NATIONAL™

Refrigerant Reference Guide

National Refrigerants, Inc.

2011 Fifth Edition 2011

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National Refrigerants, Inc.

Refrigerant Reference Guide Fifth Edition

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REFRIGERANTS

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200R11	200 LB. DRUM OF REFRIGERANT 11
30R12	30 LB. CYLINDER OF REFRIGERANT 12
145R12	145 LB. CYLINDER OF REFRIGERANT 12 RETURNABLE/DEPOSIT
5R13	5 LB. CYLINDER OF REFRIGERANT 13
9R13	9 LB. CYLINDER OF REFRIGERANT 13 RETURNABLE/DEPOSIT
23R13	23 LB. CYLINDER OF REFRIGERANT 13 RETURNABLE/DEPOSIT
80R13	80 LB. CYLINDER OF REFRIGERANT 13 RETURNABLE/DEPOSIT
5R13B1	5 LB. CYLINDER OF REFRIGERANT 13B1
10R13B1	10 LB. CYLINDER OF REFRIGERANT 13B1 RETURNABLE/DEPOSIT
28R13B1	28 LB. CYLINDER OF REFRIGERANT 13B1 RETURNABLE/DEPOSIT
90R13B1	90 LB. CYLINDER OF REFRIGERANT 13B1 RETURNABLE/DEPOSIT
30R22	30 LB. CYLINDER OF REFRIGERANT 22
50R22	50 LB. CYLINDER OF REFRIGERANT 22
125R22	125 LB. CYLINDER OF REFRIGERANT 22 RETURNABLE/DEPOSIT
1000R22	1000 LB. CYLINDER OF REFRIGERANT 22 RETURNABLE/DEPOSIT
1750R22	1750 LB. CYLINDER OF REFRIGERANT 22 RETURNABLE/DEPOSIT
5R23	5 LB. CYLINDER OF REFRIGERANT 23
9R23	9 LB. CYLINDER OF REFRIGERANT 23 RETURNABLE/DEPOSIT
20R23	20 LB. CYLINDER OF REFRIGERANT 23 RETURNABLE/DEPOSIT
70R23	70 LB. CYLINDER OF REFRIGERANT 23 RETURNABLE/DEPOSIT
100R113	100 LB. DRUM OF REFRIGERANT 113
200R113	200 LB. DRUM OF REFRIGERANT 113
30R114	30 LB. CYLINDER OF REFRIGERANT 114
100R123	100 LB. DRUM OF REFRIGERANT 123
200R123	200 LB. DRUM OF REFRIGERANT 123
650R123	650 LB. DRUM OF REFRIGERANT 123
100CR123	100 LB. CYLINDER OF REFRIGERANT 123 RETURNABLE/DEPOSIT
200CR123	200 LB. CYLINDER OF REFRIGERANT 123 RETURNABLE/DEPOSIT
30R124	30 LB. CYLINDER OF REFRIGERANT 124
145R124	145 LB. CYLINDER OF REFRIGERANT 124 RETURNABLE/DEPOSIT
012R134a	12 OZ. CAN OF REFRIGERANT 134a
30R134a	30 LB. CYLINDER OF REFRIGERANT 134a
A30R134a	30 LB. CYLINDER OF REFRIGERANT 134a AUTOMOTIVE VALVE
125R134a	125 LB. OF REFRIGERANT 134a RETURNABLE/DEPOSIT
1000R134a	1000 LB. CYLINDER OF REFRIGERANT 134a RETURNABLE/DEPOSIT
1750R134a	1750 LB. CYLINDER OF REFRIGERANT 134a RETURNABLE /DEPOSIT

REFRIGERANTS

PART NO.	DESCRIPTION
30R401A	30 LB. CYLINDER OF REFRIGERANT 401A
125R401A	125 LB. CYLINDER OF REFRIGERANT 401A RETURNABLE/DEPOSIT
30R401B	30 LB. CYLINDER OF REFRIGERANT 401B
125R401B	125 LB. CYLINDER OF REFRIGERANT 401B RETURNABLE/DEPOSIT
27R402A	27 LB. CYLINDER OF REFRIGERANT 402A
110R402A	110 LB. CYLINDER OF REFRIGERANT 402A RETURNABLE/DEPOSIT
13R402B	13 LB. CYLINDER OF REFRIGERANT 402B
25R403B	25 LB. CYLINDER OF REFRIGERANT 403B
110R403B	110 LB. CYLINDER OF REFRIGERANT 403B RETURNABLE/DEPOSIT
24R404A	24 LB. CYLINDER OF REFRIGERANT 404A
100R404A	100 LB. CYLINDER OF REFRIGERANT 404A RETURNABLE/DEPOSIT
800R404A	800 LB. CYLINDER OF REFRIGERANT 404A RETURNABLE/DEPOSIT
1300R404A	1300 LB. CYLINDER OF REFRIGERANT 404A RETURNABLE/DEPOSIT
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100R407A	100 LB. CYLINDER OF REFRIGERANT 407A RETURNABLE/DEPOSIT
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1550R407A	1550 LB CYLINDER OF REFRIGERANT 407A RETURNABLE/DEPOSIT
25R407C	25 LB. CYLINDER OF REFRIGERANT 407C
115R407C	115 LB. CYLINDER OF REFRIGERANT 407C RETURNABLE/DEPOSIT
925R407C	925 LB. CYLINDER OF REFRIGERANT 407C RETURNABLE/DEPOSIT
1550R407C	1550 LB. CYLINDER OF REFRIGERANT 407C RETURNABLE/DEPOSIT
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100R408A	100 LB. CYLINDER OF REFRIGERANT 408A RETURNABLE/DEPOSIT
30R409A	30 LB. CYLINDER OF REFRIGERANT 409A
125R409A	125 LB. CYLINDER OF REFRIGERANT 409A RETURNABLE/DEPOSIT
25R410A	25 LB. CYLINDER OF REFRIGERANT 410A
100R410A	100 LB. CYLINDER OF REFRIGERANT 410A RETURNABLE/DEPOSIT
850R410A	850 LB. CYLIDNER OF REFRIGERANT 410A RETURNABLE/DEPOSIT
1450R410A	1450 LB. CYLIDNER OF REFRIGERANT 410A RETURNABLE/DEPOSIT
25R414B	25 LB. CYLINDER OF REFRIGERANT 414B
25R422B	25 LB. CYLINDER OF REFRIGERANT 422B
110R422B	110 LB. CYLINDER OF REFRIGERANT 422B RETURNABLE/DEPOSIT
24R422C	24 LB. CYLINDER OF REFRIGERANT 422C
25R422D	25 LB. CYLINDER OF REFRIGERANT 422D
110R422D	110 LB. CYLINDER OF REFRIGERANT 422D RETURNABLE/DEPOSIT

REFRIGERANTS

PART NO.	DESCRIPTION
30R500	30 LB. CYLINDER OF REFRIGERANT 500
125R500	125 LB. CYLINDER OF REFRIGERANT 500 RETURNABLE/DEPOSIT
30R502	30 LB. CYLINDER OF REFRIGERANT 502
125R502	125 LB. CYLINDER OF REFRIGERANT 502 RETURNABLE/DEPOSIT
5R503	5 LB. CYLINDER OF REFRIGERANT 503
9R503	9 LB. CYLINDER OF REFRIGERANT 503 RETURNABLE/DEPOSIT
20R503	20 LB. CYLINDER OF REFRIGERANT 503 RETURNABLE/DEPOSIT
80R503	80 LB. CYLINDER OF REFRIGERANT 503 RETURNABLE/DEPOSIT
25R507	25 LB. CYLINDER OF REFRIGERANT 507
100R507	100 LB. CYLINDER OF REFRIGERANT 507 RETURNABLE/DEPOSIT
800R507	800 LB. CYLINDER OF REFRIGERANT 507 RETURNABLE/DEPOSIT
1400R507	1400 LB. CYLINDER OF REFRIGERANT 507 RETURNABLE/DEPOSIT
5R508B	5 LB. CYLINDER OF REFRIGERANT 508B
10R508B	10 LB. CYLINDER OF REFRIGERANT 508B RETURNABLE/DEPOSIT
20R508B	20 LB. CYLINDER OF REFRIGERANT 508B RETURNABLE/DEPOSIT
70R508B	70 LB. CYLINDER OF REFRIGERANT 508B RETURNABLE/DEPOSIT
3R170	3 LB. CYLINDER OF R-170 (ETHANE) RETURNABLE/DEPOSIT
004R170	4 OZ. CYLINDER OF R-170 (ETHANE)
004R1150	4 OZ. CYLINDER OR R-1150 (ETHYLENE)
016R600	16 OZ. CYLINDER OF R-600 (BUTANE)
016R600a	16 OZ. CYLINDER OF R-600A (ISOBUTANE)
014R290	14 OZ. CYLINDER OF R-290 (PROPANE)
016RPENTANE	16 OZ. METAL CAN OF PENTANE LIQUID

ANALYTICAL TESTING

PART NO.	DESCRIPTION
NRIHPN	HIGH PRESSURE LIQUID REFRIGERANT TEST KIT
NRILP	LOW PRESSURE LIQUID REFRIGERANT TEST KIT
NRINCN	NON-CONDENSABLE VAPOR REFRIGERANT TEST KIT
NRIOA	OIL ANALYSIS TEST KIT
NRIHALON	HALON ANALYSIS

LUBRICANTS

PART NO.	DESCRIPTION
1501G	REFRIGERATION MINERAL OIL 150 SUS / 32 ISO VISCOSITY*
3001G	REFRIGERATION MINERAL OIL 300 SUS / 68 ISO VISCOSITY*
5001G	REFRIGERATION MINERAL OIL 500 SUS / 100 ISO VISCOSITY*
WF32	WAX-FREE REFRIGERATION MINERAL OIL 150 SUS / 32 ISO VISCOSITY*
1TD	WAX-FREE REFRIGERATION MINERAL OIL 300 SUS / 68 ISO VISCOSITY*
150AKB1G	ALKYLBENZENE OIL 150 SUS / 32 ISO VISCOSITY*
200AKB1G	ALKYLBENZENE OIL 200 SUS / 46 ISO VISCOSITY*
300AKB1G	ALKYLBENZENE OIL 300 SUS / 68 ISO VISCOSITY*
AKB500E1G	ALKYLBENZENE OIL 500 SUS / 100 ISO VISCOSITY*
PE321G	POLYOLESTER LUBRICANT 150 SUS / 32 ISO VISCOSITY**
PE681G	POLYOLESTER LUBRICANT 300 SUS / 68 ISO VISCOSITY**
VPO1G	VACUUM PUMP OIL 200 SUS / 46 ISO VISCOSITY**

* Also available in 5 gallon and 55 gallon containers.

**Also available in pint, quart and 5 gallon containers

SOLEST LUBRICANTS

PART NO.	DESCRIPTION
SOLEST321G	POLYOLESTER LUBRICANT 150 SUS / 32 ISO VISCOSITY*
SOLEST461G	POLYOLESTER LUBRICANT 200 SUS / 46 ISO VISCOSITY*
SOLEST681G	POLYOLESTER LUBRICANT 300 SUS / 68 ISO VISCOSITY*
SOLEST1001G	POLYOLESTER LUBRICANT 500 SUS / 100 ISO VISCOSITY*
SOLEST1201G	POLYOLESTER LUBRICANT 600 SUS / 120 ISO VISCOSITY*
SOLEST1501G	POLYOLESTER LUBRICANT 700 SUS / 150 ISO VISCOSITY*
SOLEST1701G	POLYOLESTER LUBRICANT 800 SUS / 170 ISO VISCOSITY*
SOLEST2201G	POLYOLESTER LUBRICANT 1000 SUS / 220 ISO VISCOSITY*
CP4214-3201G	CP4214-320 LUBRICANT 1500 SUS / 320 ISO VISCOSITY*
SOLEST3701G	POLYOLESTER LUBRICANT 1700 SUS / 370 ISO VISCOSITY*

*Also available in 5 gallon and 55 gallon containers.

CHEMICALS

PART NO.	DESCRIPTION
N4820	12 OZ SPRAY ADHESIVE
N4830	14 OZ ELECTRIC CONTACT CLEANER
N4835	20 OZ ELECTRIC MOTOR CLEANER
N4840	11 OZ FOOD GRADE SILICONE
N4855	19 OZ PENETRATING LUBRICANT
N4860	19 OZ MULTI KLEEN, AEROSOL
N4880	20 OZ BLAST KLEEN CONDENSER COIL CLEANER
N4890	19 OZ EVAP KLEEN, EVAPORATOR COIL CLEANER
NDS17OZ	17 OZ HD SOLVENT
NDS1G	1 GALLON HD SOLVENT
NS16OZ	16 OZ NICKEL SAFE ICE MACHINE CLEANER
NS1G	1 GALLON NICKEL SAFE ICE MACHINE CLEANER
NIMC	8 OZ ICE MACHINE CLEANER
NIMC1G	1 GALLON ICE MACHINE CLEANER
NSR1G	1 GALLON SCALE REMOVER
NSR5G	5 GALLON SCALE REMOVER
AN1GN	1 GALLON CONTAINER OF ALKA KLEEN COIL CLEANER**
KB1GN	1 GALLON CONTAINER OF KLEEN BRITE COIL CLEANER**
KN1GN	1 GALLON CONTAINER OF KLEEN COIL CLEANER**
KF1GN	1 GALLON CONTAINER OF KLEEN FOAM COIL CLEANER**
MK1GN	1 GALLON CONTAINER OF MULTI KLEEN COIL CLEANER**

**Also available in 2.5 gallon and 55 gallon containers

5PG96	5 GALLON CONTAINER OF 96% INHIBITED PROPYLENE GLYCOL
55PG96	55 GALLON CONTAINER OF 96% INHIBITED PROPYLENE GLYCOL
1PG70	1 GALLON CONTAINER OF 70% INHIBITED PROPYLENE GLYCOL
5PG70	5 GALLON CONTAINER OF 70% INHIBITED PROPYLENE GLYCOL
55PG70	55 GALLON CONTAINER OF 70% INHIBITED PROPYLENE GLYCOL
5PG40	5 GALLON CONTAINER OF 40% INHIBITED PROPYLENE GLYCOL
55PG40	55 GALLON CONTAINER OF 40% INHIBITED PROPYLENE GLYCOL
55PG35D	55 GALLON CONTAINER OF 35% INHIBITED PROPYLENE GLYCOL
PROPYL55G	55 GALLON CONTAINER OF 99.9% UNINHIBITED USP FOOD GRADE PROPYLENE GLYCOL

RECOVERY CONTAINERS

PART NO.	DESCRIPTION
DC30	EZ ONE SHOT DISPOSABLE RECOVERY CYLINDER
100RC30	30 LB. RECOVERY CYLINDER ($100.00 DEPOSIT)
100RC40	40 LB. RECOVERY CYLINDER ($100.00 DEPOSIT)
100RC50	50 LB. RECOVERY CYLINDER ($100.00 DEPOSIT)
125RC50F	50 LB. RECOVERY CYLINDER W/FLOAT ($125.00 DEPOSIT)
125RC50HP	50 LB. RECOVERY CYLINDER RATED 400 PSI ($125.00 DEPOSIT)
200RC125	125 LB. RECOVERY CYLINDER ($200.00 DEPOSIT)
1500RC1000	1000 LB. RECOVERY CYLINDER ($1500.00 DEPOSIT)
4500RC2000	2000 LB. RECOVERY CYLINDER ($4500.00 DEPOSIT)
130RC9	9 LB. VERY HIGH PRESSURE RECOVERY CYLINDER ($130.00 DEPOSIT)
150RC23	23 LB. VERY HIGH PRESSURE RECOVERY CYLINDER ($150.00 DEPOSIT)
200RC80	80 LB. VERY HIGH PRESSURE RECOVERY CYLINDER ($200.00 DEPOSIT)

Deposits subject to change

CYLINDER REFURBISHING

PART NO.	DESCRIPTION
CYLDISP	DISPOSAL OF EMPTY NON-REFILLABLE CYLINDER
DRUMDISP	DISPOSAL OF EMPTY NON-REFILLABLE DRUMS
HST	HYDROSTATIC TESTING - 30 / 40 / 50 LB. CYLINDER
125HST	HYDROSTATIC TESTING - 125 LB. CYLINDER
240HST	HYDROSTATIC TESTING - 240 LB. CYLINDER
1/2TONHST	HYDROSTATIC TESTING - 1/2 TON CYLINDER
TONHST	HYDROSTATIC TESTING - TON CYLINDER
HSTR	REFURBISHING & HYDROSTATIC TESTING - 30 / 40/ 50 LB. CYLINDER
125HSTR	REFURBISHING & HYDROSTATIC TESTING - 125 LB. CYLINDER
240HSTR	REFURBISHING & HYDROSTATIC TESTING - 240 LB. CYLINDER
1/2TONHSTR	REFURBISHING & HYDROSTATIC TESTING - 1/2 TON CYLINDER
TONHSTR	REFURBISHING & HYDROSTATIC TESTING - TON CYLINDER

Refrigerant Name	COMPONENTS (Weight %)	TYPE	TEMP. GLIDE (˚F)	LUBRICANTS	COMMENTS
R-22	PURE	HCFC	0	Mineral Oil or Alkylbenzene	Refrigeration systems, commercial refrigeration, air conditioning, chillers.
R-23	PURE	HFC	0	Polyolester	Very low temperature refrigeration. Properties similar to R-13; can also retrofit R-503.
R-123	PURE	HCFC	0	Mineral Oil or Alkylbenzene	Low pressure centrifugal chillers. Can retrofit R-11 equipment with modifications.
R-124	PURE	HCFC	0	Mineral Oil or Alkylbenzene	High ambient air conditioning. Can retrofit R-114 equipment with modifications.
R-134a	PURE	HFC	0	Polyolester	Medium temperature refrigeration, chillers, automotive A/C. Can retrofit R-12 and R-500 equipment.
R-401A	22/152a/124 (53/13/34)	HCFC BLEND	8	Alkylbenzene or MO/AB Mix	Low/medium temperature refrigeration. Can retrofit R-12 and R-500 equipment.
R-401B	22/152a/124 (61/11/28)	HCFC BLEND	8	Alkylbenzene or MO/AB Mix	Low/medium temperature refrigeration. Can retrofit R-12 and R-500 equipment.
R-402A	125/290/22 (60/2/38)	HCFC BLEND	2.5	Alkylbenzene or MO/AB Mix	Low/medium temperature refrigeration. Can retrofit R-502 equipment.
R-402B	125/290/22 (38/2/60)	HCFC BLEND	2.5	Alkylbenzene or MO/AB Mix	Ice machines. Can retrofit R-502 equipment.
R-403B	290/22/218 (5/56/39)	HCFC BLEND	2	Mineral Oil or Alkylbenzene	Has been used successfully to retrofit R-13B1-type equipment, but has slightly different operating conditions.
R-404A	125/143a/134a (44/52/4)	HFC BLEND	1.5	Polyolester	Low/medium temperature refrigeration. Can retrofit R-502 or R-22 equipment with modifications.

Property Summary

Refrigerant Name	COMPONENTS (Weight %)	TYPE	TEMP. GLIDE (˚F)	LUBRICANTS	COMMENTS
R-407A	32/125/134a (20/40/40)	HFC BLEND	10	Polyolester or POE/MO Mix	Low/medium temperature refrigeration. Can retrofit R-22 equipment.
R-407C	32/125/134a (23/25/52)	HFC BLEND	10	Polyolester or POE/MO Mix	Low/medium temperature refrigeration, air conditioning. Can retrofit R-22 equipment.
R-408A	125/143a/22 (7/46/47)	HCFC BLEND	1	Mineral Oil or Alkylbenzene	Low/medium temperature refrigeration. Can retrofit R-502 equipment.
R-409A	22/124/142b (60/25/15)	HCFC BLEND	13	Mineral Oil or Alkylbenzene	Low/medium temperature refrigeration, some A/C. Can retrofit R-12 or R-500 equipment.
R-410A	32/125 (50/50)	HFC BLEND	0.2	Polyolester	New residential A/C systems. Not for retrofitting.
R-414B	22/124/600a/142b (50/39/1.5/9.5)	HCFC BLEND	13	Mineral Oil or Alkylbenzene	Low/medium temperature refrigeration, some A/C, automotive A/C. Can retrofit R-12 equipment.
R-416A	134a/124/600 (59/39.5/1.5)	HCFC BLEND	3	Mineral Oil, Alkylbenzene or Polyolester	Medium temperature refrigeration, automotive A/C. Can retrofit R-12 equipment.
R-422B	125/134a/600a (55/42/3)	HFC BLEND	5	Mineral Oil, Alkylbenzene or Polyolester	Medium temperature refrigeration, air conditioning. Can retrofit R-22 equipment.
R-422C	125/134a/600a (82/15/3)	HFC BLEND	5	Mineral Oil, Alkylbenzene or Polyolester	Low/medium temperature refrigeration. Can retrofit R-502 and R-22 equipment, with modifications.
R-422D	125/134a/600a (65.1/13.5/3.4)	HFC BLEND	5	Mineral Oil, Alkylbenzene or Polyolester	Low/medium temperature refrigeration. Can retrofit R-22 equipment.
R-507	125/143a (50/50)	HFC BLEND	0	Polyolester	Low/medium temperature refrigeration. Can retrofit R-502 or R-22 equipment with modifications.
R-508B	23/116 (46/54)	HFC BLEND	0	Polyolester	Very low temperature refrigeration. Can retrofit R-13 or R-503 equipment.

ASHRAE #	COMPONENTS (WEIGHT %)	CHARGING (% ORIGINAL)	APPLICATION COMMENTS
Low-Medium Temperature Refrigeration (R-502 type)			
R-402A	125/290/22 (60/2/38)	95 -100%	**Overall Concerns:** Discharge temperature is important - can't tolerate large increase. Higher discharge pressure can affect controls. If oil return is not already a problem with R-502, the blends will not necessarily make things worse. HFC blends will need POE. Most of the blends have very low glide. **Retrofit Recommendations** (in order of preference based on performance/ease of use): **R-408A** Closest match to R-502 properties and performance. Slightly higher discharge temperature **R-402A** Higher discharge pressure, lower discharge temperature than R-408A **R-402B** Similar discharge pressure, higher discharge temperature. Good for ice machines. ***R-408A, R-402A and R-402B might have problems with oil circulation and will benefit from at least a partial change to alkylbenzene. They are also HCFC-based and are subject to leak repair regulations.*** **R-422C** Similar in pressure/temperature to R-502, but will show some loss in capacity. Hydrocarbon components in the blend will promote mineral oil circulation in some systems. Addition of POE may be required in larger systems for proper oil return. **R-404A & R-507** Can be used to retrofit R-502 but mineral oil must be flushed with POE. **Options in New Equipment** **R-407A** Being used in some supermarkets as a lower GWP option. **R-404A & R-507** Off the shelf equipment (standard design). These two are interchangeable with each other in new equipment.
R-402B	125/290/22 (38/2/60)	95 -100%	
R-404A	125/143a/134a (44/52/4)	85 - 90%	
R-408A	125/143a/22 (7/46/47)	85 - 90%	
R-422C	125/134a/600a (82/15/3)	95 -100%	
R-507	125/143a (50/50)	85 - 90%	
Low-Medium Temperature Refrigeration (R-22 type)			
R-404A	125/143a/134a (44/52/4)	85 - 90%	**Overall Concerns:** Capacity match to R-22 is important in capacity-critical applications. Storage applications can tolerate a loss of capacity traded off for longer run times. TXV operation and distributor capacity should be close to R-22 to avoid costly component changes. All retrofit blends will operate at lower discharge temperatures than R-22. **Retrofit Recommendations** (in order of preference based on performance/ease of use): **R-407A** Similar capacity and TXV/distributor/pressure drop performance. **R-407C** Slightly lower capacity, similar TXV/distributor/pressure drop performance. R-407A and R-407C will require a change from mineral oil to POE for proper oil circulation. Partial POE replacement of mineral should work in most systems. **R-422D** Lower capacity, change in TXV/distributor/pressure drop performance. **R-422B** Significant drop in capacity at lower temperatures, change in TXV/distributor/pressure drop. **R-422C** Higher capacity, TXV change. Similar to R-404A. All R-422 blends contain a hydrocarbon that will promote mineral oil circulation in some systems. Addition of POE may be required in larger systems for proper oil return. **R-404A & R-507** Can be used to retrofit, however mineral oil must be flushed, POE used instead, and system components (TXVs, etc.) will need to be changed. **Options in New Equipment** **R-407A** Being used in some supermarkets as a lower GWP option. **R-404A & R-507** Off the shelf equipment (standard design). These two are interchangeable with each other in new equipment.
R-407A	32/125/134a (20/40/40)	95 -100%	
R-407C	32/125/134a (23/25/52)	95 -100%	
R-422B	125/134a/600a (55/42/3)	95 -100%	
R-422C	125/134a/600a (82/15/3)	95 -100%	
R-422D	125/134a/600a (65.1/31.5/3.4)	95 -100%	
R-507	125/143a (50/50)	85 - 90%	

ASHRAE #	COMPONENTS (WEIGHT %)	CHARGING (% ORIGINAL)	APPLICATION COMMENTS
Low-MediumTemperature Refrigeration (R-12 type)			
R-134a	PURE	90%	**Overall Concerns:** Match R-12 evaporator conditions (slightly higher discharge pressures OK). Oil return must be addressed. Temperature glide not a problem in most applications. **Retrofit Recommendations** (in order of preference based on performance/ease of use): **R-409A** Better at lower temperatures, maintains performance, higher discharge temperature and pressure. **R-414B** Better at warmer temperatures, lower discharge temperature than R-409A. **R-401A** Good overall performance, need AB oil below 30˚F coil temperatures. **R-401B** Better at lower temperatures, needs AB oil to replace 50% mineral oil. **R-416A** Biggest change in properties, poor low temperature performance.
R-401A	22/152a/124 (53/13/34)	80 - 85%	
R-401B	22/152a/124 (61/11/28)	80 - 85%	
R-409A	22/124/142b (60/25/15)	80 - 85%	
Medium-High Temperature Refrigeration (R-12 type), Automotive Air Conditioning			
R-414B	22/124/600a/142b (50/39/1.5/9.5)	80-85%	**Overall Concerns:** At higher evaporator temperatures, blends that contain R-22 will cause higher discharge temperatures. R-414B contains less R-22 and R-416A is based on R-134a. These products will produce lower discharge temperatures, but they will also lose some capacity compared to the other R-12 retrofit products listed above. **Retrofit Recommendations** (in order of preference based on performance/ease of use): **R-414B, R-416A** Only these two products are approved for automotive A/C retrofit. **R-401A, R-401B, R-409A** For R-12 or R-500 air conditioning (direct expansion systems).
R-416A	134a/124/600 (59/39.5/1.5)	95 -100%	
Air Conditioning (R-22 type)			
R-407C	32/125/134a (23/25/52)	95 -100%	**Overall Concerns:** Keep component changes to a minimum (similar TXV or orifice size, minimize pressure drop), maintain capacity unless the system is oversized enough to handle a drop in capacity. **Retrofit Recommendations** (in order of preference based on performance/ease of use): **R-407C** Lowest GWP, similar capacity and component operation (TXV/orifice). **R-422B or R-422D** Slight drop in capacity, possible change of components based on pressure drop. Hydrocarbon components in the blends will promote mineral oil circulation in some systems. Addition of POE may be required in larger systems for proper oil return. New equipment is designed around R-410A. Higher pressure and capacity exclude R-410A from being used as a retrofit blend.
R-410A	32/125 (50/50)	New Equip. only	
R-422B	125/134a/600a (55/42/3)	9 5-100%	
R-422D	125/134a/600a (65.1/31.5/3.4)	95 -100%	
High Ambient and Centrifugal Chillers			
R-124	PURE	N/A	Existing R-114 high ambient A/C systems can be modified to use R-124. New systems are available with R-134a. Centrifugal chillers require major equipment upgrades to retrofit to another refrigerant. Chiller manufacturers will need to be consulted for such jobs.
R-123	PURE	N/A	
Very Low Temperature and Cascade Refrigeration (R-13 and R-503 type)			
R-23	PURE	95%	R-13 systems can be retrofitted to R-23 or R-508B. R-23 will have similar run-time properties to R-13 but there will be higher discharge temperatures. R-503 systems should use R-508B R-403B has been successfully used in R-13B1 systems but the evaporator will likely run under vacuum conditions.
R-508B	23/116 (46/54)	R-13: 105-110% R-503: 90-95%	
R-403B	290/22/218 (5/26/39)	70 - 75%	

R-11 and R-12

Physical Properties of Refrigerants	R-11	R-12
Environmental Classification	CFC	CFC
Molecular Weight	137.4	120.9
Boiling Point (1 atm, ˚F)	74.7	-21.6
Critical Pressure (psia)	639.3	600
Critical Temperature (˚F)	388	233.5
Critical Density, (lb./ft^ 3)	34.6	35.3
Liquid Density (70 ˚F, lb./ft ^ 3)	92.73	82.96
Vapor Density (bp, lb./ft ^ 3)	0.365	0.393
Heat of Vaporization (bp, BTU/lb.)	77.9	71.2
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.2093	0.2324
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1444 (sat)	0.1455
Ozone Depletion Potential (CFC 11 = 1.0)	1.0	1.0
Global Warming Potential (CO_2 = 1.0)	4750	10910
ASHRAE Standard 34 Safety Rating	A1	A1

Available in the following sizes

R-11
100 LB DRUM
200 LB. DRUM

R-12
30 LB. CYLINDER
145 LB. CYLINDER

R-11

Application: Large low pressure centrifugal chillers

Lubricant Recommendation: Compatible with mineral oil

Retrofitting:
- R-123 is being successfully used to retrofit R-11 chillers
- Retrofit jobs are usually done in cooperation with equipment manufacturers

R-12

Application: Large centrifugal chillers, open drive A/C, process cooling, high-medium-low temperature refrigeration (large and small systems)

Lubricant Recommendation: Compatible with mineral oil

Retrofitting to:

R-134a	page	90, 91
R-401A, R-401B	page	90, 92
R-409A	page	90, 92
R-414B	page	90, 92
R-416A	page	90, 93

Pressure-Temp Chart

R-11 psig	Temp (˚F)	R-12 psig
	-40	*11.0″*
	-35	*8.4″*
	-30	*5.5″*
	-25	*2.3″*
27.0″	**-20**	0.6
26.5″	**-15**	2.4
26.0″	**-10**	4.5
25.4″	**-5**	6.7
24.7″	**0**	9.2
23..9″	**5**	11.8
23.1″	**10**	14.6
22.1″	**15**	17.7
21.1″	**20**	21.0
19.9′	**25**	24.6
18.6′	**30**	28.5
17.2″	**35**	32.6
15.6″	**40**	37.0
13.9″	**45**	41.7
12.0″	**50**	46.7
10.0″	**55**	52.0
7.8″	**60**	57.7
5.4″	**65**	63.8
2.8″	**70**	70.2
0.0	**75**	77.0
1.5	**80**	84.2
3.2	**85**	91.8
4.9	**90**	99.8
6.8	**95**	108
8.8	**100**	117
10.9	**105**	127
13.2	**110**	136
15.6	**115**	147
18.2	**120**	158
21.0	**125**	169
24.0	**130**	181
27.1	**135**	194
30.4	**140**	207
34.0	**145**	220
37.7	**150**	234

THERMODYNAMIC PROPERTIES OF R-11

Temp [˚F]	Pressure Liquid [psia]	Density Liquid [lb/ftˆ3]	Density Vapor [lb/ftˆ3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
30	5.6	95.93	0.1481	14.14	95.94	0.03112	0.1982
35	6.3	95.54	0.1654	15.16	96.56	0.03321	0.1977
40	7.0	95.14	0.1842	16.19	97.17	0.03528	0.1973
45	7.9	94.75	0.2047	17.23	97.79	0.03733	0.197
50	8.8	94.35	0.2269	18.26	98.41	0.03937	0.1966
55	9.8	93.95	0.2509	19.30	99.02	0.04139	0.1963
60	10.9	93.55	0.2769	20.34	99.64	0.0434	0.196
65	12.1	93.14	0.3049	21.39	100.3	0.0454	0.1957
70	13.4	92.73	0.3351	22.44	100.9	0.04738	0.1955
75	14.8	92.32	0.3676	23.49	101.5	0.04935	0.1952
80	16.3	91.91	0.4024	24.54	102.1	0.05131	0.1950
85	17.9	91.50	0.4397	25.60	102.7	0.05326	0.1948
90	19.7	91.08	0.4797	26.66	103.3	0.05519	0.1946
95	21.6	90.66	0.5224	27.73	103.9	0.05711	0.1945
100	23.6	90.23	0.5680	28.80	104.5	0.05902	0.1943
105	25.7	89.81	0.6167	29.87	105.1	0.06092	0.1942
110	28.1	89.38	0.6684	30.94	105.7	0.06281	0.1941
115	30.5	88.94	0.7235	32.02	106.3	0.06469	0.1940
120	33.2	88.51	0.7820	33.11	106.9	0.06656	0.1939
125	36.0	88.07	0.8442	34.20	107.5	0.06842	0.1939
130	38.9	87.62	0.910	35.29	108.1	0.07027	0.1938
135	42.1	87.17	0.980	36.39	108.7	0.07211	0.1937
140	45.4	86.72	1.054	37.49	109.3	0.07394	0.1937
145	49.0	86.26	1.132	38.59	109.9	0.07576	0.1937
150	52.8	85.80	1.215	39.70	110.5	0.07758	0.1936
155	56.7	85.33	1.302	40.82	111.0	0.07939	0.1936
160	60.9	84.86	1.394	41.94	111.6	0.08119	0.1936
165	65.3	84.39	1.492	43.06	112.2	0.08298	0.1936
170	70.0	83.91	1.594	44.19	112.7	0.08476	0.1936
175	74.9	83.42	1.702	45.33	113.3	0.08654	0.1936
180	80.0	82.93	1.816	46.47	113.8	0.08832	0.1936
185	85.4	82.43	1.936	47.62	114.4	0.09008	0.1936
190	91.1	81.93	2.062	48.77	114.9	0.09184	0.1936
195	97.1	81.42	2.195	49.93	115.4	0.09360	0.1937
200	103.3	80.90	2.335	51.09	116.0	0.09535	0.1937
205	109.8	80.38	2.482	52.26	116.5	0.09710	0.1937
210	116.7	79.85	2.636	53.44	117.0	0.09884	0.1937
215	123.8	79.31	2.799	54.62	117.5	0.1006	0.1937
220	131.3	78.76	2.970	55.82	118.0	0.1023	0.1938
225	139.1	78.21	3.149	57.01	118.5	0.1040	0.1938
230	147.2	77.65	3.338	58.22	118.9	0.1058	0.1938
235	155.6	77.08	3.536	59.43	119.4	0.1075	0.1938
240	164.5	76.50	3.745	60.65	119.8	0.1092	0.1938

THERMODYNAMIC PROPERTIES OF R-12

Temp [˚F]	Pressure Liquid [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	5.4	96.63	0.1537	-4.145	70.99	-0.01010	0.1779
-55	6.2	96.14	0.1756	-3.115	71.56	-0.00754	0.1770
-50	7.1	95.66	0.1999	-2.081	72.13	-0.00501	0.1761
-45	8.1	95.17	0.2268	-1.043	72.70	-0.00249	0.1753
-40	9.3	94.68	0.2565	0.000	73.27	0.00000	0.1746
-35	10.6	94.18	0.289	1.047	73.84	0.00247	0.1739
-30	12.0	93.68	0.3247	2.098	74.41	0.00493	0.1732
-25	13.5	93.18	0.3637	3.154	74.98	0.00736	0.1726
-20	15.2	92.67	0.4063	4.214	75.55	0.00978	0.1720
-15	17.1	92.16	0.4525	5.280	76.11	0.01218	0.1715
-10	19.2	91.65	0.5028	6.350	76.68	0.01457	0.1710
-5	21.4	91.13	0.5573	7.425	77.24	0.01693	0.1705
0	23.8	90.61	0.6162	8.505	77.80	0.01929	0.1700
5	26.4	90.08	0.6798	9.591	78.35	0.02162	0.1696
10	29.3	89.55	0.7483	10.68	78.90	0.02395	0.1692
15	32.4	89.02	0.8221	11.78	79.45	0.02625	0.1688
20	35.7	88.48	0.9013	12.88	80.00	0.02855	0.1685
25	39.3	87.93	0.9864	13.99	80.54	0.03083	0.1681
30	43.1	87.38	1.078	15.10	81.07	0.03310	0.1678
35	47.2	86.82	1.175	16.22	81.61	0.03536	0.1675
40	51.6	86.25	1.279	17.35	82.13	0.03761	0.1673
45	56.3	85.68	1.391	18.48	82.65	0.03984	0.1670
50	61.3	85.10	1.510	19.62	83.17	0.04207	0.1668
55	66.6	84.52	1.637	20.77	83.68	0.04428	0.1665
60	72.3	83.92	1.772	21.92	84.18	0.04649	0.1663
65	78.4	83.32	1.915	23.08	84.67	0.04869	0.1661
70	84.8	82.71	2.068	24.25	85.16	0.05088	0.1659
75	91.5	82.09	2.231	25.43	85.64	0.05306	0.1657
80	98.7	81.47	2.404	26.61	86.11	0.05524	0.1655
85	106.3	80.83	2.588	27.80	86.58	0.05740	0.1653
90	114.3	80.18	2.783	29.01	87.03	0.05957	0.1651
95	122.7	79.52	2.991	30.22	87.47	0.06173	0.1649
100	131.6	78.85	3.211	31.44	87.90	0.06388	0.1648
105	141.0	78.16	3.445	32.67	88.32	0.06603	0.1646
110	150.8	77.46	3.694	33.91	88.73	0.06818	0.1644
115	161.1	76.75	3.958	35.16	89.12	0.07032	0.1642
120	172.0	76.02	4.238	36.43	89.50	0.07247	0.1640
125	183.3	75.28	4.537	37.70	89.87	0.07461	0.1638
130	195.2	74.51	4.855	38.99	90.22	0.07676	0.1636
135	207.7	73.73	5.193	40.30	90.55	0.07890	0.1634
140	220.7	72.93	5.554	41.61	90.86	0.08106	0.1632
145	234.4	72.10	5.939	42.95	91.15	0.08321	0.1629
150	248.6	71.24	6.351	44.30	91.42	0.08538	0.1627
155	263.5	70.36	6.792	45.67	91.66	0.08755	0.1624
160	279.0	69.45	7.265	47.06	91.87	0.08973	0.1621

R-13

Physical Properties of Refrigerants	R-13
Environmental Classification	CFC
Molecular Weight	104.5
Boiling Point (1 atm, ˚F)	-114.3
Critical Pressure (psia)	567.8
Critical Temperature (˚F)	84.6
Critical Density, (lb./ft^ 3)	35.9
Liquid Density (20 ˚F, lb./ft ^ 3)	72.7
Vapor Density (bp, lb./ft ^ 3)	0.4332
Heat of Vaporization (bp, BTU/lb.)	64.35
Specific Heat Liquid (20 ˚F, BTU/lb. ˚F)	0.2121
Specific Heat Vapor (1 atm, 20 ˚F, BTU/lb. ˚F)	0.1451
Ozone Depletion Potential (CFC 11 = 1.0)	1.0
Global Warming Potential (CO_2 = 1.0)	14400
ASHRAE Standard 34 Safety Rating	A1

Available in the following sizes

R-13
5 LB. CYLINDER
9 LB. CYLINDER
23 LB. CYLINDER
80 LB. CYLINDER

R-13

Applications: Very low temperature refrigeration

Performance: Operates in the low temperature stage of the cascade system because of its low boiling point

Lubricant Recommendation: Compatible with mineral oil

Retrofitting to: R-23 page 101
R-508B page 101

See Ultra-Low Temperature Refrigeration Section - Pages 64 - 65

Pressure-Temp Chart

Temp (˚F)	R-13 (psig)
-120	*4.5″*
-115	0.3
-110	2.1
-105	4.7
-100	7.6
-95	10.8
-90	14.3
-85	18.2
-80	22.5
-75	27.2
-70	32.3
-65	37.8
-60	43.9
-55	50.4
-50	57.5
-45	65.1
-40	73.3
-35	82.1
-30	91.6
-25	102
-20	113
-15	122
-10	136
-5	149
0	163
5	177
10	193
15	209
20	226
25	244
30	264
35	284
40	305

THERMODYNAMIC PROPERTIES OF R-13

Temp [˚F]	Pressure Liquid [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-140	6.4	98.20	0.2008	-21.91	45.08	-0.059	0.1506
-135	7.7	97.56	0.2359	-20.89	45.58	-0.05582	0.1489
-130	9.1	96.92	0.2756	-19.86	46.08	-0.05268	0.1473
-125	10.7	96.27	0.3204	-18.82	46.57	-0.04957	0.1458
-120	12.5	95.62	0.3707	-17.78	47.06	-0.04649	0.1444
-115	14.5	94.96	0.4269	-16.73	47.55	-0.04343	0.1430
-110	16.8	94.30	0.4894	-15.67	48.03	-0.04040	0.1418
-105	19.3	93.63	0.5588	-14.61	48.51	-0.03739	0.1406
-100	22.2	92.95	0.6356	-13.54	48.98	-0.03441	0.1394
-95	25.4	92.27	0.7203	-12.46	49.45	-0.03145	0.1383
-90	28.9	91.58	0.8135	-11.37	49.91	-0.02851	0.1373
-85	32.7	90.87	0.9158	-10.28	50.37	-0.02559	0.1363
-80	37.0	90.17	1.028	-9.173	50.82	-0.02269	0.1353
-75	41.6	89.45	1.150	-8.061	51.26	-0.01980	0.1344
-70	46.7	88.72	1.283	-6.939	51.70	-0.01693	0.1335
-65	52.2	87.98	1.428	-5.809	52.12	-0.01408	0.1327
-60	58.2	87.23	1.586	-4.668	52.54	-0.01124	0.1319
-55	64.7	86.46	1.757	-3.517	52.95	-0.00841	0.1311
-50	71.7	85.69	1.942	-2.356	53.34	-0.00560	0.1304
-45	79.3	84.90	2.143	-1.184	53.73	-0.00280	0.1296
-40	87.4	84.10	2.360	0.000	54.11	0.00000	0.1289
-35	96.2	83.27	2.594	1.196	54.47	0.00279	0.1282
-30	105.6	82.44	2.848	2.405	54.82	0.00557	0.1276
-25	115.6	81.58	3.121	3.627	55.15	0.00834	0.1269
-20	126.4	80.71	3.416	4.863	55.47	0.01111	0.1262
-15	137.8	79.81	3.735	6.114	55.77	0.01388	0.1256
-10	150.0	78.89	4.078	7.381	56.06	0.01665	0.1249
-5	163.0	77.94	4.450	8.666	56.32	0.01943	0.1242
0	176.7	76.96	4.851	9.968	56.57	0.02220	0.1236
5	191.3	75.96	5.286	11.29	56.79	0.02499	0.1229
10	206.8	74.91	5.756	12.63	56.98	0.02778	0.1222
15	223.1	73.83	6.267	14.00	57.15	0.03059	0.1215
20	240.4	72.71	6.823	15.39	57.28	0.03342	0.1207
25	258.6	71.54	7.430	16.81	57.38	0.03627	0.1200
30	277.9	70.31	8.094	18.27	57.43	0.03915	0.1191
35	298.2	69.01	8.824	19.76	57.44	0.04206	0.1182
40	319.5	67.64	9.632	21.29	57.39	0.04503	0.1173

R-22

Physical Properties of Refrigerants	R-22
Environmental Classification	HCFC
Molecular Weight	86.5
Boiling Point (1 atm, ˚F)	-41.5
Critical Pressure (psia)	723.7
Critical Temperature (˚F)	205.1
Critical Density, (lb./ft^ 3)	32.7
Liquid Density (70 ˚F, lb./ft ^ 3)	75.3
Vapor Density (bp, lb./ft ^ 3)	0.294
Heat of Vaporization (bp, BTU/lb.)	100.5
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.2967
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1573
Ozone Depletion Potential (CFC 11 = 1.0)	0.05
Global Warming Potential (CO_2 = 1.0)	1810
ASHRAE Standard 34 Safety Rating	A1

Available in the following sizes

R-22
30 LB. CYLINDER
50 LB. CYLINDER
125 LB. CYLINDER
1000 LB. CYLINDER
1750 LB. CYLINDER

R-22

Applications: Medium and low temperature commercial and industrial refrigeration and air conditioning

Lubricant Recommendation: Compatible with mineral, alkylbenzene and polyolester lubricant

Retrofitting to:

R-407A or R-407C	page	94
R-422B	page	95
R-422C	page	96
R-422D	page	95
R-404A or R-507	page	96

Pressure-Temp Chart

Temp (˚F)	R-22 psig
-40	0.5
-35	2.6
-30	4.9
-25	7.4
-20	10.1
-15	13.2
-10	16.5
-5	20.1
0	24.0
5	28.2
10	32.8
15	37.7
20	43.0
25	48.8
30	54.9
35	61.5
40	68.5
45	76.0
50	84.0
55	92.6
60	102
65	111
70	121
75	132
80	144
85	156
90	168
95	182
100	196
105	211
110	226
115	243
120	260
125	278
130	297
135	317
140	337
145	359
150	382

