NATIONAL™

Retrofit HandBook

R-22 Retrofit Guidelines and Procedures

National Refrigerants, Inc.

NATIONAL REFRIGERANTS, INC.

TABLE OF CONTENTS

PAGE

Introduction

As customers face economic pressure, environmental regulations, product shortages, or just a general company desire to "go green," there will be continued interest in retrofitting away from R-22 in existing refrigeration and air conditioning systems. This handbook provides basic information about the retrofit process as well as product-specific data on the commercially available retrofit blends. Multiple checklists and data recording tables are provided so this handbook can be used to provide a history of a specific project or series of retrofits.

National Refrigerants, Inc.

R-22 Retrofit Guideline Handbook

R-22 Alternative Retrofit Guidelines

Seals and O-Rings

R-22 and mineral oil interact with many elastomers causing some swelling, which actually helps complete the intended seal. There is also a measurable increase in hardness over time. One consequence of this process, however, is that during a retrofit away from R-22, the new refrigerant / oil combination may cause the seal to shrink and allow leakage. Any process that disturbs the seating of the gasket, such as depressing Schrader valves or operating ball valves, may also cause leaks to occur. Therefore, for any retrofit job it is recommended to change Schrader valve cores, o-rings on caps, elastomeric seals, and any seals found to be leaking before the retrofit takes place.

TXVs

Some refrigerants will have very similar run-time capacity and pressure drop across a TXV while others may be different enough from R-22 that the valve will become undersized. TXV capacity is determined by: (1) three system conditions: evaporator refrigerant saturation temperature, liquid refrigerant temperature entering the TXV and the pressure drop across the TXV port, and (2) thermodynamic properties of the refrigerant. It cannot be assumed that the TXV capacity will remain the same after converting a R-22 system to an alternative refrigerant because in some cases the TXV capacity will be reduced when used with the alternative refrigerant. Since each refrigerant has its own pressure/temperature characteristics, some R-22 alternative refrigerants might require the use of a TXV with a R-404A thermostatic element. Regardless of whether the TXV is replaced, for maximum evaporator efficiency, the superheat should be checked and set to the equipment manufacturer's specification. (See Appendix II)

Distributor Nozzles

It is the small orifice in the nozzle of a refrigerant distributor which takes the liquid-vapor mixture at the outlet of the TXV and converts it into a homogeneous mixture. This allows each evaporator circuit to receive an equal mass flow of refrigerant, maintaining evaporator efficiency.

Given the varying thermodynamic properties between refrigerants, there will be some alternative refrigerants which will yield abnormally high pressure drops in the existing R-22 nozzle orifice. The higher nozzle pressure drop will result in less available pressure drop across the TXV port, reducing valve capacity. For some alternative refrigerants, this combined effect can produce a greater than expected loss of TXV capacity.

(continued)

R-22 Alternative Retrofit Guidelines

Distributor Nozzles (continued)

In particular, on larger tonnage applications where refrigerant distributors will have replaceable nozzles, they should be checked for capacity prior to the retrofit.

Capillary Tubes

Smaller systems with capillary tubes may not perform the same when retrofitted. Unless the length of the tube is adjusted to match the performance of the blend, the only other way to change the operation of a cap tube system is to adjust the refrigerant charge size.

Filter Driers

Filter driers and/or cores should be replaced during the retrofit process. The filter drier should be replaced with the same type currently in use in the system.

Temperature Glide/Fractionation

Most of the retrofit blends have some degree of temperature glide. System operation can be affected (superheat setting, other controls) and fractionation must be considered for systems that may leak while not running for long periods. (See Appendix I)

Pressure Controls

Some refrigerant blends will run at different pressures than R-22 to achieve the same temperatures. Any pressure-related control should be adjusted to compensate for the different pressure.

Lubricant Issues

In general, HFC blends will require the use of polyol ester (POE) lubricant. Traditional retrofit guidelines call for the mineral oil level to be below 5%. This is typically achieved by draining oil from compressors and the oil management system and replacement with POE up to 3 times. Follow compressor manufacturer guidelines for recommended levels and procedures.

(continued)

R-22 Alternative Retrofit Guidelines

Lubricant Issues (continued)

Some retrofit blends contain hydrocarbon additives to help circulate mineral oil with the HFC refrigerant. This strategy works well to thin the mineral oil and push it back along the suction line; however, the HFC/hydrocarbon blend still does not mix with mineral oil on the high side of the system. If there is a receiver, mineral oil might pool on top of the refrigerant and hold up there. Addition of POE to the system has been proposed as a solution to this problem.

