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# Forane®

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## Refrigerants

We have expanded our Forane® line of refrigerants to meet our customers' needs. Forane® refrigerants are used wherever cooling or freezing applications are required, including appliances, automotive, construction, food processing, industrial refrigeration, supermarkets and transportation refrigeration.

All Forane® refrigerants have low ozone depletion potential and have received UL approval, and some are as close to "drop-in" replacements as possible, making for easy retrofits.

We provide information to help you select the right product for your application and detailed instructions on how to use it. You can compare temperature-pressure data for CFCs and the new alternative products. Or, you can examine the basic property data for our products.

Forane® 134a

Forane® 404A

Forane® 407C

Forane® 408A

Forane® 409A

Forane® 410A

# Forane® 134a

Forane® 134a is an HFC, zero ozone depletion potential (ODP) refrigerant with properties very similar to R-12. It can be used both as a pure refrigerant in a number of traditional R-12 applications, and as a component in refrigerant blends targeted for R-502 and R-22 applications.

Compressor and system manufacturers are selling new equipment that has been specifically designed for R-134a.

In addition, laboratory testing and field trials have confirmed that R-134a will work in the retrofit of many existing R-12 and R-500 installations.

## New Equipment

Applications that have successfully made the transition from R-12 to R-134a include automotive air conditioning, specialized air conditioning or climate control applications, positive pressure centrifugal chillers, medium temperature commercial refrigeration, refrigeration appliances, refrigeration plants, and transport refrigeration.

## Retrofit

Applications where R-134a is being proven reliable for retrofitting R-12

systems include R-12 centrifugal chillers, semi-hermetic, reciprocating, and screw refrigeration applications, industrial refrigeration plants, automotive systems and some hermetic compressor applications. See *Retrofitting with Forane 134a* section for more considerations.

This brochure has been designed to give a broad background of properties and technical considerations to help you determine if Forane 134a will meet your CFC alternative needs.

## Performance of Forane® 134a in New Equipment

### Lubrication

For all R-134a applications, lubrication is a very important consideration.

- Miscibility between refrigerant and oil is critical for most equipment designs. Miscibility is required to ensure oil return to the compressor.
- R-134a is not miscible with mineral oils. Polyolester (POE) lubricants and poly alkylene glycol (PAG) lubricants have been recommended by various equipment manufacturers for use with R-134a.
- POE and PAG lubricants are hygroscopic and will absorb moisture quickly. They must be handled properly to avoid prolonged exposure to air.

Generally, new equipment will be shipped by the manufacturer with a

compatible lubricant already charged. All of the manufacturer's recommendations should be followed.

### System Performance

#### Climate control

Chillers and specially designed A/C systems have been engineered to use R-134a while providing energy efficiency equivalent to R-12.

- Manufacturers have successfully introduced products for mobile air conditioning and positive pressure chillers using R-134a.

#### Refrigeration

##### Low temperature

- At lower evaporator temperatures (below 24°F), the pressure ratio of R-134a rises in relation to R-12, and

the capacity may drop off significantly. Check with equipment manufacturers for specific recommendations regarding the use of their equipment with R-134a at lower application temperatures.

#### Medium and high temperature applications

- R-134a can be used in most medium and high temperature R-12 applications.
- An ideal theoretical cycle analysis using the thermodynamic properties of R-134a shows a slight decrease in capacity and efficiency. When improvements such as liquid subcooling are introduced into the equation, the performance of R-134a becomes equal to that of R-12. These improvements are being taken advantage of by equipment manufacturers.

## Retrofitting with Forane® 134a

When retrofitting R-12 systems to R-134a, it is necessary to replace the existing lubricant with POE oil, except in

some automotive retrofit applications (see Automotive A/C). In most cases the mineral oil or alkylbenzene oil levels must be

reduced below 5% of the new POE charge. Check with OEMs for any specific recommendations regarding oils or

procedures. The most popular method of oil flushing is to remove as much of the existing lubricant as possible, add POE, and run the system on R-12 for some time. When the residual oil concentration is appropriate, change oil, refrigerant, and filter driers one last time.

## Retrofit Applications

### Centrifugal Chillers

R-12 chillers that are retrofitted to R-134a will generally suffer in capacity and efficiency if no changes are made to the equipment. Manufacturers of chillers will provide engineering recommendations and retrofit kits to ensure the best performance from their equipment.

### Automotive A/C

R-134a is the only alternative approved by OEMs and service organizations for use in retrofitting automotive air conditioning systems.

