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Hot Gas Defrost for Ammonia Evaporators

Bulletin 90-11c

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NOTE 1:

The piping arrangement and control sequence examples given in this manual are intended only to illustrate how hot gas defrost might be implemented on the multiplicity of systems that exist. Some features are shown to spur ideas for alternate approaches to evaporator piping, and should not be construed as recommendations for the best arrangement for a particular application. Operating conditions will vary from one application to the next, so the reader is encouraged to consult local codes and industry standards before designing any refrigeration system.

NOTE 2:

This manual is specific for ammonia refrigeration evaporator hot gas defrost systems and is not applicable or suitable for CFC, HCFC, HFC or other refrigerants.

SAFETY PRACTICES

People doing any work on a refrigeration system must be qualified and completely familiar with the system and the Refrigerating Specialties Division valves involved, or all other precautions will be meaningless. This includes reading and understanding pertinent Refrigerating Specialties Division product Bulletins and Safety Bulletin RSB prior to installation or servicing work.

Where cold ammonia liquid lines are used, it is necessary that certain precautions be taken to avoid damage that could result from trapped liquid expansion.

- Temperature increase in a valved off piping section completely full of liquid will cause high pressure due to the expanding liquid which can possibly rupture a gasket, pipe or valve.
- All hand valves isolating such sections should be marked, warning against accidental closing, and must not be closed until all liquid is removed.
- Check valves must never be installed upstream of solenoid valves, regulators with electric shut-off, nor should hand valves upstream of solenoid valves or downstream of check valves be closed until all liquid ammonia has been removed.
- It is advisable to install liquid relief devices suitable to safely and automatically bypass any trapped liquid ammonia to the low side of the system. This method is preferred since it operates automatically and requires little attention.
- Avoid all piping or control arrangements that might produce thermal or pressure shock. For the protection of people and products, all refrigerant must be removed from the section to be worked on before a valve, strainer, or other device is opened or removed. Flanges with ODS connections are not suitable for ammonia service.

This manual is provided by:

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Refrigerating Specialties Hot Gas Defrost Applications Manual for Ammonia Evaporators

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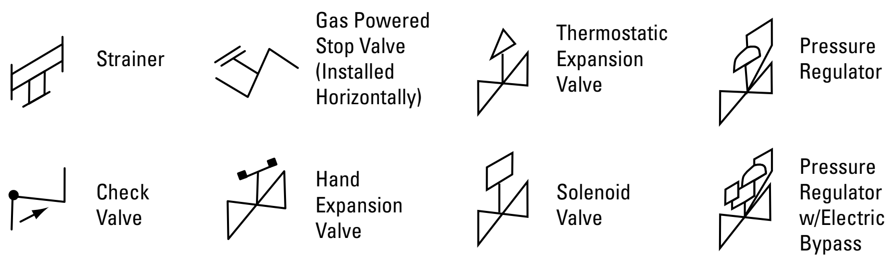
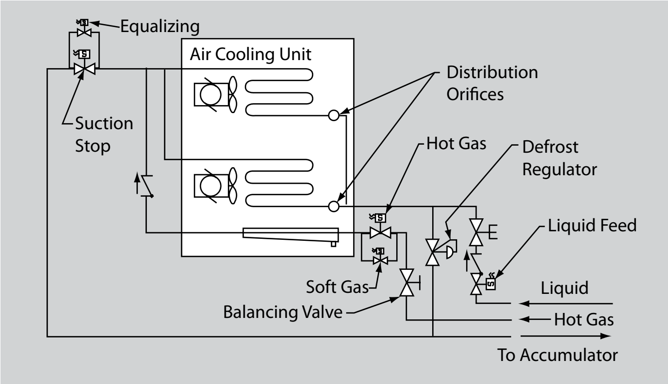


BASIC HOT GAS DEFROST PROCESS

Frost collecting on the evaporator reduces coil capacity by acting as a layer of insulation and reducing the airflow between the fins. In hot gas defrost, refrigerant vapor from either the compressor discharge or the high pressure receiver[1] is used to warm the evaporator coil and melt the frost that has collected there. The vapor condenses to a liquid during this process, and is then routed back to a protected suction line or to an accumulator. The basic concept is straightforward. However variations in system piping arrangements, and the management of pressures, temperatures and liquid refrigerant make implementation of hot gas defrost very complex. This manual will review a number of different system components and arrangements in order to provide a detailed understanding of hot gas defrost.

Before addressing the details, it is instructive to review the basic hot gas defrost process. Figure 1 shows schematically a typical evaporator piping arrangement. The sequence of events that occur during hot gas defrost are as follows:

Figure 1: Basic Hot Gas Defrost Arrangement



1. **REFRIGERATION PHASE:** Saturated liquid refrigerant flows through a liquid feed valve, into the evaporator. Heat is absorbed and some (or all) of the refrigerant vaporizes. The refrigerant exits through the open suction stop valve and flows to an accumulator.

2. **PUMP OUT PHASE:** The liquid feed valve is closed. The fans continue to run, and liquid inside the coil vaporizes and exits through the suction stop valve. Removing liquid from the coil during this phase allows heat from the hot gas to be applied directly to the frost instead of being wasted on warming liquid refrigerant. In addition, removal of the cold liquid prevents damaging pressure shocks. At the end of pump out, the fans are shut down and the suction stop valve is closed.

3. **SOFT GAS PHASE:** Especially on low temperature liquid recirculation systems, a small solenoid valve should be installed in parallel with the larger hot gas valve. This smaller valve gradually introduces hot gas to the coil. Opening this valve first further reduces the likelihood of damaging pressure shocks. At the conclusion of this phase, the soft gas valve is closed.

4. **HOT GAS PHASE:** The hot gas solenoid is opened and hot gas now flows more quickly through the drain pan, warming it, and then into the coil. The gas begins condensing as it gives up heat to melt the frost, and pressure inside the coil rises sufficiently for control by the defrost regulator.

   The condensed refrigerant flows through the regulator and is routed to an accumulator or protected suction line. Hot gas continues to flow into the evaporator until either a pre-set time limit is reached, or until a temperature sensor terminates this phase and closes the hot gas valve.

5. **EQUALIZATION PHASE:** Especially on low temperature liquid recirculating units, pressure inside the coil is permitted to decrease slowly by opening a small equalizing valve that is installed in parallel with the larger main suction stop valve. The equalization phase reduces or eliminates system disruptions, which would occur if warm refrigerant were released quickly into the suction piping. This also reduces the possibility of vapor propelled liquid. In addition to the pressure-related forces, the high-pressure liquid could quickly generate a great deal of vapor in the low side of the system, resulting in sudden compressor loading.

6. **FAN DELAY PHASE:** At the conclusion of the equalization phase, the equalizing valve is closed. The suction stop and liquid feed valves are opened. The fan is not yet energized. Instead, the coil temperature is allowed to drop, freezing any water droplets that might remain on the coil surface after the hot gas phase, thereby preventing the possibility of blowing water droplets off the coil into the refrigerated space.

7. **RESUME REFRIGERATION:** After the fan delay has elapsed, the fan is energized. The refrigeration phase continues until the next defrost cycle is initiated.

DEFROST CONSIDERATIONS

Component types and system arrangements vary greatly from one refrigeration system to another. Regardless of the variations, however, there are a number of issues that should always be considered when designing or operating a hot gas defrost system. While this manual presents a number of ways to address these issues, ultimate responsibility for safe and reliable system operation rests with the designers and operators. Designers and operators should be familiar with a variety of resources, including the latest revisions of:

- ANSI/ASHRAE Standard 15 “Safety Standard for Refrigeration Systems”[2]

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[1] Hot gas collected downstream of the oil separator or from the high pressure receiver contains less lubricant than gas directly from the compressor discharge. Using clean gas will more effectively remove lubricant from inside the coil during defrost. Because latent heat provides most of the defrost effect, the de-superheated gas far downstream of the compressor is still highly effective for defrost.

[2] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA, ASHRAE Refrigeration Handbook 2006, Chapters 1 & 3.

- IIAR Refrigeration Piping Handbook[3]
- IIAR Bulletin 116: "Guidelines for Avoiding Component Failure in Industrial Refrigeration Systems Caused by Abnormal Pressure or Shock"

FOLLOW SAFETY GUIDELINES: Pressures and temperatures inside evaporator piping will vary significantly from one phase of defrost to the next. Furthermore, the state of the refrigerant within the pipes could be liquid, vapor, or some combination of the two. Under these changing conditions pressure shocks can occur, causing gradual or sudden damage to components and piping. In addition, pressures can grow dangerously high in sections of piping where liquid is isolated.

In lines that might contain liquid refrigerant, precautions must be taken to avoid damage due to liquid expansion when a section of piping can be isolated. Always arrange defrost control valves such that hydrostatic expansion can be relieved.

Pressure shocks can be grouped into three categories: sudden liquid deceleration, vapor-propelled liquid, and condensation-induced shock. All three of these pressure shocks can occur too quickly for relief devices to respond and other methods must be used to avoid the damage that these phenomenom can create. The most obvious evidence of their occurrence is noise. Defrost should proceed with minimal noise. Loud thuds, slams and piping vibration should be considered signs of pressure shocks.

Sudden liquid deceleration is caused by fast-acting solenoid valves that suddenly close. The force produced by quickly reducing the liquid velocity generates a pressure pulse similar to water hammer in a water distribution system. In water systems, air pockets act as shock absorbers to dissipate the forces resulting from these pressure pulses. Vapor pockets in refrigerant piping will condense and fill with liquid, and therefore cannot be used to prevent pressure pulses. Sudden deceleration in refrigerant piping can be avoided by using slow-closing valves, staged closing valves (which close in discreet increments), or small valves in parallel.

According to IIAR Bulletin 116, most instances of **vapor propelled liquid** occur in low temperature, liquid overfeed systems using hot gas defrost. Vapor propelled liquid results from the sudden release of high-pressure vapor into a line that is partially filled with liquid. The impact force of high-velocity liquid slugs can severely damage system components and/or piping.

Vapor propelled liquid is most likely to occur at two points in the hot gas defrost process. First, when the hot gas valve is suddenly opened and any condensate in the hot gas line or residual cold liquid in the coil is propelled by the high-pressure vapor. Second, is at the conclusion of defrost, when liquid condensate inside the coil is suddenly released to the low side of the system. Precautions to prevent these events include the use of soft gas and equalizing valves and importantly, avoid having a section of the hot gas supply with a drop leg below the coil level. This can fill with liquid, and feed a large amount of liquid into the coil at initiation of the defrost cycle, and possibly result in the generation of shock loading the coil manifold.

In slug or plug flow, pockets of vapor move with liquid refrigerant inside the pipe or evaporator coil. **Condensation-induced shock** can occur when high-pressure vapor is quickly introduced to slug/plug flow, causing the pockets to suddenly condense. The imploding pockets can generate large pressure waves within the system. Complete pump out and slow operating valves are the most effective means to prevent condensation-induced shock.

MINIMIZE CONDENSATE IN THE HOT GAS LINE: During normal refrigeration, when little or no hot gas is flowing, the refrigerant in the hot gas supply line can condense. Depending on the layout of the system and the conditions, the amount of condensate can be considerable. As discussed earlier, liquid that is pushed by high-pressure vapor can be damaging to the system. In addition, liquid passing through the hot gas solenoid, into the lower pressure evaporator, will erode internal valve parts as some of the liquid flashes back to vapor.

