Honeywell | Refrigerants

HCFC to HFO Blend Retrofit Guidelines
Commercial Refrigeration Systems

R-22, R-402A, R-408A & R-404A to Solstice® N40 (R-448A)

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Preface

R-22 is an HCFC refrigerant and is regulated under the Clean Air Act.

R-402A and R-408A were refrigerants employed as replacements for R-502 in many medium- and low-temperature refrigeration systems. R-402A and R-408A contain R-22 and are also regulated under the HCFC phaseout mandated through the Clean Air Act. This includes a ban on production or import of any HCFC as of 2020.

R-404A is an HFC refrigerant blend with a global warming potential (GWP) significantly higher than R-448A. R-404A can no longer be used in the United States for new supermarket equipment or retrofits. R-404A is also the subject of possible future regulation under amendments to the Montreal Protocol.

This guideline is based on a retrofit of supermarket refrigeration systems but can be used as a guideline for any commercial refrigeration system retrofit.

As supermarket owners work to comply with regulations, as well as reduce their carbon footprint, existing refrigeration equipment may need to be either replaced or retrofitted with an alternative refrigerant. The selection of a retrofit refrigerant depends, in part, upon retrofit objectives that include factors such as efficiency, first cost, regulatory compliance and capacity.

Technicians may follow equipment manufacturers’ recommendations and Honeywell’s guidelines outlined in this publication to help retrofit existing R-22, R-402A, R-404A, and R-408A medium- and low-temperature refrigeration systems to R-448A.

Introduction

As the commercial refrigeration industry continues to move away from the use of ozone-depleting and high GWP hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), refrigeration contractors and technicians will play a key role in the transition to alternatives through retrofitting. Honeywell has produced this guide to help contractors and technicians better understand the various technical and operational aspects of carrying out retrofit procedures using R-448A.

Although the information can be helpful as a general guide, it should not be used as a substitute for the equipment manufacturer's specific recommendations. Also, retrofitting should be considered system-specific.

Since systems can differ in condition and configuration, retrofit actions applied to one system will not necessarily result in the same level of success in another system. For this reason, Honeywell strongly recommends contacting the equipment manufacturer for detailed information on retrofitting the specific model under consideration. Also, review the Safety Data Sheet (SDS) for safety information on the specific refrigerant you choose. Visit msds-resource.honeywell.com.

Solstice® N40 Refrigerant

ASHRAE number, components and applications appear in the table below.

Refrigerant	Type	Replaces	Applications	Comments
Solstice® N40 (R-448A)	Blend R-32 R-125 R-1234yf R-134a R-1234ze	R-22 R-404A R-507 R-402A R-408A	Supermarket freezers, coolers, display cases. Liquid (DX) chillers. Warehouse refrigeration	Among the most efficient refrigerant replacements. Lowest GWP value compared to available nonflammable alternatives. Make appropriate control adjustments.

R-448A is not a "Drop-in" Replacement

R-448A is an HFO-blended refrigerant that utilizes synthetic lubricants. Check with the compressor manufacturer to determine if the existing lubricant is acceptable. The retrofit procedures listed here have been developed by Honeywell to address these issues and to help technicians perform successful retrofits utilizing positive-displacement (reciprocating, rotary, scroll or screw) compressors.

Retrofit Procedures - Summary

A successful retrofit includes several steps to produce a low maintenance and efficient system. The steps outlined below have been developed through the experience of Honeywell's technical team as well as many of our service company partners. This guide is only a recommendation based on field experience. Refer to individual retailer procedures to ensure adherence to product integrity and other protocols.

The first step is a site survey. A site survey is recommended to identify existing conditions that impact the retrofit as well as identifying system upgrades that can be done cost effectively during the retrofit. A refrigerant retrofit is an ideal time to increase the life cycle and efficiency of the refrigeration system. The survey also identifies components that may need to be replaced or added to match the new refrigerant and to reduce future leaks.

The second step includes activities to prepare for the retrofit. These are activities that can be done prior to the retrofit. Preparation also includes store coordination and procurement of needed parts.

This step shortens the down time during the retrofit as well as reducing overall risk.

The final step is the actual retrofit. This is typically started as early in the evening as the store leadership will allow. The retrofit team will typically include a recovery crew, a construction crew for charging and adjustments, a controls expert, and a supervisor. Retrofitting a single parallel system can be done in one night. Fine tuning of superheat may continue into the operating hours on the next day.

Retrofit Procedures - Detailed

Step 1 - Site survey

(download at http://bit.ly/2qasBHi)

1. Compressors
   - Record manufacturer, model and serial numbers
   - Identify failed compressors, failed fans, and any capillary control lines
   - Identify discharge temperature mitigation devices requirements (if any)

2. System issues
   - Walk the store, machine room and roof to identify any items that impact system operation. Some example areas to identify include failed condenser fans, clogged evaporator coils, failed sub coolers, degraded condensers, poor insulation, obsolete components, etc.

3. Review expansion valves
   - Any non-adjustable expansion valves should be identified. Replacement valves or adjustment kits should be purchased for these valves prior to the retrofit.
   - In general, most valves will have an increase in capacity with R-448A and if the valve was sized in the mid-range of its capacity curve the valve will work well from a capacity perspective.
   - Due to the higher capacity, take care to avoid refrigerant flood back during startup. This is especially true with R-404A, R-402A, and R-408A. Pre-adjustment of expansion valves to prevent flood back is recommended. This adjustment is not a replacement for superheat adjustment after startup.
   - With R-448A the pressure acting on the expansion valve will act to open the valve more with R-404A, R-402A, and R-408A. This may result in an inability to close the valve enough to allow superheat adjustment. In this case the power head should be changed to an R-22 or R-448A power head. If changing the power head does not allow for superheat adjustment the valve should be replaced.
   - Ample supplies of elements and valves should be on-hand during the retrofit

4. Identify seals and O-rings for replacement
   - Chlorine-based refrigerants such as R-22, R-408A and R-402A can result in elastomer seal failure when the chlorine-based refrigerant is removed. There are also common seals that should be replaced for a leak-free system. Refer to Appendix D for recommended seals and O-rings for replacement.
   - R-404A does not contain chlorine and therefore the leak potential from chlorine removal is not a concern when retrofitting from R-404A to R-448A.