Some OEMs have recommended that the existing mineral oil be left in the system and that an additional charge of PAG or POE be added for proper oil return. This makes R-134a auto retrofits quick and easy. See OEM for specific details and material compatibilities.

### Refrigeration

Larger refrigeration systems can be successfully retrofitted if the following factors are considered:

- Lubricant Flushing — most refrigeration systems require less than 5% residual

mineral oil before retrofitting to R-134a.

- Compatibility of materials must be checked. Any materials that will cause leaks or failure of systems must be replaced.

- Application Temperature Range — the performance of R-134a should be evaluated at the application temperature to confirm if it should be used.

### Small hermetic

Since it is difficult to flush the oil in a hermetic system, it is recommended that R-134a not be used to retrofit. Instead, we recommend 409A (FX-56) which can be used with the existing system oil for most cases (see 409A section).

# Forane® 404A

Forane® 404A (FX-70) is a zero ozone depletion potential (ODP), near azeotropic blend of HFC refrigerants R-125, R-143a and R-134a. Forane 404A is formulated to closely match the properties of R-502, that makes it useful for a variety of medium and low temperature refrigeration applications.

## New Systems

Forane 404A has been approved by most refrigeration compressor and system manufacturers for use in new refrigeration equipment. Applications where R-404A equipment is available include food display and storage cases, cold storage rooms, ice machines, transportation, and process refrigeration.

## Retrofit

Forane 404A can be used to retrofit many existing R-502 systems. The physical and refrigeration properties of the blend cause it to behave much like R-502 when used in a retrofit; however, it is not intended to be a direct, “drop-in” service fluid for R-502 systems.

## Considerations for Using Near Azeotropic Blends

Common refrigerants used in the past were either single component refrigerants, or azeotropic blends that behaved as a single component when used in refrigeration systems. Near azeotropic blends, such as R-404A, will behave almost the same as azeotropes, such as R-502, for all practical purposes.

The temperature glide of R-404A is less than 1.5°F. In most systems, this

glide is not noticeable compared to normal temperature changes due to pressure drops. Equipment manufacturers indicate potential influences from R-404A's glide on given applications.

R-404A will not change significantly in composition due to fractionation. There will, however, be a slight difference in composition in the vapor phase, which is in equilibrium with

liquid (such as in a cylinder).

For this reason Forane 404A should be removed from the cylinder as a liquid during charging operations. In situations where vapor is normally fed to the system, a valve should be installed in the charging line to flash the liquid to vapor during charging.

Our testing shows that most system leaks are not a problem. Top off the system as you would with R-502.

## *Use of Forane® 404A in New Refrigeration Systems*

### **Performance**

In new installations, the process for sizing and selecting compressors and other system components for use with R-404A is the same as it has always been for R-502. The compressor capacity, line sizes, etc. will be chosen properly to fit the needs of the job. Operating experience has shown no significant loss of efficiency in R-404A installations compared to historical R-502 performance.

### **Lubrication**

R-404A requires a POE lubricant to ensure complete miscibility between oil and refrigerant. Miscibility is important for oil return to the compressor, especially in larger systems with long runs of piping. Manufacturers supply equipment with the proper lubricant already charged, or provide specific recommendations on the type or brand of lubricant to be installed in the field.

### **Material Compatibility**

New systems are constructed with materials that are compatible with R-404A. Follow manufacturers' recommendations regarding materials that are to be installed in the field. Most new driers, sight glasses and system components should be rated for new HFC refrigerants.

## *Considerations for Retrofitting R-502 Systems for Use with Forane® 404A*

Retrofit projects should be included as part of an overall refrigerant management program. Forane 404A can be used in the retrofit of many existing R-502 installations, with the following considerations:

### **Lubrication**

R-404A is not miscible with existing lubricants used in R-502 systems. The mineral oil will need to be replaced with a POE lubricant to a residual mineral oil level less than 5%. Failure to do this can cause system waxing or system inefficiencies.

### **Pressure Relief**

Due to higher operating pressures associated with the use of Forane R-404A as opposed to R-502, OEM product specific retrofit requirements should be consulted for any and all pressure relief modifications and/or requirements.

# Forane® 407C

**F**orane® 407C is a zero ozone depletion blend of HFC refrigerants R-32, R-125 and R-134a. It has been formulated to closely match the properties of R-22, and will be used for many air conditioning and refrigeration applications in either new equipment or in retrofitting existing R-22 installations. This brochure provides a broad description of properties and technical information to help determine if Forane 407C meets your air conditioning and refrigeration requirements.