To minimize condensation, hot gas lines should not be oversized. The hot gas lines should be insulated and have a liquid drainer installed at the lowest point. Locating a hot gas "king valve" (ideally slow-opening) in the machinery room will minimize the amount of refrigerant that can condense in the branch lines.

DRAIN MAXIMUM LIQUID FROM THE COIL BEFORE DEFROST: Any cold liquid remaining in the coil after pump out must be warmed before frost can begin to melt. This increases hot gas injection time. In addition, residual liquid can be propelled at dangerously high speeds should high pressure gas be introduced too quickly.

PROVIDE AN ADEQUATE HOT GAS SUPPLY: The hot gas for defrost is generated by compression of cold gas from operating evaporators. When one or more evaporators are being defrosted, they are no longer generating cold vapor to the compressor. This reduces the system's supply of hot gas. For this reason, defrosting more than ⅓ the total system capacity at any given time is generally not recommended.

In addition to the quantity of the hot gas, the pressure is also important. Condensing pressures can be 180 psig (12.4 barg) or higher, and will vary greatly. For safe, consistent defrost, hot gas pressure should be as low as possible and still provide sufficient heat to melt worst-case frost accumulation. Best results are obtained if the gas supplied to the hot gas solenoid is above 120 psig (6.9 to 8.3 barg).

SET THE PROPER EVAPORATOR DEFROST TEMPERATURE: Control of evaporator pressure (and therefore temperature) is accomplished with the defrost regulator. If this device is under-sized, excess evaporator pressure will result. If this device is over-sized, the valve will cycle open and closed, causing valve wear and unsteady system conditions.

[3] International Institute of Ammonia Refrigeration, Arlington, VA

The pressure setting of the defrost regulator should be between 60 and 80 psig (4.1 to 5.5 barg) in order to maintain the temperature in the coil between 40° and 55°F (5° to 15°C). Warmer temperatures will not necessarily improve defrost efficiency. This is because most of the heat for melting frost comes from the hot gas's latent, rather than sensible, heat. The table below shows the latent heat for ammonia at various temperatures.

Temperature	Pressure	Latent Heat
40ºF (4°C)	58 psig (4.0 barg)	536 BTU/lb (1240 kJ/kg)
50ºF (10°C)	74 psig (5.1 barg)	527 BTU/lb (1220 kJ/kg)
60ºF (16°C)	92 psig (6.3 barg)	518 BTU/lb (1200 kJ/kg)
70ºF (21°C)	114 psig (7.8 barg)	508 BTU/lb (1180 kJ/kg)

A 70ºF (21°C) defrost temperature would actually require 5% more hot gas than 40ºF (4°C) to provide the same latent heat content. Moreover, because the flow of hot gas into the evaporator is driven by pressure, increasing the pressure inside the coil slows the flow into it. As noted earlier, taking hot gas from the high side of the system and metering the condensate into the low side adds load to the compressors. Higher quantities of gas needed for defrost prolongs the compressor load.

Higher defrost temperatures also increase the amount of water that re-evaporates into the room air. This can increase room humidity and lead to more frequent defrosts.

Finally, once portions of the coil become free of frost they add heat to the refrigerated space through radiation and convection. This heat must be removed, increasing the load on the overall system.

ENSURE THE SYSTEM HAS AN ADEQUATE LIQUID SUPPLY: When refrigerant vapor is taken from the high side of the system for defrost, less refrigerant is available for evaporators still in operation. Receiver levels can drop as a result. Again, limiting defrost to ⅓ the total system load will help prevent this condition.

PROPERLY RECYCLE THE DEFROST CONDENSATE:
If the system operates at two temperature levels, condensate from defrosting the low temperature evaporators can be metered to the intermediate stage. Doing so will generate less flash gas and can provide make-up liquid for the intermediate stage. Any vapor sent to the compressor that did not provide refrigeration is a source of system inefficiency.

On large systems that generate significant condensate, it may be advantageous to catch the liquid in a suction trap. The refrigerant could then be moved to the high pressure receiver with a transfer pump.

DETERMINE THE PROPER DEFROST FREQUENCY AND DURATION:
The rate at which frost accumulates on a coil is broadly determined by several factors:

Coil Temperature: A larger temperature difference between the evaporator coil and the air in the refrigerated space will cause more moisture to condense and freeze onto the coil.

Infiltration: Outside air can enter the refrigerated space by doors opening and closing, or simply by leaking through cracks. The warm outside air generally has more moisture than the air in the refrigerated space. The quantity of infiltrating air will vary with, for example, how many times doors are opened. In addition, the amount of moisture in the infiltrating air will vary with the seasons.

Product: Moisture can simply evaporate from the product stored in the refrigerated space. A new load of fresh, warm product will give off more moisture than a load that has already been cooled.

People: People, of course, give off moisture in their respiration and perspiration. The number of people and their activity level inside the space can affect the amount of moisture in the room.

Equipment: Many types of equipment, such as propane-fueled fork trucks, give off water vapor during their operation.

Defrost frequency and duration will have an effect on system efficiency.

A number of demand defrost control schemes have been tried with mixed success, including:

Initiating defrost based on:
- Elapsed time since last defrost
- Cumulative liquid feed time since last defrost
- Direct observation of frost on the coil
- Optical detection of excessive frost on the coil
- Detection of excessive frost on the coil based on air flow
- Detection of frost on the coil based on air temperature leaving the coil

Terminating defrost based on:
- Elapsed hot-gas time
- Coil temperature
- Space temperature
- Direct observation of defrosted coil
- Optical detection of defrosted coil
- Detection of water no longer draining from the pan

System operators may want to experiment with these or other methods to find the ones that work best on a particular application.

ESTABLISH A SATISFACTORY CONTROL SCHEME: Once the proper frequency and duration is determined, a sequence of valves opening and closing must be implemented for each defrost cycle. Control schemes are generally implemented by means of an electric or electronic timer, or a computerized control system. A number of system configurations and their control schemes are reviewed later in this manual.

ENSURE ADEQUATE WATER DRAINAGE: Melt water should be prevented from falling onto the floor or the products/processes in the refrigerated space. Adequate means should be provided to warm the drainpipes leading out of the refrigerated space. The drains should be adequately sized to permit the melt-water to exit as quickly as possible. Allowing the water to stay in the refrigerated space lets some of it evaporate and re-freeze on an operating evaporator. In addition, water in the drain pan when refrigeration is resumed could freeze and block drainage during the next defrost cycle.

CONTROL COMPONENTS

The types and arrangements of components in a defrost control group will vary depending on the evaporator's liquid-delivery scheme (that is, whether it is top or bottom feed). However, the characteristics of the components are the same, regardless of their arrangement. Above all, control components must be rugged and reliable for a long service life. They must tolerate the harsh conditions that are typical of a broad range of refrigeration installations.

A detailed listing of Refrigerating Specialties' control components for hot gas defrost is given in the Valve Selection Matrices, later in this manual. For more information, visit the Refrigerating Specialties website at www.parker.com/refspec.

Following is a brief summary of the various control devices used in hot gas defrost arrangements.

Suction Stop Valves

The **suction stop valve** must provide positive closing for defrost and have minimal pressure loss when open for normal refrigeration. These valves must also be capable of opening at large pressure differentials and tolerate the significant swings in temperature that occur between the start and end of a defrost cycle.

Refrigerating Specialties offers a number of solenoid and gas-powered valves for suction stop applications. The following valves are most typically used for suction stop applications:

- **S7A and S5A:** Normally closed, pilot-operated solenoid valves that open wide when energized
- **CK-2:** Normally open, gas-powered valve; closes when a separate pilot solenoid valve is energized
- **CK-5:** Normally open, gas-powered valve; closes when a separate pilot solenoid valve is energized; this valve remains closed if electrical power fails during defrost or if other equalizing valves fail to open or adequately reduce the defrost evaporator pressure
- **S9A/S9W:** Normally closed, gas powered valve; opens when one pilot solenoid is energized, closes when the second pilot solenoid is energized
- **CK-2D:** Normally open, two position, gas powered valve; both integral pilot solenoids energized completely closes the valve and one solenoid energized keeps the valve at 90% closed to allow for equalization
- **CK-6D:** Normally open, two position, gas powered valve; both integral pilot solenoids energized completely closes the valve and one solenoid energized keeps the valve at 90% closed to allow for equalization

The 1⅝" and larger S4A and the S4W valves can also be used for suction stop applications. Because these valves require a 2 psi pressure drop to open, they will impose a small additional Bhp requirement on the compressor.

Liquid Feed Valves

The liquid feed valve should provide positive, tight closing and open reliably at high pressure differences. These valves should also tolerate small amounts of gas in the liquid flow.

Refrigerating Specialties offers a number of solenoid and gas-powered valves for liquid feed applications. The following valves are most typically used for liquid feed applications:

- **S8F, S5A, S7A and S4A/S4W:** Normally closed, pilot-operated solenoid valves that open wide when energized
- **S9A/S9W** normally closed, gas powered valves
- **S4AD** normally closed, two position valve substantially reduces liquid hammer on both opening and closing

Liquid line solenoid valves should all be installed with a strainer immediately upstream to ensure long, reliable service life. Refrigerating Specialties offers the **RSF** (flange connection) and **RSW** (weld connection) strainers in a variety of sizes up to 8".

Most solenoid valves and regulators will permit reverse flow if the outlet pressure is greater than inlet pressure. If at any time, such reverse pressure conditions are possible, such as during defrost, and reverse flow is unacceptable, a check valve should be installed at the control valve outlet.

Many installations incorporate flow regulators or hand expansion valves to balance liquid feed to multiple evaporators. Refrigerating Specialties offers hand expansion valves with connection sizes ranging from ¼" through 2". Refrigerating Specialties also offers a variety of automatic flow regulators: the **CFR, AFR** and **FFR.**

Hot Gas Valves

These valves open to admit the hot gas into the evaporator coil for defrost. They must be capable of opening at very large pressure differences, and closing at large pressure differences. They must tolerate wide swings in temperature and the erosive effects of small amounts of condensate normally found in hot gas lines. Refrigerating Specialties offers several long-life solenoid valves for controlling hot gas delivery, including:

- **S6N:** Normally closed, direct-operated solenoid valve; opens wide when energized. Typically used as a hot gas pilot valve for larger gas powered valves.
- **SV2:** Normally closed, pilot-operated solenoid valve; opens wide when energized
- **S4A/S4W:** Normally closed, pilot-operated solenoid valve; opens wide when energized
- **S4AD:** Normally closed, two position, pilot-operated solenoid valve; opens approximately 10% when one solenoid is energized and all the way when both pilot solenoids are energized. Primarily for soft gas applications

On a limited number of applications, the following pressure regulators can be used for the delivery of hot gas:

- **A2BO:** Outlet pressure regulator
- **A4AOS:** Outlet pressure regulator with electric shutoff

Condensate Removal Devices

These devices modulate the flow of condensed liquid refrigerant out of the evaporator during defrost. They must be capable of closing tightly and tolerate gas and liquid flows, as well as gas/liquid mixtures.