Capacity and Efficiency

Some retrofit blends have lower run-time capacity compared to R-22. For larger, multi-compressor systems such as supermarket racks, this difference is less important because the system can make up the loss in capacity by running more compressors. In single compressor systems that are properly oversized, the loss in capacity will mean longer run times in order to satisfy the thermostat. Other systems that are designed to run at full capacity, such as process chillers or blast freezers, will lose processing capability as the capacity is reduced. The choice of retrofit blend based on its capacity match to R-22 will be more important for these applications.

It is highly recommended that after the system has been retrofitted to the new refrigerant, that the necessary time is taken during the startup process to tune the system properly. While some alternative refrigerants might be inherently less efficient than R-22, the actual efficiency of the former R-22 system may increase after the retrofit if the following steps are taken:

- replace existing filter driers and suction filters
- conduct a thorough leak check and repair all leaks
- properly charge the system
- optimize the compressor staging
- set all pressure regulating valves per design specifications
- most important -- set all TXVs to the correct superheat

The thermodynamic gain or loss of efficiency of a given blend is often overshadowed by these project-related factors. Most low temperature retrofits will benefit greatly from not running the liquid-injection system required for R-22. Most air conditioning systems will probably not see much efficiency improvement over R-22.

Supermarket or Large Refrigeration Systems General Retrofit Procedures

1. Collect baseline data for operation of the system with existing R-22 charge. Make note of any cases or system components that do not appear to be running properly and note any required repairs.

2. Leak check the system while still charged with R-22 to identify any repairs needed during the retrofit process.

3. Disconnect electrical power to system and properly recover the R-22 charge. Record the amount of R-22 recovered.

4. Perform any required maintenance or repair operations previously identified, including:
   - replacement of seals and gaskets
   - leak repairs
   - filter drier replacement
   - compressor oil change
   - replace TXV, TXV element and refrigerant distributor nozzle as required

5. If desired, pressurize and leak check the system by preferred method. Evacuate the system down to 250 microns and confirm that it holds.

6. Charge the system with the retrofit blend to about 90% to 95% of the recovered R-22 charge size. Make sure the refrigerant is removed from the cylinder as a liquid.

7. Restart the system and allow it to come to normal operation conditions. Compare the new operation data to the R-22 run time data. Adjust operation as needed.

8. Check superheat on the TXVs and adjust as necessary.
   Note: The temperature glide of a blend will likely affect TXVs by showing a lower than expected superheat value. (see Appendix I)

9. Label the system with identification stickers showing the new refrigerant and oil charge.

General Retrofit Procedures

1. Collect baseline data for operation of the system with existing R-22 charge. Make note of any obvious performance problems with the system.

2. Leak check the system while still charged with R-22 to identify any repairs needed during the retrofit process.

3. Disconnect electrical power to system and properly recover the R-22 charge. Record the amount of R-22 recovered.

4. Perform any required maintenance or repair operations previously identified, including:
   - replacement of Schrader cores
   - filter drier replacement
   - change oil or add small amount of POE if required (follow equipment manufacturer's guidelines).

5. If desired, pressurize and leak check the system by preferred method. Evacuate the system down to 250 microns and confirm that it holds.

6. Charge the system with the retrofit blend to about 90% to 95% of the recovered R-22 charge size. Make sure the refrigerant is removed from the cylinder as a liquid.

7. Restart the system and allow it to come to normal operation conditions. Compare the new operation data to the R-22 run time data. Adjust operation as needed.

8. Check superheat on the TXVs and adjust as necessary.
   Note: The temperature glide of a blend will likely affect TXVs by showing a lower than expected superheat value. (See Appendix I)

9. Label the system with identification stickers showing the new refrigerant and oil charge.

R-407C

Air Conditioning
Refrigeration

Physical Properties	R-407C
Environmental Classification	HFC
Molecular Weight	86.2
Boiling Point (1 atm, ˚F)	-43.6
Critical Pressure (psia)	672.1
Critical Temperature (˚F)	187
Critical Density, (lb./ft^ 3)	32
Liquid Density (70 ˚F, lb./ft^ 3)	72.4
Vapor Density (bp, lb./ft^ 3)	0.289
Heat of Vaporization (bp, BTU/lb.)	106.7
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3597
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1987
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	1770
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F)	10

Available in the following sizes
25 lb. cyl
115 lb. cyl
925 lb. cyl
1550 lb. cyl

R-407C

(R-32/R-125/R-134a)
(23/25/52 wt%)

PRIMARY
R-22 retrofit application ~*
Air Conditioning
SECONDARY
R-22 retrofit application ~*
Low/Medium
Temperature Refrigeration