5. Record baseline data
   - Record baseline data to identify issues and as a reference for post-retrofit performance
   - Refer to survey form at http://bit.ly/2qasBHi for data to be recorded

6. Line sizes
   - Review refrigerant line sizes, especially horizontal suction and riser lines. The Genetron Properties program is available as a free download on the Honeywell Refrigerants web site and can be used to calculate line sizes. Refer to Appendix B for line size examples.

7. Test oil and refrigerant
   - Test oil to identify any signs of serious system issues
   - If recovered refrigerant is to be used at other stores, or otherwise re-used, it is recommended to test it for purity

8. Forward completed survey form to the customer

Step 2 - Preparation

1. Store coordination
   - It is recommended to meet with store leader and department managers
   - Items to discuss include
     i. Retrofit dates and times
     ii. Store hours
     iii. Unloading of cases
     iv. Opportunity for case cleaning
     v. Food safety (dry ice, keeping doors closed, plastic sheeting, etc.)

2. Order parts and refrigerant

3. Technician training
   - Ensure that technicians are trained on setting superheat using dew point temperature with refrigerants with glide. Refer to Appendix C.
   - Refer to pressure-temperature chart in Appendix E. Inconsistencies have been observed in on-line and 3rd party applications.
   - Ensure that technicians are trained on setting pressure valves based on average pressure when using refrigerants with glide. Refer to Appendix C.
   - Honeywell technical team is available to provide on-site or web-based training

4. System changes
   - Perform any activities identified in the survey that can be safely done before the retrofit. This includes any valves without elastomer seals, compressor changes, pilot lines, control adjustments, coil cleaning, etc.
   - Add discharge temperature mitigation if required. Refer to Appendix A.

5. Recover excess refrigerant from receiver
   - This will reduce recovery time on the night of the retrofit. Weigh refrigerant for use in calculating R-448A charge.

6. Change oil from mineral to POE
   - In most instances, the lubricant in use with R-22, R-402A, and R-408A is not suitable for use with R-448A and a change to a synthetic lubricant is required. Honeywell recommends using a miscible lubricant approved by the compressor manufacturer.
   - Usually (1) full oil change is required
   - 95% of synthetic is preferred. Refer to compressor manufacturer for specific applications
   - In most instances a system with R-404A will already have POE oil and an oil change is not required
   - Refer to Appendix A for oil change recommendations

7. Change suction and liquid filters and driers

8. Upgrade controller with R-448A pressure / temperature curves. Honeywell recommends using average pressures for control when using refrigerants with glide.

9. Leak check and repair

Step 3 - Retrofit

1. Remind store personnel the day prior to retrofit
2. Secure food safety (dry ice, plastic sheeting, signs on coolers, etc.)
3. Recover existing refrigerant
   - Use Green Chill guidelines at www.epa.gov/greenchill to recover refrigerant
4. Record amount of refrigerant removed including refrigerant previously removed
5. Break vacuum from recovery machine
6. Replace seals, gaskets, and valves as needed. Refer to Appendix D for recommendations.
7. Replace expansion valves and add adjustment kits as determined in survey
8. Replace driers and filters
9. Evacuate system
   - Honeywell recommends evacuating the system to 500 microns from both sides of the system. Attempting to evacuate a system with the pump connected only to the low-side of the system will not adequately remove moisture and non-condensables such as air.
   - Use a good electronic micron gauge to measure the vacuum. An accurate reading cannot be made with an analog refrigeration gauge.
   - Repair any leaks
10. Charge system with Solstice® N40 refrigerant
    - When working with R-448A, it is important to remember that it is a blended refrigerant. It is essential that blended refrigerants be liquid-charged by removing only liquid from the cylinder. **Never vapor charge the system with vapor from a R-400 series refrigerant cylinder**. Vapor-charging may result in a

change in the refrigerant composition and unpredictable system performance.

- A throttling valve should be used to control the flow of refrigerant if charging to the suction side to ensure that the liquid is converted to vapor prior to entering the system.
- **NOTE:** To prevent compressor damage, do not charge liquid into the suction line of the compressor.
- Systems being charged with R-448A require:
  - Approximately 3% higher charge than R-408A
  - Approximately 8% lower charge than R-22
  - Approximately 5% higher charge than R-404A

  Allow conditions to stabilize. If the system is undercharged, add refrigerant in increments of 5 percent by weight of the original charge. Continue until desired operating conditions are achieved.

11. Adjust expansion valves
    - Adjusting valves is a very important part of any retrofit. Properly adjusted valves will prevent compressor damage, ensure safe food temperatures, and result in an efficient system.
    - Most valves will require some adjustment
    - Refer to step 1, item 3 for details on expansion valves
    - In the absence of specific manufacturer recommendations, a 4 to 6 ºF superheat for low temperature and 6 to 8 ºF for medium temperature is recommended.

12. Adjust pressure controls
    - All mechanical controls should be reviewed for adjustment. This includes safety controls, EPR valves, holdback valves, etc. Refer to Appendix C prior to making any set point adjustments.
    - Adjusting pressures on R-448A requires the use of an average of dew and bubble pressures as shown on Honeywell PT charts
    - For condenser fan control, an average pressure should be used. Verify control system is using an average pressure. Refer to Appendix C prior to making any set point adjustments.

