Application Engineering

Internal Capacity Control Valves for 4, 6, and 8 Cylinder Compressors

BULLETIN NO: AE21-1216 R17

Contents

COPELAND

Safety

Important Safety Information

Those involved in the design, manufacture, and installation of a system, system purchasers, and service personnel may need to be aware of hazards and precautions discussed in this section and throughout this document. OEMs integrating the compressor into a system should ensure that their own employees follow this bulletin and provide any necessary safety information to those involved in manufacturing, installing, purchasing, and servicing the system.

Responsibilities, Qualifications and Training

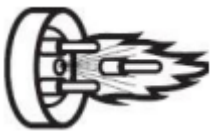
• OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.

• OEMs are also responsible for ensuring that all product, service, and cautionary labels remain visible or are appropriately added in a conspicuous location on the system to ensure they are clear to any personnel involved in the installation, commissioning, troubleshooting or maintenance of this equipment.

• Only qualified and authorized HVAC or refrigeration personnel are permitted to install, commission, troubleshoot and maintain this equipment. Electrical connections must be made by qualified electrical personnel.

• Observe all applicable standards and codes for installing, servicing, and maintaining electrical and refrigeration equipment.

Terminal Venting and Other Pressurized System Hazards



If a compressor's electrical terminal pin loses its seal, pressurized oil, refrigerant, and debris may spray out. This is called "terminal venting".

The ejected debris, oil, and refrigerant can injure people or damage property. The oil and refrigerant spray can be ignited by electrical arcing at the terminal or any nearby ignition source, producing flames that may project a significant distance from the compressor. The distance depends on the pressure and the amount of refrigerant and oil mixture in the system. The flames can cause serious or fatal burns and ignite nearby materials.

Each compressor has a terminal cover or molded plug that covers electrical connections. The cover or plug helps to protect against electric shock and the risks of terminal venting. If terminal venting occurs, the cover or plug helps contain the spray of refrigerant and oil and reduces the risk of ignition. If ignition occurs, the plug or cover helps contain the flames. However, neither the terminal cover nor the molded plug can completely eliminate the risk of venting, ignition, or electric shock.

See copeland.com/terminal-venting for more details about terminal venting. Additionally, a compressor's refrigerant lines keep refrigerant and oil under pressure. When removing or recharging refrigerant from this component during service, this can pose a pressurized fluid hazard.

Flammable Refrigerant Hazards

If flammable refrigerant is released from a system, an explosive concentration can be present in the air near the system. If there is an ignition source nearby, a release of flammable refrigerant can result in a fire or explosion. While systems using flammable refrigerant are designed to mitigate the risk of ignition if the refrigerant is released, fire and explosion can still occur.

See copeland.com/flammable-refrigerants for more information on flammable refrigerant safety.

Electrical Hazards

Until a system is de-energized, and capacitors have been discharged, the system presents a risk of electric shock.

Hot Surface and Fire Hazards

While the system is energized, and for some time after it is deenergized, the compressor may be hot. Touching the compressor before it has cooled can result in severe burns. When brazing system components during service, the flames can cause severe burns and ignite nearby combustible materials.

Lifting Hazards

Certain system components may be very heavy. Improperly lifting system components or the compressor can result in serious personal injury. Use proper lifting techniques when moving.

POE Oil Hazards

This equipment contains polyol ester (POE) oils. Certain polymers (e.g., PVC/CPVC and polycarbonate) can be harmed if they come into contact with POE oils. If POE oil contacts bare skin, it may cause an allergic skin reaction.

Precautions

• Always wear personal protective equipment (gloves, eye protection, etc.).

• Keep a fire extinguisher at the jobsite at all times.

• Keep clear of the compressor when power is applied.

- IMMEDIATELY GET AWAY **if you hear unusual sounds in the compressor. They can indicate that terminal pin ejection may be imminent. This may sound like electrical arcing (sizzling, sputtering or popping). However, terminal venting may still occur even if you do not hear any unusual sounds.**

• Never reset a breaker or replace a blown fuse without performing appropriate electrical testing

- **A tripped breaker or blown fuse may indicate an electrical fault in the compressor. Energizing a compressor with an electrical fault can cause terminal venting. Perform checks to rule out an electrical fault.**

• Disconnect power and use lock-out/tag-out procedures before servicing.

- Before removing the terminal cover or molded plug, check that ALL electrical power is disconnected from the unit. Make sure that all power legs are open. (Note: The system may have more than one power supply.)

- Discharge capacitors for a minimum of two minutes

- Always use control of hazardous energy (lock-out/tag-out) procedures to ensure that power is not reconnected while the unit is being serviced.

• Allow time for the compressor to cool before servicing.

- Ensure that materials and wiring do not touch high temperature areas of the compressor.

• Keep all non-essential personnel away from the compressor during service.

• For A3 refrigerants (R290) remove refrigerant from both the high and low sides of the compressor. Use a recovery machine and cylinder designed for flammable refrigerants. Do not use standard recovery machines because they contain sources of ignition such as switches, high- and low-pressure controls and relays. Only vent the R290 refrigerant into the atmosphere if the system is in a well-ventilated area.