Application	TXV Load Rating	Capacity	Efficiency	Oil Issue
Air Conditioning	No changes similar pressure drop	Very similar	Very similar	Replace MO with POE following manufacturer's guidelines
Low/Medium Temp Refrigeration	No changes similar pressure drop	Slightly lower	Similar	Replace MO with POE following manufacturer's guidelines

Pressure-Temp Chart

R-407C		
Temp (˚F)	Liquid (psig)	Vapor (psig)
-40	3.0	4.4
-35	5.4	0.6
-30	8.0	1.8
-25	10.9	4.1
-20	14.1	6.6
-15	17.6	9.4
-10	21.3	12.5
-5	25.4	15.9
0	29.9	19.6
5	34.7	23.6
10	39.9	28.0
15	45.6	32.8
20	51.6	38.0
25	58.2	43.6
30	65.2	49.6
35	72.6	56.1
40	80.7	63.1
45	89.2	70.6
50	98.3	78.7
55	108	87.3
60	118	96.8
65	129	106
70	141	117
75	153	128
80	166	140
85	180	153
90	195	166
95	210	181
100	226	196
105	243	211
110	261	229
115	280	247
120	300	266
125	321	286
130	342	307
135	365	329
140	389	353

**Performance comparison to R-22 system operation*

RED FIGURES (IN Hg) VACUUM

NATIONAL REFRIGERANTS, INC.

R-422B

Air Conditioning

Physical Properties	R-422B
Environmental Classification	HFC
Molecular Weight	108.5
Boiling Point (1 atm, ˚F)	-40.5
Critical Pressure (psia)	590.3
Critical Temperature (˚F)	186.3
Critical Density (lb./ft ^ 3)	32.9
Liquid Density (70 ˚F, lb./ft ^ 3)	73.05
Vapor Density (bp, lb./ft ^ 3)	0.29
Heat of Vaporization (bp, BTU/lb.)	80.5
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	--
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	--
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO2=1.0)	2525
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F)	5

Available in the following sizes
25 lb. cyl
110 lb. cyl

R-422B

(R-125/R-134a/R-600a)
(55/42 /3 wt%)

PRIMARY
R-22 retrofit application ~*
Air Conditioning

Application	TXV Load Rating	Capacity	Efficiency	Oil Issue
Air Conditioning	Possible change-out based on pressure drop	Lower	Similar	Possible POE addition if oil circulation becomes a concern

**Performance comparison to R-22 system operation*

Pressure-Temp Chart

R-422B		
Temp (F)	Liquid (psig)	Vapor (psig)
-40	0.9	2.7
-35	3.0	0.9
-30	5.4	1.1
-25	7.9	3.2
-20	10.7	5.7
-15	13.8	8.3
-10	17.1	11.3
-5	20.7	14.5
0	24.7	18.0
5	29.0	21.9
10	33.6	26.1
15	38.6	30.6
20	43.9	35.5
25	49.7	40.8
30	55.9	46.6
35	62.5	52.7
40	69.6	59.4
45	77.2	66.5
50	85.3	74.1
55	93.9	82.2
60	103	90.9
65	113	100
70	123	110
75	134	120
80	145	132
85	158	143
90	170	156
95	184	169
100	198	183
105	213	198
110	229	213
115	246	230
120	263	247
125	281	265
130	301	284
135	321	304
140	342	326

RED FIGURES (IN Hg) VACUUM

R-438A

Refrigeration

Physical Properties	R-438A
Environmental Classification	HFC
Molecular Weight	99.1
Boiling Point (1 atm, ˚F)	-44.2
Critical Pressure (psia)	624.3
Critical Temperature (˚F)	185.5
Critical Density, (lb./ft^ 3)	31.9
Liquid Density (70 ˚F, lb./ft^3)	72.6
Vapor Density (bp, lb./ft^3)	0.239
Heat of Vaporization (bp, BTU/lb.)	91.2
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	--
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	--
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO2 = 1.0)	2265
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F)	6

Available in the following sizes

25 lb. cylinder
110 lb. cylinder

R-438A

(R-32/R-125/R-134a/R-600/R-601a)
(8.5/45/44.2/1.7/0.6 wt%)

PRIMARY

R-22 retrofit application ~*
Low and Medium
Temperature Refrigeration

SECONDARY

R-22 retrofit application ~*
Air Conditioning

Application	TXV Load Rating	Capacity	Efficiency	Oil Issue
Low/Medium Temp Refrigeration	Possible change-out based on pressure drop	Slightly lower	Similar	Possible POE addition if oil circulation becomes a concern
Air Conditioning	Possible change-out based on presssure drop	Lower	Similar	Possible POE addition if oil circulation becomes a concern