THERMODYNAMIC PROPERTIES OF R-22

Temp [˚F]	Pressure Liquid [psia]	Density Liquid [lb/ftˆ3]	Density Vapor [lb/ftˆ3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	8.8	89.82	0.1827	-5.189	98.09	-0.01264	0.2458
-55	10.2	89.33	0.2087	-3.897	98.66	-0.00943	0.2440
-50	11.7	88.83	0.2374	-2.602	99.22	-0.00626	0.2423
-45	13.4	88.33	0.2692	-1.303	99.79	-0.00311	0.2407
-40	15.3	87.82	0.3042	0.000	100.3	0.00000	0.2391
-35	17.3	87.32	0.3427	1.308	100.9	0.00309	0.2376
-30	19.6	86.80	0.3849	2.620	101.4	0.00615	0.2361
-25	22.1	86.29	0.4310	3.937	102.0	0.00918	0.2348
-20	24.9	85.76	0.4813	5.260	102.5	0.01220	0.2334
-15	27.9	85.24	0.5360	6.588	103.0	0.01519	0.2321
-10	31.2	84.71	0.5955	7.923	103.6	0.01815	0.2309
-5	34.8	84.17	0.6600	9.263	104.1	0.02110	0.2296
0	38.7	83.63	0.7299	10.61	104.6	0.02403	0.2285
5	43.0	83.08	0.8054	11.96	105.1	0.02694	0.2273
10	47.5	82.52	0.8868	13.33	105.6	0.02983	0.2263
15	52.5	81.96	0.9746	14.69	106.1	0.03270	0.2252
20	57.8	81.39	1.069	16.07	106.5	0.03556	0.2242
25	63.5	80.82	1.171	17.46	107.0	0.03841	0.2231
30	69.7	80.24	1.280	18.85	107.4	0.04124	0.2222
35	76.2	79.65	1.396	20.25	107.9	0.04406	0.2212
40	83.3	79.05	1.522	21.66	108.3	0.04686	0.2203
45	90.8	78.44	1.656	23.08	108.7	0.04966	0.2194
50	98.8	77.83	1.799	24.51	109.1	0.05244	0.2185
55	107.3	77.20	1.952	25.96	109.5	0.05522	0.2176
60	116.3	76.57	2.116	27.41	109.9	0.05798	0.2167
65	125.9	75.92	2.291	28.87	110.3	0.06074	0.2159
70	136.1	75.27	2.478	30.35	110.6	0.06350	0.2150
75	146.9	74.60	2.678	31.84	110.9	0.06625	0.2142
80	158.3	73.92	2.891	33.34	111.2	0.06899	0.2133
85	170.4	73.23	3.118	34.86	111.5	0.07173	0.2125
90	183.1	72.52	3.361	36.39	111.8	0.07447	0.2117
95	196.5	71.80	3.620	37.94	112.0	0.07721	0.2108
100	210.6	71.06	3.897	39.50	112.3	0.07996	0.2100
105	225.5	70.30	4.193	41.08	112.5	0.08270	0.2091
110	241.1	69.52	4.510	42.69	112.7	0.08545	0.2083
115	257.5	68.72	4.849	44.31	112.8	0.08821	0.2074
120	274.7	67.90	5.213	45.95	112.9	0.09098	0.2065
125	292.7	67.05	5.604	47.62	113.0	0.09376	0.2056
130	311.6	66.18	6.024	49.32	113.0	0.09656	0.2046
135	331.4	65.27	6.477	51.04	113.0	0.09937	0.2036
140	352.1	64.32	6.966	52.80	113.0	0.1022	0.2026
145	373.7	63.34	7.497	54.59	112.9	0.1051	0.2015
150	396.4	62.31	8.075	56.42	112.8	0.1080	0.2004
155	420.0	61.22	8.706	58.31	112.5	0.1110	0.1992
160	444.7	60.07	9.400	60.24	112.2	0.1140	0.1979

Physical Properties of Refrigerants	R-23
Environmental Classification	HFC
Molecular Weight	70
Boiling Point (1 atm, ˚F)	-115.6
Critical Pressure (psia)	701.4
Critical Temperature (˚F)	78.7
Critical Density, (lb./ft^ 3)	32.8
Liquid Density (20 ˚F, lb./ft ^ 3)	67.46
Vapor Density (bp, lb./ft ^ 3)	0.29
Heat of Vaporization (bp, BTU/lb.)	102.7
Specific Heat Liquid (20 ˚F, BTU/lb. ˚F)	0.4063
Specific Heat Vapor (1 atm, 20 ˚F, BTU/lb. ˚F)	0.1663
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	14800
ASHRAE Standard 34 Safety Rating	A1

Available in the following sizes

R-23
5 LB. CYLINDER
9 LB. CYLINDER
20 LB. CYLINDER
70 LB. CYLINDER

R-23

Applications: Very low temperature refrigeration

Performance: Operates in the low temperature stage of a cascade system

Lubricant Recommendation: Compatible with polyolester lubricant

Retrofitting: Replacement for R-13 page 101

See Ultra-Low Temperature Refrigeration Section - page 64-65

Pressure-Temp Chart

Temp (˚F)	R-23 psig
-125	*7.8″*
-120	*4.0″*
-115	0.3
-110	2.9
-105	5.8
-100	9.0
-95	12.7
-90	16.7
-85	21.3
-80	26.3
-75	31.8
-70	37.9
-65	44.6
-60	52.0
-55	60.0
-50	68.7
-45	78.1
-40	88.3
-35	99.4
-30	111
-25	124
-20	138
-15	152
-10	168
-5	185
0	203
5	222
10	242
15	264
20	287

THERMODYNAMIC PROPERTIES OF R-23

Temp [˚F]	Pressure Liquid [psia]	Density Liquid [lb/ftˆ3]	Density Vapor [lb/ftˆ3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-140	6.3	92.72	0.1312	-30.60	77.43	-0.08247	0.2555
-135	7.6	92.20	0.1562	-29.15	77.98	-0.07799	0.2520
-130	9.1	91.66	0.1850	-27.70	78.52	-0.07356	0.2486
-125	10.8	91.12	0.2178	-26.25	79.05	-0.06919	0.2455
-120	12.8	90.57	0.2550	-24.78	79.58	-0.06486	0.2424
-115	15.1	90.00	0.2972	-23.31	80.09	-0.06058	0.2394
-110	17.6	89.43	0.3446	-21.84	80.59	-0.05634	0.2366
-105	20.6	88.84	0.3978	-20.35	81.09	-0.05214	0.2339
-100	23.8	88.24	0.4572	-18.86	81.56	-0.04798	0.2312
-95	27.5	87.63	0.5234	-17.35	82.03	-0.04385	0.2287
-90	31.6	87.00	0.5970	-15.84	82.48	-0.03975	0.2262
-85	36.1	86.36	0.6784	-14.32	82.92	-0.03568	0.2238
-80	41.2	85.70	0.7684	-12.78	83.34	-0.03163	0.2215
-75	46.7	85.03	0.8675	-11.23	83.75	-0.02762	0.2193
-70	52.9	84.35	0.9765	-9.671	84.14	-0.02362	0.2171
-65	59.6	83.64	1.096	-8.097	84.51	-0.01964	0.2150
-60	67.0	82.93	1.227	-6.509	84.86	-0.01569	0.2129
-55	75.0	82.19	1.370	-4.906	85.19	-0.01175	0.2109
-50	83.7	81.43	1.527	-3.288	85.50	-0.00782	0.2089
-45	93.2	80.66	1.698	-1.653	85.79	-0.00390	0.2070
-40	103.5	79.86	1.884	0.000	86.06	0.00000	0.2051
-35	114.6	79.04	2.087	1.671	86.30	0.00390	0.2032
-30	126.6	78.20	2.307	3.361	86.52	0.00779	0.2013
-25	139.5	77.34	2.547	5.072	86.70	0.01168	0.1995
-20	153.3	76.44	2.808	6.806	86.86	0.01556	0.1976
-15	168.1	85.52	3.092	8.563	86.98	0.01946	0.1958
-10	184.0	74.57	3.402	10.34	87.06	0.02335	0.1940
-5	201.0	73.58	3.739	12.15	87.11	0.02726	0.1921
0	219.1	72.55	4.106	13.99	87.11	0.03119	0.1903
5	238.4	71.49	4.508	15.87	87.07	0.03513	0.1884
10	258.9	70.38	4.948	17.77	86.97	0.03910	0.1864
15	280.8	69.22	5.431	19.72	86.81	0.04310	0.1844
20	303.9	68.00	5.963	21.71	86.59	0.04715	0.1824
25	328.5	66.72	6.551	23.76	86.28	0.05124	0.1802
30	354.6	65.36	7.206	25.86	85.89	0.05541	0.1780
35	382.1	63.92	7.940	28.03	85.39	0.05966	0.1756
40	411.3	62.36	8.769	30.28	84.75	0.06402	0.1730

R-123 and R-124

Physical Properties of Refrigerants	R-123	R-124
Environmental Classification	HCFC	HCFC
Molecular Weight	152.9	136.5
Boiling Point (1 atm, ˚F)	82.1	10.3
Critical Pressure (psia)	531.1	527.1
Critical Temperature (˚F)	362.6	252.5
Critical Density, (lb./ft^ 3)	34.3	34.6
Liquid Density (70 ˚F, lb./ft ^ 3)	91.95	85.5
Vapor Density (bp, lb./ft ^ 3)	0.404	0.419
Heat of Vaporization (bp, BTU/lb.)	73.2	70.6
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.2329	0.265
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1645(sat)	0.1762
Ozone Depletion Potential (CFC 11 = 1.0)	0.0015	0.03
Global Warming Potential (CO_2 = 1.0)	77	609
ASHRAE Standard 34 Safety Rating	B1	A1

Available in the following sizes

R-123
100 LB DRUM
200 LB. DRUM
650 LB. DRUM

R-124
30 LB. CYLINDER
145 LB. CYLINDER

R-123

Replaces: R-11

Applications: Large low presure centrifugal chillers

Performance: May require replacement seals, gaskets and other components to obtain the correct operating conditions and prevent leakage

Lubricant Recommendation: Compatible with mineral and alkylbenzene oil

Retrofitting: Consult equipment manufacturer to retrofit R-11 chiller to R-123

R-124

Replaces: R-114

Applications: High ambient air conditioning

Performance: Slightly higher pressures and slightly lower capacity when used in an R-114 system

Lubricant Recommendation: Compatible with mineral oil and alkylbenzene oil

Retrofitting: Consult equipment manufacturer's guidelines

Pressure-Temp Chart

R-123 psig	Temp (˚F)	R-124 psig
27.8″	**-20**	*16.1″*
27.4″	**-15**	*14.1″*
26.9″″	**-10**	*12.0″*
26.4″	**-5**	*9.6″*
25.9″	**0**	*6.9″*
25.2″	**5**	*3.9″*
24..5″	**10**	*0.6″*
23.8″	**15**	1.6
22.8″	**20**	3.5
21.8″	**25**	5.7
20.7″	**30**	8.1
19.5″	**35**	10.5
18.1″	**40**	13.2
16.6″	**45**	16.1
14.9′	**50**	19.2
13.0″	**55**	22.6
11.2″	**60**	26.3
8.9″	**65**	30.2
6.5″	**70**	34.4
4.1″	**75**	38.9
1.2″	**80**	43.7
0.9	**85**	48.8
2.5	**90**	54.2
4.3	**95**	60.0
6.1	**100**	66.1
8.1	**105**	72.6
10.3	**110**	79.5
12.6	**115**	86.8
15.1	**120**	94.5
17.8	**125**	103
20.6	**130**	111
23.6	**135**	120
26.8	**140**	130
30.2	**145**	140
33.9	**150**	150

THERMODYNAMIC PROPERTIES OF R-123

Temp [˚F]	Pressure Liquid [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-20	1.0	99.54	0.03413	4.558	87.35	0.01061	0.1989
-15	1.2	99.14	0.03978	5.706	88.05	0.01320	0.1984
-10	1.4	98.73	0.04618	6.857	88.75	0.01578	0.1979
-5	1.7	98.33	0.05339	8.012	89.46	0.01833	0.1975
0	2.0	97.92	0.06149	9.170	90.16	0.02086	0.1971
5	2.3	97.51	0.07055	10.33	90.87	0.02337	0.1967
10	2.6	97.10	0.08067	11.50	91.58	0.02587	0.1964
15	3.0	96.69	0.09192	12.67	92.29	0.02834	0.1961
20	3.5	96.28	0.1044	13.84	93.01	0.03080	0.1958
25	4.0	95.86	0.1182	15.02	93.72	0.03324	0.1956
30	4.5	95.44	0.1334	16.20	94.44	0.03566	0.1954
35	5.1	95.02	0.1502	17.38	95.16	0.03806	0.1953
40	5.8	94.60	0.1686	18.57	95.88	0.04045	0.1952
45	6.5	94.17	0.1887	19.76	96.60	0.04282	0.1951
50	7.3	93.74	0.2106	20.96	97.32	0.04518	0.1950
55	8.2	93.31	0.2346	22.16	98.04	0.04752	0.1950
60	9.2	92.88	0.2606	23.36	98.76	0.04984	0.1949
65	10.3	92.44	0.2889	24.57	99.48	0.05215	0.1949
70	11.4	92.01	0.3195	25.78	100.2	0.05444	0.1949
75	12.7	91.56	0.3526	27.00	100.9	0.05673	0.1950
80	14.1	91.12	0.3883	28.22	101.6	0.05899	0.1950
85	15.6	90.67	0.4268	29.44	102.4	0.06124	0.1951
90	17.2	90.22	0.4682	30.67	103.1	0.06348	0.1952
95	18.9	89.77	0.5128	31.90	103.8	0.06571	0.1953
100	20.8	89.31	0.5605	33.14	104.5	0.06792	0.1955
105	22.8	88.85	0.6117	34.38	105.2	0.07012	0.1956
110	25.0	88.39	0.6664	35.63	106.0	0.07231	0.1958
115	27.3	87.92	0.7249	36.88	106.7	0.07449	0.1959
120	29.8	87.45	0.7874	38.13	107.4	0.07665	0.1961
125	32.4	86.98	0.8540	39.39	108.1	0.07881	0.1963
130	35.3	86.50	0.9249	40.66	108.8	0.08095	0.1965
135	38.3	86.01	1.000	41.93	109.5	0.08308	0.1967
140	41.5	85.52	1.081	43.20	110.2	0.08520	0.1969
145	44.9	85.03	1.166	44.48	110.9	0.08732	0.1972
150	48.5	84.53	1.256	45.76	111.6	0.08942	0.1974
155	52.3	84.03	1.353	47.05	112.3	0.09151	0.1976
160	56.4	83.52	1.454	48.35	113.0	0.09359	0.1979
165	60.7	83.01	1.562	49.65	113.7	0.09567	0.1981
170	65.2	82.49	1.676	50.95	114.3	0.09773	0.1984
175	70.0	81.96	1.797	52.27	115.0	0.09979	0.1987
180	75.0	81.43	1.925	53.58	115.7	0.1018	0.1989
185	80.3	80.89	2.060	54.91	116.3	0.1039	0.1992
190	85.9	80.34	2.203	56.24	117.0	0.1059	0.1995
195	91.7	79.79	2.354	57.57	117.7	0.1079	0.1997
200	97.9	79.23	2.513	58.92	118.3	0.1100	0.2000

THERMODYNAMIC PROPERTIES OF R-124

Temp [˚F]	Pressure Liquid [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-40	3.8	97.03	0.1181	0	76.75	0	0.1829
-35	4.5	96.55	0.1359	1.222	77.46	0.00289	0.1824
-30	5.2	96.06	0.1557	2.449	78.17	0.00576	0.1820
-25	5.9	95.57	0.1779	3.681	78.88	0.00861	0.1816
-20	6.8	95.08	0.2024	4.918	79.59	0.01143	0.1813
-15	7.8	94.58	0.2295	6.159	80.30	0.01424	0.1810
-10	8.9	94.08	0.2594	7.406	81.01	0.01702	0.1807
-5	10.1	93.57	0.2924	8.657	81.72	0.01978	0.1805
0	11.4	93.06	0.3285	9.914	82.43	0.02253	0.1803
5	12.9	92.55	0.3680	11.18	83.14	0.02525	0.1801
10	14.5	92.04	0.4112	12.44	83.84	0.02796	0.1800
15	16.3	91.52	0.4583	13.72	84.55	0.03065	0.1799
20	18.3	90.99	0.5095	15.00	85.25	0.03332	0.1798
25	20.4	90.46	0.5651	16.28	85.95	0.03597	0.0797
30	22.7	89.93	0.6253	17.57	86.65	0.03861	0.1797
35	25.2	89.39	0.6904	18.87	87.35	0.04124	0.1797
40	27.9	88.84	0.7608	20.17	88.05	0.04385	0.1797
45	30.8	88.29	0.8366	21.48	88.74	0.04644	0.1797
50	34.0	87.73	0.9183	22.80	89.43	0.04902	0.1798
55	37.4	87.17	1.006	24.12	90.11	0.05159	0.1798
60	41.0	86.60	1.100	25.45	90.79	0.05415	0.1799
65	44.9	86.03	1.202	26.79	91.47	0.05669	0.1800
70	49.1	85.44	1.310	28.13	92.14	0.05922	0.1801
75	53.6	84.85	1.426	29.48	92.81	0.06174	0.1802
80	58.4	84.25	1.551	30.84	93.47	0.06425	0.1803
85	63.5	83.65	1.683	32.21	94.13	0.06676	0.1804
90	69.0	83.03	1.825	33.58	94.78	0.06925	0.1806
95	74.8	82.41	1.977	34.97	95.42	0.07173	0.1807
100	80.9	81.77	2.139	36.36	96.06	0.07420	0.1809
105	87.4	81.13	2.311	37.76	96.69	0.07667	0.1810
110	94.3	80.48	2.495	39.17	97.31	0.07913	0.1812
115	101.6	79.81	2.691	40.59	97.92	0.08158	0.1813
120	109.3	79.13	2.900	42.02	98.53	0.08403	0.1815
125	117.5	78.44	3.123	43.46	99.12	0.08648	0.1817
130	126.0	77.73	3.360	44.92	99.70	0.08892	0.1818
135	135.1	77.01	3.614	46.38	100.3	0.09135	0.1820
140	144.6	76.28	3.884	47.86	100.8	0.09379	0.1821
145	154.6	75.52	4.172	49.35	101.4	0.09622	0.1823
150	165.1	74.75	4.480	50.85	101.9	0.09866	0.1824
155	176.2	73.96	4.809	52.37	102.4	0.1011	0.1825
160	187.7	73.14	5.161	53.91	102.9	0.1035	0.1826
165	199.9	72.30	5.538	55.46	103.4	0.1060	0.1827
170	212.6	71.44	5.942	57.03	103.8	0.1084	0.1828
175	225.9	70.54	6.377	58.62	104.3	0.1109	0.1828
180	239.8	69.61	6.845	60.23	104.7	0.1134	0.1828

Physical Properties of Refrigerants	R-134a
Environmental Classification	HFC
Molecular Weight	102.3
Boiling Point (1 atm, ˚F)	-14.9
Critical Pressure (psia)	588.3
Critical Temperature (˚F)	213.8
Critical Density, (lb./ft^ 3)	32.0
Liquid Density (70 ˚F, lb./ft ^ 3)	76.2
Vapor Density (bp, lb./ft ^ 3)	0.328
Heat of Vaporization (bp, BTU/lb.)	93.3
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3366
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.2021
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	1430
ASHRAE Standard 34 Safety Rating	A1

Available in the following sizes

R-134a
12 oz. can
30 LB. CYLINDER
30 LB CYLINDER/with Automotive Fitting
125 LB. CYLINDER
1000 LB. CYLINDER
1750 LB. CYLINDER

R-134a

Replaces: R-12

Applications: Household appliances, refrigeration (commercial and self-contained equipment), centrifugal chillers and automotive air conditioning

Performance:
- Similar PT properties in air-conditioning
- Slight drop in capacity at lower temperature applications (below -10˚F)

Lubricant Recommendation: Compatible with polyolester lubricant for stationary equipment and polyalkaline glycol for automotive A/C systems

Retrofitting: Replacement for R-12 page 90, 91

Pressure-Temp Chart

Temp (˚F)	R-134a psig
-40	*14.8″*
-35	*12.5″*
-30	*9.9″*
-25	*6.9″*
-20	*3.7″*
-15	0.6
-10	1.9
-5	4.0
0	6.5
5	9.1
10	11.9
15	15.0
20	18.4
25	22.1
30	26.1
35	30.4
40	35.0
45	40.1
50	45.5
55	51.3
60	57.5
65	64.1
70	71.2
75	78.8
80	86.8
85	95.4
90	104
95	114
100	124
105	135
110	147
115	159
120	171
125	185
130	199
135	214
140	229
145	246
150	263

THERMODYNAMIC PROPERTIES OF R-134a

Temp [°F]	Pressure Liquid [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	4.0	90.49	0.09689	-5.957	94.13	-0.01452	0.2359
-55	4.7	90.00	0.1127	-4.476	94.89	-0.01085	0.2347
-50	5.5	89.50	0.1305	-2.989	95.65	-0.00720	0.2336
-45	6.4	89.00	0.1505	-1.498	96.41	-0.00358	0.2325
-40	7.4	88.50	0.1729	0.000	97.17	0.00000	0.2315
-35	8.6	88.00	0.1978	1.503	97.92	0.00356	0.2306
-30	9.9	87.49	0.2256	3.013	98.68	0.00708	0.2297
-25	11.3	86.98	0.2563	4.529	99.43	0.01058	0.2289
-20	12.9	86.47	0.2903	6.051	100.2	0.01406	0.2282
-15	15.3	85.95	0.3277	7.580	100.9	0.01751	0.2274
-10	16.6	85.43	0.3689	9.115	101.7	0.02093	0.2268
-5	18.8	84.90	0.4140	10.66	102.4	0.02433	0.2262
0	21.2	84.37	0.4634	12.21	103.2	0.02771	0.2256
5	23.8	83.83	0.5173	13.76	103.9	0.03107	0.2250
10	26.6	83.29	0.5761	15.33	104.6	0.03440	0.2245
15	29.7	82.74	0.6401	16.90	105.3	0.03772	0.2240
20	33.1	82.19	0.7095	18.48	106.1	0.04101	0.2236
25	36.8	81.63	0.7848	20.07	106.8	0.04429	0.2232
30	40.8	81.06	0.8663	21.67	107.5	0.04755	0.2228
35	45.1	80.49	0.9544	23.27	108.2	0.05079	0.2224
40	49.7	79.90	1.050	24.89	108.9	0.05402	0.2221
45	54.8	79.32	1.152	26.51	109.5	0.05724	0.2217
50	60.2	78.72	1.263	28.15	110.2	0.06044	0.2214
55	65.9	78.11	1.382	29.80	110.9	0.06362	0.2212
60	72.2	77.50	1.510	31.45	111.5	0.06680	0.2209
65	78.8	76.87	1.647	33.12	112.2	0.06996	0.2206
70	85.8	76.24	1.795	34.80	112.8	0.07311	0.2204
75	93.5	75.59	1.953	36.49	113.4	0.07626	0.2201
80	101.4	74.94	2.123	38.20	114.0	0.07939	0.2199
85	109.9	74.27	2.305	39.91	114.6	0.08252	0.2197
90	119.0	73.58	2.501	41.65	115.2	0.08565	0.2194
95	128.6	72.88	2.710	43.39	115.7	0.08877	0.2192
100	138.9	72.17	2.935	45.15	116.3	0.09188	0.2190
105	149.7	71.44	3.176	46.93	116.8	0.09500	0.2187
110	161.1	70.69	3.435	48.73	117.3	0.09811	0.2185
115	173.1	69.93	3.713	50.55	117.8	0.1012	0.2183
120	185.9	69.14	4.012	52.38	118.3	0.1044	0.2180
125	199.3	68.32	4.333	54.24	118.7	0.1075	0.2177
130	213.4	67.49	4.679	56.12	119.1	0.1106	0.2174
135	228.3	66.62	5.052	58.02	119.5	0.1138	0.2171
140	243.9	65.73	5.455	59.95	119.8	0.1169	0.2167
145	260.4	64.80	5.892	61.92	120.1	0.1201	0.2163
150	277.6	63.83	6.366	63.91	120.4	0.1233	0.2159
155	295.7	62.82	6.882	65.94	120.6	0.1265	0.2154
160	314.7	61.76	7.447	68.00	120.7	0.1298	0.2149

R-401A and R-401B

Technical Guidelines

Physical Properties of Refrigerants	R-401A	R-401B
Environmental Classification	HCFC	HCFC
Molecular Weight	94.4	92.8
Boiling Point (1 atm, ˚F)	-29.9	-32.3
Critical Pressure (psia)	669	679.1
Critical Temperature (˚F)	221	218.3
Critical Density, (lb./ft^ 3)	30.9	31.1
Liquid Density (70 ˚F, lb./ft ^ 3)	74.6	74.6
Vapor Density (bp, lb./ft ^ 3)	0.306	0.303
Heat of Vaporization (bp, BTU/lb.)	97.5	98.2
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3037	0.3027
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1755	0.1725
Ozone Depletion Potential (CFC 11 = 1.0)	0.037	0.039
Global Warming Potential (CO_2 = 1.0)	1182	1288
ASHRAE Standard 34 Safety Rating	A1	A1
Temperature Glide (˚F) (see section 2)	8	8

Available in the following sizes

R-401A
30 LB. CYLINDER
125 LB. CYLINDER

R-401B
30 LB. CYLINDER
125 LB. CYLINDER

R-401A

(R-22 /152a/124)
(53 / 13 / 34 wt%)

R-401B

(R-22 /152a/124)
(61 / 11 / 28 wt%)

Replaces: R-12 and R-500

Applications:

R-401A: Medium and low temperature commercial and industrial direct expansion refrigeration

R-401B: Low temperature commercial and industrial direct expansion refrigeration, R-12 air conditioning, R-500 systems

Performance:

- Very similar capacity, higher glide
- Similar evaporator pressure when average evaporator temperature is the same as R-12
- Head pressure runs higher

Lubricant Recommendation: Compatible with a combination of mineral oil and alkylbenzene or polyolester lubricants.

Retrofitting:

Replacement for R-12 page 90, 92
Replacement for R-500 page 97

Pressure-Temp Chart

R-401A Liquid (psig)	R-401A Vapor (psig)	Temp (˚F)	R-401B Liquid (psig)	R-401B Vapor (psig)
8.1″	*13.2″*	**-40**	*6.5″*	*11.8″*
5.1″	*10.7″*	**-35**	*3.3″*	*9.1″*
1.7″	*7.9″*	**-30**	0.2	*6.1″*
1.0	*4.8″*	**-25**	2.1	*2.8″*
3.0	*1.4″*	**-20**	4.3	0.5
5.2	1.2	**-15**	6.6	2.5
7.7	3.3	**-10**	9.2	4.7
10.3	5.5	**-5**	12.0	7.1
13.2	8.0	**0**	15.1	9.7
16.3	10.7	**5**	18.4	12.6
19.7	13.7	**10**	22.0	15.8
23.4	16.9	**15**	25.9	19.2
27.4	20.4	**20**	30.1	23.0
31.7	24.2	**25**	34.6	27.0
36.4	28.3	**30**	39.5	31.4
41.3	32.8	**35**	44.8	36.1
46.6	37.6	**40**	50.4	41.1
52.4	42.7	**45**	56.4	46.6
58.5	48.2	**50**	62.8	52.4
65.0	54.1	**55**	69.6	58.7
71.9	60.4	**60**	76.9	65.4
79.3	67.2	**65**	84.7	72.5
87.1	74.4	**70**	92.9	80.1
95.4	82.1	**75**	102	88.2
104	90.2	**80**	111	96.8
114	98.9	**85**	121	106
123	108	**90**	131	116
134	118	**95**	142	126
145	128	**100**	153	137
156	139	**105**	166	148
169	151	**110**	178	160
181	163	**115**	192	173
195	176	**120**	206	187
209	189	**125**	220	201
224	203	**130**	236	216
239	218	**135**	252	231
255	234	**140**	269	248
272	250	**145**	287	265
290	267	**150**	305	283

THERMODYNAMIC PROPERTIES OF R-401A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	6.5	4.7	88.18	0.1049	-5.371	94.93	-0.01309	0.2418
-55	7.5	5.5	87.71	0.1215	-4.035	95.60	-0.00977	0.2402
-50	8.7	6.4	87.24	0.1401	-2.694	96.26	-0.00648	0.2386
-45	9.9	7.4	86.77	0.1610	-1.350	96.93	-0.00323	0.2372
-40	11.4	8.6	86.29	0.1842	0.000	97.59	0.00000	0.2358
-35	12.9	9.9	85.82	0.2101	1.354	98.25	0.00320	0.2345
-30	14.7	11.3	85.33	0.2386	2.714	98.91	0.00637	0.2333
-25	16.6	12.9	84.85	0.2701	4.078	99.56	0.00952	0.2321
-20	18.7	14.7	84.36	0.3048	5.449	100.2	0.01265	0.2310
-15	21.0	16.6	83.86	0.3429	6.825	100.9	0.01575	0.2299
-10	23.6	18.8	83.37	0.3846	8.207	101.5	0.01882	0.2289
-5	26.4	21.2	82.86	0.4302	9.595	102.1	0.02188	0.2279
0	29.4	23.8	82.36	0.4799	10.99	102.8	0.02492	0.2269
5	32.7	26.6	81.84	0.5340	12.39	103.4	0.02793	0.2261
10	36.2	29.7	81.33	0.5927	13.80	104.0	0.03093	0.2252
15	40.1	33.1	80.80	0.6563	15.21	104.6	0.03391	0.2244
20	44.2	36.7	80.27	0.7251	16.64	105.2	0.03687	0.2236
25	48.7	40.7	79.74	0.7995	18.07	105.8	0.03982	0.2229
30	53.5	45.0	79.20	0.8798	19.51	106.4	0.04275	0.2221
35	58.6	49.6	78.65	0.9662	20.95	107.0	0.04566	0.2214
40	64.2	54.6	78.10	1.059	22.41	107.6	0.04857	0.2208
45	70.1	59.9	77.54	1.159	23.88	108.2	0.05145	0.2201
50	76.4	65.6	76.97	1.267	25.35	108.7	0.05433	0.2195
55	83.1	71.8	76.39	1.382	26.83	109.3	0.05720	0.2189
60	90.2	78.3	75.81	1.505	28.33	109.8	0.06005	0.2183
65	97.8	85.3	75.21	1.637	29.83	110.4	0.06290	0.2178
70	105.9	92.8	74.61	1.779	31.35	110.9	0.06573	0.2172
75	114.5	100.7	74.00	1.930	32.87	111.4	0.06856	0.2167
80	123.5	109.2	73.37	2.092	34.41	111.9	0.07138	0.2162
85	133.1	118.1	72.74	2.265	35.96	112.4	0.07420	0.2156
90	143.2	127.6	72.09	2.449	37.52	112.8	0.07701	0.2151
95	153.9	137.7	71.43	2.647	39.10	113.3	0.07981	0.2146
100	165.2	148.3	70.76	2.858	40.69	113.7	0.08261	0.2141
105	177.0	159.6	70.08	3.083	42.30	114.1	0.08541	0.2136
110	189.5	171.4	69.38	3.324	43.92	114.5	0.08822	0.2131
115	202.6	183.9	68.66	3.581	45.56	114.9	0.09102	0.2126
120	216.3	197.1	67.93	3.857	47.21	115.2	0.09382	0.2120
125	230.7	211.0	67.17	4.152	48.89	115.6	0.09663	0.2115
130	245.8	225.6	66.40	4.468	50.58	115.9	0.09945	0.2110
135	261.7	240.9	65.60	4.807	52.30	116.2	0.1023	0.2104
140	278.2	257.1	64.77	5.171	54.04	116.4	0.1051	0.2098
145	295.5	274.0	63.92	5.564	55.81	116.6	0.1080	0.2092
150	313.6	291.7	63.04	5.987	57.61	116.8	0.1108	0.2085
155	332.6	310.3	62.12	6.444	59.43	116.9	0.1137	0.2078

THERMODYNAMIC PROPERTIES OF R-401B

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	6.9	5.2	88.34	0.1145	-5.346	95.56	-0.01302	0.2430
-55	8.0	6.1	87.87	0.1324	-4.016	96.21	-0.00972	0.2414
-50	9.2	7.1	87.40	0.1524	-2.681	96.86	-0.00645	0.2398
-45	10.6	8.2	86.92	0.1748	-1.343	97.51	-0.00321	0.2383
-40	12.1	9.4	86.44	0.1997	0.000	98.16	0.00000	0.2369
-35	13.7	10.8	85.96	0.2273	1.348	98.80	0.00318	0.2355
-30	15.6	12.4	85.47	0.2577	2.701	99.44	0.00634	0.2343
-25	17.6	14.1	84.98	0.2914	4.059	100.1	0.00947	0.2330
-20	19.8	16.0	84.48	0.3283	5.422	100.7	0.01258	0.2318
-15	22.3	18.1	83.99	0.3688	6.791	101.3	0.01567	0.2307
-10	25.0	20.5	83.48	0.4131	8.166	102.0	0.01873	0.2296
-5	27.9	23.0	82.97	0.4614	9.548	102.6	0.02177	0.2286
0	31.1	25.8	82.46	0.514	10.94	103.2	0.02479	0.2276
5	34.5	28.9	81.94	0.5713	12.33	103.8	0.02779	0.2267
10	38.3	32.2	81.42	0.6333	13.73	104.4	0.03077	0.2258
15	42.3	35.8	80.89	0.7005	15.14	105.0	0.03374	0.2249
20	46.7	39.7	80.35	0.7732	16.56	105.6	0.03669	0.2241
25	51.4	43.9	79.81	0.8516	17.98	106.2	0.03962	0.2233
30	56.4	48.5	79.26	0.9362	19.42	106.7	0.04253	0.2225
35	61.8	53.4	78.71	1.027	20.86	107.3	0.04544	0.2218
40	67.6	58.7	78.15	1.125	22.31	107.8	0.04832	0.2211
45	73.8	64.4	77.58	1.23	23.76	108.4	0.05120	0.2204
50	80.4	70.5	77.00	1.343	25.23	108.9	0.05406	0.2197
55	87.5	77.0	76.42	1.464	26.71	109.5	0.05692	0.2190
60	95.0	84.0	75.82	1.594	28.20	110.0	0.05976	0.2184
65	102.9	91.4	75.22	1.732	29.70	110.5	0.06259	0.2178
70	111	99.3	74.61	1.881	31.21	111.0	0.06542	0.2172
75	120	108	73.99	2.039	32.73	111.4	0.06824	0.2166
80	130	117	73.36	2.209	34.26	111.9	0.07105	0.2160
85	140	126	72.71	2.39	35.81	112.4	0.07385	0.2154
90	150	136	72.06	2.584	37.37	112.8	0.07665	0.2149
95	162	147	71.39	2.791	38.94	113.2	0.07945	0.2143
100	173	158	70.70	3.012	40.53	113.6	0.08224	0.2137
105	186	170	70.01	3.248	42.13	114.0	0.08504	0.2131
110	199	182	69.29	3.501	43.75	114.3	0.08783	0.2126
115	212	195	68.56	3.771	45.39	114.7	0.09063	0.2120
120	227	209	67.81	4.06	47.05	115.0	0.09343	0.2114
125	242	224	67.04	4.369	48.72	115.3	0.09624	0.2108
130	258	239	66.25	4.701	50.42	115.5	0.09905	0.2102
135	274	255	65.44	5.058	52.14	115.8	0.1019	0.2095
140	291	272	64.59	5.441	53.88	116.0	0.1047	0.2089
145	309	290	63.72	5.854	55.66	116.1	0.1076	0.2082
150	328	309	62.81	6.3	57.46	116.3	0.1105	0.2074
155	348	328	61.87	6.783	59.30	116.3	0.1134	0.2067

R-402A and R-402B

Physical Properties of Refrigerants	R-402A	R-402B
Environmental Classification	HCFC	HCFC
Molecular Weight	101.6	94.7
Boiling Point (1 atm, ˚F)	-56.5	-52.9
Critical Pressure (psia)	600	645
Critical Temperature (˚F)	168	180.7
Critical Density, (lb./ft^ 3)	33.8	33.1
Liquid Density (70 ˚F, lb./ft ^ 3)	72.61	72.81
Vapor Density (bp, lb./ft ^ 3)	0.356	0.328
Heat of Vaporization (bp, BTU/lb.)	83.58	90.42
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3254	0.317
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1811	0.1741
Ozone Depletion Potential (CFC 11 = 1.0)	0.019	0.03
Global Warming Potential (CO_2 = 1.0)	2788	2416
ASHRAE Standard 34 Safety Rating	A1	A1
Temperature Glide (˚F) (see section2)	2.5	2.5

Available in the following sizes

R-402A
27 LB. CYLINDER
110 LB. CYLINDER

R-402B
13 LB. CYLINDER

R-402A

(R-125/290/22)
(60 / 2 / 38 wt%)

Replaces: R-502

Applications: Low temperature commercial and industrial direct expansion refrigeration

Performance: Lower discharge temperature, Higher discharge pressure

Lubricant Recommendation: Compatible with mineral and alkylbenzene oil. If oil return becomes a concern, addition of polyolester lubricant in 5% increments could help resolve the issue.

R-402B

(R-125/290/22)
(38 / 2 / 60 wt%)

Replaces: R-502

Applications: Ice machines

Performance: Higher discharge temperature, Lower discharge pressure

Lubricant Recommendation: Compatible with mineral and alkylbenzene oil. If oil return becomes a concern, addition of polyolester lubricant in 5% increments could help resolve the issue.

Retrofitting: Replacement for R-502 page 98
to R422C page 100

Pressure-Temp Chart

R-402A (psig)	Temp (˚F)	R-402B (psig)
6.3	**-40**	3.6
9.1	**-35**	6.0
12.1	**-30**	9.0
15.4	**-25**	12.0
18.9	**-20**	15.4
22.9	**-15**	18.6
27.1	**-10**	22.6
31.7	**-5**	27.0
36.7	**0**	31.0
42.1	**5**	36.0
48.0	**10**	42.0
54.2	**15**	47.0
60.9	**20**	54.0
68.1	**25**	60.0
75.8	**30**	67.0
84.0	**35**	75.0
92.8	**40**	83.4
102	**45**	91.6
112	**50**	100
123	**55**	110
134	**60**	120
146	**65**	133
158	**70**	143
171	**75**	155
185	**80**	170
200	**85**	183
215	**90**	198
232	**95**	213
249	**100**	230
267	**105**	247
286	**110**	262
305	**115**	283
326	**120**	303
347	**125**	323
370	**130**	345
393	**135**	-
418	**140**	-
443	**145**	-
470	**150**	-

THERMODYNAMIC PROPERTIES OF R-402A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	13.4	12.0	89.70	0.2946	-5.410	78.16	-0.01316	0.1968
-55	15.3	13.8	89.14	0.3355	-4.067	78.80	-0.00983	0.1958
-50	17.4	15.8	88.58	0.3807	-2.718	79.45	-0.00653	0.1948
-45	19.8	18.0	88.01	0.4305	-1.362	80.09	-0.00325	0.1939
-40	22.3	20.5	87.44	0.4854	0.000	80.73	0.00000	0.1931
-35	25.2	23.2	86.86	0.5455	1.369	81.37	0.00323	0.1923
-30	28.3	26.1	86.28	0.6113	2.746	82.00	0.00644	0.1915
-25	31.7	29.4	85.69	0.6832	4.130	82.62	0.00962	0.1908
-20	35.4	32.9	85.09	0.7615	5.522	83.24	0.01279	0.1901
-15	39.4	36.8	84.48	0.8467	6.923	83.85	0.01594	0.1895
-10	43.8	41.0	83.87	0.9392	8.331	84.46	0.01906	0.1889
-5	48.6	45.6	83.25	1.039	9.749	85.06	0.02218	0.1883
0	53.7	50.6	82.62	1.148	11.18	85.65	0.02527	0.1878
5	59.2	56.0	81.99	1.265	12.61	86.23	0.02835	0.1873
10	65.2	61.7	81.34	1.392	14.06	86.81	0.03142	0.1868
15	71.6	68.0	80.68	1.528	15.52	87.37	0.03448	0.1863
20	78.4	74.7	80.02	1.675	16.98	87.93	0.03752	0.1858
25	85.8	81.8	79.34	1.834	18.46	88.48	0.04055	0.1854
30	93.6	89.5	78.65	2.004	19.95	89.01	0.04357	0.1850
35	102.0	97.7	77.95	2.187	21.46	89.53	0.04659	0.1846
40	110.9	106.4	77.24	2.383	22.97	90.05	0.04959	0.1842
45	120.3	115.8	76.51	2.595	24.50	90.54	0.05259	0.1838
50	130.4	125.7	75.76	2.821	26.04	91.02	0.05559	0.1834
55	141.1	136.2	75.00	3.065	27.60	91.49	0.05858	0.1830
60	152.4	147.4	74.23	3.326	29.18	91.94	0.06157	0.1826
65	164.4	159.2	73.43	3.607	30.77	92.37	0.06456	0.1822
70	177.1	171.8	72.61	3.909	32.38	92.78	0.06755	0.1818
75	190.5	185.0	71.78	4.233	34.00	93.17	0.07054	0.1814
80	204.6	199.0	70.91	4.583	35.65	93.54	0.07354	0.1810
85	219.5	213.8	70.02	4.959	37.32	93.88	0.07654	0.1806
90	235.1	229.3	69.10	5.366	39.01	94.19	0.07956	0.1801
95	251.6	245.7	68.15	5.805	40.73	94.47	0.08259	0.1797
100	269.0	263.0	67.17	6.281	42.48	94.71	0.08564	0.1791
105	287.2	281.1	66.14	6.799	44.25	94.91	0.08871	0.1786
110	306.3	300.2	65.06	7.362	46.07	95.07	0.09181	0.1780
115	326.4	320.2	63.93	7.979	47.92	95.18	0.09494	0.1773
120	347.4	341.3	62.74	8.658	49.81	95.22	0.09812	0.1766
125	369.5	363.3	61.48	9.408	51.76	95.20	0.1013	0.1758
130	392.6	386.5	60.13	10.25	53.76	95.09	0.1046	0.1748
135	416.9	410.8	58.67	11.19	55.84	94.88	0.1080	0.1738
140	442.2	436.3	57.07	12.26	58.01	94.55	0.1115	0.1725

THERMODYNAMIC PROPERTIES OF R-402B

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	12.2	10.8	88.76	0.2454	-5.366	85.51	-0.01306	0.2154
-55	13.9	12.4	88.23	0.2798	-4.033	86.14	-0.00975	0.2141
-50	15.9	14.2	87.70	0.3178	-2.694	86.76	-0.00647	0.2129
-45	18.0	16.2	87.16	0.3598	-1.350	87.38	-0.00322	0.2117
-40	20.4	18.5	86.62	0.4061	0.000	87.99	0.00000	0.2106
-35	23.0	20.9	86.07	0.4568	1.356	88.61	0.00320	0.2095
-30	25.9	23.6	85.52	0.5124	2.719	89.21	0.00638	0.2085
-25	29.1	26.6	84.96	0.5731	4.089	89.81	0.00953	0.2075
-20	32.5	29.9	84.40	0.6392	5.466	90.40	0.01266	0.2066
-15	36.2	33.4	83.83	0.7112	6.850	90.99	0.01577	0.2057
-10	40.3	37.3	83.25	0.7894	8.242	91.57	0.01877	0.2049
-5	44.7	41.5	82.67	0.8742	9.643	92.15	0.02194	0.2041
0	49.5	46.1	82.08	0.9659	11.05	92.71	0.02500	0.2033
5	54.7	51.1	81.48	1.065	12.47	93.27	0.02804	0.2025
10	60.2	56.4	80.88	1.172	13.89	93.82	0.03107	0.2018
15	66.2	62.2	80.26	1.287	15.33	94.36	0.03408	0.2011
20	72.6	68.3	79.64	1.412	16.78	94.89	0.03708	0.2005
25	79.4	75.0	79.01	1.545	18.23	95.41	0.04006	0.1998
30	86.7	82.1	78.37	1.689	19.70	95.92	0.04304	0.1992
35	94.6	89.7	77.72	1.843	21.18	96.42	0.04600	0.1986
40	102.9	97.8	77.05	2.008	22.67	96.91	0.04896	0.1980
45	111.8	106.5	76.38	2.186	24.17	97.38	0.05191	0.1974
50	121.2	115.7	75.69	2.376	25.68	97.84	0.05485	0.1968
55	131.2	125.5	74.99	2.580	27.21	98.29	0.05778	0.1963
60	141.9	136.0	74.28	2.798	28.75	98.71	0.06071	0.1957
65	153.1	147.0	73.55	3.032	30.31	99.13	0.06364	0.1952
70	165.0	158.7	72.81	3.283	31.88	99.52	0.06657	0.1946
75	177.6	171.1	72.05	3.552	33.47	99.89	0.06949	0.1940
80	190.8	184.1	71.27	3.840	35.08	100.2	0.07242	0.1935
85	204.8	197.9	70.47	4.149	36.70	100.6	0.07525	0.1929
90	219.5	212.5	69.64	4.482	38.35	100.9	0.07828	0.1923
95	235.0	227.8	68.80	4.839	40.01	101.2	0.08123	0.1917
100	251.3	243.9	67.92	5.224	41.70	101.4	0.08418	0.1911
105	268.4	260.9	67.02	5.638	43.42	101.6	0.08715	0.1904
110	286.3	278.7	66.08	6.086	45.16	101.8	0.09013	0.1898
115	305.2	297.4	65.11	6.572	46.94	101.9	0.09314	0.1891
120	324.9	317.1	64.09	7.099	48.74	102.0	0.09617	0.1883
125	345.6	337.7	63.03	7.674	50.59	102.1	0.09924	0.1875
130	367.3	359.3	61.91	8.303	52.48	102.1	0.1024	0.1866
135	390.0	382.0	60.73	8.996	54.42	102.0	0.1055	0.1856
140	413.7	405.7	59.47	9.764	56.41	101.8	0.1087	0.1846