• Never use a torch to remove the compressor. Only tubing cutters should be used for both A2L and A3 refrigerants.

• Use an appropriate lifting device to install or remove the compressor.

• Never install a system and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system.

• Always wear appropriate safety glasses and gloves when brazing or unbrazing system components.

• Charge the system with only approved refrigerants and refrigeration oils.

• Keep POE oils away from certain polymers (e.g., PVC/CPVC and polycarbonate) and any other surface or material that might be harmed by POE oils. Proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. Handle POE oil with care. Refer to the Safety Data Sheet (SDS) for further details.

• Before energizing the system:

1. Securely fasten the protective terminal cover or molded plug to the compressor, and

2. Check that the compressor is properly grounded per the applicable system and compressor requirements.

Signal Word Definitions

The signal word explained below are used throughout the document to indicate safety messages.

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

Introduction

Blocked suction internal unloading has been successfully used for many years to unload 4- and 6-cylinder reed compressors for air-conditioning applications. More recently, blocked suction unloading has been applied on selected 4-, 6-, and 8-cylinder Discus™ compressors for high, medium, and low temperature applications. Compressor capacity modulation can reduce power consumption, provide continuous dehumidification, reduce compressor cycling and decrease the starting electrical load. Blocked suction capacity control also makes efficient compressor operation possible when the compressor is unloaded.

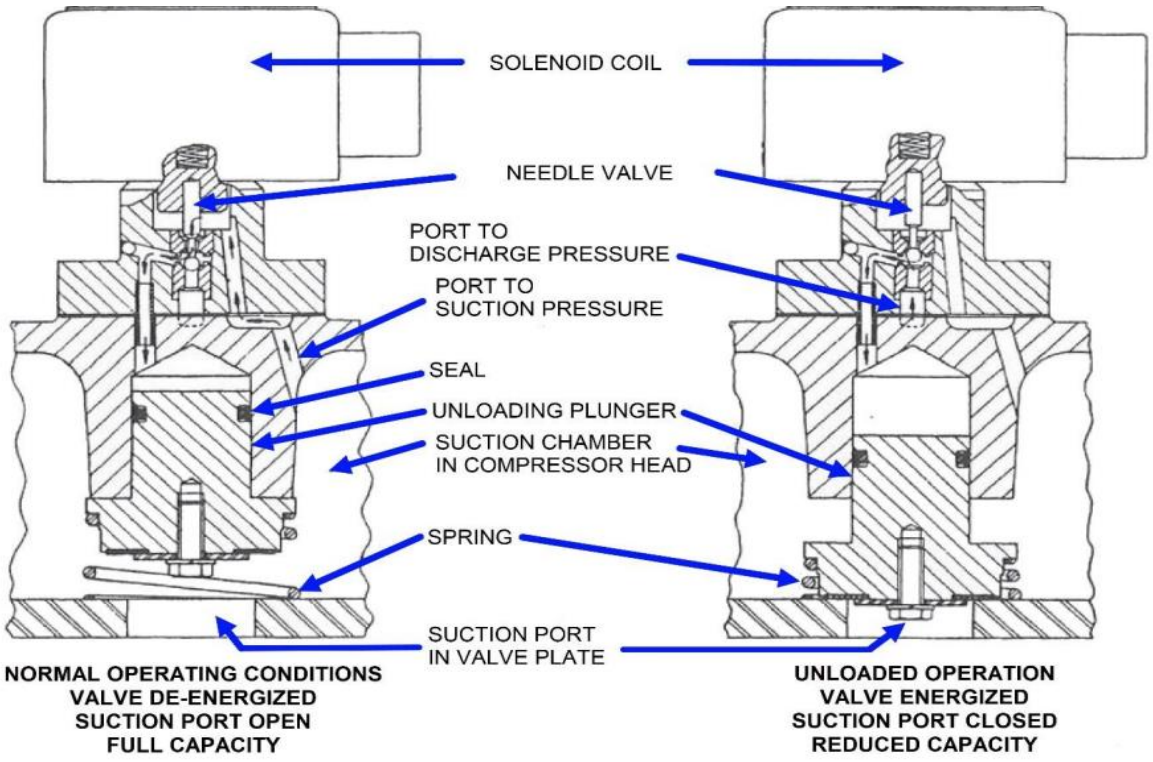
Internal Capacity Control Valve Construction

A schematic illustration of the internal valve operation is shown in **Figure 1**. In the normal (full capacity) operating position with the solenoid valve de-energized, the needle valve is seated on the lower port, and the unloading plunger chamber is exposed to suction pressure through the suction port. Since the face of the plunger is open to the suction chamber, the gas pressures across the plunger are equalized, and the plunger is held in the open position by the spring.

When the solenoid valve is energized, the needle valve is seated on the upper port, and the unloading plunger chamber is exposed to discharge pressure through the discharge pressure port. The differential between discharge and suction pressure forces the plunger down, sealing the suction port in the valve plate, thus preventing the entrance of suction vapor into the unloaded cylinders.