**Performance comparison to R-22 system operation*

Pressure-Temp Chart

R-438A

Temp (˚F)	Liquid (psig)	Vapor (psig)
-40	1.7	2.6
-35	3.9	0.8
-30	6.4	1.2
-25	9.1	3.5
-20	12.0	5.9
-15	15.3	8.6
-10	18.8	11.6
-5	22.7	14.9
0	26.8	18.5
5	31.4	22.4
10	36.3	26.6
15	41.6	31.2
20	47.3	36.2
25	53.4	41.6
30	59.9	47.5
35	67.0	53.7
40	74.5	60.5
45	82.5	67.8
50	91.1	75.5
55	100	83.8
60	110	92.7
65	120	102
70	131	112
75	143	123
80	155	134
85	168	146
90	181	159
95	196	173
100	211	187
105	226	202
110	243	219
115	261	235
120	279	253
125	298	272
130	319	292
135	340	313
140	362	335

RED FIGURES (IN Hg) VACUUM

R-407A

Refrigeration

Physical Properties	R-407A
Environmental Classification	HFC
Molecular Weight	90.1
Boiling Point (1 atm, ˚F)	-49.9
Critical Pressure (psia)	658.6
Critical Temperature (˚F)	181
Critical Density, (lb./ft^ 3)	31.4
Liquid Density (70 ˚F, lb./ft ^ 3)	72.6
Heat of Vaporization (bp, BTU/lb.)	100.8
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3554
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1967
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	2110
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F)	8

Available in the following sizes
25 lb. cyl
100 lb. cyl
925 lb cyl
1550 lb. cyl

R-407A

(R-32/R-125/R-134a)
(20/40/40 wt%)

PRIMARY
*R-22 retrofit*application ~*
Low / Medium
Temperature Refrigeration

Application	TXV Load Rating	Capacity	Efficiency	Oil Issue
Low / Medium Temp Refrigeration	No changes similar pressure drop	Very similar	Similar	Replace MO with POE following manufacturer's guidelines

**Performance comparison to R-22 system operation*

RED FIGURES (IN Hg) VACUUM

Pressure-Temp Chart

R-407A		
Temp (˚F)	Liquid (psig)	Vapor (psig)
-40	3.9	1.0
-35	6.4	1.0
-30	9.2	3.3
-25	12.2	5.8
-20	15.6	8.5
-15	19.2	11.5
-10	23.2	14.9
-5	27.5	18.5
0	32.2	22.5
5	37.3	26.9
10	42.8	31.6
15	48.7	36.7
20	55.1	42.3
25	62.0	48.3
30	69.3	54.8
35	77.2	61.8
40	85.6	69.4
45	94.6	77.4
50	104	86.1
55	114	95.3
60	125	105
65	137	116
70	149	127
75	162	139
80	175	152
85	190	165
90	205	179
95	221	194
100	238	210
105	255	227
110	274	245
115	293	264
120	314	284
125	335	305
130	358	327
135	382	350
140	406	375

R-404A

Type Blends

Refrigeration

Physical Properties	R-404A	R-507	R-422C
Environmental Classification	HFC	HFC	HFC
Molecular Weight	97.6	98.9	113.5
Boiling Point (1 atm, ˚F)	-51.8	-52.8	-50.7
Critical Pressure (psia)	548.2	539	568.5
Critical Temperature (˚F)	162.5	159	163.5
Critical Density (lb./ft ^ 3)	35.8	30.7	33.7
Liquid Density (70 ˚F, lb./ft ^ 3)	66.4	66.7	72.5
Vapor Density (bp, lb./ft^ 3)	0.342	0.349	0.39
Heat of Vaporization (bp, BTU/lb.)	86.1	84.4	77.2
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3600	0.3593	--
Specific Heat Vapor (1 atm, 70 F, BTU/lb. ˚F)	0.2077	0.2064	--
Ozone Depletion Potential (CFC 11 = 1.0)	0	0	0
Global Warming Potential (CO_2 = 1.0)	3920	3985	3080
ASHRAE Standard 34 Safety Rating	A1	A1	A1
Temperature Glide (˚F)	2	0	5

Available in the following sizes:

R-404A
24 lb. cyl
100 lb. cyl

R-507
25 lb. cyl
100 lb. cyl

R-422C
24 lb. cyl
100 lb. cyl

R-404A

(R-125/R-143a/R-134a)
(44/52/4 wt%)

R-507

(R-125/R-143a)
(50/50 wt%)

R-422C

(R-125/R-134a/r-600a)
(82/15/3 wt%)

PRIMARY

R-22 retrofit application ~ Low/Medium Temperature Refrigeration*

Application	TXV Load Rating	Capacity	Efficiency	Oil Issue
Low / Medium Temp Refrigeration	Requires change-out because higher capacity	Higher	Similar	Replace MO with POE following manufacturer's guidelines