Refrigerating Specialties offers the following devices for condensate removal during hot gas defrost:

- **A2AK/A2BK:** Inlet pressure regulator
- **A4AK:** Inlet pressure regulator
- **ALD (Automatic Liquid Drainer):** Permits only liquid refrigerant to leave the defrosting evaporator, prevents vapor from escaping

On some applications, it is possible to use a defrost regulator with electric bypass feature (A4ABK) to serve as an equalizing valve as well. If an A4ABK is used as a combination defrost regulator and suction stop valve there are pressure drop issues to consider. (See Figure 2.) The pressure drop required to hold the valve open during normal refrigeration can be as high as 4 psi (0.3 bar). This may be unacceptable from an efficiency standpoint. More importantly, the pressure drop across the valve during defrost is much higher than during normal refrigeration. This means that a properly sized defrost regulator must be considerably smaller than the suction stop valve. Over-sizing the regulator for suction stop duty will cause the valve to cycle open-and-closed during defrost. This can lead to premature valve wear and poor system performance.

Check Valves

Check valves are designed to allow flow in one direction only. They are used to prevent backflow. They are also used to isolate components such as the drain pan from cold refrigerant during normal refrigeration mode.

Check valves must never be installed at the inlet of either a solenoid valve, or most pressure regulators. Doing so can trap liquid between the check valve and the solenoid or regulator inlet. This condition can lead to hydrostatic expansion and the resultant dangerously high pressure levels. If a check valve is needed, install it on the **outlet** side of such valves.

Refrigerating Specialties offers a wide range of disc and plug type check valves, including:

- **CK-1**: Plug type check valve
- **CK-3**: Compact plug type check valve
- **CK-4A**: Disc type check valve

Electronic Defrost Controller

A controller of some type must be used to energize and de-energize solenoid valves at appropriate times during the defrost cycle. The controller should be flexible enough to accommodate a wide variety of schedules, yet be easy to use and provide safe transitions between the phases of hot gas defrost. The controller should also be capable of a variety of defrost initiation and termination schemes.

The Refrigerating Specialties Electronic Defrost Controller is a powerful yet user-friendly device for controlling the sequence of events that occur during defrost cycles. In regular operation, the status of the refrigeration system is displayed on an LCD screen. The Controller is programmed using on-screen prompts and four push buttons on the front panel of the unit. Please visit our website for a current description of our defrost controller.

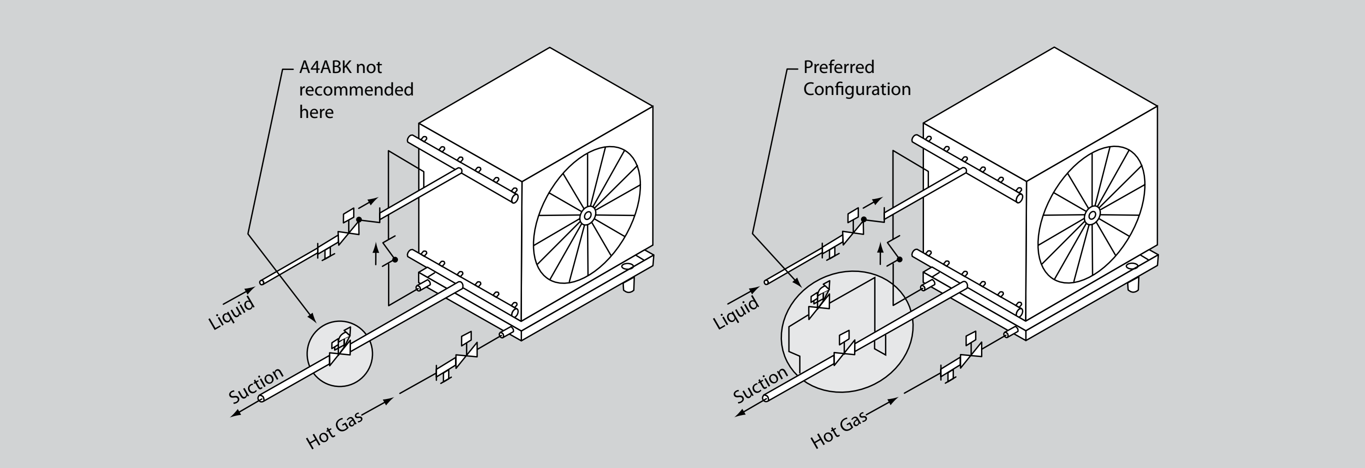
Defrost cycles are initiated or terminated based on a number of criteria that can be easily tailored to a specific system. A number of examples are given. The flexibility of the Controller gives the user a means to customize the defrost cycle for maximum energy efficiency.

EXAMPLE PIPING CONFIGURATIONS

The number of possible variations of evaporator piping schemes is limitless, as are the conditions under which the systems must operate. These variations can be broadly classified as:

- Direct-expansion (DX),
- Gravity flooded, and
- Liquid recirculation (overfeed)

Figure 2: A4ABK is not suited for Suction Stop



Within these classifications, piping variations will occur depending, for example, on whether the evaporator is top or bottom-fed, the system has a 3 or 4-pipe arrangement, and whether the coil is horizontally or vertically-circuited.

With so many possible variations, it is not possible to address all the issues related to defrost piping and components within this manual. Evaporator manufacturers sometimes make specific recommendations for hot gas defrost piping. In such cases, the manufacturers' recommendations should be followed. In addition, system designers should consult local codes, ASHRAE Standards, and the IIAR Piping Handbook to ensure the system operates safely and with optimal overall results.

Guidance for properly selecting and sizing valves based on system capacity and temperatures is given later in this manual. The examples that follow are intended only to provide a more detailed understanding of the hot gas defrost process.

Valve sequencing in the following examples will vary from the generic case discussed at the beginning of this manual. For example, not all systems require soft gas or two valves to isolate the coil. In addition, when a gas powered valve such as the S9A is used, two pilot solenoids must be controlled.

Direct Expansion Systems

While not as common in ammonia refrigeration as either flooded or liquid recirculation configurations, direct expansion evaporators are somewhat simpler to arrange for hot gas defrost. This is because DX systems generally operate at higher coil temperatures, have lower refrigerating capacities, and contain a smaller volume of liquid than a comparably sized flooded or recirc coil. All of this makes DX units somewhat less suceptible to pressure shocks. In addition, solenoid valves, rather than gas-powered valves, can frequently be used to isolate the coil during defrost.

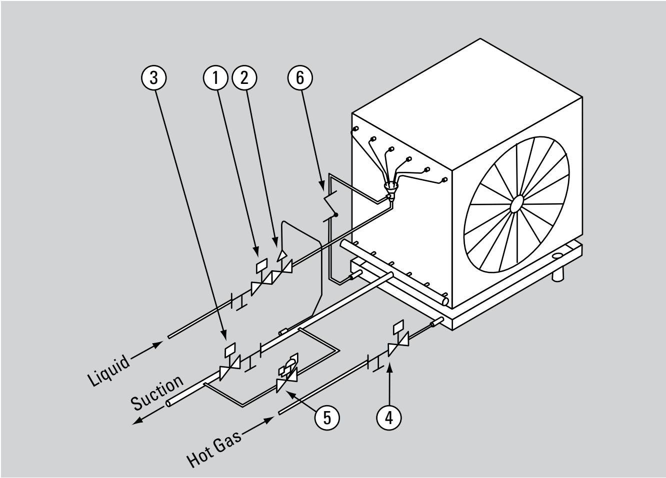
Of special concern when defrosting DX systems is the management of liquid refrigerant in the system. DX coils can hold significantly more liquid during defrost than they do in normal refrigeration mode. Consequently the sizing of high and low side vessels need to take this into consideration. In addition, DX coils that operate at low temperatures or reduced loads may tend to accumulate more oil. Clearing this oil during defrost can be an issue for some configurations, as noted below.

In the down-fed configuration shown in Figures 3 and 4, the hot gas is routed to the distributor after it warms the drain pan. Injecting hot gas into the distributor ensures an equal distribution among the circuits. Because flow is downward, oil clearing is not a major concern here, provided condensate velocities are relatively high.

Notice in Figures 3 and 4 that the defrost regulator has an electric wide opening feature. During defrost, condensed liquid is flowing through this valve with a high pressure drop. Consequently, the valve will be smaller than the suction stop valve. At the end of defrost, the wide-opening feature provides the function of an equalizing valve.

Figure 3: DX, Vertical Circuit, Downfeed

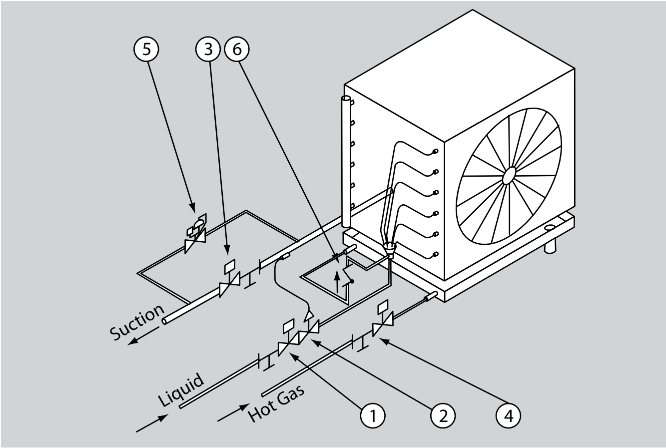
Figure 4: DX, Horizontal Circuit, Downfeed



No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S7A, S4A or SV2
2	1	Thermal Expansion Valve	TEV Type D or Type A
3	1	Suction Stop Valve with Close-Coupled Strainer	S7A, S5A or CK-2 with pilot solenoid
4	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
5	1	Defrost Relief Regulator with Electric Bypass	A4ABK
6	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed Solenoid ① closes. At the end of pump out the Suction Stop Valve ③ closes.
Soft Gas	A Soft Gas Valve is not usually needed on higher temperature systems where complete pump out is assured.
Defrost	Immediately after pump out the Hot Gas Valve ④ opens. Hot gas flows while the Defrost Regulator ⑤ maintains coil defrost pressure.
Equalization	At the end of the Hot Gas phase, the Hot Gas Valve closes and the Bypass feature on the Regulator ⑤ opens.
Fan Delay	The Regulator Bypass closes. The Liquid Feed and Suction Stop Valves open.

See Defrost Valve Sequence - Same as Figure 3.



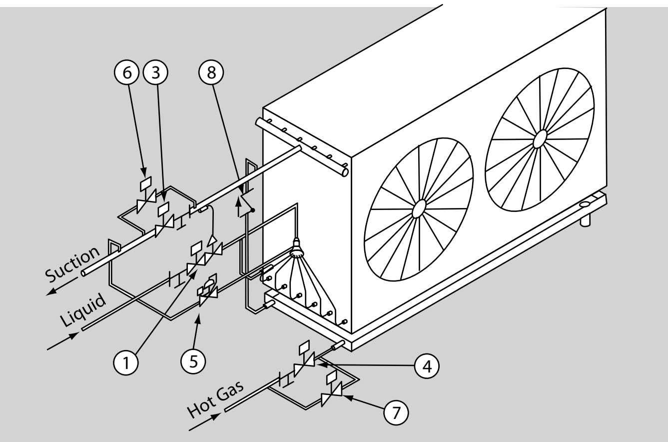
No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Thermal Expansion Valve	TEV Type D or Type A
3	1	Suction Stop Valve with Close-Coupled Strainer	S5A or CK-2 with pilot solenoid
4	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
5	1	Defrost Relief Regulator with Electric Wide Opening	A4ABK
6	1	Check Valve	CK-3 or CK-4

The gravity-draining evaporator coils shown in Figures 3 and 4 will drain well through the suction stop valve during pump out, provided there are no traps in the suction line. In the up-fed configuration shown in Figure 6 pump out through the suction stop valve is not as certain. A soft gas valve may be useful on these arrangements, particularly for low temperature coils.