R-403B

Physical Properties of Refrigerants	R-403B
Environmental Classification	HCFC
Molecular Weight	103.25
Boiling Point (1 atm, ˚F)	-46.8
Critical Pressure (psia)	637.7
Critical Temperature (˚F)	191.6
Critical Density, (lb./ft^ 3)	32.9
Liquid Density (70 ˚F, lb./ft ^ 3)	72.8
Vapor Density (bp, lb./ft ^ 3)	0.35
Heat of Vaporization (bp, BTU/lb.)	82.1
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.313
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.182
Ozone Depletion Potential (CFC 11 = 1.0)	0.028
Global Warming Potential (CO_2 = 1.0)	4460
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F) (see section 2)	2

Available in the following sizes

R-403B
25 LB. CYLINDER
110 LB. CYLINDER

R-403B

(R-290/22/218)
(5 / 56 / 39 wt%)

Replaces: R-13B1

Applications: Very low temperature single-stage refrigeration

Performance:
- Evaporator operates in a vacuum when the low side temperature is below -55˚F
- Capillary tube must be replaced with a longer/ more restrictive size

Lubricant Recommendation: Compatible with mineral and alkylbenzene oil. If oil return becomes a concern, addition of polyolester lubricant in 5% increments could help resolve the issue

Retrofitting: Follow equipment manufacturer's guidelines

Pressure-Temp Chart

Temp (˚F)	R-403B (psig)
-70	*10.5"*
-65	*7.8"*
-60	*4.5"*
-55	*1.2"*
-50	1.3
-45	3.3
-40	4.8
-35	7.4
-30	10.1
-25	13.2
-20	16.5
-15	20.1
-10	24.0
-5	28.2
0	32.8
5	37.7
10	43.0
15	48.7
20	54.9
25	61.4
30	68.4
35	75.9
40	84.8
45	93.3
50	102
55	112
60	122
65	132
70	144
75	156
80	168
85	181
90	195
95	210
100	225
105	242
110	258
115	276
120	295

THERMODYNAMIC PROPERTIES OF R-403B

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-70	9.7	9.4	88.22					
-65	11.0	10.8	87.65					
-60	12.6	12.3	87.07					
-55	14.2	14.0	86.50					
-50	16.1	15.8	85.92					
-45	18.1	17.8	85.35					
-40	20.2	19.5	84.77	0.470	4.23	82.89	0.02197	0.2087
-35	22.8	22.1	84.23	0.527	5.52	83.54	0.02501	0.2080
-30	25.6	24.8	83.69	0.590	6.83	84.18	0.02804	0.2073
-25	28.6	27.9	83.14	0.658	8.14	84.82	0.03105	0.2067
-20	32.0	31.2	82.58	0.731	9.46	85.46	0.03405	0.2062
-15	35.6	34.8	82.02	0.812	10.79	86.08	0.03703	0.2056
-10	39.5	38.7	81.45	0.898	12.13	86.70	0.03999	0.2051
-5	43.8	42.9	80.87	0.992	13.48	87.31	0.04294	0.2046
0	48.4	47.5	80.29	1.094	14.83	87.91	0.04587	0.2042
5	53.3	52.4	79.70	1.203	16.20	88.51	0.04880	0.2037
10	58.6	57.7	79.10	1.321	17.58	89.09	0.05171	0.2033
15	64.4	63.4	78.49	1.448	18.96	89.66	0.05460	0.2029
20	70.5	69.6	77.87	1.584	20.36	90.22	0.05749	0.2025
25	77.1	76.1	77.25	1.730	21.76	90.78	0.06036	0.2021
30	84.1	83.1	76.61	1.888	23.18	91.31	0.06322	0.2018
35	91.6	90.6	75.96	2.056	24.61	91.84	0.06608	0.2014
40	99.5	98.5	75.30	2.237	26.04	92.35	0.06892	0.2011
45	108.0	107.0	74.63	2.431	27.49	92.85	0.07176	0.2007
50	117.0	116.0	73.94	2.638	28.95	93.33	0.07458	0.2004
55	126.6	125.5	73.24	2.860	30.43	93.80	0.07740	0.2000
60	136.7	135.6	72.53	3.098	31.91	94.25	0.08022	0.1997
65	147.4	146.3	71.80	3.352	33.41	94.68	0.09303	0.1993
70	158.7	157.6	71.06	3.624	34.92	95.09	0.08583	0.1990
75	170.6	169.5	70.29	3.915	36.45	95.48	0.08863	0.1986
80	183.2	182.1	69.51	4.227	37.99	95.85	0.09143	0.1982
85	196.4	195.3	68.71	4.560	39.55	96.20	0.09423	0.1978
90	210.4	209.2	67.89	4.918	41.12	96.53	0.09702	0.1974
95	225.0	223.9	67.05	5.301	42.71	96.83	0.09982	0.1970
100	240.4	239.2	66.18	5.711	44.32	97.10	0.1026	0.1966
105	256.5	255.3	65.29	6.153	45.94	97.34	0.1054	0.1961
110	273.4	272.2	64.37	6.627	47.59	97.55	0.1082	0.1956
115	291.0	289.9	63.41	7.138	49.26	97.73	0.1111	0.1951
120	309.5	308.3	62.43	7.689	50.95	97.87	0.1139	0.1946

R-404A

Physical Properties of Refrigerants	R-404A
Environmental Classification	HFC
Molecular Weight	97.6
Boiling Point (1 atm, ˚F)	-51.8
Critical Pressure (psia)	548.2
Critical Temperature (˚F)	162.5
Critical Density, (lb./ft^ 3)	35.84
Liquid Density (70 ˚F, lb./ft ^ 3)	66.37
Vapor Density (bp, lb./ft ^ 3)	0.342
Heat of Vaporization (bp, BTU/lb.)	86.1
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3600
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.2077
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	3920
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F) (see section 2)	1.5

Available in the following sizes

R-404A
24 LB. CYLINDER
100 LB. CYLINDER
800 LB. CYLINDER
1300 LB. CYLINDER

R-404A

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

Replaces: R-22 & R-502

Applications: Medium and low temperature commercial and industrial direct expansion refrigeration and ice machines

Performance:
- Similar PT and flow properties to R-502
- Higher capacity than R-22, therefore requires TXV change

Lubricant Recommendation: Compatible with polyolester lubricant

Retrofitting:
Replacement for R-502 page 99
Replacement for R-22 page 96

Pressure-Temp Chart

Temp (˚F)	R-404A psig
-40	4.3
-35	6.8
-30	9.5
-25	12.5
-20	15.7
-15	19.3
-10	23.2
-5	27.5
0	32.1
5	37.0
10	42.4
15	48.2
20	54.5
25	61.2
30	68.4
35	76.1
40	84.4
45	93.2
50	103
55	113
60	123
65	135
70	147
75	159
80	173
85	187
90	202
95	218
100	234
105	252
110	270
115	289
120	310
125	331
130	353
135	377
140	401

THERMODYNAMIC PROPERTIES OF R-404A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	11.8	11.3	82.53	0.2671	-5.913	81.19	-0.01439	0.2041
-55	13.5	13.0	82.01	0.3044	-4.447	81.92	-0.01075	0.2032
-50	15.4	14.9	81.48	0.3457	-2.973	82.64	-0.00714	0.2023
-45	17.6	16.9	80.94	0.3913	-1.490	83.36	-0.00356	0.2015
-40	19.9	19.3	80.40	0.4414	0.000	84.08	0.00000	0.2008
-35	22.5	21.8	79.86	0.4965	1.499	84.79	0.00354	0.2001
-30	25.4	24.6	79.31	0.5568	3.007	85.50	0.00705	0.1994
-25	28.5	27.7	78.75	0.6228	4.524	86.20	0.01054	0.1988
-20	31.9	31.0	78.19	0.6947	6.051	86.90	0.01402	0.1982
-15	35.6	34.7	77.62	0.7730	7.587	87.59	0.01747	0.1977
-10	39.7	38.7	77.05	0.8582	9.133	88.28	0.02091	0.1972
-5	44.1	43.0	76.46	0.9506	10.69	88.95	0.02433	0.1967
0	48.8	47.7	75.87	1.051	12.26	89.62	0.02773	0.1963
5	54.0	52.8	75.27	1.159	13.84	90.29	0.03112	0.1959
10	59.5	58.3	74.66	1.276	15.43	90.94	0.03449	0.1955
15	65.5	64.2	74.05	1.403	17.03	91.58	0.03785	0.1951
20	71.9	70.5	73.42	1.539	18.64	92.21	0.04120	0.1948
25	78.7	77.3	72.78	1.686	20.27	92.83	0.04454	0.1945
30	86.1	84.6	72.13	1.845	21.91	93.44	0.04787	0.1941
35	93.9	92.4	71.46	2.016	23.57	94.04	0.05120	0.1938
40	102.3	100.7	70.79	2.200	25.24	94.62	0.05451	0.1935
45	111.2	109.5	70.10	2.397	26.92	95.19	0.05782	0.1932
50	120.7	118.9	69.39	2.610	28.62	95.74	0.06113	0.1930
55	130.7	128.9	68.67	2.839	30.34	96.28	0.06443	0.1927
60	141.4	139.6	67.93	3.086	32.08	96.80	0.06774	0.1924
65	152.8	150.8	67.16	3.352	33.84	97.29	0.07104	0.1921
70	164.7	162.8	66.38	3.638	35.62	97.76	0.07435	0.1918
75	177.4	175.4	65.58	3.947	37.42	98.21	0.07767	0.1915
80	190.8	188.8	64.75	4.281	39.24	98.63	0.08099	0.1911
85	204.9	202.8	63.89	4.642	41.09	99.03	0.08433	0.1908
90	219.9	217.7	62.99	5.033	42.97	99.39	0.08768	0.1904
95	235.6	233.4	62.07	5.458	44.87	99.71	0.09105	0.1900
100	252.1	249.9	61.10	5.921	46.81	100.0	0.09444	0.1895
105	269.5	267.3	60.09	6.426	48.79	100.2	0.09786	0.1890
110	287.8	285.5	59.03	6.981	50.81	100.4	0.1013	0.1884
115	307.0	304.7	57.91	7.592	52.88	100.5	0.1048	0.1878
120	327.2	324.9	56.73	8.271	54.99	100.6	0.1084	0.1870
125	384.4	346.1	55.46	9.029	57.18	100.5	0.1120	0.1862
130	370.6	368.4	54.08	9.886	59.43	100.4	0.1157	0.1852
135	394.0	391.8	52.58	10.87	61.79	100.1	0.1196	0.1840
140	418.5	416.4	50.92	12.01	64.26	99.60	0.1236	0.1825
145	444.3	442.3	49.01	13.39	66.9	98.89	0.1278	0.1807
150	471.4	469.6	46.73	15.13	69.81	97.78	0.1324	0.1783
155	500.0	498.4	43.74	17.55	73.21	95.98	0.1378	0.1748

Physical Properties of Refrigerants	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
Vapor Density (bp, lb./ft ^ 3)	0.291
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) (see section 2)	10

Available in the following sizes

R-407A
25 LB. CYLINDER
100 LB. CYLINDER
925 LB. CYLINDER
1550 LB. CYLINDER

R-407A

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

Replaces: R-22

Applications: Medium and low temperature commercial and industrial direct expansion refrigeration

Performance:
- Slightly lower discharge temperature
- Closest capacity match
- Similar PT and flow properties = no component changes

Lubricant Recommendation: Compatible with polyolester lubricant

Retrofitting to: R-407A in R-22 Refrigeration page 94

Pressure-Temp Chart

Temp (˚F)	R-407A Liquid (psig)	R-407A 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

THERMODYNAMIC PROPERTIES OF R-407A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	10.8	7.6	88.81	0.164	-6.1454	95.41	-0.01496	0.2434
-55	12.5	8.9	88.26	0.189	-4.6163	96.12	-0.01117	0.2418
-50	14.3	10.3	87.72	0.218	-3.0826	96.82	-0.00741	0.2404
-45	16.4	11.9	87.17	0.250	-1.5440	97.52	0.00369	0.2390
-40	18.6	13.7	86.61	0.285	0.000	98.21	0.00000	0.2376
-35	21.1	15.7	86.05	0.325	1.5496	98.90	0.00366	0.2364
-30	23.9	18.0	85.49	0.368	3.1052	99.59	0.00729	0.2351
-25	26.9	20.4	84.92	0.416	4.6672	100.3	0.01088	0.2340
-20	30.3	23.2	84.35	0.469	6.2358	100.9	0.01446	0.2329
-15	33.9	26.2	83.77	0.527	7.8114	101.6	0.01800	0.2319
-10	37.9	29.6	83.18	0.591	9.3945	102.3	0.02152	0.2309
-5	42.2	33.2	82.59	0.660	10.99	102.9	0.02502	0.2299
0	46.9	37.2	81.99	0.736	12.58	103.6	0.02849	0.2290
5	52.0	41.6	81.39	0.818	14.19	104.2	0.03195	0.2281
10	57.5	46.3	80.77	0.908	15.81	104.8	0.03538	0.2273
15	63.4	51.4	80.15	1.005	17.44	105.4	0.03880	0.2264
20	69.8	57.0	79.52	1.111	19.07	106.0	0.04219	0.2257
25	76.7	63.0	78.88	1.225	20.72	106.6	0.04558	0.2249
30	84.0	69.5	78.23	1.349	22.38	107.2	0.04894	0.2242
35	91.9	76.5	77.57	1.482	24.05	107.8	0.05230	0.2235
40	100	84.1	76.90	1.626	25.73	108.3	0.05564	0.2228
45	109	92.1	76.21	1.782	27.42	108.9	0.05897	0.2221
50	119	101	75.52	1.949	29.13	109.4	0.06229	0.2214
55	129	110	74.81	2.130	30.85	109.9	0.06561	0.2208
60	140	120	74.08	2.325	32.59	110.4	0.06892	0.2202
65	151	130	73.34	2.534	34.35	110.9	0.07222	0.2195
70	164	142	72.58	2.760	36.12	111.3	0.07552	0.2189
75	176	154	71.80	3.003	37.91	111.7	0.07882	0.2182
80	190	166	71.01	3.265	39.72	112.1	0.08213	0.2176
85	204	180	70.19	3.548	41.55	112.5	0.08543	0.2169
90	220	194	69.34	3.853	43.40	112.9	0.08874	0.2163
95	236	209	68.48	4.183	45.27	113.2	0.09206	0.2156
100	252	225	67.58	4.539	47.17	113.4	0.09539	0.2148
105	270	242	66.65	4.925	49.10	113.7	0.09874	0.2141
110	289	260	65.69	5.345	51.06	113.9	0.1021	0.2133
115	308	279	64.69	5.801	53.06	114.1	0.1055	0.2125
120	329	299	63.64	6.298	55.09	114.2	0.1089	0.2116
125	350	320	62.55	6.843	57.16	114.2	0.1124	0.2107
130	373	342	61.39	7.443	59.28	114.2	0.1159	0.2097
135	396	365	60.17	8.106	61.45	114.1	0.1194	0.2086
140	421	390	58.87	8.843	63.69	113.9	0.1230	0.2074

R-407C

Physical Properties of Refrigerants	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) (see section 2)	10

Available in the following sizes

R-407C
25 LB. CYLINDER
115 LB. CYLINDER
925 LB. CYLINDER
1550 LB. CYLINDER

R-407C

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

Replaces: R-22

Applications: Medium temperature commercial and industrial direct expansion refrigeration and A/C

Performance:
- Slightly lower discharge temperature
- Closest capacity match
- Similar PT and flow properties = no component changes

Lubricant Recommendation: Compatible with polyolester lubricant

Retrofitting to:
R-407C in R-22 Refrigeration page 94
R-407C in R-22 Air Conditioning page 94

Pressure-Temp Chart

Temp (˚F)	R-407C Liquid (psig)	R-407C 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*

THERMODYNAMIC PROPERTIES OF R-407C

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	10.2	6.9	87.66	0.1418	-6.192	100.9	-0.01508	0.2575
-55	11.8	8.0	87.14	0.1641	-4.653	101.6	-0.01126	0.2558
-50	13.5	9.4	86.61	0.1890	-3.108	102.3	-0.00747	0.2542
-45	15.4	10.8	86.08	0.2169	-1.557	103.0	-0.00372	0.2527
-40	17.6	12.5	85.55	0.2480	0.000	103.7	-0.00000	0.2512
-35	19.9	14.3	85.01	02825	1.564	104.4	0.00369	0.2498
-30	226	16.4	84.46	0.3206	3.134	105.1	0.00735	0.2484
-25	25.4	18.7	83.91	0.3628	4.711	105.8	0.01099	0.2472
-20	28.6	21.2	83.36	0.4092	6.296	106.5	0.01460	0.2459
-15	32.0	24.0	82.80	0.4602	7.888	107.2	0.01818	0.2448
-10	35.8	27.1	82.23	0.5160	9.488	107.9	0.02174	0.2437
-5	39.9	30.5	81.66	0.5771	11.10	108.5	0.02528	0.2426
0	44.3	34.2	81.08	0.6438	12.71	109.2	0.02879	0.2416
5	49.1	38.3	80.50	0.7164	14.34	109.8	0.03229	0.2406
10	54.3	42.7	79.90	0.7954	15.97	110.5	0.03576	0.2396
15	59.9	47.4	79.30	0.8812	17.62	111.1	0.03922	0.2387
20	66.0	52.6	78.70	0.9742	19.27	111.7	0.04265	0.2378
25	72.5	58.3	78.08	1.075	20.94	112.3	0.04608	0.2370
30	79.4	64.3	77.46	1.184	22.62	112.9	0.04948	0.2361
35	86.9	70.9	76.82	1.302	24.30	113.5	0.05288	0.2353
40	94.9	77.9	76.18	1.429	26.00	114.1	0.05626	0.2346
45	103.4	85.4	75.52	1.566	27.72	114.6	0.05963	0.2338
50	112.5	93.5	74.85	1.714	29.44	115.1	0.06298	0.2331
55	122.2	102.2	74.18	1.873	31.18	115.7	0.06633	0.2323
60	132.4	111.5	73.48	2.044	32.94	116.2	0.06968	0.2316
65	143.4	121.4	72.78	2.229	34.71	116.7	0.07301	0.2309
70	154.9	131.9	72.06	2.428	36.49	117.1	0.07635	0.2302
75	167.2	143.1	71.32	2.642	38.30	117.6	0.07968	0.2295
80	180.2	155.1	70.57	2.872	40.12	118.0	0.08301	0.2288
85	193.8	167.7	69.80	3.120	41.96	118.4	0.08634	0.2281
90	208.3	181.2	69.00	3.387	43.82	118.8	0.08967	0.2274
95	223.5	195.4	68.19	3.675	45.71	119.1	0.09301	0.2266
100	239.6	210.5	67.35	3.985	47.62	119.4	0.09636	0.2259
105	256.5	226.5	66.48	4.321	49.55	119.7	0.09972	0.2251
110	274.3	243.4	65.59	4.684	51.52	120.0	0.1031	0.2243
115	292.9	261.2	64.66	5.078	53.51	120.2	0.1065	0.2235
120	312.5	280.0	63.70	5.505	55.54	120.3	0.1099	0.2226
125	333.0	299.9	62.70	5.971	57.60	120.4	0.1133	0.2217
130	354.6	320.8	61.65	6.479	59.71	120.5	0.1168	0.2208
135	377.1	342.9	60.55	7.037	61.86	120.5	0.1203	0.2197
140	400.7	366.1	59.39	7.652	64.06	120.4	0.1239	0.2186

R-408A

Physical Properties of Refrigerants	R-408A
Environmental Classification	HCFC
Molecular Weight	87
Boiling Point (1 atm, ˚F)	-49.8
Critical Pressure (psia)	641.6
Critical Temperature (˚F)	182
Critical Density, (lb./ft^ 3)	30
Liquid Density (70 ˚F, lb./ft ^ 3)	66.9
Vapor Density (bp, lb./ft ^ 3)	0.303
Heat of Vaporization (bp, BTU/lb.)	96.74
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3416
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1901
Ozone Depletion Potential (CFC 11 = 1.0)	0.024
Global Warming Potential (CO_2 = 1.0)	3152
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F) (see section 2)	1

Available in the following sizes

R-408A
24 LB. CYLINDER
100 LB. CYLINDER

R-408A (R-125/143a/22) (7 / 46 / 47 wt%)

Replaces: R-502

Applications: Medium and low temperature commercial and industrial direct expansion refrigeration

Performance:
- Similar PT properties across the whole operating range of temperatures
- Slightly higher discharge temp

Lubricant Recommendation: Compatible with mineral oil, alkylbenzene and polyolester lubricant

Retrofitting:

from R-502 page 98
to R-422C page 100

Pressure-Temp Chart

Temp (˚F)	R-408A (psig)
-40	2.8
-35	5.1
-30	7.6
-25	10.4
-20	13.5
-15	16.8
-10	20.4
-5	24.4
0	28.7
5	33.3
10	38.3
15	43.7
20	49.5
25	55.8
30	62.5
35	69.7
40	77.4
45	85.6
50	94.3
55	104
60	114
65	124
70	135
75	147
80	159
85	173
90	186
95	201
100	217
105	233
110	250
115	268
120	287
125	307
130	327
135	349
140	372

THERMODYNAMIC PROPERTIES OF R-408A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	11.2	10.9	81.70	0.2288	-5.734	92.47	-0.01396	0.2320
-55	12.8	12.5	81.21	0.2604	-4.311	93.14	-0.01043	0.2306
-50	14.6	14.3	80.72	0.2954	-2.881	93.79	-0.00692	0.2293
-45	16.7	16.3	80.22	0.3339	-1.444	94.45	-0.00345	0.2280
-40	18.9	18.5	79.72	0.3763	0.000	95.10	0.00000	0.2268
-35	21.4	21.0	79.21	0.4228	1.451	95.74	0.00342	0.2257
-30	24.1	23.7	78.70	0.4736	2.910	96.38	0.00682	0.2246
-25	27.1	26.6	78.18	0.5291	4.376	97.01	0.01020	0.2235
-20	30.3	29.8	77.65	0.5896	5.851	97.64	0.01356	0.2225
-15	33.9	33.3	77.13	0.6554	7.334	98.26	0.01689	0.2215
-10	37.7	37.1	76.59	0.7268	8.826	98.87	0.02021	0.2206
-5	41.9	41.3	76.05	0.8042	10.33	99.47	0.02350	02197
0	46.4	45.8	75.50	0.8879	11.84	100.1	0.02678	0.2189
5	51.3	50.7	74.95	0.9784	13.36	100.7	0.03005	0.2181
10	56.6	55.9	74.39	1.076	14.89	101.2	0.03329	0.2173
15	62.3	61.5	73.82	1.181	16.43	101.8	0.03653	0.2165
20	68.4	67.6	73.24	1.295	17.98	102.4	0.03975	0.2158
25	74.9	74.1	72.65	1.416	19.54	102.9	0.04295	0.2150
30	81.9	81.1	72.06	1.547	21.12	103.4	0.04615	0.2143
35	89.4	88.5	71.45	1.688	22.71	103.9	0.04934	0.2137
40	97.4	96.5	70.84	1.839	24.31	104.4	0.05251	0.2130
45	105.9	104.9	70.21	2.001	25.92	104.9	0.05568	0.2124
50	115.0	113.9	69.58	2.175	27.55	105.4	0.05885	0.2117
55	124.6	123.5	68.93	2.361	29.19	105.9	0.06200	0.2111
60	134.8	133.7	68.26	2.561	30.85	106.3	0.06516	0.2105
65	145.6	144.5	67.59	2.775	32.52	106.7	0.06831	0.2098
70	157.1	155.9	66.90	3.005	34.22	107.1	0.07146	0.2092
75	169.2	167.9	66.19	3.251	35.93	107.5	0.07461	0.2086
80	181.9	180.7	65.46	3.515	37.66	107.9	0.07776	0.2079
85	195.4	194.1	64.72	3.799	39.41	108.2	0.08092	0.2073
90	209.6	208.3	63.95	4.104	41.18	108.5	0.08409	0.2066
95	224.6	223.2	63.16	4.433	42.98	108.8	0.08726	0.2060
100	240.3	238.9	62.34	4.787	44.80	109.0	0.09045	0.2052
105	256.9	255.5	61.50	5.169	46.65	109.2	0.09365	0.2045
110	274.3	272.8	60.62	5.583	48.53	109.4	0.09688	0.2037
115	292.6	291.1	59.71	6.031	50.45	109.5	0.1001	0.2029
120	311.7	310.2	58.76	6.520	52.40	109.6	0.1034	0.2021
125	331.8	330.3	57.76	7.053	54.40	109.6	0.1067	0.2012
130	352.8	351.3	56.71	7.638	56.44	109.5	0.1101	0.2002
135	374.9	373.3	55.60	8.284	58.54	109.4	0.1135	0.1991
140	398.0	396.4	54.41	9.002	60.71	109.2	0.1170	0.1979

R-409A

Physical Properties of Refrigerants	R-409A
Environmental Classification	HCFC
Molecular Weight	97.4
Boiling Point (1 atm, ˚F)	-31.8
Critical Pressure (psia)	680.7
Critical Temperature (˚F)	224.4
Critical Density, (lb./ft^ 3)	31.7
Liquid Density (70 ˚F, lb./ft ^ 3)	76.1
Vapor Density (bp, lb./ft ^ 3)	0.313
Heat of Vaporization (bp, BTU/lb.)	94.75
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.2908
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1685
Ozone Depletion Potential (CFC 11 = 1.0)	0.047
Global Warming Potential (CO_2 = 1.0)	1585
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F) (see section 2)	13

Available in the following sizes

R-409A
30 LB. CYLINDER
125 LB. CYLINDER

R-409A

(R-22 /124/142b)
(60 / 25 / 15 wt%)

Replaces: R-12 and R-500

Applications: Medium and low temperature commercial and industrial direct expansion refrigeration and non-centrifugal air conditioning

Performance:
- Pressure and system capacity match R-12 when operating at an average evaporator temperature 10˚F to 20˚F.
- Discharge pressure and temperature are higher than R-12
- Capacity match to R-500 at air conditioning temperatures

Lubricant Recommendation: Compatible with mineral oil, alkylbenzene and polyolester lubricant

Retrofitting: from R-12 page 90, 92
from R-500 page 97

Pressure-Temp Chart

Temp (˚F)	R-409A Liquid (psig)	R-409A Vapor (psig)
-30	*0.2″*	*9.8″*
-25	1.8	*7.0″*
-20	3.9	*3.8″*
-15	6.2	*0.3″*
-10	8.7	1.7
-5	11.4	3.8
0	14.4	6.1
5	17.6	8.6
10	21.1	11.4
15	24.9	14.4
20	29.0	17.6
25	33.4	21.2
30	38.1	25.0
35	43.2	29.2
40	48.6	33.6
45	54.4	38.5
50	60.6	43.6
55	67.2	49.2
60	74.2	55.2
65	81.7	61.5
70	89.6	68.4
75	98.0	75.6
80	107	83.4
85	116	91.6
90	126	100
95	137	110
100	148	120
105	159	130
110	172	141
115	184	153
120	198	165
125	212	178
130	227	192
135	242	207
140	258	222

THERMODYNAMIC PROPERTIES OF R-409A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-40	11.9	8.0	87.87	0.1779	0.000	94.00	0.00000	0.2287
-35	13.6	9.3	87.38	0.2030	1.295	94.64	0.00306	0.2274
-30	15.4	10.6	86.90	0.2308	2.594	95.28	0.00609	0.2262
-25	17.4	12.1	86.41	0.2616	3.899	95.92	0.00910	0.2250
-20	19.5	13.8	85.92	0.2954	5.209	96.55	0.01209	0.2239
-15	21.9	15.7	85.42	0.3326	6.524	97.18	0.01505	0.2229
-10	24.6	17.7	84.92	0.3734	7.846	97.81	0.01799	0.2219
-5	27.4	20.0	84.41	0.4180	9.174	98.43	0.02092	0.2209
0	30.5	22.5	83.90	0.4666	10.51	99.05	0.02382	0.2200
5	33.9	25.2	83.38	0.5196	11.85	99.67	0.02670	0.2191
10	37.5	28.2	82.86	0.5771	13.20	100.3	0.02957	0.2182
15	41.5	31.4	82.34	0.6395	14.55	100.9	0.03242	0.2174
20	45.7	34.9	81.80	0.7070	15.91	101.5	0.03525	0.2167
25	50.3	38.7	81.26	0.7800	17.28	102.1	0.03807	0.2159
30	55.2	42.8	80.72	0.8588	18.66	102.6	0.04088	0.2152
35	60.5	47.3	80.17	0.9437	20.05	103.2	0.04367	0.2145
40	66.1	52.0	79.61	1.035	21.44	103.8	0.04645	0.2139
45	72.1	57.2	79.04	1.133	22.84	104.4	0.04921	0.2132
50	78.5	62.7	78.47	1.239	24.25	104.9	0.05197	0.2126
55	85.4	68.6	77.89	1.352	25.67	105.5	0.05471	0.2120
60	92.6	74.9	77.30	1.473	27.11	106.0	0.05744	0.2115
65	100.3	81.7	76.70	1.603	28.55	106.5	0.06017	0.2109
70	108.5	88.9	76.09	1.742	30.00	107.0	0.06288	0.2104
75	117.2	96.6	75.48	1.891	31.46	107.5	0.06559	0.2099
80	126.3	104.8	74.85	2.050	32.93	108.0	0.06829	0.2093
85	136.0	113.4	74.21	2.219	34.42	108.5	0.07089	0.2088
90	146.2	122.7	73.56	2.401	35.92	109.0	0.07367	0.2083
95	157.0	132.4	72.90	2.594	37.43	109.4	0.07636	0.2078
100	168.3	142.7	72.22	2.801	38.95	109.9	0.07904	0.2074
105	180.2	153.7	71.54	3.022	40.49	110.3	0.08172	0.2069
110	192.7	165.2	70.83	3.258	42.04	110.7	0.08440	0.2064
115	205.9	177.4	70.11	3.510	43.61	111.1	0.08708	0.2059
120	219.6	190.2	69.38	3.779	45.19	111.4	0.08977	0.2054
125	234.1	203.7	68.62	4.068	46.80	111.8	0.09245	0.2049
130	249.2	217.9	67.85	4.376	48.42	112.1	0.09515	0.2043
135	265.0	232.9	67.05	4.707	50.06	112.4	0.09785	0.2038
140	281.5	248.6	66.22	5.062	51.72	112.6	0.1006	0.2033
145	298.8	265.1	65.38	5.443	53.41	112.9	0.1033	0.2027
150	316.8	282.5	64.50	5.853	55.13	113.1	0.1060	0.2021
155	335.6	300.7	63.58	6.296	56.87	113.2	0.1088	0.2014
160	355.2	319.8	62.63	6.775	58.65	113.4	0.1116	0.2008

R-410A

Physical Properties of Refrigerants	R-410A
Environmental Classification	HFC
Molecular Weight	72.6
Boiling Point (1 atm, ˚F)	-61
Critical Pressure (psia)	691.8
Critical Temperature (˚F)	158.3
Critical Density, (lb./ft^ 3)	34.5
Liquid Density (70 ˚F, lb./ft ^ 3)	67.74
Vapor Density (bp, lb./ft ^ 3)	0.261
Heat of Vaporization (bp, BTU/lb.)	116.8
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3948
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1953
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	2088
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F) (see section 2)	0.2

Available in the following sizes

R-410A
25LB. CYLINDER
100 LB. CYLINDER
850LB. CYLINDER
1450 LB. CYLINDER

R-410A

(R-32/125)
(50 / 50 wt%)

Replaces: R-22

Applications: Air conditioning equipment and heat pumps. Only for newly manufactured equipment, not for retrofitting R-22 systems

Performance: Presures are 60% higher than R-22, therefore should be used only in new equipment

Lubricant Recommendation: Compatible with polyolester lubricant

Retrofitting: For new equipment only

Pressure-Temp Chart

Temp (˚F)	R-410A psig
-40	11.6
-35	14.9
-30	18.5
-25	22.5
-20	26.9
-15	31.7
-10	36.8
-5	42.5
0	48.6
5	55.2
10	62.3
15	70.0
20	78.3
25	87.3
30	96.8
35	107
40	118
45	130
50	142
55	155
60	170
65	185
70	201
75	217
80	235
85	254
90	274
95	295
100	317
105	340
110	365
115	391
120	418
125	446
130	476
135	507
140	539
145	573
150	608

THERMODYNAMIC PROPERTIES OF R-410A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-40	25.6	25.5	82.02	0.4384	0.000	112.5	0.00000	0.2682
-35	28.9	28.9	81.45	0.4929	1.648	113.1	0.00389	0.2664
-30	32.6	32.6	80.88	0.5526	3.303	113.7	0.00774	0.2647
-25	36.7	36.6	80.30	0.6179	4.967	114.3	0.01157	0.2631
-20	41.1	41.0	79.71	0.6892	6.640	114.8	0.01537	0.2615
-15	46.0	45.8	79.12	0.7669	8.321	115.4	0.01915	0.2599
-10	51.2	51.1	78.51	0.8514	10.01	115.9	0.02290	0.2584
-5	56.9	56.8	77.91	0.9431	11.71	116.4	0.02663	0.2570
0	63.1	63.0	77.29	1.043	13.42	116.9	0.03035	0.2555
5	69.8	69.7	76.66	1.151	15.15	117.4	0.03404	0.2541
10	77.1	76.9	76.03	1.267	16.88	117.9	0.03771	0.2528
15	84.9	84.6	75.38	1.394	18.63	118.3	0.04137	0.2514
20	93.2	93.0	74.73	1.530	20.39	118.8	0.04502	0.2501
25	102.2	101.9	74.06	1.677	22.16	119.2	0.04865	0.2488
30	111.9	111.5	73.38	1.836	23.95	119.6	0.05227	0.2476
35	122.2	121.8	72.69	2.007	25.75	119.9	0.05588	0.2463
40	133.2	132.8	71.99	2.192	27.58	120.3	0.05949	0.2451
45	144.9	144.5	71.27	2.391	29.41	120.6	0.06309	0.2438
50	157.4	156.9	70.53	2.606	31.27	120.9	0.06668	0.2426
55	170.7	170.2	69.78	2.838	33.14	121.2	0.07028	0.2413
60	184.8	184.3	69.01	3.088	35.04	121.4	0.07387	0.2401
65	199.8	199.2	68.22	3.357	36.96	121.6	0.07747	0.2388
70	215.7	215.1	67.41	3.648	38.90	121.8	0.08107	0.2376
75	232.5	231.8	66.58	3.963	40.87	121.9	0.08469	0.2363
80	250.3	249.6	65.71	4.304	42.87	122.0	0.08832	0.2350
85	269.1	268.3	64.82	4.674	44.90	122.0	0.09196	0.2336
90	289.0	288.2	63.90	5.075	46.96	122.0	0.09562	0.2322
95	310.0	309.1	62.95	5.513	49.06	122.0	0.09932	0.2308
100	332.0	331.1	61.95	5.990	51.21	121.8	0.1030	0.2293
105	355.3	354.3	60.90	6.513	53.39	121.6	0.1068	0.2277
110	379.8	378.8	59.81	7.089	55.63	121.4	0.1106	0.2261
115	405.6	404.5	58.65	7.725	57.93	121.0	0.1145	0.2243
120	432.7	431.6	57.42	8.434	60.30	120.5	0.1185	0.2224
125	461.2	460.1	56.11	9.230	62.76	119.9	0.1225	0.2203
130	491.2	490.1	54.68	10.13	65.31	119.2	0.1267	0.2180
135	522.7	521.6	53.12	11.17	67.99	118.2	0.1310	0.2155
140	555.9	554.8	51.38	12.40	70.84	117.0	0.1356	0.2125

R-414B

Physical Properties of Refrigerants	R-414B
Environmental Classification	HCFC
Molecular Weight	101.6
Boiling Point (1 atm, ˚F)	-29.9
Critical Pressure (psia)	665.4
Critical Temperature (˚F)	226.4
Critical Density, (lb./ft^ 3)	31.6
Liquid Density (70 ˚F, lb./ft ^ 3)	76.02
Vapor Density (bp, lb./ft ^ 3)	0.325
Heat of Vaporization (bp, BTU/lb.)	91.5
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.2913
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1723
Ozone Depletion Potential (CFC 11 = 1.0)	0.043
Global Warming Potential (CO_2 = 1.0)	1365
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F) (see section 2)	13

Available in the following sizes

R-414B
25 LB. CYLINDER

R-414B

(R-22 /124 /600a /142b)
(50 / 39 / 1.5 / 9.5 wt%)

Replaces: R-12 and R-500

Applications: Medium and low temperature commercial and industrial direct expansion refrigeration and stationary and automotive air-conditioning

Performance:
- Pressure and capacity match R-12 in 30˚F to 40˚F evaporators
- Slightly higher discharge pressure

Lubricant Recommendation: Compatible with mineral oil, alkylbenzene and polyolester lubricant

Retrofitting: from R-12 page 90, 92
from R-500 page 97

Pressure-Temp Chart

Temp (˚F)	R-414B Liquid (psig)	R-414B Vapor (psig)
-30	0.0	*9.7″*
-25	1.9	*6.8″*
-20	4.0	*3.6″*
-15	6.3	0.0
-10	8.8	2.0
-5	11.5	4.1
0	14.5	6.5
5	17.7	9.0
10	21.2	11.9
15	25.0	14.9
20	29.0	18.3
25	33.4	21.9
30	38.1	25.8
35	43.1	30.0
40	48.5	34.6
45	54.3	39.5
50	60.4	44.8
55	67.0	50.4
60	73.9	56.5
65	81.3	62.9
70	89.1	69.8
75	97.4	77.1
80	106	85.0
85	116	93.3
90	125	102
95	136	111
100	146	121
105	158	132
110	170	143
115	183	155
120	196	167
125	210	180
130	224	193
135	239	208
140	255	223
145	272	239
150	289	255

THERMODYNAMIC PROPERTIES OF R-414B

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-40	11.4	7.5	87.77	0.1727	0.000	90.85	0.00000	0.2212
-35	12.9	8.6	87.29	0.1973	1.298	91.51	0.00307	0.2200
-30	14.7	9.9	86.81	0.2247	2.601	92.17	0.00611	0.2189
-25	16.6	11.4	86.32	0.2549	3.909	92.83	0.00913	0.2179
-20	18.7	12.9	85.83	0.2883	5.222	93.48	0.01212	0.2169
-15	21.0	14.7	85.33	0.3250	6.542	94.13	0.01509	0.2159
-10	23.5	16.7	84.83	0.3652	7.867	94.78	0.01804	0.2151
-5	26.2	18.8	84.32	0.4093	9.198	95.43	0.02098	0.2142
0	29.2	21.2	83.81	0.4573	10.54	96.07	0.02389	0.2134
5	32.4	23.7	83.30	0.5097	11.88	96.71	0.02678	0.2127
10	35.9	26.6	82.78	0.5666	13.23	97.34	0.02966	0.2119
15	39.7	29.6	82.25	0.6284	14.59	97.97	0.03251	0.2112
20	43.7	33.0	81.72	0.6953	15.96	98.59	0.03536	0.2106
25	48.1	36.6	81.18	0.7677	17.33	99.21	0.03818	0.2100
30	52.8	40.5	80.64	0.8458	18.71	99.82	0.04100	0.2094
35	57.8	44.7	80.09	0.9300	20.10	100.4	0.04379	0.2088
40	63.2	49.3	79.53	1.021	21.49	101.0	0.04658	0.2083
45	69.0	54.2	78.96	1.118	22.90	101.6	0.04935	0.2078
50	75.1	59.5	78.39	1.223	24.32	102.2	0.05211	0.2073
55	81.7	65.1	77.81	1.335	25.74	102.8	0.05486	0.2068
60	88.6	71.2	77.23	1.456	27.17	103.3	0.05760	0.2063
65	96.0	77.6	76.63	1.585	28.62	103.9	0.06033	0.2059
70	103.8	84.5	76.02	1.723	30.07	104.4	0.06305	0.2055
75	112.1	91.8	75.41	1.871	31.53	105.0	0.06577	0.2051
80	120.9	99.7	74.78	2.029	33.01	105.5	0.06847	0.2047
85	130.2	108.0	74.15	2.198	34.50	106.0	0.07117	0.2043
90	140.0	116.8	73.50	2.379	35.99	106.5	0.07387	0.2039
95	150.3	126.1	72.84	2.572	37.51	107.0	0.07656	0.2035
100	161.1	136.0	72.17	2.778	39.03	107.5	0.07924	0.2031
105	172.5	146.5	71.48	2.998	40.57	107.9	0.08193	0.2027
110	184.6	157.5	70.78	3.233	42.12	108.4	0.08461	0.2024
115	197.2	169.2	70.06	3.484	43.69	108.8	0.08729	0.2020
120	210.4	181.5	69.33	3.753	45.28	109.2	0.08998	0.2016
125	224.2	194.4	68.57	4.040	46.88	109.6	0.09267	0.2012
130	238.7	208.1	67.80	4.348	48.50	110.0	0.09536	0.2008
135	253.9	222.4	67.00	4.677	50.14	110.3	0.09806	0.2004
140	269.7	237.5	66.18	5.031	51.80	110.6	0.1008	0.1999
145	286.3	253.3	65.34	5.412	53.49	110.9	0.1035	0.1995
150	303.6	270.0	64.46	5.821	55.20	111.1	0.1062	0.1990
155	321.7	287.4	63.55	6.263	56.94	111.4	0.1090	0.1984
160	340.5	305.7	62.60	6.741	58.71	111.5	0.1118	0.1979

R-416A

Physical Properties of Refrigerants	R-416A
Environmental Classification	HCFC
Molecular Weight	111.9
Boiling Point (1 atm, ˚F)	-10
Critical Pressure (psia)	582
Critical Temperature (˚F)	227
Critical Density, (lb./ft^ 3)	32.3
Liquid Density (70 ˚F, lb./ft ^ 3)	77.68
Vapor Density (bp, lb./ft ^ 3)	0.354
Heat of Vaporization (bp, BTU/lb.)	85.51
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3139
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1949
Ozone Depletion Potential (CFC 11 = 1.0)	0.012
Global Warming Potential (CO_2 = 1.0)	1085
ASHRAE Standard 34 Safety Rating	A1
Temperature Glide (˚F) (see section 2)	3

Available in the following sizes

R-416A
25 LB. CYLINDER

R-416A

(R-134a /600/124)
(59 / 1.5 / 39.5 wt%)

Replaces: R-12

Applications: Automotive air conditioning and higher temperature refrigeration

Performance: Capacity matches R-12 at condenser temperatures; pressures in the evaporator will need to be a few psi lower than R-12 to maintain proper temperature

Lubricant Recommendation: Compatible with mineral oil, aklylbenzene and polyolester lubricant

Retrofitting: for R-12 page 90, 93

Pressure-Temp Chart

Temp (˚F)	R-416A Liquid (psig)	R-416A Vapor (psig)
-30	*12.1″*	*13.4″*
-25	*9.6″*	*11.0″*
-20	*6.7″*	*8.3″*
-15	*3.5″*	*5.3″*
-10	0.0	*2.0″*
-5	1.9	0.8
0	4.0	2.8
5	6.3	5.0
10	8.9	7.4
15	11.6	10.0
20	14.6	12.8
25	17.8	15.9
30	21.4	19.3
35	25.2	22.9
40	29.3	26.8
45	33.7	31.1
50	38.4	35.6
55	43.5	40.5
60	49.0	45.7
65	54.8	51.3
70	61.1	57.3
75	67.7	63.7
80	74.8	70.6
85	82.3	77.8
90	90.3	85.5
95	98.8	93.7
100	108	102
105	117	112
110	127	121
115	138	132
120	149	143
125	161	154
130	173	166
135	186	179
140	200	192
145	214	206
150	229	221