**Performance comparison to R-22 system operation*

Pressure-Temp Chart

Temp (F)	R-404A (psig)	R-507 (psig)	R-422C Liquid (psig)	R-422C Vapor (psig)
-40	4.3	5.5	4.7	2.2
-35	6.8	8.2	7.2	4.5
-30	9.5	11.1	10.1	7.1
-25	12.5	14.3	13.1	10.0
-20	15.7	17.8	16.5	13.2
-15	19.3	21.7	20.2	16.6
-10	23.2	25.8	24.2	20.4
-5	27.5	30.3	28.6	24.5
0	32.1	35.2	33.3	29.0
5	37.0	40.5	38.4	33.8
10	42.4	46.1	43.9	39.1
15	48.2	52.2	49.8	44.7
20	54.5	58.8	56.1	50.8
25	61.2	65.8	63.0	57.4
30	68.4	73.3	70.3	64.4
35	76.1	81.3	78.1	72.0
40	84.4	89.8	86.4	80.1
45	93.2	98.9	95.3	88.7
50	103	109	105	97.9
55	113	119	115	108
60	123	130	125	118
65	135	141	137	129
70	147	154	149	141
75	159	167	161	153
80	173	180	175	167
85	187	195	189	181
90	202	210	204	195
95	218	226	219	211
100	234	244	236	227
105	252	252	253	244
110	270	281	272	263
115	289	301	291	282
120	310	322	311	302
125	331	344	332	323
130	353	368	354	345
135	377	393	377	369
140	401	419	402	394

R-422D

Refrigeration

Physical Properties	R-422D
Environmental Classification	HFC
Molecular Weight	109.9
Boiling Point (1 atm, ˚F)	-45.8
Critical Pressure (psia)	566.2
Critical Temperature (˚F)	175.2
Critical Density (lb./ft ^ 3)	33.0
Liquid Density (70 ˚F, lb./ft ^ 3)	70.9
Heat of Vaporization (bp, BTU/lb.)	81.8
Specific Heat Liquid (70 ˚F, BTU/lb.)	0.35
Specific Heat Vapor (1 atm, 70 F, BTU/lb. ˚F)	0.20
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	2730
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F)	5

Available in the following sizes
25 lb. cyl
110 lb. cyl

R-422D

(R-125/R-134a/R-600a)
(65.1/31.5/3.4 wt%)

PRIMARY

R-22 retrofit application ~ Low /Medium Temperature Refrigeration*

Application	TXV Load Rating	Capacity	Efficiency	Oil Issue
Low/Medium temp refrigeation	Possible change-out based on pressure drop	Lower	Similar	Possible POE addition if oil circulation becomes a concern

**Performance comparison to R-22 system operation*

Pressure-Temp Chart

R-422D		
Temp (F)	Liquid (psig)	Vapor (psig)
-40	2.4	2.3
-35	4.6	0.8
-30	7.1	3.0
-25	9.9	5.4
-20	12.9	8.1
-15	16.2	11.0
-10	19.8	14.3
-5	23.7	17.8
0	27.9	21.7
5	32.5	25.8
10	37.5	30.4
15	42.8	35.3
20	48.5	40.7
25	54.7	46.4
30	61.3	52.6
35	68.4	59.3
40	75.9	66.4
45	84.0	74.0
50	92.6	82.2
55	102	90.9
60	111	100
65	122	110
70	133	121
75	144	132
80	156	144
85	169	156
90	183	170
95	197	184
100	212	198
105	228	214
110	245	231
115	262	248
120	281	266
125	300	286
130	320	306
135	341	327
140	364	350

RED FIGURES (IN Hg) VACUUM

R-22 Alternative Retrofit Guidelines

SYSTEM IDENTIFICATION

LOCATION			
ADDRESS			
REFRIGERANT CHARGE / TYPE			
LUBRICANT CHARGE / TYPE			
COMPRESSOR MODEL(S)			
CONDENSER MODEL(S)			

For larger systems: Fill in overall system data then use subsequent charts for case/evaporator run data.

For small systems: Use subsequent tables - one row for each system retrofit.

For distributed or stand-alone systems: Reference individual condensing unit(s) in the following tables.