During defrost, the condensate and lubricant must leave the coil through narrow distribution tubes and orifices. Effective flow is somewhat more difficult to accomplish with these arrangements, so keeping the refrigerant free of oil is more critical here.

Figure 5: DX, Vertical Circuit, Upfeed

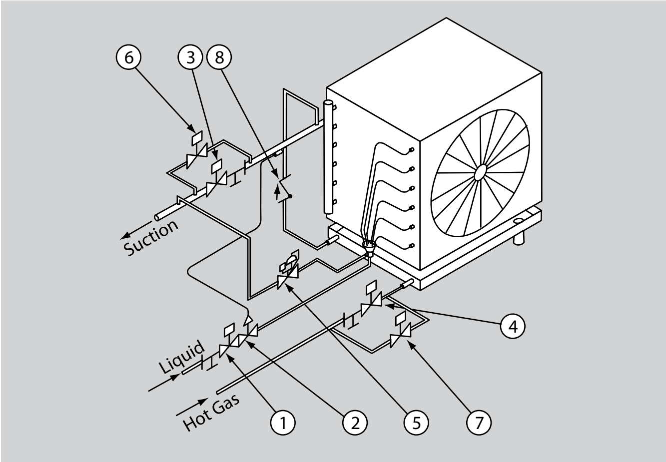
Figure 6: DX, Horizontal Circuit, Upfeed



No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Thermal Expansion Valve	TEV Type D or Type A
3	1	Suction Stop Valve with Close-Coupled Strainer	S5A or CK-2 with pilot solenoid
4	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
5	1	Defrost Relief Regulator	A4AK
6	1	Equalizing Valve	S8F, S4A or SV2
7	1	Soft Gas Valve	S8F, S4A or SV2
8	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed Solenoid ① closes. At the end of pump out the Suction Stop Valve ③ closes.
Soft Gas	Immediately after the Suction Stop Valve closes, the Soft Gas Valve ⑦ opens. The Soft Gas Valve closes immediately at the end of this phase.
Defrost	The Hot Gas Valve ④ opens. Hot gas flows while the Defrost Regulator ⑤ maintains coil defrost pressure.
Equalization	At the end of the Hot Gas phase, the Hot Gas Valve closes and the Equalizing Valve ⑥ opens.
Fan Delay	The Regulator Bypass closes. The Liquid Feed and Suction Stop Valves open.

Defrost Valve Sequence - Same as Figure 5.



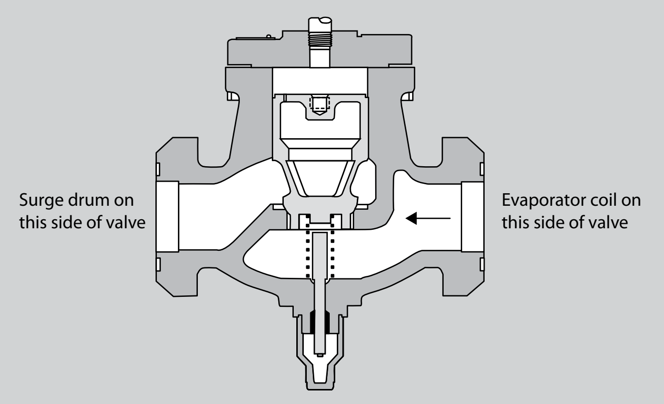
No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Thermal Expansion Valve	TEV Type D or Type A
3	1	Suction Stop Valve with Close-Coupled Strainer	S5A or CK-2 with pilot solenoid
4	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
5	1	Defrost Relief Regulator	A4AK
6	1	Equalizing Valve	S8F, S4A or SV2
7	1	Soft Gas Valve	S8F, S4A or SV2
8	1	Check Valve	CK-3 or CK-4

Gravity Flooded Systems

In gravity flooded systems it is advantageous to install gas powered valves rather than solenoid valves to isolate the evaporator coil. Solenoid valves are limited in size, and usually have pressure penalties associated with them. Gas powered valves such as the CK-2, CK-5, S9A and S9W are available in sizes up to 8". These valves are powered by high pressure gas, rather than a pressure differential across the valve.

Typical of most refrigeration valves, the CK-2 and CK-5 valves have an arrow cast into the valve body. When these valves are installed in either the liquid feed or the return line of a flooded evaporator, **the arrow should always point toward the surge drum.** The arrow shown in Figure 7 points in the same direction as the arrow cast into the valve body. When used as a suction stop valve the arrow will indicate the flow direction through the valve during normal refrigeration. When used as a liquid feed valve, liquid flow will be in a direction opposite to arrow cast into the flow.

Figure 7: CK-2 Valve (Plug shown in closed position)



During defrost, the valve is closed by the introduction of high pressure gas through the top of the valve. At the end of defrost, if equalization is not complete, the liquid feed valve will still be able to open because the coil pressure acting under the plug is higher than the liquid pressure above the plug. If the liquid feed valve were installed with normal flow in the direction of the arrow, then incomplete equalization would result in pressure above the plug higher than the pressure below. Under these circumstances, the valve would be unable to open until the coil pressure equalizes to very nearly valve outlet pressure.

The CK-2/5's and the S9A/W's can be installed in either horizontal or vertical lines. When installed in horizontal lines, these valves should be installed "lying on their sides," so the piston travels horizontally. This will prevent trapping liquid upstream of the valve.

The use of CK-2 or CK-5 valves is appropriate for flooded systems down to -60ºF (-50ºC), provided the valves' piston space can be kept reasonably free of lubricants. Otherwise, the S9A or S9W should be used. The S9 valves have a stronger return spring, and will be better able to overcome the viscous drag of cold lubricants.

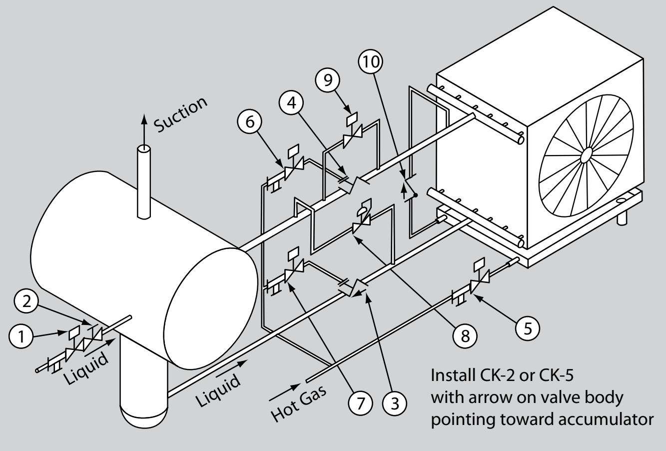
Pump-out is accomplished differently from the generic example given at the beginning of this manual. For the flooded evaporator, the suction stop valve is closed and the liquid feed valve is left open. With the fans still running and high pressure gas being introduced, the cold liquid is forced back into the surge drum. This liquid will then be available upon resumption of refrigeration. Defrost then begins when the liquid valve is closed.

Any liquid condensate created during defrost is expelled through the defrost regulator. The surge drum must be designed with adequate vapor space to prevent liquid carryover to the suction line during defrost with the heaviest frost accumulation.

The equalization phase is of special importance in this arrangement. If the coil isolation valves are opened before equalization is complete, liquid can be forced out of the surge drum. This liquid will need to be replenished, causing a delay in attaining full evaporator capacity. A slow and complete equalization period will help ensure liquid is not displaced from the surge drum supply.

Note that this defrost scheme will require a somewhat different wiring schematic than the standard.

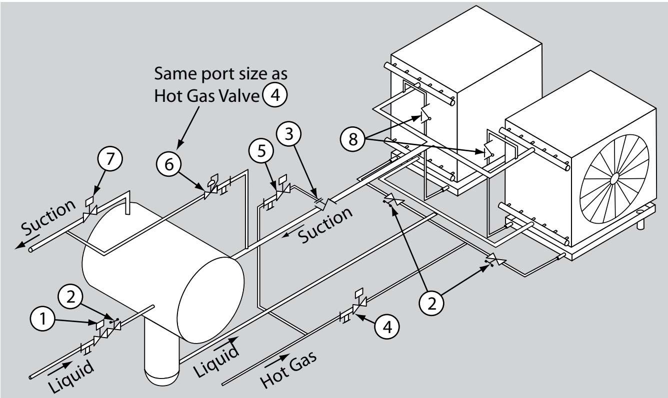
Figure 8: Flooded, Vertical Circuits



No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Hand Expansion Valve	Hand Expansion Valve
3	1	Liquid Shut-Off Valve	CK-2 or CK-5
4	1	Suction Stop Valve	CK-2 or CK-5
5	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
6	1	Suction Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
7	1	Liquid Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
8	1	Defrost Relief Regulator	A4AK
9	1	Equalizing Valve	S8F, S4A or SV2
10	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Suction Valve ④ closes and the Hot Gas Valve ⑤ opens, pushing refrigerant back to the surge drum through the Liquid Valve.
Soft Gas	Nothing changes, hot gas continues to flow.
Defrost	The Liquid Shut-Off Valve ③ closes. Hot gas continues to flow while the Defrost Regulator maintains coil defrost pressure.
Equalization	The Equalizing Valve ⑨ and the Hot Gas Solenoid Valve ⑤ close.
Fan Delay	At the end of equalization the Suction and Liquid Valves open.

Figure 9: Flooded, Small Capacity, Higher Temperature (Low first-cost, Example 1)



No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	3	Hand Expansion Valve	Hand Expansion Valve
3	1	Suction Stop Valve	CK-2 or CK-5
4	1	Hot Gas Solenoid with Close-Coupled Strainer	SA-4 or SV2
5	1	Suction Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
6	1	Defrost Relief Regulator with Companion Strainer	A4AK
7	1	Suction Solenoid	S5A
8	2	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed Valve ① is de-energized, and closes. The Suction Solenoid ⑦ is closed. The Suction Stop Valve E is closed.
Soft Gas	A Soft Gas Valve is not usually needed on higher temperature systems.
Defrost	The Hot Gas Valve ④ opens. The Defrost Regulator maintains coil defrost pressure.
Equalization	The Hot Gas Valve closes and the Suction Solenoid ⑦ opens simultaneously.
Fan Delay	The Suction Stop Valve ③ is opened.

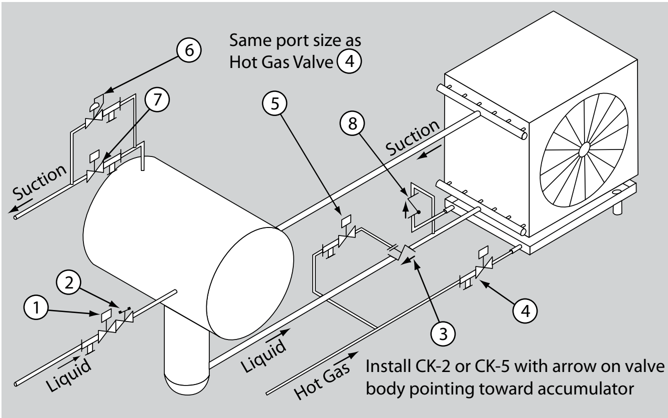
Normally, the surge drum should be isolated from the evaporators during defrost, as shown in Figure 9. However, it is also possible to design arrangements in which both the coil and surge drum are pressurized during defrost. This arrangement can help reduce initial system cost by reducing the number of valves that must be installed. There are penalties to be paid with this approach in terms of longer defrost times due to the need to first warm and pressurize the surge drum, and then return it to suction pressure. In general, smaller systems with higher temperatures are better candidates for this low first-cost approach. Two examples of this approach are shown in Figures 9 and 10.

