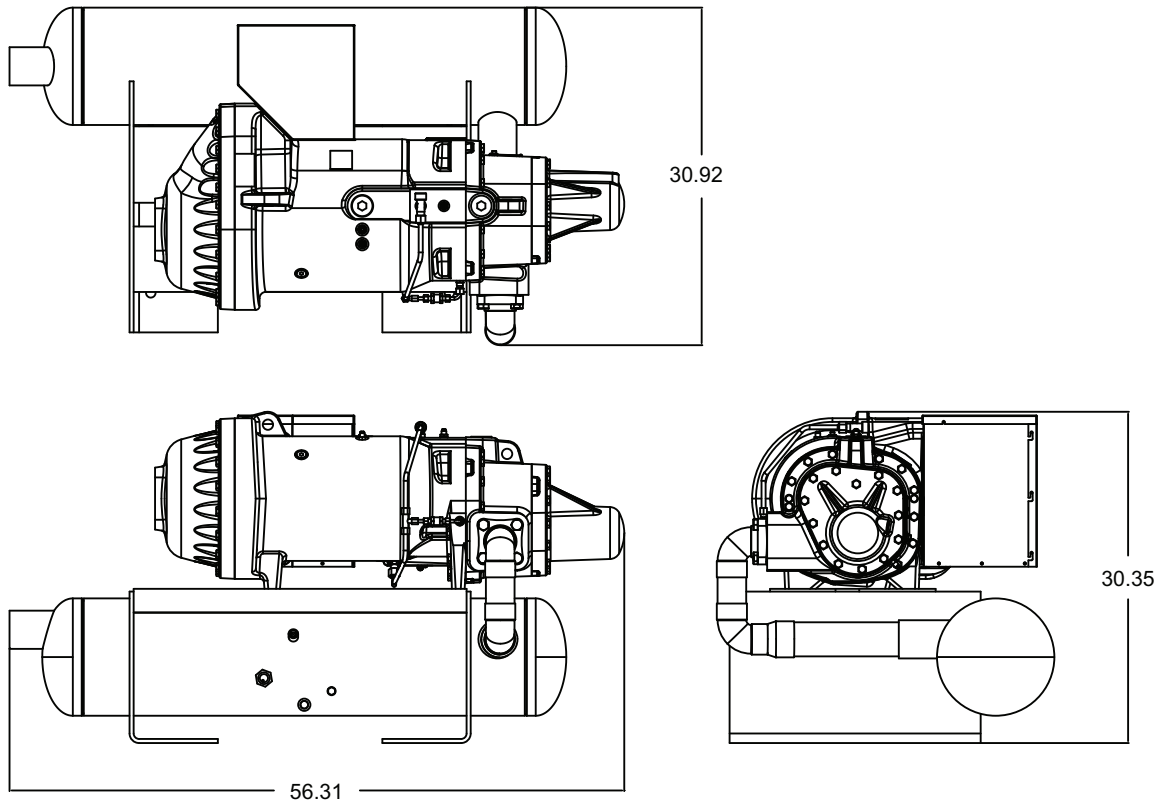
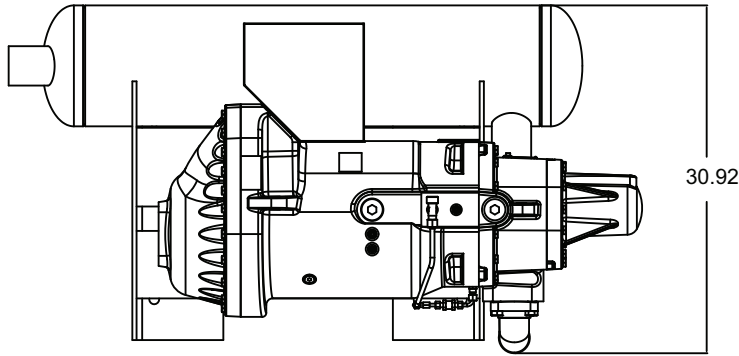
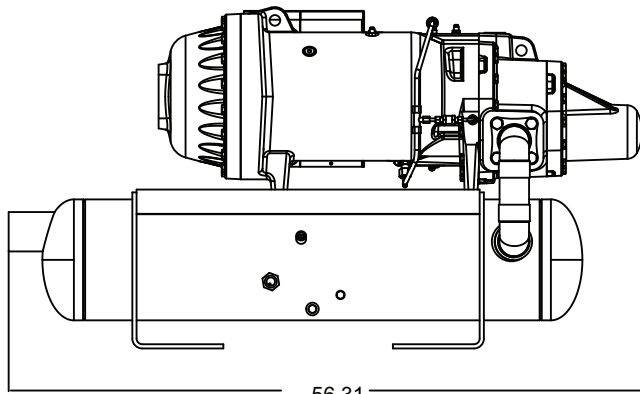


