INTRODUCTION

Description

The whole process of temperature control in a refrigeration system depends entirely upon proper control of the various system pressures. Therefore, it becomes important that certain parts of the system have their pressures rigidly controlled/regulated. These pressures are attainable with either upstream or downstream regulating valves, i.e., pressure regulators.

General Operation

The operation of a regulator usually requires balancing a pilot pressure and/or spring force on one side of a movable piston or diaphragm against the system pressure on the opposite side of the movable part. The side with the greater force will cause the piston to move in the direction of the lesser force, opening or closing a valve in its orifice. The piston will continue to move until the opposite forces are again in balance, at which time, movement will stop. The last movement repositions the valve to allow more or less flow through the orifice. Therefore, as the flow is regulated, so is the pressure, and the desired temperature is maintained.

Note of Caution

All piping diagrams contained in this section are schematics for illustration purposes only. Care must be exercised when actually laying out a working system.

Comparison of Functions (Tev Vs. Regulator)

A thermostatic expansion valve (TEV) comes in many sizes and shapes, a variety of tonnage ranges, and requires specialized applications. Nevertheless, a TEV has but one and only one function in the refrigeration circuit, and that is to control the superheat content of the evaporator gas as it enters the suction line.

On the other hand, "pressure regulators" have many functions. Upstream or downstream, large or small, iron or brass, head pressure, suction pressure, crankcase or evaporator pressure, high to low side pressure, and constant pressure control, these are some of the various types of pressure regulators. Therefore, it is necessary to know what the intended use of the regulator will be before the tonnage, refrigerant, temperature range, connections, and pressure range conditions are selected.

TYPES OF REGULATORS

Suction Line Regulators

Suction line regulators provide a wide variety of refrigerant control functions, but are primarily designed for regulating suction gas pressures. These regulators provide an effective method of balancing the output of the refrigeration system with the load requirements.

Two basic types are covered in this chapter:

1. Upstream pressure regulators, or those which control from an inlet pressure signal.
2. Downstream pressure regulators, which control from an outlet pressure signal.
PRESSURE REGULATORS FOR REFRIGERATION, AIR CONDITIONING, AND HEAT PUMP SYSTEMS

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See Figure 2 and 2A for typical EPRs used with halocarbon supermarket systems.

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**Figure 2** — A typical suction line pressure regulator. This is an upstream pressure regulator that can be used to separate evaporators working at different temperatures but connected to a single compressor system. The EPR shown here is very popular for use with supermarket systems.
Evaporator Pressure Regulators (Upstream Pressure Regulators)

Simple control of compressor operation by a thermostat or pressure switch is inadequate for many refrigeration systems. In many of the present day installations, the best control cannot be attained with the “on—off” method of operation.

Evaporator pressure regulators offer a very effective method of balancing the capacity of the refrigeration system with the requirements of the load. Such regulators, by controlling the operating pressure of the
Evaporator, enable the system to meet the requirements of a wide range of load and therefore, to
maintain maximum operating efficiency.

The sole function of an EPR is to prevent the evaporator pressure from falling below a predetermined
point for which the regulator has been set. As the name implies, an evaporator pressure regulator
regulates the upstream or evaporator pressure. It controls from a pressure signal on the inlet side of the
valve, opening the regulator if the inlet pressure rises above the set point, closing if the inlet pressure falls
below the set point.

Evaporator pressure regulators may be divided into two groups: the direct acting regulators (see Figures
3 and 4), and Pilot Operated (see Figure 7). Pilot Operated EPR valves are often furnished in a variety of
multiple combined pilot controls to perform specific functions. These will be discussed later in this chapter.

**Figure 3 — Direct acting, small tonnage Take-A-Part EPR (obsolete).**
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Figure 4 — Direct acting, small tonnage hermetic EPRs.
Direct Acting EPR Valves

Two types of direct acting EPR valves are illustrated because they differ in basic construction, and also in past and present usage. The type shown in Figure 3 is the take-apart, serviceable design, which has a synthetic seat, spring-loaded diaphragm, and an integral shut off valve with gauge connection. When the inlet pressure, acting under the power assembly diaphragm, exceeds the spring setting, the port opens. A decrease in inlet pressure below the adjusted spring setting causes the port to close. Attaching a gauge to the gauge port permits an accurate means of adjusting the valve to the proper set point. In recent years, this rather expensive, serviceable, small type of valve has given way to a less costly hermetic model.

The valve shown in Figure 4 consists of a hermetic assembly having a spring-loaded bellows seal and lower stem guide. Its operation is quite different than other controls. The area of the bellows is matched to the area of the poppet (see Figure 5). Outlet pressure acts on the bellows in an opening direction and equally on the poppet in a closing direction; in order to balance and offset each other. Therefore, the only operational forces that affect control are the inlet pressure and the spring adjustment. When the inlet pressure acts on the poppet in a opening direction, and reaches the balance point created by the spring adjustment, the port opens. When the inlet pressure drops below the spring setting, the port closes. An additional feature is the access fitting that permits a gauge connection to permit accurate settings. As in all EPR valves, turning the adjusting screw clockwise increases the spring setting and raises the pressure.
set point. Turning the adjusting screw counterclockwise decreases the spring tension and lowers the pressure setting. The lower stem guide provides quiet, chatter-free operation necessary for good control.

Pilot Operated EPR Valves (Iron Bodied)

Figures 6 and 7 show typical evaporator pressure regulators. Inlet pressure acting under the pilot diaphragm will lift the diaphragm of the pilot seat whenever it is greater than the spring setting (see Figure 8). This admits inlet pressure through the internal pilot passage and pilot seat to act on the main piston, forcing the valve to open. When the inlet pressure through the inlet pilot passage drops below the spring load above the pilot diaphragm, the pilot seat will close. This allows the pressure above the piston to bleed off through the piston bleed hole, to the valve outlet, and the valve closes. Turning the spring
adjustment clockwise increases the spring setting; turning it counterclockwise decreases the setting. EPR valves are available in a variety of adjustment ranges.

Figure 6 — Iron bodied EPR: pilot operated.
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Figure 8 — Operation of upstream regulators (cutaway Figure 6).
EPR valves are required to provide smooth modulation, and therefore, are constructed with "V" ports or parabolic restrictor plugs. EPR seats are usually of synthetic material for tight seating. Nearly all have manual opening stems.

Evaporator pressure regulators come in a variety of combinations, such as, with pneumatic control connections (see Figures 9 and 10) for automatically varying the setting in response to a pneumatic controller signal. With remote pressure pilots, that can be located in a convenient place for ease of adjustment (see Figure 11), or for combining multiple settings automatically selected by pilot line solenoids. And with many integral pilot combinations. These and their specific applications will be covered later under the “FA” (Factory Assembled) types.
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Figure 10 — Pneumatic pilot converts EPR into EAC regulator.
SELECTION (BRASS BODY REGULATORS)

Energy Efficient Brass Body Regulators

This evaporator pressure regulator is a new lightweight, energy efficient pilot operated regulator. It is supplied with copper connections to allow easy installation into the system. The pilot operation is dependent upon high side system pressure which minimizes the pressure drop across the regulator. This regulator is of normally open construction so that a manual operator is not required for system evacuation. A solenoid version having the suction stop is available as an option (see Figure 12).
Selection (Iron Body)

Proper selection of an iron bodied EPR valve (see Figures 13, 14, and 14A), is extremely important. Since a minimum of 2 psi pressure drop across the valve is required to provide full port opening, the valve should never be selected for a load or flow rate less than 2 psi pressure drop. Consult the catalog ratings for the actual available pressure drop which will be the required setting minus the common suction line pressure. For example, assume an R-22 system has a required setting of 30°F or 55 psig. The load is 5 tons R-22 and the compressor rating curves show the compressor will have 5 tons at a 47.6 psig suction pressure. The difference between the required setting (55 psig), and the common suction pressure (47.6 psig) is 7.4 psi pressure drop. So be sure to select a valve with a 5 ton R-22 rating at the pressure drop, NOT the nominal 2 psi drop rating, as this will result in considerable oversizing. Oversized valves not only cost more, but produce poorer results. Be sure the valve is selected not only for the proper pressure drop, but at the proper saturated evaporator temperature. Do not select valves by nominal capacity or line size.
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Figure 13 — Cast iron Evaporator Pressure Regulator lesser tonnage two–bolt flange.
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Figure 14 — Cast iron EPR with 4-bolt flange.
Vacuum Service

Where evaporator pressure regulators are required to regulate evaporator pressure in the vacuum range, the EPR series is available with special vacuum springs under the following regulator series numbers:

With the refrigerant R-502 and its popularity with the supermarket industry, especially in low temperature conditions, it has become increasingly favorable to use the EPRV as a standard production item.

