

PROFILE OF AUTOFROST® REFRIGERANTS

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ABSTRACT

Autofrost refers to a family of zeotropic refrigerants marketed by Monroe Airtech, Bloomington, IN, and their subdistributors. Autofrost-X3 (R-406A), Autofrost-X4 (pending ASHRAE Standards 34 committee as R-414A), GHG-X5, and GHG-HP refrigerant will be discussed. Used refrigerant return/reclaim policies along with warranties and availability of product will be discussed along with performance.

INTRODUCTION

Autofrost refrigerants are designed as high performance direct replacements for CFC-12 and R-500, and with some retrofit effort (removing PAG oil) for poorly performing R-134a systems. All Autofrost refrigerants require no oil changes as they operate well in mineral oil (or alkylbenzene oil) found in CFC-12 systems. These refrigerants are all EPA SNAP acceptable for stationary applications and acceptable with use restrictions for the MVAC sector. Performance is equal to or often better than that of the original CFC-12 system. Autofrost-X3 (R-406A) was developed in 1990 and was first known as "GHG Refrigerant-12 Substitute"[1].

Reclaiming Policy

Monroe Air Tech, Inc. (master distributor for Autofrost refrigerants) will accept all used refrigerants (even if not Autofrost) from their refrigerant customers regardless of purity or flammability. Customer pays freight to Monroe. However, Monroe may have a local distributor available. Call 800-424-3836 for shipping instructions, paperwork, boxes and material. Monroe will test each cylinder for composition. Credit will be issued immediately toward purchase of virgin Autofrost. Credit will range from \$1.65 to \$7.00 per pound depending on percentages of components (i.e. pure R-12 is \$7.00 per pound). Cylinders will be purged with nitrogen and checked for certification. If needed, re-certification is available for \$20. Cylinders are returned within 10 days, freight prepaid. Reclaimers can now separate out mixed refrigerants, even blends of R-12/R-22.

The Authors' Views on Fittings/Recycling/Recovery/Reclaiming MVAC Refrigerant.

Since the public can legally buy R-134a (with no certification) or most any other refrigerant after passing the easy EPA 609 MVAC Technician test (open book test for \$10 - \$20, even available on the Internet), the current regulations of fittings, labels, etc, to "prevent contamination", are being thwarted and are not serving the purpose for which they were intended..

Some cars, including Ford Tauruses, some 92-93 Honda Accords and some 90-92 Toyota Celicas, have R-12 access ports that run along the top of the radiator or other areas with very little hood clearance. Adding on any retrofit fitting for R-134a or other refrigerant, results in not being able to close the hood. In general, the public (do-it-yourselfers "DIYers"), after having obtained (legally or illegally) refrigerants by whatever means, usually totally disregard EPA regulations on venting, fittings, and labeling for MVACs. "Permanently attached" fittings are often easily removed with a wrench or a little heat, and labels will often fall off or be removed on purpose. When the service fittings are beat-up, the retrofit fittings may fail to work or cause leaks.

Another issue with the "Permanently Attached Fittings" part of the current EPA retrofit regulations is that a "restraint of trade" issue is involved. Assume, that John Citizen takes his car to Joe's Service Station for a gasoline fill-up, and unbeknownst to Mr. Citizen, Joe's Service Station "Permanently Attaches" a filler neck fitting to Mr. Citizen's car, such that it accepts only filler hoses from Joe's stations. Now Mr. Citizen MUST buy his gasoline at Joe's. This is restraint of trade. Mr. Citizen takes his car in for A/C work, and Joe's Garage does an EPA regulation retrofit to alternative refrigerant X (including permanently attached unique threaded fittings for refrigerant X). Mr. Citizen is not happy with the performance of refrigerant X or he needs service and has traveled to an area where refrigerant X is not available. Mr. Citizen becomes frustrated with refrigerant X's poor cooling, finds another shop and wants refrigerant Y installed for better performance. What is the second shop going to do with the permanently attached fittings for refrigerant X? What if he/she does not have adapters for them? "Leak of Convenience" (illegal venting)? In this predicament, changing to another refrigerant would incur major costs of subassembly, labor and possible condenser replacement; all because "permanently attached" fittings can not be removed. This raises the issue of "restraint of trade".

If the EPA had allowed the unique threaded fittings to be attached "non permanently", the restraint of trade issues and a large number of "Leaks of Convenience" would be eliminated. Unique fittings serve as a unique "label" to identify the alternative refrigerant. They will tend not to fall off as often as labels.

The air shop mechanic very often has to face the "unknown refrigerant" question in an incoming vehicle for A/C service. Given the nearly total disregard for EPA fittings and labeling regulations by DIYers, air shops still might want to purchase a basic refrigerant identifier. Current identifiers will not often accurately identify the current compositions of mixed refrigerants, and blends. Blend compositions in vapor space are different than in liquid space and the result is very temperature dependent. Leaking (fractionation) further complicates the issue. It is difficult to properly identify these compositions even with expensive equipment (Gas Chromatographs) and trained operators. All the identifier really needs to do is to tell you whether you have pure R-12, R-134a or something else. Easy enough, even for the basic identifiers.