### **New Systems**

Applications include residential and other unitary air conditioning, non-flooded evaporator chillers, and commercial refrigeration. Since R-407C has similar properties to R-22, it will be possible (with few modifications) to use the new blend in the same equipment designed for use with R-22 today.

### **Retrofit**

R-407C can also be used to retrofit existing R-22 systems. The blend should not

be used, however, as a direct, "drop-in" service fluid. In addition, this blend should not be used in centrifugal chillers or other equipment that uses a flooded evaporator because of the high temperature glide (9–12°F for most applications) and fractionation behavior within the system. (See "Zeotropic Blends: Definition of Terms" in the Forane 409A section.)

### **Lubrication**

The HFC refrigerant components in R-407C will not be compatible with the mineral oil or alkylbenzene lubricants

present in most R-22 systems. POE lubricants must be used with R-407C. When retrofitting, a lubricant flush procedure will be necessary to lower the original oil content below 5%. New R-407C equipment will be charged with the OEM recommended lubricant, ready to use with R-407C.

### Charging

If a leak were to occur in a cylinder, or in the vapor space of a system at rest, fractionation of the blend may cause a permanent change in the composition of the refrigerant charge.

For this reason Forane 407C should be removed from the cylinder as a

liquid during charging operations. In situations where vapor is normally fed to the system, a valve should be installed in the charging line to flash the liquid to vapor while charging. (Follow charging instructions on the cylinder.)

## Retrofitting with Forane 407C

Although the properties closely match R-22, R-407C is not suitable for use in all R-22 systems. We recommend retrofitting only positive displacement, direct expansion refrigeration and air conditioning equipment with R-407C. In all cases, the mineral or alkylbenzene oil must be flushed from the system and replaced with an approved POE lubricant. Consult any manufacturer's guidelines for additional consideration.

### Retrofitting Procedures

1. Gather baseline data from the system using R-22.

2. Recover the existing R-22 charge.

3. Drain the original oil from the system. Recharge using an approved POE lubricant.

4. Recharge the system using R-22 and run the system to circulate the new lubricant.

5. Recover the R-22 charge again and check the residual oil content of the lubricant. The amount of the original lubricant in the POE must be below 5%.

6. Repeat steps 3-5 until the lubricant charge is greater than 95% POE. At this

point standard maintenance should be performed on the system, such as replacing the filter-drier and fixing any leaks that have been located.

7. Evacuate the system using a deep vacuum (less than 500 microns).

8. Charge the system with R-407C. Be sure to remove the refrigerant from the cylinder as a liquid.

9. Start the system and adjust controls and/or charge until desired operation is achieved. Label the system to identify the R-407C charge and the lubricant used.

# Forane<sup>®</sup> 408A

Forane 408A (FX-10) is a low ozone depletion potential (ODP), near-azeotropic blend of HCFC 22 and HFC refrigerants R-125 and R-143A. Forane 408A has been added to the Forane family of refrigerants to provide a convenient and reliable retrofit solution for medium and low temperature refrigeration systems that are

currently using R-502 and mineral or alkylbenzene oils.

### Use Forane 408A to Retrofit R-502 Systems

Forane 408A can be used to retrofit many existing R-502 systems. R-408A has been blended to closely match the

physical and refrigeration properties of R-502 because the equipment being retrofitted was designed for R-502. R-408A should not be mixed with R-502 or used to top off existing systems. (See Considerations for Retrofitting R-502 systems)



## Use Forane® 404A for New Low and Medium Temperature Systems

Forane 408A is not intended for use in new equipment. Refrigeration applications that were previously

designed to use R-502 can now be specified to use a long term alternative HFC blend, Forane 404A. Manufacturers are making compressors and refrigeration systems available for use in food display and storage cases, cold storage rooms, ice

machines, transportation, and process refrigeration.

This section has been designed to give a broad background of properties and technical considerations to help you apply Forane 408A to your refrigeration needs.

## Considerations for Using Near Azeotropic Blends

Common refrigerants used in the past were either single component refrigerants or azeotropic blends that behaved as a single component when used in a refrigeration system. Near azeotropic blends such as R-408A will behave almost the same as azeotropes such as R-502, for all practical purposes.

- The temperature glide of R-408A is less than 1.0°F. This glide is usually not noticeable compared to normal temperature changes due to pressure drops across the tubing. Manufacturers in general have not indicated any special considerations for low-glide blends in normal retrofit applications.

- R-408A will not significantly change in composition due to fractionation, so recharging is not a problem. There will, however, be a slight difference in composition in the vapor phase, which is in equilibrium with liquid such as in a cylinder. R-408A should therefore be transferred to charging equipment or systems from the cylinder as a liquid.