NOTES:

System/Case Numbers								
CONDENSING UNIT MODEL								
EVAPORATOR MODEL								
	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT
EXPANSION DEVICE								
AMBIENT TEMPERATURE/RH								
SUCTION TEMPERATURE								
SUCTION PRESSURE								
CONDENSER PRESSURE								
CASE/BOX TEMPERATURE								
SUPERHEAT SETTING								
SUBCOOLING SETTING								
SIGHT GLASS APPEARANCE								

System/Case Numbers								
CONDENSING UNIT MODEL								
EVAPORATOR MODEL								
	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT
EXPANSION DEVICE								
AMBIENT TEMPERATURE/RH								
SUCTION TEMPERATURE								
SUCTION PRESSURE								
CONDENSER PRESSURE								
CASE/BOX TEMPERATURE								
SUPERHEAT SETTING								
SUBCOOLING SETTING								
SIGHT GLASS APPEARANCE								

Retrofit Checklist

R-22 Alternative Retrofit Guidelines

System/Case Numbers								
CONDENSING UNIT MODEL								
EVAPORATOR MODEL								
	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT
EXPANSION DEVICE								
AMBIENT TEMPERATURE/RH								
SUCTION TEMPERATURE								
SUCTION PRESSURE								
CONDENSER PRESSURE								
CASE/BOX TEMPERATURE								
SUPERHEAT SETTING								
SUBCOOLING SETTING								
SIGHT GLASS APPEARANCE								

System/Case Numbers								
CONDENSING UNIT MODEL								
EVAPORATOR MODEL								
	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT
EXPANSION DEVICE								
AMBIENT TEMPERATURE/RH								
SUCTION TEMPERATURE								
SUCTION PRESSURE								
CONDENSER PRESSURE								
CASE/BOX TEMPERATURE								
SUPERHEAT SETTING								
SUBCOOLING SETTING								
SIGHT GLASS APPEARANCE								

System/Case Numbers								
CONDENSING UNIT MODEL								
EVAPORATOR MODEL								
	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT
EXPANSION DEVICE								
AMBIENT TEMPERATURE/RH								
SUCTION TEMPERATURE								
SUCTION PRESSURE								
CONDENSER PRESSURE								
CASE/BOX TEMPERATURE								
SUPERHEAT SETTING								
SUBCOOLING SETTING								
SIGHT GLASS APPEARANCE								

System/Case Numbers								
CONDENSING UNIT MODEL								
EVAPORATOR MODEL								
	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT
EXPANSION DEVICE								
AMBIENT TEMPERATURE/RH								
SUCTION TEMPERATURE								
SUCTION PRESSURE								
CONDENSER PRESSURE								
CASE/BOX TEMPERATURE								
SUPERHEAT SETTING								
SUBCOOLING SETTING								
SIGHT GLASS APPEARANCE								

R-22 Alternative Retrofit Guidelines

System/Case Numbers								
CONDENSING UNIT MODEL								
EVAPORATOR MODEL								
	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT
EXPANSION DEVICE								
AMBIENT TEMPERATURE/RH								
SUCTION TEMPERATURE								
SUCTION PRESSURE								
CONDENSER PRESSURE								
CASE/BOX TEMPERATURE								
SUPERHEAT SETTING								
SUBCOOLING SETTING								
SIGHT GLASS APPEARANCE								

System/Case Numbers								
CONDENSING UNIT MODEL								
EVAPORATOR MODEL								
	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT	BEFORE RETROFIT	AFTER RETROFIT
EXPANSION DEVICE								
AMBIENT TEMPERATURE/RH								
SUCTION TEMPERATURE								
SUCTION PRESSURE								
CONDENSER PRESSURE								
CASE/BOX TEMPERATURE								
SUPERHEAT SETTING								
SUBCOOLING SETTING								
SIGHT GLASS APPEARANCE								

Fractionation/Temperature Glide

Single Component Refrigerants vs. Refrigerant Blends

Blends are made up of two or more single component refrigerants. Each single component refrigerant has it own pressure-temperature relationship and unique physical properties. In order to match the properties of a single component refrigerant with a blend, the individual components must be mixed in the right proportions. This mixing provides an opportunity for the blend to behave as a zeotrope or azeotrope. Azeotropic blends behave like single component refrigerants at or near their defined 'azeotropic point', while zeotropic blends do not behave like single component refrigerants and can present some unique behavior during system operation or when leaked.

Fractionation of Blends

When vapor is removed from a cylinder or system containing a zeotropic blend, two things are going to happen: 1. The vapor being removed is at the wrong composition ~ it will have more of the higher pressure/higher capacity refrigerant component; 2. The liquid that is left behind boils more of the higher pressure component out of the liquid to replace the vapor, leaving more of the low-pressure components behind. Therefore, refrigerant blends should be removed from the cylinder as liquid to avoid causing fractionation.

Fractionation Effects on System Charge

A system at ***rest*** will allow the refrigerant to pool and the vapor to come to an equilibrium concentration above the liquid. Leaks occurring with high temperature glide blends need to be recovered and re-charged with new refrigerant, while leaks occurring with low temperature glide blends (<2.5 F) could be topped off.