THERMODYNAMIC PROPERTIES OF R-416A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-40	6.6	6.1	88.98	0.1541	0.000	89.58	0.00000	0.2142
-35	7.6	7.0	88.49	0.1765	1.413	90.33	0.00334	0.2135
-30	8.7	8.1	88.00	0.2015	2.832	91.09	0.00666	0.2128
-25	10.0	9.3	87.50	0.2292	4.257	91.84	0.00995	0.2122
-20	11.4	10.6	87.00	0.2598	5.688	92.60	0.01322	0.2116
-15	13.0	12.1	86.50	0.2935	7.125	93.35	0.01646	0.2110
-10	14.7	13.8	86.00	0.3306	8.569	94.10	0.01968	0.2105
-5	16.7	15.6	85.49	0.3713	10.02	94.84	0.02288	0.2101
0	18.8	17.5	84.97	0.4159	11.48	95.59	0.02605	0.2097
5	21.1	19.7	84.45	0.4646	12.94	96.33	0.02921	0.2093
10	23.6	22.1	83.93	0.5177	14.41	97.07	0.03235	0.2089
15	26.3	24.7	83.40	0.5754	15.89	97.80	0.03546	0.2086
20	29.3	27.6	82.86	0.6381	17.37	98.53	0.03856	0.2083
25	32.6	30.7	82.32	0.7060	18.87	99.26	0.04164	0.2081
30	36.1	34.0	81.78	0.7796	20.37	100.0	0.04471	0.2078
35	39.9	37.6	81.22	0.8591	21.88	100.7	0.04776	0.2076
40	44.0	41.6	80.66	0.9448	23.39	101.4	0.05079	0.2074
45	48.4	45.8	80.10	1.037	24.92	102.1	0.05381	0.2073
50	53.2	50.3	79.52	1.137	26.46	102.8	0.05681	0.2071
55	58.3	55.2	78.94	1.244	28.00	103.5	0.05981	0.2070
60	63.7	60.4	78.35	1.359	29.55	104.2	0.06279	0.2069
65	69.6	66.0	77.76	1.483	31.12	104.9	0.06575	0.2068
70	75.8	72.0	77.15	1.615	32.69	105.5	0.06871	0.2067
75	82.4	78.4	76.53	1.757	34.28	106.2	0.07166	0.2066
80	89.5	85.2	75.90	1.909	35.87	106.8	0.07460	0.2065
85	97.0	92.5	75.27	2.072	37.48	107.5	0.07753	0.2064
90	105.0	100.2	74.62	2.247	39.10	108.1	0.08045	0.2064
95	113.5	108.4	73.95	2.433	40.73	108.7	0.08337	0.2063
100	122.4	117.0	73.28	2.633	42.38	109.3	0.08629	0.2063
105	131.9	126.2	72.59	2.847	44.04	109.9	0.08920	0.2062
110	141.9	136.0	71.88	3.076	45.71	110.5	0.09210	0.2061
115	152.5	146.2	71.16	3.322	47.40	111.0	0.09501	0.2061
120	163.6	157.1	70.42	3.584	49.11	111.6	0.09791	0.2060
125	175.4	168.5	69.67	3.866	50.83	112.1	0.1008	0.2059
130	187.7	180.6	68.89	4.168	52.57	112.6	0.1037	0.2058
135	200.7	193.3	68.09	4.492	54.33	113.1	0.1066	0.2057
140	214.4	206.6	67.26	4.841	56.12	113.5	0.1096	0.2056
145	228.7	220.7	66.41	5.216	57.92	113.9	0.1125	0.2054
150	243.8	235.4	65.52	5.622	59.75	114.3	0.1154	0.2052
155	259.5	250.9	64.61	6.060	61.61	114.7	0.1184	0.2050
160	276.0	267.2	63.65	6.534	63.50	115.0	0.1214	0.2048

R-422A and R-422C

Physical Properties of Refrigerants	R-422A	R-422C
Environmental Classification	HFC	HFC
Molecular Weight	113.6	113.5
Boiling Point (1 atm, ˚F)	-51.7	-50.7
Critical Pressure (psia)	543.7	547.7
Critical Temperature (˚F)	161.2	163.5
Critical Density, (lb./ft^ 3)	33.63	33.7
Liquid Density (70 ˚F, lb./ft ^ 3)	72.03	72.5
Vapor Density (bp, lb./ft ^ 3)	0.394	0.391
Heat of Vaporization (bp, BTU/lb.)	76.8	77.0
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3385	0.3373
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1976	0.1973
Ozone Depletion Potential (CFC 11 = 1.0)	0	0
Global Warming Potential (CO_2 = 1.0)	3145	3085
ASHRAE Standard 34 Safety Rating	A1	A1
Temperature Glide (˚F) (see section 2)	5	5

Available in the following sizes

R-422C
24 LB. CYLINDER
100 LB. CYLINDER

R-422A

(R-125 /134a /600a)
(85.1 / 11.5 / 3.4 wt%)

R-422C

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

Replaces: R-502 / R-22

Applications: Medium and low temperature commercial and industrial direct expansion refrigeration

Performance:
- Slightly lower discharge temperature
- TXV may appear undersized when retrofitting a R-22 application
- Up to 10% lower capacity

Lubricant Recommendation: Compatible with mineral and alkylbenzene oil and if oil return becomes a concern, addition of polyolester lubricant in 5% increments could help resolve the issue

Retrofitting:

from R-22	page	96
from R-502	page	100
from R-402A and R-402B	page	100
from R-408A	page	100

Pressure-Temp Chart

R-422A Liquid (psig)	R-422A Vapor (psig)	Temp (˚F)	R-422C Liquid (psig)	R-422C Vapor (psig)
5.2	3.2	**-40**	4.7	2.2
7.8	5.6	**-35**	7.2	4.5
10.7	8.3	**-30**	10.1	7.1
13.9	11.3	**-25**	13.1	10.0
17.3	14.6	**-20**	16.5	13.2
21.1	18.2	**-15**	20.2	16.6
25.2	22.1	**-10**	24.2	20.4
29.6	26.3	**-5**	28.6	24.5
34.4	30.9	**0**	33.3	29.0
39.6	35.6	**5**	38.4	33.8
45.2	41.4	**10**	43.9	39.1
51.3	47.2	**15**	49.8	44.7
57.8	53.5	**20**	56.1	50.8
64.7	60.2	**25**	63.0	57.4
72.2	67.5	**30**	70.3	64.4
80.1	75.2	**35**	78.1	72.0
88.6	83.5	**40**	86.4	80.1
97.6	92.3	**45**	95.3	88.7
107	102	**50**	105	97.9
117	112	**55**	115	108
128	122	**60**	125	118
140	134	**65**	137	129
152	146	**70**	149	141
165	158	**75**	161	153
179	172	**80**	175	167
193	186	**85**	189	181
208	201	**90**	204	195
224	217	**95**	219	211
241	234	**100**	236	227
258	251	**105**	253	244
277	270	**110**	272	263
296	289	**115**	291	282
317	310	**120**	311	302
338	331	**125**	332	323
361	354	**130**	354	345
385	378	**135**	377	369
410	403	**140**	402	394

THERMODYNAMIC PROPERTIES OF R-422A

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	13.1	11.7	89.74	0.2803	-5.602	71.10	-0.01365	0.1798
-55	14.9	13.3	89.16	0.3217	-4.200	71.82	-0.01015	0.1791
-50	16.9	15.1	88.60	0.3659	-2.848	72.56	-0.00683	0.1785
-45	19.1	17.1	88.01	0.4166	-1.446	73.24	-0.00339	0.1780
-40	21.5	19.4	87.41	0.4727	0	73.97	0	0.1774
-35	24.2	22.0	86.82	0.5346	1.446	74.69	0.00339	0.1770
-30	27.1	24.7	86.21	0.6027	2.848	75.41	0.00676	0.1765
-25	30.2	27.7	85.62	0.6745	4.255	76.11	0.00997	0.1762
-20	33.7	31.0	85.00	0.7558	5.731	76.79	0.01329	0.1758
-15	37.5	34.6	84.38	0.8446	7.177	77.51	0.01659	0.1755
-10	41.7	38.6	83.74	0.9415	8.666	78.19	0.01987	0.1752
-5	46.0	42.7	83.12	1.0430	10.10	78.84	0.02301	0.1750
0	50.8	47.4	82.47	1.1572	11.59	79.52	0.02626	0.1748
5	56.1	52.4	81.80	1.2809	13.08	80.20	0.02950	0.1746
10	61.7	57.8	81.13	1.4151	14.60	80.85	0.03271	0.1744
15	67.8	63.7	80.45	1.5604	16.13	81.52	0.03590	0.1742
20	74.1	69.8	79.78	1.7116	17.62	82.16	0.03897	0.1741
25	81.1	76.6	79.07	1.881	19.16	82.77	0.04216	0.1739
30	88.5	83.8	78.35	2.063	20.73	83.41	0.04533	0.1738
35	96.5	91.6	77.62	2.260	22.29	84.01	0.04847	0.1737
40	104.7	99.6	76.89	2.465	23.85	84.59	0.05153	0.1736
45	113.8	108.5	76.13	2.694	25.42	85.20	0.05467	0.1735
50	123.4	117.9	75.34	2.940	27.06	85.75	0.05780	0.1734
55	133.7	128.0	74.54	3.206	28.67	86.32	0.06095	0.1733
60	144.6	138.7	73.72	3.493	30.33	86.85	0.06408	0.1732
65	155.7	149.6	72.90	3.791	31.94	87.36	0.06710	0.1731
70	167.9	161.6	72.03	4.125	33.62	87.84	0.07025	0.1729
75	180.8	174.4	71.13	4.486	35.35	88.32	0.07339	0.1728
80	194.4	187.8	70.21	4.876	37.07	88.76	0.07654	0.1726
85	208.2	201.5	69.29	5.284	38.75	89.16	0.07958	0.1724
90	223.2	216.5	68.29	5.743	40.53	89.52	0.08275	0.1722
95	239.1	232.3	67.26	6.242	42.34	89.89	0.08593	0.1719
100	255.8	248.9	66.17	6.788	44.18	90.17	0.08915	0.1716
105	273.3	266.5	65.04	7.387	46.04	90.45	0.09240	0.1712
110	291.0	284.1	63.89	8.020	47.88	90.63	0.09556	0.1708
115	310.2	303.4	62.63	8.746	49.85	90.79	0.09887	0.1703
120	330.4	323.6	61.27	9.556	51.86	90.87	0.1023	0.1697
125	351.3	346.0	59.82	10.47	53.91	90.85	0.1057	0.1690
130	372.5	367.6	58.30	11.47	55.99	90.73	0.1091	0.1681
135	395.4	390.9	56.55	12.66	58.25	90.46	0.1128	0.1671
140	419.3	415.2	54.58	14.07	60.63	90.01	0.1166	0.1658
145	444.3	440.7	52.27	15.82	63.19	89.30	0.1207	0.1640
150	470.2	467.2	49.39	18.11	66.07	88.13	0.1253	0.1616

THERMODYNAMIC PROPERTIES OF R-422C

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	11.4	9.6	90.27	0.26	-5.616	71.83	-0.01367	0.1819
-55	13.1	11.1	89.70	0.30	-4.222	72.55	-0.01021	0.1812
-50	15.0	12.8	89.12	0.34	-2.822	73.27	-0.00678	0.1805
-45	17.1	14.8	88.54	0.39	-1.414	73.98	-0.00338	0.1800
-40	19.4	16.9	87.95	0.45	0.000	74.70	0.00000	0.1794
-35	21.9	19.2	87.36	0.50	1.422	75.41	0.00335	0.1789
-30	24.7	21.8	86.76	0.57	2.851	76.11	0.00669	0.1785
-25	27.8	24.7	86.16	0.64	4.287	76.82	0.01000	0.1781
-20	31.2	27.9	85.54	0.72	5.732	77.51	0.01328	0.1777
-15	34.9	31.3	84.92	0.80	7.185	78.21	0.01655	0.1773
-10	38.9	35.1	84.30	0.89	8.647	78.90	0.01980	0.1770
-5	43.3	39.2	83.66	0.99	10.12	79.58	0.02303	0.1768
0	48.0	43.7	83.02	1.10	11.60	80.25	0.02625	0.1765
5	53.1	48.5	82.36	1.22	13.09	80.92	0.02945	0.1763
10	58.6	53.8	81.70	1.35	14.59	81.59	0.03263	0.1761
15	64.5	59.4	81.03	1.49	16.10	82.24	0.03580	0.1759
20	70.8	65.5	80.34	1.64	17.62	82.88	0.03896	0.1757
25	77.6	72.1	79.64	1.80	19.15	83.52	0.04210	0.1756
30	84.9	79.1	78.93	1.98	20.70	84.14	0.04524	0.1754
35	92.8	86.7	78.21	2.16	22.25	84.76	0.04837	0.1753
40	101	94.8	77.47	2.37	23.82	85.36	0.05148	0.1752
45	110	103	76.72	2.59	25.41	85.94	0.05460	0.1751
50	119	113	75.95	2.82	27.01	86.52	0.05770	0.1750
55	129	122	75.16	3.08	28.62	87.07	0.06081	0.1748
60	140	133	74.35	3.35	30.25	87.61	0.06391	0.1747
65	151	144	73.52	3.65	31.90	88.13	0.06701	01.746
70	163	156	72.66	3.97	33.56	88.62	0.07011	0.1745
75	176	168	71.78	4.31	35.25	89.10	0.07322	0.1743
80	189	181	70.87	4.69	36.96	89.54	0.07633	0.1741
85	204	195	69.93	5.09	38.69	89.96	0.07945	0.1739
90	218	210	68.96	5.53	40.44	90.35	0.08258	0.1737
95	234	225	67.95	6.01	42.22	90.70	0.08573	0.1734
100	251	242	66.89	6.53	44.03	91.02	0.08890	0.1731
105	268	259	65.78	7.09	45.88	91.29	0.09210	0.1728
110	286	277	64.62	7.72	47.76	91.52	0.09532	0.1724
115	305	296	63.39	8.41	49.68	91.69	0.09859	0.1719
120	326	317	62.09	9.17	51.65	91.79	0.1019	0.1713
125	347	338	60.69	10.02	53.68	91.82	0.1053	0.1707
130	369	360	59.17	10.99	55.78	91.75	0.1087	0.1699
135	392	384	57.52	12.09	57.97	91.55	0.1123	0.1689
140	416	408	55.67	13.38	60.27	91.20	0.1160	0.1677
145	442	434	53.54	14.94	62.72	90.63	0.1199	0.1662
150	469	462	51.00	16.90	65.41	89.72	0.1242	0.1642

R-422B and R-422D

Physical Properties of Refrigerants	R-422B	R-422D
Environmental Classification	HFC	HFC
Molecular Weight	108.5	109.9
Boiling Point (1 atm, ˚F)	-42.4	-45.8
Critical Pressure (psia)	574.1	566.2
Critical Temperature (˚F)	181.8	175.2
Critical Density, (lb./ft^ 3)	32.9	33.0
Liquid Density (70 ˚F, lb./ft ^ 3)	73.05	70.9
Vapor Density (bp, lb./ft ^ 3)	0.363	0.372
Heat of Vaporization (bp, BTU/lb.)	84.2	81.8
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3385	0.339
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.201	0.20
Ozone Depletion Potential (CFC 11 = 1.0)	0	0
Global Warming Potential (CO_2 = 1.0)	2525	2730
ASHRAE Standard 34 Safety Rating	A1	A1
Temperature Glide (˚F) (see section 2)	5	5

Available in the following sizes

R-422D
25 LB. CYLINDER
110 LB. CYLINDER

R-422B

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

R-422D

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

Replaces: R-22

Applications:

R-422B: Medium temperature commercial and industrial direct expansion refrigeration and A/C

R-422D: Medium and low temperature commercial and industrial direct expansion refrigeration

Performance:

- Slightly lower discharge temperature
- Possible undersized TXV based on pressure drop
- Up to 10% lower capacity

Lubricant Recommendation: Compatible with mineral and alkylbenzene oil and if oil return becomes a concern, addition of polyolester lubricant in 5% increments could help resolve the issue

Retrofitting to:

R-422B for R-22 Air Conditioning page 95
R-422B for R-22 Refrigeration page 95
R-422D for R-22 Refrigeration page 95

Pressure-Temp Chart

R-422B Liquid (psig)	R-422B Vapor (psig)	Temp (˚F)	R-422D Liquid (psig)	R-422D Vapor (psig)
0.9	*2.7″*	**-40**	2.4	*2.3″*
3.0	*0.9″*	**-35**	4.6	0.8
5.4	1.1	**-30**	7.1	3.0
7.9	3.2	**-25**	9.9	5.4
10.7	5.7	**-20**	12.9	8.1
13.8	8.3	**-15**	16.2	11.0
17.1	11.3	**-10**	19.8	14.3
20.7	14.5	**-5**	23.7	17.8
24.7	18.0	**0**	27.9	21.7
29.0	21.9	**5**	32.5	25.8
33.6	26.1	**10**	37.5	30.4
38.6	30.6	**15**	42.8	35.3
43.9	35.5	**20**	48.5	40.7
49.7	40.8	**25**	54.7	46.4
55.9	46.6	**30**	61.3	52.6
62.5	52.7	**35**	68.4	59.3
69.6	59.4	**40**	75.9	66.4
77.2	66.5	**45**	84.0	74.0
85.3	74.1	**50**	92.6	82.2
94	82.2	**55**	102	90.9
103	90.9	**60**	111	100
113	100	**65**	122	110
123	110	**70**	133	121
134	120	**75**	144	132
145	132	**80**	156	144
158	143	**85**	169	156
170	156	**90**	183	170
184	169	**95**	197	184
198	183	**100**	212	198
213	198	**105**	228	214
229	213	**110**	245	231
246	230	**115**	262	248
263	247	**120**	281	266
281	265	**125**	300	286
301	284	**130**	320	306
321	304	**135**	341	327
342	326	**140**	364	350

THERMODYNAMIC PROPERTIES OF R-422B

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ftˆ3]	Density Vapor [lb/ftˆ3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	9.1	6.6	89.17	0.17	-5.810	79.45	-0.01415	0.2022
-55	10.5	7.7	88.63	0.20	-4.366	80.19	-0.01057	0.2013
-50	12.0	9.0	88.09	0.23	-2.916	80.94	-0.00701	0.2004
-45	13.7	10.4	87.54	0.26	-1.461	81.68	-0.00349	0.1996
-40	15.6	12.0	86.99	0.30	0.000	82.42	0.00000	0.1989
-35	17.7	13.8	86.44	0.34	1.467	83.16	0.00346	0.1982
-30	20.0	15.7	85.88	0.39	2.941	83.89	0.00690	0.1976
-25	22.6	17.9	85.32	0.44	4.421	84.63	0.01031	0.1970
-20	25.4	20.4	84.75	0.49	5.908	85.35	0.01370	0.1964
-15	28.5	23.0	84.17	0.56	7.402	86.08	0.01707	0.1959
-10	31.8	26.0	83.59	0.62	8.904	86.80	0.02041	0.1955
-5	35.4	29.2	83.00	0.70	10.41	87.51	0.02373	0.1951
0	39.4	32.7	82.41	0.78	11.93	88.22	0.02703	0.1947
5	43.7	36.6	81.81	0.86	13.46	88.92	0.03031	0.1943
10	48.3	40.8	81.20	0.96	14.99	89.62	0.03358	0.1940
15	53.3	45.3	80.58	1.06	16.54	90.31	0.03682	0.1937
20	58.6	50.2	79.95	1.17	18.09	90.99	0.04006	0.1934
25	64.4	55.5	79.32	1.29	19.66	91.66	0.04327	0.1931
30	70.6	61.3	78.67	1.42	21.23	92.33	0.04648	0.1929
35	77.2	67.4	78.01	1.57	22.82	92.99	0.04967	0.1927
40	84.3	74.1	77.35	1.72	24.42	93.63	0.05285	0.1925
45	91.9	81.2	76.67	1.88	26.03	94.26	0.05601	0.1923
50	100.0	88.8	75.97	2.06	27.65	94.89	0.05917	0.1921
55	109	96.9	75.27	2.25	29.28	95.50	0.06233	0.1919
60	118	106	74.55	2.45	30.93	96.09	0.06547	0.1918
65	127	115	73.81	2.68	32.60	96.67	0.06861	0.1916
70	138	125	73.05	2.91	34.28	97.23	0.07175	0.1914
75	149	135	72.28	3.17	35.97	97.78	0.07489	0.1912
80	160	146	71.49	3.45	37.69	98.30	0.07802	0.1911
85	172	158	70.67	3.74	39.42	98.81	0.08116	0.1909
90	185	170	69.83	4.06	41.17	99.29	0.08430	0.1907
95	199	184	68.96	4.41	42.95	99.74	0.08745	0.1904
100	213	198	68.07	4.78	44.74	100.2	0.09060	0.1902
105	228	212	67.14	5.19	46.57	100.6	0.09377	0.1899
110	244	228	66.18	5.63	48.42	100.9	0.09696	0.1896
115	260	244	65.17	6.11	50.30	101.2	0.1002	0.1893
120	278	262	64.13	6.63	52.21	101.5	0.1034	0.1889
125	296	280	63.03	7.21	54.16	101.8	0.1067	0.1885
130	315	299	61.87	7.83	56.15	101.9	0.1100	0.1879
135	335	319	60.64	8.53	58.20	102.0	0.1133	0.1874
140	357	340	59.32	9.31	60.29	102.1	0.1167	0.1867

THERMODYNAMIC PROPERTIES OF R-422D

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ftˆ3]	Density Vapor [lb/ftˆ3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	10.0	7.5	89.08	0.20	-5.756	76.71	-0.01402	0.1951
-55	11.5	8.8	88.53	0.23	-4.326	77.45	-0.01047	0.1943
-50	13.1	10.2	87.98	0.26	-2.890	78.19	-0.00695	0.1935
-45	15.0	11.8	87.42	0.30	-1.448	78.92	0.00346	0.1928
-40	17.1	13.5	86.86	0.34	0.000	79.65	0.00000	0.1921
-35	19.3	15.5	86.30	0.39	1.455	80.39	0.00343	0.1915
-30	21.8	17.7	85.73	0.44	2.916	81.11	0.00684	0.1909
-25	24.6	20.1	85.15	0.50	4.384	81.84	0.01023	0.1904
-20	27.6	22.8	84.57	0.56	5.860	82.56	0.01359	0.1899
-15	30.9	25.7	83.98	0.63	7.343	83.27	0.01693	0.1894
-10	34.5	29.0	83.39	0.71	8.835	83.98	0.02024	0.1890
-5	38.4	32.5	82.79	0.79	10.34	84.69	0.02354	0.1886
0	42.6	36.3	82.18	0.88	11.84	85.39	0.02682	0.1883
5	47.2	40.5	81.56	0.98	13.36	86.08	0.03008	0.1880
10	52.2	45.1	80.93	1.08	14.89	86.77	0.03332	0.1877
15	57.5	50.0	80.30	1.20	16.42	87.45	0.03655	0.1874
20	63.2	55.4	79.66	1.32	17.97	88.12	0.03977	0.1872
25	69.4	61.1	79.00	1.46	19.53	88.78	0.04297	0.1870
30	76.0	67.3	78.34	1.60	21.10	89.43	0.04615	0.1868
35	83.1	74.0	77.66	1.76	22.68	90.08	0.04933	0.1866
40	90.6	81.1	76.97	1.93	24.27	90.71	0.05250	0.1864
45	98.7	88.7	76.27	2.11	25.87	91.33	0.05565	0.1863
50	107	96.9	75.55	2.30	27.49	91.93	0.05880	0.1861
55	116	106	74.82	2.52	29.12	92.53	0.06194	0.1860
60	126	115	74.07	2.74	30.77	93.10	0.06508	0.1858
65	136	125	73.30	2.99	32.43	93.66	0.06822	0.1857
70	147	135	72.52	3.25	34.11	94.21	0.07135	0.1855
75	159	147	71.71	3.54	35.81	94.73	0.07448	0.1853
80	171	158	70.88	3.84	37.53	95.23	0.07762	0.1852
85	184	171	70.03	4.18	39.26	95.70	0.08076	0.1850
90	197	184	69.15	4.53	41.02	96.16	0.08391	0.1848
95	212	198	68.23	4.92	42.80	96.58	0.08706	0.1845
100	227	213	67.29	5.34	44.61	96.97	0.09023	0.1843
105	243	229	66.31	5.80	46.44	97.32	0.09342	0.1840
110	259	245	65.28	6.30	48.31	97.64	0.09662	0.1836
115	277	263	64.21	6.84	50.21	97.91	0.09986	0.1832
120	295	281	63.08	7.44	52.15	98.14	0.1031	0.1828
125	315	300	61.89	8.09	54.13	98.30	0.1064	0.1823
130	335	321	60.63	8.82	56.16	98.40	0.1098	0.1817
135	356	342	59.28	9.63	58.25	98.42	0.1132	0.1810
140	378	364	57.82	10.55	60.41	98.35	0.1167	0.1802

R-500 and R-502

Physical Properties of Refrigerants	R-500	R-502
Environmental Classification	CFC	CFC
Molecular Weight	99.3	111.6
Boiling Point (1 atm, ˚F)	-28.5	-49.5
Critical Pressure (psia)	605.2	582.8
Critical Temperature (˚F)	215.8	177.3
Critical Density, (lb./ft^ 3)	30.7	35.5
Liquid Density (70 ˚F, lb./ft ^ 3)	73	77
Vapor Density (bp, lb./ft ^ 3)	0.329	0.388
Heat of Vaporization (bp, BTU/lb.)	86.4	74.2
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.2782	0.2958
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.1725	0.1641
Ozone Depletion Potential (CFC 11 = 1.0)	0.66	0.23
Global Warming Potential (CO_2 = 1.0)	8077	4657
ASHRAE Standard 34 Safety Rating	A1	A1

Available in the following sizes

R-500
30 LB. CYLINDER
125 LB. CYLINDER

R-502
30 LB. CYLINDER
125 LB. CYLINDER

R-500

(R-12/152a)
(73.8 / 26.2 wt%)

Application: Air conditioning, dehumidifiers and centrifugal chillers

Lubricant Recommendation: Compatible with mineral and alkylbenzene oil

Retrofitting to:

R-134a	consult equipment manufacturer
R-401A, R-401B	page 97
R-409A	page 97
R-414B	page 97

R-502

(R-22/115)
(48.8 / 51.2 wt%)

Application: Low temperature commercial and industrial direct expansion refrigeration and ice machines

Lubricant Recommendation: Compatible with mineral and alkylbenzene oil

Retrofitting to:

R-402A, R-402B	page 98
R-404A, R-507	page 99
R-408A	page 98
R-422C	page 100

Pressure-Temp Chart

R-500 (psig)	Temp (˚F)	R-502 (psig)
7.6"	**-40**	4.1
4.6"	**-35**	6.5
1.2"	**-30**	9.2
1.2	**-25**	12.1
3.2	**-20**	15.3
5.4	**-15**	18.8
7.8	**-10**	22.6
10.4	**-5**	26.7
13.3	**0**	31.1
16.4	**5**	35.9
19.7	**10**	41.0
23.4	**15**	46.5
27.3	**20**	52.4
31.5	**25**	58.8
36.0	**30**	65.6
40.9	**35**	72.8
46.1	**40**	80.5
51.6	**45**	88.7
57.6	**50**	97.4
63.9	**55**	107
70.6	**60**	116
77.8	**65**	127
85.4	**70**	138
93.5	**75**	149
102	**80**	161
111	**85**	174
121	**90**	187
131	**95**	201
141	**100**	216
152	**105**	232
164	**110**	248
177	**115**	265
189	**120**	283
203	**125**	301
217	**130**	321
232	**135**	341
248	**140**	363

THERMODYNAMIC PROPERTIES OF R-500

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	6.3	6.3	85.26	0.1498	-5.016	85.98	-0.01222	0.2155
-55	7.3	7.3	84.81	0.1713	-3.770	86.63	-0.00913	0.2143
-50	8.4	8.4	84.35	0.1951	-2.519	87.27	0.00606	0.2131
-45	9.6	9.6	83.89	0.2215	-1.262	87.92	0.00302	0.2120
-40	11.0	11.0	83.43	0.2506	0.000	88.56	0.00000	0.2110
-35	12.5	12.5	82.97	0.2826	1.268	89.20	0.00299	0.2100
-30	14.2	14.2	82.50	0.3177	2.541	89.83	0.00597	0.2091
-25	16.0	16.0	82.03	0.3561	3.820	90.47	0.00892	0.2083
-20	18.0	18.0	81.55	0.3980	5.106	91.10	0.01185	0.2074
-15	20.2	20.2	81.07	0.4436	6.397	91.73	0.01476	0.2066
-10	22.6	22.6	80.59	0.4932	7.695	92.35	0.01765	0.2059
-5	25.3	25.3	80.10	0.5470	9.000	92.97	0.02052	0.2052
0	28.1	28.1	79.61	0.6053	10.31	93.58	0.02337	0.2045
5	31.3	31.2	79.11	0.6682	11.63	94.19	0.02621	0.2039
10	34.6	34.6	78.61	0.7362	12.96	94.80	0.02903	0.2033
15	38.3	38.2	78.10	0.8095	14.29	95.40	0.03184	0.2027
20	42.2	42.1	77.59	0.8883	15.63	95.99	0.03463	0.2022
25	46.4	46.4	77.07	0.9730	16.98	96.58	0.03741	0.2016
30	50.9	50.9	76.55	1.064	18.34	97.16	0.04017	0.2011
35	55.8	55.7	76.01	1.161	19.70	97.73	0.04292	0.2007
40	61.0	60.9	75.48	1.266	21.08	98.29	0.04566	0.2002
45	66.6	66.5	74.93	1.378	22.46	98.85	0.04838	0.1998
50	72.5	72.4	74.38	1.497	23.85	99.40	0.05110	0.1993
55	78.9	78.7	73.82	1.625	25.25	99.94	0.05381	0.1989
60	85.6	85.4	73.25	1.761	26.66	100.5	0.05650	0.1985
65	92.8	92.5	72.67	1.907	28.09	101.0	0.05919	0.1982
70	100.4	100.1	72.08	2.062	29.52	101.5	0.06187	0.1978
75	108.4	108.1	71.48	2.228	30.96	102.0	0.06455	0.1974
80	116.9	116.6	70.87	2.405	32.42	102.5	0.06722	0.1970
85	125.9	125.5	70.25	2.593	33.89	102.9	0.06988	0.1967
90	135.4	135.0	69.62	2.794	35.37	103.4	0.07254	0.1963
95	145.5	145.0	68.98	3.008	36.86	103.8	0.07520	0.1960
100	156.1	155.5	68.32	3.236	38.37	104.3	0.07785	0.1956
105	167.2	166.6	67.64	3.479	39.89	104.7	0.08051	0.1952
110	178.9	178.2	66.95	3.739	41.43	105.0	0.08316	0.1949
115	191.2	190.4	66.25	4.016	42.99	105.4	0.08582	0.1945
120	204.1	203.3	65.52	4.313	44.56	105.8	0.08849	0.1941
125	217.7	216.8	64.77	4.630	46.15	106.1	0.09115	0.1937
130	231.9	230.9	64.00	4.970	47.77	106.4	0.09383	0.1933
135	246.8	245.7	63.21	5.335	49.40	106.6	0.09652	0.1928
140	262.4	261.2	62.39	5.726	51.06	106.9	0.09922	0.1923
145	278.7	277.4	61.54	6.148	52.74	107.1	0.1019	0.1918
150	295.7	294.4	60.66	6.604	54.45	107.2	0.1047	0.1913
155	313.6	312.1	59.73	7.097	56.20	107.3	0.1074	0.1907

THERMODYNAMIC PROPERTIES OF R-502

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	11.1	10.9	93.91	0.2941	-4.736	70.99	-0.01153	0.1781
-55	12.7	12.5	93.35	0.3342	-3.561	71.59	-0.00861	0.1772
-50	14.5	14.3	92.78	0.3786	-2.380	72.18	-0.00572	0.1764
-45	16.5	16.3	92.20	0.4273	-1.193	72.77	-0.00285	0.1756
-40	18.7	18.5	91.62	0.4808	0.000	73.36	0.00000	0.1749
-35	21.1	20.9	91.04	0.5394	1.200	73.95	0.00283	0.1742
-30	23.7	23.5	90.45	0.6034	2.406	74.53	0.00564	0.1736
-25	26.6	26.4	89.85	0.6731	3.619	75.11	0.00843	0.1730
-20	29.8	29.6	89.25	0.7490	4.839	75.68	0.01121	0.1724
-15	33.2	33.0	88.64	0.8313	6.066	76.25	0.01397	0.1719
-10	37.0	36.8	88.03	0.9205	7.301	76.81	0.01671	0.1713
-5	41.0	40.8	87.40	1.017	8.544	77.37	0.01944	0.1709
0	45.4	45.2	86.78	1.121	9.795	77.92	0.02216	0.1704
5	50.1	50.0	86.14	1.234	11.05	78.47	0.02486	0.1700
10	55.2	55.1	85.49	1.355	12.32	79.00	0.02755	0.1696
15	60.7	60.6	84.84	1.486	13.60	79.53	0.03023	0.1692
20	66.6	66.5	84.17	1.626	14.89	80.06	0.03290	0.1688
25	72.9	72.8	83.50	1.777	16.18	80.57	0.03556	0.1684
30	79.6	79.5	82.82	1.939	17.49	81.07	0.03821	0.1681
35	86.8	86.7	82.12	2.113	18.80	81.57	0.04085	0.1677
40	94.5	94.4	81.42	2.299	20.13	82.05	0.04348	0.1674
45	102.7	102.6	80.70	2.499	21.47	82.52	0.04611	0.1671
50	111.4	111.3	79.97	2.712	22.82	82.98	0.04874	0.1668
55	120.6	120.5	79.22	2.942	24.18	83.43	0.05135	0.1665
60	130.4	130.3	78.46	3.187	25.56	83.86	0.05397	0.1662
65	140.7	140.7	77.68	3.450	26.95	84.28	0.05658	0.1659
70	151.7	151.6	76.88	3.731	28.35	84.68	0.05920	0.1656
75	163.3	163.2	76.07	4.033	29.77	85.07	0.06181	0.1652
80	175.5	175.4	75.23	4.357	31.20	85.43	0.06442	0.1649
85	188.4	188.3	74.37	4.705	32.66	85.78	0.06704	0.1646
90	201.9	201.9	73.49	5.079	34.13	86.10	0.06967	0.1642
95	216.2	216.2	72.58	5.481	35.62	86.40	0.07230	0.1639
100	231.3	231.2	71.64	5.914	37.13	86.67	0.07495	0.1635
105	247.1	247.0	70.66	6.382	38.67	86.91	0.07761	0.1630
110	263.6	263.6	69.65	6.889	40.23	87.11	0.08029	0.1626
115	281.0	281.0	68.59	7.438	41.82	87.28	0.08298	0.1621
120	299.3	299.3	67.48	8.037	43.44	87.41	0.08571	0.1616
125	318.4	318.4	66.32	8.692	45.10	87.49	0.08847	0.1610
130	338.5	338.5	65.08	9.412	46.80	87.51	0.09127	0.1603
135	359.5	359.5	63.77	10.21	48.55	87.47	0.09412	0.1596
140	381.4	381.4	62.36	11.10	50.36	87.35	0.09704	0.1587

R-503

Physical Properties of Refrigerants	R-503
Environmental Classification	CFC
Molecular Weight	87.25
Boiling Point (1 atm, ˚F)	-125.5
Critical Pressure (psia)	618.6
Critical Temperature (˚F)	65.2
Critical Density, (lb./ft^ 3)	34.4
Liquid Density (20 ˚F, lb./ft ^ 3)	68.4
Vapor Density (bp, lb./ft ^ 3)	0.373
Heat of Vaporization (bp, BTU/lb.)	77.1
Specific Heat Liquid (20 ˚F, BTU/lb. ˚F)	0.3671
Specific Heat Vapor (1 atm, 20 ˚F, BTU/lb. ˚F)	0.1537
Ozone Depletion Potential (CFC 11 = 1.0)	0.06
Global Warming Potential (CO_2 = 1.0)	14560
ASHRAE Standard 34 Safety Rating	A1

Available in the following sizes

R-503
5 LB. CYLINDER
9 LB. CYLINDER
20 LB. CYLINDER
80 LB. CYLINDER

R-503

(R-23/13)
(40.1 / 59.9 wt%)

Applications: Very low temperature refrigeration (low stage of a cascade system)

Performance:
- R-503 runs with better capacity and lower discharge pressure than R-13
- Operates in the low temperature stage of the cascade system because of its low boiling point

Lubricant Recommendation: Compatible with mineral oil

Retrofitting to: R-508B page 101

See Ultra Low Temperature Refrigeration Section page 64-65

Pressure-Temp Chart

Temp (˚F)	R-503 (psig)
-125	0.5
-120	3.1
-115	6.0
-110	9.3
-105	12.9
-100	16.9
-95	21.4
-90	26.3
-85	31.8
-80	37.7
-75	44.2
-70	51.3
-65	59.0
-60	67.3
-55	76.4
-50	86.1
-45	96.6
-40	108
-35	120
-30	133
-25	147
-20	161
-15	177
-10	194
-5	212
-0	230
5	250
10	272
15	294
20	318

THERMODYNAMIC PROPERTIES OF R-503

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-140	9.1	9.1	94.67	0.2374	-25.81	53.32	-0.06936	0.1782
-135	10.8	10.8	94.04	0.2788	-24.60	53.82	-0.06562	0.1759
-130	12.7	12.7	93.40	0.3257	-23.39	54.30	-0.06192	0.1737
-125	14.9	14.9	92.75	0.3785	-22.16	54.79	-0.05826	0.1717
-120	17.4	17.4	92.09	0.4377	-20.94	55.26	-0.05464	0.1697
-115	20.3	20.2	91.43	0.5039	-19.70	55.73	-0.05105	0.1678
-110	23.5	23.4	90.75	0.5776	-18.46	56.19	-0.04748	0.1660
-105	27.0	26.9	90.06	0.6595	-17.21	56.64	-0.04395	0.1643
-100	31.0	30.9	89.36	0.7500	-15.95	57.08	-0.04045	0.1627
-95	35.4	35.2	88.65	0.8500	-14.68	57.51	-0.03698	0.1611
-90	40.2	40.0	87.93	0.9601	-13.40	57.93	-0.03352	0.1595
-85	45.6	45.3	87.19	1.081	-12.12	58.34	-0.03010	0.1580
-80	51.4	51.1	86.44	1.214	-10.82	58.74	-0.02669	0.1566
-75	57.9	57.5	85.67	1.359	-9.512	59.12	-0.02330	0.1552
-70	64.9	64.4	84.89	1.517	-8.192	59.49	-0.01993	0.1539
-65	72.5	72.0	84.09	1.690	-6.861	59.85	-0.01658	0.1525
-60	80.8	80.1	83.28	1.878	-5.517	60.19	-0.01324	0.1513
-55	89.7	89.0	82.45	2.083	-4.159	60.51	-0.00992	0.1500
-50	99.4	98.6	81.60	2.306	-2.788	60.82	-0.00660	0.1488
-45	109.9	108.9	80.72	2.549	-1.402	61.11	-0.00330	0.1476
-40	121.1	120.0	79.83	2.812	0.000	61.37	0.00000	0.1464
-35	133.2	131.9	78.91	3.097	1.419	61.62	0.00329	0.1452
-30	146.1	144.7	77.96	3.408	2.855	61.84	0.00659	0.1440
-25	160.0	158.3	76.99	3.745	4.312	62.04	0.00988	0.1428
-20	174.8	172.9	75.99	4.112	5.789	62.21	0.01318	0.1416
-15	190.5	188.5	74.95	4.511	7.289	62.35	0.01648	0.1404
-10	207.3	205.1	73.87	4.946	8.813	62.45	0.01980	0.1392
5	225.2	222.7	72.76	5.421	10.37	62.52	0.02313	0.1379
0	244.1	241.5	71.59	5.941	11.95	62.54	0.02648	0.1367
5	264.2	261.4	70.37	6.512	13.56	62.52	0.02987	0.1353
10	285.6	282.5	69.09	7.142	15.22	62.44	0.03329	0.1339
15	308.1	304.8	67.74	7.839	16.92	62.30	0.03676	0.1325
20	332.0	328.5	66.31	8.616	18.67	62.09	0.04029	0.1309

R-507

Physical Properties of Refrigerants	R-507
Environmental Classification	HFC
Molecular Weight	98.9
Boiling Point (1 atm, ˚F)	-52.8
Critical Pressure (psia)	539
Critical Temperature (˚F)	159
Critical Density, (lb./ft^ 3)	30.7
Liquid Density (70 ˚F, lb./ft ^ 3)	66.65
Vapor Density (bp, lb./ft ^ 3)	0.349
Heat of Vaporization (bp, BTU/lb.)	84.35
Specific Heat Liquid (70 ˚F, BTU/lb. ˚F)	0.3593
Specific Heat Vapor (1 atm, 70 ˚F, BTU/lb. ˚F)	0.2064
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	3985
ASHRAE Standard 34 Safety Rating	A1

Available in the following sizes

R-507
25 LB. CYLINDER
100 LB. CYLINDER
800 LB. CYLINDER
1400 LB. CYLINDER

R-507

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

Applications: Medium and low temperature commercial refrigeration and industrial refrigeration

Performance:
- Similar to R-404A in operation
- Pressure and capacity are slightly higher than R-404A

Lubricant Recommendation: Compatible with polyolester lubricant

Retrofitting: from R-502 page 99
from R-22 page 96

Pressure-Temp Chart

Temp (˚F)	R-507 (psig)
-40	5.5
-35	8.2
-30	11.1
-25	14.3
-20	17.8
-15	21.7
-10	25.8
-5	30.3
-0	35.2
5	40.5
10	46.1
15	52.2
20	58.8
25	65.8
30	73.3
35	81.3
40	89.8
45	98.9
50	109
55	119
60	130
65	141
70	154
75	167
80	180
85	195
90	210
95	226
100	244
105	252
110	281
115	301
120	322
125	344
130	368
135	393
140	419
145	446
150	475

THERMODYNAMIC PROPERTIES OF R-507

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-60	12.1	12.1	83.10	0.2899	-5.871	79.54	-0.01429	0.1994
-55	13.9	13.9	82.57	0.3298	-4.416	80.26	-0.01068	0.1986
-50	15.8	15.8	82.03	0.3738	-2.952	80.98	-0.00709	0.1978
-45	18.0	18.0	81.49	0.4223	-1.480	81.69	-0.00354	0.1970
-40	20.4	20.4	80.94	0.4756	0.000	82.40	0.00000	0.1964
-35	23.1	23.1	80.39	0.5340	1.489	83.11	0.00351	0.1957
-30	26.0	26.0	79.83	0.5980	2.987	83.81	0.00700	0.1951
-25	29.2	29.2	79.27	0.6678	4.494	84.51	0.01047	0.1946
-20	32.7	32.7	78.70	0.7439	6.010	85.20	0.01392	0.1940
-15	36.5	36.5	78.12	0.8267	7.537	85.88	0.01735	0.1935
-10	40.7	40.7	77.53	0.9166	9.073	86.56	0.02077	0.1931
-5	45.2	45.2	76.94	1.014	10.62	87.23	0.02417	0.1927
0	50.1	50.0	76.34	1.120	12.18	87.89	0.02755	0.1923
5	55.3	55.3	75.73	1.234	13.75	88.55	0.03091	0.1919
10	61.0	60.9	75.11	1.357	15.33	89.19	0.03427	0.1915
15	67.1	67.0	74.48	1.491	16.92	89.83	0.03761	0.1912
20	73.6	73.6	73.84	1.634	18.52	90.45	0.04094	0.1909
25	80.6	80.6	73.18	1.789	20.14	91.07	0.04426	0.1906
30	88.1	88.1	72.52	1.956	21.77	91.67	0.04757	0.1903
35	96.1	96.1	71.84	2.136	23.42	92.26	0.05087	0.1900
40	104.7	104.6	71.15	2.329	25.08	92.84	0.05417	0.1898
45	113.8	113.7	70.45	2.537	26.76	93.40	0.05746	0.1895
50	123.5	123.4	69.73	2.761	28.45	93.94	0.06075	0.1892
55	133.8	133.7	68.99	3.002	30.17	94.47	0.06404	0.1890
60	144.7	144.6	68.23	3.262	31.90	94.97	0.06733	0.1887
65	156.3	156.1	67.45	3.541	33.65	95.46	0.07062	0.1884
70	168.5	168.3	66.65	3.843	35.42	95.92	0.07392	0.1882
75	181.5	181.3	65.82	4.169	37.21	96.36	0.07722	0.1879
80	195.1	194.9	64.97	4.521	39.03	96.77	0.08053	0.1875
85	209.6	209.4	64.08	4.902	40.87	97.15	0.08386	0.1872
90	224.8	224.6	63.17	5.315	42.75	97.50	0.08720	0.1868
95	240.8	240.6	62.21	5.764	44.65	97.80	0.09056	0.1864
100	257.7	257.5	61.21	6.255	46.59	98.07	0.09395	0.1859
105	275.5	275.2	60.17	6.792	48.57	98.28	0.09737	0.1854
110	294.2	293.9	59.07	7.382	50.59	98.43	0.1008	0.1848
115	313.8	313.5	57.91	8.035	52.66	98.52	0.1043	0.1842
120	334.4	334.1	56.67	8.762	54.79	98.53	0.1079	0.1834
125	356.1	355.8	55.34	9.580	56.98	98.44	0.1116	0.1825
130	378.8	378.6	53.89	10.51	59.26	98.24	0.1153	0.1814
135	402.7	402.5	52.29	11.59	61.64	97.87	0.1192	0.1801
140	427.9	427.6	50.50	12.86	64.17	97.30	0.1233	0.1785