Application of Iron Body Regulators

Evaporator pressure regulators can be used on any refrigeration system fed by thermostatic expansion valves, low side floats, or solenoid liquid valve and float switch combination. Their use is indicated wherever a minimum evaporator pressure or temperature is desired. Controlling from an inlet side pressure signal, they prevent upstream pressure from going below a preset point.

For example, in multi-evaporator systems, a thermostat can be used to control a solenoid valve, (see Figure 15), or to permit the evaporator pressure regulator to function as a suction stop valve (see Figure 16). This is particularly useful on a flooded evaporator, to prevent "freeze-up" or further lowering of product temperature.
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Figure 15 — Solenoid valves controlling multiple evaporators.
When the pilot solenoid is de-energized, the valve assumes the closed position. This offers considerable cost reduction over a separate suction solenoid as well as a tight shutoff. The FA (Factory Assembled) models incorporate integral pilots to expand the application of the EPR.

On multi-evaporator installations (see Figure 17), evaporator pressure regulators are installed to provide temperature control on the individual evaporators. The regulators prevent lowering of the desired temperature in the warmer evaporators, while the compressor continues operating to satisfy the coldest evaporator. With such a system, the compressor is controlled by a low pressure switch, or by thermostats installed on the individual units.
EPR valves are used on brine or water chillers to prevent freeze-up during low load periods, by keeping the refrigerant saturation pressure above the fluid freezing temperature. Similarly, they may be used to prevent frost formation on fan coil evaporators. They may also be used to provide a given evaporator saturation pressure to produce the required evaporation/room temperature difference, (especially useful where humidity control is required). On multiple evaporator systems where different evaporator temperatures are required, EPR valves will hold the saturation pressure at the required set point above the common system suction pressure. Here, the EPRs prevent lowering of the desired temperature in the warmer evaporators, while the compressor continues operating to satisfy the coldest evaporators. On systems such as this, a check valve may be required in the colder evaporator's suction line (see Figure 17).

EPR valves are generally used on various defrost systems to perform a relief function, permitting a rise in the defrost pressure to some pressure well above freezing before they open and relieve pressure to the common suction.

An evaporator pressure regulator is often used on a blower type finned evaporator where dehumidification should be prevented or minimized, for example, in vegetable storage. The regulator will prevent the evaporator pressure (and corresponding saturation temperature) from falling below a predetermined pressure setting at low loads. This prevents large temperature splits between evaporator and air temperature with consequent excessive dehumidification.
EPR Installation

EPRs are generally installed as close to the evaporator as possible. If the EPR must be located at some distance from the evaporator or downstream from a riser, the valve may be converted to an external pilot arrangement, and the pilot line connected at the evaporator.

The evaporator pressure regulator, with internal pilot connection, receives its source of pressure for pilot operation at the regulator inlet connection. Under some conditions of fluctuating load, the stability of EPR performance can be improved by using a regulator with an external pilot connection attached to or near a surge tank.

By connecting the external pilot line to the surge drum or suction header on the evaporator, a steadier source of pressure is obtained for pilot operation, and the evaporator pressure regulator will give better performance. The larger EPRs generally provide external pilot connections.

A remote pilot operated evaporator pressure regulator can be provided by removing the integral pressure pilot, capping this connection, and substituting the remote pressure pilot (see Figure 18) in the external pilot line. Other types of pilots can be used in the external pilot line for various special applications. As noted, the EPR valve is constructed of cast iron and is easily removed from the system because flanges are mounted in the line.

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**Figure 18 — Remote 724 pilot and 722 regulator.**

**NOTE:** When the pilot is removed from the EPR, the regulator is called a 722.
Multiple Pilot Combined Controls (or FA Series)

Evaporator pressure regulators are often required to perform multiple functions. Refrigerant control manufacturers furnish a wide variety of these special multiple function EPR valves. The completely integral FA (Factory Assembled) pilots provide a simple, economical installation with high reliability. A brief description of several types of pilot operated regulators follows.

In order to insure proper pilot selection and installation, the FA regulator and matching pilot are offered in the following combinations:

**FA1** This series enables the main EPR body to function at either of two preset pressure ranges. See Figure 19.

![Image of FA1 series](image)

**Figure 19 — FA1 Series, dual Evaporator Pressure Regulator.**

**FA2** This series enables the regulator to function as an EPR or as a wide open, no restriction valve. See Figure 20.
This series enables the regulator to function as an EPR or as a suction stop valve. A more recent economic version would be the EPRVS. See Figure 22.
FA4. This converts the EPR body into a positive suction stop valve or a very low pressure drop wide open solenoid. See Figure 23.

Figure 23 — FA4 Series. Converts EPR body into a positive suction stop or a very low pressure drop wide open solenoid, popular with ammonia operators.
FA5 This converts an upstream regulator into a downstream regulator. See Figure 24.

Figure 24 — FA5 Series. Pressure regulator (downstream) holdback valve. Pilot operated crankcase pressure regulator (CPR).
FA6 This converts the EPR into a temperature responding regulator. See Figure 25.

**Figure 25 — FA6 Series. Evaporator pressure regulators (upstream), “temperature” compensated.**

FA6 temperature pilot operated EPR with optional suction stop combination.
FA7 same as FA6, but with a pressure pilot override. See Figure 26.

Figure 26 — FA7 temperature pilot operated Evaporator Pressure Regulator with pressure pilot override and standard suction stop combination.
FA8 This causes the regulator to respond as a hot gas bypass or system capacity regulator. See Figure 27.

The FA1 regulator is a standard evaporator pressure regulator with an auxiliary Factory Assembled pilot which permits automatic selection of two pre-adjusted settings. The higher pressure setting must always be made on the integral pilot, and the lower pressure setting must always be made on the pilot on the pilot body. Operating pressure selection is controlled by the pilot solenoid. When the solenoid is energized, the FA1 will control evaporator pressure at the lower setting. In the de-energized position, the FA1 will control at the higher pressure setting.

The FA2 regulator is a standard evaporator pressure regulator with an integral, factory-installed pilot solenoid. They may be automatically changed to meet either of two conditions: controlled evaporator pressure or no pressure control. When the pilot solenoid is de-energized, the FA2 operates as an evaporator pressure regulator and will prevent the upstream pressure from going below the pressure pilot setting. When the pilot solenoid is energized, the regulator will remain in the wide open position with no pressure control (see Figure 20).

The FA3 regulator is a combination evaporator pressure regulator and suction stop valve. When the pilot solenoid is energized, the FA3 operates as a standard evaporator pressure regulator. When the pilot solenoid is de-energized, the regulator will close. Thus, the FA3 serves to take the place of two valves, an EPR and a suction solenoid (see Figure 21).
More recently, an adaptation of a standard EPR, modified with an integral solenoid (named EPRVS), has proven more popular than the FA3, simply due to a lower cost (see Figure 22).

**Crankcase or Suction Pressure Regulators (Holdback Valves)**

On some installations, the load may exceed the ampere value that can be safely carried by the compressor motor. In order to protect the compressor motor from overloads, and possible burnout from excessive suction pressure, a valve must be provided that will limit the suction pressure at the compressor inlet.