## Considerations for Retrofitting R-502 Systems for Use with Forane® 408A

Retrofit projects should be included as part of an overall refrigerant management program. Forane 408A can be used in most existing R-502 installations, with the following considerations:

### Performance

In most retrofit applications, R-408A capacity and efficiency are slightly higher than R-502. The compressor, line sizes, and other components will not need replacement, and should operate the same with R-408A as they did with R-502.

### Lubrication

R-408A is capable of being used with mineral oil, alkylbenzene oil, or POE lubricants. Systems that operate with R-502 and mineral oil, and that show adequate lubricant return to the compressor may continue to use mineral oil with R-408A. Alkylbenzene and/or POE may be used alone or in combination with mineral oil in order to improve lubricant miscibility and return to the compressor. Consult any manufacturer's guidelines for additional recommendations.

### Material Compatibility

Check ATOFINA Chemicals, Inc. retrofit literature and obtain recommendations from equipment manufacturers regarding compatibility of materials with R-408A. Replace any materials not acceptable for use with R-408A. Generally, materials compatible with R-22 can be used for R-408A.

## Retrofit Procedure

1. Gather baseline data from the system while still operating on R-502.
2. Leak check system to identify necessary repairs.
3. Recover existing R-502 charge.

4. If necessary, remove mineral oil and replace with alkylbenzene or POE.
5. Replace filter driers.
6. Evacuate system using a deep vacuum (at least 250 microns).
7. Charge system with R-408A using

liquid phase only. (Approximate charge will be 85–90% of R-502 charge.)

8. Properly mark and identify R-408A refrigerant charge for the retrofitted system.
9. Start system and adjust expansion device if necessary.

# Forane<sup>®</sup> 409A

**F**orane<sup>®</sup> 409A (FX-56) is a low ozone depleting blend of HCFC refrigerants R-22, R-124, and R-142b. Forane 409A is formulated to closely resemble the properties of R-12.

## Retrofit

Forane 409A is an alternative refrigerant blend for retrofitting R-12 and R-500 medium and low temperature refrigeration systems. These systems, which typically contain a hermetic or semi-hermetic compressor, are used in commercial food storage, vending/beverage machines, ice machines, and transport refrigeration.

R-409A provides a slightly higher capacity than R-12 and R-134a in lower temperature applications.

## Lubrication

For intended applications, R-409A is sufficient for use with mineral, alkylbenzene or POE oils. Miscibility is important for proper oil return to

the compressor. Charging the existing lubricant is not required in most cases. (See *Retrofitting with R-409A* later in this section.)

## Charging

If a leak were to occur in a cylinder or in the vapor space of a system at rest, fractionation of the blend may cause a permanent change in composition of the refrigerant charge.

For this reason, Forane 409A should be removed from the cylinder as a liquid during charging operations. In situations where vapor is normally fed to the system, a valve should be installed in the charging line to flash the liquid to vapor while charging.

Testing has shown that for those systems at rest, four to five 20% vapor leaks/ recharges are allowable before system performance might be affected. Leaks while a system is running, or on the liquid side, should not be a problem and can be topped off.

Follow charging instructions on the cylinder. The approximate R-409A charge for most applications will be 85–90% of the original (R-12) charge.

## Performance

Evaporator pressures using R-409A are similar to operating pressures for R-12.

High side pressures will typically be 15 to 25 psi higher than the pressure seen with R-12.

Equal or better heat transfer characteristics are obtained using R-409A. The temperature glide seen with R-409A is not a problem in most direct expansion evaporators (see Figure 2).

This brochure provides a broad description of properties and technical information to determine if Forane 409A meets your system's needs.

## Zeotropic Blends: Definition of Terms

Since Forane® 409A and 407C are zeotropic blends, it is important to understand the terms Bubble Point, Dew Point, Fractionation, and Glide.