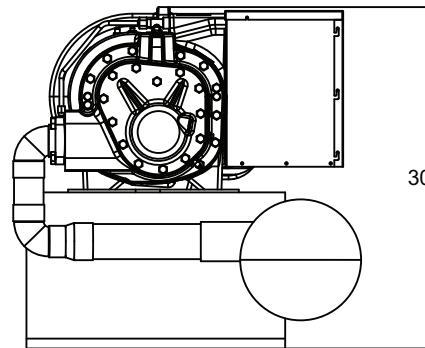
Fig. 36 — 06TSA155 Assembly Drawing



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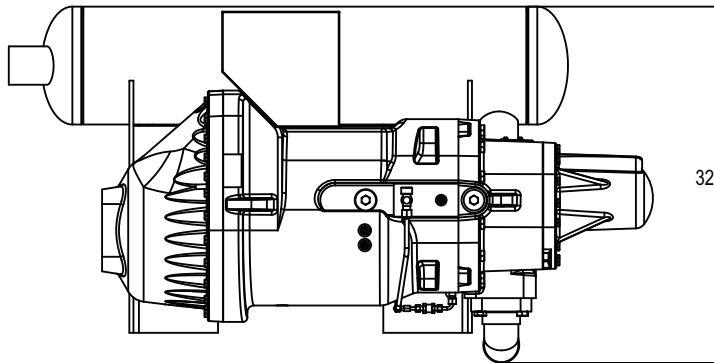


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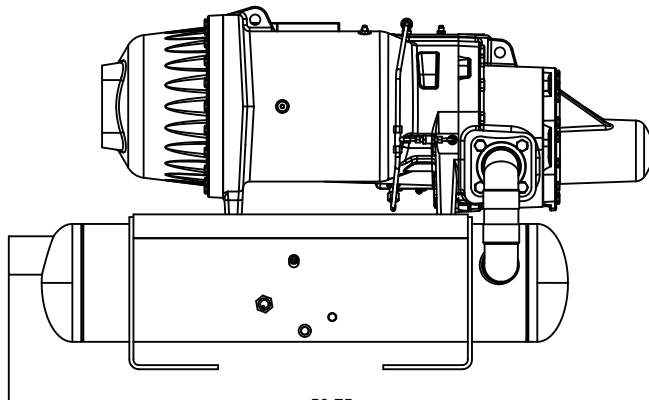