13. Label Components and System
    - After retrofitting the system with R-448A, label the system components to identify the refrigerant and specify the type of lubricant (by brand name) in the system. This will help ensure that the proper refrigerant and lubricant will be used to service the equipment in the future.
    - Contact Honeywell wholesaler for labels, PT charts, etc.

Appendix A - Compressors

Disclaimer: Some of the following information was obtained from manufacturers' information. Please refer to the manufacturer for updates to the information. In some cases it may be possible that the recommendations are quite conservative.

Compressor Oil

Process:

In most instances, the lubricant in use with R-22, R-402A, and R-408A is not suitable for use with R-448A and a change to a synthetic lubricant is required. Honeywell recommends using a miscible lubricant approved by the compressor manufacturer. Differences among lubricants make it difficult to assume they are interchangeable. Check with the compressor manufacturer for the correct viscosity grade and brand for the compressor in the system being retrofitted. R-404A systems typically already have POE oil and so an oil change is not required.

If the lubricant is contaminated or an acid test indicates high levels of acidity, then a full lubricant change is warranted.

Recommended process:

1. Remove existing oil from compressor, reservoir, and separator.
2. Measure volume of lubricant removed. This volume will be used as a guide to determine the amount of new lubricant to add.
3. Change lubricant filters if present.
4. Add new lubricant. It is recommended that polyol ester (POE) lubricant be pumped rather than poured to avoid pick-up of atmospheric moisture.
5. Run for 24 hours ensuring all circuits are defrosted and that all coils such as heat reclaim and split condensers are engaged periodically.
6. Test for % of mineral oil using oil refractometer. 95% synthetic is preferred.
7. Repeat if needed.

Systems charged with POE lubricant should not be left open to the atmosphere for more than 10 to 15 minutes. This is due to the moisture absorbing nature of POE oil.

Note that evacuation will not remove moisture from POE lubricant. A solid core filter drier designed for moisture removal is the only effective means to remove moisture from POE lubricant.

Carlyle reciprocating compressors

Per 06deaguide.pdf, Lit. No. 574-069 Rev B 6/04 the following POE oils are approved for use on Carlyle 06D/E compressors.

Manufacturer	Brand Name
Castrol ICI EMKARATE CPI	E68 RL68H SOLEST 68
Mobil Arctic† Castrol†	EAL 68 SW 68

Copeland reciprocating compressors

Per Emerson 93-11 R32 (1/16) Copeland recommends POE-32 for use with Solstice® N40 (R-448A)**. Visit Emerson web site for latest approved lubricants. POE-32 includes:

- Polyolester Oil (Copeland Ultra 32-3MAF) - Preferred
- Lubrizol Emkarate RL32-3MAF
- Everest 32-3MAF
- Parker EMKARATE RL32-3MAF/ (Virginia) LE323MAF
- Nu Calgon 4314-66/EMKARATE RL32-3MAF

Approved for 'top off' only:

- Everest 22 CC
- Copeland Ultra 22 CC
- Mobil Arctic 22 CC

Appendix A - Compressors

Compressor Compatibility

Copeland reciprocating compressors

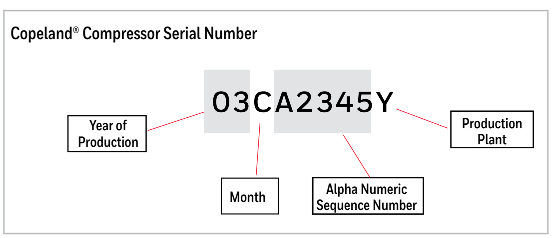
Older Copeland reciprocating compressors are recommended to be replaced with new models. This is because the older models were never qualified for use with HFO refrigerants and POE oil. These compressors can be identified by an “R” in the second letter in the model. For example, a 4RA3-1000-TSK compressor is not qualified for use with POE oil.

Compressor replacement should occur prior to any change to synthetic oil.

Newer model Discus compressors are approved for use with POE oil and R-448A.

The compatible models are:

- 2D all
- 3D manufactured after 1999
- 4D & 6D manufactured after April 2003



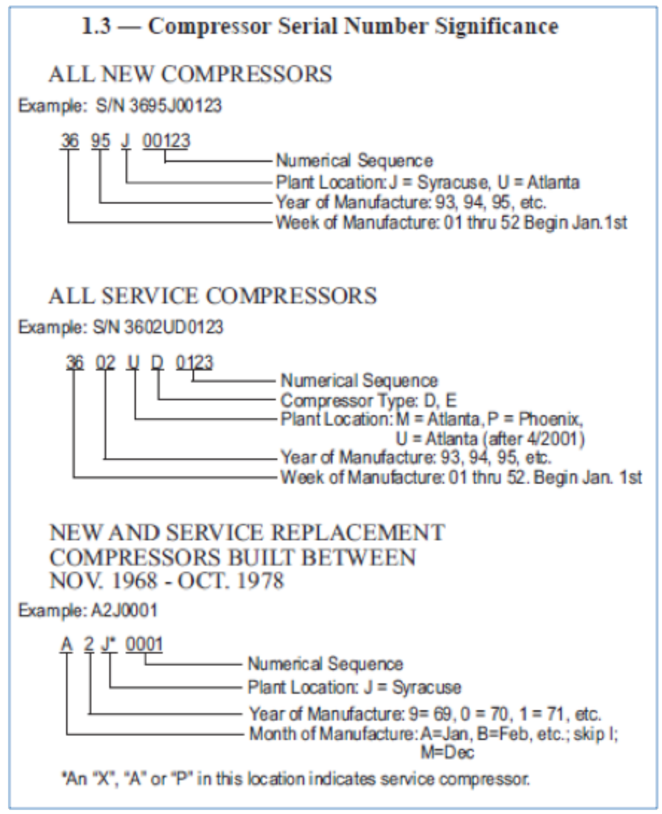
3D compressor Moduload systems should be checked for applicability. Retrofit kits are available.