In a ***running*** system, it has been found that the circulating composition is the bulk blend composition. Therefore, leaks occurring with either high or low temperature glide blends could be topped-off.

Fractionation Effects on Some System Components

Flooded evaporators are designed to keep a pool of boiling refrigerant surrounding a bundle of tubes. In the case of zeotropic blends, the vapor that boils off this pool of refrigerant will be at the fractionated composition. This will cause the properties to differ from what the compressor expects, causing high head pressures, high amperage draw at the compressor, and reduced cooling effectiveness in the evaporator. Normally, it is not recommended to use refrigerant blends in this type of system.

Suction accumulators are placed in the suction line before the compressor to keep liquid from flowing into the compressor. Zeotropic blends will fractionate in the accumulator, however the temporary shift in composition will only show a short-lived spike of higher pressure at the compressor.

Appendix I

Fractionation/Temperature Glide

Temperature Glide in the Evaporator

The composition of the vapor and liquid phases are different for refrigerant blends at a given temperature or pressure, with the vapor composition having a higher concentration of the low boiling point components (higher vapor pressure) in the mixture. As a result of this composition difference, refrigerant blends have measurable temperature glide when they boil or condense. This glide may show colder or warmer spots in the evaporator that will affect frost formation, temperature sensors, or control settings.

Pressure / Temperature Charts

Single component refrigerants will stay at one temperature as they boil (the boiling point), and will need only one column on a PT chart to show this relationship. Higher glide blends will boil across a range of temperatures in an evaporator at constant pressure (the temperature glide), and therefore you cannot have just one column to explain the PT relationship. Blends at a given pressure will begin boiling at the saturated liquid temperature (Bubble Point) and finish the process at the saturated vapor temperature (Dew Point). PT charts for higher glide blends have two columns to show these end points.

Setting Superheat and Subcooling

When a single refrigerant boils, any heat picked up after it reaches the vapor state will cause the temperature to rise (superheat). Similarly, when a single refrigerant condenses, any heat removed after it reaches saturated liquid will cause the temperature to go down (subcooling). The process is the same for higher glide blends: the refrigerant will boil until it reaches saturated vapor, then any additional heat will cause it to superheat. The difference is that the blend changes temperature while boiling, so superheat should not be confused with temperature glide.

It is especially important to check the superheat setting for TXVs after a retrofit since the temperature glide of a blend can reduce the original superheat value. The superheat setting should be checked on the PT chart against the saturated vapor column. Subcooling should be checked against the liquid column. Some PT charts might only show one value, but the data at lower temperatures will be for saturated vapor (for setting superheat on the evaporator), and the data at high temperatures will be saturated liquid (for setting subcooling out of the condenser).

TXV Rating Example

The nominal capacity of a Thermostatic Expansion Valve (TXV) is simply the capacity at the conditions it is rated. For high pressure refrigerants, such as R-22 or its alternatives, the AHRI industry standard rating point is: 40˚F evaporator temperature, 100˚F liquid temperature, and a 100 psi pressure drop across the TXV port. If any of these conditions change, the valve's capacity will also change.

Table 1 shows the capacities of a nominal 2 ton R-22 TXV when used with R-22, R-407A, and R-407C. Capacities are shown at varying evaporator temperatures, but in each instance the standard rating conditions of 100˚F liquid temperature and a 100 psi pressure drop across the TXV port are used in conjunction with the various evaporator temperatures. Note the highlighted nominal capacities for the three refrigerants listed and how they differ. This is the result of differing thermodynamic properties between the three refrigerants.

Table 1

Nominal TXV Capacities

Valve Type	Nominal Capacity	Refrigerant														
		R-22						R-407A						R-407C		
		Recommended Thermostatic Charges														
		VC, VCP100, VGA			VZ, VZP			VC, VCP100, VGA			VZ, VZP40			NC, NCP100, NGA		
		40˚	20˚	0˚	-10˚	-20˚	-40˚	40˚	20˚	0˚	-10˚	-20˚	-40˚	40˚	20˚	0˚
G	2	2.00	2.18	1.91	1.96	1.75	1.31	1.87	2.00	1.71	1.74	1.54	1.12	1.84	1.97	1.70

If a specific application is utilizing a liquid temperature or pressure drop across the TXV port which is different than the AHRI rating condition, the correction factors in Table 2 and/or Table 3 would be applied to the capacity listed in Table 1 to determine the actual TXV capacity.