R-508B

Physical Properties of Refrigerants	R-508B
Environmental Classification	HFC
Molecular Weight	95.4
Boiling Point (1 atm, ˚F)	-125.3
Critical Pressure (psia)	556.1
Critical Temperature (˚F)	53.7
Critical Density, (lb./ft^ 3)	35.6
Liquid Density (20 ˚F, lb./ft ^ 3)	65.4
Vapor Density (bp, lb./ft ^ 3)	0.426
Heat of Vaporization (bp, BTU/lb.)	71.4
Specific Heat Liquid (20 ˚F, BTU/lb. ˚F)	0.4221
Specific Heat Vapor (1 atm, 20 ˚F, BTU/lb. ˚F)	0.1701
Ozone Depletion Potential (CFC 11 = 1.0)	0
Global Warming Potential (CO_2 = 1.0)	13400
ASHRAE Standard 34 Safety Rating	A1

Available in the following sizes

R-508B
5 LB. CYLINDER
10 LB. CYLINDER
20 LB. CYLINDER
70 LB. CYLINDER

R-508B

(R-23/116)
(46 / 54 wt%)

Replaces: R-503 and R-13

Applications: Very low temperature refrigeration (low stage of a cascade system)

Performance:
- PT properties are very similar to R-503 and can be used to replace R-13 or R-503 in an existing system
- Higher capacity and lower discharge temperature compared to R-23

Lubricant Recommendation: Compatible with polyolester lubricant; it may still be necessary to use hydrocarbon additives to help with oil circulation

Retrofitting: from R-503 page 101
from R-13 page 101

See Ultra Low Temperature Refrigeration Section - page 64-65

Pressure-Temp Chart

Temp (˚F)	R-508B (psig)
-125	0.5
-120	3.1
-115	6.0
-110	9.3
-105	12.9
-100	16.9
-95	21.4
-90	26.4
-85	31.8
-80	37.8
-75	44.4
-70	51.5
-65	59.3
-60	67.8
-55	76.9
-50	86.8
-45	97.5
-40	109
-35	121
-30	135
-25	149
-20	164
-15	180
-10	197
-5	216
0	235
5	256
10	278
15	301
20	326

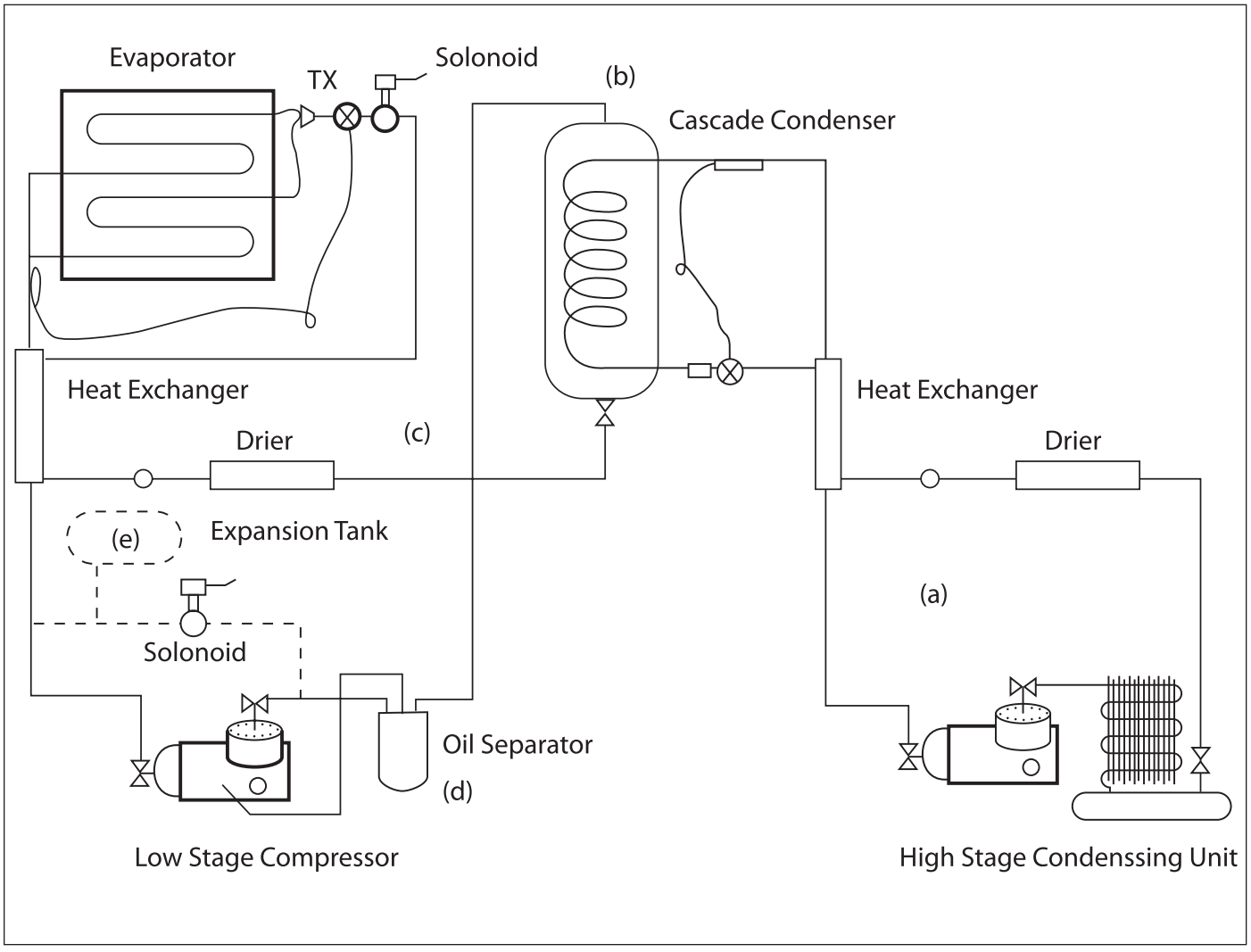
THERMODYNAMIC PROPERTIES OF R-508B

Temp [˚F]	Pressure Liquid [psia]	Pressure Vapor [psia]	Density Liquid [lb/ft^3]	Density Vapor [lb/ft^3]	Enthalpy Liquid [Btu/lb]	Enthalpy Vapor [Btu/lb]	Entropy Liquid [Btu/R-lb]	Entropy Vapor [Btu/R-lb]
-160	4.1	3.9	100.7	0.1181	-32.27	44.15	-0.08953	0.1664
-155	5.1	4.8	99.96	0.1438	-30.98	44.72	-0.08527	0.1640
-150	6.2	5.9	99.24	0.1737	-29.70	45.29	-0.08109	0.1618
-145	7.5	7.2	98.52	0.2083	-28.42	45.85	-0.07699	0.1596
-140	8.9	8.6	97.80	0.2482	-27.14	46.40	-0.07297	0.1576
-135	10.6	10.3	97.08	0.2937	-25.86	46.95	-0.06900	0.1557
-130	12.6	12.3	96.37	0.3455	-24.57	47.49	-0.06509	0.1539
-125	14.8	14.5	95.65	0.4041	-23.29	48.03	-0.06124	0.1522
-120	17.4	17.1	94.92	0.4701	-22.00	48.56	-0.05743	0.1505
-115	20.2	19.9	94.19	0.5441	-20.70	49.08	-0.05366	0.1490
-110	23.4	23.1	93.45	0.6269	-19.40	49.59	-0.04993	0.1476
-105	27.0	26.7	92.70	0.7191	-18.09	50.10	-0.04623	0.1462
-100	31.0	30.8	91.94	0.8214	-16.77	50.59	-0.04256	0.1449
-95	35.5	35.2	91.18	0.9347	-15.45	51.08	-0.03892	0.1436
-90	40.4	40.1	90.39	1.060	-14.11	51.56	-0.03531	0.1424
-85	45.8	45.6	89.60	1.198	-12.76	52.02	-0.03172	0.1412
-80	51.7	51.6	88.79	1.349	-11.40	52.48	-0.02815	0.1401
-75	58.3	58.1	87.96	1.515	-10.03	52.92	-0.02460	0.1391
-70	65.4	65.3	87.12	1.697	-8.648	53.35	-0.02106	0.1381
-65	73.2	73.0	86.25	1.896	-7.249	53.76	-0.01753	0.1371
-60	81.6	81.5	85.36	2.114	-5.834	54.17	-0.01402	0.1361
-55	90.7	90.7	84.45	2.351	-4.403	54.55	-0.01051	0.1352
-50	100.6	100.6	83.51	2.611	-2.955	54.92	-0.00701	0.1343
-45	111.3	111.3	82.55	2.893	-1.487	55.27	-0.00350	0.1334
-40	122.8	122.8	81.55	3.202	0.000	55.60	0.00000	0.1325
-35	135.2	135.1	80.52	3.539	1.509	55.90	0.00351	0.1316
-30	148.4	148.4	79.45	3.906	3.041	56.18	0.00702	0.1307
-25	162.6	162.6	78.34	4.308	4.598	56.44	0.1055	0.1298
-20	177.8	177.8	77.18	4.748	6.182	56.66	0.01409	0.1289
-15	194.0	194.0	75.98	5.231	7.796	56.85	0.01765	0.1280
-10	211.3	211.3	74.72	5.763	9.441	56.99	0.02123	0.1270
-5	229.7	229.6	73.40	6.350	11.12	57.10	0.02484	0.1260
0	249.3	249.2	72.02	7.000	12.84	57.15	0.02849	0.1249
5	270.1	270.0	70.56	7.725	14.59	57.13	0.03218	0.1237
10	292.2	292.1	69.02	8.540	16.40	57.05	0.03592	0.1225
15	315.7	315.6	67.39	9.461	18.26	56.88	0.03972	0.1211
20	340.6	340.5	65.63	10.52	20.18	56.60	0.04361	0.1195

Ultra-low temperature systems are used to achieve low temperature baths or boxes for laboratory use, storage of pharmaceutical or biological samples, low temperature manufacturing of metals, or extreme-temperature-environment testing.

The lowest temperature that can practically be achieved in single-stage refrigeration systems is about -40˚F to -50˚F. A single-stage system is limited by the compression ratio of the compressor and the ambient temperature in which it must condense the refrigerant. Temperatures from -50˚F down to -120˚F or lower can only be achieved economically by using cascade refrigeration systems.

A typical cascade system is shown in Figure 1. A standard refrigeration system is used on the "high side" (a) to create a cold temperature in the cascade condenser (b). The "low side" system (c) is able to condense at -20˚F to -30˚F and evaporate as low as -120˚F with the available refrigerants before they go into vacuum. Larger systems tend to have some kind of oil separator and oil management system (d) to keep the oil in the compressor. Some systems also employ an expansion tank (e) to keep the refrigerant from generating extreme pressures at room temperature when the system is off.



Traditional High Side Refrigerants:	R-12,	R-22,	R-502
Alternative High Side Refrigerants:	R-134a,	R-404A,	R-507
Traditional Low Side Refrigerants:	R-13,	R-503	
Alternative Low Side Refrigerants:	R-23,	R-508B	

Oil Circulation: Standard refrigeration oils will become very thick at low temperatures and will not flow around the system back to the compressor. If the compressor gets too cold, the oil will gel inside the compressor sump and not provide lubrication. Many systems rely on the refrigerant to soak into the oil and move it around the system. This method of oil circulation works well down to about -100F evaporator temperature. In addition, systems with short run times will allow the oil to return to the compressor when the evaporator warms.

Systems that run for longer times at colder temperatures, or involve complicated piping, will need to use an oil separator after the low stage compressor(s). In addition, hydrocarbon refrigerants are typically added to the system so they can soak into the oil and keep it fluid at very low temperatures. The amount of hydrocarbon used is typically between 5 - 10% (by weight) of the refrigerant charge. National Refrigerants, Inc. supplies these hydrocarbons for use in cascade systems:

Part No.	Size	Product
3R170	3 lb. cyl	R-170 (ETHANE)
004R170	4 oz. cyl.	R-170 (ETHANE)
004R1150	4 oz cyl.	R-1150 (ETHYLENE)
016R600	16 oz. cyl	R-600 (BUTANE)
016R600a	16 oz. cyl	R-600a (ISOBUTANE)
014R290	14 oz. cyl.	R-290 (PROPANE)
016RPENTANE	16 oz. can	PENTANE LIQUID

Moisture: Removal of moisture is more important in cascade systems than it is at higher temperature ranges. Refrigerants such as R-22 and R-404A can absorb and carry much more water than the 10 ppm specification and the 30 to 50 ppm indication level of a sight glass. In contrast, R-13 is estimated to only hold about 0.1 ppm of water at -80˚F. Excess moisture will definitely separate from the refrigerant and clog capillary tubes or cause other problems. Maintenance of driers is very important in the low stage of a cascade system.

Expansion Volume: Refrigerants in the low stage must maintain "normal" operating pressures in the compressor at very low temperatures. These refrigerants will condense around -30˚F to -20˚F at pressures from 110 psig to 160 psig. When these refrigerants warm up to room temperature, however, the saturation pressure, or in some cases the critical pressure, can exceed 700 psig.

Rather than going to the expense of building systems to withstand these pressures, an expansion tank or other system volume is provided. The charge expands into the extra volume, allowing all liquid to boil completely to vapor. Simple gas laws dictate how much volume is needed to keep the charge at a gas pressure of usually no more than 250 psig. Consequently, systems are often charged simply by bringing the empty system up to some static pressure.

For additional information on Retrofitting, see page 101

Refrigerant Color Codes (AHRI Guideline N)

Refrigerant	Chemical Name	Color	PMS #
R-11	Trichlorofluoromethane	Orange	0211
R-12	Dichlorodifluoromethane	White	N/A
R-13	Chlorotrifluoromethane	Light Blue	2975
R-113	Trichlorotrifluoroethane	Dark Purple	266
R-114	Dichlorotetrafluoroethane	Navy Blue	302
R-12/114	Dichlorodifluoromethane, Dichlorotetrafluoroethane	Light Gray	413
R-13B1	Bromotrifluoromethane	Pinkish-Red	177
R-22	Chlorodifluoromethane	Light Green	352
R-23	Trifluoromethane	Light Blue Gray	428
R-123	Dichlorotrifluoroethane	Light Blue Gray	428
R-124	Chlorotetrafluoroethane	DOT Green	335
R-134a	Tetrafluoroethane	Light Blue	2975
R-401A	Chlorodifluoromethane, Difluoroethane, Chlorotetrafluoroethane	Pinkish-Red	177
R-401B	Chlorodifluoromethane, Difluoroethane, Chlorotetrafluoroethane	Yellow-Brown	124
R-402A	Chlorodifluoromethane, Pentafluoroethane, Propane	Light Brown	461
R-402B	Chlorodifluoromethane, Pentafluoroethane, Propane	Green-Brown	385
R-403B	Chlorodifluoromethane, Pentafluoroethane, Propane	Light Gray	413
R-404A	Pentafluoroethane, Trifluoroethane, Tetrafluoroethane	Orange	021
R-407A	Difluoromethane,Pentafluoroethane, Tetrafluoroethane	Lime Green	368
R-407C	Difluoromethane, Pentafluoroethane, Tetrafluoroethane	Brown	471
R-408A	Chlorodifluoromethane, Trifluoroethane, Pentafluoroethane	Medium Purple	248
R-409A	Chlorodifluoromethane, Chlorotetrafluoroethane, Chlorodifluoroethane	Medium Brown	465
R-410A	Difluoromethane, Pentafluoroethane	Rose	507
R414B	Chlorodifluoromethane, Chlorotetrafluoroethane, Chlorodifluoroethane, Isobutane	Medium Blue	2995
R-416A	Tetrafluoroethane, Chlorotetrafluoroethane, Butane	Yellow-Green	381
R-417A	Pentafluoroethane, Tetrafluoroethane, Butane	Green	3275
R-422A	Pentafluoroethane, Tetrafluoroethane, Isobutane	Pale Orange	1495
R-422B	Pentafluoroethane, Tetrafluoroethane, Isobutane	Navy Blue	-
R-422C	Pentafluoroethane, Tetrafluoroethane, Isobutane	Yellow	-
R-422D	Pentaflurorоethane, Tetrafluoroethane, Isobutane	Green-Yellow	375
R-500	Dichlorodifluoromethane, Difluoroethane	Yellow	109
R-502	Chlorodifluoromethane, Chloropentafluoroethane	Light Purple	251
R-503	Chlorotrifluoromethane, Trifluoroethane	Blue -Green	3268
R-507	Pentafluoroethane, Trifluoroethane	Aqua Blue	326
R-508B	Trifluoromethane, Hexafluoroethane	Navy Blue	302

2. Retrofits and Conversions

Background

The components of a specific piece of air conditioning or refrigeration equipment have been engineered specifically around the properties of the refrigerant used. When replacement of that refrigerant becomes necessary for technical, regulatory, or economic reasons, the replacement refrigerant should have as many properties similar to the original refrigerant as possible. This will minimize hardware changes, controls adjustments, or other time consuming operations such as oil changes.

Since the late 1980s, the development of blends has focused on matching the properties of the original refrigerant in order to offer some advantage over the competing blends. Early R-12 blends focused on evaporator performance in refrigeration systems; however, it became clear that more R-12 was sold for use in automotive air conditioning rather than in refrigeration. Since these systems experience higher condenser temperatures, a second wave of blends came into the market that had lower head pressures.

Manufacturers introduced R-502 retrofit blends that simply removed the R-115, a CFC, and mixed HFC components with R-22. While this approach was very effective at reducing R-502 use during the transition away from CFCs in the mid 1990's, it now leaves equipment owners with the challenge of replacing the HCFC-based blends again.

As early as 1992, manufacturers and suppliers of R-22 based air conditioning equipment were looking for alternatives. While the focus was mainly on replacing R-22 for newly built equipment, several retrofit blends were also identified in the process.

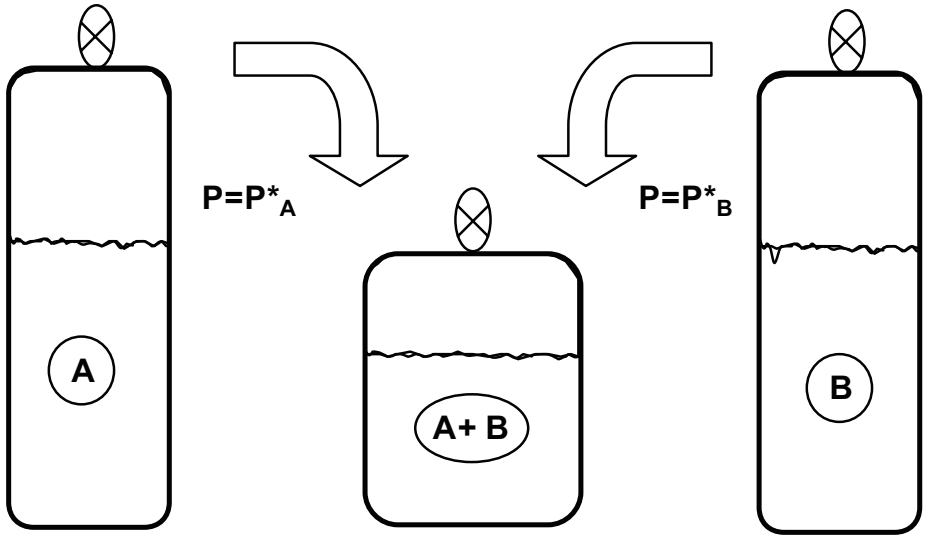
Today

2010 begins the first year of restriction on the use of R-22 in new equipment. Although R-22 will still be available for servicing, available quantities will be more and more limited and the need for retrofitting will increase. Some market applications, such as residential and commercial air conditioning, have not had to deal with the product restrictions that have occurred over the last 15 years. They will now see many new products that behave dramatically different than R-22.

Blends Tutorial

The following information is designed to help technicians understand how blends are different from single-component refrigerants. Fractionation and temperature glide are explained in a way that shows the effect on system operation and controls. Actual products and their impact on the market are discussed, and retrofit procedures are provided for a variety of products and equipment.

Single Components vs. Blends



By Convention, Higher Pressure Component is First ($P^*_A > P^*_B$)

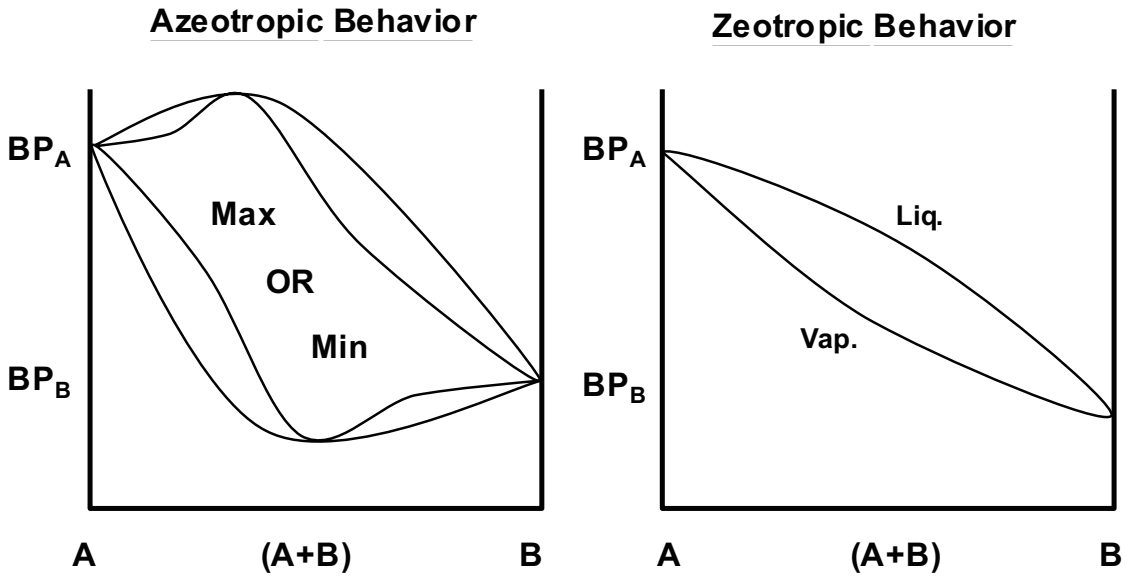
Blends are made up of two or more single component refrigerants. When mixing refrigerants, for example, refrigerant "A" and refrigerant "B", we generally speak about the higher pressure, higher capacity component first. For purposes of this tutorial, "A" will be the higher pressure product.

When two or more refrigerants are placed into the same container, one of two situations will occur, depending on how strongly the different molecules are attracted to each other:

> Azeotrope: a blend that behaves like a single component refrigerant. When a blend forms an azeotrope, it displays unique and unexpected properties.
>
> Zeotrope: a blend that behaves like a mixture of the individual components. Zeotropes have predictable properties based on combinations of the pure components' properties.

Two properties of concern are Fractionation and Temperature Glide. We can split the zeotropic blends into Low Fractionation Potential, which also exhibit Low Temperature Glide, and High Fractionation Potential, which also exhibit High Temperature Glide. Generally speaking, zeotropic blends with lower temperature glides do not show the same problems with fractionation that are seen with higher glide blends.

Pressure Temperature Curves for Refrigerant Blends

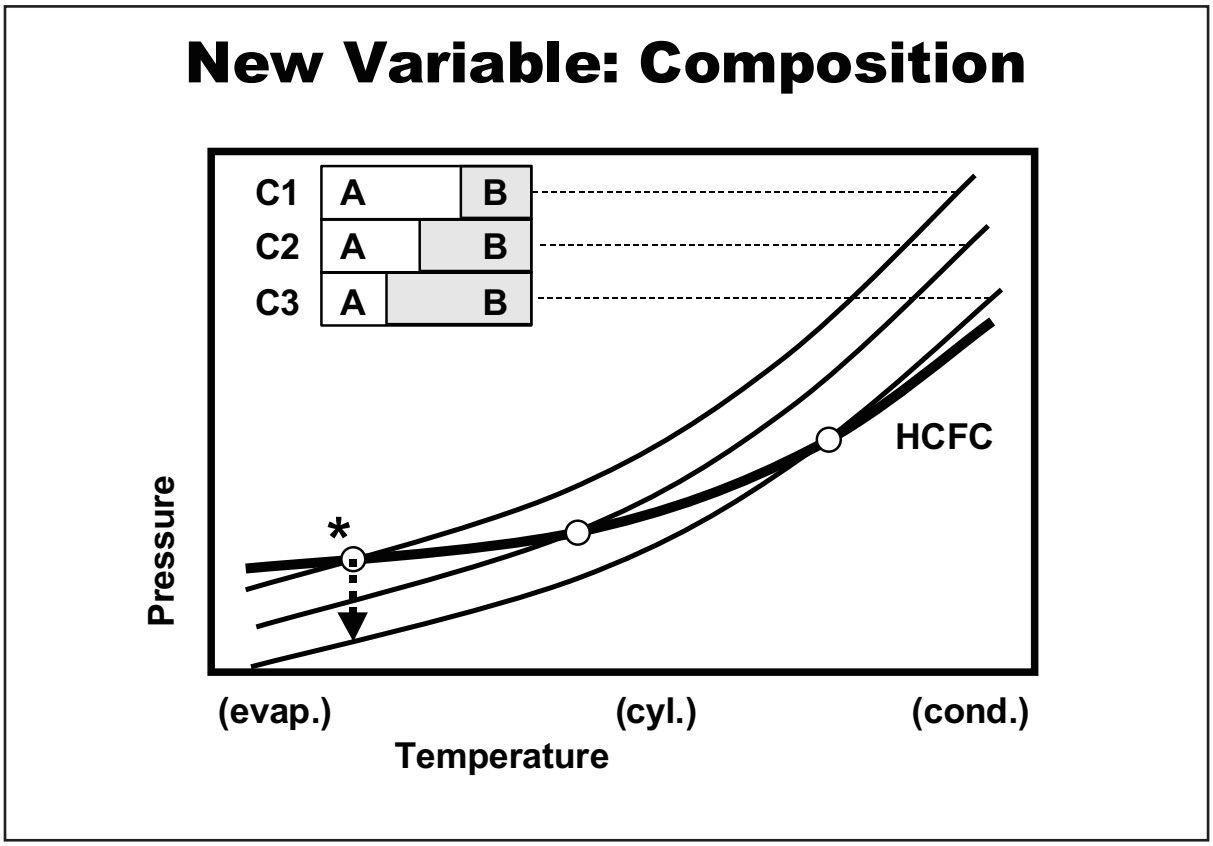


Azeotrope: a special case where the refrigerants combine in a unique way. In an azeotropic composition, the blend behaves like a single refrigerant with its own pressure-temperature (P-T) relationship. The pressure after mixing is either higher than the pressures of the individual components, or is lower than either component. Because the refrigerants are attracted to each other in a special way, the vapor in equilibrium with the liquid is at the same composition during phase change.

> Note: The azeotropic composition depends on temperature. The same combination of refrigerants may form an azeotrope at a different ratio, or not at all, at some other temperature.

Zeotrope: the P-T relationship is a natural combination of the components' properties. The pressure for the blend falls between the pressures of its components and can be calculated according to established formulas. Considering the P-T relationship for each refrigerant, the resulting pressure and the vapor composition above the liquid for any given liquid composition can be calculated.

In general, if a lot of A is mixed with B, then the blend will have a pressure close to A. If more B is in the mix, then the blend will have a pressure close to B. If you mix equal amounts, the resulting pressure will fall in between. Blend compositions can be adjusted so the blend properties fall exactly where you want. The problem, however, is that you usually can't get all the properties to match the original refrigerant under all conditions. You must trade off which properties you want to match and which ones that will be different.



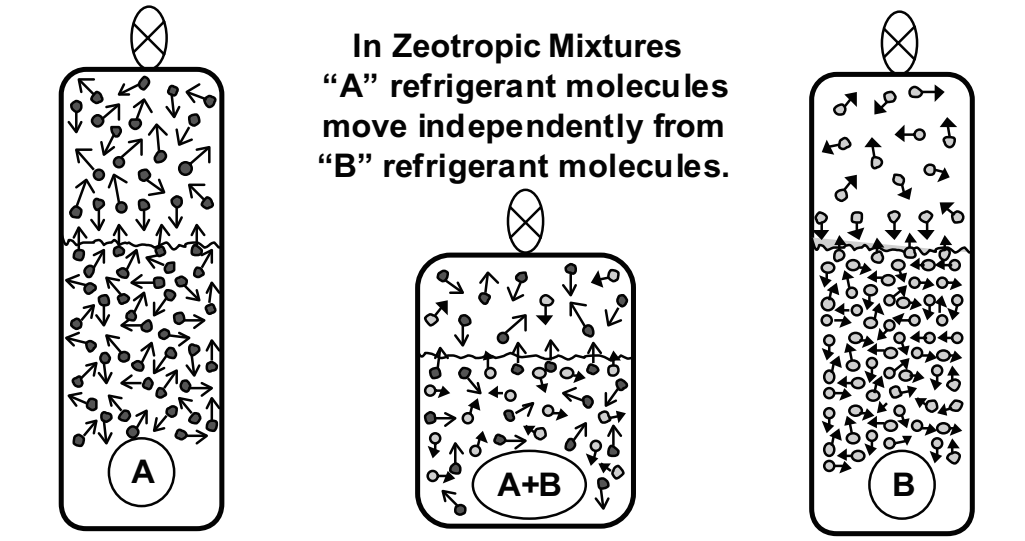
Once a blend is mixed at a given composition, the pressure-temperature relationships follow the same general rules for pure components; for example, the pressure goes up when the temperature goes up. For three blends containing different amounts of A and B, the pressure curve is similarly shaped, but the resulting pressure will be higher for the blend which contains more of the A (higher pressure) component.

Refrigerant blends that are intended to match some other product (R-22, for example) will rarely match the pressure at all points in the desired temperature range. More commonly, the pressure of the blend will match in one temperature range, but will be different elsewhere.

In the above example, the blend with concentration C1 matches the pure refrigerant at cold evaporator temperatures, but the pressure runs higher at condenser conditions. The blend with composition C2 matches closer to room temperature and, for example, might show the same pressure in a cylinder being stored. The operating pressures at evaporator and condenser temperatures, however, will be somewhat different. Finally, the blend at C3 will generate the same pressures at hot condenser conditions, but the evaporator must run at lower pressures to get the same temperature. The choice of where the blend matches the pressure relationship can solve (or cause) certain retrofit-related problems.

The other thing that can be seen from this graph is that if a blend loses some of the higher-pressure component through fractionation, the remaining blend will have lower operating pressures in order to achieve the same temperatures.(*)

Introduction to Fractionation:
Behavior of Individual Refrigerant Molecules



There are two basic behaviors of refrigerant molecules that will help explain why fractionation occurs.

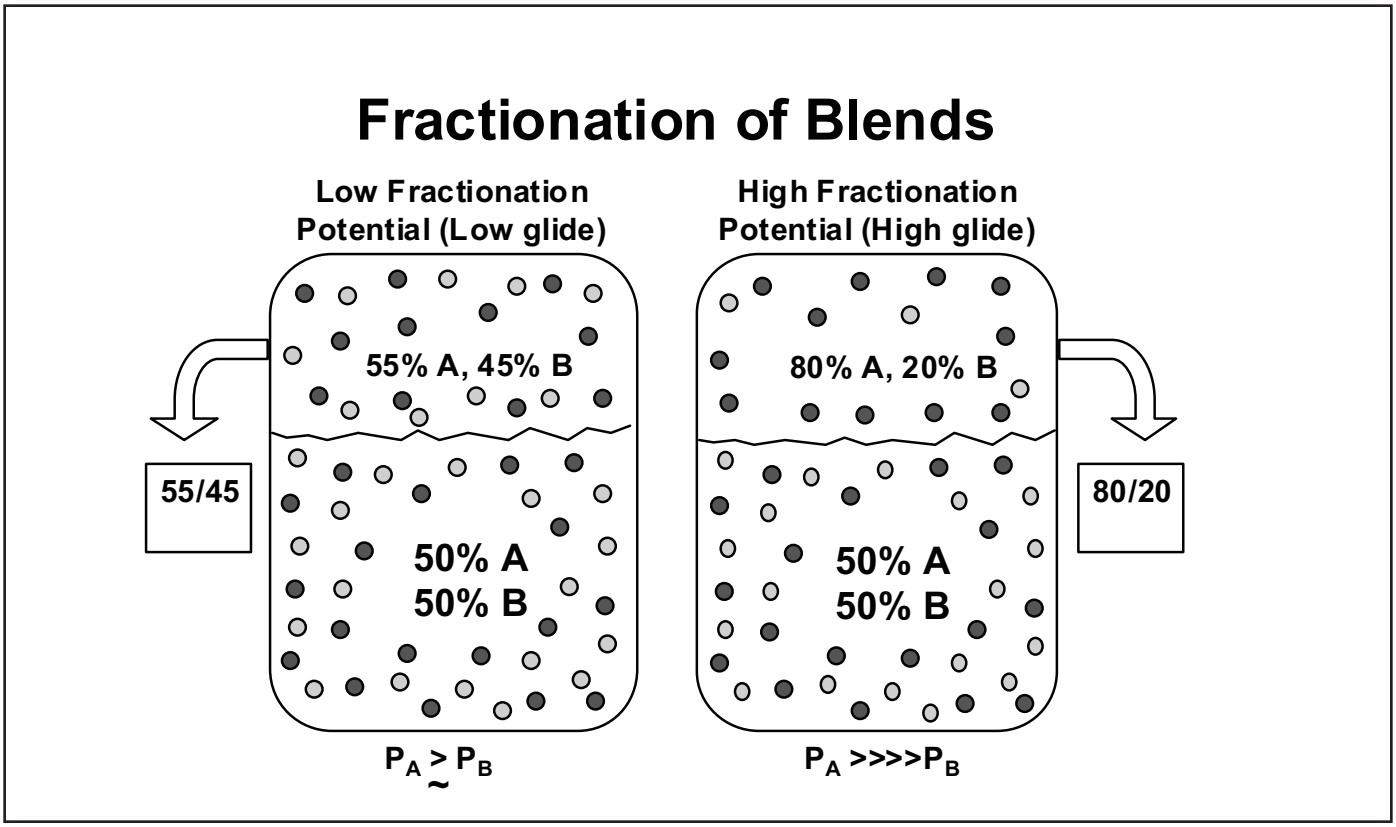
1. Pure refrigerants, A or B, exert pressure on the cylinder (or a system) because the molecules are moving around. At higher temperatures, they move around faster, which creates more pressure. At lower temperatures there is less movement, so the pressure is lower.

   Different refrigerants have different energies at the same temperature, and therefore, generate higher or lower pressures.

2. Molecules of refrigerant are constantly moving from liquid to vapor and vapor to liquid at the surface of the liquid. Vapor and liquid at equilibrium transfer the same number of molecules back and forth; boiling liquid transfers more from liquid to vapor; and condensing vapor transfers more from vapor to liquid.

   Different refrigerants transfer molecules back and forth to the vapor at different rates.

When you mix A and B together, and they don't form an azeotrope, the individual refrigerant molecules behave as if the other type is not there. The A's bounce harder than the B's, contributing more pressure to the blend, but more importantly - *the A's transfer back and forth to the vapor faster than the B's*. This means there are more A's in the vapor than there are B's.



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, so it will have more of the higher pressure/higher capacity refrigerant component; and 2) the liquid that is left behind boils more of the higher pressure component out of the liquid to replace the vapor. Eventually, the liquid composition changes because more of the A component leaves the container or system compared to the bulk liquid composition.

> *FRACTIONATION is the change in composition of a blend because one (or more) of the components is lost or removed faster than the other(s).*

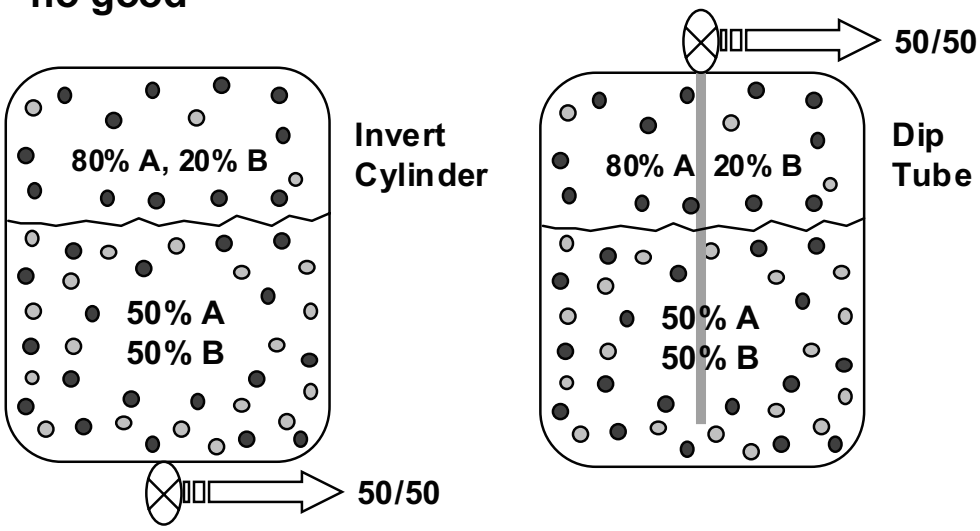
A large difference between the pressures of the starting components will cause a greater difference in the vapor composition compared to the liquid composition. This will worsen the effect of fractionation on that blend. The High Fractionation Potential blend shown above will produce a vapor composition of 80% A and 20% B above the liquid composition of 50/50.

Molecules will transfer back and forth to the vapor at a similar rate when the pressures of the individual components are close to each other. The Low Fractionation Potential blend shown above will have a very similar vapor composition compared to the liquid. In this case, it will take a long time to noticeably change the liquid composition away from 50/50.

Temperature Glide will be higher for High Fractionation blends, and lower for Low Fractionation blends.

Effects of Fractionation in a Cylinder

- **Charge wrong composition - poor system behavior**
- **Leave behind wrong composition - rest of cylinder no good**



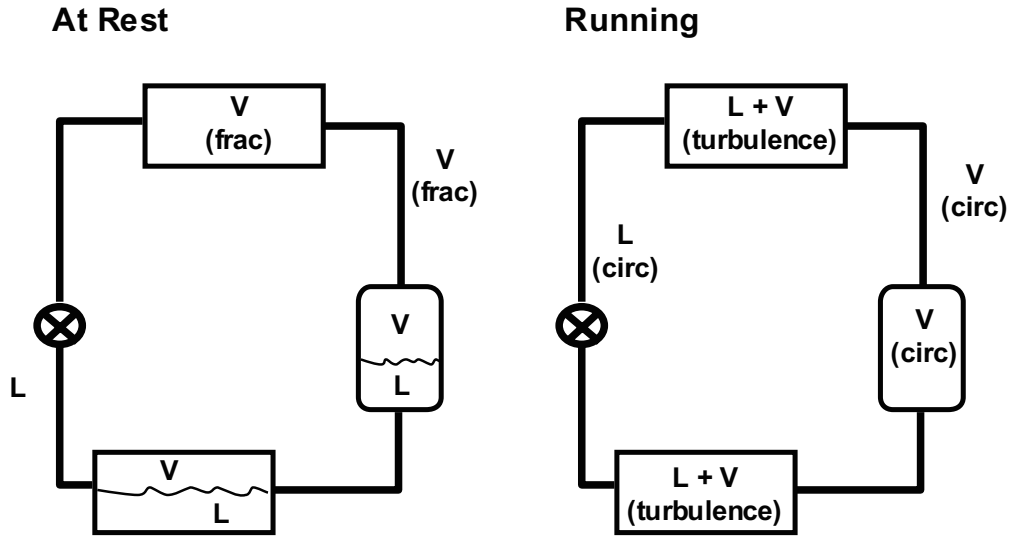
To avoid charging the wrong composition and fractionating the remaining blend, *zeotropic blends must be removed from the cylinder as a liquid*. This can be done by turning the cylinder over so the valve is on the bottom. For larger cylinders with two valves, use the 'liquid' valve. Liquid refrigerant will come up through a dip tube to the valve.

* All refrigerant suppliers have removed dip tubes in their "30 lb." packages. Check the box or cylinder label for instructions on which side should be up for liquid removal.

"Liquid charging" does not mean that liquid refrigerant should be pushed into the suction line of the system, allowing it to slug the compressor. After the initial charge into the high side of a system, the technician should start the compressor and complete the charging process by flashing the refrigerant from liquid to vapor in the charging hose or across specially designed valves. Any method that allows the refrigerant to go to vapor before it hits the compressor should work. Generally, the refrigerant needs to be added slowly at this point.

Please note: When liquid and vapor are together in a cylinder or in a system, IT IS ALWAYS THE VAPOR THAT WILL BE AT THE WRONG COMPOSITION.

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 that occur in vapor areas of the equipment will fractionate the blend. The worst case will occur when about half of the refrigerant charge has leaked. Small amounts leaked from a system will not change the remaining blend by much. Large leaks will shift the composition, but the majority of the pounds after recharge will be from fresh product at the correct composition.

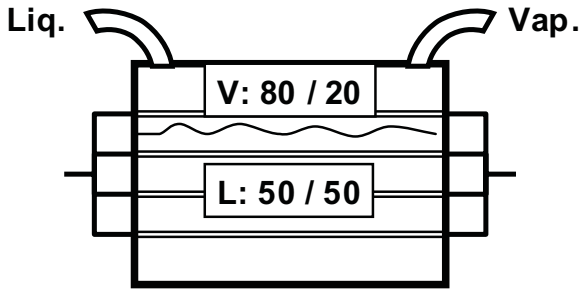
Recharging the system after repair will result in a blend with slightly reduced capacity and operating pressures. In smaller systems, where charge size is critical, it will be best to recover any remaining refrigerant and charge with fresh blend. In larger systems, you will need to make a decision whether the remaining charge should be recovered or not. Note: for Low Fractionation Potential blends you will not see much shift in composition anyway, and therefore the charge can be topped off after repair without loss of properties.

In **running systems** it has been found that the circulating composition is the original blend composition. In liquid and suction lines there is no second phase, and in the heat exchangers there is much turbulence so leaks will lose both vapor and liquid. Testing has shown that leaks from a running system do not cause fractionation, and a normally cycling system will not fractionate much during the off cycle.

In other words, in most refrigeration applications, servicing systems with blends does not require full recovery of the charge. After repair, most systems can be topped off with the blend. In most air conditioning systems, however, a leak during the off season will likely require a full change of refrigerant charge.

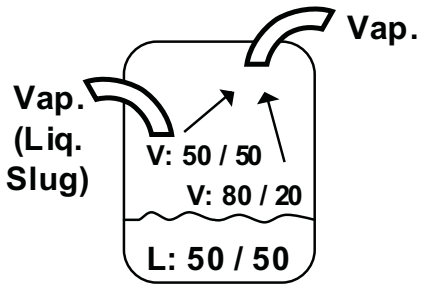
Fractionation Effects on Some System Components

Flooded Evaporator



Continuous

Suction Accumulator



Periodic

Flooded Evaporators are designed to keep a pool of boiling liquid refrigerant surrounding a bundle of tubes. The water, brine, or product to be cooled flows through the tubes. The vapor that boils off this pool is returned to the compressor, condensed, and then poured back into the pool.

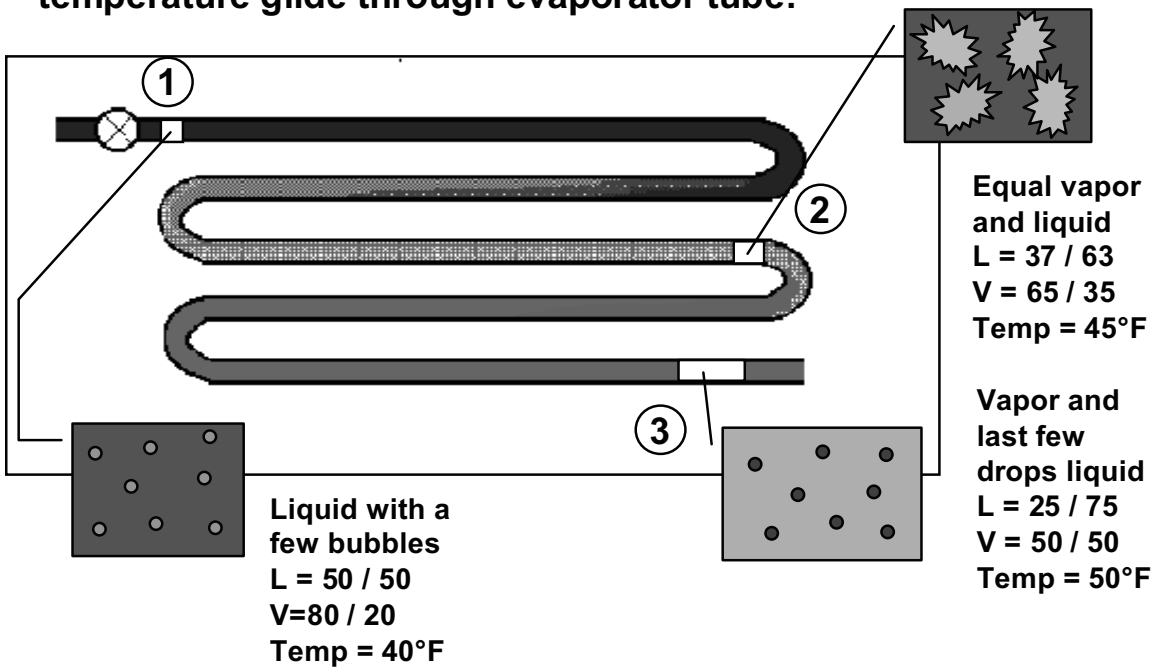
In the case of zeotropic blends, the vapor that boils off this pool of refrigerant will be at the fractionated composition. If the properties at this composition differ significantly from what the compressor expects, then the system could develop high head pressures, high amperage draw at the compressor, reduced cooling effectiveness (capacity) in the evaporator, etc. Normally the use of blends in this type of system is not recommended.