To a degree, this has been accomplished on some systems by using pressure limiting types of thermostatic expansion valves. However, on other systems, the refrigerant contained in the evaporator will create excessive suction pressures during a prolonged shutdown period, or following the defrost period.

This suction pressure regulator is designed to prevent motor overload caused by excessively high suction pressure (see Figure 24).
NOTE:

Suction pressure regulators or holdback valves, are often referred to as crankcase pressure regulators. They should not be confused with evaporator pressure regulators. Under no circumstance can they be used to regulate evaporator pressure.

Direct Operated Holdback Regulators—Function

As with EPRS, the holdback or suction pressure regulators come in one of two groups: direct acting, or pilot operated. The modern direct acting hold-back valve is of hermetic or one piece assembly, usually employing a spring loaded bellows seal with a poppet at one end (see Figure 28). The area of the poppet is matched to the area of the orifice—both are balanced and offset one another. Therefore, the only operational forces that affect control are the outlet pressure and spring adjustment (see Figure 28A).
Pilot Operated Holdback Regulators—Function

Pilot operated type suction pressure regulators are composed of a piston operated regulator having a spring loaded poppet identical to those used in EPR valves. Pilot operated holdback valves are available with an optional integral solenoid in the pilot circuit (see Figure 24), to combine the regulator into a suction stop device.

Application—Downstream Regulators

The suction pressure regulator should be used on any installation where compressor motor protection is required because of:

1. High starting loads.
2. Surges in suction pressure.
3. High suction pressure caused by hot gas defrost.
4. Prolonged operation at excessive suction pressures.

5. Low voltage and high suction pressure conditions.

Figure 29 shows a typical application of a direct acting holdback valve. Figure 30 shows the application of a pilot operated suction pressure regulator with the integral pilot solenoid for positive shutoff.

Figure 29 — Typical application of an OPR series valve.
On low temperature installations where minimum suction line pressure drop is of the utmost importance, it is desirable to operate suction pressure regulators without the normal pressure drop necessary to move the valve through full stroke. This can be accomplished by using the compressor discharge gas to pilot the regulator as shown in Figure 31. With this arrangement, the only pressure drop through the regulator is due to friction, and this can be made negligible by choosing a regulator with the same port size as the suction line size. The loss due to the hot gas bleed through the regulator is insignificant, because of the small quantity involved.
Selection—Iron Body Downstream Regulator

The iron bodied series regulator, whether with regular or Factory Assembled (FA Series) pilots, are usually selected for the required capacity, refrigerant, and temperature range at the lowest pressure drop across the valve port, for the best economical compressor operation (see Figure 32). It must be kept in mind that most iron bodied regulators do require a minimum of two pounds pressure drop for automatic operation. For less than a two pound drop, see Application Downstream Regulators (for low temperature). Use the same capacity tables as for regular EPR operation at a two-pound pressure drop.
As with all FA series, the letter “V” in the nomenclature (e.g., FAV5) indicates usage is possible in a vacuum condition.

**Installation—Iron Bodied Regulators**

The installation is the same as any EPR, except it should be kept in mind that these are downstream, or outlet type regulators, and that all pilot sensitive lines must be connected to the downstream or crankcase side of the regulator (see Figure 30).

**722 Regulators**

At times the main regulator has no pilot, or has a remote pilot. For example, the EPR may have a remote pilot or the holdback regulator may have a remote pilot, etc. (see Figure 33).
When the pilot valve is removed from the main regulator, it becomes, in essence, a body without a brain. To highlight this condition, the main regulator is now known as a "722" regulator. A flange cap is installed in place of the pilot to seal the valve (see Figures 34 and 35).
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Figure 34 — The 722 (-11,12,13,14) regulator.
Type 722 regulators are extremely versatile. They are designed for and must be used with various pilot valves. The type of pilot valve used determines the function and operating characteristics of the main regulator. 722 series valves are the same as standard EPR valves, except that the pressure pilot is omitted and they are arranged for external pilot service. Pilot connection size, and pilot solenoid valves (for suction stop service) are the same as for the corresponding EPR valve. Used with a 724 remote pressure pilot, they perform exactly the same as EPR valves. If a 935 temperature pilot is used, the valve functions as an EPR, except that it modulates in response to temperature changes at the remote bulb of the temperature pilot.

Temperature Actuated Pressure Regulators (Temp Pilot)

Suction line regulators are often modified to provide control directly from a temperature signal. They still may be classified as a pressure regulator even though they do not obtain the control signal directly from a pressure source. There are many applications where it may be more desirable to control the temperature of the medium being cooled, rather than controlling the evaporator pressure and temperature.

Function—Temperature Pilot Operated Regulators

A pilot operated type regulator is shown in Figure 36. It consists of a main regulator identical to the type described in the section on EPR and holdback valves. In the pilot circuit is a pilot valve that responds to a sensible temperature signal only. It has no pressure connection under the diaphragm to effect the control. With the bulb of the pilot valve placed to respond to the temperature of the load, the pilot valve moves in a closing direction gradually as the temperature of the bulb decreases. This, in turn, causes the main valve
to move in a closing direction, gradually. The result is an increase in evaporation pressure and temperature, and a reduction in the temperature difference between the evaporator and the load. At full load, the regulator opens wide and permits the evaporator pressure to be approximately the same value as the suction pressure, except for the pressure drop loss through the regulator and suction piping. See Figure 37 for typical application.

Figure 36 — Temperature pilot operated 722 regulator.
Selection—Temperature Operated Regulators

Temperature operated regulators are selected in the same manner as evaporator pressure regulators, but the adjustable range must be specified. They are available for nearly any temperature range. Adjustment is accomplished by changing the spring setting in the pilot valve. Turning the external adjustment clockwise increases the setting; turning the adjustment counterclockwise lowers the temperature setting.

Temperature operated suction line regulators are also available with an optional integral pilot solenoid to provide positive closure (see Figure 38). Another version of the temperature operated suction line regulator is shown in Figure 39. This control is shown with an integral pressure pilot in the pilot circuit to provide a low limit control or override. This model is especially useful on water chiller application to provide positive protection from freeze-up.
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Figure 38 — FAV6 temperature pilot with optional solenoid.
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Suction pressure regulators (holdback or temperature regulators) are rated in terms of tons of refrigeration at given inlet pressures and pressure drops across the regulator, the same as EPRs. The only difference is suction pressure regulators are usually selected for the required capacity at the lowest pressure drop across the valve for economical compressor operation. For best results, do not oversize.

Direct acting regulators may be selected for a pressure drop of less than 2 psi. However, pilot operated valves must be selected for a pressure drop of 2 psi or greater in the same manner as an EPR, unless the special piping configuration illustrated in Figure 31 is used.

Figure 39 — 935 temperature pilot for 722 regulator (remote control).
Pilot Selection

After the main regulator has been properly selected, care should then be taken in the selection of the temperature range of the pilot valve. See Table 1. This "Temp. Pilot Valve" is an integral part of the FAV6 series, but may be selected for remote control with a 722 regulator (see Figure 39).

Table 1- For 935 Pilots

<table>
<thead>
<tr>
<th>Temperature Range °F</th>
<th>Temperature Range °F Suffix Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>-35 to -15</td>
<td>-8</td>
</tr>
<tr>
<td>-15 to +10</td>
<td>-1</td>
</tr>
<tr>
<td>+10 to +30</td>
<td>-2</td>
</tr>
<tr>
<td>+20 to +40</td>
<td>-104</td>
</tr>
<tr>
<td>+30 to +50</td>
<td>-3</td>
</tr>
<tr>
<td>+35 to +65</td>
<td>-4</td>
</tr>
<tr>
<td>+50 to +70</td>
<td>-5</td>
</tr>
<tr>
<td>+70 to +90</td>
<td>-6</td>
</tr>
<tr>
<td>+85 to +105</td>
<td>-7</td>
</tr>
<tr>
<td>+95 to +125</td>
<td>-9</td>
</tr>
</tbody>
</table>

Example: 722-16, 935-104 plus connections, plus options

Options For 722, Fa6, Fa7

- Vacuum Range.
- Access Valve.
- Temperature Ranges (935 pilots).
- Integral Pilot Solenoid.
- Gauge and Shut-off Valve.
- Special Remote Bulb Tube Lengths.
- Conduit Boss.
- Special Voltages.
- Remote Bulb Well. Specify style and size of connection on order.