The seal on the unloading plunger minimizes any leakage in pressure so that a pumpdown cycle may be used with the valve either energized or de-energized without excessive compressor cycling.

Figure 1 Schematic Operation of Internal Unloader Valve



4R-6R Copelametic Compressors

A typical capacity control valve plate for conventional Copelametic compressors is shown in **Figure 2**.

An interior view of the internal unloading head is shown in **Figure 3**. Note that the unloader plunger chamber has been cast in the head, but that the gasketed surfaces of the head are the same as a standard head. A standard head gasket is used with the internal capacity control valve - no special unloading gasket is required.

Figure 2 Valve Plate for Unloaded Head on 4R and 6R compressors

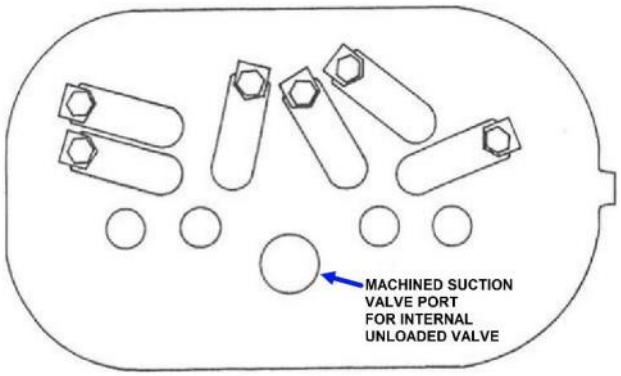


Figure 3 Mounting Pad on Compressor Head for Internal Unloaded Solenoid Valve, Reed Compressors

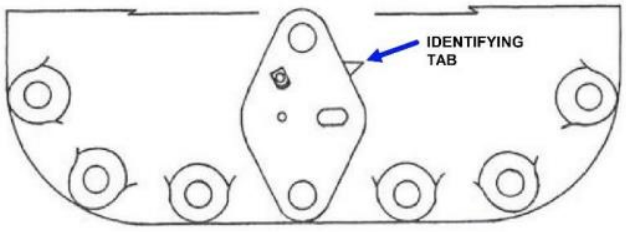


Figure 4 and **Figure 5** show the pressure port connections to the unloading solenoid valve. The action of the valve determines which pressure is applied to the unloading valve plunger. There are 2 gaskets to use with the unloader. Figure 17 shows the gasket that is to be used with reed models or with *1, *3, and *D models. Figure 6 shows the gasket that is to be used with the *N and *X models.

Figure 4 Interior - Head for Internal Capacity

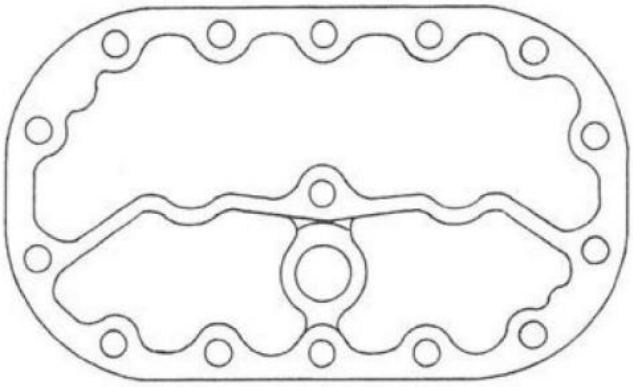


*Figure 5 - Discus 4D*3, 4D*1, 4D*D, 6D*3, 6D*1, 6D*D Gasket for Internal Unloading Solenoid Valve Part # 020-0783-00*

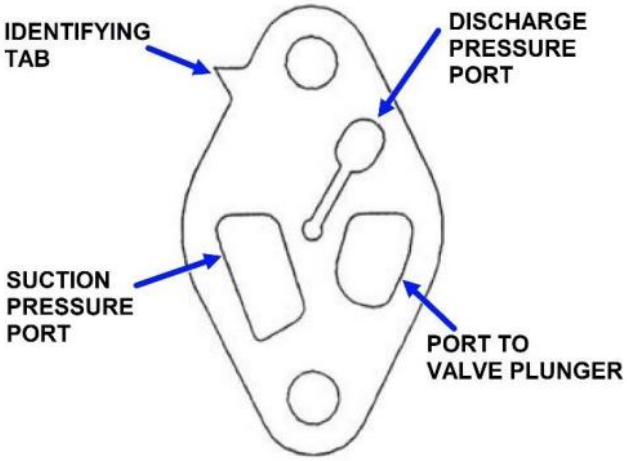
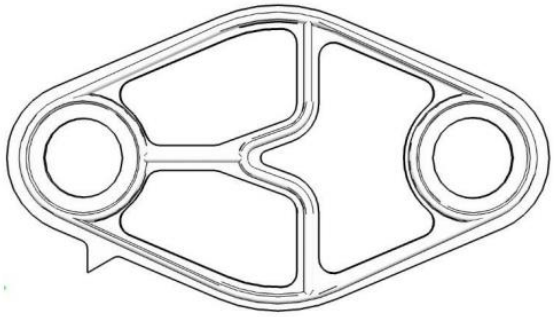


*Figure 6 Discus™ 4D*N, 4D*X, 6D*N, 6D*X Gasket for Internal Unloading Solenoid Valve P/N 020-1465-00*



Copelametic Discus Compressors

The same basic internal unloading mechanism is used on both Discus™ and conventional compressors. Figures 6, 7, 8 and 9 below show typical Discus construction.

