ARKEMA

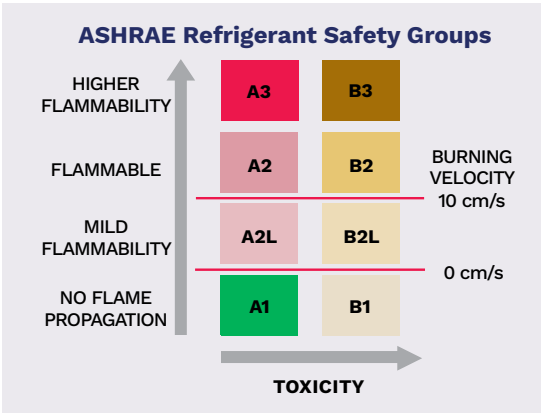
FORANE®
REFRIGERANTS

FORANE® 32
OEM Application Guide

INTRODUCTION

In the ever changing global regulatory landscape, there have been, and will continue to be, many changes that determine what refrigerant gases can be used for air-conditioning applications across the globe. These regulation changes drive the need to convert from one refrigerant product to another based on ozone depletion potential (ODP), and global warming potential (GWP). Most regulations can be broken down into Global (Montreal Protocol, Kigali Amendment), country level (EU F-Gas and the United States Federal rules) and sub-country (US States and other localities). Please visit www.forane.com for the latest updates and details on regulations.

Arkema believes that regulation of HFCs should be market-based, allow for innovation and be uniform at the country level (rather than implemented through a patchwork of state and local regulations). However, there is no question that the worldwide transition beyond high GWP HFCs is ongoing and will continue. In the United States, Arkema is actively supporting this transition, and we believe R-32 is currently the best lower GWP product to replace R-410A in HVAC applications.



R-32 A2L FLAMMABILITY (WHAT DOES IT MEAN)

R-32, as a stand alone refrigerant, is a lower toxicity and lower flammability refrigerant with an A2L classification per ASHRAE Standard 34 and ISO 817.

Unlike higher flammability class 3 refrigerants such as R-290 (propane) and R-600a (iso-butane), 2L refrigerants not only have lower HOC values upon combustion, but also result in slower burning flames (BV). 2L refrigerants have high MIE values making it difficult to ignite. High energy sparks generated from a hair dryer will ignite a class 3 refrigerant but not a 2L refrigerant. However, open flames would ignite 2L refrigerants, so it is important to work with 2L refrigerants with well-ventilated areas or outdoor environments to minimize risks.

The higher LFL of 2L refrigerants means higher concentration of refrigerants has to be accumulated to start an ignition with the presence of an ignition source. Safety standards such as EN 378 have different levels of restrictions based on the refrigerant charge amount in a system. Below a certain charge amount, also known as M1 value, there is no room volume or location restrictions for system installation. This value is proportionate to the LFL value, and A2L refrigerants are allowed 50% more charge than A2 or A3 refrigerants, which allows broader usage. For example, R-32's m1 value is 1.8 kg compared to R-290's 0.15 kg.

Table 1. Flammability Properties of Refrigerants

REFRIGERANTS	R-32	R-454B	R-1234yf	R-290	R-600a
ASHRAE CLASSIFICATION	A2L	A2L	A2L	A3L	A3
BV (cm/s)	6.7	5.2	1.5	46	41
MIE (mJ)	29	100 - 300	780	0.35	0.62
HOC (Mj/kg)	9.5	10.3	10.7	46.3	45.6
LFL (v/v%)	14.4	11.8	6.1	2.1	1.8

BV = Burning Velocity, MIE = Min. Ignition Energy, HOC = Heat of Combustion, LFL = Lower Flammability Limit

R-32: THE R-410A REPLACEMENT PRODUCT

R-32, as a stand alone refrigerant, is the best low-GWP replacement for R-410A in new systems. R-32 has a GWP of just 677 compared to 1924 for R-410A. R-32 provides the best balance of lowering GWP, while providing the performance, efficiency, compatibility and cost manufacturers require.