Systems with several small-capacity evaporators fed from a common surge drum can be defrosted as shown in Figure 10. Besides the reduction in the number of isolation valves and regulators, an advantage of this arrangement is that lubricant can be drained from the surge drum during defrost when temperatures will be higher, and the lubricant will flow more freely.

Several considerations must be kept in mind when employing this approach. First, is the guideline of defrosting no more that ¾ the system load. Second, is maintaining the temperature of the refrigerated space. Obviously, if both defrosting evaporators are in the same room, the heat generated by them will need to be removed by remaining, operating units.

Finally, notice the flow direction of hot gas and condensate during defrost. Hot gas injected through the suction header, forces condensate back to the surge drum. The surge drum must be adequately sized to capture the liquid from pump-out as well as the defrost condensate, and allow only vapor to flow through the regulator to the suction line. In this case, the defrost regulator can have the same port size as the hot gas solenoid.

Figure 10: Flooded, Small Capacity, Higher Temperature (Low first-cost, Example 2)



No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Hand Expansion Valve	Hand Expansion Valve
3	1	Liquid Shut-Off Valve	CK-2 or CK-5
4	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
5	1	Liquid Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
6	1	Defrost Relief Regulator with Electric Bypass and Companion Strainer	A4ABK
7	1	Suction Solenoid	S5A
8	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed Valve ① is de-energized and closes. At the same time the Pilot Solenoid ⑤ is energized, closing Liquid Feed Valve ③. At the end of the pump out phase, the Suction Solenoid ⑦ is de-energized and closes.
Soft Gas	A Soft Gas Valve is not usually needed on higher temperature systems.
Hot Gas	The Hot Gas Valve ④ is energized and opens. The Defrost Regulator maintains coil pressure.
Equalization	The Hot Gas Valve is de-energized and closes, and the Electric Bypass feature on the Regulator ⑥ is energized and opens simultaneously.
Fan Delay	The Electric Bypass closes. The Suction Solenoid opens, as do both Liquid Feed Valves.

Another economical approach to defrosting a small, higher-temperature evaporator with individual surge drum is shown in Figure 11. Here, pump-out is accomplished through the suction line and hot gas is injected through the liquid header. This takes longer than pump-out by injecting hot gas through the top header. Any liquid remaining after pump-out, must be warmed by hot gas before frost can be melted.

Problems may occur with this arrangement if the evaporator is horizontally circuited. In that case, lower circuits filled with residual cold liquid will be unable to accept hot gas. Instead, the hot gas will flow to the upper circuits, which generally have lighter frost. In vertical circuits, the hot gas will bubble up equally through the standing liquid, warming it and defrosting the coil evenly.

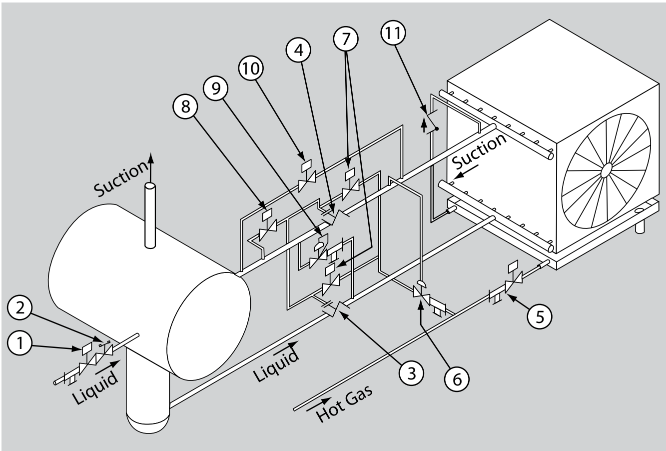
Oil management is also a concern with this arrangement. Because the defrost process will not be as effective at removing oil from the evaporator, it is critical that the surge drum's liquid column be properly designed to trap the oil before it can reach the coil.

In applications where low temperatures and/or the presence of lubricants prohibit the use of the CK-2 or CK-5 valves, Refrigerating Specialties recommends that the S9A or S9W stop valves be used. The S9's normally each require two pilot solenoids to function: one with strainer to supply hot gas and open the valve, and one to vent the hot gas and close the valve. Notice in Figure 11, however, that only one vent solenoid and one supply strainer is needed to operate both stop valves. A small pressure regulator monitors coil pressure and feeds both supply solenoids to prevent premature opening of the stop valves.

During normal refrigeration, the vent solenoid ⑧ is de-energized and the supply solenoids ⑦ are energized so the stop valves are open. During defrost the stop valves are closed by closing the supply solenoids and opening the vent solenoid.

In the event that coil pressure is too high, due to incomplete equalization, the A2BOE regulator ⑥ will remain closed. This will prevent hot gas from reaching and opening the stop valves, even though the supply solenoids are open. Once the coil pressure has dropped below the regulator set point, hot gas will be provided to open the stop valves.

Figure 11: Flooded, Low Temperature, with Evaporator Pressure Monitor



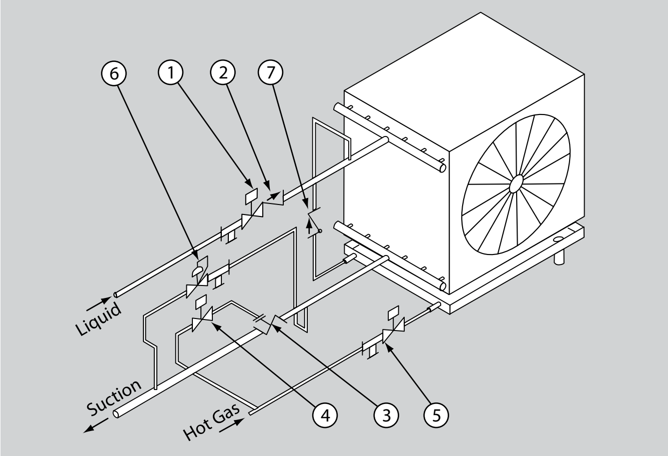
No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Hand Expansion Valve	Hand Expansion Valve
3	1	Liquid Shut-Off Valve	S9A or S9W
4	1	Suction Stop Valve	S9A or S9W
5	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
6	1	Pilot Flow Regulator with Close-Coupled Strainer	A2BOE
7	2	Pilot Solenoid (Opens to open valves ③ & ④)	S6N or S8F
8	1	Pilot Solenoid (Closes to open valves ③ & ④)	S6N or S8F
9	1	Defrost Relief Regulator with Electric Wide Opening & Companion Strainer	A4ABK
10	1	Equalizing Valve	S8F, S4A or SV2
11	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	Pilot Solenoids ⑦ are energized, Pilot ⑧ is de-energized, causing the Liquid Feed and Suction Stop Valves to close. The Electric Bypass feature on the Defrost Regulator ⑨ opens.
Soft Gas	A Soft Gas Valve is not usually needed on medium temperature systems.
Hot Gas	After the Electric Bypass on the Defrost Regulator closes, the Hot Gas Valve opens. The Regulator maintains coil pressure.
Equalization	The Hot Gas Valve closes and the Equalizing Valve opens simultaneously.
Fan Delay	The Equalizing Valve closes. Pilot Solenoids ⑦ are de-energized, Pilot ⑧ is energized, causing the Liquid Feed and Suction Stop Valves to open.

Liquid Recirculation Systems

The design of a successful hot gas defrost arrangement becomes increasingly complex when considering liquid recirculation systems. Evaporators may be configured with either vertical or horizontal circuits, and be fed from either the top or bottom of the unit. In addition, the occurrence of vapor propelled liquid is more likely in low temperature, liquid overfeed systems using hot gas defrost.

Figure 12: Liquid Recirculation, Vertical Circuit, Down Feed



No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Check Valve	CK-4
3	1	Suction Stop Valve	CK-2 or CK-5
4	1	Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
5	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
6	1	Defrost Relief Regulator with Electric Bypass Close-Coupled Strainer	A4ABK
7	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed Valve closes.
Soft Gas	The Pilot Solenoid is energized, which closes the Suction Stop Valve. A Soft Gas Valve is not usually needed on medium temperature systems.
Hot Gas	The Hot Gas Valve opens. The Defrost Regulator maintains coil pressure.
Equalization	The Hot Gas Valve closes and the Equalizing Valve opens simultaneously.
Fan Delay	The Equalizing Valve closes. The Liquid Feed and Suction Stop Valves open.

The simplest approach, from a defrost standpoint is a top-fed, medium temperature unit with vertical circuits, illustrated in Figure 12. Ideally, liquid in the coil here will drain by gravity through the open suction stop valve when the liquid solenoid is closed. Any cold liquid that remains in the coil when the suction stop valve is closed will be distributed evenly among the circuits. Hot gas injected into the top of the coil will condense and force the colder liquid out.

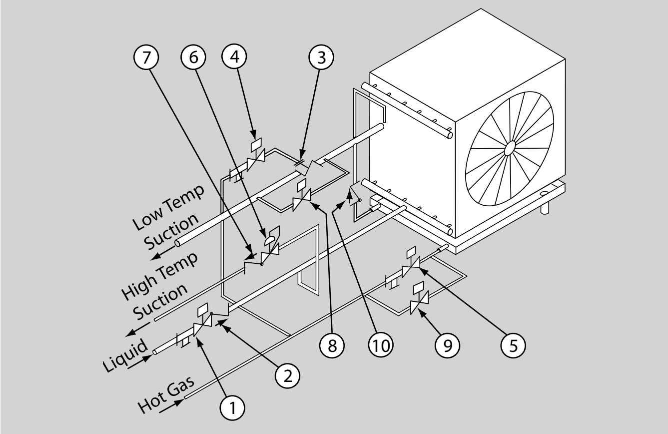
As long as hot gas is condensing, only liquid will flow through the defrost regulator. This permits the use of a regulator much smaller than either the hot gas solenoid or the suction stop valve. In this case, a defrost regulator with wide-opening feature can also serve as an equalizing solenoid at the end of hot gas injection.

Attention should be given to this arrangement near the end of a defrost cycle. If hot gas continues to be injected after all the frost has melted, condensation will cease and vapor will flow through the regulator. This will cause the coil pressure to increase, which is an indication to the system operator that the hot gas injection period can be decreased.

A low-temperature bottom-fed unit is shown in Figure 13. Pump-out here is accomplished through the suction stop valve at the top of the coil, and will take longer to accomplish than in the top-fed arrangement. Use of a soft gas valve should be considered here to prevent vapor propelled liquid.

In this 4-pipe configuration, condensate is sent to the high-temperature suction. The pressure differential across the defrost regulator will be smaller than if its outlet was at low-temp suction. This results in a larger regulator. Notice the check valve that has been added because the defrost regulator will permit backward flow through the valve during normal refrigeration.