For further information, consult the Manufacturer's Regulator Catalog.

The pilots are designed to give modulating temperature control. They are satisfactory for all refrigerants except ammonia. A temperature change of 4°F at the remote bulb is sufficient to move the main regulator.
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Applications—Temperature Operated Regulators

Temperature operated regulators are more and more in demand because of their ability to accurately control from a temperature signal. One of the most successful applications has been on supermarket installations. On low temperature open type display fixtures, the accumulation of frost on the evaporator retards proper heat transfer. A temperature operated regulator will immediately sense the increase in air temperature and open to provide a lower evaporator pressure and consequently, a higher temperature difference.

On direct expansion air handling units, the remote bulb may be located in either the entering air or leaving air stream. Similarly, the remote bulb may be located in either the leaving or entering line on water or brine chillers. Among the many applications in supermarkets, this type of control has been found especially useful in meat coolers and display cases. It also offers a convenient solution to applications where intermittent or seasonal radiation loads occur.

Type 935 Modulating (Temp. Pilot) Valves (Used For Independent Control)

The 935 valve has many uses in its own right, for example:

1. Oil temperature control.
2. De-superheating control.
3. Discharge temperature control.

Also, the 935 is useful when temperature control can be accomplished by intermittent feeding of liquid refrigerant into a low pressure chamber.

Function—935 Valve

The 935 valve is designed to open as the sensing bulb warms up, and close as the bulb cools down. Therefore, as the product mix tends to warm up, the 935 opens and allows raw liquid refrigerant to enter the product chamber, and flash cool the product mix to a desired temperature.

Selection—935 Valve

The 935 may be used with any common halocarbon refrigerant. A wide variety of temperature ranges are available (see Table 2). Through a change of the power assembly and/or cage, the temperature range is controlled. With a cage change only, several tonnage ranges are available similar to an expansion valve.
## Table 2 Temperature Ranges Of 935 Temperature Pilot Valve Used Independently (Not As A Pilot)

<table>
<thead>
<tr>
<th>Valve Type</th>
<th>Temperature Range °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>935 - 1</td>
<td>-15 to +10</td>
</tr>
<tr>
<td>935 - 2</td>
<td>+10 to +30</td>
</tr>
<tr>
<td>935 - 3</td>
<td>+30 to +50</td>
</tr>
<tr>
<td>935 - 4</td>
<td>+35 to +55</td>
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<td>935 - 5</td>
<td>+50 to +70</td>
</tr>
<tr>
<td>935 - 6</td>
<td>+70 to +90</td>
</tr>
<tr>
<td>935 - 7</td>
<td>+85 to +105</td>
</tr>
<tr>
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<td>-35 to -15</td>
</tr>
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<td>+95 to +125</td>
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<tr>
<td>935 - 106</td>
<td>+130 to +155</td>
</tr>
<tr>
<td>935 - 107</td>
<td>+175 to +200</td>
</tr>
</tbody>
</table>

Table 2 courtesy of Aco Controls

**CAUTION:**

Do not attempt to use the 935 valve as a thermostatic expansion valve; it will not work. Contact the ALCO Technical Services Dept. for final selection of refrigerant, range, and tonnage.

### Application—935 Valve

Flash cooling, either direct or indirect may be accomplished by use of the 935. An example of direct cooling is the introduction of raw liquid refrigerant into a compressor oil line to cool crankcase oil. An example of indirect cooling would be the use of a heat exchanger chamber with liquid refrigerant on one side of the tubing and the mix to be cooled on the other side of the tubing.

### Installation—935 Valve

Type 935 temperature pilots may be mounted in any position. The remote bulb should be located to sense the temperature of the medium being cooled. When installing these pilots, remove the power assembly and cage before soldering the body flange connections. Do this by removing the two cap screws which hold the assembly together. The inlet connection is at the bottom, the outlet is at the side. When reassembling, make sure that all gaskets are in place and are in good condition. DO NOT APPLY...
HEAT TO POWER ELEMENT OR REMOTE BULB. DOING SO MAY DAMAGE THE PILOT. Remote bulb tubing can be furnished in any multiple of 10 feet, up to a maximum of 50 ft. length.

Adjustment - 935 Valve

The temperature adjustment stem on the 935 is located on the side of the power assembly under the seal cap. Turning the adjustment stem clockwise increases the control temperature (increases the evaporator pressure). Turning the stem counterclockwise decreases the control temperature (lowers the evaporator pressure). Adjustments should not be made until the load has pulled down to a constant temperature. One complete turn of the adjusting stem will change the control point approximately 1/2°F.

More Pilots !!!

Certain small valves may be used as pilots for larger bodied (large tonnage) regulators.

Holdback Valve

As previously mentioned, the FA5 uses a built-in (Factory Assembled) CP valve to create a downstream regulator out of a 722 body. However, there are instances where it is more desirable to have a remote pilot installed some distance from the main body.

A CPH (EE) valve used as a pilot connected to a 722 body (properly piped) creates a CPR or holdback valve the same as an FA5, similar to Figure 31 without high pressure connection.

Large Bodied Solenoid (Large Tonnage)

A standard small sized (1 ton) solenoid remotely piped to a 722 will convert the regulator to a large tonnage solenoid. As with the 905 solenoid, caution should be taken to provide a choke fitting in the pilot passage of the main regulator for liquid line and discharge gas service.

Hot Gas Bypass Regulator

A CPH (EE) used as a remote pilot may be installed to an HGR body to create a hot gas bypass regulator. The action is the same as, or similar to, an FA8 (see Figure 41).
Mix And Match

With the use of the remote pilots, a service person has a choice not only of a variety of regulator action, but also regulator placement. A serviceable location for the pilots, such as a control board, may be more accessible than the regulator located in a maze of piping in the machinery room. For any questions regarding various regulators, contact manufacturer's Technical Service Dept.
Table 3 specifies the pilots available for duty with a 722 regulator. If an FA series is available for the same duty, it is specified.

**NOTE:**

Do not confuse the manual opening stem found on most pilot-operated suction pressure regulators with the setting adjustment, which is found on the pilot valve.

<table>
<thead>
<tr>
<th>Remote Pilot Valve</th>
<th>Regulator Body</th>
<th>Similar FA Valve available</th>
<th>Function of the Regulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>724</td>
<td>722</td>
<td>FA1</td>
<td>Dual Setting</td>
</tr>
<tr>
<td>935</td>
<td>722</td>
<td>FA2</td>
<td>EPR or wide open</td>
</tr>
<tr>
<td>CP(EE)</td>
<td>722</td>
<td>EPRV, FA3</td>
<td>EPR or Solenoid Stop</td>
</tr>
<tr>
<td>Solenoid</td>
<td>722</td>
<td>FA6 - FA7</td>
<td>Temperature actuated EPR</td>
</tr>
<tr>
<td>EAC (not remote)</td>
<td>EPR</td>
<td>Replaces D865 on EPR body</td>
<td>Pneumatic Override Control</td>
</tr>
<tr>
<td>CP (EE)</td>
<td>HGR</td>
<td>FA8</td>
<td>Hot Gas Bypass Capacity Control</td>
</tr>
<tr>
<td>TCLE - Thermo® Valve</td>
<td>POS</td>
<td></td>
<td>Pilot Operated TEV (large tonnage)</td>
</tr>
</tbody>
</table>

**Automatic System Capacity Control—Hot Gas Bypass**

The purpose of this section is to review the fundamentals of automatic system capacity control methods, based on new developments and experience in the refrigeration and air conditioning industry. Although the basic principles are not new, there is very little reference material available concerning the selection and application of external capacity control devices, to assist in the solution of ever increasing problems of maintaining proper operation throughout a wide range of partial loading.