Proven Track Record

R-32 is a trusted refrigerant that has been used commercially for many years. As 50% of R-410A, R-32 has already been used as a component in HVAC systems successfully, and reliably, by every major OEM across the globe. In addition, R-32 has been successfully used globally as a standalone product in HVAC systems. With an installation base of over 84 million air conditioners in over 70 countries, R-32 has a track record of performance that speaks for itself.

It has become the primary low-GWP product for HVAC systems in Japan, Australia, and India. It is also quickly becoming a widely used product in Europe and the United States. JARN (Japan Air Conditioning, Heating & Refrigeration News, Ltd.) reports that R-32 is now being utilized in over 25% of all residential air conditioners in Japan, and 50% of all window air conditioners in the United States. According to a recent report from BSRIA, R-32 will grow from its current 37% market share to over 80% of the total market for split air conditioning systems by 2023 in the EU.

Efficient and Cost Effective

Manufacturers designing R-32 systems across the globe have found that R-32 provides energy efficiency gains of up to 10% vs. R-410A, while reducing the overall charge size by up to 30%. Increased efficiencies allow manufacturers to potentially hit higher efficiency requirements without increasing equipment footprint. This provides OEM's with the benefit of reduced redesign time and cost. The increased efficiency and reduced charge size, also often allow air conditioning equipment size to be reduced while still providing the same levels of performance. Reduced equipment size can provide material cost savings, that combined with a reduced refrigerant volume, can provide substantial cost savings.

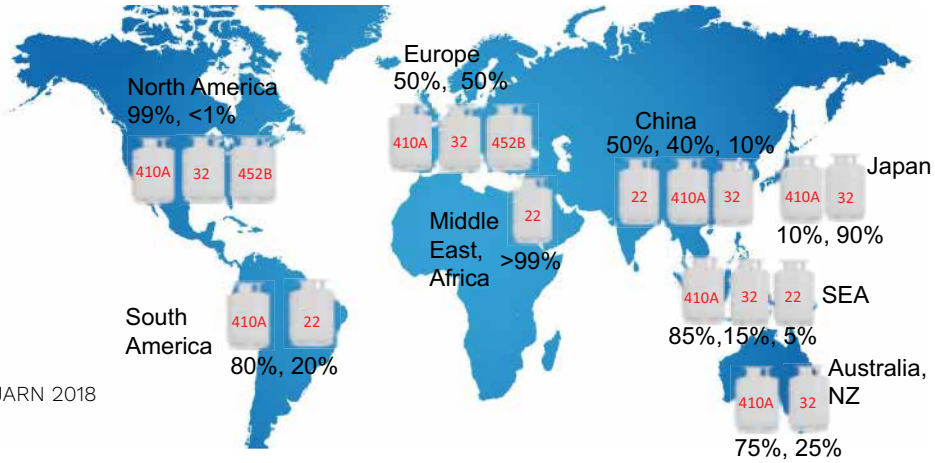
In addition, R-32 is not a patented product, is readily available, and is typically a fraction of the cost of patented products. Many of these patented products that are promoted as R-410A replacements also contain R-32 as the major component. Refrigerant manufacturers use R-32 as a major component in these blends because of its outstanding performance. R-32 as a standalone product offers equivalent, or better, performance compared to any blends, while being more readily available at typically a much lower price.

Table 2. R-32 vs. R-410A Simulated Performance Comparison

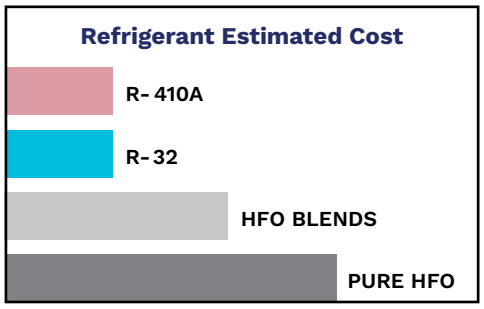
45°F EVAP 105°F CONDENSER	R-410	R-32	DIFFERENCE
DISCH P, PSI	405	414	(+)2%
CAPACITY BTU/LB	128	144	(+)10%
COP COMPRESSOR COPC	3.146	3.303	(-)5%
MASS FLOW RATE LB/HOUR	742	476	(-)36%
DISCH TEMP °F	178	214	(+)20%