Blocked suction capacity control on 4D and 6D compressors is compatible with POE oil and R-448A.

Carlyle reciprocating compressors

Carlyle began using a higher flow oil pump in June 1994. This pump is recommended in order to prevent oil failures when using synthetic oils. It is recommended that compressors with serial numbers beginning with 0694 or older be retrofitted with the high flow oil pump.
Per 06deaguide.pdf, Lit. No. 574-069 Rev B 6/04

Carlyle serial number / date reference



Per 06D/E Pocket Service Guide, page 8, literature number 020-611 at www.carlylecompressor.com

Carlyle screw compressors

Carlyle 06T screw compressors are currently being evaluated for compatibility with POE oil and HFO refrigerants.

Appendix A - Compressors

Discharge temperature mitigation

With Solstice® N40 (R-448A), the system will exhibit discharge temperatures higher than with R-404A/R-402A/R-408A but lower than with R-22.

The necessity for discharge temperature mitigation will depend greatly on condensing and return gas temperature.

Carlyle reciprocating compressors

Carlyle 06D/06E compressors will require head fans and liquid injection as described below for R-407A.

CYLINDER HEAD COOLING FAN		R407A	R404A/ R507A*			
Comp Type	*Recommendation*	*SST Range*	*SST Range*	*SDT Range*		*RGT Range*
06D/E Single-Stage	Required	SST < -15F	SST < -25F	ALL		ALL
	Required	SST < 0F	-	SDT > 120F	OR	RGT > 30F
06CC Two-Stage	Cylinder Head Fan is recommended, but not required for all 06CC applications.					
LIQUID INJECTION						
Comp Type	*Recommendation*	*SST Range*	*SST Range*	*SDT Range*		*RGT Range*
06D/E Single-Stage	Required	SST < -25F	SST < -25F	ALL		ALL
	Required	SST < -15F	-	SDT > 120F	OR	RGT > 30F
06CC Two-Stage	Required	SST < -25F	SST < -30F	ALL		ALL

* R404A/R507A data provided for reference.

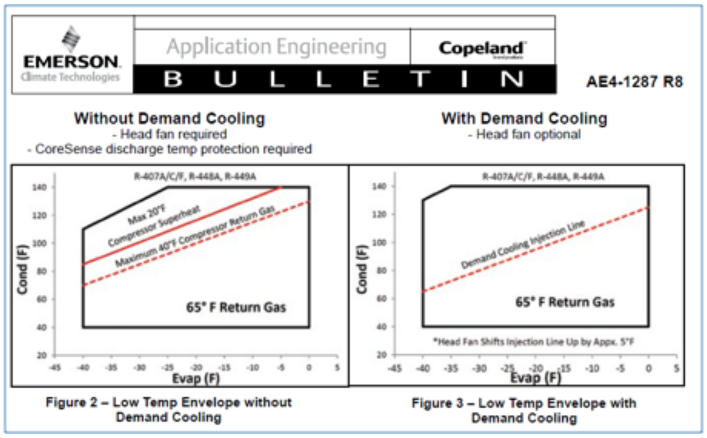
Refer to Carlyle bulletin 16T-01 at www.carlylecompressor.com for additional information.

Copeland reciprocating compressors

Per Copeland AE bulletin AE4-1287 R8, the following chart gives recommendations for temperature mitigation.

Demand cooling is recommended in most system designs and head fans are optional when using demand cooling.

Please note that using the core sense discharge temperature protection without demand cooling will result in the compressor shutting down in high temperature situations. While this will protect the compressor it may result in loss of system operating performance.



Copeland AE-1287 R8

For recent updates, visit www.emersonclimate.com

Copeland scroll compressors

Existing medium temperature ZB and ZS scroll compressors will operate with R-448A and POE oil and do not require liquid injection.

The low temperature application of ZF* Copeland Scroll™ compressors with refrigerant R-448A requires the use of dedicated injection technologies in order to provide excellent compressor efficiencies and to keep the operation within safe limits.

Liquid injection is typically accomplished by a discharge temperature control valve (DTC) for ZF06K4E to ZF18K4E compressors or a capillary device for ZF24K4E to ZF48K4E compressors. The injection is not required, but can be used, for medium temperature applications.

These compressors are compatible with R-448A.

Appendix B – Refrigerant Line Sizing

Introduction

Refrigerant line sizes in a typical supermarket system consist of the compressor discharge, condenser return, and individual circuit liquid and suction lines.

The correct line sizes help to ensure a properly running system. Prior to a retrofit it is recommended to review horizontal and vertical suction line sizes.

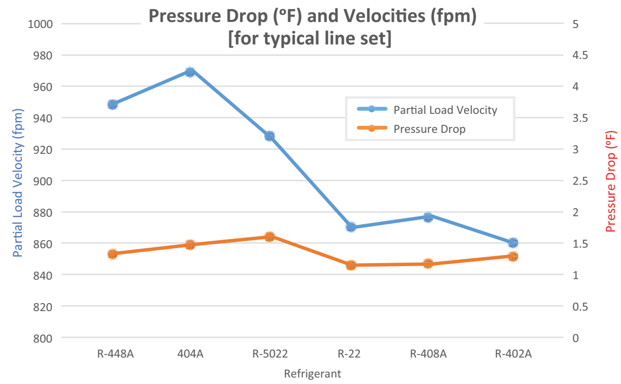
This review will identify any line size changes needed due to the new refrigerant and/or existing line size design concerns.