Application

When an unloading valve in an operating system is switched from the loaded to the unloaded position, a new system balance takes place. In air-cooled systems the suction pressure will rise, and the condensing pressure will drop. In water-cooled systems the suction pressure will rise, but the condensing pressure will remain essentially the same.

The pressure or temperature control should have as wide a differential as necessary to prevent rapid cycling of the unloading valve. Rapid cycling can lead to wear and premature failure of the solenoid valve and/or internal unloader components. The unloader cycle rates should be limited to no more than 10 to 12 per hour to ensure satisfactory unloader life. A wider differential will be required with the pressure control method than the temperature control method because of the thermal mass (or flywheel effect) of the cooled medium.

Application Requirements

Because of the decreased volume of suction vapor returning to the compressor from the system and available for motor cooling, the operating range of unloaded compressors must be restricted. Reed style compressors should be limited to a minimum evaporating temperature of 25°F when operating unloaded. Discus compressors can be operated unloaded below -25°F with the addition of head cooling fans. Some Discus II compressor models used to include an “Oil Cooler” part, “Oil cooler” is an obsolete part, See more details in AE4-1135 bulletin. **Low Temperature Application Discus™ III models using Demand Cooling don’t require Head Fan (Discus™ models 4D*N, 4D*X, 6D*N, 6D*X)**. See **Table 1** and **Table 2** for specific requirements for Discus. See **Figure 19** for detailed description of Low and Medium Temp. Models.

The capacity control valve is in the normal discharge position (loaded) when de-energized, and in the unloaded position when energized. The solenoid valve may be energized either by means of a reverse acting low pressure control or a temperature control thermostat. On six-cylinder compressors with two unloaders, two step thermostats may be employed, but if sequence control of unloaders from compressor suction pressure is desired, two separate controls are necessary.

Although the leak back rate when the coil is energized during a compressor off cycle is minimal, to prolong the solenoid coil life it is recommended that the capacity control solenoid valve be de-energized when the compressor is not operating.

In control circuits operating at line voltage, the solenoid valve and control can be connected to the load side of the contactor as in **Figure 13**. The unloader solenoid valve will then be de-energized and closed when the compressor is not operating.

Note: As with any unloading compressor it is recommended the unloader solenoid be de-energized before pumping down the low side. Operating in the unloaded mode will greatly increase the time period for pumpdown.

Figure 7 Valve Plate for Unloader Head Copelametic Discus Compressor

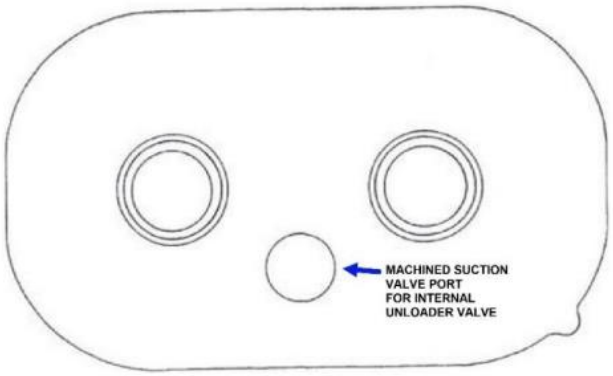


Figure 8 - Interior View - Head for Internal Capacity Control

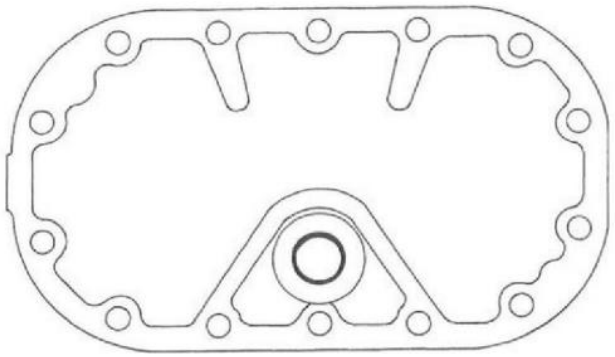


*Figure 9 Mounting Pad on Short Compressor Head Internal Unloading Solenoid Valve Copelametic 4D*1 and 6D*1 Discus Compressors*