Arkema: NIST Cycle D-HX Ver 1.45 45°F evaporator, 110°F condenser 10°F superheat/subcooling

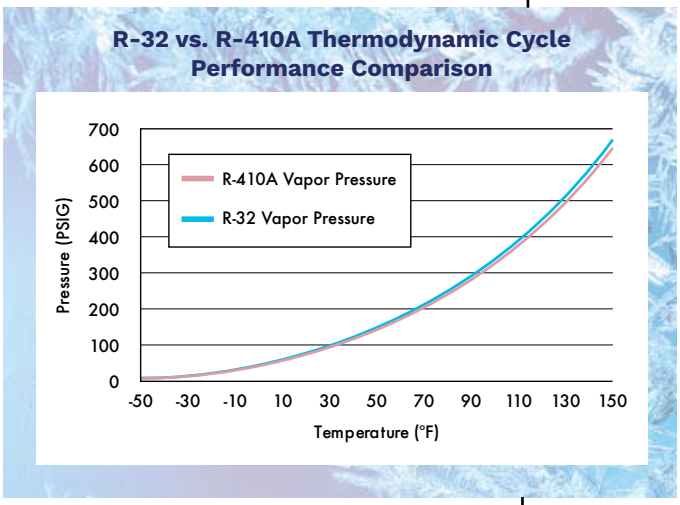
Global HVAC Refrigerants Usage



*Estimates from JARN 2018



Estimates are only relative, and pricing may vary depending on location, quantities, and delivery methods.



Single Component Simplicity

R-32 is a single pure component refrigerant. As a pure product, this refrigerant has zero glide and does not fractionate as blended refrigerants do. No fractionation allows the product to be charged as a liquid or vapor, and systems can be easily topped off if some charge is removed during repair work. R-32 provides simplified charging, refrigerant recovery, and recycling than blended, multi-component products.

Component Compatibility

OEMs who are redesigning their existing R-410A product lines will find that R-32 provides the opportunity for them to retain much of their unit designs, by incorporating required R-32 specific components.If the system design is kept similar to the R-410A design, the system will typically have more capacity and higher efficiency than the R-410A design. However, OEMs also have the option to reduce the size of the system when using R-32, if similar capacities and efficiencies are desired, when compared to the current R-410A design. The pressure/temperature relationship for R-32 is very similar to R-410A.

The primary components that must be changed are the compressor, expansion device, and possibly pressure switches. Those items must be designed and/or approved specifically for R-32 use. These components are widely available through all the major component suppliers. Most compressor manufacturers have compressor models designed specifically for R-32, which are all capable of handling the slightly higher discharge pressures temperatures without requiring external design features. Liquid injection and other ways of handling high discharge temperatures are no longer required with compressor designs that have been introduced by all major compressor producers. These new compressors are typically the same physical size and capacity ratings of their equivalent R-410A designs.

To ensure proper oil return, R-32 is typically used with polyolester (POE) oil, although this may be a slightly different POE oil than used with R-410A. Manufacturers typically provide compressors already charged with the appropriate lubricant. The specific compressor manufacturer chosen should be consulted regarding the specific recommended lubricant for use with their compressor design.

As with R-410A lubricants today, care must be taken when handling POE lubricants because they are hygroscopic, which means that they can readily absorb moisture from the air. This is especially a concern when handling POEs in humid environments. High levels of moisture in the system can lead to oil degradation and system failure. Piping, valves, heat exchangers, and other components used for R-410A are typically compatible with R-32. Elastomers used in R-410A components for seals, o-rings, etc. should all be compatible with R-32, as they're currently exposed to the product as 50% of the R-410A blend. Component suppliers should always be consulted to confirm compatibility and suitability for each unique system design.

While R-32 can be incorporated into system designs by OEMs using R-32 specific components, retrofits of existing systems should never be attempted. Retrofitting any systems in the field with R-32 could potentially be extremely dangerous and lead to poor performance and voiding of any warranties.