Figure 13: Liquid Recirc (4-Pipe), Vertical Circuit, Bottom Feed

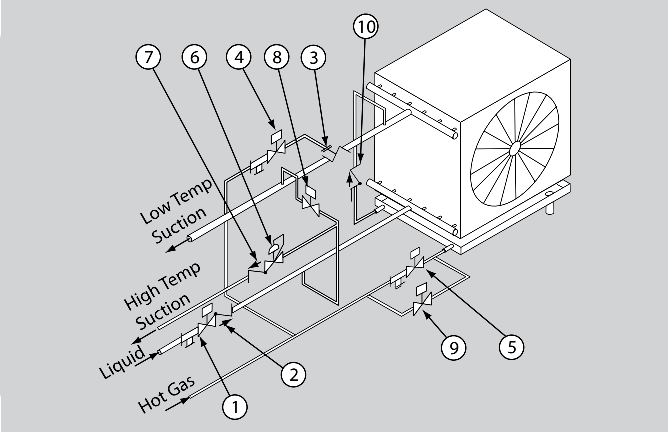


No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Check Valve	CK-4
3	1	Suction Stop Valve	CK-2 or CK-5
4	1	Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
5	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
6	1	Defrost Relief Regulator	A4AK
7	1	Check Valve	CK-4
8	1	Equalizing Valve	S8F or S7A
9	1	Soft Gas Valve	S8F, S4A or SV2
10	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed Valve closes.
Soft Gas	The Suction Stop Valve and the Soft Gas Valve opens simultaneously.
Hot Gas	The Soft Gas Valve closes and the Hot Gas Valve opens simultaneously. The Defrost Regulator maintains coil pressure.
Equalization	The Hot Gas Valve closes and the Equalizing Valve opens simultaneously.
Fan Delay	The Equalizing Valve closes. The Liquid Feed and Suction Stop Valves open.

An alternative to the previous arrangement is shown in Figure 14. Here a more complete pump-out is possible by closing both the liquid feed and suction stop valves and opening valve ⑧ and pulling liquid from the bottom of the coil into the protected suction line. The same valve is used to equalize the coil after defrost. Although the possibility of cold liquid in the coil is lessened, a soft gas solenoid should still be considered to protect against condensate in the hot gas line.

Figure 14: Liquid Recirc (4-Pipe), Vertical Circuit, Bottom Feed (Alternate)



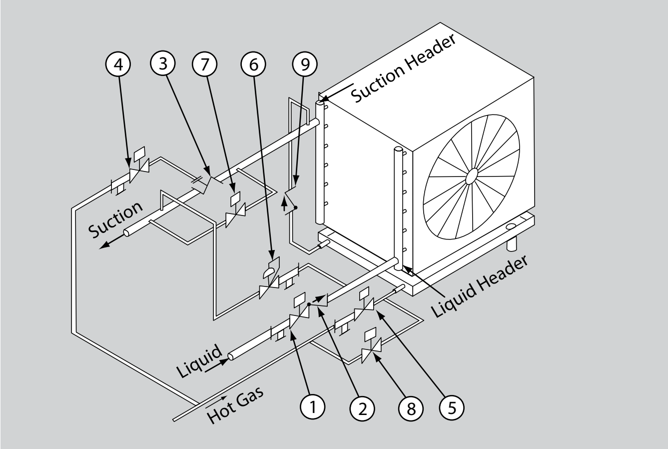
No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Check Valve	CK-4
3	1	Suction Stop Valve	CK-2 or CK-5
4	1	Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
5	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
6	1	Defrost Relief Regulator	A4AK
7	1	Check Valve	CK-4
8	1	Equalize/Pump-Out Solenoid	S8F or S7A
9	1	Soft Gas Valve	S8F, S4A or SV2
10	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed and Suction Stop Valves close simultaneously. The Equalize/Pump-Out Solenoid opens at the same time.
Soft Gas	The Equalize/Pump-Out Solenoid closes, and the Soft Gas Valve opens simultaneously.
Hot Gas	The Soft Gas Valve closes and the Hot Gas Valve opens simultaneously. The Defrost Regulator maintains coil pressure.
Equalization	The Hot Gas Valve closes and the Equalize/Pump-Out Solenoid opens.
Fan Delay	The Equalize/Pump-Out Solenoid closes. The Liquid Feed and Suction Stop Valves open.

Special considerations must be made for horizontally circuited evaporators. These units may be top or bottom fed. For the purpose of this manual, it will be assumed that top fed evaporators incorporate a defrost condensate outlet connection near the bottom of the liquid header. It will also be assumed that the evaporators incorporate orifices in the liquid header to properly distribute liquid during normal refrigeration mode. These orifices also help to distribute hot gas during defrost and prevent "short circuiting" when the lower circuits are filled with liquid. For units that do not meet these criteria, a knowledgeable system designer should be consulted.

Suggested arrangements for bottom and top fed units are shown in Figures 14 and 15.

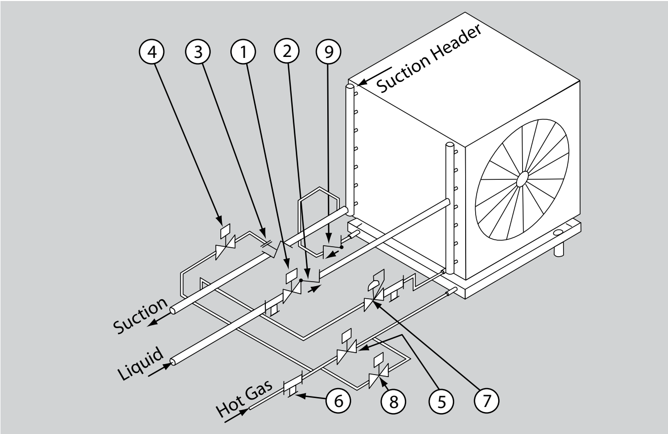
Figure 15: Liquid Recirc, Horizontal Circuit, Bottom Feed



No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Check Valve	CK-4
3	1	Suction Stop Valve	CK-2 or CK-5
4	1	Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
5	1	Hot Gas Solenoid with Close-Coupled Strainer	S4A or SV2
6	1	Defrost Relief Regulator	A4AK
7	1	Equalizing Valve	S8F, S4A or SV2
8	1	Soft Gas Valve	S8F S4A or SV2
9	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed Valve closes. At the end of Pump Out, Pilot Solenoid ④ is energized, and the Suction Stop Valve closes.
Soft Gas	The Soft Gas Valve opens.
Hot Gas	The Soft Gas Valve closes and the Hot Gas Valve opens simultaneously. The Defrost Regulator maintains coil pressure.
Equalization	The Hot Gas Valve closes and the Equalize Solenoid opens.
Fan Delay	The Equalize Solenoid closes. The Liquid Feed and Suction Stop Valves open.

Figure 16: Liquid Recirc, Horizontal Circuit Top Feed



No.	Qty.	Description	Recommended Valve Type
1	1	Liquid Feed Solenoid with Close-Coupled Strainer	S8F, S4A or SV2
2	1	Check Valve	CK-4
3	1	Suction Stop Valve	CK-2 or CK-5
4	1	Pilot Solenoid with Close-Coupled Strainer	S6N or S8F
5	1	Hot Gas Solenoid	S4A or SV2
6	1	Strainer with Companion Flanges	RSF
7	1	Defrost Relief Regulator with Electric Bypass Close-Coupled Strainer	A4AK
8	1	Soft Gas Valve	S8F, S4A, or SV2
9	1	Check Valve	CK-3 or CK-4

Defrost Valve Sequence	
Pump Out	The Liquid Feed Valve closes. At the end of Pump Out, Pilot Solenoid ④ is energized, and the Suction Stop Valve closes.
Soft Gas	The Soft Gas Valve opens.
Hot Gas	The Soft Gas Valve closes and the Hot Gas Valve opens simultaneously. The Defrost Regulator maintains coil pressure.
Equalization	The Hot Gas Valve closes and the Electric Bypass on the Defrost Regulator opens.
Fan Delay	The Electric Bypass closes. The Liquid Feed and Suction Stop Valves open.

APPENDIX 1: VALVE SELECTION

A number of different valve types are needed to serve the varieties of evaporator defrost arrangements. Within these valve types, a number of different valve model families exist. These families may be further broken down by valve size. Because this breadth of options can be overwhelming, the matrices on the following pages are given to provide a quick overview of available choices. Valve descriptions in the matrices are intended for reference only. Consult the most current product bulletins for the latest updates.

Suction Line Valves

Suction stop valves are available in two types: solenoid and gas-powered. Solenoid valves generally require 1 - 4 psi (0.07 - 0.28 bar) differential to fully open. Because suction line pressure losses should be kept to a minimum, Refrigerating Specialties offers the **CK-2, CK-5, CK-2D, CK-6D** and **S9A/W** gas-powered valves from 1¼" to 8" (32mm to 200mm) with minimal pressure drop penalties during refrigeration. For medium temperature applications, Refrigerating Specialties offers the S8F, S7A and S5A families of solenoid valves with operating pressure differentials of 1 psi (0.07 bar) or less.

In addition to pressure drop, operating temperature should also be considered. With the exception of the S8F, solenoid valves have a minimum recommended temperature of -25ºF (-32ºC). The CK-2 and CK-5 valves also have a minimum recommended operating temperature of -25ºF (-32ºC), if the hot gas contains significant amounts of lubricant. A relatively oil free source of high pressure gas for these valves can be had by using gas from the top of the high pressure liquid receiver. (At low temperatures, lubricant viscosity can cause these valves to operate slowly.) For low temperature applications, the S9A and S9W valves are recommended.

Regardless of the type selected, the valve port size for gas powered suction stop valves should generally be the same as the line size.

Hot Gas Delivery Valves

Hot gas lines can be either regulated or unregulated. In an unregulated line, refrigerant at condensing pressure (which may vary) is sent directly to the coil and gas powered valves. The actual pressure that arrives will depend on the equivalent length of piping between the hot gas source and the coil.

Notes about Gas-Powered Valves

The **CK-2** and **CK-5** each require one pilot solenoid; the **CK-2D** and **CK-6D** each require two pilot solenoids which are integral to the valve; the **S9A** and **S9W** each require two pilot solenoids. Refrigerating Specialties offers the **S6N** and **S8F** normally closed, pilot solenoid valves for these valves.

The **CK-2, CK-5, CK-2D and CK-6D** valves require a pilot pressure 5 psi (0.34 bar) higher than upstream pressure in order to close. The valves will remain closed until the pressure above the piston drops to less than 3 psi (0.21 bar) above the upstream pressure. The **CK-5 and CK-6D** incorporate design features that prevent the valve from completely opening in the event of a power failure during defrost. When open, the **CK-2, CK-2D, CK-5 and CK-6D** valves will permit flow in either direction.

The **CK-2, CK-2D, CK-5 and CK-6D** are suitable for evaporator temperatures down to -60°F (-50°C). However, below -25°F (-32°C), liquid refrigerant and viscous lubricants can accumulate in the space above the piston in these valves. This can cause the valves to be very slow to open at the end of defrost. Therefore, for colder applications, the normally-closed S9A and S9W, with more powerful springs, are recommended particularly if a practically oil free gas source cannot be supplied.

The **CK-2, CK-5, S9A and S9W** impose about the same resistance to flow as a globe valve when fully open. Installing these valves "lying on their sides" in horizontal lines helps minimize flow resistance.