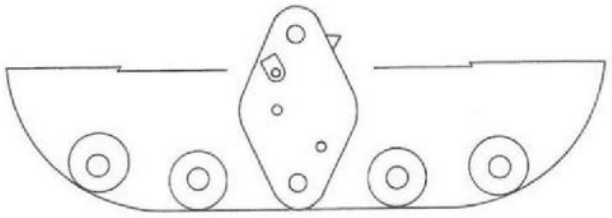
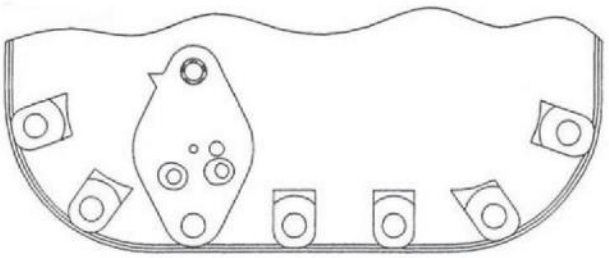


*Figure 10 Mounting Pad on Tall Compressor Head Internal Unloading Solenoid Valve Copelametic 4D*3 and 6D*3 Discus Compressors*



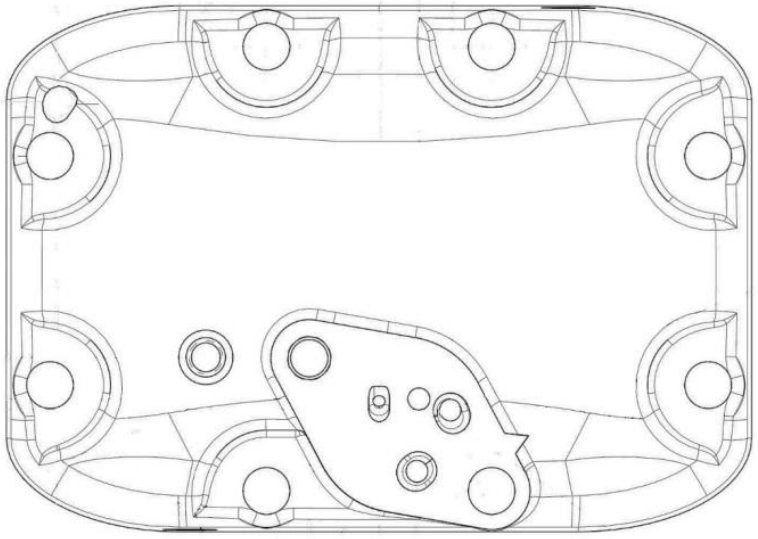
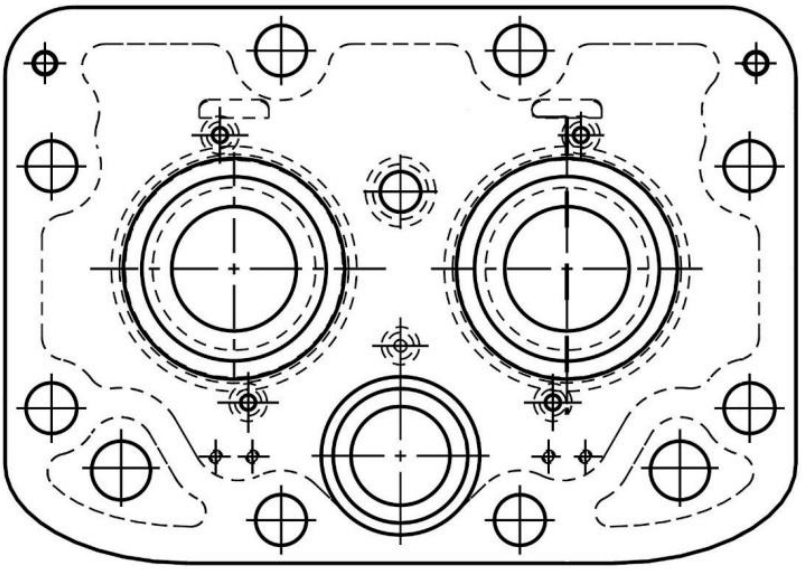


Figure 11 Discus III unloader Head

Figure 12 Discus III blocked suction valve plate



On large installations, the control circuit may have a power source independent of the compressor power supply. In such cases the unloading solenoid valve and control may be connected as shown in **Figure 13**, or they may be connected in parallel with the compressor contactor coil as in **Figure 14**.

Demand Cooling Applications

Demand Cooling is approved with Discus compressors unloading. See AE4-1287 for specific model and additional information.

Piping

One very important factor to be considered in the design of any system equipped with an unloading type compressor is the gas velocity. It must be maintained at a sufficiently high level to ensure oil return to the compressor when it is unloaded. When an unloading type compressor is employed on a single evaporator with a single suction line, it may be necessary to employ double risers constructed as shown to insure oil return. (See Copeland Refrigeration Manual AE-104). If the unloading type compressor is to be installed on a system employing multiple evaporators with solenoid valves to control the flow of refrigerant to the evaporators, a separate suction line should be run from each evaporator to the machine room and there connected into a common line, which must slope downward toward the compressor. See **Figure 15**.