30.35

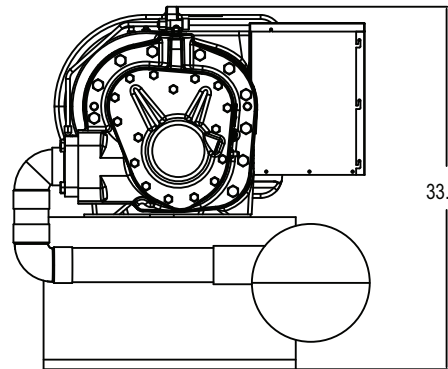
Fig. 37 — 06TSA186 Assembly Drawing



32.50



58.75



33.06

Fig. 38 — 06TTA266 Assembly Drawing

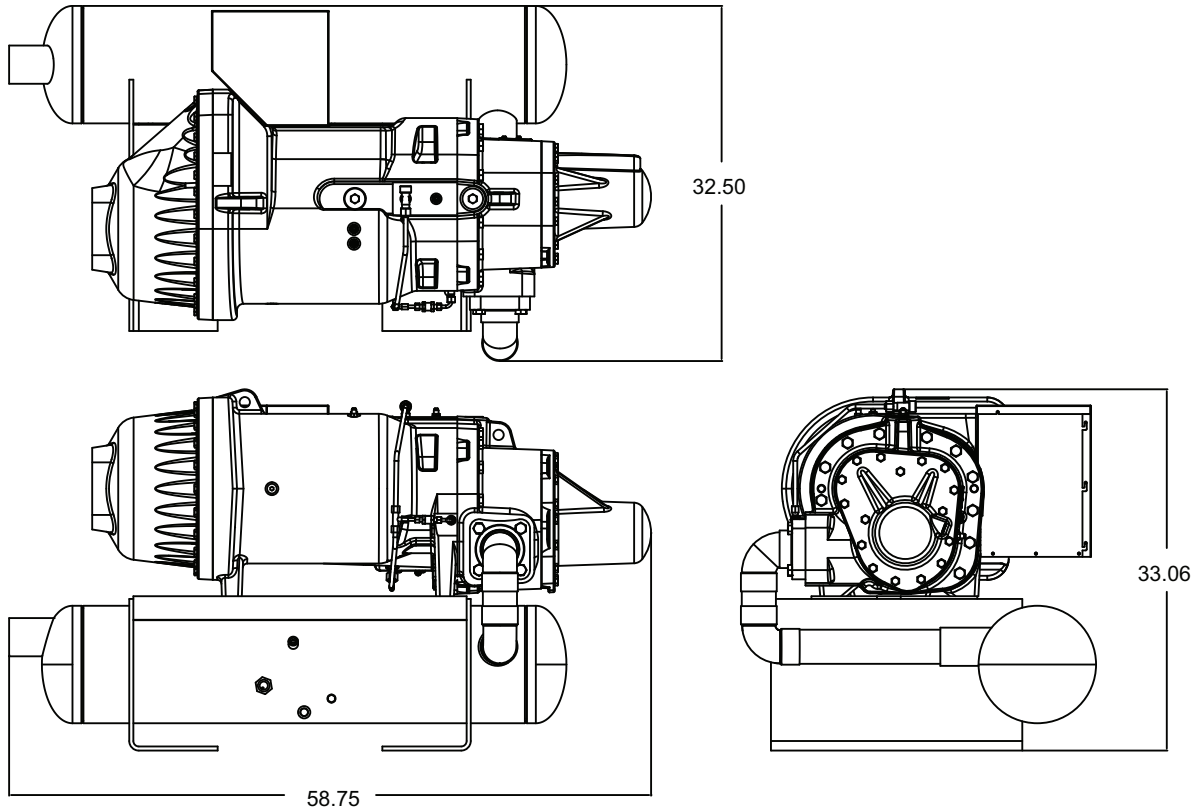


Fig. 39 — 06TTA301 Assembly Drawing

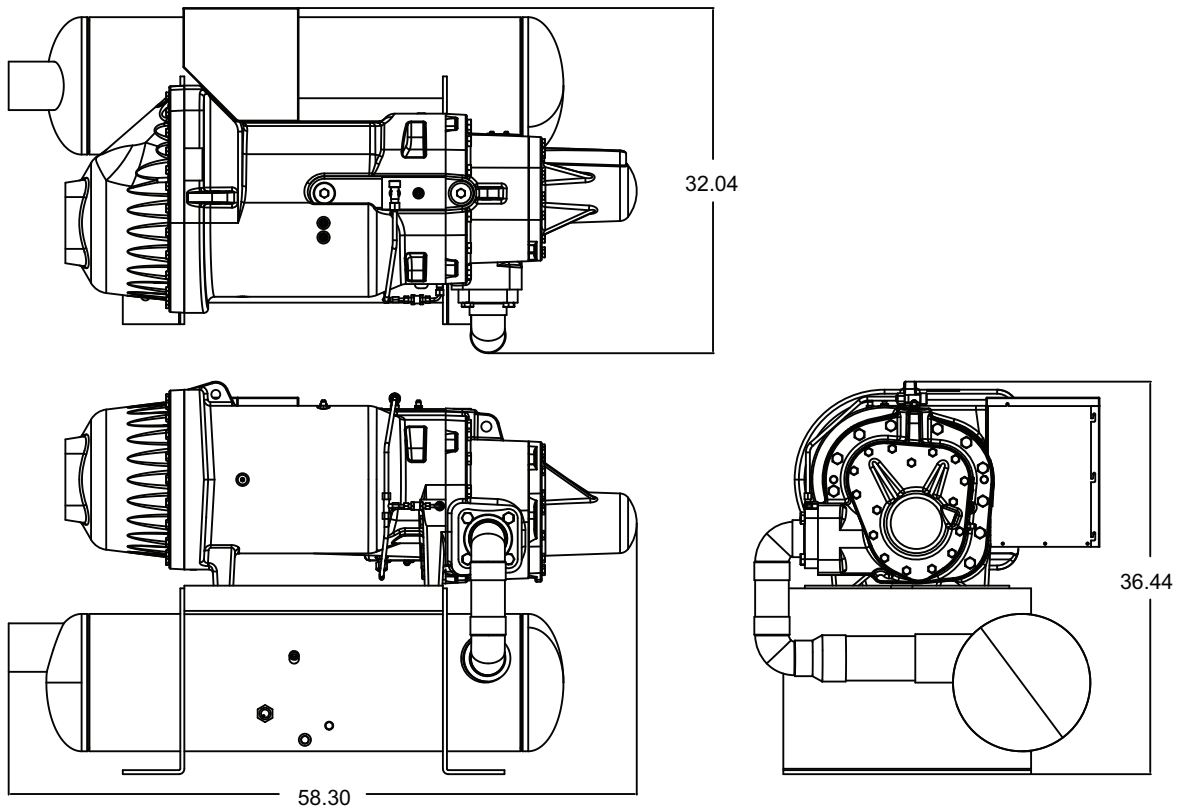


Fig. 40 — 06TTA356 Assembly Drawing