Pure R-12 can then be recovered and be sent to a reclaimer or recycled on site. Anything else can be recovered into a “mixed refrigerants” cylinder and sent to a reclaimer. R-134a is so cheap now, that on site recycling makes little economic sense. The authors strongly feel that any refrigerant should not be recycled on site, but instead be recovered and sold to a reclaimer. When one gets an oil change, the shop does NOT NEED DIFFERENT recovery machines for each type of oil. It is not necessary to “recycle” it on site and reintroduce it into cars at oil change time. Instead, all the oil can be collected in one bucket and sent off for rerefining (reclaiming). In many cases, it doesn’t even make economic sense to purchase a refrigerant identifier. Just recover ALL refrigerants into a single cylinder and return to a reclaimer for separation and cleaning. Considering that most cars come in “empty” or with at most ½ the charge; it takes a lot of recovered R-12 to pay for a refrigerant identifier.

Visits to twelve air shops in 1993/4 showed that all of them had “wet” dry eyes (moisture indicators) on their recycling equipment. When technicians were asked about the last time they changed their dryers; most of them, surprised, exclaimed: “WHAT DRYERS?”. The authors feel that the current MVAC recycling program causes extensive damage and venting of CFC-12 due to moisture and acids being passed from customer to customer. Moisture laden refrigerant (except for 100% hydrocarbon blends) slowly hydrolyzes to form acids (hydrochloric and hydrofluoric) and “sludges” (aluminum chloride and fluoride). The acids corrode the insides of the system, often causing leaks, thus venting the charges and the sludges plug up expansion devices, compressors, or dryers/accumulators, and results in system failure. The damaging effects of “wet” refrigerant often take a few months to surface, so blame is often wrongly directed toward the car maker instead of the mechanic/air shop. POE (ester) and PAG oils are extremely hygroscopic and absorb large amounts of moisture when the system is “open” for service. Wet refrigerant generates lots of repeat business the following season. “Wet” PAG oils often turn bright orange. Unless a complete flush (including compressor) and dryer change is done, after PAG oil is wet (system open for days or weeks), the wet oil will begin the acid destruction problems again at the completion of service to be repeated ad infinitum. The extreme moisture sensitivity of PAG and POE oils compared to mineral oil make R-134a failures of this type occur more often. Mineral oil is fairly resistant to absorbing moisture when in open containers or systems. A dryer change followed by a good vacuum would result in a stable R-12 system for many years.

These problems are solved in a large part, by using the recover/reclaim route for *ALL REFRIGERANTS*. The equipment outlay for the air shop is minimal, with only a single “recover only” machine, at less than \$1000, compared to many thousands of dollars for multiple recycling machines and the hassles of maintaining them. Reclaimers have the proper equipment to know when refrigerant purity has been achieved and they operate under ARI-700 [2] specifications for moisture, acids, and a number of other contaminants. Reclaimed refrigerant is often more pure than virgin refrigerant. Much reclaimed refrigerant just “disappears” into the feed streams of new (virgin) refrigerants (after first being cleaned and moisture removed) at below contaminate specifications (1/2%).

The problems of mixed refrigerants[3] and “contamination” have been blown way out of proportion by some segments of the industry. The main concern is keeping chlorinated refrigerants (CFCs, HCFCs) out of systems with PAG oil (R-134a new or some retrofits) as most PAG oils are broken down by these refrigerants. One PAG oil, DAPHNE, has literature stating resistance to chlorinated refrigerants, but one often does not know which brand of PAG oil a car contains before service. Running 100% R-134a in mineral oil in an R-12 system, as has been the case for DIYers, usually results in compressor failure after a few days since R-134a will not return the mineral oil to the compressor. Outside of these cases, mixing refrigerants (in R-12 mineral oil systems) often works acceptably. As long as 5% to 10% R-12 remains, R-12 mineral oil systems can be “topped off” with R-134a (illegally by DIYers) and they offer reasonable performance. The real enemy of system longevity is moisture.

Performance

All Autofrost refrigerants are zeotropic, and have “glides” in the order of 15° F. This increases the phase change area in the condenser compared to single component refrigerants. The increased phased change area enables the condenser to reject more heat and therefore better cooling capacities are provided. Duct temperatures 3° F to 8° F colder than R-12 are common. R-406A/Autofrost-X3 typically performs 8° F to 12° F colder duct temperatures than R-134a and 12° F to about 15° F colder than R-134a based blends.