Suction Accumulators are placed in the suction line before the compressor to keep liquid from flowing into the compressor. The liquid slug is trapped in the accumulator where it can boil off to vapor, combining with other suction gas. Zeotropic blends will fractionate in the accumulator, giving a short-lived spike of higher-pressure vapor back to the compressor.

Systems with suction accumulators should not be overcharged with the expectation that the accumulator will protect the compressor. (This may lead to frequent pressure spikes.) Also, this type of system should never be charged by dumping liquid refrigerant into the suction line and allowing it to vaporize in the accumulator. (High pressure trips may occur.)

Temperature Glide in the Evaporator

Relationship between blend fractionation and temperature glide through evaporator tube:



Let's assume that a blend of 50% A refrigerant and 50% B refrigerant flows across a valve into an evaporator coil. If we follow a small "piece" of the blend as it flows along the tube we can see the effect of fractionation:

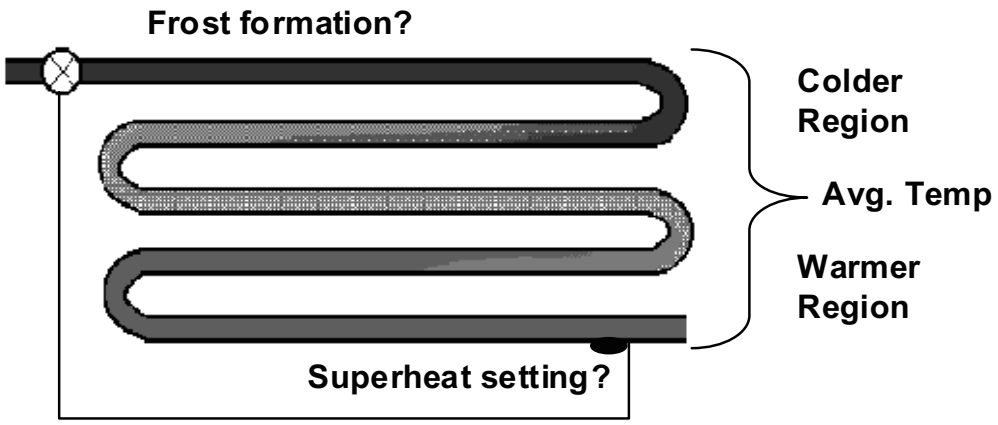
1. At the beginning of the tube the blend is mostly liquid with a few bubbles in it. The liquid composition is 50/50 and the boiling point is (for purposes of discussion) 40˚F.

2. As the "piece" of refrigerant marches along the tube, more liquid is boiled to vapor. Since A transfers to vapor faster than B, a larger proportion of A (than B) is transferred to vapor. This makes the composition of the liquid change along the length of the tube. In this example, the "piece of blend" which started at 50/50, now has a liquid composition at 37% A and 63% B. (The vapor has the extra A - at 65%.) The important point is that the boiling temperature of the current liquid composition is now about 45˚F.

3. When our "piece" of the blend gets to the end of the evaporator it is now almost all vapor. This vapor contains almost all of the refrigerant that we started with at the beginning of the tube, so the composition is almost back to 50/50. The last few remaining drops are now concentrated in the B component (about 75% in this example). The boiling point of this liquid composition is now about 50˚F.

Overall Temperature Glide: The difference in temperature between the Saturated Vapor blend at the end of the evaporator and the liquid entering the evaporator is 50˚F-40˚F = 10˚F.

Effects of Temperature Glide



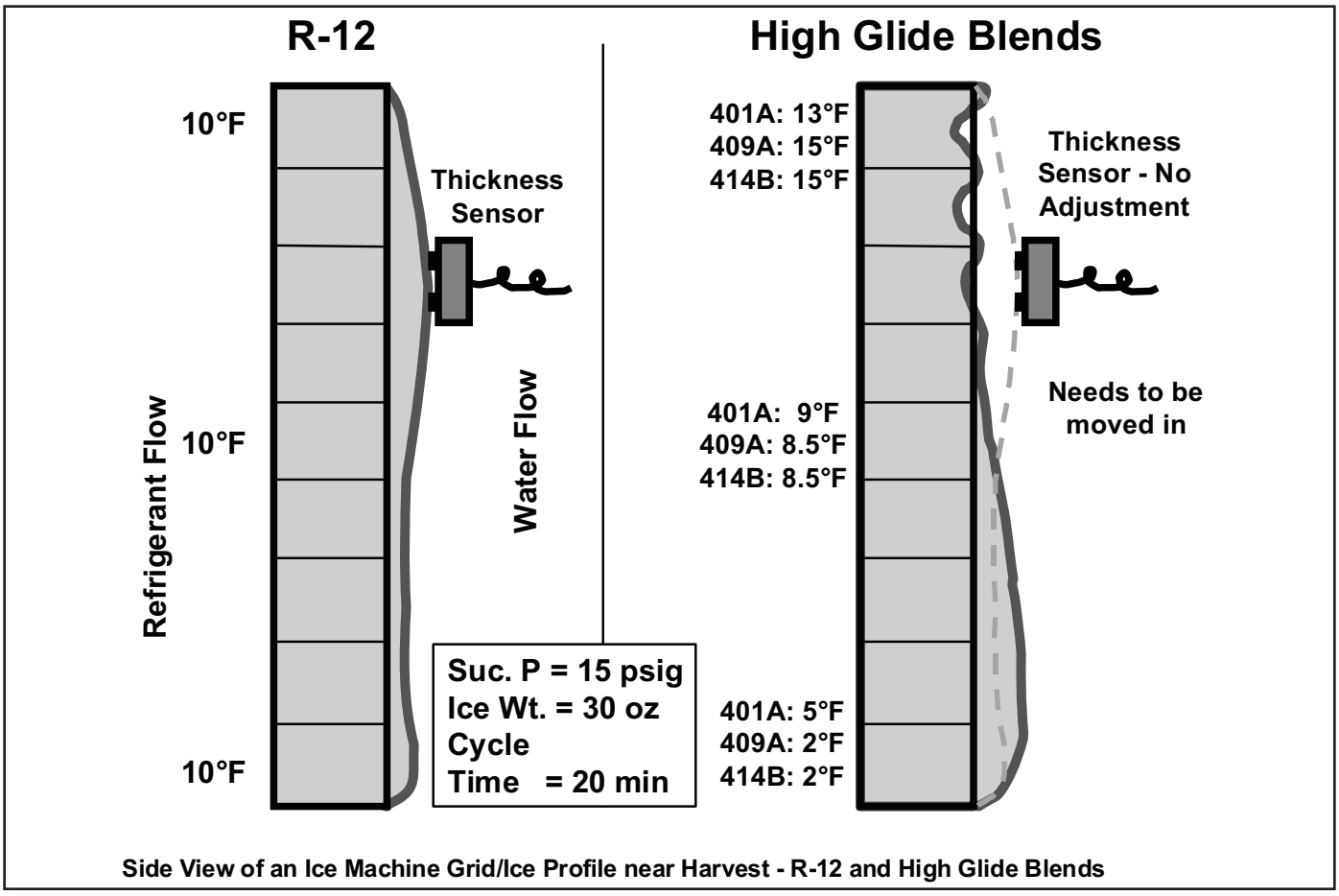
For pure refrigerants, the evaporator coil is at a constant temperature throughout. For blends, however, the temperature glide causes the tubing to be at different temperatures.

If you stand back and blow a fan across the evaporator coil, the air that blows out the other side looks like it saw an average temperature. Part of the evaporator is colder, and part is warmer, but the air mixes and generally gives the equivalent house or box temperature as if it passes over a constant temperature coil at this average. There are, however, some potential problems that can occur:

- The colder part of the coil may form frost faster than an equivalent coil at constant temp.
- The warmer part of the coil may cause "hot spots" in the case or cold box, affecting product quality.
- Temperature control sensors located in hot or cold spots may affect cycle times.
- Ice machines will produce thicker ice on the bottom of the plate and thinner ice at the top.
- TXV sensor bulbs located at the outlet of the evaporator will now see warmer gas.

Generally the temperature glide does not affect the system's ability to remove heat from the air or from product, but the glide will probably affect some of the system's controls. Superheat settings and pressure controls will be discussed further.

Frost formation and hot or cold spots must be addressed "outside" the refrigeration loop (defrost strategies, product placement, etc.). Making the whole coil warmer or colder will change the overall air or box temperature, not solve the glide-related problem.



Side View of an Ice Machine Grid/Ice Profile near Harvest - R-12 and High Glide Blends

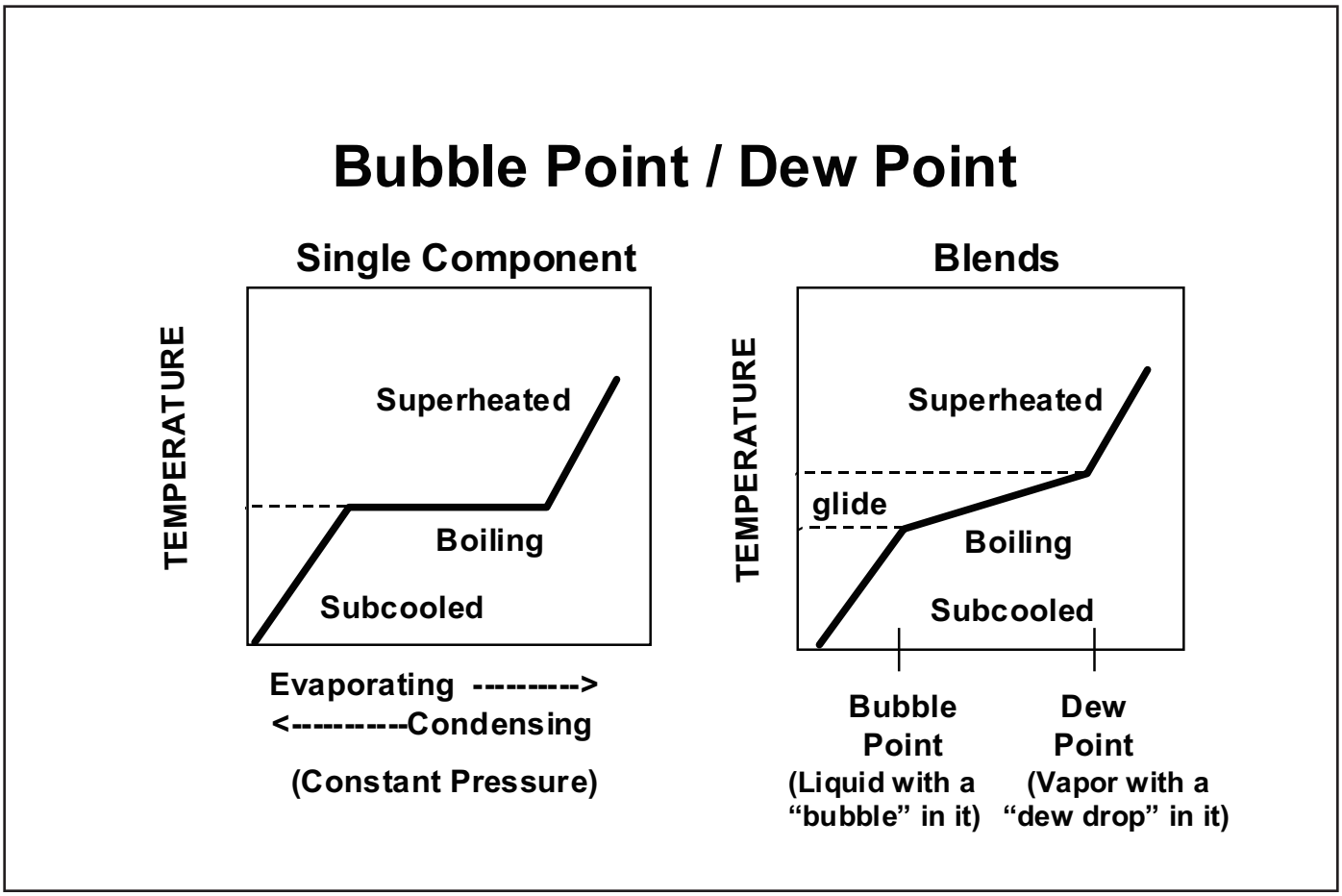
ICE MACHINE TEST RESULTS

Various R-12 retrofit blends were tested in an R-12 ice machine. The picture above represents a side-view of the plate as the water freezes.

For R-12, the water froze in a nearly constant thickness all the way down the plate. The evaporator, mounted on the back side of the plate, held a constant 10˚F along the entire length. The ice thickness sensor was located at about row 3.

For each of the blends tested, R-401A, R-409A and R-414B, the glide of the blend caused the lower portion of the plate to be from 8˚F to 13˚F colder than the upper portion of the plate. The top rows did not fill in as quickly as the bottom, and the overall ice bank that formed was weighted more towards the lower portion of the plate.

The ice machine was still operating at the same suction pressure and was generating the same 30 ounces of ice every 20 minutes. The biggest difference was the setting of the thickness sensor. For the first run, the machine did not shut off because the ice surface near the 3rd row was not forming as fast as the lower portion of the plate. When the sensor was adjusted inward to take this into account, the machine ran fine.



The process of phase change (boiling or condensing) is the same for blends as it is for pure refrigerants:

Boiling: liquid reaches a temperature where bubbles form and then the liquid boils to vapor. When the last drops of liquid disappear, any additional heat input causes the vapor to superheat.

Condensing: vapor cools to a temperature where liquid drops start to form, then the vapor condenses to liquid. When the last of the vapor disappears, any additional removal of heat causes the liquid to subcool.

When these phase changes occur in a pure refrigerant, at constant pressure, the temperature stays constant at what we normally call the "boiling point".

For blends the process is the same but, the shift in composition during phase change causes the temperature glide to occur. The vapor will still superheat and the liquid will still subcool; however, the Saturated Vapor temperature and the Saturated Liquid temperature are now the temperatures at the ends of the temperature glide for a given pressure.

Saturated Liquid = Bubble Point (Liquid with bubbles starting to form)
Saturated Vapor = Dew Point (Vapor with dew drops starting to form)

Two-Column PT Charts

- Traditional PT Charts
  - Temperature in left column, pressure in the remaining columns
  - Saturated pressure listed - same for boiling or condensing / saturated liquid or vapor
- New Blends Need Two Columns
  - Zeotropic blends have different temperatures for saturated liquid and saturated vapor at constant pressure
  - Bubble Point (or Liquid) gives pressure for saturated liquid; used as the reference point for subcooling calculations
  - Dew Point (or Vapor) gives pressure for saturated vapor; used as the reference point for superheat calculations

Temperature °F	°C	R22	R407C Liquid Psig	R407C Vapor Psig
-40	-40.0	0.5	3.0	4.4
-35	-37.2	2.6	5.4	0.6
-30	-34.4	4.9	8.0	1.8
-25	-31.7	7.4	10.9	4.1
-20	-28.9	10.1	14.1	6.6
-15	-26.1	13.2	17.6	9.4
-10	-23.3	16.5	21.3	12.5
-5	-20.6	20.1	25.4	15.9
0	-17.8	24.0	29.9	19.6
5	-15.0	28.2	34.7	23.6
10	-12.2	32.8	39.9	28.0
15	-9.4	37.7	45.6	32.8
20	-6.7	43.0	51.6	38.0
25	-3.9	48.8	58.2	43.6
30	-1.1	54.9	65.2	49.6
35	1.7	61.5	72.6	56.1
40	4.4	68.5	80.7	63.1
45	7.2	76.0	89.2	70.6
50	10.0	84.0	98.3	78.7
55	12.8	92.6	108	87.3
60	15.6	102	118	96.8
65	18.3	111	129	106
70	21.1	121	141	117
75	23.9	132	153	128
80	26.7	144	166	140
85	29.4	156	180	153
90	32.2	168	195	166
95	35.0	182	210	181
100	37.8	196	226	196
105	40.6	211	243	211
110	43.3	226	261	229
115	46.1	243	280	247
120	48.9	260	300	266
125	51.7	278	321	286
130	54.4	297	342	307
135	57.2	317	365	329
140	60.0	337	389	353
145	62.8	359	-	-
150	65.6	382	-	-

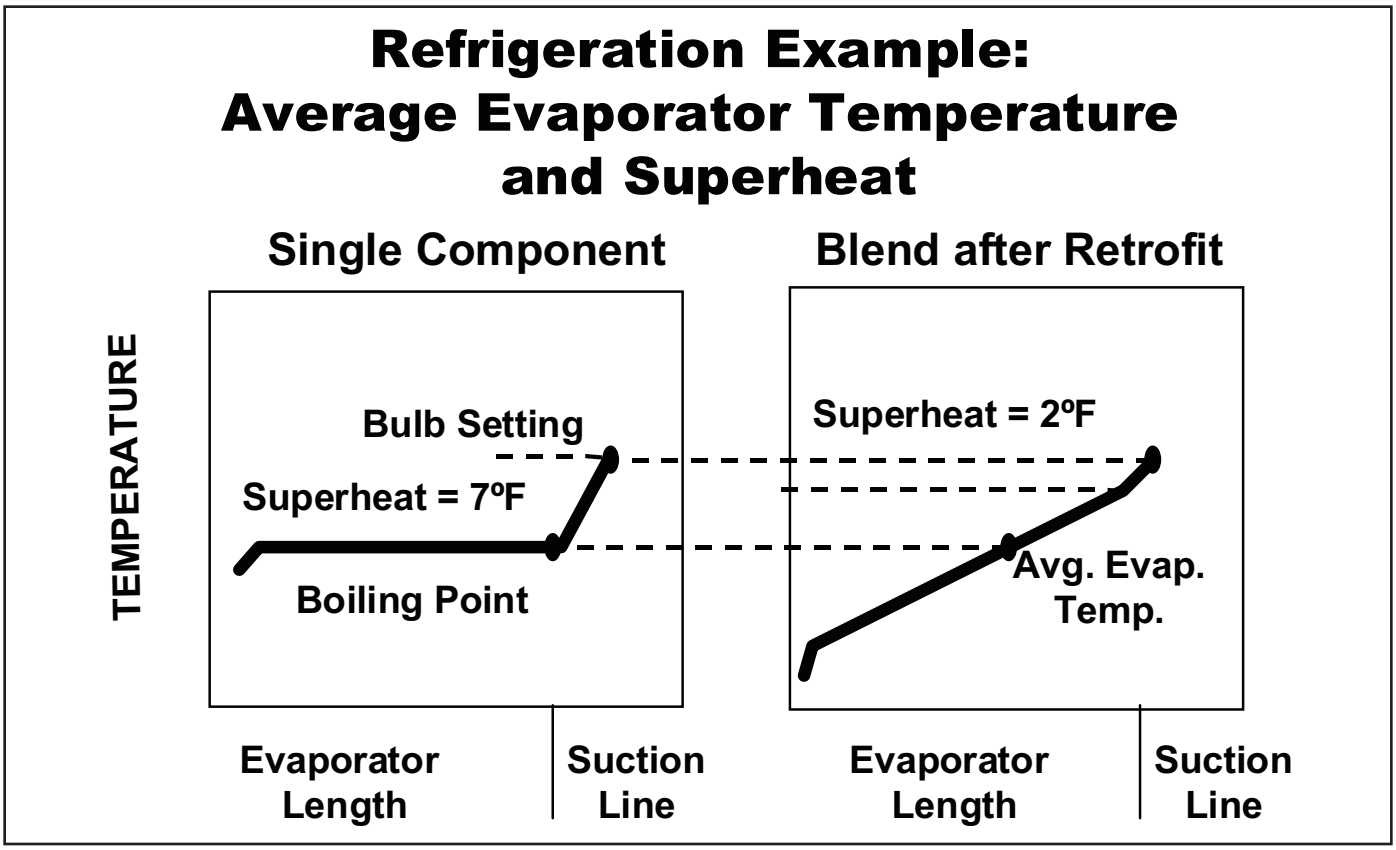
Pressure-Temperature (PT) charts traditionally have listed the temperature in the left column and pressures for various refrigerants in the remaining columns. For blends, we now need two columns per refrigerant: one for Vapor Pressures and one for Liquid pressures.

Note: You should not read a PT chart across - heat exchanges run at constant pressure, not constant temperature.

Superheat Setting: the process for obtaining superheat is the same as it has always been - measure the temperature on the suction line, for example, at the TXV bulb. To find the saturated vapor temperature you measure the suction pressure, and then refer to the PT chart for the corresponding temperature. For blends you must use the Vapor (Dew Point) column. Subtract the saturated temperature from the measured temperature to get the amount of superheat.

Subcooling: the process for obtaining subcooling is also the same as it has been - measure the temperature of the line at the point of interest. To find the saturated temperature of the liquid you measure the pressure on the condenser, and then refer to the PT chart for the corresponding temperature. For blends you must use the Liquid (Bubble Point) column. Subtract the measured value from the saturated value to get degrees of subcooling.

Keep in mind the state of the refrigerant (liquid or vapor) where the measurement is being taken to determine which column you need to use. Also keep in mind that the only practical place that you find saturated vapor, at the correct composition, is at the end of the evaporator when measuring superheat. ***Do not use the vapor column when liquid is present, since the vapor is at the wrong composition.***



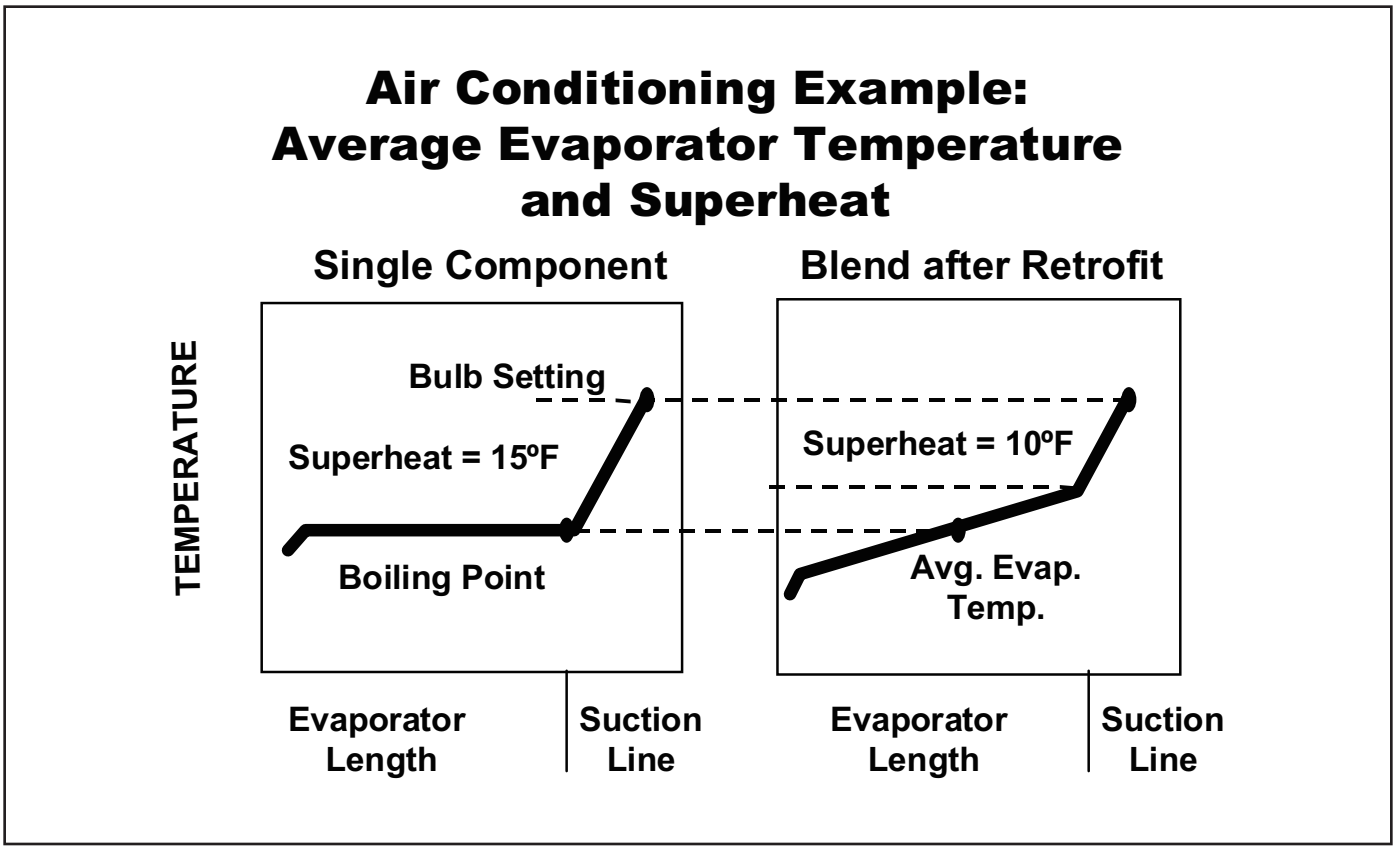
Assume a refrigeration system has been retrofitted from a single component refrigerant to a blend with a temperature glide of about 10˚F. The blend will run with an average evaporator temperature that matches the constant evaporator temperature of the refrigerant that was replaced. About half of the glide is making the front of the evaporator colder, and the other half of the glide is making the back of the evaporator warmer. The outlet is about 5˚F warmer than it used to be.

The TXV bulb has not been adjusted, and it was initially set for 7˚F superheat above the saturated temperature of the original refrigerant. With the blend, the same average evaporator temperature is achieved - but now this only provides 2˚F of superheat above the blend's vapor temperature.

If the safety margin provided by the superheat setting is reduced too far, it is possible that the refrigerant may flood back to the compressor. In many cases, reducing the superheat by 4˚F or 5˚F may not be a problem, but, it is always a good idea to check the superheat to make sure.

Some R-12 retrofit blends have as high as 14˚F glide -- enough to completely overcome an original superheat setting of 7˚F. Many of the current R-22 retrofit blends have temperature glides from 5˚F to 10˚F.

See pages 102 - 104 for a more detailed discussion of TXV operation after retrofitting.



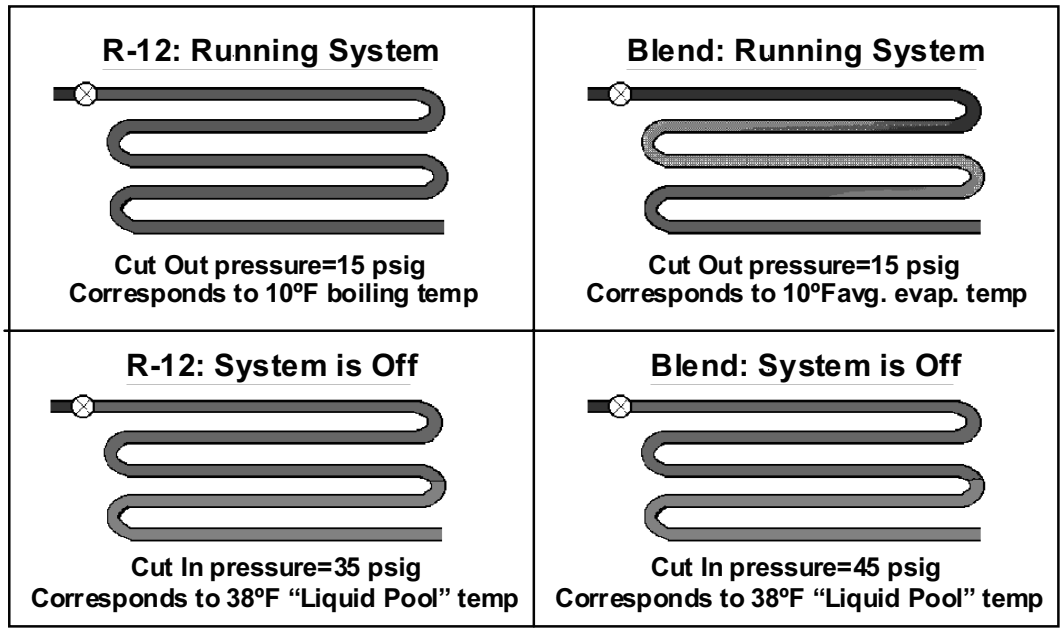
For air conditioning, the effects of temperature glide will be somewhat less severe. Using the same blend with a 10˚F glide, this example looks at the effects of temperature glide using typical superheat settings for an air conditioner (10˚F to 15˚F).

The blend will run with an average evaporator temperature that matches the constant evaporator temperature of the refrigerant that was replaced. About half of the glide is making the front of the evaporator colder, and the other half of the glide is making the back of the evaporator warmer. The outlet will be 5˚F warmer than it used to be.

The TXV bulb has not been adjusted, and it was initially set for 15˚F superheat above the saturated temperature of the original refrigerant. With the blend, the same average evaporator temperature is achieved - but now the superheat drops to 10˚F.

For most running conditions this should not be an immediate problem; however, air conditioners are critically charged to cover the worst case scenario of a hot day and cool house. In this case, the refrigerant is in danger of flooding back from the evaporator so correct superheat settings will be important. If the valve is adjustable, then superheat should be increased to compensate for the glide. If not, the system should be charged with slightly less refrigerant than the indicated amount.

Cut In / Cut Out Pressure Control Using Blends



With R-12, a Cut In/Cut Out Pressure Control work as follows:

- The R-12 coil gets down to about 10˚F and the pressure is about 15 psig. This means the box temperature is somewhere in the 20's ˚F. The pressure switch knows the box is cold enough and it turns off the compressor.

- Liquid R-12 pools in the evaporator coil and warms up to box temperature. As the box warms to about 38˚F, the R-12 in the coil generates 35 psig and the pressure switch turns the system on again.

With the R-12 Retrofit Blends, the control works similarly:

- The average blend coil temperature gets down to about 10˚F at about 15 to 16 psig (depending on the blend). The box temperature is about the same as it was with R-12, and the pressure switch shuts off the system.

- LIQUID blend settles in the coil and warms to box temperature. The blends have higher liquid pressures than R-12 - if no adjustment is made, the pressure switch will kick the system back on at 35 psig. For R-401A, this happens at 29˚F; for R-406A it is 32˚F; for R-409A it is 27˚F; for R-414B it is 28˚F; and for R-416A it is 43˚F. Most of the blends will turn the system on too cold, and short cycling will cause the system to freeze up.

You will need to check the liquid pressure at 38˚F and reset the cut in pressure accordingly. (Note: the vapor is at the wrong composition; do not use the vapor column.)

R-12 Replacement Refrigerants
Property Comparison

Refrigerant	Components	Composition	Glide	Lube	Pressure Match			
					-20	10	40	90°F
R-12	(pure)	100	0	M	0.6	14.6	37	100
R-134a	(pure)	100	0	P	4"v	12	35	104
Refrigeration Blends								
R-401A	22 / 152a / 124	53 / 13 / 34	8	MAP	1	16	41	115
R-401B	22 / 152a / 124	61 / 11 / 28	8	AP	2	19	46	124
R-409A	22 / 124 / 142b	60 / 25 / 15	13	MAP	0	15	39	116
Automotive Blends								
R-406A	22 / 600a / 142b	55 / 4 / 41	15	MAP	4"v	12	33	105
R-414B	22/600a/124/142b	50 / 1.5 / 39 / 9.5	13	MAP	0	14	37	105
R-416A	134a / 600 / 124	59 / 2 / 39	3	P	7.5"v	8	28	97

M: Mineral Oil A: Alkylbenzene P: Polyolester

R-134a: At first look, R-134a pressures match R-12 pretty well, but other properties show that R-134a needs larger equipment to perform the same job (higher compressor displacement and more surface area in the condenser). In effect, R-134a in an R-12 system has lower capacity and higher discharge pressures than expected. In addition, it requires POE flushing to remove mineral oil during a retrofit.

R-401A and R-401B: These are R22 based blends that tend to have higher temperature glide. The presence of R-152a, an HFC, hurts miscibility with mineral oil. It is recommended to change some of the mineral oil to alkylbenzene unless it is a hermetic system running at warmer temperatures. R-401A matches R-12 capacity at around 20˚F evaporator; warmer conditions will begin to show effects from being over-capacity (higher amperage draw, shorter cycle times). R-401B offers a boost in capacity at lower temperatures (-30˚F).

R-409A: This R-22 based-blend has higher temperature glide. It has moderate miscibility with mineral oil, and generally offers good oil return in systems down to 0˚F evaporator. R-12 capacity match is about 10˚F and it still works well at lower evaporator temperatures. Higher discharge temperatures and pressures can develop, especially in warmer applications.

R-414B: This R-22 based blend has been formulated to keep the head pressure down. It is approved for automotive applications, although nylon barrier hoses and special fittings are required. In refrigeration equipment there may be a drop in capacity at colder temperatures.

R-416A : This R-134a based blend has an added HCFC component that keeps the head pressure lower upon retrofit. There will be a drop in capacity compared to R-12, which could be significant in colder applications. Lower suction pressures must also be taken into account. This blend also has lower temperature glide. The manufacturer claims it is OK to use with mineral oil, however the blend does not actually mix with the oil (return is helped by a hydrocarbon component.) Adding POE lubricant is recommended for more complicated piping arrangements.

R-22 Replacements for Refrigeration and Air Conditioning

Refrigerant	Components	Glide	Lube	Pressure Match				
				-20	10	40	110	130˚F
R-22	22	0	MA	10	33	68	226	279
Look-alike Blends								
R-407A	32 / 125 / 134a	10	p	12	37	78	259	34
R-407C	32 / 125 / 134a	10	p	10	34	71	245	324
R-422B	125 / 134a / 600a	5	MAP?	8	30	65	221	292
R422D	125 / 134a / 600a	5	MAP?	10	34	71	238	313
R-404A(507)	125 / 143a / 134a	1.5	P	16	44	86	271	355
R-422C	125 / 134a / 600a	4.5	MAP?	16	43	86	273	356
New Only								
R-410A	32 / 125	0.2	P	27	62	118	365	476

M: Mineral Oil A: Alkylbenzene P: Polyolester

R-407A and R-407C: Both products have the closest capacity and run-time property match to R-22. All products will have lower discharge temperatures than R-22. R-407A is a closer match at lower application temperatures, such as in commercial refrigeration applications. R-407C will work better in medium temperature and air conditioning applications. Replacement of mineral oil with polyolester (POE) is recommended

R-422B and R-422D: These blends will have lower capacity than R-22 in the same system, and in many cases there will be an increase in pressure drop that may require changing TXVs or distributors. They contain hydrocarbons that will help circulate mineral oil in smaller systems. Larger systems, especially ones with receivers, will need addition of POE to help keep the mineral oil from being stranded.

R-404A and R-507: These blends can be used to retrofit R-22 systems that would otherwise be able to run R-404A , such as in commercial refrigeration applications. TXVs would need to be changed to the appropriate R-404A model. Discharge pressures would also increase, although discharge temperatures would come down. An oil change to POE is also required.

R-422C: This blend can be used to retrofit low temperature R-22 systems. The performance characteristics (pressure/temperature) will look much like R-404A, but with a drop in capacity of up to 10%. The hydrocarbon additive will help circulate mineral oil around the system. In larger systems, however, some oil holdup may occur in the receiver. Addition of POE will solve this problem.

R-502 Replacement Refrigerants
Property Comparison

Refrigerant	Components	Composition	Glide	Lube	Pressure Match			
					-20	10	40	90°F
R-502	22 / 115	49 / 51	0	MA	15	41	81	187
HCFC Blends								
R-402A	125 / 290 / 22	60 / 2 / 38	2.5	M+AP	19	48	93	215
R-402B	125 / 290 / 22	38 / 2 / 60	2.5	M+AP	15	42	83	198
R-408A	125 / 143a / 22	7 / 46 / 47	1	M+AP	14	38	77	186
HFC Blends								
R-404A	125 / 143a / 134a	44 / 52 / 4	1.5	P	16	48	84	202
R-507	125 / 143a	50 / 50	0	P	18	46	89	210
R-422C	125 / 134a / 600a	82 / 15 / 3	5	MAP	18	44	87	205

M: Mineral Oil A: Alkylbenzene P: Polyolester

R-402A and R-402B: R-402A shows higher discharge pressures than R-502, however the discharge temperature is lower. R-402B is a closer match in pressure, but the discharge temperature runs higher (this is good for ice machines, which is where R-402B is primarily used). Although propane is added to improve oil circulation, it is still recommended to replace some mineral oil with alkylbenzene oil.

R-408A: R-408A has the closest PT match to R-502 across the whole application range. It also has very low temperature glide. R-408A does generate higher discharge temperatures than R-502, and this could be a problem in extreme application conditions, such as transport refrigeration in hot climates. R-408A can be used in most refrigeration systems.

R-404A and R-507: These two blends are virtually the same in terms of operation and equipment. In a retrofit situation, they will require POE flushing to be performed. They will also generate higher discharge pressures. Generally speaking, retrofitting with these HCFC blends will add more complexity and cost to a retrofit job, especially when compared to using one of the other blends.

R-422C: This blend can be used to retrofit low temperature R-22 systems. The performance characteristics (pressure/temperature) will look much like R404A, but with a drop in capacity of up to 10%. The hydrocarbon additive will help circulate mineral oil around the system. In larger systems, however, some oil holdup may occur in the receiver. Addition of POE oil will solve this problem.

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:

Additional copies of page 88 and 89 are available in NRI's R-22 Retrofit Guideline and Procedures Handbook.

SYSTEM DATA COLLECTION

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								

Additional copies of page 88 and 89 are available in NRI's R-22 Retrofit Guideline and Procedures Handbook.

R-12 Systems - General Considerations

R-12 and R-500 Air Conditioning

1. For centrifugal compressors, it is recommended that the manufacturer's engineering staff become involved in the project - special parts or procedures may be required. This will ensure proper capacity and reliable operation after the retrofit.
2. Most older, direct expansion systems can retrofit to R-401A, R-409A, R-414B or R-416A (R-500 to R-401B or R-409A), as long as there are not components that will cause fractionation within the system to occur.
3. Filter driers should be changed at the time of conversion.
4. System should be properly labeled with refrigerant and lubricant type.

R-12 Medium / High Temperature Refrigeration (>0˚F evap)

1. See Recommendation Table for blends that work better in high ambient heat conditions.
2. Review the properties of the new refrigerant you will use, and compare them to R-12. Prepare for any adjustments to system components based on pressure difference or temperature glide.
3. Filter driers should be changed at the time of conversion.
4. System should be properly labeled with refrigerant and lubricant type.

R-12 Low Temperature Refrigeration (<20˚F evap)

1. See Recommendations Table for blends that have better low temperature capacity.
2. Review the properties of the new refrigerant you will use, and compare them to R-12. Prepare for any adjustments to system components based on pressure difference or temperature glide.
3. Filter driers should be changed at the time of conversion.
4. System should be properly labeled with refrigerant and lubricant type.

Recommendations for R-12 Retrofit Products

Closest Match / Easiest

R-12 AC	R-500 AC	R-12 small equipment Higher T	R-12 small equipment Lower T	R-12 larger equipment Higher T	R-12 larger equipment Lower T
R-414B	R-409A	R-416A	R-409A	R-414B	R-409A
R-416A	R-401B	R-414B	R-401A	R-409A	R-401A
R-401A	R-401A	R-401A	R-414B	R-401A	R-414B
R-409A	R-414B	R-409A	R-416A	R-416A	R-416A
R-134a	R-134a	R-134a	R-134a	R-134a	R-134a
	R-416A				

Most Different / Hardest

General Retrofit Procedure: Centrifugal, Reciprocating AC and Refrigeration Systems

1. If the system is able to run -- collect system data and operating conditions prior to retrofit.
2. Isolate the compressor and recover the R-12. Change the lubricant in the compressor to polyolester (POE). For hermetic compressors this may require removal of the compressor.
3. Replace any oil in auxiliary components such as oil separators or oil feed systems.
4. Close the system and run with R-12 for 24 hours to circulate the POE and flush the mineral oil back to the compressor.
5. Repeat steps 2-4 until residual mineral oil level is below manufacturer's recommendations (typically 5%). (If the unit is not operational, then perform the oil flushing procedure immediately after startup with R-134a.)
6. Recover the R-12 from the entire system.
7. Perform any maintenance, repair, or component replacements, and change filter/driers.
8. Evacuate the system to manufacturer's specifications.
9. Charge the system with the proper amount of R-134a (usually 85% to 90% of the original R-12 charge by weight).
10. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation.
11. Label the system with the new refrigerant and lubricant type.

Most common areas that require adjustment or attention:

- Changing the lubricant to POE
- TXV valve adjustment / superheat setting

General Retrofit Procedure: Reciprocating AC and Refrigeration Systems

1. If the system is able to run -- collect system data and operating conditions prior to retrofit.

2. Recover the R-12 from the entire system.

3. Perform any maintenance, repair or component replacements, and change filter/driers. If needed (for low temperatures) remove mineral oil from the system and replace with an equivalent amount of alkylbenzene oil.

4. Evacuate the system to manufacturer's specifications.

5. Charge the system with the proper amount of the blend (usually 80% to 85% of the original R-12 charge by weight). Be sure to remove liquid refrigerant from the cylinder to get the proper composition (but flash the refrigerant before feeding into a running system).

6. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation.

7. Label the system with the new refrigerant and lubricant type.

Most common areas that require adjustment or attention:

- TXV valve adjustment / superheat setting (use Vapor side of PT chart)
- Pressure controls (cut in / cut out)
- Pressure related switches or controls - difference from R-12 pressures
- Irregular frost formation with high glide blends
- High discharge pressure or temperature, high amps in high ambient temperature conditions (abuse of compressor)

General Retrofit Procedure: Reciprocating AC and Refrigeration Systems

1. If the system is able to run -- collect system data and operating conditions prior to retrofit.

2. Recover the R-12 from the entire system.

3. Perform any maintenance, repair or component replacements, and change filter/driers. If needed (for complicated piping, large hold-up volumes) remove mineral oil from the system and replace with an equivalent amount of polyolester lubricant.

4. Evacuate the system to manufacturer's specifications.

5. Charge the system with the proper amount of the blend (about 90% R-12 charge by weight). Be sure to remove liquid refrigerant from the cylinder to get the proper composition (but flash the refrigerant before feeding into a running system).

6. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation. Cap tube systems may need slight charge adjustment to achieve proper operation.

7. Label the system with the new refrigerant and lubricant type.

Most common areas that require adjustment or attention:

- TXV valve adjustment / superheat setting (use Vapor side of PT chart)
- Pressure controls (cut in / cut out)
- Pressure related switches or controls - lower from R-12 pressures
- Loss of capacity at lower evaporator temperatures / longer run times

General Retrofit Procedure: AC and Refrigeration Systems

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. Change the lubricant in the compressor to the oil specified by the manufacturer. For hermetic compressors this may require removal of the compressor.

4. Replace any oil in auxiliary components such as oil separators or in oil feed system.

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

6. Perform any required maintenance or repair operations previously identified, including:
   - replacement of seals and gaskets
   - pressure controls (cut in / cut out)
   - pressure related switches or controls - difference from R-22 pressures
   - leak repairs
   - filter drier replacement
   - compressor oil change

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

8. 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.

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

10. 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. (Reference TXV section- page 102 - 104)

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

General Retrofit Procedure: AC and Refrigeration Systems

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. Change the lubricant in the compressor to the oil specified by the manufacturer. Oil return is determined by a number of design and operating conditions. In some systems a small amount, up to 10%, of POE may need to be added to assist in oil return.

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

5. Perform any required maintenance or repair operations previously identified, including:
   - replacement of seals and gaskets
   - pressure controls (cut in / cut out)
   - pressure related switches or controls - difference from R-22 pressures
   - leak repairs
   - filter drier replacement
   - compressor oil change
   - replace TXV, TXV element, and refrigerant distributor nozzle as required

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

7. 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.

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

9. 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. (Reference TXV section - page 102- 104)

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

General Retrofit Procedure: Refrigeration Systems

1. If the system is able to run - collect system data and operating conditions prior to retrofit.

2. If an oil change is indicated (R-404A, R-507, possible R-422A/C), isolate the compressor and recover the R-22. Change the lubricant in the compressor to polyolester (POE). For hermetic compressors, this may require removal of the compressor.

3. Replace any oil in auxiliary components such as oil separators or oil feed systems.

4. Close the system and run with R-22 for 24 hours to circulate the POE and flush the mineral oil back to the compressor.

5. Repeat steps 2-4 until residual mineral oil level is below manufacturer's recommendations (typically 5%). If the unit is not operational, then perform the oil flushing procedure immediately after startup.

6. Recover the R-22 from the entire system.

7. Perform any maintenance, repair, or component replacements, especially TXVs, and change filter/driers.

8. Evacuate the system to manufacturer's specifications.

9. Charge the system with the proper amount of the blend (usually 85% to 95% of the original R-22 charge by weight). Be sure to remove liquid refrigerant from the cylinder to get the proper composition (but flash the refrigerant before feeding into a running system).

10. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation.