R-409A (°F)		R-22	R-124	R-142b
Dew	Bubble	(°F)	(°F)	(°F)
(vapor)	(liquid)			
7.5	-7.5	-20.0	33.9	39.8

**TABLE 1:** R-409A and component saturation temperatures at 10 psig.

### Bubble Point

(Saturated Liquid Temperature)

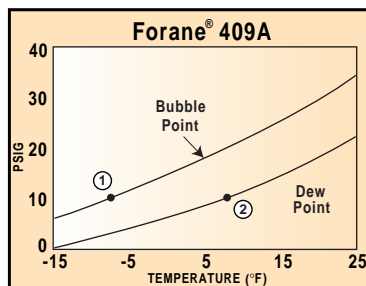
Bubble Point is the temperature at which R-409A (at constant pressure) begins to evaporate. In other words, the Bubble Point is the temperature where the first bubble of vapor appears in the liquid R-409A. The Bubble Point is equivalent to the boiling point for single component refrigerants. From Table 1, at 10 psig, the Bubble Point for R-409A is -7.5°F. The graph in Figure 1 plots the Bubble temperatures for various pressures. The Bubble Point temperature is indicated in Figure 1 as point 1. At operating conditions to the left of the Bubble Point line, the refrigerant is a subcooled liquid.

### Dew Point

(Saturated Vapor Temperature)

Dew Point is the temperature where condensation begins (at constant pressure), which corresponds to the condensation point of a single component refrigerant. This is also the temperature at which the last droplet of liquid evaporates and saturated gas exists. Table 1 lists the Dew Point temperature of 7.5°F at 10 psig. This point is shown as Point 2 in Figure 1. At operating conditions to the right of this line, the refrigerant is at a superheated vapor state.

Bubble Point and Dew Point are used to describe the behavior of zeotropic blends in an evaporator and condenser. “Boiling Point” is not appropriate since the temperature of the blend changes as it evaporates or condenses.



**FIGURE 1:** R-409A pressure temperature graph.

### Fractionation

Fractionation is change in composition of a refrigerant blend when it changes phase from liquid to vapor (evaporation) or from vapor to liquid (condensation). For R-409A, fractionation occurs between its Bubble and Dew Points (points 1 and 2 in Figure 1). Since the components of R-409A evaporate (or condense) at different rates in the evaporator (or condenser), the composition of R-409A constantly changes between the Bubble and Dew Points. Once the temperature passes the Dew Point (to the right of the Dew Point line), the refrigerant is in a superheated vapor state.

### Glide

Glide is the difference in temperature between the evaporator outlet and inlet due to fractionation of the blend. Theoretically, this can be calculated by finding the difference between the Dew and Bubble temperatures at constant pressure. Actual measurements may differ slightly, depending on the state of the liquid refrigerant at either end of the evaporator (or condenser). Pressure losses through the evaporator may also affect glide. At most common system pressures, R-409A has a temperature glide of 10-12°F.



## Setting System Temperature Using Forane 409A

It is important to gather baseline data, if possible, prior to retrofitting systems with new refrigerants such as R-409A.

### Setting System Temperatures

- From baseline data using R-12, take the desired evaporator temperature using R-12 and add 5°F. This gives the Dew Point (vapor) temperature for R-409A (outlet of evaporator). The 5°F compensates for the glide across the evaporator when using R-409A.

Example: Evaporator operating temperature using R-12: 10°F.

$10^{\circ}\text{F} + 5^{\circ}\text{F}$  (1/2 of 409A glide) = 15°F Dew Point (vapor) temperature at evaporator outlet (if 0°F superheat).

- Using the Pressure/Temperature Chart for 409A found on the back of this brochure, the Dew Point (vapor) pressure for R-409A at 15°F is 15.4 psig. This pressure is equal to the suction pressure of the compressor.

- Notice that the vapor temperature of 409A at the outlet is higher than the operating temperature of R-12. In contrast, at the evaporator inlet the temperature of R-409A (liquid) is colder than R-12 operating condition. The average temperature across the evaporator is 10°F (see example below).

## Typical Behavior of Forane 409A in the Evaporator

### Figure 2 Illustrates Typical Conditions For Achieving An Average Evaporator Temperature Of 10°F

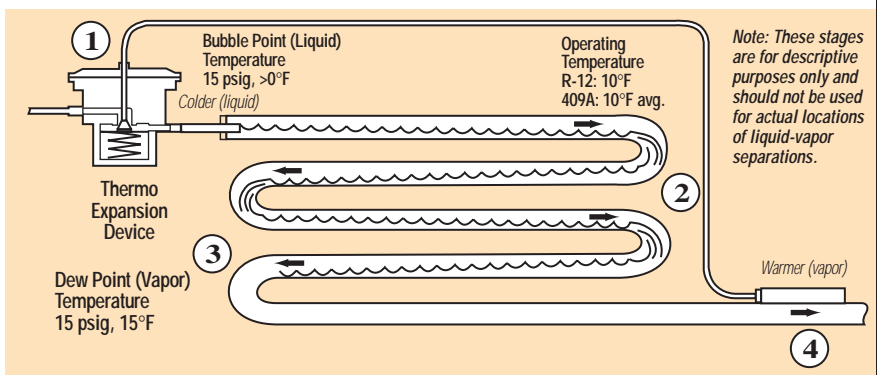
- ① At the expansion valve, R-409A is close to a saturated liquid. For example, if the pressure is 15 psig, the saturated liquid temperature of R-409A is 0°F. Typically, evaporator inlet temperatures run a few degrees above saturation temperatures.
- ② As the temperature increases, R-409A begins to evaporate. The resulting vapor that forms first contains more of the higher pressure component (R-22). As the vapor separates from the liquid, the remaining liquid shifts in composition toward the less volatile components (more R-124 and R-142b than R-22). As the composition of the