VALVE SELECTION MATRICES

Solenoid Valve Selection Matrix				
Valve Designation	**Valve Descripition**	**Most Common Application**	**Other Possible Applications**	**Specifications & Limitations**
S6N 3/16” (5mm) Port, Cv = 0.6 Bulletin 30-90	NC, direct operated, Direct-operating, PTFE seat, Flanged-connection	Pilot for Gas-Powered Valves [A] HP Liquid Feed Valve [A] (Small Evaporators)	Hot Gas Feed Valve (Small Evaporators)	0 psid (0 bar) to open MOPD = 300 psig (20.7 barg) MRP = 400 psig (27.6 barg) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC)
S8F 1/2” (13mm) Port, Cv = 2.7 Bulletin 30-91	NC, spring assisted, Pilot-operated, PTFE seat, Flanged-connection	Pilot for Gas-Powered Valves [A] Equalizing Valve HP Liquid Feed Valve [A] (Small Evaporators) Hot Gas Feed Valve (Small Evaporators)	Suction Stop Valve (Small Evaporators)	1 psid (0.07 bar) to open MOPD = 300 psig (20.7 barg) MRP = 400 psig (27.6 barg) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC)
S7A 3/4” (, 1” Ports, Cv = 10, 11 Bulletin 30-92	NC, direct operated, Pilot-operated, PTFE seat, Flanged-connection	LP Liquid Feed Valve [A] (Liquid Recirculation) Equalizing Valve Pump-Out Valve Suction Stop Valve (Small Evaporators)	—	Less than 1 psid (<.07 bar) to open MOPD = 300 psig (20.7 barg) MRP = 400 psig (27.6 barg) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -25ºF (-30ºC) Not for HP Liquid Feed Not for Hot Gas Feed
SV2 (SV2A has solenoid operator external) 1/2” - 1 1/4” Ports, Cv = 3.0 – 19 Bulletin 30-06	NC, spring closing, Pilot-operated, PTFE seat, Flanged-connection	HP Liquid Feed Valve [A] LP Liquid Feed Valve [A] (Liquid Recirculation) Hot Gas Feed Valve	—	3.5 psid (0.24 bar) to open MOPD = 300 psig (20.7 barg) MRP = 450 psig (31 barg) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -50ºF (-45ºC) Not for Suction Stop
S5A 1 1/4” Port, Cv = 19 Bulletin 30-93 (S5AE has external equalizer port)	NC, gravity closing, Pilot-operated, PTFE seat, Flanged-connection	Suction Stop Valve (Small, Medium Temperature Evaporators) LP Liquid Feed Valve [A] (Liquid Recirculation) Equalizing Valve (Larger Evaporators)	—	1 psid (0.07 bar) to open MOPD = 300 psig (20.7 bar) MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -25ºF (-30ºC) Not for HP Liquid Feed Not for Hot Gas Feed
S5A 1 5/8” - 3” Ports, Cv = 37 – 120 Bulletin 30-93	Same as above, except metal seat			

NOTES:

[A] Pilot and liquid line solenoid valves should all be installed with a strainer immediately upstream to ensure long, reliable service life. Refrigerating Specialties offers the **RSF** (flange connection) and **RSW** (weld connection) strainers in a variety of sizes up to 8”. (See R/S Bulletins 00-10 and 00-12)

Solenoid Valve Selection Matrix

Valve Designation	Valve Description	Most Common Application	Other Possible Applications	Specifications & Limitations
S4A 3/4" - 1-1/4" Ports, Cv=8.1 – 20 Bulletin 30-94	Dual piston, NC, spring assisted, Pilot-operated, PTFE seat, Flanged-connection	HP Liquid Feed Valve [A] Hot Gas Feed Valve	—	4 psid (0.28 bar) to open MOPD = 300 psig (20.7 bar) MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -50ºF (-45ºC) Not for Suction Stop
S4A 1-5/8" - 4" Ports, Cv=32 – 150 Bulletin 30-94	Same as above, except metal seat	HP Liquid Feed Valve [A] LP Liquid Feed Valve [A] (Liquid Recirculation) Hot Gas Feed Valve Discharge Line Solenoid	Suction Stop Valve	2 psid (0.14 bar) to open MOPD = 300 psig (20.7 bar) MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC)
S4W 5" - 8" Ports, Cv=200 – 550 Bulletin 30-05	NC, spring assisted, Pilot-operated, Metal seat, Weld-in-Line	Suction Stop Valve (Higher Temperature Evaporators) LP Liquid Feed Valve [A] (Liquid Recirculation) Hot Gas Feed Valve Discharge Line Solenoid	HP Liquid Feed Valve (Very Large Applications) Hot Gas Feed Valve (Very Large Applications)	2 psid (0.14 bar) to open MOPD = 300 psig (20.7 bar) MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC)
S4AD 3/4" - 1-1/4" Ports, Cv=8.1 – 20 Bulletin 30-95	NC, spring assisted, Pilot-operated, PTFE seat, Flanged-connection	To reduce liquid hammer on opening or closing To slowly introduce hot gas at the start of defrost	—	4 psid (0.28 bar) to open MOPD = 300 psig (20.7 bar) MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -50ºF (-45ºC) Not for Suction Stop
S4AD 1-5/8 - 4" Port, Cv=32 - 150 Bulletin 30-95	NC, spring assisted, Pilot-operated, PTFE seat, Flanged-connection	To reduce liquid hammer on opening or closing To slowly introduce hot gas at the start of defrost	—	4 psid (0.28 bar) to open MOPD = 300 psig (20.7 bar) MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -50ºF (-45ºC) Not for Suction Stop

NOTES:

[A] Pilot and liquid line solenoid valves should all be installed with a strainer immediately upstream to ensure long, reliable service life. Refrigerating Specialties offers the **RSF** (flange connection) and **RSW** (weld connection) strainers in a variety of sizes up to 8". (See R/S Bulletins 00-10 and 00-12)

Gas Powered Valve Selection Matrix

Valve Designation	Valve Description	Most Common Application	Other Possible Applications	Specifications & Limitations
CK-2 1-1/4" Port, Cv=19 Bulletin 50-12	NO, spring assisted, Requires one pilot solenoid to close, PTFE seat, Flanged-connection	Suction Stop Valve Liquid Feed Valve Requires lubricant-free pilot flow at evaporator temperatures below -25°F (-30°C)	—	0 psid (0 bar) to open 5 psid (.35 bar) to close MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC) Requires lubricant-free pilot flow at evaporator temperatures below -25°F (-30°C)
CK-2 1-5/8" - 6" Ports, Cv=37 – 400 Bulletin 50-12	Same as above, except metal seat			
CK-5 1-1/4" Port, Cv=19 Bulletin 50-23	Same as 1-1/4" CK-2, but will remain closed in the event of power failure during defrost.	Suction Stop Valve Liquid Feed Valve Requires lubricant-free pilot flow at evaporator temperatures below -25°F (-30°C)	—	0 psid (0 bar) to open 5 psid (.35 bar) to close MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC) Requires lubricant-free pilot flow at evaporator temperatures below -25°F (-30°C)
CK-5 1-5/8" - 6" Ports, Cv=37 – 400 Bulletin 50-23	Same as 1-5/8" - 6" CK-2, but will remain closed in the event of power failure during defrost.			
S9A 2-4" Port, Cv=45 – 180 Bulletin 31-90	NC, spring assisted, Requires two pilot solenoids: One to open, one to close, Metal seat, Flanged-connection	Suction Stop Valve Liquid Feed Valve	—	0 psid (0 bar) to close 10 psid (.7 bar) to open MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC)
S9W 5" - 8" Ports, Cv=200 – 550 Bulletin 30-05	Same as above, except weld-in-line			
CK-2D 2" - 6" Ports, Cv=51 – 400 Bulletin 50-24	NO, spring assisted, Requires both integral pilot solenoids energized to close, one pilot solenoid energized to open 10%, Metal seat, Flanged-connection	Suction Stop Valve Requires lubricant-free pilot flow at evaporator temperatures below -25°F (-30°C)	—	0 psid (0 bar) to open 5 psid (.35 bar) to close MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC) Requires lubricant-free pilot flow at evaporator temperatures below -25°F (-30°C)
CK-6D 2" - 6" Ports, Cv=51 – 400 Bulletin 50-25	Same as CK-2D, but... will open to 10% in the event of power failure during defrost or insufficient reduction of coil pressure after defrost.	Suction Stop Valve Requires lubricant-free pilot flow at evaporator temperatures below -25°F (-30°C)	—	0 psid (0 bar) to open 5 psid (.35 bar) to close MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC) Requires lubricant-free pilot flow at evaporator temperatures below -25°F (-30°C)

Pressure Regulator / Liquid Drainer Selection Matrix

Valve Designation	Valve Description	Most Common Application	Other Possible Applications	Specifications & Limitations
ALD Inlet Connection: 3/4" FPT or 1" weld Outlet Connection: 3/4" FPT Bulletin 62-01	Evaporator capacities at temperatures listed 20°F (-7°C) / 0°F (-18°C) / -20°F (-29°C) R-717: 35 TR (120 kW) / 29 TR (100 kW) / 25 TR (87 kW) R-22: 14 TR (48 kW) / 11 TR (39 kW) / 10 TR (34 kW)		Heat Reclaim Condenser Drainer	Drains liquid from bottom of evaporator. Hot gas flow must be downward through coil.
A4AOES 3/4" (17%) - 4" Ports, Cv=1.3 – 150 Bulletin 23-07	NC, pilot operated, externally equalized, outlet pressure regulator with electric shut-off Flanged-connection	Upstream of a coil with ALD to control defrost pressure.	Hot gas supply line to reduce pressure from condensing value to 100-120 psig.	2 psid (0.14 bar) to open MOPD = 300 psig (20.7 bar) MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -50ºF (-45ºC)
A2BO 1/4" - 3/4" Connections, Cv=0.5 Bulletin 21-02	Small capacity, outlet regulator Flanged-connection	Hot gas supply line to reduce pressure from condensing value to 100-120 psig.	—	MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -50ºF (-45ºC)
A2BK 1/4" - 3/4" Connections, Cv=0.4 Bulletin 21-02	Small capacity, relief regulator Flanged-connection	Defrost relief regulator	—	MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -50ºF (-45ºC)
A4AK 3/4" (17%) - 4" Ports, Cv=1.3 – 150 Bulletin 23-05	NC, pilot-operated, reseating regulator PTFE seat: 3/4" (Full Capacity) through 1-1/4" Ports Metal Seat: 3/4" (Reduced Capacity) & 1-5/8" through 4" Ports Flanged-connection	Defrost relief regulator	—	2 psid (0.14 bar) to open MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -50ºF (-45ºC)

Check Valve Selection Matrix

Valve Designation	Valve Description	Most Common Application	Other Possible Applications	Specifications & Limitations
CK-1 3/4" - 1-1/4" Ports, Bulletin 50-10	Piston-type check, PTFE seat, Close-couple to valve/ strainer	Liquid Lines Suction Lines	—	0.5 psid (0.03 bar) to open MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -25ºF (-30ºC)
CK-1 1-5/8" - 6" Ports, Bulletin 50-10	Piston-type Check, Metal Seat	Liquid Lines Suction Lines	—	0.5 psid (0.03 bar) to open MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -25ºF (-30ºC)
CK-3 1/2", 3/4", 1" FPT, Bulletin 50-13	In-line Check, PTFE seat	Hot Gas Line from drain pan to evaporator Liquid Lines	—	5 psid (0.34 bar) to open MRP = 400 psig (27.6 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -25ºF (-30ºC)
CK-4A 1/2" - 4" Ports, Bulletin 50-16	In-line Check, Metal seat, Can close-couple to valve/strainer	Hot Gas Line from drain pan to evaporator Liquid Lines Suction Lines Defrost regulator to intermed pressure	—	0.75 psid (0.05 bar) to open MRP = 500 psig (34.5 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC)
CK-4A 5" - 8" Ports, Bulletin 50-20	In-line Check, Metal seat,	Hot Gas Line from drain pan to evaporator Liquid Lines Suction Lines Defrost regulator to intermed pressure	—	0.6 psid (0.04 bar) to open MRP = 500 psig (34.5 bar) Max Fluid Temp 220ºF (105ºC) Min Fluid Temp -60ºF (-50ºC)

APPENDIX 2: VALVE SIZING

When selecting valves for an evaporator defrost arrangement, four types of valves need to be correctly sized for optimal results:

1. Liquid Feed Valves,
2. Suction Stop Valves,
3. Hot Gas Feed Valves, and
4. Defrost Regulators

Liquid Feed and Suction Stop Valves

For gravity flooded systems, suction stop and liquid shut off valves should match line size. This will result in a pressure loss across the valve approximately the same as that of a fully open globe valve.