11. Label the system with the new refrigerant and lubricant type.

Most Common Areas that Require Adjustment or Attention:

- TXV valve replacement / superheat setting (use Vapor side of PT chart)
- Pressure controls (cut in / cut out)
- Pressure related switches or controls - difference from R-22 pressures
- Changing the lubricant to POE (R-404A / R-507)

General Retrofit Procedure: Reciprocating AC and Transport Refrigeration Systems

1. If the system is able to run - collect system data and operating conditions prior to retrofit.
2. Recover the R-500 from the entire system.
3. Perform any maintenance, repair, or component replacements and change filter/driers. If needed (for low temperatures) remove mineral oil from the system and replace with an equivalent amount of alkylbenzene oil.
4. Evacuate the system to manufacturer's specifications.
5. Charge the system with the proper amount of the blend (usually 85% to 95% of the original R-22 charge by weight). Be sure to remove liquid refrigerant from the cylinder to get the proper composition (but flash the refrigerant before feeding into a running system).
6. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation.
7. Label the system with the new refrigerant and lubricant type.

Most Common Areas that Require Adjustment or Attention:

- TXV valve adjustment/ superheat setting (use Vapor side of PT chart)
- Pressure related switches or controls - most have lower pressure than R-500

General Retrofit Procedure: Refrigeration Systems and Ice Machines

1. If the system is able to run - collect system data and operating conditions prior to retrofit.

2. Recover the R-502 from the entire system.

3. Perform any maintenance, repair or component replacements and change filter/driers. If oil return has been a problem with R-502, remove mineral oil from the system and replace with an equivalent amount of alkylbenzene oil.

4. Evacuate the system to manufacturer's specifications.

5. Charge the system with the proper amount of the blend (usually 80% to 85% of the original R-502 charge by weight). Be sure to remove liquid refrigerant from the cylinder to get the proper composition (but flash the refrigerant before feeding into a running system).

6. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation.

7. Label the system with the new refrigerant and lubricant type.

Most Common Areas that Require Adjustment or Attention:

- TXV valve adjustment/ superheat setting (use Vapor side of PT chart)
- Pressure controls (cut in / cut out)
- Pressure related switches or controls - difference from R-502 pressures

General Retrofit Procedure: Refrigeration Systems

1. If the system is able to run - collect system data and operating conditions prior to retrofit.
2. Isolate the compressor and recover the R-502. Change the lubricant in the compressor to polyolester (POE). For hermetic compressors, this may require removal of the compressor.
3. Replace any oil in auxiliary components, such as oil separators or oil feed systems.
4. Close the system and run with R-502 for 24 hours to circulate the POE and flush the mineral oil back to the compressor.
5. Repeat steps 2-4 until residual mineral oil level is below manufacturer's recommendations (typically 5%). (If the unit is not operational then perform the oil flushing procedure immediately after startup with R-404A/R-507.)
6. Recover the R-502 from the entire system.
7. Perform any maintenance, repair or component replacements and change filter/driers.
8. Evacuate the system to manufacturer's specifications.
9. Charge the system with the proper amount of R-404A or R-507 (usually 85% to 90% of the original R-502 charge by weight).
10. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation.
11. Label the system with the new refrigerant and lubricant type.

Most Common Areas that Require Adjustment or Attention:

- Changing the lubricant to POE
- TXV valve adjustment/ superheat setting

General Retrofit Procedure: Refrigeration Systems

1. If the system is able to run - collect system data and operating conditions prior to retrofit.
2. Recover the refrigerant charge from the entire system.
3. If there are large system components that may retain oil as a non-miscible layer, then replace at least 50% of the oil with polyolester (POE) lubricant.
4. Perform any maintenance, repair, or component replacements and change filter/driers.
5. Evacuate the system to manufacturer's specifications.
6. Charge the system with the proper amount of R-422C (about 90% to 95% of the original R-502 charge by weight, or about the same charge as R-402A/B, or about 105% of the R-408A charge).
7. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation.
8. Label the system with the new refrigerant and lubricant type.

Most Common Areas that Require Adjustment or Attention:

- Small addition of POE in some cases
- Slight TXV valve adjustment/ superheat setting

General Retrofit Procedure: Cascade Systems - High Side

Follow guidelines for high stage refrigerant.

General Retrofit Procedure: Cascade Systems - Low Side

1. If the system is able to run - collect system data and operating conditions prior to retrofit.
2. Recover the refrigerant charge from the low stage. Special recovery equipment and cylinders are required to accommodate the high pressure of these refrigerants.
3. Replace mineral oil or alkylbenzene with POE lubricant. Low residual mineral oil is important for circulation.
4. Perform any maintenance, repair or component replacements and change filter/driers.
5. Evacuate the system to manufacturer's specifications.
6. Charge the system according to manufacturer's specifications, with the proper amount of hydrocarbon additive (if required), then the proper amount of refrigerant. (see notes below)
7. Operate the system and record new system operation data. Make adjustments to controls as needed to ensure proper operation.
8. Label the system with the new refrigerant and lubricant type.

Performance Changes upon Retrofitting (-120˚F evap. -30˚F cond.)

Product	Capacity	Efficiency	Suction P (psig)	Discharge P (psig)	Discharge T (˚F)
R-13 to R-23	100 104	100 91	12 13	104 123	198 280
R-503 to R-508B	100 98	100 103	18 18	145 147	225 186

Expansion Tanks should be adequate upon retrofit.

Static Charge Adjustment
R-13 to R-23: increase up to 30%
R13 to R-508B: increase up to 7%
R-503 to R-508B: decrease down to -8%

If indicated, charge hydrocarbons from 5% to 10% of the refrigerant static charge

Sizing Thermostatic Expansion Devices (TXV)

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.

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

Pressure Drop Correction Factors

Table 3

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: An 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.

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											
Evaporator Temp (˚F)	Condensing Temp (˚F)	Liquid Temp (˚F)	R-22	Capacity Multiplier* 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

3. Refrigerant Management Services

ANALYTICAL TESTING SERVICE

National Refrigerants, Inc. analytical testing service offers easy-to-use sample kits for:

- ✓ Refrigerant
- ✓ Refrigerant Oil
- ✓ Halon
- ✓ Specialty Testing/ GC-MS

Refrigerant - Testing to AHRI Standard 700 Specifications.

Refrigeration Oil - Testing oil quality as indication of system condition.

Halon Testing - Testing to Military/ASTM/ISO Specifications.

Sampling Kit Features

- Easy to use, single use, new sample cylinders
- High-pressure sample cylinder rated to 400 psig suitable for most alternative refrigerants and blends
- Instructions included for proper sampling procedures
- All analysis forms and necessary DOT labeling included
- Pre-paid return postage to NRI's analytical laboratory for non-hazardous samples
- All analysis reports are returned with written commentary and recommendations
- Same day results available upon request for additional fee
- Sample cylinders available for very high pressure (VHP) refrigerants like R-508B and R-503

REFRIGERANTS

Part # NRIHPN - High pressure refrigerant analysis
Part # NRILP - Low pressure refrigerant analysis
Testing liquid phase to AHRI 700 Specifications for Fluorocarbon Refrigerants for one or more of the following:

- IDENTIFICATION (Infrared Spectroscopy)
- MOISTURE
- ACIDITY
- HIGH BOILING RESIDUE/OIL CONTENT
- PARTICULATES/SOLIDS
- PURITY (Gas Chromatography)/Impurity listing
- CHLORIDE

LUBRICANTS

Part # NRIOA (Oil Analysis)
Testing of lubricant for one or more of the following:

- IDENTIFICATION (Infrared Spectroscopy)
- MOISTURE / ACIDITY
- APPEARANCE
- VISCOSITY
- METALS / ADDITIVES by ICP
- RESIDUAL MINERAL OIL (as requested)
- FLUORIDE, CHLORIDE and CONDUCTIVITY (as requested, extra cost)

NON-CONDENSABLE GAS

Part # NRINCN*
Testing vapor phase to AHRI 700 Specifications for Fluorocarbon Refrigerants; (Requires a vapor-only sample taken from the source vapor phase)
*Not applicable to R-11, R-113, R-123

HALONS

Testing to MILITARY / ASTM / ISO Specifications

LAB CAPABILITIES

- Purity / Impurities	- Pack/Cap Col. GC, FID, TCD, GC-MS
- Water	- KF Coulometric Titration
- Halogen Ion	- Ag^+ Qualitative / Visual / ISE
- Non-Absorbable Gas	- Packed Col. GC TCD
- High Boiling Residue	- Evaporation/Gravimetric/Volumetric
- Suspended Matter	- Visual Observation / Gravimetric
- Acidity	- Aqueous Extraction / Base Titration
- Color	- APHA Color Comparison
- Free Halogen	- Iodimetry / S_20_3 - Titration
- Viscosity	- Cannon-Fenske
- FT-IR	- Transmission / ATR
- Flash Point	- Closed Cup

NATIONAL REFRIGERANTS, INC.

LAB USE ONLY
LAB NOTEBOOK NO: _____
SAMPLE ID# _____

REQUEST FOR REFRIGERANT ANALYSIS

• Complete this form and attach to the filled test cylinder. • Follow cylinder filling instructions on reverse side.
• One form must be completed for each sample submitted.

Company:

Address:

Job Location:

Phone # Fax#

Contact:

Email Address:

PO # UR Store #

At time of sampling:
- System running? ❒ yes ❒ no
- Temperature of sample: _____ ˚F

System Serial #

Type of oil in system:

Sample is: ❒ liquid ❒ cond. vapor ❒ vapor

Sample ID:

Submitted by: Date:

REFRIGERANT

❒ R-11	❒ R-404A
❒ R-12	❒ R-407A/B/C/D
❒ R-22	❒ R-408A
❒ R-113	❒ R-409A
❒ R-114	❒ R-410A/B
❒ R-123	❒ R-416A
❒ R-124	❒ R-417A
❒ R-125	❒ R-422A/B/C/D
❒ R-134a	❒ R-500
❒ R-142b	❒ R-502
❒ R-401A/B	❒ R-507
❒ R-402A/B	❒ R-509
❒ R-403B	❒ OTHER

SAMPLE TAKEN FROM

- ❒ Vapor Phase at:
- ❒ Liquid Line
- ❒ Condenser
- ❒ Evaporator
- ❒ Compressor-Suction
- ❒ Compressor-Discharge
- ❒ Receiver
- ❒ Recovery / Recycle Unit
- ❒ Recovery Cylinder / Drum
- ❒ Other

SOURCE OF SAMPLE

- ❒ New factory filled cylinders
- ❒ Used-Refrigerant drum or cylinder
- ❒ Centrifugal refrigerant system with purge unit
- ❒ Centrifugal refrigerant system without purge unit
- ❒ Reciprocating refrigerant system
- ❒ Hermetic ❒ Open
- ❒ Rotary System
- ❒ Other:

REASON FOR ANALYSIS REQUEST

- ❒ Air / Water leak suspected
- ❒ Evidence of corrosion
- ❒ Oil sludged or darkened
- ❒ Excessive head pressure
- ❒ Suspect excess oil evaporator
- ❒ Compressor burn-out
- ❒ Desire condition of refrigerant
- ❒ Other

APPLICATION

- ❒ Evaporator temperature:
- ❒ Condensing medium
- ❒ Evaporator type:
- ❒ DX:
- ❒ Flooded:
- ❒ Shell & Tube
- ❒ System Size: HP Tons
- ❒ Refrigerant Charge: lbs.

ANALYSIS DESIRED

- ❒ Moisture - ppm
- ❒ High boiling residue (oil)-%
- ❒ Acidity - ppm as HC1
- ❒ Identification - IR
- ❒ Purity - GC
- ❒ Particulates
- ❒ Chloride

Comments or special requests:

Ship Sample to:

ANALYTICAL LABORATORY
661 Kenyon Avenue
Rosenhayn, NJ 08352

Sampling Procedures on reverse side

NATIONAL REFRIGERANTS, INC.

CYLINDER SAMPLING PROCEDURES

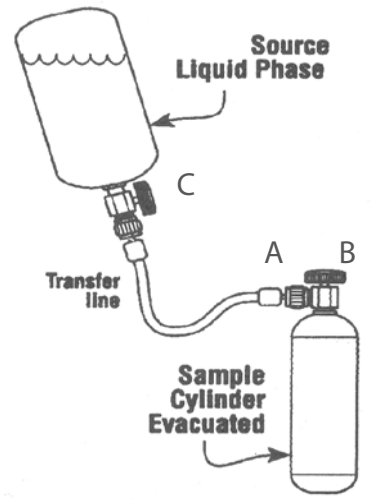
ANALYTICAL LABORATORY
661 Kenyon Avenue
Rosenhayn, NJ 08352

Liquid Phase

(Refer to Figure 1.)

1. Use a heat gun, or otherwise dry the connection at the sample source, "C".
2. Connect a vacuum gauge to the sample cylinder or otherwise ensure that the sample cylinder is a full vacuum (-30"Hg). Tare weigh the cylinder to the nearest ounce.
3. Connect a clean, dry, flex transfer line to the refrigerant source at point "C". Dry the sample cylinder at point "A".
4. Carefully open valve "C" and purge a small amount of liquid phase through the line. Then immediately connect the line to the sample cylinder at point "A".
5. Open valve "B". Then slowly open valve "C" as to fill the cylinder to about 85-90% volume capacity. Close valves "C" and "B". NOTE: External cooling of the sample cylinder may be necessary to sample the refrigerant.
6. Disconnect the flex line at "A" and re-weigh the cylinder to ensure sufficient sample has been taken.
7. Soap bubble check the sample cylinder valve and valve connection to the cylinder for any leaks.

Figure 1

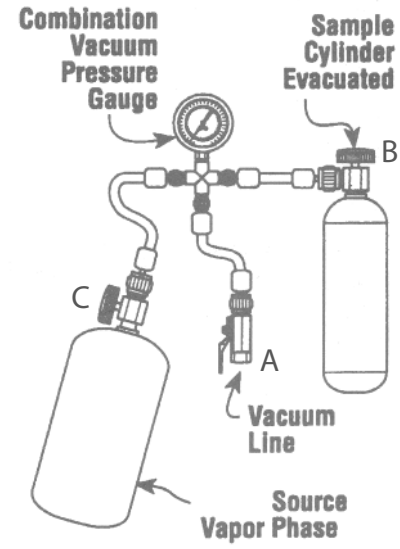


Vapor Phase

(Refer to Figure 2.)

1. Connect as shown and then with valve "C" closed and valve "B" opened, slowly open valve "A" until the gauge reads -30 in. Hg.
2. Close valve "A".
3. Slowly open valve "C" as to bring the pressure to slightly above 1 atm. Close valve "C".
4. Open valve "A" until full vacuum is attained. Close valve "A".
5. Wait 5 minutes to ensure there are no leaks. Gauge should hold full vacuum.
6. Slowly open valve "C" and bring cylinder to either full headspace pressure or to a <u>maximum</u> of 100 psig, whichever comes first. <u>Do not exceed 100 psig</u>. Close valve "C" and "B".
7. Disconnect sample cylinder and soap bubble check for leaks.
8. Submit for NCG analysis.

Figure 2



Checklist

Did you remember to:

- ☑ Tightly close all valves?
- ☑ Weigh cylinder to make sure a sufficient sample was taken?
- ☑ Completely fill out the Request for Refrigerant Analysis Form (on reverse side)?
- ☑ Provide your FAX number and email address so we can return your test results?

Analysis Request Form
on reverse side

NATIONAL REFRIGERANTS, INC.

ID #

LAB USE ONLY

REQUEST FOR OIL ANALYSIS

• Complete this form and attach to the filled test cylinder. • Follow cylinder filling instructions on reverse side.
• One form must be completed for each sample submitted.

Company:

Attn:

Address

Job Location:

Phone # Fax#

Email address:

PO # UR Store #

Sample ID:

Date sample taken:

COMPRESSOR INFORMATION

Hermetic? Yes ❒ No ❒

❒ Centrifugal ❒ Rotary
❒ Reciprocating ❒ Screw
❒ Other (describe)

*Compressor serial no:

Oil mfr/brand or type/grade:

Last date of oil change:

Hours operating since last oil change:

Sump Cap: Gal: Qt: L:

Oil additive present:

Compressor mfr/brand:

PLEASE CHECK TESTS REQUIRED

❒ Identification of type of oil
❒ Residual mineral oil in POE oil
❒ Residual mineral oil in AB oil
❒ Compressor-Discharge
❒ Appearance Unit
❒ Moisture
❒ Other (explain below

❒ Acidity
❒ Viscosity
❒ Wear Metals

Comments or special requests:

SYSTEM INFORMATION

Unit mfr/model:

Unit serial no:

Refrigerant:

No. filter/driers

Last date of filter/drier change:

Retrofit in progress: Yes ❒ No ❒

If YES, please complete below:

Original oil type:

New oil type:

*required for historical data reporting

Ship Sample to:

ANALYTICAL LABORATORY
661 Kenyon Avenue
Rosenhayn, NJ 08352

Sampling instructions on reverse side

NATIONAL REFRIGERANTS, INC.

OIL LABORATORY

This kit contains:

(1) Sample bottle
(1) Identification label
(1) Sample

How to use this service:

1. **Collecting Samples:**
Oil should be taken from the unit immediately after shutdown, and/or while running at operating temperature so as to obtain a representative sample. The sample should be taken from the crankcase at the drain plug. Upon opening the plug, drain off a small amount of oil before taking the sample as to avoid contamination. Once drawn, allow the sample to de-gas before tightening the lid. Fill the container about 3/4 full.
NOTE: Synthetic oils are hygroscopic and must be sampled without excessive exposure to ambient air, i.e., attach the lid securely immediately following the degassing period.

2. **Identification Labels:**
Fill out a label completely for each compressor sampled. Print your name, job, compressor serial number and sampling date on the label.

3. **Sample Request Form:**
Be sure to include all of the information requested (hours since oil change, hours since new/overhauled, or last major repair, oil type, etc.) Include all unit/component information.

4. **Sending the Sample:**
Be sure the identification label is attached to the sample bottle. Be sure the sample bottle lid is securely tightened. Fold the sample request form and place it around the other bottle inside the pre-addressed mailing box. Always use first class postage, air freight or overnight (FedEx, etc.) for quick service.

Return Sample to:

ANALYTICAL LABORATORY
661 Kenyon Avenue
Rosenhayn, NJ 08352

Oil Analysis Request Form on reverse side

Recovery Cylinder Hydrotest & Refurbish Program

Refrigerant recovery cylinders require a Department of Transportation (DOT) hydrostatic recertification every 5 years. This requires the cylinder to have a visual, internal and external examination and a test by interior hydrostatic pressure in a water jacket for determination of the expansion of the cylinders. NRI is a DOT approved hydrostatic test facility and offers other cylinder refurbishing services. Below are details of NRI's cylinder refurbishing program offered to owners of recovery cylinders. Please call for a quotation for any service not listed.

HYDROSTATIC TEST

Includes:

- hydrostatic test
- internal drying
- test date engraved on collar/body of cylinder

HYDROSTATIC TEST & REFURBISH

Includes:

- hydrostatic test
- removal of old paint
- application of grey/yellow paint
- test date engraved on collar/body of cylinder
- dip tube replacement
- internal drying
- dual port valve replacement

The above services are generally available for all cylinders listed below

30 lb. & 50 lb. recovery cylinders (DOT 4BA, 4BW)
125 lb. recovery cylinders (DOT 4BA, 4BW)
240 lb. recovery cylinders (DOT 4BA, 4BW)
1000 lb. recovery cylinders (DOT 4BA, 4BW)
2000 lb. recovery cylinders (DOT 106A, 110A)

Additional work may be necessary for DOT Certification. Customer will be notified before work begins if additional costs will be incurred. Please call for pricing.

Refrigerant Recovery Containers

Pressurized Recovery Cylinders

Size	Deposit**
30 lb.	$ 100.00
40 lb.	100.00
50 lb.	100.00
50 lb. HP*	125.00
50 lb w/float	125.00
125 lb.	200.00
1000 lb.	1500.00
2000 lb.	4500.00

Recovery Drums for R11, R113 , R123

Size
100 lb. (10 gal)
200 lb. (20 gal)
650 lb. (55 gal)

Drums can be purchased for one time use

EZ ONE-SHOT™ disposable cylinder is rated to 400 psi and is guaranteed to be rated to recover R410A.
***50 lb. HP** cylinder is also rated to 400 psi and can be used to recover R410A.

Very High Pressure Recovery Cylinders

Size	Deposit**
9 lb.	$130.00
23 lb.	150.00
80 lb.	200.00

Guidelines

- ◊ A service fee is charged when cylinders are taken for use by customer.
- ◊ Cylinder deposits are credited back to customer upon return of cylinder.
- ◊ Drums for low pressure refrigerant recovery are rated as single trip containers, therefore they are purchased outright.
- ◊ National uses its own on-site DOT approved hydrostatic testing equipment. All cylinders are shipped under vacuum. For the user's protection, a plastic shrink wrap covers the valve.
- ◊ Please read Filling Procedures and Safety Recommendations to ensure proper transfer of recovered refrigerant in to containers.
- ◊ National reserves the right to charge a cylinder cleaning fee for cylinders used as receivers or returned less than 50% full.

*** prices subject to change without notice*

INSTRUCTIONS FOR PARTICIPATING IN NRI'S REFRIGERANT RECLAMATION PROGRAM

1. Obtain a Recovered Refrigerant tag/label and container(s) from either NRI or an authorized distributor.

2. Fill out a Recovered Refrigerant Tag for each recovery cylinder and a Recovered Refrigerant Label for each drum. Bill of Lading number must be written on each label/tag and the appropriate panel on the EZ ONE-SHOT™ disposable 30 lb. recovery cylinder.

3. Fill the containers according to NRI Filling Instructions.

4. All Material must meet NRI Recovered Refrigerant Acceptance Specifications. Please see Terms and Conditions for additional information.

5. Ship your properly filled and tagged containers to:

National Refrigerants, Inc.
661 Kenyon Avenue
Rosenhayn, NJ 08352
or
an authorized NRI Distributor

RECOVERED REFRIGERANT ACCEPTANCE SPECIFICATIONS

1. Only fluorocarbon refrigerants from refrigeration and air conditioning systems are accepted. Halons will not be accepted. Fluorocarbons from other applications, such as solvents or cleaning agents, are NOT acceptable.

2. Non-Fluorocarbon refrigerants, such as ammonia, methylene chloride, propane, ethane, sulfur dioxide, etc. are NOT acceptable. Also, fluorocarbon refrigerants contaminated with hydrocarbons in excess of 0.5% by weight (total hydrocarbons) will not be accepted.

3. Only one type of refrigerant per container is acceptable. Refrigerant must be shipped in DOT-approved recovery containers. Refer to AHRI Guideline K. R-11 R-113 and R-123 must be shipped in drums to avoid additional handling fees.

4. Containers must not exceed Maximum Allowable Gross Weight as specified in NRI's Cylinder Weight Chart. Overfilled containers will be subject to a handling fee.

5. Refrigerant Contaminants are acceptable with the following limits:

Purity	-	99% for all CFCs, HCFCs and HFCs. R11 may not exceed greater than 0.5% R123 contamination.
Component Ratios/Composition	-	Must be within AHRI 700 Specifications for allowable composition (weight). Composition must be within ASHRAE classification for toxicity and flammability.
Oil	-	Not to exceed 20% by weight in R11, R113 & R123; 10% for all others.
Water	-	Water exceeding saturation point of refrigerant requires special processing to separate the free standing water from the refrigerant; fee will be charged for each pound of free water.
Acid	-	pH must be greater than 2.0 and less than 12.0; pH level between 2.0 - 5.0 requires special handling to neutralize acid in the material; fee will be based on the gross weight of material
Dyes	-	Not to exceed 1% by weight

FILLING PROCEDURE FOR RECOVERED REFRIGERANT

1. Visually inspect the container to be filled. Use vacuum pump to pull cylinder into full vacuum. For all cylinders, leak test with a vacuum gauge. Do not fill a leaking cylinder. NRI is not responsible for refrigerant recovered into a leaking cylinder.

2. Place the container on a scale. Note empty weight of container to determine maximum gross weight. Add the corresponding maximum refrigerant weight to the tare weight to get the maximum allowable gross shipping weight. (See guidelines for Maximum Shipping Weight.)

3. Connect transfer hoses to the container. Make certain hoses are leak free. If possible, change hoses when recovering different types of refrigerant to avoid contamination by unintentionally mixing refrigerants.

4. Open container outlets and begin the transfer process following manufacturer's instructions for the recovery unit. DO NOT LEAVE THE CONTAINER UNATTENDED. Do not fill more than 80% by volume. It is illegal to transport an overfilled cylinder.

5. When the scale reaches the gross weight limit-stop the transfer process. Tightly close all valves and other outlets. Disconnect the transfer hose. AVOID CONTACT WITH LIQUID REFRIGERANT/OIL MIXTURES. Immediately replace all valve outlet caps and other container closures. NRI does not recommend using a recovered refrigerant cylinder as a temporary storage container.

6. Weigh the container. Always use a scale. DO NOT OVERFILL. Write the weight on all appropriate forms and on the container tag or label.

7. Completely fill out the container tag or label. Be sure the tag or label indicates the correct refrigerant in the container. It is illegal to transport a container without identifying the contents (including empty cylinders).

8. There will be cylinder cleaning charge for all cylinders returned less than 50% full. Check off the "For Cleaning Only" box on the hangtag. R11, R113 & R123 must be shipped in drums to avoid additional handling fees.

9. NRI recommends the use of the EZ ONE-SHOT™ disposable recovery cylinder when the recovered refrigerant will be returned to a system without processing.

SAFETY RECOMMENDATIONS

1. Only fill cylinders that are currently DOT approved for fluorocarbon refrigerants. Always inspect the cylinder for proper pressure rating and latest hydrostatic test date. Thoroughly check each cylinder and drum for dents, gouges, bulges, cuts or other imperfections, which may render it unsafe to hold refrigerant.

2. It is highly recommended to read the Air Conditioning, Heating & Refrigeration Institute "Guideline K – Guideline for Containers for Recovered Fluorocarbon Refrigerants."

3. Be sure all connections are made tight before transferring refrigerant into containers. Be sure all closures are made tight on the container immediately after filling. Be sure to replace valve outlet caps on cylinders.

4. Caution: Liquid refrigerant can cause frostbite if skin contact occurs. Be aware that the refrigerant/oil being removed from a system may contain contaminants, which may be harmful to breathe. Avoid contact with skin. Always provide fresh air when working in enclosed areas. Avoid breathing vapors. Always wear safety glasses and gloves (cold resistant for pressurized refrigerants and rubber-type for R11, R113 & R123). Avoid contact with clothing.

TERMS AND CONDITIONS

1. All used refrigerants must meet "Recovered Refrigerant Acceptance Specifications". NRI will accept title to shipment only after it has been verified through analysis, in NRI's laboratory, that these standards have been met. Off specification material may, at NRI's option, be returned to the customer freight-collect or disposed of in a manner agreeable to both NRI and the customer at customer's sole expense.

2. Refrigerant must be shipped in DOT approved containers. Any shipments not meeting this specification will be refused. Containers must be properly skidded and banded for shipment. Drums must not have any rust, dents, bulges or leaks. Open-top drums are not acceptable. NRI will not be liable for any claims, damages, lawsuits, judgements or liablities caused by or resulting from the fault or negligence of the shipper.

3. NRI reserves the right to charge cylinder refurbishing fees for any NRI owned cylinder that is returned damaged or defaced. A cleaning fee may be charged for each container that is returned with less than 50% of the maximum fill weight of recovered refrigerant. Handling fees may be charged for recovered refrigerant that requires special handling by NRI.

RECOVERED REFRIGERANT HANDLING FEES

1. Customers returning recovery cylinders containing recovered refrigerant will be charged a handling fee according to the current price schedules.

2. ***Free standing water***
Water exceeding saturation point of refrigerant; requires special processing to separate the water from the refrigerant; waste must be sent to waste water processing facility for purification.

3. ***Excessive oil content***
Refrigerant oil (mineral or synthetic) that exceeds ARI Acceptance Specification (10% for high pressure; 30% for low pressure): fee will be charged for each pound of oil exceeding Acceptance Specifications.

4. ***High acid content***
Acid present in the refrigerant at such a concentration that the pH level of the material is between 2.0 and 5.0 (a pH level below 2.0 would classify the material as hazardous waste according the 40CFR); such material must be handled as a priority in order to effectively neutralize the acid in the material

5. ***Over-filled container***
Cylinders and drums exceeding the maximum Gross Weight as specified in NRI's Cylinder Weight Chart that require special handling; these containers must be handled as a priority as soon as they are received to prevent injury to NRI or other persons and to prevent the release of the material in the container to the atmosphere.

EZ One-Shot™ Recovery Cylinder

EZ ONE-SHOT™ cylinders use DOT-39 disposable cylinder technology to provide an inexpensive, lightweight cylinder for use in one-time fill recovery situations

Applications for the EZ ONE-SHOT™

- Temporary storage receiver (where policy demands clean cylinder for each job)
- Single recovery job where gas will need to be returned or stored
  - One 20 to 30 lb. recovery job
  - Several smaller jobs at the same site
  - Burned gas: avoid contamination of your everyday recovery cylinder
  - Infrequent jobs or products not regularly recovered: won't tie up a standard cylinder
  - Dedicated shop machines
  - Download everyday cylinder to return refrigerant

Back Flow Prevention Valves

EZ ONE-SHOT™ cylinders are equipped with back flow prevention devices inside the valves. THE CYLINDERS ARE SHIPPED WITH THE VALVES OPEN.

• Cylinders must be evacuated before use, but after hoses are connected.

• Once the cylinder valve is closed for the first time, the back flow prevention device seats in the valve. No more refrigerant can be added to the cylinder through that valve.

• Be sure that all recovery operations are complete before closing both valves to the cylinder.

One-Time Fill

One-time fill means that once refrigerant has been put into the cylinder and then removed, the cylinder may no longer be used for further recovery operations. It must be scrapped or disposed of properly. Recovering refrigerant with an EZ ONE-SHOT™ recovery cylinder is considered the first filling operation. Recovery from several units, one after the other, until the cylinder is full represents one filling operation (for example, a dedicated shop machine).

EZ ONE-SHOT™ recovery cylinders are subject to the same regulations as the "disposable" refrigerant cylinders that refrigerant is supplied in. Federal law forbids transportation if REFILLED. Federal law also requires that cylinders be filled and transported in the box provided. Penalty up to $500,000 fine and 5 years imprisonment (49 U.S.C. 5124).

Procedures for Using EZ ONE-SHOT Recovery Cylinder

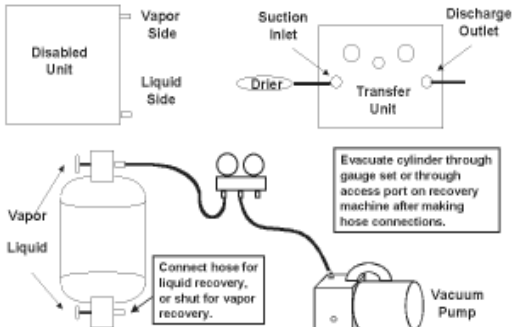


Figure 1: Evacuate Cylinder

- If performing liquid recovery, arrange hoses as indicated in Fig. 2.
- If performing vapor recovery, arrange hoses as indicated in Fig. 3.
- Evacuate cylinder with vacuum pump through a gauge set placed in the vapor line, or through an access port on the recovery machine, if available.

Do not close cylinder valves.

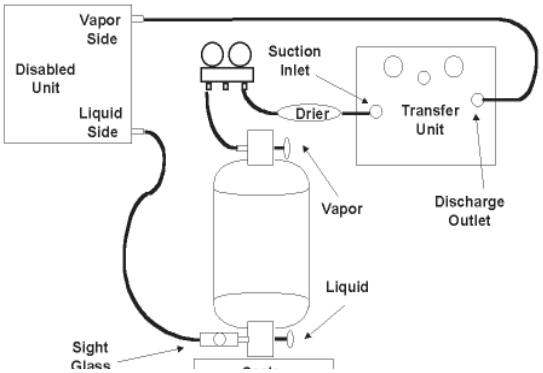


Figure 2: Liquid Recovery

Recovery machine draws vapor from the cylinder and uses this vapor to push liquid out of the system back into the cylinder.

- Vapor valve is at top of cylinder
- Liquid valve is at bottom

If also performing vapor recovery:

- Close liquid valve when the sight glass clears, BEFORE turning off the recovery machine.
- Use gauge set on vapor line to transfer hoses on recovery machine to configuration in Fig. 3.

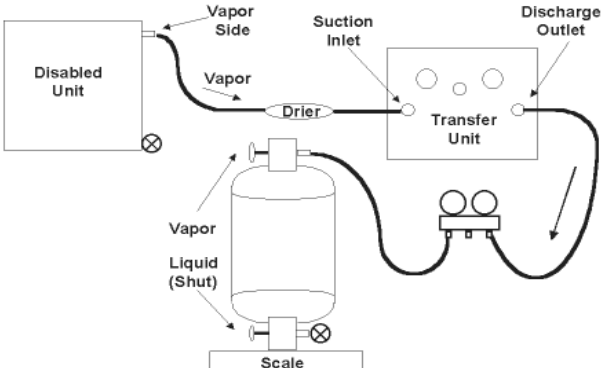


Figure 3: Vapor Recovery

Vapor recovery operations are performed normally, with access to the cylinder only through the vapor valve. Close bottom valve on cylinder.

Complete all recovery operations, including purging procedures for the recovery unit, before closing the vapor valve.

Once cylinder valves are closed no more refrigerant can be added to the cylinder.

Maximum Shipping Weight of Recovered Refrigerant in EZ ONE-SHOT Recovery Cylinder

Refrigerant	Max Shipping Wt./lbs.	Refrigerant	Max Shipping Wt./lbs.
R-12	39	R-407A/B/C	35
R-22	36	R-408A	33
R-114	43	R-409A	37
R-134a	36	R-410A	33
R-401A/B	36	R-500	36
R-402A/B	34	R-502	36
R-404A	31	R-507	31

What is Refrigerant Banking?

This program, designed by NRI, is aimed at helping companies guarantee their future refrigerant needs. Recent changes in the refrigerant industry have caused refrigerant supply and pricing to rapidly change. Now is the time to begin managing your existing inventories. NRI is an EPA and AHRI certified reclamation facility with a world-class Analytical Laboratory that will ensure that all refrigerant returned to you

meets or exceeds AHRI 700 Specifications.

Now is the time to take advantage of this program!

- It's your refrigerant, your investment - don't waste it!
- NRI will clean and store your recovered refrigerant for you at TODAY'S price.
- You will have access to your refrigerant when you need it without paying TOMORROW'S price.
- Don't sell or give away your valuable asset -- BANK it for YOURSELF!

Program Highlights

- An initial deposit of 1,000 pounds of recovered refrigerant is required to open an account.
- Refrigerant must meet NRI's Recovered Refrigerant Acceptance Specifications.
- Customer is invoiced for the total weight of refrigerant that can be recertified and restored to AHRI 700 Specifications.
- Storage fees are charged on a monthly basis.
- Withdrawals can be made 30 days after the initial deposit. A faxed, written or E-mail request is all that is needed for the refrigerant to be made available. All withdrawal requests are processed immediately.
- Refrigerant withdrawals are available at over 275 locations around the United States.
- Monthly activity statements, including all deposits and withdrawals, are sent along with your monthly storage invoice.

All rates, terms and prices are subject to change. Prices do not include sales tax, if any. NRI reserves the right to alter its program upon 30 days notice.1/2010

REFRIGERANT BANKING PROGRAM

Initial Deposit

An initial deposit of 1000 pounds of refrigerant is required to open an account. This can be comprised of different types of refrigerant. Refrigerant must meet NRI's Recovered Refrigerant Acceptance Specifications.

Future Deposit

After the initial deposit of a minimum of 1000 pounds, subsequent deposits are accepted for a minimum of 500 pounds per deposit.

Deposits of low pressure refrigerants are accepted in 100 pound drums and larger.

Deposits of high pressure refrigerants are accepted in 125 pound cylinders and larger.

CYLINDERS LESS THAN 125 LBS. ARE NOT ELIGIBLE FOR BANKING.

Minimum Balance

If during the course of any month, customer account balance falls below a total of 1000 pounds, NRI may purchase the balance of refrigerants as outlined below.

Charges

NRI will invoice you for the cleaning repurification of the total weight of verified refrigerant that can be recertified and restored to AHRI 700 Specifications plus any contaminant/disposal fees. A nominal charge for disposable 30 lb. and 50lb. cylinders is charged at time of withdrawal. Please call for current pricing.

Handling Fees/Disposal Charges

- Oil Disposal greater than 20% (low pressure)
- Oil Disposal greater than 10% (high pressure)
- Free Standing Water
- High Acid Content
- Mixed Refrigerant
- Over-filled container

Disposal charges for contaminants above accepted levels will be determined on a case-by-case basis.

Storage

The net reclaimed refrigerant is placed in bulk storage. A storage fee is billed on a monthly basis.

Withdrawal

A faxed or written authorization is required for withdrawal of refrigerant from the bank. Upon receipt of the withdrawal authorization at NRI, product will be made available as soon as reasonably possible for pick up or shipment. Customer will be responsible for freight on all shipments.

Reports

A banking report and invoice will be issued to the customer monthly.

NRI Purchase

If, at a later date, the customer does not require the banked refrigerant, NRI may purchase same at a mutually agreed upon price.

All rates, terms and prices are subject to change. Prices do not include sales tax, if any. NRI reserves the right to alter its program upon 30 days notice.

Guidelines for Maximum Shipping Weights for Recovered Refrigerant Containers

Cylinder Size	30 lb.	One Shot 30 lb.	40 lb.	50 lb.*	125 lb.	1/2 ton	ton
Water Capacity	26.2 lbs.	29.7 lbs.	38.1 lbs.	47.7 lbs.	123 lbs.	1000 lbs.	1600 lbs.

*includes 50F and 50HP

Maximum Refrigerant Weight Allowed

R-12	*	24	28	36	45	117	952	1523
R-22	*	22	25	32	40	103	839	1342
R-500	*	21	25	31	39	102	836	1337
R-502	*	22	25	32	40	103	842	1347
R-114	*	28	32	41	51	133	1088	1740
R-134a	*	22	25	32	41	106	864	1382
R-401B	*	22	25	32	40	103	857	1334
R-402A	***	21	24	31	39	99	809	1294
R-402B	**	21	24	30	38	97	792	1267
R-403B	**	19	22	28	35	91	736	1177
R-404A	**	18	20	26	33	85	688	1100
R-407A	**	21	24	31	39	99	808	1292
R-407C	**	21	23	30	38	97	790	1264
R-408A	**	19	22	28	35	90	735	1176
R-409A	*	23	26	34	42	109	888	1420
R-410A	****	19	22	28	35	89	726	1162
R-416A	*	25	29	37	46	120	979	1566
R-417A	*	20	22	29	36	94	770	1231
R-422A	***	18	21	27	34	88	723	1157
R-422B	***	21	24	30	38	98	793	1268
R-422C	***	20	23	29	36	93	758	1213
R-422D	***	20	23	30	37	96	777	1243
R-507	***	18	20	26	33	85	688	1100

Minimum cylinder service pressure required (psig) for each different refrigerant is indicated above by*

260 psig = * 300 psig = ** 350 psig = *** 400 psig = ****

Low Pressure Containers	**Drum Size**	**Max Allowable Refrigerant Wt**	**Average Drum Tare Wt**	**Max Gross Shipping Wt**
R11, R113, R123	100 lbs	90 lbs	10 lbs	100 lbs
	200 lbs	180 lbs	20 lbs	200 lbs
	650 lbs	585 lbs	65 lbs	650 lbs

Very High Pressure Cylinders	**RC9 avg tw 20**		**RC23 avg tw 30**		**RC80 avg tw 140**	
	Recovered Refrigerant Weight + Tare Weight of Cylinder = Maximum Gross Shipping Weight					
	Ref Wt	Ship Wt	Ref Wt	Ship Wt	Ref Wt	Ship Wt
R13	14	34	19	49	74	211
R23	11	31	15	45	58	198
R503	12	32	16	46	64	206
R508B	12	32	17	47	65	205
R13B1	17	37	12	52	89	229

IMPORTANT: The tare weights listed in this guideline are only average weights. In order to determine actual gross shipping weight, the tare weight of each individual cylinder must be used.

Always use a scale when filling any cylinder. DO NOT OVERFILL

(rev 4/2010)

4. Additional Technical Literature

Alkylbenzene Oil - A synthetic refrigeration oil similar to mineral oil; it offers better low temperature mixing with HCFCs.

Appliance - Any device that contains and uses a Class I or Class II substance as a refrigerant and is used for household or commercial purposes, including any air conditioner, refrigerator, chiller or freezer.

Azeotrope - A mixture of two or more refrigerants that acts as a single fluid. The components of azeotropic mixtures will not separate under normal operating conditions.

Blend - A mixture of two or more refrigerant components.

Brazed - Joined by fusion using very high heat; equivalent of hard soldering.

Capacity - The measure of heat energy removed by a system per hour. The capacity is very dependent on running and ambient conditions and it is typically quoted for a compressor or system at some standard rating condition.

Centrifugal Air Conditioning - Compressor technology used in larger air conditioning chillers, based on a rotating impeller to "spin" refrigerant to a higher pressure/temperature.

CFC - Chloro-Fluoro-Carbon; a refrigerant comprised of carbon atoms connected to only chlorine and fluorine atoms. The common CFCs are R-11, R-12, R-13, R-113, R-114 and R-115.

Class I - Chemicals listed in the Clean Air Act having an ozone depletion potential of 0.2 or higher. These include CFCs, halons, carbon tetrachloride, methyl chloroform, and bromine compounds.

Class II - Chemicals listed in the Clean Air Act having an ozone depletion potential of less than 0.2. All of the HCFCs are considered Class II.

Commercial Refrigeration - The refrigeration appliances used in the retail food and cold storage warehouse sectors. Retail food includes the refrigeration equipment found in supermarkets, convenience stores, restaurants and other food service establishments. Cold storage includes the equipment used to store meat, produce, dairy, and other perishable goods, usually in very large facilities.

Direct Expansion - A system design that meters refrigerant into the evaporator with the intention that it will all boil to vapor by the time it reaches the end. Orifice plates, capillary tubes, automatic expansion valves, and TXVs are all expansion devices that provide for direct expansion of refrigerant in the evaporator.

Disposal - The process leading to and including (1) the discharge, deposit, dumping or placing of any discarded appliance into or on any land or water, (2) the disassembly of any appliance for discharge, deposit, dumping or placing of its discarded component parts into or on any land or water, or (3) the disassembly of any appliance for reuse of its component parts.

Efficiency - Ratio of the work output to the energy input.

Elastomer - Material which can be stretched or squeezed and, immediately on release of the stress, returns to its approximate dimensions.

Equilibrium - Liquid and Vapor phases of refrigerant existing in contact with each other at a saturated pressure/temperature condition. For blends, the composition of the vapor will contain more of the higher pressure components.

Flooded Evaporator Systems - A system design that allows the refrigerant to boil in a pool in the evaporator, which cools the water, glycol, or product that is circulating through tubing or panels in the boiling pool, and only the vapor that is boiled goes back to the compressor.

Fractionation - Change in composition of a blend by preferential evaporation of the more volatile component(s) or condensation of the less volatile component(s).

Global Warming or "Greenhouse Effect"- Occurs when carbon dioxide and other gases, including refrigerants, build up in the atmosphere. These gases allow sunlight to pass through to the earth; however, the gases trap heat energy from the earth and the planet's average temperature is raised.

Global Warming Potential or GWP - A relative measure of how effective a chemical is at retaining heat in the atmosphere. The value shows the effect of an equivalent number of kilograms of CO_2 on global warming.

HC - Hydrocarbon refrigerants, used primarily as additives in blends. They will help promote circulation of mineral oil when the blend components will not accomplish this alone.

HCFC - Hydro-Chloro-Fluoro-Carbon; a refrigerant comprised of carbon atoms connected to chlorine, fluorine, and *hydrogen*

HCFC (continued)
atoms. The common HCFCs are R-22, R-123, R-124, R-142b.

HFC - Hydro-Fluoro-Carbon; a refrigerant comprised of carbon atoms connected to fluorine and hydrogen only. The common HFCs are R-134a, R-125, R-143a, R-152a, R-32 and R-23.

High Ambient Air Conditioning - An air conditioning application where the surrounding air temperatures are higher than normal, which requires a slightly lower refrigerant pressure and very large condensing surface in order to work correctly. (Example: crane control room in a steel mill.)

High Pressure Appliance - An appliance that uses a refrigerant with a boiling point between -50˚C (-55˚F) and 10˚C (40˚F) at atmospheric pressure. This definition includes, but is not limited to, appliances that use R-12, R-22, R-114, R-500 or R-502.

High Temperature Refrigeration - Refrigeration applications where the evaporator temperature normally runs higher than 30˚F.

Household Appliance - The standard refrigerator/freezer found in most kitchens, as well as small freezer appliances sold to homeowners.

Hygroscopic- A tendency for refrigeration oils to absorb moisture from the atmosphere.

Industrial Process Refrigeration - Complex, customized appliances used in the chemical, pharmaceutical, petrochemical and manufacturing industries. This sector also includes industrial ice machines and ice rinks.

Low-Loss Fitting - Any device that is intended to establish a connection between hoses, appliances, or recovery or recycling machines, which is designed to close automatically or will be closed manually when disconnected, thereby minimizing the release of refrigerant from hoses, appliances, and recovery / recycling machines.