liquid (or vapor) changes, the Bubble Point temperature (or Dew Point temperature) of the remaining refrigerant changes as well, causing a temperature glide.

- ③ Fractionation continues as the less volatile components (R-124, R-142b) boil more rapidly along with the remaining R-22. For R-409A vapor at 15 psig, the temperature is 15°F.

- ④ 409A has completely evaporated and has returned to its original composition. The vapor is slightly superheated, and the expansion valve is controlled as normal.

The average evaporator temperature will be approximately 10°F since the inlet will be slightly higher than 0°F.



**FIGURE 2:** R-409A fractionation in the evaporator. Bubble and Dew Point temperatures for 409A at 15 psig.

## Retrofitting with Forane 409A

Retrofitting R-12 systems to R-409A is recommended where R-134a is not practical. Systems where mineral oil removal is difficult are good candidates for R-409A. These include vending/beverage machines and transport, restaurant, and home refrigeration systems. Retrofit projects should be included as part of an overall refrigerant management program.

### Retrofit Procedures

1. Gather baseline data from system using R-12.

2. Recover existing R-12 charge.

3. Mineral oil removal is not necessary in most cases. If oil miscibility becomes a concern at lower temperatures (less than 0°F), oil return can be improved by using at least 30% alkylbenzene lubricant mixed with mineral oil. R-409A is fully miscible with pure alkylbenzene or POE lubricants.

4. Replace filter driers.

5. Evacuate system using a deep vacuum.

6. Charge R-409A refrigerant in the liquid phase only (approximately 85–90% of original charge).

7. Properly mark and identify R-409A refrigerant charge on the system.

8. Start system and adjust expansion valve for proper superheat settings if applicable.

# Forane<sup>®</sup> 410A

Forane<sup>®</sup> 410A is a zero ozone depletion potential (ODP) refrigerant for use as a replacement for HCFC-22 in a variety of new equipment applications. Forane 410A is a near azeotropic blend consisting of HFCs R-32 and R-125.

### New Systems

Forane 410A is a suitable replacement for new applications that formerly operated with HCFC-22. Many refrigeration and air conditioning manufacturers have equipment specifically designed for R-410A. Applications where R-410A might be used include air conditioning, chillers and commercial refrigeration.

### Retrofit

Due to the higher capacity and pressure of Forane 410A, it is not recommended as a retrofit to existing R-22 systems. Mandatory changes would need to be made to existing equipment to accommodate the higher capacity and pressures of Forane 410A. Included in these changes would be expansion valves, compressors, condensers, and other high and low side components. In situations where a retrofit would need to be performed, R-407C would be recommended due to its similarity to R-22.

### Lubrication

R-410A, as with other HFC refrigerants, requires POE lubricant to ensure complete miscibility between oil and refrigerant. Manufacturers of R-410A equipment will supply equipment with the proper lubricant already charged.

### Performance

For new installations with properly charged equipment, line sizes, etc., Forane 410A has shown to have a 5–6% higher Energy Efficiency Rating (EER) than R-22. Forane 410A also has a higher capacity and pressure than R-22, allowing for the design of smaller, more compact air conditioning equipment.