Continued operation at partial load conditions, whether for cooling or dehumidifying, can produce undesirable conditions such as low suction pressure, short cycling, evaporator frosting, poor compressor lubrication, etc. If these conditions can be anticipated in the initial design stage, several methods of controlling partial loading might be considered:

1. Installation of multiple compressors.
2. Single units with multiple compressors.
3. Variable speed compressors, such as the gas engine drive unit.
4. Integral compressor cylinder unloading.

5. Artificial evaporator coil loading.

6. Compressor loading or unloading by means of external automatic control devices.

The last method requires proper attention to application details. It is most commonly recommended by equipment manufacturers as a supplement to integral cylinder unloading devices, or for smaller units having hermetic or semi-hermetic compressors.

Demand continues to mount for improved comfort conditioning combined with lower operating costs. New architectural designs have created real problems for contractors and engineers to maintain humidity control at reduced loads, and to control load variations. Refrigeration and air conditioning systems are usually designed to provide a given capacity at maximum conditions. These operate with little fluctuation throughout a narrow load range. However, only the larger size machines make any provisions for operation at reduced capacity. In some systems, integral cylinder unloading, the installation of a gas engine drive with variable speed control, or even multiple smaller systems, provide a logical solution.

Function—Hot Gas Bypass Method

Many manufacturers now recommend use of a modulating control valve to provide a metered flow of compressor discharge gas to the system low side, in a proportion that will balance the system capacity to the load demand. This is commonly known as the hot gas bypass method. It permits full modulation of capacity on all types of reciprocating compressors, and extends capacity reduction below the last step of cylinder unloading.

Basically, the system must provide a means of bypassing high pressure refrigerant to the system low pressure side, in order to maintain operation at a given minimum suction pressure. Proper bypass control can be accomplished by a modulating type pressure regulator, which opens on a decrease in valve outlet pressure.

Operation of Bypass Valves

Bypass pressure regulators are grouped into the following categories:

1. Direct acting unbalanced port valves (Figures 42 and 43).
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Figure 42
Adjustable hot gas bypass regulator.

Figure 43
Non-adjustable hot gas bypass regulator.
2. Direct acting balanced port valves (Figure 44).

Figure 44 — Balance port adjustable (field-serviceable) bypass regulator.
3. Pilot operated valves (Figure 45).

Any of these regulators are available with either an adjustable setting, or a fixed, non-adjustable setting.

For most field installations, it is recommended that the direct acting balanced port valve or the pilot operated characterized parabolic plugged valve be used, and that they have an adjustable setting.

OPERATION OF VARIOUS VALVES

DIRECT ACTING VALVES

Direct acting valves, either with or without a balanced port, operate with a spring loading above a diaphragm. Or they operate with bellows that directly move the valve stem and seat open or closed, depending on the equalizer pressure below the diaphragm or bellows.

When the equalizer pressure (either internal or external) falls below the spring setting, the valve begins to move in an opening direction. As the equalizer pressure rises, it overrides the spring setting above the
diaphragm and the valve closes. Direct acting valves are usually designed with a 5 to 7 psi "gradient." Gradient is defined as the change in pressure required to move the valve from the closed position to the opening needed to deliver rated flow. This is, of course, an average figure and it will vary with the spring setting, sizing, and actual operating conditions.

The balanced port design provides a smooth flow modulation from the instant of opening to full open position. Valves without a balanced port may sometimes chatter or hunt slightly at the instant of opening, or at periods where very low flow is required. Aside from the equalizer pressure and spring setting, which are the forces that must operate the bypass regulator, there is always a high pressure differential across the valve port, that may tend to override valve control in an unbalanced valve. Some direct acting valves are non-adjustable. That is, they have a fixed inert gas charge pressure above the diaphragm in place of a spring (see Figure 43). Valves of this design may be ordered with the fixed setting specified. These valves are more frequently used by package equipment manufacturers who are in a position to tailor a fixed setting to their particular requirements. Although a wide temperature change may affect the fixed charge setting, it is usually negligible.

Pilot Operated Bypass Regulators (FA8)

The larger size regulators are generally of the pilot operated design (see Figure 45). They use a small direct acting regulator to operate a larger valve, generally called the main regulator. The pilot valve must have an external equalizer that is connected to the system low side at the point where pressure control is required. The pilot valve operates exactly as described in the paragraph above covering direct acting regulators. When the equalizer pressure drops below the diaphragm spring setting, the pilot valve port opens, admitting high pressure gas into the cylinder above the main regulator piston.

The piston is driven downward, opening the main regulator port. When the main regulator port opens, high side gas is bypassed to the system low side. As the low side pressure increases, the pilot valve closes. The main regulator piston has a small bleed hole which permits the pressure above the piston to bleed to the system low side, permitting the main regulator spring to close the valve and reduce or stop the main flow.

Hot Gas Bypass to Compressor Suction Line Application

Figure 46 shows what is possibly the most common hot gas bypass system. In this system, the bypass line is taken directly from the compressor discharge line, through a bypass regulator, and into the suction line at the compressor. While the hot gas bypass regulator is considered a downstream control, there is a big difference in function between a Crankcase Regulator (FA5) and a hot gas regulator (FA8).
Pilot operated bypass valve main regulators have a long stroke stem with a restrictor plug characterized by either a parabolic or vee port restrictor plug design. This prevents the valve from operating close to the seat where pressure differential unbalance may occur, eliminating the need for a balanced port design.

The characterized port will provide smooth bypass flow modulation. Pilot operated valves usually have the extra features of a manual opening stem for testing or emergency operation, flanged connections, synthetic tight seating seats, and replaceable parts. Hot gas bypass valves can be applied to a system in several general ways, differing only in the point to which the hot gas is to be bypassed. Several mixing methods are available. The one generally recommended is piped so that discharge gas is admitted to the suction line to flow against the direction of the suction gas as in Figures 46 and 47.
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With this method, a liquid injection thermostatic expansion valve is sometimes required for de-superheating the suction gas to prevent overheating of the motor or compressor (see Figure 47).

Bypass to Evaporator Inlet

Another method is to bypass the hot discharge gas to the evaporator inlet, usually between the thermostatic expansion valve and the refrigerant distributor (see Figures 48 and 49). This provides distinct advantages. The artificial load imposed on the evaporator causes the thermostatic expansion valve to respond to the increase in superheat, eliminating the need for the liquid injection valve. The evaporator serves as an excellent chamber to provide homogeneous mixing of the gases before reaching the compressor. It is essential that this type system be equipped with a Venturi flow type refrigerant distributor (i.e., no restrictor orifice).
Hot gas bypass into the evaporator is suggested when the evaporator elevation is below the compressor, to prevent oil trapping due to low velocity at low loads. This assures proper oil return. Although there are many advantages to this system, it is not generally used on a multiple coil system, or where the evaporator sections may be located a distance from the compressor. The coil should be a free draining
circuiting design to prevent the increase in velocity, due to forcing a large quantity of trapped liquid out of the low side, which in some cases may have enough volume to flood the compressor crankcase.

**NOTE:**
Separate regulators must be used for each evaporator when bypassing to multiple evaporators located below the compressor to facilitate oil return.

Bypass to flooded evaporators and suction line accumulators also present special cases. Contact the equipment manufacturer or the bypass control valve manufacturer for specific, detailed information.

**Special Application Where Evaporator Pressure Regulator Is Used**

When the evaporator pressure must be regulated by an EPR valve to prevent the evaporator saturation pressure from going below a given setting, the hot gas can still be bypassed into the evaporator. However, it is important to remember that the bypass regulator external equalizer line must be connected on the compressor side of the evaporator pressure regulator (see Figure 50).