Low-Pressure Appliance - An appliance that uses a refrigerant with a boiling point above 10˚C (40˚F) at atmospheric pressure. This definition includes, but is not limited to, equipment utilizing R-11, R-113, and R-123.

Low Temperature Refrigeration - Refrigeration applications that normally run evaporator temperatures between -40˚F and 0˚F.

Medium Temperature Refrigeration - Refrigeration applications that normally run evaporator temperatures between 0˚F and 40˚F.

Mineral Oil - Traditional refrigeration oil, refined from petroleum products. Generally not compatible with new HFC refrigerants.

Miscibility - Ability of a gas or liquid to dissolve uniformly (mix) in another gas or liquid.

Motor Vehicle Air Conditioner (MVAC) - Any appliance that is contained in a motor vehicle and is used to cool the driver's or passenger's compartment. MVAC is regulated under the Clean Air Act Section 609.

MVAC-Like Appliance - Air conditioning equipment used to cool the driver's or passenger's compartment of a non-road vehicle. The system is similar in construction to MVAC equipment; however R-22 equipment is excluded from this definition.

Oil Flushing - The process of changing from one type of lubricant (typically mineral oil or alkylbenzene) to another type (typically POE), which involves the removal of an oil charge and replacement with the new oil type. Successive oil changes will quickly lower the concentration of the original oil type.

Opening an Appliance - Any service, maintenance, or repair on an appliance that could be reasonably expected to release refrigerant from the appliance to the atmosphere unless the refrigerant was previously recovered from the appliance.

Ozone Depletion - The interruption by free chlorine radicals of the normal ozone creation/ breakdown process which occurs in the upper atmosphere. The free chlorine causes ozone molecules to come apart, then ties up the free oxygen used to make for ozone. The result is a net decrease in the ozone concentration.

Poly-Alkylene-Glycol (PAG) Oil - A general term that applies to a family of synthetic oils based on polyalkylene glycols chemistry. PAGs are used primarily with HFC refrigerants in the automotive air conditioning industry.

Process Stub - A length of tubing that provides access to the refrigerant inside an appliance and that can be resealed at the conclusion of repair or service.

Propylene Glycol - A type of heat transfer fluid used in secondary loop chillers. Because of the low toxicity of propylene glycol, this product is often used when failure of the cooling piping might allow contact of the glycol with food products.

Pump-Down (Out) - The withdrawal of all refrigerant from the low side of a system by pumping it into either the condenser or the liquid receiver.

Reclaim - To reprocess refrigerant to at least the purity specified in the AHRI Standard 700, Specifications for Fluorocarbon Refrigerants, and to verify this purity using the specified analytical methods.

Recovery - To remove refrigerant from a system, regardless of condition, and store it in an external container without necessarily testing or processing the refrigerant in any way.

Recovery Efficiency -The percentage of refrigerant recovered compared to the total amount in the appliance.

Recycle - To extract refrigerant from an appliance to attempt to clean water, oil, acidity and particulates from it. These procedures may not necessarily return the refrigerant to AHRI 700 purity. The refrigerant may be returned to the same system after recycling.

Repair - Fix what is wrong with a broken system without changing the type of refrigerant.

Replace - Install a new piece of equipment in the same application instead of repair or retrofit.

Retrofit - The replacement of the original refrigerant in a system with a different refrigerant, which may involve changing valves, oil, other components, or adjusting controls in some manner.

Self-Contained Recovery Equipment - Recovery equipment that is capable of removing refrigerant from an appliance without the assistance of components within the appliance.

Small Appliances - Any self-contained, hermetic appliance that contains 5 pounds or less of refrigerant.

System-Dependent Recovery Equipment - Recovery equipment that requires the assistance of components contained in an appliance to remove the refrigerant.

Temperature Glide - the change in temperature from when a blend first starts boiling in an evaporator to when it reaches saturated vapor at the end of the evaporator.

TXV (or TEV) - Thermal Expansion Valve, which is used to meter the flow of refrigerant from the liquid line into the evaporator and provide the correct pressure drop.

Very Low Temperature or Ultra Low Temperature Refrigeration - Refrigeration applications that normally run evaporator temperatures below -60˚F. These applications will often use a cascade or 2 stage refrigeration system.

Weight Percent - The relative amount of each component in a refrigerant blend on a mass basis (the pounds of each component relative to the total pounds in the blend).

Zeotrope - A blend that behaves normally as a mixture of refrigerants. The properties are a combination of the individual component properties, and the vapor composition is different from the liquid, which promotes fractionation and temperature glide effects. (see Section 2)

OEM PART #	Lubricant Type	Viscosity	National Lubricants Product Name
York A	Mineral Oil/Capella	300 SUS/68 ISO	National WF 68
York C	Mineral Oil	300 SUS/68 ISO	National 300
York D	Mineral Oil	150 SUS/32 ISO	National 150
York E	Mineral Oil	500 SUS/100 ISO	National 500
York F	Mineral Oil	150 SUS/32 IS0	National 150
York G	Polyolester	320 ISO (very heavy)	CP 4214-320
York H	Polyolester	300 SUS/68 ISO	National PE 68
York J	Polyolester	200 SUS/46 ISO	Solest 46
York K	Polyolester	150 SUS/32 ISO	National PE 32
York L	Polyolester	120 SUS (very heavy)	Solest 120
York O	Polyolester	150 SUS/32 ISO	National PE 32
York P	Polyolester	750 SUS/150 ISO	CP 4214-150
York S	Polyolester	500 SUS/100 ISO	Solest 100
Trane 15	Pale Mineral Oil	300 SUS/68 ISO	National 300
Trane 22	White Mineral Oil	300 SUS/68 ISO	
Trane 31	Pale Oil w/ Silicone	300 SUS/68 ISO	National 300
Trane 32	Pale Mineral Oil	150 SUS/32 ISO	National 150
Trane 37	Polyolester	300 SUS/68 ISO	National PE 68
Trane 42	Pale Oil w/ Phosphate	150 SUS/32 ISO	
Trane 43	Pale Mineral Oil	150 SUS/32 ISO	National 150
Trane 45	Pale Mineral OIl	300 SUS/68 ISO	National 300
Trane 48	Polyolester	300 SUS/68 ISO	National PE 68
Trane 78	Polyolester	150 SUS/32ISO	National PE 32
Maneurop 160 SZ	Polyolester	150 SUS/32 ISO	National PE 32

McQuay Polyolester Specifications	Equivalent Lubricant
McQuay CE050, 063, 079, 087	Mobil EAL Arctic 22, Emkarate RL22N
McQuay CE100, 126	Mobil EAL Arctic 32, Emkarate Rl32H National PE 32
McQuay SLIC	PlanetElf AWF 68, Emkarate RL68HP

National Lubricants Product Name	Part #	Viscosity	Equivalent Part #	OEM Part #
Mineral Oil				
NL 150	1501G	150 SUS/32 ISO	Calumet C3, Suniso 3GS	York D, F - Trane 32, 43
NL 300	3001G	300 SUS/68 ISO	Calumet C4, Sunios 4GS	York C - Trane 15, 45
NL 500	5001G	500 SUS/100 ISO	Calumet C5, Suniso 5GS	York E
NL WF 32	WF 32	150 SUS/32 IS0	Texaco WF 32	
NL WF 68	1 TD	300 SUS/68 ISO	Texaco WF 68	
Alkylbenzene Lubricants				
NL AKB 150	150AKB1G	150 SUS/32 ISO	Zerol 150, Soltex 150	
NL AKB 200R	200AKB1G	200 SUS/46 ISO	Zerol 200TD	
NL AKB 300	300AKB1G	300 SUS/68 ISO	Zerol 300, Soltex 300	
Polyolester Lubricants				
NL PE 32	PE321G	150 SUS/32 ISO	Ultra 32-3MAF, Castrol SW32	York K, O
NL PE 68	PE681G	300 SUS/68 ISO	Emkarate 68H, Castrol SW68	York H - Trane 48

NuCalgon Product Name	Part #	Viscosity	Equivalent Lubricant
C3	430307	150 SUS/32 ISO	National 150 (1501G)
C4	430407	300 SUS/68 ISO	National 300 (3001g)
C5	460507	500 SUS/100 ISO	National 500 (5001G)
Zerol 150	431007	150 SUS/32 IS0	National AKB 150 (150AKB1G)
Zerol 200TD	430807	200 SUS/46 ISO	National AKB 200R (200AKB1G)
Zerol 300	431107	300 SUS/68 ISO	National AKB 300 (300AKB1G)
Emkarate RL32H	431446	150 SUS/32 ISO	National PE 32 (PE321G)
Emkarate RL68H	431646	300 SUS/68 ISO	National PE 68 (PE681G)

MINERAL OIL

Naphthenic Mineral Oils (pale oils) are the traditional choice for lubrication in air conditioning and refrigeration compressors. They are used primarily in systems designed for CFCs (R-12, R-502) and HCFCs (R-22, retrofit blends).

Mineral Oils are made from the highest quality base stocks and provide outstanding performance and protection in compressors. Available in 150 SUS, 300 SUS and 500 SUS viscosities, these products can be used in most reciprocating, scroll, screw and many centrifugal compressors on the market today.

Mineral Oils perform well over a wide temperature range. They have very good chemical stability and provide very good protection and lubrication at higher compressor temperatures. In addition, they have low wax content and have chemical characteristics that promote a low pour point and good oil return to the compressor at low evaporator temperatures. Naphthenic Mineral Oils do a very good job of preventing system deposits compared to paraffinic (white) mineral oils.

Available Sizes & Part Numbers

1 Gallon	1501G 3001G 5001G
5 Gallon	1505G 3005G 5005G
55 Gallon	15055G 30055G 50055G

TYPICAL PROPERTIES

Property	Test Method	150	300	500
Viscosity, SUS @ 100°F	ASTM D445	155	325	510
Flash Point, °F	ASTM D92	350	400	405
Pour Point, °F	ASTM D97	-50	-30	-15
Floc Point, °F	ASHRAE 86	-72	-56	-51
Color Gardner	ASTM D1500	<0.5	<0.5	<0.5
Specific Gravity	ASTM D1250	0.904	0.910	0.916

ALKYLBENZENE

Alkylbenzene (AKB) synthetic refrigeration lubricants provide outstanding performance for extended drain intervals and better thermal stability compared to traditional mineral oil. They can be used in systems designed for CFCs (R-12, R-502) and HCFCs (R-22, retrofit blends).

Alkylbenzenes are made from the highest quality synthetic base stocks and provide outstanding performance and protection in compressors. These synthetic lubricants do not contain wax and can survive longer than mineral oils at high compressor discharge temperatures. Alkylbenzenes typically run cleaner in systems than mineral based oils. Available in 150 SUS, 200 SUS and 300 SUS viscosities, these products can be used in most reciprocating, rotary vane, and scroll compressors on the market today.

Alkylbenzenes are particularly well suited for use in retrofit projects. In some cases, equipment manufacturers suggest the replacement of some mineral oil with alkylbenzene when using HCFC-based retrofit blends. During HFC retrofit projects, using alkylbenzene for initial oil flushing helps remove mineral oil and contaminants in preparation for a final POE flush, thus saving money on POE.

AKB 200R meets the strict retrofit recommendations imposed by some equipment manufacturers, such as Copeland.

Available Sizes & Part Numbers

1 Gallon	150AKB1G 200AKB1G 300AKB1G
5 Gallon	150AKB5G 200AKB5G 300AKB5G
55 Gallon	150AKB55G 200AKB55G 300AKB55G

TYPICAL PROPERTIES

Property	Test Method	AKB150	AKB200R	AKB300
Viscosity, SUS @ 100°F	ASTM D445	150	205	280
Color Gardner	ASTM D1500	1	<1	1
Flash Point, °F	ASTM D92	347	365	365
Pour Point, °F	ASTM D97	-49	-49	-49
Refractive Index		1.4864	1.4857	1.4841

POLYOLESTER

Polyolester (POE) synthetic refrigeration lubricant is recommended for use with all new HFC refrigerants such as R-404A and R-410A. It is also compatible with HCFC refrigerants and can be used with confidence in systems containing R-22 or HCFC based blends

POEs are made from the highest quality base stocks and provide outstanding performance in a wide variety of air conditioning and refrigeration compressors. Available in 32 cSt and 68 cSt viscosities, these products can be used in most reciprocating, scroll, screw and many centrifugal compressors on the market today.

POEs perform well over a wide temperature range. They provide maximum protection and lubrication at higher compressor temperatures. In addition, good refrigerant miscibility at low evaporator temperatures will help promote oil return to the compressor.

POEs are based on the most current industry-standard formulations. These lubricants contain no extra antiwear additives that can leave deposits. They are compatible with existing mineral oil and alkylbenzene lubricants, making them excellent for retrofitting older systems to HFC refrigerants.

Available Sizes and Part Numbers

1 Pint	PE321P PE681P
1 Quart	PE321Q PE681Q
1 Gallon	PE321G PE681G
5 Gallon	PE685G

TYPICAL PROPERTIES

Property	Test Method	PE32	PE68
Viscosity, cSt @ 104°F	ASTM D445	32	68
Viscosity, cSt @ 212°F	ASTM D445	5.8	9.3
Flash Point, °F	ASTM D92	496.5	518
Pour Point, °F	ASTM D97	-51	-38.2
Total acid number, mgKOH/g	ASTM D664	<0.02	<0.02
Miscibility Temp, °F	--	-44	-15
Density, g/ml @ 68°F	ASTM D1298	0.977	0.980

Quality Solest™ Lubricant Products

Solest® products are high quality polyolester synthetic lubricants designed for use with air conditioning and industrial refrigeration compressors. These new products extend the viscosity range of synthetic lubricants available from NRI. The Solest® lubricants are excellent choices for initial fill, service, and retrofit applications.

Product Line

Solest LT 32	specifically designed for very low temperature applications; provides good miscibility with R-404A, eliminating the need to use two lubricants in a cascade system
Solest 46	used in centrifugal, reciprocating, and rotary vane compressors
Solest 68	can be used in a wide variety of compressor units
Solest 100	used primarily in scroll and screw compressors
Solest 120	provides good oil return in screw applications
Solest 150 & Solest 170	these two lubricants are used mainly in Bitzer and Carlyle screw compressors
Solest 220	mostly used in large srew type applications with R-134a
CP-4214-320	a complex ester lubricant that cannot be used with HFC refrigerants; provides good oil return in R-22 screw type applications
Solest 370	used in screw type applications with HFC refrigerants
Alkylbenzene 500E	alkylbenzene based lubricant; provides good miscibility with HCFC refrigerants and has the higher viscosity needed to work well with screw compressors

Product	Viscosity	Equivalent to OEM Part No.
Solest LT 32	32 ISO/150 SUS	York K
Solest 46	46 ISO/200 SUS	York J
Solest 68	68 ISO/300 SUS	York H - Trane 37 - Frick 13
Solest 100	100 ISO/500 SUS	York S
Solest 120	120 ISO/600 SUS	York L
Solest 150	150 ISO/700 SUS	York P
Solest 170	170 ISO/800 SUS	York P
Solest 220	220 ISO/1000 SUS	Castrol SW220
CP-4214-320	320 ISO/1500 SUS	York G
Solest 370	370 ISO/1700 SUS	
AKB 500 E	100 ISO/500 SUS	BVA 100E

Solest® Lubricants are available in the following sizes

- 1 gallon
- 5 gallon
- 55 gallon

Solest® is a registered trademark of CPI Engineering Services Inc.

NATIONAL CHEMICALS & COIL CLEANERS

Available in 1 gallon, 2 1/2 gallon, and 55 gallon containers

Part No. AN1GN, AN2GN

Part No. KF1GN, KF2GN

Part No. MK1GN, MK2GN

Part No. KN1GN, KN2GN

Part No. KB1GN, KB2GN

AlkaKleen
- Strongest non-acid cleaner and brightener
- Removes grease, smoke, and insects

KleenFoam
- Extra heavy foam
- Removes stubborn deposits
- Outdoor non-acid cleaner

MultiKleen
- Multi-purpose alkaline cleaner
- For use on filters, electronic air filters, fan blades, and metal cabinets

KleenBrite
- Acid based Cleaner
- Fast acting formula makes fins look like new

KleenCoil
- Non-acid indoor evaporator cleaner
- Self rinsing

	AlkaKleen	KleenFoam	MultiKleen	KleenBrite	KleenCoil
Best to Use On	Outdoor	Outdoor	Outdoor	Outdoor	Indoor
Condenser Coils	x	x	x	x	
Evaporator Coils					x
Air Filters	x	x	x		
Best to Remove					
Oil and Grease	x	x	x		x
Cooking Grease	x	x	x		
Mineral Deposits, Salt and Scale				x	
Corrosion and Oxides	x	x	x	x	
Dirt and Grime	x	x	x	x	x
Dust and Lint	x	x	x	x	x
Bugs	x	x	x	x	
Grass and Cottonwood	x	x	x	x	
Tobacco Stains	x	x	x		x
Major Features					
Foaming	x	x		x	
Brightening	x	x	x	x	
Non-Rinsing					x

	National Product Name	Nu-Calgon	Virginia KMP	Rectorseal Stewart Hall	Specialty Chemical	Vapco
Coil Cleaners	**OUTDOOR**					
	Alka Kleen	Alka Brite Nu Brite	Alki Foam	Renewz	Free Foam	Plus
	Kleen Brite (Acid)	Cal Brite	Acti Brite	Con Coil	Coil Kleen	Blu Brite
	Kleen Foam	Foam Brite	Foam Max	Renewz	Foam Power	Foaminator
	Multi Kleen	HD Cal Clean, TriPowr	ProKlean MPC	-	Triple "D"	-
	INDOOR					
	Kleen Coil	Coil Power & Evap Power	Acti Klean	Coil Rite	Power-Plus	Power Clean
	Evap Kleen (Aerosol)	Evap Foam (Aerosol)	Coil Klean (Aerosol)	Renewz	Foam Plus	Foaminator
Degreasers, Cleaners and Scale Removers	**Blast Kleen**	Nu Blast	Blast-A-Coil	KO Dirt Blaster	-	Blow Out
	Electric Motor Cleaner	Em Degreasing Solvent	Switch & Contact Cleaner	Zipp	Saf-T-Kleen	Degreaser
	Electric Contact Cleaner	Electric Contact Cleaner	Switch & Contact Cleaner	Contact Cleaner	-	Electric Contact Cleaner
	HD Degreasing Solvent	Degreasing Solvent ef	Virginia 10N	Continental #1	-	Degreaser
	Scale Remover & Inhibitor	Liquid Scale Dissolver	Liquid Scale Remover	Liquid Descalit	D'Scale	Scale Remover

WHY USE A COIL CLEANER?

Dirty or blocked coils will result in reduced air flow and poor heat transfer. Equipment could run hotter, reducing its useful lifetime, increasing operating costs and reducing comfort or refrigeration capacity. Properly cleaning the coils will keep equipment running at peak performance.

HOW DO COIL CLEANERS REALLY WORK?

The two active ingredients are soap and an acid or alkaline based surface brightener.

- The soap's job is obvious -- to break up and carry away dirt and grease.
- The surface brightener's job is also straightforward: Air, moisture and other chemicals will react with aluminum coil surfaces to form layers that can collect dirt and reduce heat transfer. The strong alkaline or acid compounds in the coil cleaner will chemically clean the layers away until bright metal is exposed, returning the coil surface to its original design performance.

CAN COIL CLEANERS BE USED TO CLEAN OTHER SURFACES?

Indoor coils, cabinets, air filters and fan blades can be cleaned with a diluted concentrate. Each NC coil cleaner has a dilution chart on the bottle as a guideline.

HOW CAN YOU CALCULATE DILUTION LEVELS?

Concentrated coil cleaners are meant to be diluted with water. Using the concentrate straight from the bottle or strong mixtures on lightly soiled coils can result in damage to the surface being cleaned.

- Extremely dirty coils require a higher content of the coil cleaner versus water to get the desired cleaning.
- Moderately soiled coils can be cleaned with an equal amount of coil cleaner and water content.
- Slightly soiled coils can be cleaned with a higher water content to coil cleaner content to get the desired cleaning.

WHAT IS THE DIFFERENCE BETWEEN TYPES OF COIL CLEANERS?

They will all clean and treat the surface of the coil. The major differences are:

- Acid or Alkaline based (acid for strong surface treatment, alkaline for general brightening)
- Formulation
- Amount and type of soap
- Color

Aerosol Products

	PART #
BlastKleen	N4880
EvapKleen	N4890
Energized Electrical Cleaner	N4835
HD Solvent	NDS17OZ
MultiKleen	N4860
Spray Adhesive	N4820
Electric Contact Cleaner	N4830
Silicone Spray	N4840
Penetrating Lubricant	N4855

BlastKleen instantly penetrates and dissolves grease, oil and dirt deposits from refrigeration condenser coils. Due to its ability to evaporate quickly, it does not need to be rinsed off the coils.

EvapKleen is a foaming, no-rinse product used to clean either condenser or evaporator coils

Energized Electrical Cleaner is a self rinsing solvent that cleans and protects electric motors, generators, oil burners, and fans from corrosion.

HD Solvent is an "environmentally friendly" heavy duty cleaner and degreaser used where washing or flushing is not possible.

MultiKleen spray is used to clean condenser or evaporator coils, metal cabinets, refrigeration parts and components.

Spray Adhesive is used for forming temporary or permanent bonds between most surfaces. It can be used on paper, foil, cardboard, cloth, leather, glass, Mylar, acetate sheet, foam rubber, urethane foam, Styrofoam and light metal sections.

Electric Contact Cleaner lubricates and protects electrical contacts from corrosion. It helps to restore and maintain the original efficiency of electrical contacts.

Silicone Spray contains FDA approved ingredients allowing it to be used in food-processing applications. It prevents sticking and grinding on ice-machines, freezing plates, feed racks, conveyors, dairy machinery, knives and other processing equipment.

Penetrating Lubricant has penetrating and lubricating properties that prevent the accumulation of rust and corrosion.

PROPYLENE GLYCOL

NC Inhibited Propylene Glycol heat transfer fluid contains *DOWFROST*™ *blended to different concentrations. It contains a performance additive that prevents metal corrosion, lowers maintenance cost, and improves heat transfer. It also provides freeze and burst protection based on the type of application.

NC Inhibited Propylene Glycol has a low toxicity level, so it can be used in applications that have contact with food or beverage products such as immersion freezing and packaging carbonated beverages. It is also used for secondary cooling and heating applications, and for various defrosting and dehumidifying applications.

Based on the desired application temperature, the amount of propylene glycol can be calculated with the following formula:

Volume of PG required = (System Volume) * (percentage of PG based on Table 1 value)* (0.01)

TABLE 1

Temperature	For Freeze Protection Volume %				For Burst Protection Volume %			
F	PG35%	PG40%	PG70%	PG96%	PG35%	PG40%	PG70%	PG96%
20	49	43	25	18	33	29	16	12
10	80	70	40	29	55	48	27	20
0	99	86	49	36	66	58	33	24
-10	-	-	58	42	77	67	38	28
-20	-	-	63	46	82	72	41	30
-30	-	-	69	50	91	79	45	33
-40	-	-	74	54	96	84	48	35
-50	-	-	78	57	96	84	48	35
-60	-	-	82	60	96	84	48	35

	PART #	CONCENTRATION	CONTAINER SIZE
BLUE DYE	55PG35D	35%	55 gallon
	5PG40	40%	5 gallon
	55PG40	40%	55 gallon
	1PG70	70%	1 gallon
	5PG70	70%	5 gallon
	55PG70	70%	55 gallon
NO DYE	5PG96	96%	5 gallon
	55PG96	96%	55 gallon
	PROPYL55G	Uninhibited USP Food Grade Kosher 99.9%	55 gallon

* Trademark of The Dow Chemical Company (DOW) or an affiliated company of Dow.

4. Regulatory & Legislative Issues

The following section is a compilation of
EPA publications relating to the HVAC/R industry.

For further information on these publications,
or any other regulatory questions, contact the
EPA Stratospheric Hotline at

1-800-296-1996

or visit the EPA Website:

www.epa.gov/ozone

Complying With Section 608 Regulations

This section provides an overview of the refrigerant recycling requirements of Section 608 of the Clean Air Act of 1990, as amended (CAA), including final regulations published on May 14, 1993 (58 FR 28660), August 19, 1994 (59 FR 42950), November 9, 1994 (59 FR 55912), and July 24, 2003 (68 FR 43786). This section also describes the prohibition on intentional refrigerant venting that became effective on July 1, 1992.

- Overview
- Prohibition on Venting
- Regulatory Requirements
- Service Practice Requirements
- Evacuation Requirements
- Exceptions to Evacuation Requirements
- Reclamation Requirement
- Refrigerant Recovery and Recycling Equipment Certification
- Refrigerant Leaks
- Technician Certification
- Refrigerant Sales Restrictions
- Certification by Owners of Refrigerant Recovery and Recycling Equipment
- Refrigerant Reclaimer Certification
- Safe Disposal Requirements
- For Further Information

Overview

Under Section 608 of the CAA, EPA has established regulations (40 CFR Part 82, Subpart F) that:

- Require service practices that maximize recovery and recycling of ozone-depleting substances (both chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) and their blends) during the servicing and disposal of air-conditioning and refrigeration equipment.

- Set certification requirements for refrigerant recycling and recovery equipment, technicians, and refrigerant reclaimers.

- Restrict the sale of refrigerant to certified technicians.

- Require persons servicing or disposing of air-conditioning and refrigeration equipment to certify to EPA that they have acquired refrigerant recovery and/or recycling equipment and are complying with the requirements of the rule.

- Require the repair of substantial leaks in air-conditioning and refrigeration equipment with a refrigerant charge greater than 50 pounds.

- Establish safe disposal requirement to ensure removal of refrigerants from goods that enter the waste stream with the charge intact (e.g., motor vehicle air conditioners, home refrigerators, and room air conditioners.

The Prohibition on Venting

Effective July 1, 1992, Section 608 of the Act prohibits individuals from intentionally venting ozone-depleting substances used as refrigerants (generally CFCs and HCFCs) into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment (appliances). Only four types of releases are permitted under the prohibition.

1. "De minimis" quantities of refrigerant released in the course of making good faith attempts to recapture and recycle or safely dispose of refrigerant.

2. Refrigerants emitted in the course of normal operation of air-conditioning and refrigeration equipment (as opposed to during the maintenance, servicing, repair or disposal of this equipment) such as from mechanical purging and leaks. However, EPA requires the repair of leaks above a certain size in large equipment. (see Refrigerant Leaks)

3. Releases of CFCs or HCFCs that *are not used as refrigerants.* For instance, mixtures of nitrogen and R-22 that are used as holding charges or as leak test gases may be released.

4. Small releases of refrigerant that result from purging hoses or from connecting or disconnecting hoses to charge or service appliances will not be considered violations of the prohibition on venting. However, recovery and recycling equipment manufactured after November 15, 1993, must be equipped with low-loss fittings.

Regulatory Requirements

Service Practice Requirements

1. Evacuation Requirements

Technicians are required to evacuate air-conditioning and refrigeration equipment to established vacuum levels when opening the equipment for maintenance, service, repair, or disposal. If the technician's recovery and/or recycling equipment was manufactured any time before November 15, 1993, the air-conditioning and refrigeration equipment must be evacuated to the levels described in the first column of Table 1. If the technician's recovery or recycling equipment was manufactured on or after November 15, 1993, the air-conditioning and refrigeration equipment must be evacuated to the levels described in the second column of Table 1, and the recovery or recycling equipment must have been certified by an EPA -approved equipment testing organization.

Technicians repairing small appliances, such as household refrigerators, window air conditioners, and water coolers, must recover:

80 percent of the refrigerant when
- the technician uses recovery or recycling equipment manufactured before November 15, 1993, or
- the compressor in the appliance is not operating; ***OR***

90 percent of the refrigerant when
- the technician uses recovery or recycling equipment manufactured after November 15, 1993, and
- the compressor in the appliance is operating

In order to ensure that they are recovering the correct percentage of refrigerant, technicians must use the recovery equipment according to the directions of its manufacturer. Technicians may also satisfy recovery requirements by evacuating the small appliance to four inches of mercury vacuum.

Required Levels of Evacuation

REQUIRED LEVELS OF EVACUATION FOR APPLIANCES EXCEPT FOR
SMALL APPLIANCES, MVACS, AND MVAC-LIKE APPLIANCES

TABLE 1

Type of Appliance	Inches of Mercury Vacuum* Using Equipment Manufactured:	
	Before Nov. 15,1993	On or after Nov.15, 1993
HCFC-22 appliance** normally containing less than 200 pounds of refrigerant	0	0
HCFC-22 appliance** normally containing 200 pounds or more of refrigerant	4	10
Other high-pressure appliance** normally containing less than 200 pounds of refrigerant (CFC-12,-500, -502 -114)	4	10
Other high-pressure appliance** normally containing 200 pounds or more of refrigerant (CFC-12, -500, -502, -114)	4	15
Very high pressure appliance (CFC-13 -503)	0	0
Low pressure appliance (CFC-11, HCFC-123)	25	25 mm Hg absolute

*Relative to standard atmospheric pressure of 29.9" Hg
** Or isolated component of such an appliance

2. Exceptions to Evacuation Requirements

EPA has established limited exceptions to its evacuation requirements for 1) repairs to refrigeration and air-conditioning equipment and 2) repairs that are not major and that are not followed by an evacuation of the equipment to the environment.

If, due to leaks, evacuation to the levels in Table 1 is not attainable, or would substantially contaminate the refrigerant being recovered, the persons opening the appliance must:

- isolate leaking from non-leaking components wherever possible;
- evacuate non-leaking components to the levels in Table 1; and
- evacuate leaking components to the lowest level that can be attained without substantially contaminating the refrigerant. This level cannot exceed 0 psig.

If evacuation of the equipment to the environment is not to be performed when repairs are complete, and if the repair is not major, then the appliance must:

- be evacuated to at least 0 psig before it is opened if it is a high or very-high pressure appliance, or
- be pressurized to 0 psig before it is opened if it is a low-pressure appliance. Methods that require subsequent purging (e.g., nitrogen) cannot be used except with appliances containing R-113.

3. Reclamation Requirement

EPA has also established that refrigerant recovered and/or recycled can be returned to the same system or other systems owned by the same person without restriction.

If refrigerant changes ownership, it must be reclaimed (i.e., cleaned to the AHRI 700-1193 Standard of purity) by an EPA certified refrigerant reclaimer.

Refrigerant Recovery and Recycling Equipment Certification

The Agency has established a certification program for refrigerant recovery and recycling equipment. EPA required that manufacturers or importers of refrigerant recovery and recycling equipment manufactured on or after November 15, 1993, have their equipment tested by an EPA-approved testing organization to ensure that it meets EPA requirements. Equipment intended for use with air-conditioning and refrigeration equipment must be tested under EPA requirements based upon the AHRI 740 test protocol (i.e., EPA Appendices B and B1 to 40 CFR 82 subpart F). Recycling and recovery equipment intended for use with small appliances must be tested under EPA Appendix C or alternatively under requirements bases upon the AHRI 740 test protocol (i.e., Appendices B and B1 to 40 CFR 82 subpart F).

The Agency requires recovery efficiency standards that vary depending on the size and type of air-conditioning or refrigeration equipment being serviced. For recovery and recycling equipment intended for use with air-conditioning and refrigeration equipment besides small appliances, these standards are the same as those in the second column of Table 1. Recovery equipment intended for use with small appliances must be able to recover 90 percent of the refrigerant in the small appliance when the compressor is not operating.

EPA has approved both the Air-conditioning, Heating, and Refrigeration Institute (AHRI) and Underwriters Laboratories (UL) to certify recycling and recovery equipment. Certified equipment can be identified by a label reading: "This equipment has been certified by ARI/UL to meet EPA's minimum requirements for recycling and/or recovery equipment intended for use with (appropriate category of appliance -- e.g., small appliances, HCFC appliances containing less than 200 pounds of refrigerant, all high-pressure appliances, etc.)." Lists of certified equipment may be obtained by contacting AHRI at 703-5248800 and UL at 708-272-8800 ext. 42371.

Refrigerant Leaks

Owners or operators of refrigeration and air-conditioning equipment with refrigerant charges greater than 50 pounds are required to repair leaks within 30 days when those leaks result in the loss of more than a certain percentage of the equipment's refrigerant charge over a year. For the commercial (e.g. grocery stores and warehouses) and industrial process refrigeration sectors, leaks must be repaired within 30 days when the equipment leaks at a rate that would release 35 percent or more of the charge over a year. For all other sectors, including comfort cooling (such as building chillers), leaks must be repaired when the appliance leaks at a rate that would release 15 percent or more of the charge over a year.

The trigger for repair requirements is the current leak rate projected over a consecutive 12-month period rather than the total quantity of refrigerant lost. For instance, owners or operators of a commercial refrigeration system containing 100 pounds of charge must repair leaks if they find that the system has lost 10 pounds of charge over the past month; although 10 pounds represents only 10 percent of the system charge in this case, a leak rate of 10 pounds per month would result in the release of over 100 percent of the charge over the year. To track leak rates, owners or operators of air-conditioning and refrigeration equipment with more than 50 pounds of charge must keep records of the quantity of refrigerant added to their equipment during servicing and maintenance procedures. Owners or operators are required to repair leaks within 30 days of discovery. This requirement is

Refrigerant Leaks (continued)

waived if, within 30 days of discovery, owners develop a one-year retrofit or retirement plan for the leaking equipment. Owners of industrial process refrigeration equipment may qualify for additional time under certain circumstances. For example, if an industrial process shutdown is required to repair a leak, owners have 120 days to repair the leak. Owners of industrial process refrigeration equipment should reference the Compliance Assistance Guidance Document for Industrial Process Refrigeration Leak Repair for additional information concerning time extensions and pertinent recordkeeping and reporting requirements.

The leak repair regulations do not apply to refrigeration and air-conditioning equipment with refrigerant charge sizes less than 50 pounds (such as residential split air-conditioning systems). However, smaller equipment is not exempt from the refrigerant venting prohibition. EPA regulations prohibit the intentional release of all refrigerants during the maintenance, service, repair, or disposal of air-conditioning and refrigeration equipment.

Technician Certification

EPA has established a technician certification program for persons ("technicians") who perform maintenance, service, repair, or disposal that could be reasonably expected to release refrigerants into the atmosphere. The definition of "technician" specifically includes and excludes certain activities as follows:

Included:

- attaching and detaching hoses and gauges to and from the appliance to measure pressure within the appliance;
- adding refrigerant to (for example "topping off") or removing refrigerant from the appliance.
- any other activity that violates the integrity of the MVAC-like appliances, and small appliances.

In addition, apprentices are exempt from certification requirements provided the apprentice is closely and continually supervised by a certified technician.

The Agency has developed four types of certification:

1. For servicing small appliances (Type I)
2. For servicing or disposing of high or very high-pressure appliances, except small appliances and MVACs (Type II)
3. For servicing or disposing of low-pressure appliances (Type III).
4. For servicing all types of equipment (Universal).

Technicians are required to pass an EPA-approved test given by an EPA-approved certifying organization to become certified under the mandatory program. Section 608 Technician Certification credentials do not expire.

Technician Certification (Section 608): Steps for Replacing a Lost Card

Step 1. Is your testing organization that issued your certification still in business? Check the list of certifying organizations that are still operating.

Yes, my organization is still operating.
Go to that organization and get a replacement card. They are required to maintain records of people issued cards.

No. - Go to 2 (next page)

Technician Certification (Section 608): Steps for Replacing a Lost Card (continued)

Step 2. Do you have documentation from your original testing organization that demonstrates successful completion of the Section 608 Technician Certification exam? Do you or a current or former employer have a copy of your lost card?

> ***Yes.*** I have documentation from my original testing organization.
> Go to the list of certifying organizations that will replace cards. Send a copy of your documentation to one of the organizations (who have volunteered to make cards for people who can't get them from their certifying organization) on the list. They will issue you a new card and they will maintain a record of your certification.
>
> ***No.*** - Go to 3 below.

Step 3. Is the record of your certification in our centralized files which were compiled from data submitted by certifying organizations that have gone out of business? Go to the list of certifying organizations that have closed.

> ***Yes,*** the record of my certification is in the data submitted by companies that have gone out of business. Download and complete the Assistance with Obtaining a Replacement Card form (PDF, 1 pp., 14K, about PDF). After completing the form mail or fax it to the Section 608 Technician Certification Program Manager. Once it is received EPA will contact you with information on how to obtain a replacement card.
>
> ***No***. - Go to 4 below

Step 4. If you cannot answer "yes" to any of the steps above, EPA will not issue a replacement card. You will need to retake the Section certification test. Please go to the Section 608 Technician Certification Programs page to find testing organizations which meet your needs.

Refrigerant Sales Restrictions

The sale of ozone-depleting refrigerant (such as R-11, R-12, and R-22) in any size container has been restricted to technicians certified either under the program described in Technician Certification above or under EPA's motor vehicle air conditioning regulations. The sales restriction covers ozone-depleting refrigerant contained in bulk containers, such as cans, cylinders, or drums.

The restriction *excludes* refrigerant contained in refrigerators or air conditioners with fully assembled refrigerant circuits(such as household refrigerators, window air conditioners, and packaged air conditioners), and HFC refrigerants (such as R-134a and R-410A).

Under Section 609 of the Clean Air Act, sales of CFC-12 in containers smaller than 20 pounds are restricted solely to technicians certified under EPA's motor vehicle air-conditioning regulations (i.e., Section 609 certified technicians). Technicians certified under EPA's stationary refrigeration and air-conditioning equipment (i.e., Section 608 certified technicians) may buy containers of CFC-12 larger than 20 pounds.

Section 609 technicians are only allowed to purchase refrigerants that are suitable for use in motor vehicle air-conditioners. Effective September 22, 2003, EPA has restricted the sale of ozone-depleting refrigerants, approved for use in stationary refrigeration and air-conditioning equipment, to Section 608 certified technicians. Therefore, the sale of ozone-depleting refrigerants (such as HCFC-22) that are approved for use in stationary equipment but not for use in motor vehicle air-conditioners is restricted to Section 608 certified technicians.

Certification by Owners of Refrigerant Recovery and Recycling Equipment

EPA requires that persons servicing, disposing, or recycling air-conditioning and refrigeration equipment certify to the appropriate EPA Regional Office that they have acquired (built, bought, or leased) refrigerant recovery or recycling equipment and that they are complying with the applicable requirements of this rule. This certification must be signed by the owner of the owner of the equipment or another responsible officer and sent to the appropriate EPA Regional Office. Although owners of recycling and recovery equipment are required to list the number of trucks based at their shops, they do not need to have a piece of recycling or recovery equipment for every truck. Owners do have to send in a new form each time they add recycling or recovery equipment to their inventory.

Refrigerant Reclaimer Certification

Refrigerant reclaimers are companies that reprocess used refrigerant back to virgin specifications. EPA restricts the resale of used refrigerant to a new owner, unless it has been reclaimed by an EPA certified refrigerant reclaimer. Reclaimers are required to return refrigerant to the purity level specified in AHRI Standard 700 (an industry-set purity standard) and to verify this purity using the laboratory protocol set forth in the same standard. In order to be recognized by EPA, refrigerant reclaimers must certify to the Section 608 Recycling Program Manager at EPA headquarters that they are complying with these requirements and that the information given is true and correct. Certification must also include the name and address of the reclaimer and a list of equipment used to process and to analyze the refrigerant.

Safe Disposal Requirements

Refrigeration and air-conditioning equipment that is typically dismantled on-site before disposal (e.g., retail food refrigeration, central residential air conditioning, chillers, and industrial process refrigeration) has to have the refrigerant recovered in accordance with EPA 's requirements for servicing prior to their disposal. However, equipment that typically enters the waste stream with the charge intact, (e.g. motor vehicle air conditioners, household refrigerators and freezers, and room air conditioners) are subject to special safe disposal requirements.

Under these requirements, the final person in the disposal chain (e.g., a scrap metal recycler or landfill owner) is responsible for ensuring that refrigerant is recovered from equipment before the final disposal of the equipment. If the final person in the disposal chain accepts appliances that no longer hold a refrigerant charge, that person is responsible for maintaining a signed statement from whom the appliance/s is being accepted. The signed statement must include the name and address of the person who recovered the refrigerant, and the date that the refrigerant was recovered, or a copy of a contract stating that the refrigerant will be removed prior to delivery. EPA does not mandate a sticker as a form of verification that the refrigerant has been removed prior to disposal of the appliance. Such stickers do not relieve the final disposer of their responsibility to recover any remaining refrigerant in the appliance, unless the sticker consists of a signed statement that includes the name and address of the person who recovered the refrigerant, and the date that the refrigerant was recovered.

Technician certification is not required for individuals removing refrigerant from small appliances, motor vehicle air conditioners, and motor vehicle-like air conditioners, when preparing them for disposal. However, the equipment used to recover refrigerant from appliances prior to their final disposal must meet the same performance standards as refrigerant recovery equipment used prior to servicing. Persons involved in the final disposal of appliances must certify to their EPA Regional Office that they have obtained and are properly using EPA certified refrigerant recovery equipment.

Major Recordkeeping Requirements

Technicians servicing appliances that contain 50 or more pounds of refrigerant must provide the owner with an invoice that indicates the amount of refrigerant added to the appliance. Technicians must also keep a copy of their proof of certification at their place of business.

Owners or Operators of appliances that contain 50 or more pounds of refrigerant must keep servicing records documenting the date and type of service, as well as the quantity of refrigerant added.

Wholesalers who sell CFC and HCFC refrigerants must retain invoices that indicate the name of the purchases, the date of sale, and the quantity of refrigerant purchased.

Reclaimers must maintain records of the names and addresses of persons sending them material for reclamation and the quantity of material send to them for reclamation. This information must be maintained on a transactional basis. Within 30 days of the end of the calendar year, reclaimers must report to EPA the total quantity of material sent to them that year for reclamation, the mass of refrigerant reclaimed that year, and the mass of waste products generated that year.

EPA Final HCFC Rules Summary

1) Allocation Rule - Adjustments to the Allowance System for Controlling HCFC Production, Import & Export allocates the production and import of ***HCFCs including R-22,*** R-142b, R-123 and R-124 for 2010 through 2014.

2) Precharged Equipment Rule - Ban of the Sale or Distribution of Precharged Equipment establishes regulations related to the sale or distribution or offer for sale or distribution in interstate commerce of air conditioning and refrigeration appliances containing R-22, R-142b and blends containing these refrigerants beginning January 1, 2010.

EPA definition of Appliance, Component and Manufactured:

Appliance: Any device which contains and uses a refrigerant and which is used for household or commercial purposes, including air conditioners, refrigerators, chillers and freezers.

Component: Any portion of the refrigerant circuitry that is necessary for the appliance to function in its intended purpose (examples: condenser, evaporator, compressor, TXV, line set, coil)

Manufactured: The date of manufacture is when the appliance meets the following four criteria:

1) Refrigerant circuit is complete and
2) Appliance is charged with refrigerant and
3) Appliance can function and
4) Appliance is ready for use for its intended purpose

Allocation Rule

EPA is allocating 80% of the estimated quantity of R-22 needed for aftermarket servicing in 2010 *and will decrease the allocation each year* so that the supply of R-22 will be less than the estimated demand. EPA will issue allocations for 2015-2019 at a later date based on projected servicing demand for those years.

Virgin R-123 and R-124 are allowed in newly manufactured appliances until January 1,2020.

As indicated in the chart below, reclaimed R-22 will be necessary to meet the continued servicing needs of the installed equipment base:

	2010	2011	2012	2013	2014
Estimated R-22 Demand for Service	137.7 M	127.6 M	117.2 M	106.7 M	96 M
EPA Virgin R-22 Allocation	110.2 M	100 M	89.7 M	79.1 M	68.6 M
Shortfall to be filled with Reclaim R-22	27.55M	27.55 M	27.55 M	27.55 M	27.55 M

All numbers in pounds

Precharged Equipment Rule

The Precharged Equipment Rule prohibits the precharging of all air conditioning and refrigeration appliances and components by OEMs beginning January 1, 2010.

The prohibition ....

- Does not apply to precharged appliances and components that were manufactured prior to January 1, 2010
- Does not prohibit the sale or distribution of pre-2010 inventory
- Allows the sale and distribution of uncharged appliances and components
- Allows use of reclaimed R-22 to field charge appliances manufactured after January 1, 2010
- Allows uncharged components to be charged with virgin or reclaimed refrigerant if used for service only

Precharged Appliances & Components manufactured *before* January 1, 2010

- No restriction on sale or distribution
- Precharged components can only be used to service existing appliances
- Virgin or reclaimed refrigerant can be used to service existing appliances

Appliances & Components manufactured *after* January 1, 2010

- Appliances cannot be initially charged with virgin refrigerant, reclaimed refrigerant is okay
- Components can be charged with virgin refrigerant if being used for service of existing appliance; otherwise, charge only with reclaimed refrigerant

Important Exceptions

1) Virgin R-22 may be used for the onsite manufacture (i.e. installation) of appliances for a specific project if the components being used on that project were manufactured before January 1, 2010 and if a building permit or contract was issued and dated prior to January 1, 2010. Projects that qualify for this exception must be completed by December 31, 2011.

2) Thermostatic expansion valve (TXV) manufacturers can use R-22 manufactured before January 1, 2010 to produce precharged TXVs until January 1, 2015.

For more information, please visit EPA's website: http://www.epa.gov/ozone/strathome.html