The correct design of these line sizes ensures that:

1. The line size is large enough to result in a pressure drop that is compatible with the design. Designers will normally account for a suction line pressure drop. (The design pressure drop can be determined by a review of the refrigeration schedule, contact Honeywell technical services for assistance).
2. The line size is small enough to result in refrigerant velocity sufficient to ensure oil is returned to the compressor. This is especially important on vertical risers.

The following chart shows the high suction line velocities (a benefit) when using R-448A as well as the R-448A pressure drop which is similar to other refrigerants.

With these characteristics it is generally true that a system that had proper line sizing before the retrofit will work well with R-448A.



Suction line sizes

ASHRAE recommends horizontal suction line refrigerant velocities from 900 to 4000 fpm. A vertical suction riser should maintain a minimum of 900 fpm at the lowest load condition expected for the system.

On a typical refrigeration system the saturated condensing temperature can vary from 60°F up to 120°F. The capacity of the refrigerant at the lower temperatures can reduce required flow rate as much as 35%. In addition, the load for the display cases is significantly reduced when humidity is low in lower ambient conditions.

Example 1: An R-448A system with 100,000 BTUh of case load, 70°F condensing temperature, and 30% RH inside the store.

Appendix B – Refrigerant Line Sizing

Mass flow rate @ 120°F condensing = .46 lb/s

Mass flow rate @ 70°F condensing = .35 lb/s (76%) (from Honeywell Genetron properties software)

Case load @ 30% RH = 75,000 (75%) (per ASHRAE chart)

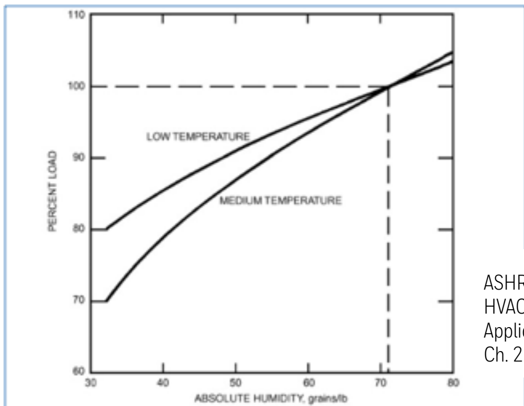


Figure 1. Refrigerated Case Load Variation with Store Air Humidity

4. SUPERMARKETS

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Accumulative effect = 76% x 75% = 57%

The cumulative effect of the increased capacity and reduced load in lower ambient results in a flow reduction approaching 50%.

It is recommended to use the reduced refrigeration load when calculating suction riser velocities. In locations with wide extremes of temperature and humidity, a value of 50% should be used.

As long as horizontal suction lines are properly sloped in the direction of the compressor, oil can be transported on horizontal runs with normal design velocities. Due to this the 100% design loads can be used when calculating horizontal line sizes.

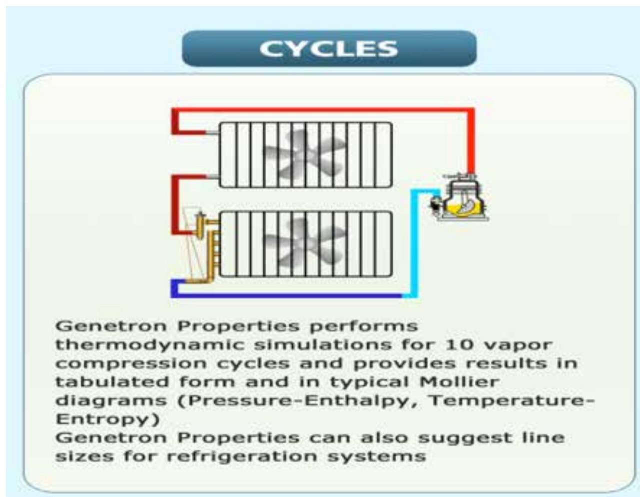
Pipe size calculation:

The Genetron Properties program is available as a free download from www.Honeywell-refrigerants.com and can be used to calculate line sizes.

Step 1: Determine circuit design temperatures and refrigeration load.

Step 2: Determine existing line sizes.

Step 3: Choose Cycles in the Genetron software.



Step 4: Select line sizing

Step 5: Calculate the drop in saturation temperature and velocity for the horizontal lines and risers.

Note: When calculating riser temperature rise, enter a main line length of zero.

Appendix B – Refrigerant Line Sizing

Example 2: Calculate the best line size for R-448A.

- Evaporator temp = -19ºF
- Load = 24,750 BTUh
- Riser height = 30'
- Equivalent length = 180'

The Genetron properties program generates the following results for R-448A.

	Horizontal			Riser			
Refrigerant	Size	Full load Temperature Rise	Full load Velocity	Size	Full load Temperature Rise	Partial load Velocity	Total PD (F)
448A	1-3/8	1.7	1630	1-1/8	0.16	1242	1.86

The total pressure drop of 1.86ºF is well within normal recommendations. The velocities for the horizontal at full load is above 500 fpm and the riser velocity at 50% load is above 900 fpm.

Example 3: Review the line sizing for this existing circuit.

- Refrigerant R-408A being retrofitted to R-448A
- Evaporator temp = -19ºF
- Load = 24,750 BTUh
- Horizontal line size = 1-1/8"
- Riser line size = 1-1/8"
- Equivalent length = 180'
- Riser height = 30'

The Genetron properties program generates the following results for R-408A and R-448A.