Expansion valves for systems with unloading compressors must be able to control the refrigerant flow while the compressor is unloaded as well as when loaded. They generally cannot maintain stable control below 25-35% of their rated capacity and, therefore must not be oversized for the fully loaded condition.]

Field Service and Conversion 4-6 Compressors

Standard 4 and 6 compressors may be converted to internal capacity control models by means of the appropriate conversion kit. See **Table 1** for requirements.

To convert a standard reed compressor to unloading, it is only necessary to remove the existing head, install a new head gasket, install the new head and unloader assembly, and install the solenoid valve. A new valve plate is also required on Discus™ compressors. Torque head bolts to 375-inch pounds on reed compressors and 550 inch pounds on Discus compressors.

Figure 13 Typical Control Circuit for Compressor with Unloading Valve

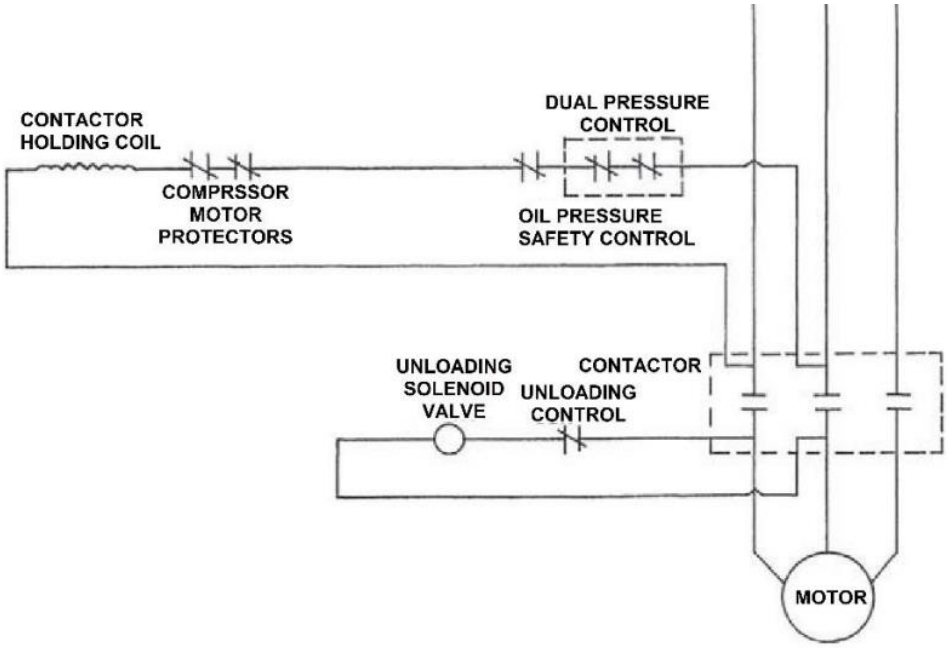
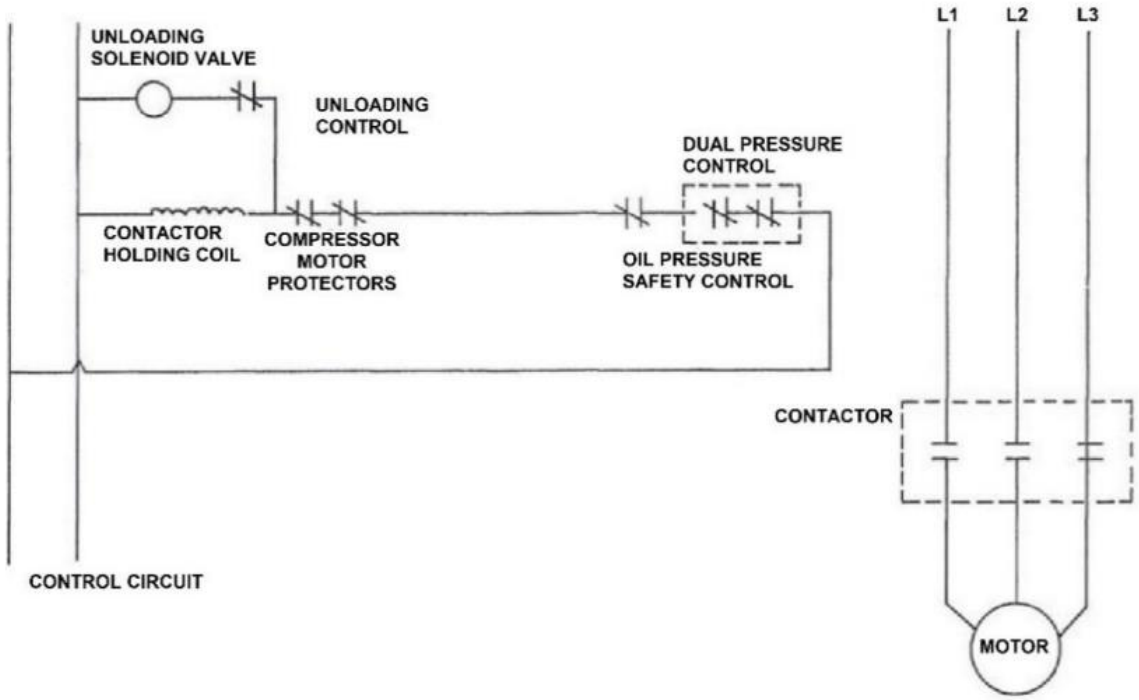