![Diagram of Pilot operated hot gas regulator, bypassing flow into chiller barrel inlet downstream of TEV.](image)

**General Recommendations for Hot Gas Bypass Applications**

For all hot gas bypass applications, the problem of head pressure control must be considered. Where low condensing temperatures occur during low load periods, when bypass capacity control is required, the head pressure must be maintained well above the required hot gas bypass valve suction pressure setting.
A method of piping the hot gas into the system low side should insure a homogeneous mixing of the gases. Pipe sizes usually dictate the best method to use: a tee, a 45°Y connection, or an elbow turned upstream to the flow of suction gas (see Figure 51). Some manufacturers are recommending baffles or mixing chambers.

![Figure 51 — Elbow turned upstream inside suction line against main flow, to assure good mixing.](image)

A tee in the bypass valve outlet is recommended so that a liquid injection valve might be installed at a later date, if required. Bullhead mixing of the liquid quench can then be accomplished in the bypass line before it enters the low side. A typical example is shown in Figures 46 and 47.

Most major manufacturers have specific instructions concerning these applications. Consult the application manual for the compressor or the unit manufacturer.

**Selection—Hot Gas Bypass Valves**

For proper selection of a hot gas bypass valve, determine:

1. System refrigerant.
2. Capacity to be bypassed in tons (compressor capacity minus system load equals tons to be bypassed).
3. Evaporator temperature at which regulator is to operate.
4. Hot gas bypass valves from the Quick Selection Chart found in ALCO's "Hot Gas Bypass" Catalog.

**Example:**

A refrigeration system operating at 30°F evaporator has a compressor capacity of 20 tons against a system load of 15 tons. To balance the load between compressor and system, 5 tons must be bypassed (20 - 15 = 5 tons). Refer to the Quick Selection Chart for 30°F evaporator and 5 tons to be bypassed. If the hot gas is to be bypassed into the suction line, a liquid injection valve may be needed to de-superheat this discharge gas in order to protect the compressor (see Figure 47).
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Technical Consultant, Alco Controls – Emerson Electric Co.
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NOTE:

1. Selection of regulators is based on a 6 degree gradient, i.e., rated capacity of the regulator is attained when the suction pressure falls 6 degrees below the set point of the pilot.

2. Applications that vary from normal system conditions will not effect selection of the regulator, as selections are based on average conditions at 65°F superheated suction gas entering the compressor, with isentropic compression to 100°F saturation, plus 50 degrees.

Installation and service of hot gas bypass regulators would be very similar to standard CPHE and EPR regulators.

Thermo® Valves for Liquid Injection Applications

When the capacity control application requires some means of suction superheat control, primarily to prevent overheating of the compressor during prolonged periods of hot gas bypass, a special type of thermostatic expansion valve may be selected (i.e. the Liquid Injection Valves: LCL, LJL, LER, etc.).

Function—Liquid Injection Thermo® Valves

Without a small Thermo® valve to reduce suction gas temperature to tolerable limits, compressor damage may occur. Standard Thermo® valves cannot be adjusted for control in excess of 20°F superheat and therefore, are not generally recommended. Liquid Injection Thermo® valves with special adjustment ranges are used to conform to compressor manufacturer temperature recommendations.

Selection—Liquid Injection Thermo® Valves

To simplify selection, ALCO Controls has developed Liquid Injection Thermo® valves with five basic adjustment ranges. These are designated as models A, B, C, D and E. The adjustable superheat range chart shows the proper power assembly charge symbol suffix for a given saturated suction temperature and a given superheated suction gas temperature entering the compressor.

Nearly all Thermo® valves for liquid injection may be internally equalized. However, if pressure drop occurs at the valve outlet due to a distributor, spray nozzle or other restrictive device, externally equalized valves may be necessary.

Model LER and LIR valves are furnished with a 1/4" SAE male flare external equalizer as standard. Other models must include the code letter "E" to specify the 1/4" SAE external equalizer.

Example:

LCLE and LJLE.
Application and Installation—Liquid Injection Thermo® Valves

Liquid injected into a gas to be de-superheated should be injected by a method that provides homogeneous mixing of the liquid and superheated gas. De-superheating hot gas bypass in the suction line may be accomplished in several ways.

Application and installation of liquid injection was described earlier in conjunction with hot gas regulators, but it is again presented here to emphasize the importance of compressor protection.

The preferred method is to bullhead the hot gas and liquid injection in a tee to permit good mixing before it enters the suction line (See Figures 47 and 52). Arranging a bypass directly into a suction accumulator is often a convenient way to obtain proper de-superheating of suction gas.

Special Applications

Extremely close control can be obtained with pneumatic compensation. Any pneumatic controller can be applied to CPH and FA8 regulators with external air connection (EAC). Controllers that respond to leaving water or air temperature or entering water or air temperature, as well as humidity, pressure, etc., are often used to reset the hot bypass regulator to a setting appropriate for the desired condition (see Figure 53).
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CHECK CHART FOR SELECTION OF LIQUID INJECTION VALVES FOR COOLING OF SUCTION GAS TO PREVENT OVERHEATING OF THE COMPRESSOR.

Liquid Injection Thermo® Valves

When hot gas is bypassed directly into the suction line, it is necessary to make some provision for desuperheating the gas returning to the compressor. Without a small Thermo valve to reduce suction gas temperature to tolerable limits, compressor damage may occur. Standard Thermo Valves cannot be adjusted for control in excess of 20°F superheat and, therefore, are not generally recommended. Liquid Injection Thermo Valves with special adjustment ranges are used to conform with compressor manufacturer temperature recommendations.

To simplify selection, ALCO has developed Liquid Injection Thermo Valves with four basic adjustment ranges. These are designated as models A, B, C and D. The adjustable superheat range chart shows the proper power assembly charge symbol suffix for a given saturated suction temperature and a given superheated suction gas temperature entering the compressor.

Nearly all Thermo valves for liquid injection may be internally equalized. However, if pressure drop occurs at the valve outlet due to a distributor, spray nozzle or other restrictive device, externally equalized valves may be necessary.
Model LER and LIR valves are furnished with a ¼” SAE male flare external equalizer as standard. Other models must include the code letter “E” to specify the ¼” SAE male flare external equalizer connection. Example: LCLE and LJLE.

Special Applications

On systems where evaporator pressure regulators are used, better control can be achieved by locating the bypass regulator equalizer line on the downstream (outlet) side of the EPR so it responds to compressor suction pressure, not evaporator pressure. This results in nearly constant evaporator load balance.

Extremely close control can be obtained with pneumatic compensation. Any pneumatic controller may be applied to CPH and FA8 regulators with external air connection. Controllers that respond to: leaving water or air temperature, or entering water or air temperature, as well as humidity, pressure, etc., are often used to reset the hot gas bypass regulator to a setting appropriate for the desired condition.

For any special or unusual applications, consult Alco Applications Engineering Department.

Application and Installation

Liquid injected into a gas to be desuperheated should be injected in a manner which provides a homogeneous mixing of the liquid and superheated gas. Desuperheating hot gas bypass in the suction line may be accomplished in several ways.

The preferred method is to bullhead the hot gas and liquid injection in a tee to permit good mixing before it enters the suction line. A good mix with the suction gas may be gained by injecting the liquid / hot gas mixture into the suction line at approximately a 45° angle against the flow of suction gas to the compressor. See Figure 52.

For suction lines 7/8" OD and smaller, the bypass mixture may be introduced into a tee rather than an angle connection. For lines larger than 2-5/8" OD, introduce the desuperheated bypass mixture into a 90° ell inserted against the flow of suction gas to the compressor.

Arranging a bypass directly into a suction accumulator is often a convenient way to obtain proper desuperheating of suction gas.