	Horizontal			Riser			
Refrigerant	Size	Full load Temperature Rise	Full load Velocity	Size	Full load Temperature Rise	Partial load Velocity	Total PD (F)
408A	1-1/8	4.82	2403	1-1/8	0.17	1201	4.99
448A	1-1/8	4.88	2484	1-1/8	0.16	1242	5.04

In this example the velocities are well within recommendations and oil return is assured. However, the pressure drop is excessive and should be reviewed.

Example 4: using the same circuit as in example 2 but with larger existing line size.

- R-408A being retrofitted to R-448A
- Evaporator temp = -19ºF
- Load = 24,750 BTUh
- Horizontal line size = 2-1/8"
- Riser line size = 1-5/8"
- Equivalent length = 180'
- Riser height = 30'

The Genetron Properties program generates the following results for R-408A and R-448A.

	Horizontal			Riser			
Refrigerant	Size	Full load Temperature Rise	Full load Velocity	Size	Full load Temperature Rise	Partial load Velocity	Total PD (F)
408A	2-1/8	0.19	641	1-5/8	0.17	556	0.36
448A	2-1/8	0.19	663	1-5/8	0.16	575	0.35

Appendix B – Refrigerant Line Sizing

In this example the pressure drop is well within recommendations. However, riser velocities are below ASHRAE recommendations and should be reviewed.

Liquid line sizes

ASHRAE recommends less than 300 fpm of velocity in the liquid line from the receiver to the evaporator.

It is also recommended that the pressure drop in the liquid line be limited to a 1°F to 2°F change in saturation temperature. This is to limit any chance of flash gas in the liquid line prior to the expansion valve. In some cases, liquid subcooling is required to eliminate flash gas in the liquid line.

Of special consideration is the effect of an elevation rise from the receiver to the evaporator. An example is a ground mounted refrigeration unit supplying an evaporator in a 15' tall walk-in cooler. This would result in a more than 2°F pressure drop just from the elevation rise.

Using Honeywell's Genetron Properties software program, the proper liquid line sizes can be determined based on the refrigeration load, suction pressure, subcooling, line length and vertical rise.

Contact Honeywell technical support with any questions.

Appendix C – Control Settings

Control Settings with R-448A

- Superheat
- Liquid subcooling
- Evaporator Pressure Regulator (EPR)
- Condenser

Introduction

The proper setting of superheat, subcooling and pressures is critical to a well-performing system. During a retrofit it will be necessary to check and adjust mechanical control valves.

Superheat

Procedure:

1. Use a thermometer to determine the actual temperature at the evaporator coil outlet.
2. Use gauges to determine the pressure at the evaporator coil outlet.
3. Using this pressure, determine the dew temperature using the "dew" column of the PT chart.
4. Calculate superheat.

Superheat = actual temperature at evaporator coil outlet - dew temperature from PT chart.

Example: Determine the superheat on a system which uses Solstice® N40 (R-448A) when the pressure at theEvaporator coil outlet reads 45 psig and the actual temperature at the coil outlet is 30°F.

1. Actual temperature at coil outlet = 30°F
2. Pressure = 45.0 psig
3. Find 45 psig in the dew column of the PT chart and read across to find the temperature at that pressure. In chart below we see the temperature at 45 psig is 20°F.

Temp	(psig)		
(°F)	Bubble	Dew	Average
10	45	34	39
15	51	39	45
20	58	45	51
25	65	51	58
30	72	57	65

4. Calculate superheat
   Superheat = 30°F – 20°F
   Superheat = 10°F

Subcooling at condenser outlet

Procedure:

1. Use gauges to determine the pressure at the outlet of the condenser
2. Using this pressure determine the bubble temperature using the "bubble" column of the PT chart.
3. Use a thermometer to get the actual temperature at the same point on the condenser outlet.
4. Calculate sub cooling.

Sub cooling = bubble temperature from PT chart - actual temperature at condenser coil outlet.

Example: Find the amount of subcooling on a system using Solstice N40 (R-448A) when the condenser outlet pressure is 195 psig and the condenser outlet temperature is 80°F.

1. Outlet pressure is 195 psig
2. Actual temperature of pipe is 80°F degrees

Appendix C – Control Settings

3. Find 195 psig in the bubble column of the PT chart and read across to find the temperature at that pressure. In chart below we see the temperature at 195psig is 85°F.

Temp (°F)	(psig)		
	Bubble	Dew	Average
75	167	142	155
80	181	155	168
85	195	169	182

4. Calculate subcooling
   Subcooling = 85°F - 80°F
   Subcooling = 5°F

Note: The same procedure can be used to determine subcooling on the liquid line exiting a subcooler expansion valve inlet, etc.

Evaporator Pressure Regulator (EPR)

Procedure:

1. Determine desired suction temperature at the EPR valve based on design data for the fixture. This can be found on the refrigeration schedule or manufacturer specification sheet.
2. Use gauges to measure the pressure on the fixture side of the EPR valve.
3. Using this pressure find the average pressure column from the PT chart to determine the current setting of the EPR valve.
4. Adjust valve to match required fixture pressure. Some adjustment from the design set point will be necessary based on system pressure drop and other factors.

Example: Set the EPR valve on a circuit which uses Solstice® N40 (R-448A) when the pressure at the EPR reads 58 psig and the required fixture suction temperature is 20°F

1. Desired fixture suction temperature is 20°F.
2. Pressure on the fixture side of valve is 58 psig.
3. Using the average pressure column on the PT chart gives a fixture temp of 25°F.

Temp (°F)	(psig)		
	Bubble	Dew	Average
10	45	34	39
15	51	39	45
20	58	45	51
25	65	51	58
30	72	57	65

4. The EPR valve should be adjusted to a pressure of 51 psig to match the 20°F required by the fixture.

Temp (°F)	(psig)		
	Bubble	Dew	Average
10	45	34	39
15	51	39	45
20	58	45	51
25	65	51	58
30	72	57	65

Condenser Pressure Control

There are three main methods of condenser fan / pressure control. These are

A: Condensing Pressure

B: Drop leg temperature

C: Temperature difference (TD)

Appendix C – Control Settings

A: Pressure control

The pressure at the outlet of the condenser is sensed and compared to the setting. Fans are cycled to achieve this setting.