Figure 14 Typical Control Circuit for Compressor with Unloading Valve and Separate Power Source Control Circuit



Unloader Valve Location

NOTICE

4R:	right bank
4D:	right bank
6R, 33%:	right bank
6R, 67%:	right & left bank
6D*1, 33%:	right bank
6D*1, 67%:	right & left bank
6D*3, 33%:	right bank
6D*3, 67%:	right & top bank
6D*N, 33%:	right bank
6D*N, 67%:	right & top bank
8D:	lower right & upper left banks

The right bank is the terminal box side. While unloaders could be physically mounted on the other banks, to do so would interfere with the internal crankcase pressure suppression and prevent proper oil return.

Therefore, we recommend unloading the right bank first, followed by either the left or top bank depending on which Discus models you are working on from the list above.

Capacity Control Variations (6D*1-vs-6D*3 and 6D*N)

There are three styles of unloader heads presently used by Copeland. To identify the styles, see **Figure 9**, **Figure 10** and **Figure 11**. The hole configuration is different depending on what model compressor you have.

Prior to 1991 all 4D & 6D compressors were the *1 version (see **Figure 9**). This style unloader used gasket 020-0690-00. The *3 and *N model (see **Figure 10**) has different hole configurations and requires a different style unloader gasket. **Figure 5** and **Figure 17** show the gasket that was made to fit both the *1 & *3 models.

Discus III compressors (6D*N models: *N, *X gasket) use a different gasket than Discus™ II compressor models, See **Figure 18**.

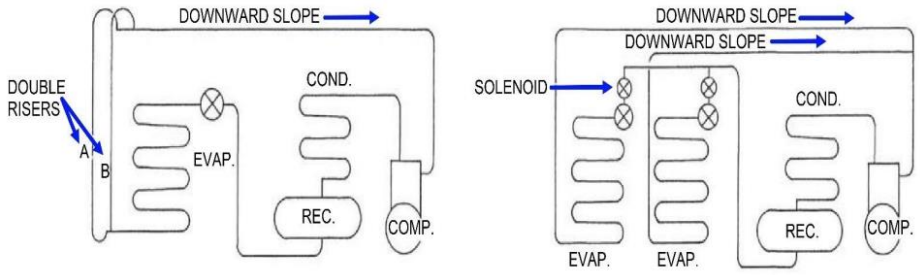
When changing from the *1 to the *3/*D type head you must do the following:

- Use gasket (**Figure 5**) on all 4D/6D unloader type heads. Make sure the tab of the gasket is aligned with the tab of the head.
- The unloader valve pin fits in the small hole on the *1 style head. For the ***3** style head the unloader valve must be turned 180 degrees, and the valve pin fits into a much larger hole. If the old-style gasket is used on a ***3** head, the port to the plunger will be covered up and the unloader will not work.

Non unloading Operation

The 4, 6, and 8 cylinder capacity control models are shipped from the factory with a shipping plate and gasket on the unloading pad, and the unloading valve and coils as a “ship remote” item. See **Figure 16**. These compressors can be operated continuously full loaded without the valve and coil installed if desired for any reason. The gasket needs to be replaced when mounting the valve and coil for unloading. See **Figure 17** for ***1**. ***3**. ***D** model gasket and **Figure 18** for ***N**, ***X** model gasket.

Figure 15 Single and Multiple Evaporator Piping



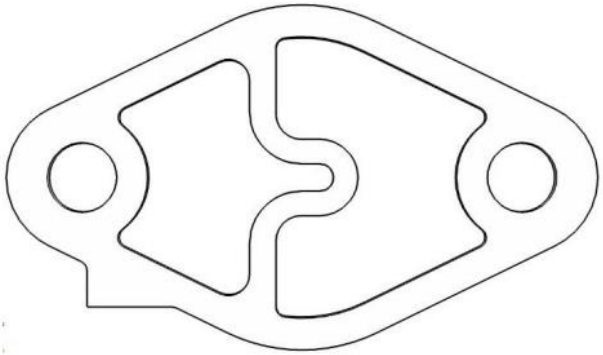
Installation

The unloading valve and coil assembly is included in the capacity control model standard bill of material as a “ship remote” item. The capacity control model can be operated without the unloading valve and coil installed, if desired for any reason.

*N,*X models will use 020-1465-00 for both shipping plate and valve gasket. Customer will need to change to new gasket when installing the valve on the compressor. If the compressor was received with a blank off plate, gasket 020-1465-00 will need to be replaced.

If mounting the valve and coil for *1, *3, and *D models, use the correct gasket per the following instructions.