R-32 HANDLING PRACTICES

R-32 is handled in essentially the same way as R-410A, with the exception of being mildly flammable. Local and national electrical, fire, and building codes should be reviewed to verify all regulations are followed. Those codes and regulations may vary from location to location, so they must be reviewed on a case-by-case basis.

Bulk deliveries and storage will be very similar to R-410A. R-32 can be transported in bulk trailers, ISO containers, and railcars. Some locations may be required to have tank and pumping systems designed specifically for mildly flammable refrigerants. Those systems may contain special provisions in codes and regulations related to fire and electrical systems. Otherwise, most components will be common between R-410A and R-32. The storage location should be in a location away from any ignition, spark producing, or other types of heat sources. The storage area should be well ventilated to prevent the accumulation of refrigerant vapor.

In addition to bulk, R-32 is available in smaller volume cylinders. Cylinder styles are very similar to current R-410A cylinders. However, some design differences exist. Cylinder valves all have left handed thread CGA outlets. DOT-39 non-refillable cylinders for R-32 utilize a pressure relief valve in place of the rupture disc. All R-32 cylinders must be shipped in the upright position (with the relief valve in the vapor space) and must have a red band around the shoulder of the cylinder.

Charging and recovery equipment would also be very similar to R-410A. However, the refrigerant recovery machine for R-32 must be rated to handle mildly flammable 2L refrigerants. Codes and regulations may vary from location to location, so they must be reviewed on a case-by-case basis. The location of this equipment should be in a location away from any ignition, spark producing, or other types of heat sources. The area should be well ventilated to prevent the accumulation of refrigerant vapor.

R-32 PROPERTIES

Difluoromethane (CH_2F_2)

General Description

Forane® 32 has a unique balance of cost, performance, low GWP, and availability, making it a growing choice for HVAC. Forane® 32 (HFC-32 or R-32) is one of the next generation low GWP (677) solutions being implemented globally. R-32 is a refrigerant gas for air conditioning, with high capacity and zero glide, and electronics. Forane® 32 is growing in consensus as the choice for new air conditioning units, designed for mildly flammable refrigerants as a replacement for R-410A (GWP 1924).

Specifications

(Meets AHRI 700-2019 Specifications)

	Maximum (unless otherwise noted)
DIFLUOROMETHANE (R-32), WT %	99.5 (min.)
AIR AND OTHER NON-CONDENSABLE GASES, VOL %	1.5
VOLATILE IMPURITIES, WT %	0.5
HIGH BOILING RESIDUE, VOL %	0.01
MOISTURE (H_2O), PPM BY WT	10
ACIDITY, PPM BY WT (AS HCL)	1.0
CHLORIDE, NO VISIBLE TURBIDITY (INDICATES ABOUT 3 PPM)	Pass
PARTICULATES/SOLIDS (VISUALLY CLEAN TO PASS)	Pass

Properties

APPEARANCE	Clear, colorless, liquid and vapor
ODOR	Faint, either-like odor
MOLECULAR MASS (G/MOLE OF BLEND)	52.02
BOILING POINT AT 1 ATM	-61.1°F / -51.7°C
FLAMMABLE LIMITS (LFL, UFL), VOL % (1 ATM, 25°C)	14.4% / 31.0%
ANSI/ASHRAE STANDARD 34 SAFETY GROUP CLASSIFICATION	A2L
OZONE DEPLETION POTENTIAL (ODP) (CFC-11 = 1.0)	0.000
GLOBAL WARMING POTENTIAL (GWP[1]) (CO_2 = 1.0)	677

(1) GWP according to IPCC AR5. Values for 100-year time horizon

Temperature

	50°F	70°F	105°F	115°F	130°F
VAPOR PRESSURE, PSIA[2]	160.5	220.5	364.3	416.1	504.2
LIQUID DENSITY, LB./FT^3 [2]	63.6	61.0	55.6	53.6	50.7

(2) Generated using NIST REFPROP Version 10.0

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