For refrigerants with glide, such as R-448A, the average pressure should be used.

Example: A common setting is 70ºF saturated condensing pressure. Determine the corresponding pressure setting for R-448A.

1. On the PT chart find the average pressure corresponding to 70ºF.
2. This equals a 142 psig setting.
3. The mechanical or electronic fan control should be set to 142 psig.

Temp	(psig)		
(°F)	Bubble	Dew	Average
65	141	119	130
70	154	130	142
75	167	142	155

B: Drop leg temperature control

The temperature of the condenser outlet piping is sensed and compared to the setting. Fans are cycled to achieve this setting.

For refrigerants with glide, the temperature of the refrigerant leaving the condenser is lower than the average value across the entire coil. Due to this the setting should be changed to reflect the average coil temperature.

Example: A common setting is to maintain a 90ºF condenser outlet pipe temperature for refrigerants without glide. Determine the temperature setting for R-448A.

Refer to chart below:

1. Find the average pressure corresponding to the temperature setting. In this example 90ºF equals an average pressure of 197 psig.
2. Find this pressure in the Bubble column. If close pressure is not found some interpolation will be necessary.
3. Read the corresponding temperature. In this example temperature of ~85ºF would be read from the PT chart.

Temp Setting

Temp	Bubble	Dew	Average
(°F)	(psig)		
85	195	169	182
90	211	183	197
95	227	198	212
100	244	214	229
105	262	231	246

The new setting will be the bubble temperature for the average pressure.

New setting = 85ºF

Appendix C – Control Settings

C: Temperature Difference (TD) control

The condenser design and the outdoor ambient temperature are used to calculate the condenser pressure setting. This setting will change as the ambient changes.

Condenser setting

= current ambient + condenser design TD.

Example: For a condenser designed for 10 degree temperature difference on an 85 degree day.

1. Condenser setting = ambient + TD
   a. = 85°F + 10°F
   b. = 95°F
2. Reading the average pressure corresponding to 95°F gives a pressure setting of 212 psig.
3. The electronic fan control should be controlling to a value of 212 psig. Contact retailer for specific settings. Some retailers will lower the TD setting to achieve increased subcooling.

Temp (°F)	(psig)		
	Bubble	Dew	Average
85	195	169	182
90	211	183	197
95	227	198	212
100	244	214	229
105	262	231	246

For mechanical controls simply convert fan cycling schedule from pressure (original gas) back to temp and find average bubble and dew for R-448A for each stage.

Note for pressure and TD control methods

Some electronic controllers may use the bubble pressure (instead of average) for control. This will lead to a higher effective set point.

It is recommended to make set points as described in the examples above and monitor the system to see if it controls as expected.

If control performance is not correct it will be necessary to either adjust the set points or put offsets into the sensors to account for the difference between bubble and average pressures.

Contact Honeywell technical team or the specific controller technical teams for assistance.

Appendix D – Leak Prevention Measures

Introduction

During the retrofit from an HCFC to an HFO refrigerant, the elimination of chlorine from the refrigerant, as well as the solvent nature of the required synthetic oils can contribute to system leaks.

These leaks are concentrated in component elastomeric O-rings and seals.

When retrofitting from an HCFC to an HFO refrigerant, the material compatibility and the condition of existing seals and gaskets should also be taken into account. Heat set, compression set, and seal shrinkage can all impact the condition of an existing seal or gasket. When the system is then put under vacuum, the sealing device can be displaced, creating the potential for leakage.

It is recommended to replace the entire component, or the O-ring / seal, in the following areas.

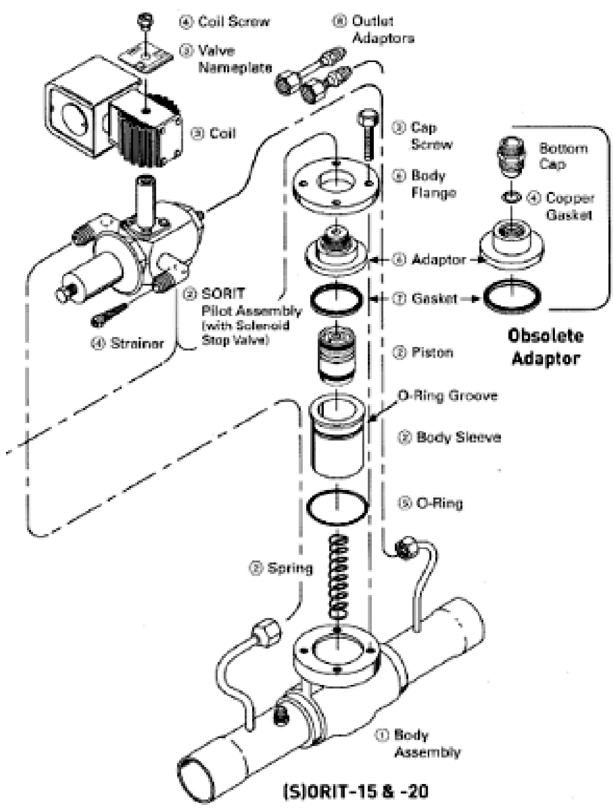
- Schrader valves and caps
- Receiver level indicators and alarms
- Heat reclaim and condenser splitting valves
- Evaporator Pressure Regulators (EPRs)
- Solenoid Valves
- Pilot hoses
- Ball valves

Some ball valve manufacturers have an available retrofit cap that eliminates the need to replace the O-rings.