# Forane® Basic Property Data

	R-123	R-134a	R-404A (FX-70)	R-407C	R-408A (FX-10)	R-409A (FX-56)	R-410A
Average Molecular Weight	152.9	102.0	97.6	86.2	87.0	97.4	72.6
Boiling Pt. @ 1 atm (°F)	82.1	-14.9	-51.5*	-46.1*	-47.9*	-30.1*	-61.6*
Density of Saturated Vapor @ b.p. (lb./cu. ft.)	0.40	0.33	0.34	0.29	0.30	0.31	0.26
Density of Saturated Liquid @ 77°F (lb./cu. ft.)	91.29	75.31	65.17	71.12	66.31	75.91	67.66
Critical Temp. (°F)	362.8	214.0	161.6	187.2	182.6	224.2	162.0
Critical Pressure (psia)	532.9	589.8	539.5	690.1	629.5	667.2	713.0
Latent Heat of Vaporization @ b.p. (BTU/lb.)	73.7	92.8	86.0	107.4	97.6	94.6	116.7
Specific Heat of Liquid @ 77°F (BTU/lb. °F)	0.23	0.34	0.39	0.38	0.37	0.30	0.44
Specific Heat of Vapor @ 1 atm (BTU/lb. °F)	0.16	0.19	0.18	0.17	0.16	0.15	0.17
Temperature Glide (°F)	0.0	0.0	1.5	10.5	1.2	14.4	0.2
Flammable Limits in Air	non flammable	non flammable	non flammable	non flammable	non flammable	non flammable	non flammable
Ozone Depletion Potential (ODP, CFC 11=1.0)	0.014	0.000	0.000	0.000	0.026	0.050	0.000
Halocarbon Greenhouse Warming Potential (HGWP, CFC 11=1.0)	0.02	0.33	0.96	0.34	0.77	0.38	0.34
ASHRAE Safety Group Classification	B1	A1	A1/A1	A1/A1	A1/A1	A1/A1	A1/A1
Workplace Environment Exposure Level (WEEL) ( 8 hr. time/wt. avg.)	10 ppm	1000 ppm	1000 ppm	1000 ppm	1000 ppm	1000 ppm	1000 ppm

\*Bubble Point Temperature

# Vapor Pressure PSIG

Temp°F	11	12	22	113	114	500	502	134a	123
-50	28.9	15.4	6.2	—	27.1	12.8	0.2	18.7	29.2
-45	28.7	13.3	2.7	—	26.6	10.3	1.9	16.9	29.0
-40	28.4	11.0	0.5	—	26.0	7.6	4.1	14.8	28.9
-35	28.1	8.4	2.6	—	25.4	4.6	6.5	12.5	28.7
-30	27.8	5.5	4.9	29.3	24.6	1.2	9.2	9.8	28.4
-25	27.4	2.3	7.4	29.2	23.8	1.2	12.1	6.9	28.1
-20	27.0	0.6	10.1	29.1	22.9	3.2	15.3	3.7	27.8
-15	26.5	2.4	13.2	28.9	21.8	5.4	18.8	0.1	27.4
-10	26.0	4.5	16.5	28.7	20.6	7.8	22.6	1.9	27.0
-5	25.4	6.7	20.0	28.5	19.3	10.4	26.7	4.1	26.5
0	24.7	9.1	23.9	28.2	17.8	13.3	31.1	6.5	25.9
5	23.9	11.8	28.2	27.9	16.2	16.4	35.9	9.1	25.3
10	23.1	14.6	32.8	27.6	14.4	19.7	41.0	11.9	24.6
15	22.1	17.7	37.7	27.2	12.4	23.3	46.5	15.0	23.7
20	21.1	21.0	43.0	26.8	10.2	27.2	52.5	18.4	22.8
25	19.9	24.6	48.7	26.3	7.8	31.5	58.8	22.1	21.8
30	18.6	28.4	54.9	25.8	5.2	36.0	65.6	26.0	20.7
35	17.2	32.5	61.5	25.2	2.3	40.8	72.8	30.3	19.5
40	15.6	36.9	68.5	24.5	0.4	46.0	80.5	35.0	18.1
45	13.9	41.6	76.0	23.8	2.0	51.6	88.7	40.0	16.6
50	12.0	46.7	84.0	22.9	3.8	57.5	97.4	45.4	15.0
55	10.0	52.0	92.5	22.2	5.8	63.9	106.6	51.1	13.1
60	7.8	57.7	101.6	21.0	7.9	70.6	116.4	57.3	11.2
65	5.4	63.7	111.2	19.9	10.1	77.8	126.7	63.9	9.0
70	2.7	70.2	121.4	18.7	12.6	85.4	137.6	71.0	6.6
75	0.0	76.9	132.2	17.3	15.2	93.4	149.1	78.6	4.0
80	1.5	84.1	143.6	15.8	18.0	101.9	161.2	86.6	1.2
85	3.2	91.7	155.7	14.3	20.9	111.0	174.0	95.1	0.9
90	4.9	99.7	168.4	12.5	24.1	120.5	187.4	104.2	2.5
95	6.8	108.2	181.8	10.6	27.5	130.5	201.4	113.8	4.2
100	8.8	117.1	195.9	8.6	31.1	141.1	216.2	124.1	6.1
105	10.9	126.5	210.7	6.4	35.0	152.2	231.7	134.9	8.1
110	13.2	136.4	226.3	4.0	39.1	164.0	247.9	146.3	10.3
115	15.6	146.7	242.7	1.4	43.4	176.3	264.9	158.4	12.6
120	18.3	157.6	259.9	0.7	48.0	189.2	282.7	171.1	15.1
125	21.0	169.0	277.9	2.2	52.8	202.8	301.4	184.5	17.7
130	24.0	180.9	296.8	3.7	58.0	217.0	320.8	198.7	20.6
135	27.1	193.5	316.5	5.4	63.4	231.9	341.2	213.6	23.6
140	30.4	206.5	337.2	7.2	69.0	247.4	362.6	229.3	26.8
145	34.0	220.2	358.8	9.2	75.0	263.7	385.0	245.7	30.2
150	37.7	234.5	381.5	11.2	81.3	280.7	408.4	263.0	33.8