Introducing the hot gas and liquid into the suction line with separate connections is not generally recommended.

NOTE:

Excessive suction gas superheat can cause serious damage to the compressor. As a safety precaution, the bypass line solenoid valve should be wired in series with a discharge line thermostat.
Ordering Liquid Injection Valves

To order a liquid injection valve, specify:

1. Complete valve type number including type equalizer (external or internal) and charge symbol.
2. Remote bulb tubing length.
3. Required line connection size and style.

Example:
LJLE12B, 5ft. tubing, 5/8 x 7/8" ODF angle

To order a liquid injection solenoid valve, specify:

1. Complete solenoid type number.
2. Coil voltage and frequency.
3. Size line connections.

Table 6 — Selection of Liquid Injection Thermo® & Solenoid Valves
To Assist Hot Gas Bypass Systems

<table>
<thead>
<tr>
<th>LIQUID INJECTION VALVE NUMBER</th>
<th>ALL-PURPOSE CAGE PART NUMBER</th>
<th>LIQUID INJECTION THERMO VALVE NOMINAL CAPACITY — TONS*</th>
<th>POWER ASSEMBLY PART NUMBER</th>
<th>COMPANION SOLENOID FOR LIQUID INJECTION VALVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCL010</td>
<td>X22440-10</td>
<td>1/4 1/2 1/4 1/4</td>
<td>X81019-010</td>
<td>100RB2 100RB2 100RB2</td>
</tr>
<tr>
<td>LCL020</td>
<td>X22440-20</td>
<td>1/2 1 1/2 3/4</td>
<td></td>
<td>200RB4 200RB4 200RB4</td>
</tr>
<tr>
<td>LCL030</td>
<td>X22440-30</td>
<td>2 2 1 1</td>
<td></td>
<td>200RB5 200RB5 200RB5</td>
</tr>
<tr>
<td>LCL040</td>
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<td>3 3 2 2</td>
<td></td>
<td>200RB6 200RB6 200RB6</td>
</tr>
<tr>
<td>LCL050</td>
<td>X22440-50</td>
<td>4 7/12 4/12 7</td>
<td></td>
<td>200RB6 200RB6 200RB6 200RB5 200RB5 200RB4</td>
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<tr>
<td>LCL060</td>
<td>X22440-60</td>
<td>5 10 7 7</td>
<td></td>
<td>200RB6 200RB6 200RB5 200RB5 200RB4 200RB4</td>
</tr>
<tr>
<td>LCL070</td>
<td>X22440-70</td>
<td>6 1/2 10 7</td>
<td></td>
<td>200RB6 200RB6 200RB5 200RB5 200RB4 200RB4</td>
</tr>
<tr>
<td>LCL080</td>
<td>X22440-80</td>
<td>7/12 12 8 9</td>
<td></td>
<td>X81020-020 240RA8 240RA8 240RA8 240RA8 240RA8</td>
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<tr>
<td>LCL090</td>
<td>X22440-90</td>
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<td></td>
<td>240RA9 240RA9 240RA9</td>
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<tr>
<td>LCL110</td>
<td>X9117-94</td>
<td>11 11 12 14</td>
<td></td>
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</tr>
<tr>
<td>LCL120</td>
<td>X8117-88</td>
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<td></td>
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<td>LCL130</td>
<td>X9117-87</td>
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<tr>
<td>LCL140</td>
<td>X9117-86</td>
<td>20 35 21 25</td>
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<td>240RA12 240RA12 240RA12</td>
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<tr>
<td>LCL150</td>
<td>X9117-85</td>
<td>25 45 27 30</td>
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<tr>
<td>LCL160</td>
<td>X9166-81B</td>
<td>35 55 37 40</td>
<td></td>
<td>240RA16</td>
</tr>
</tbody>
</table>

* Add letter "F" for external equalizer. Example: LCL3F.
* Add charge designation A, B, C, or D. (See Table 7 below)
* Add letter "A" for internal equalizer or "B" for 1/4" SAE male flare external equalizer.
* Nominal capacity based on 40°F evaporator and 100°F condensing.
Air-Cooled Condenser Head Pressure Controls

Proper control of compressor discharge pressures on systems employing air cooled condensers is essential when operation at low outdoor ambients is required. Commercial refrigeration and comfort conditioning applications often require year-round operation.

Proper system performance depends upon maintaining discharge pressures above minimum to obtain optimum operation of solenoid valves, thermostatic expansion valves and pressure regulators. At low discharge pressures, the pressure drop across the thermostatic expansion valve is reduced, decreasing the capacity of the valve. In addition, liquid line flash gas may occur, reducing the thermostatic expansion valve capacity even more.

The result of reduced thermostatic expansion valve capacity is a starved evaporator, high superheat, low suction pressure and possible compressor short cycling. On commercial systems employing hot gas defrost, the defrost cycle may be seriously impaired by inadequate discharge pressure.

Function—Condenser Pressure Control

In the past, there were many methods used to provide condenser pressure control. A few common methods included:

1. Cycle condenser fan or fans from a pressure switch or thermostat.

2. Condenser fan speed control using multi-speed motors or solid state control circuits. These employed silicone controlled rectifiers capable of varying motor voltage from a thermistor sensor in the air stream, or attached to the condenser.

3. False heat loads from strip heaters in the air stream or in a condenser enclosure.

4. Controls which automatically modulate dampers or louvers in the condenser air stream.

5. Condenser circuit control by using solenoid valves to shut off multiple condensers sections.

6. Refrigerant pressure controls to reduce condenser heat exchange surface by flooding the condenser with liquid refrigerant.
Since the last method listed uses automatic refrigerant controls, it will be covered here. Four types of control valves are generally used.

**General Requirements for All Four Types of Control Valves for Head Pressure Stability**

The application of air-cooled condensers for year-round operation, or during periods of low ambient temperatures, requires some means of control to maintain adequate condensing pressures that ensure proper system performance. It is essential that proper liquid refrigerant pressure be controlled to:

1. Maintain liquid subcooling and prevent liquid line flash gas.
2. Provide adequate pressure at the inlet side of the thermostatic expansion valve to obtain sufficient pressure drop across the valve port.
3. Properly operate systems with hot gas defrost or hot gas bypass.
4. Provide adequate pressure for operation of heat reclaim systems.

The most popular of the four is the three-way condenser pressure regulator. This "HP" (Head Pressure) valve was developed specifically to maintain proper air cooled condenser pressures during periods of low outdoor ambient conditions; it fulfills all of the requirements for wintertime use (see Figures 54A and 54B).
PRESSURE REGULATORS FOR REFRIGERATION, AIR CONDITIONING, AND HEAT PUMP SYSTEMS

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Member Emeritus – Manufacturers Service Advisory Council

Figure 54A — HP Head Pressure Control, three-way non-adjustable valve.
Operation (Function)—Three-Way Head Pressure Control

The HP control is a three-way modulating valve controlled by the discharge pressure. The charged dome exerts a constant pressure on top of the diaphragm. At high ambient air temperature, bypass gas entering Port B is allowed under the diaphragm where it counteracts the pressure of the dome charge. This upward push on the diaphragm allows the seat disc to seal against the top seat, preventing flow from Port B (discharge gas) while flow from Port C is unrestricted (see Figures 54A and 54B).

As ambient air temperature falls, an uncontrolled air cooled condenser will exhibit a corresponding decrease in head pressure. As the discharge (bypass) pressure falls, it no longer counteracts the dome charge pressure and the diaphragm moves downward, moving the push rod and seat disc towards the bottom seat.
NOTE:

This allows discharge (bypass) gas to be metered into the receiver, creating a higher pressure at the condenser outlet. The higher pressure at the condenser outlet reduces the flow from Port C and causes the level of condensed liquid to rise in the condenser.