Figure 16 P/N 020-0931-00



Shipping Gasket / Full Load Gasket:

This gasket is under the shipping plate covering the unloader mounting pad on the cylinder head. There is no need to remove the plate or change gaskets if the compressor is to be operated without a valve and coil. If a compressor was previously operated with valve and coil installed but is to be converted back to non-unloading (without valve), this gasket should be used under a shipping plate.

Unloading Valve Gasket:

Use this gasket when in- stalling the unloading valve and coil on all 4-, 6-, and 8-cylinder models. It is supplied in the gasket kit.

See **Figure 17** for ***1**. ***3**. ***D** model gasket and **Figure 18** for ***N**, ***X** model gasket.

Figure 17 P/N 020-0783-00

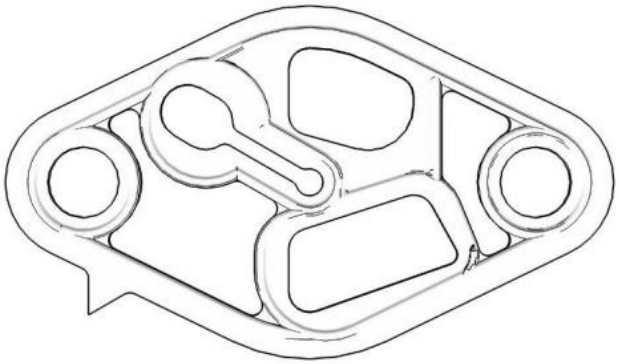


Figure 18 P/N 020-1465-00

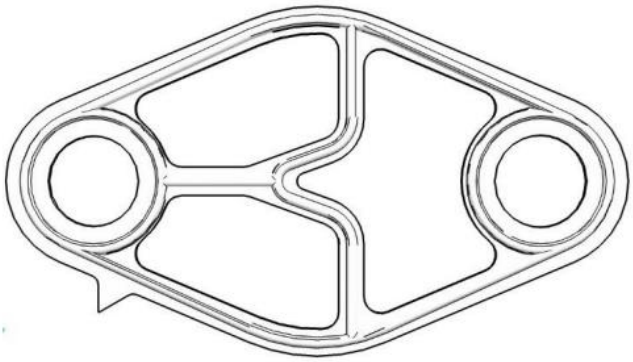


Figure 17 Discus Nomenclature with Temperature Range Description

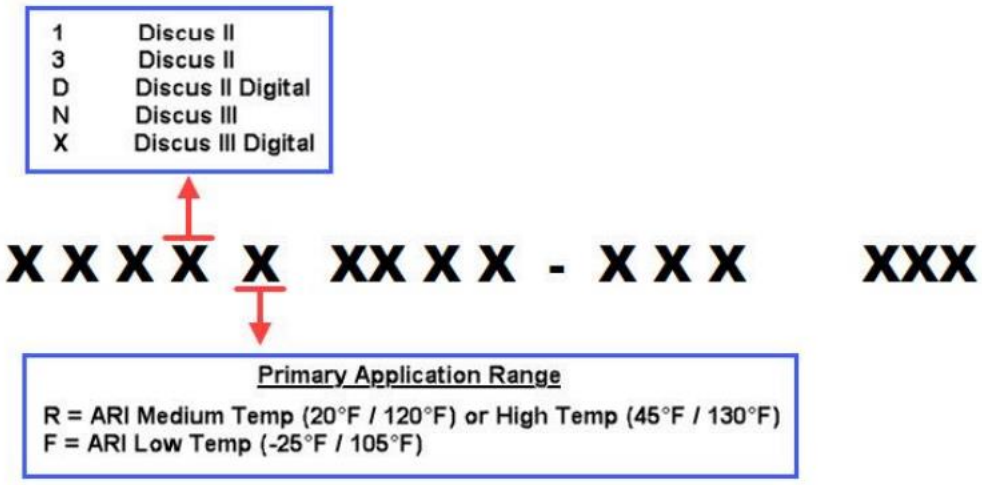


Table 1 Medium Temperature Discus Models - Unloaded Operation Criteria Evaporator Range +0°F To -25°F.

Maximum condensing temperature	130°F
Minimum evaporating temperature	- 25°F

Table 2 Low Temperature Discus Models - Unloaded Operation Criteria Evaporator Range -25°F To -40°F.

Head cooling fan required (not required if Demand Cooling is Applied)	
Maximum condensing temperature	130°F
Minimum evaporating temperature for 4D and 6D (33% unloaded)	-40°F
Minimum evaporating temperature for 6D (66% unloaded)	- 25°F

NOTE: Minimum evaporating temperature for 4R, 6R, 8R models is +25°F when unloading.

NOTE: Oil Cooler used to be a requirement for some Discus II models, but this part is obsolete. You'll find more details about "Oil Cooler" and its phased out process in AE4-1135 bulletin.

⚠CAUTION

Because of lower suction gas velocity when unloading low and medium temperature compressors, adequate oil return must be assured through piping design or defrost control.

Revision Tracking R17

The document format has been updated to the new Copeland format

All occurrences of "Emerson" have been removed

A note regarding A3 and R290 venting has been updated