For direct expansion and liquid recirculation systems, the valves should be sized to match the expected load. Guidelines for matching valves to load are given in the latest revision of Refrigerating Specialties Catalog C12.

Hot Gas Feed Valves

The hot gas feed valve should be sized to admit enough gas to remove frost in a reasonable amount of time. This is a complex goal to achieve because it involves warming the metal parts of the coil, then warming the frost itself to 32ºF (0ºC), and finally adding the latent heat to change the frost to water. Each of these three steps requires either detailed knowledge, or an approximation of the coil, frost thickness and density. (Frost may be as little as ⅓ the density of ice). If these details could be resolved, there still remains the need to determine what portion of the heat added to the coil actually reaches the frost, and what portion escapes through radiation, convection, and conduction into the refrigerated space. One estimate shows that as little as 20% of the total heat carried by the hot gas actually melts the frost.[4]

Another method to estimate the hot gas requirement is simply as some multiple of the normal refrigeration flow into the coil. One approach estimates the mass flow into the coil during defrost is one to two times the mass flow during refrigeration.[5]

A third method states that the evaporator coil acts as a condenser with a capacity three to four times as great as its refrigeration capacity. It is understood that this method has shortcomings in that it omits important factors such as the temperature differential (TD) at which the evaporator normally operates, and the temperature of the refrigerated space. It is qualitatively understood, however, that low TD coils need more heat than high TD coils, and evaporators in very cold rooms [say, -60ºF (-50ºC)] need more defrost heat than do evaporators in warmer rooms [say, 20ºF (-7ºC)].[6] This method implicitly assumes that differing frost thicknesses are dealt with by increasing or decreasing hot gas injection time.

The following example, based on the method just discussed, illustrates how the hot gas valves in Table 1, on the following page, were determined.

EXAMPLE

Consider the 1¼” (32mm) S4A, which has a Cv = 20, used as a hot gas solenoid on an ammonia evaporator. The equation for mass flow through the valve is

$$W\ (lb/hr)\ [kg/gr] = 500Cv\sqrt{\Delta P\ SG}$$

where ΔP is the pressure drop across the valve, and SG is the specific gravity of the fluid flowing through it. For hot gas supplied at 120 psig (8.3 barg) to a coil in which the pressure is maintained at 60 psig (4.1 barg), the mass flow would be about 5350 lb/hr (2427 kg/hr). The heat provided would be the difference between the enthalpy of saturated ammonia vapor entering at 120 psig, and saturated liquid leaving at 60 psig (4.1 barg): about 541 BTU/lb (1258 kJ/kg). The heat flow would be about 48275 BTU/minute (80 TR) [50932 kJ/min (849 kW)].

If the coil to be defrosted normally operates at -20ºF (-29ºC), and the condensing capacity is assumed to be three times the evaporating capacity, then the 1¼” (32mm) S4A would be suitable for up to a 27 TR (95 kW) evaporator.

If the coil normally operates at -60ºF (-50ºC), and the condensing capacity is assumed to be four times the evaporating capacity, then the 1¼” (32mm) S4A would be suitable for up to a 20 TR (70 kW) evaporator.

It should be apparent from the example and that the selections in Table 1 are approximate. System designers may either use the table as presented, modify parameters in the preceding example to meet their specific operating conditions (frost thickness, evaporator type, defrost time), or select valves based on alternate criteria that they have found to be successful.

Defrost Relief Regulators

The defrost regulators should be sized to permit all the refrigerant entering the coil through the hot gas feed valve to exit while maintaining the desired pressure. If the regulator is too small, pressure inside the coil will increase. This could cause defrost times to increase because it slows the flow of hot gas into the evaporator. If the regulator is too large, it will cause the valve to cycle open-and-closed. This will impose unsteady conditions on the system and could lead to premature valve failure.

Sizing the defrost relief regulator is complicated by the fact that only saturated liquid may be flowing through it when it first opens, but at the end of the hot injection phase the flow may be vapor or a mixture of vapor and liquid. (Of course, if only vapor is flowing at the end of defrost, it means the hot gas injection period is too long.)

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[4] Stoecker, W.F., Industrial Refrigeration Volume II, 1995, Business News Publishing Company.

[5] Ibid

[6] Strong, A.P., “Hot Gas Defrost: a One a More a Time,” Proceedings from the 1984 IIAR Annual Convention.

In addition, the pressure difference across the regulator (which drives flow through the valve) will vary from one application to another. A regulator on a -60ºF (-51ºC) evaporator set for 50ºF (10ºC) defrost would operate with about 84 psid (5.8 bard). A regulator for a 20ºF (-7ºC) coil set for 40ºF (4ºC) defrost would operate at about 45 psid (3.1 bard).

With these conditions in mind, it is possible to select defrost regulators to match the hot gas solenoids given previously. The following example illustrates.

EXAMPLE

In the preceding example, a 1¼" (32mm) S4A, used as a hot gas solenoid, allowed 5350 lb/hr (2427 kg/hr) of 120 psig (8.3 barg) ammonia vapor to enter an evaporator regulated at 60 psig (4.1 barg). Assume that this vapor flow is converted completely to liquid and is sent to a 20ºF (34 psig) [-29 ºC (2.3 bar)] intermediate pressure accumulator. Inserting these conditions into the mass flow equation gives a required Cv = 2.6. This is the minimum value to prevent pressure inside the evaporator from increasing. Because a regulator is capable of controlling down to about 25% of its rated capacity, the valve selected should have a Cv no greater than 10. A ¾" (20mm) A4AK (Cv = 8) would be good choices for this application.

Table 1: Hot Gas and Defrost Regulator Recommendations

Select Hot Gas Valve, below, based on evaporator capacity and coil temperature.	EVAPORATOR CAPACITIES FOR THE COIL TEMPERATURES SHOWN[A] Tons (kW)					Select Defrost Regulator, below, to suit the Hot Gas Valve in the first column.[B]
	+20ºF (-7ºC)	0ºF (-18ºC)	-20ºF (-29ºC)	-40ºF (-40ºC)	-60ºF (-50ºC)	
1" (25mm) SV2	20 (70)	16 (56)	13 (46)	11 (39)	10 (35)	¾" (20mm) A4AK 50% Reduced Plug
1" (25mm) S4A, A4AOS	24 (84)	19 (67)	16 (56)	14 (49)	12 (42)	
1¼" (32mm) S4A, A4AOS	40 (141)	32 (113)	27 (95)	23 (81)	20 (70)	¾" (20mm) A4AK
1¼" (32mm) SV2	38 (134)	31 (109)	26 (91)	22 (77)	19 (67)	
1⅝" (40mm) S4A, A4AOS	64 (225)	51 (179)	43 (151)	37 (130)	32 (113)	1" (25mm) A4AK
2" (50mm) S4A, A4AOS	110 (387)	86 (302)	71 (250)	61 (215)	54 (190)	
2½" (65mm) S4A, A4AOS	150 (528)	120 (422)	100 (352)	86 (302)	75 (264)	1¼" (32mm) A4AK
3" (75mm) S4A, A4AOS	200 (703)	160 (563)	134 (471)	110 (387)	100 (352)	

[A] Coil capacities are based on 120 psig (8.3 barg) hot gas supply and 60 psig (40ºF) [4.1 barg (4ºC)] defrost regulator setting. For 100 psig (6.9 barg) hot gas, multiply table capacities by 0.75. For 85 psig (53ºF) [5.9 barg (12ºC)]regulator setting multiply table capacities by 0.83.

[B] Defrost regulators selections are based on discharge to 20ºF (-7°C) intermediate pressure. For discharge to -20ºF (-7°C) or lower, consider using one size smaller valve.

APPENDIX 3: TERMINOLOGY

Vapor Propelled Liquid is the movement of liquid refrigerant at high velocity due to high-pressure vapor. It is also sometimes referred to as hydraulic shock, liquid hammer, and surge.

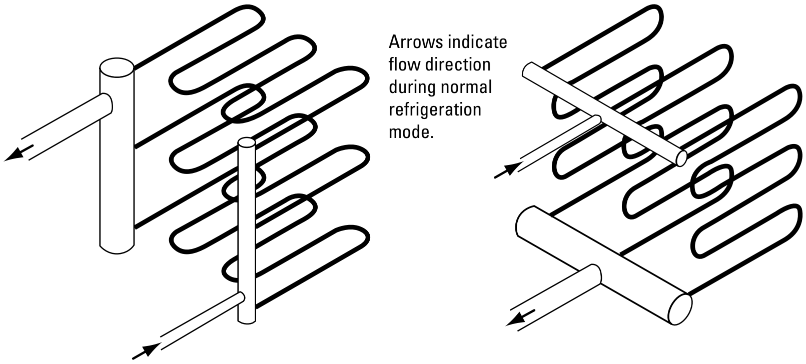
Sudden Liquid Deceleration is the rapid decrease of liquid flow due to sudden closing of a valve. It is also referred to as hydraulic shock or liquid hammer.

Condensation Induced Shock is the most difficult to imagine since it occurs only with very cold coils which are in a high vacuum. Should high pressure ammonia vapor be injected rapidly into the -40°F to -60°F (-40°C - 50°C) coil, the vapor will collapse to about 1/1000 its size, leaving a void in the line and the condensed liquid shot at extreme velocities causing shock loads in the coil manifold.

The magnitude of the instantaneous pressures forces resulting from any of the three noted shock wave systems can produce pressures on the order of 2,000 to 4,000 psi (137.9 to 275.8 bar) for very short time durations – however they do have a cumulative effect after years of improper system operation.

In general coils are designed for 300 psi (20.7 bar) maximum design pressure which is adequate for any normal expected steady pressure levels operating at refrigeration conditions, but extreme shock loads will take their toll of evaporator coils over time. The best protection is to follow the guidelines of this bulletin plus follow up with regularly scheduled operator witness of the defrost operation and reporting any unusual noises, vibrations or outright shaking of the piping during defrost.

Fortunately, failure is rare, but when undetected can be catastrophic resulting in a major release, product loss and plant fires. Be fore-warned and aware of shock phenomena.



Schematic of horizontally circuited, bottom-fed evaporator

Schematic of vertically circuited, top-fed evaporator

Conversion to Metric
1 ton = 200 Btu/min
1 ton = 3024 kcal/hr
1 kW = 0.2844 ton
1 kW = 56.89 Btu/min
1 kW = 860 kcal/hr
1 bar = 1.0197 kg/cm^2
1 bar = 14.5 psi
1 ATM = 0.98 bar = 14.7 psi

Product specifications subject to change without notice. Visit www.parker.com/ refspec for current product information, including the latest version of this catalog.

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