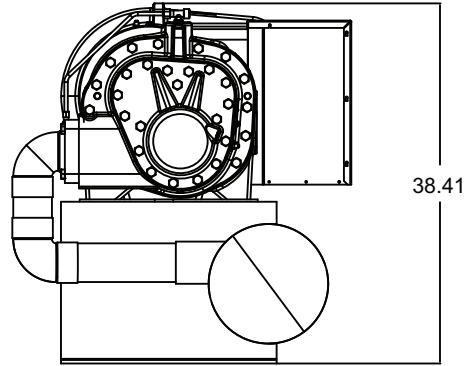
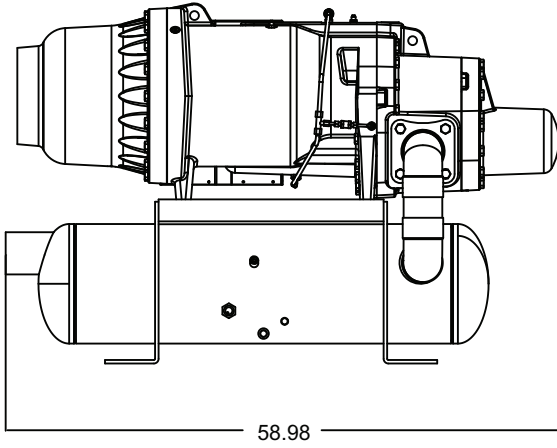
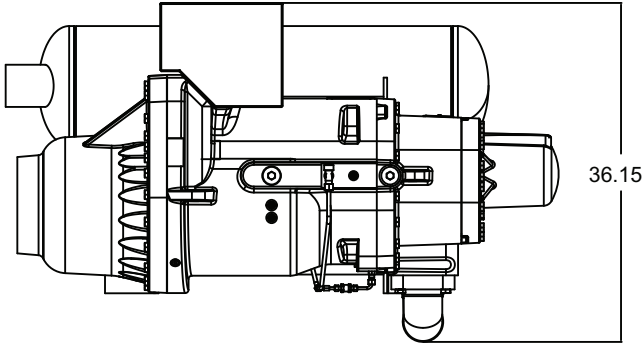


Fig. 41 — 06TUA483 Assembly Drawing

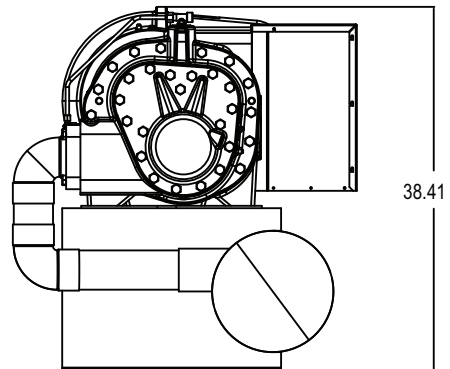
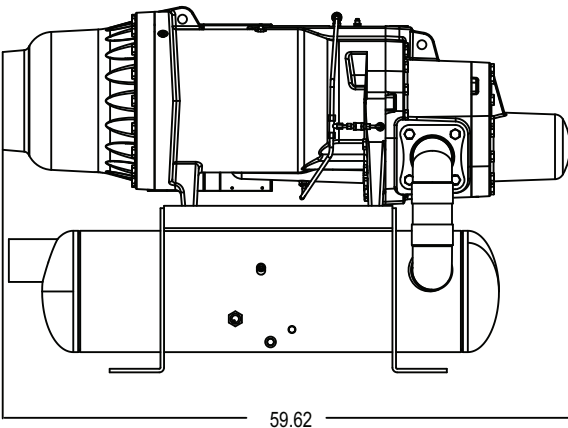
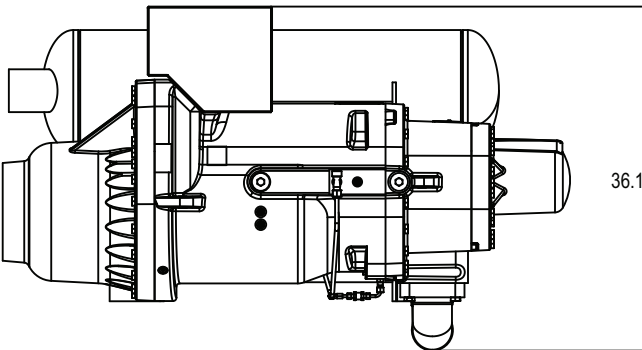


Fig. 42 — 06TUA554 Assembly Drawing