The flooding of the condenser with liquid reduces the available condensing surface. The result is to increase the pressure in the condenser and maintain an adequate high side pressure. Figure 57 illustrates a typical application of the three-way control valve. This system is perhaps the most economical and reliable means to accomplish discharge pressure control. The three-way valve, as shown in Figure 54A, is a fixed, non-adjustable valve. The wholesaler replacement setting is normally furnished for a pressure corresponding to 95° to 98°F condensing temperature for the given system refrigerant.

**Figure 57 — Typical 3-way valve (HP8) head pressure control application, multiple evaporators.**

**Two-Way Downstream Pressure Regulator**

This valve is a modified suction pressure regulator such as the ones illustrated in Figures 27 and 28. They differ only in the high pressure adjustable range or setting, since some types have a fixed non-adjustable setting. Those which are adjustable have special springs and high pressure bellows assemblies that permit operation in the range of discharge pressures.

The downstream pressure regulator is used in a bypass line from the compressor discharge to the liquid line between the condenser and receiver (see Figure 59). When the pressure at the condenser outlet (receiver inlet) drops below the set point of the valve, discharge pressure is bypassed, as the valve
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opens, to the condenser outlet. This creates a higher pressure at the condenser outlet and refrigerant
flow in the condenser slows or stops. Condensed liquid refrigerant level in the condenser rises, reducing
the available heat exchange surface for condensing discharge gas. This causes the discharge pressure
to rise. When the pressure is high enough to cause the bypass valve to close, the system returns to
normal operation. During the period when the bypass valve is open, compressor discharge gas is directed
to the top of the receiver, helping to maintain liquid line pressure.

Normally a condenser will have enough pressure drop to permit the bypass valve to work properly.
However, this pressure drop will be reduced at low ambient conditions so that a restrictive valve is
required to produce a pressure drop equivalent to approximately 4 psi. The restrictor may be a tube,
orifice, piping loop or more commonly, a spring loaded check valve.

Downstream pressure regulators are available in nearly any size port, but due to economic
considerations, it is common practice to parallel valves on larger systems. See regulator catalog for piping
diagram, or paralleled bypass valves.

Installation: Two-Way Downstream Pressure Regulators

The installation is the same as any EPR, except it should be kept in mind that these are downstream, or
outlet type regulators, and that all pilot sensitive lines must be connected to the downstream or crankcase
side of the regulator (see Figure 30).
Two-Way Upstream Pressure Regulator

This valve is a modified direct acting evaporator pressure regulator, such as the one illustrated in Figure 4. Two-way upstream pressure regulators differ only in adjustable range, use of high pressure bellows, and in the case of those types having synthetic seat poppets, special materials suitable for use with superheated discharge gas.

Two-Valve (IPR-OPR) Adjustable Head Pressure Control

Before the appearance of the three-way HeadMaster Head Pressure Control Valve, and after several one-valve methods had been tried, a two-valve method of head pressure control became popular. It required the setting of two valves, the piping of two valves (four connections), but it was a better method than the many one-valve systems (see Figure 60).

Figure 60 — OPR in discharge line. IPR between condenser and receiver. Two valve head pressure control. This popular method can be used over large tonnage range.

Various high pressure settings are offered to enable a workable operating head pressure control system where an HP valve is not desired. Information regarding sizing, pressure ranges, liquid and hot gas capacities are available in the Manufacturer's Pressure Regulator Catalog.

The upstream pressure regulator is also used in the liquid line from the condenser, as illustrated in Figure 61. Discharge bypass gas is accomplished by the opening of a differential pressure check valve (ORD) when the upstream pressure regulator (ORI) throttles. Liquid level in the condenser rises to reduce the heat exchange surface and discharge pressure is maintained.
Applications—Head Pressure: Control

As with all head pressure control applications, additional liquid receiver capacity is required to prevent loss of a liquid seal in the receiver when the condenser is flooded. The receiver must be large enough to hold the total system charge. The total system charge consists of the following:

A. An operating charge which is the necessary pounds of refrigerant to operate the system during summer (high ambient temperature) conditions.

B. An additional charge equaling the number of pounds of refrigerant required to flood the condenser with liquid. The condenser must be filled with liquid to a point where a minimum head pressure is created for cold weather (low ambient temperature) conditions.
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NOTE:

Should the outdoor temperature fall below design conditions, additional refrigerant will be required. The total of A and B is the total charge necessary for satisfactory system performance during the lowest expected ambient air temperature conditions. During summer operation the receiver must be sized to safely hold the total system charge. Good refrigeration practice states that the total system charge should not exceed 75% of the receiver capacity.

CAUTION:

1. The HP control should not be used on a system which does not have a liquid receiver or on one with a receiver which is too small. If the receiver does not have adequate storage space, the refrigerant will back up in the condenser to produce excessively high discharge pressures during high ambient air temperatures, with resulting system damage and/or personal injury.

2. The HP control should be used only on systems which employ a thermostatic expansion valve.

Head Pressure: Control, Capacity, and Selection

The nominal HP control capacity in tons for various refrigerants is found in the appropriate catalogs. The nominal capacity is based on 100°F liquid, 40°F evaporator and the pressure drop shown. To obtain capacities in tons at other liquid and evaporator conditions, multiply the nominal capacity at the desired pressure drop by the factor in the tables in the catalog given for the existing liquid temperature and evaporator temperature.

NOTE:

Do not select a valve for a capacity rating exceeding 5 psi pressure drop from Port C to Port B or for a system with more than 20 psi pressure drop across the condenser. During the normal ambient conditions the available liquid sub-cooling in the condenser will be adequate to cover the existing pressure drop through the HeadMaster control.

If a valve is selected for a given flow rate, the resulting pressure drop must not cause the liquid pressure to drop below saturation and produce flash gas. If sufficient subcooling is not available to cover this pressure drop, it is suggested that more than one valve be installed in parallel to reduce the pressure drop to tolerable limits. Do not parallel valves of different capacities. Piping suggestions for parallel valves are shown in the Pressure Regulator Catalog.

The Figures 62 and 63 show the HP installed in a single system. Note the flow (arrows) when the pressure is above and then below the valve setting.
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Figure 62 — Discharge pressure above valve setting flow through condenser.

Figure 63 — Discharge pressure below valve setting flow around condenser.
Installation of Headmaster HP Series

In general, head pressure control systems of this type are used on refrigeration systems that are temperature operated. This means that the compressor is started by a thermostat or the system operates on a pump down cycle, where the thermostat controls the liquid line solenoid valve and the compressor starts on a rise in suction pressure with a low pressure switch.

On systems that are pressure operated, migration of the refrigerant to the cold condenser on the "off" cycle should be prevented. If the system does not operate on a pump down cycle, migration can take place through some compressors, from the suction line to the condenser. The use of crankcase heaters will prevent liquid from condensing in the crankcase, but will not eliminate migration to the cold condenser. If the system is properly charged, the filled condenser will permit the excess to remain in the receiver and low side.

Under certain conditions where the receiver is located in a warm ambient, a check valve in the liquid drain line between the HeadMaster control and the receiver may be required to prevent the liquid receiver pressure from equalizing to that of the condenser during the "off" cycle. This enables the system to start on a pressure switch. Condenser fans should not be cycled when using the HeadMaster control. The sudden changes in high side pressure caused by fan cycling will result in erratic thermostatic expansion valve performance, and shortened head pressure control life.

The Figures 64, 65 and 66 show suggested piping hook-up for various layouts when the condenser and heat reclaiming coil are in parallel.

Figure 64 — Coils in parallel: one HP valve controlling outdoor coil only.
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Figure 65 — Coils in parallel: one HP valve controlling both coils.
Figures 67 and 68 show suggested piping hookup for various layouts when the condenser and heat reclaiming coil are in series. Be sure to check manufacturer’s catalog for precise information regarding parallel piping for increased capacity, capacity factors for other than nominal, and tables for wintertime charging of air cooled condensers.
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Figure 67 — Coils in series: two HP valves, one on each coil.
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Figure 68 — Coils in series: one HP valve for both coils.