Table 2

Liquid Correction Factors

Valve Type	Liquid Temperature Entering TXV ˚F											
	0˚	10˚	20˚	30˚	40˚	50˚	60˚	70˚	80˚	90˚	100˚	110˚
	Correction Factor, CF Liquid Temperature											
R-22	1.56	1.51	1.45	1.40	1.34	1.29	1.23	1.17	1.12	1.06	1.00	0.94
R-407A	1.75	1.68	1.61	1.53	1.46	1.39	1.31	1.24	1.16	1.08	1.00	0.92
R-407C	1.69	1.62	1.55	1.49	1.42	1.35	1.28	1.21	1.14	1.07	1.00	0.93

TXV Rating Example

Table 3

Pressure Drop Correction Factors

Evaporator Temperature (˚F)	Pressure Drop Across TXV (PSI)										
	30	50	75	100	125	150	175	200	225	250	275
	Correction Factor, CF Pressure Drop										
40˚	0.55	0.71	0.87	1.00	1.12	1.22	1.32	1.41	1.50	1.58	1.66
20˚ & 0˚	0.49	0.63	0.77	0.89	1.00	1.10	1.18	1.26	1.34	1.41	1.48
-10˚ & -20˚	0.45	0.58	0.71	0.82	0.91	1.00	1.08	1.15	1.22	1.29	1.35
-40˚	0.41	0.53	0.65	0.76	0.85	0.93	1.00	1.07	1.13	1.20	1.25

For example: A R-22 application, operating at +20˚F is being retrofitted to R-407C. The evaporator capacity is 24,000 Btu/hr and the evaporator has a nominal 2 ton R-22 TXV installed. The application is designed to operate at 100˚F condensing, with a 90˚F liquid temperature.

The nominal capacity of the TXV for R-407C can be calculated as follows:

» Nominal capacity at +20˚F (from Table1): 1.97 tons.

» Corrected for liquid temperature at 90˚F (from Table 2): 1.97 x 1.07 = 2.10 tons.

To determine the correct pressure drop across the TXV port, the difference between the corresponding pressures at the condensing temperature and evaporator pressure must be used:

» 223 psi (100˚F condenser saturation) - 37 psi (20˚F evaporator saturation) = 186 psi.

The pressure drop through the refrigerant distributor and feeder tubes, the evaporator, and the frictional line loss in the piping between the condenser (where the pressure value is determined based on the condenser saturation temperature) and the TXV inlet must also be considered when determining the actual pressure drop across the TXV port.

For this example, we will assume the above mentioned pressure drop to be 36 psi.

» The actual pressure drop across the TXV port will be: 186 psi - 36 psi = 150 psi.

» Actual TXV capacity at the design condition for this application:
2.10 tons (corrected for liquid temperature) x 1.10 (from Table 3) = 2.31 tons.

» This would represent the TXV capacity at the design condition in the summer time.

To ensure that the TXV has sufficient capacity, a similar sizing exercise must be undertaken at the low ambient condensing temperature expected in the winter months. If the system utilizes fan cycling or head pressure control valves and fixes the minimum condensing temperature at 70˚F (137.5 psi), the TXV capacity will also need to be considered at this condition.

TXV Rating Example

For most applications the correction factors listed in Table 4 can be used to determine if the existing R22- TXV will have sufficient capacity when used with the retrofit refrigerant of choice.

Table 4

Capacity Multipliers for R-22 Alternative Refrigerants

Refrigerants										
				Capacity Multiplier*						
Evaporator Temp (˚F)	Condensing Temp (˚F)	Liquid Temp (˚F)	R-22	R-417A	R-422B	R-422D	R-424A	R-438A	R-407A	R-407C
40	105	95	1.00	0.75	0.74	0.72	0.72	0.88	1.04	1.07
20	105	95	1.00	0.72	0.71	0.69	0.69	0.85	1.01	1.04
	70	60	1.00	0.82	0.83	0.83	0.83	1.00	1.20	1.22
0	105	95	1.00	0.69	0.68	0.66	0.66	0.81	0.98	1.00
	70	60	1.00	0.77	0.77	0.77	0.77	0.92	1.11	1.13
-20	105	95	1.00	0.67	0.66	0.64	0.64	0.79	0.96	0.97
	70	60	1.00	0.74	0.74	0.74	0.74	0.88	1.06	1.07

* Apply Capacity Multiplier to the TXV's R-22 rating to determine approximate TXV rating with the service retrofit replacement refrigerant. A total 40 psi pressure loss across the TXV from the refrigerant distributor and liquid line is assumed in the capacity multiplier caculation.

Thermodynamic data provided by NIST Refprop v8.0

Capacity and correction factors courtesy of Sporlan Division - Parker Hannifin

Please visit NRI's website *www.refrigerants.com* for links
to more detailed articles and information including
NRI's REFRIGERANT REFERENCE GUIDE

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