A retrofit is also a good time to replace valves that are beyond their life-cycle. Some valves will not have replacement seals available and will need to be replaced.

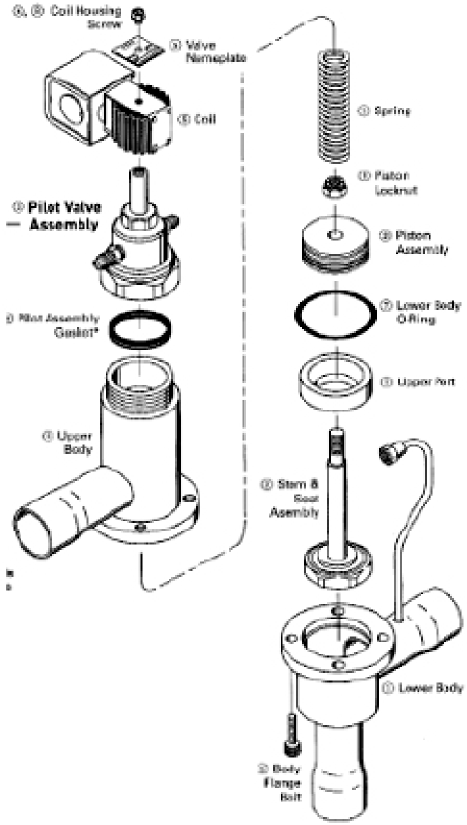
Example valves with gasket and O-ring locations

Evaporator Pressure Regulator

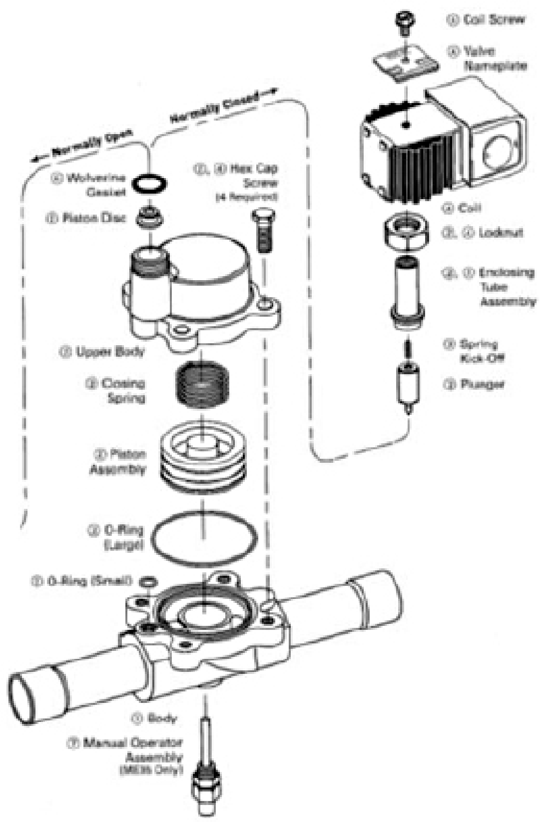


Appendix D – Leak Prevention Measures

Heat Reclaim Valve



Solenoid Valve



Appendix E
Pressure/Temperature chart

Solstice® N40 (R-448A)

Temp (°C)	Bubble	Dew (bar-g)	Average
-50	5.23	12.1	8.68
-45	1.07	6.72	2.53
-40	0.34	0.08	0.17
-35	0.69	0.28	0.49
-30	1.09	0.61	0.85
-25	1.56	1	1.28
-20	2.1	1.46	1.78
-15	2.73	2	2.37
-10	3.46	2.62	3.04
-5	4.28	3.34	3.81
0	5.22	4.16	4.69
5	6.27	5.09	5.68
10	7.46	6.15	6.81
15	8.78	7.34	8.06
20	10.3	8.68	9.5
25	11.9	10.2	11.0
30	13.7	11.8	12.8
35	15.6	13.7	14.7
40	17.8	15.7	16.8
45	20.2	18.0	19.1
50	22.7	20.5	21.6
55	25.5	23.2	24.3
60	28.5	26.2	27.4
65	31.8	29.5	30.6
70	35.3	33.1	34.2
75	39.1	37.1	38.1
80	43.1	41.7	42.4

Blue Values = inches mercury vacuum

Temp (°F)	Bubble	Dew (psig)	Average
-50	0.4	7.37	3.28
-45	2.50	3.93	0.03
-40	4.90	0.08	2.49
-35	7.50	2.1	4.80
-30	10.4	4.4	7.40
-25	13.5	7.0	10.3
-20	17	9.8	13.4
-15	20.8	13	16.9
-10	24.9	16.4	20.7
-5	29.4	20.2	24.8
0	34.2	24.3	29.3
5	39.4	28.8	34.1
10	45.1	33.6	39.4
15	51.2	38.9	45.1
20	57.8	44.6	51.2
25	64.8	50.7	57.8
30	72.3	57.3	64.8
35	80.4	64.4	72.4
40	89	72.1	80.6
45	98.2	80.3	89.3
50	108	89	98.5
55	118.4	98.4	108.4
60	129.4	108.4	118.9
65	141.1	119	130.1
70	153.5	130.3	141.9
75	166.6	142.4	154.5
80	180.5	155.1	167.8
85	195.1	168.7	181.9
90	210.5	183	196.8
95	226.7	198.2	212.5
100	243.7	214.3	229.0
105	261.6	231.3	246.5
110	280.5	249.2	264.9
115	300.2	268.1	284.2
120	320.9	288.1	304.5
125	342.6	309.1	325.9
130	365.3	331.3	348.3
135	389	354.7	371.9
140	413.8	379.3	396.6

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