# Pressure/Temperature Chart

Temp (°F)	R-408A (FX-10) Liquid Pressure	R-404A (FX-70) Liquid Pressure	R-409A (FX-56) Liquid Pressure	R-409A (FX-56) Vapor Pressure	R-407C Liquid Pressure	R-407C Vapor Pressure	R-410A Liquid Pressure
-50	1.6	0.6	12.4	17.2	2.9	11.4	3.5
-45	1.1	2.7	9.7	15.2	0.4	8.5	8.5
-40	3.3	5.0	6.8	13.1	2.5	5.2	11.6
-35	5.6	7.6	3.5	10.7	4.8	1.5	14.9
-30	8.2	10.4	0.0	8.1	7.3	1.3	18.5
-25	11.0	13.4	2.0	5.1	10.1	3.6	22.5
-20	14.1	16.8	4.1	1.9	13.1	6.1	26.9
-15	17.5	20.5	6.5	0.8	16.5	8.8	31.7
-10	21.2	24.5	9.0	2.8	20.1	11.9	36.8
-5	25.2	28.8	11.8	4.9	24.0	15.2	42.5
0	29.5	33.5	14.8	7.2	28.3	18.9	48.6
5	34.2	38.6	18.1	9.7	33.0	22.9	55.2
10	39.3	44.0	21.7	12.5	38.0	27.3	62.3
15	44.8	49.9	25.5	15.4	43.5	32.0	70.0
20	50.7	56.2	29.6	18.7	49.3	37.2	78.3
25	57.0	63.0	34.0	22.2	55.7	42.7	87.3
30	63.7	70.3	38.7	26.0	62.5	48.7	96.8
35	71.0	78.1	43.8	30.1	69.8	55.2	107.0
40	78.7	86.4	49.2	34.5	77.6	62.1	118.0
45	87.0	95.2	54.9	39.2	86.0	69.5	129.7
50	95.8	104.7	61.0	44.3	94.9	77.5	142.2
55	105.1	114.7	67.6	49.8	104.5	86.0	155.5
60	115.1	125.3	74.5	55.6	114.6	95.1	169.6
65	125.6	136.6	81.8	61.9	125.4	104.8	184.6
70	136.8	148.6	89.5	68.6	136.9	115.2	200.6
75	148.7	161.2	97.7	75.8	149.1	126.2	217.4
80	161.2	174.6	106.4	83.4	162.1	137.8	235.3
85	174.4	188.8	115.5	91.5	175.8	150.2	254.1
90	188.4	203.7	125.2	100.2	190.2	163.4	274.1
95	203.1	219.4	135.3	109.4	205.5	177.4	295.1
100	218.7	235.9	146.0	119.2	221.6	192.1	317.2
105	235.4	253.4	157.2	129.6	238.5	207.8	340.5
110	252.1	271.7	169.0	140.6	256.4	224.4	365.0
115	270.2	290.9	181.4	152.3	275.1	241.9	390.7
120	289.1	311.1	194.4	164.7	294.7	260.5	417.7
125	308.9	332.3	208.0	177.8	315.2	280.1	445.9
130	329.7	354.5	222.3	191.6	336.7	300.9	475.6
135	351.5	377.8	237.2	206.3	359.2	322.9	506.5
140	374.3	402.2	252.9	221.8	382.6	346.2	539.0
145	398.1	427.7	269.3	238.2	407.0	370.8	572.8
150	423.0	454.4	286.4	255.5	432.4	396.9	608.1

Red numerals = inches Hg. below 1 atm.

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