R-134a and especially the R-134a based blends operate with evaporator pressures too low in R-12 systems. This necessitates changing the low pressure cutout switch from 24 PSIG to 14 PSIG (R-134a blends) and about 20 PSIG (R-134a). Even with the low pressure cutout changed, the R-134a based blends will still get “cold” given enough time, but capacity is reduced due to lower mass flows. If the low pressure cutoff switch is not changed, R-134a based blends will constantly cycle the clutch during normal operation, with greatly increased clutch failure rates. For variable displacement type compressors (GM V5), the suction pressure is set at 28 PSIG, and cannot be easily changed. These systems will have greatly reduced capacity with R-134a and even worse performance with R-134a based blends.

The authors have encountered numerous R-134a systems, both new and retrofitted that have performed poorly[4]. Others have performed well. Several technicians have “reverse-retrofitted” some of these systems to Autofrost refrigerants with excellent results. The hardest task is to remove ALL of the PAG oil if installed in the system. Autofrost contains HCFCs which destroy most PAG oils. The system must be disassembled and flushed, with the compressor put on the bench and turned over 40 or 50 times while dribbling mineral oil into the intake. Experience has shown that the standard 525 SUS mineral oil used in R-12 systems has sometimes been too thick for the tighter tolerances of new R-134a compressors, causing near immediate failure. However, a thinner mineral oil, such as Ford part #YN9, has been found to work well in all systems. R-134a systems with POE oil, should have some of the oil drained if easily accessible, with the drained oil replaced with mineral oil as above.

Autofrost refrigerants

Blend compositions in weight percentages								
Refrigerant	R22	R142b	R124	R227ea	R600a	GWP	ODP	Comments
GHG-X3 Autofrost-X3	55	41			04	1560	.055	R406A – best thermodynamics, least cost
GHG-X4 Autofrost-X4	51	16.5	28.5		04	1200	.045	(Pending as R414A) – UL “practically nonflammable”
GHG-HP	65	31			04	1530	.053	Extreme performance for hot, humid climates requires “defrost” timer to prevent evap freezeups. 25° F duct temps.
GHG-X5	41	15		40	04	2045	.0304	High molecular weight, useful for centrifugal chillers
R-12	-	-	-	-	-	8100	.9	CFC-12 for comparison
R-134a	-	-	-	-	-	1300	0.0	HFC-134a for comparison

GWPs are 100 year based on mass fractions of blend components calculated on data from [5]. ODPs are the “semi-empirical” method based on mass fractions of blend components calculated on data from [6].

Autofrost-X4 offers nearly the same performance as Autofrost-X3, and it carries an UnderWriters Labs (UL) classification of “Practically Nonflammable” (same as R-22). Autofrost-X4 is also marketed as “Chillit” by McMullen Oil products of Clearwater, FL. GHG-HP is basically R-406A with 10% more R-22. HP *requires* a working high pressure cutoff switch since it runs higher pressures. Some systems (especially variable displacement compressors, continuous run) may need a “defrost timer” to be installed. This simple device installs in series with the compressor clutch circuit, and turns off the compressor for 15 seconds every 4 or 5 minutes to allow ice to clear from the evaporator. GHG-HP has demonstrated 25° F duct temperatures (MAX RECIRCULATE) in 100° F humid ambients, such as south Florida and Texas. GHG-X5 offers similar performance to Autofrost-X4 in reciprocating compressors. Due to its high molecular weight, GHG-X5 offers better performance in Centrifugal Chillers.

R-406A is comprised only of “old” molecules, ones that have been in use for decades, with toxicity characteristics well established. Some “new” molecules may be more likely to turn up surprises in the toxicity area. A recent article in the British medical journal, *The Lancet*, has reported cases of liver damage (symptoms of acute hepatitis) in nine human workers after exposure to mixtures of R-123 and R-124 [7]. The authors of [7] raise concerns on the toxicity of R-123/R-124 in human beings and urge urgent development of safer alternatives. Many current R-12 substitute blends on the market contain large amounts of R-124 (R-401A/B/C, R-409A, FRIGC® FR-12, R-414A (Autofrost-X4), R-414B (Hotshot), etc). R-406A (Autofrost-X3) contains no R-124.

Availability, Warranties, and Compatibility

Autofrost (R-406A) is available nationwide through National Refrigerants (United Refrigeration) and through wholesalers such as United Suppliers of America and ATC Specialists. Call Monroe Air Tech at 800-424-3836 for availability information. Monroe Air Tech warrants Autofrost to offer better performance than R-12 and R-134a refrigerant as well as warranting compressors against failures caused by the refrigerant.

In general, almost all O-rings and compressor shaft seals work well with Autofrost refrigerants. Buna-N, and HNBR (light green) seals and O-rings should be avoided. Neoprene is the most preferred material (blue O-rings). HNBR has only appeared in recent times though.

Conclusion

The family of Autofrost refrigerants provides suitable direct replacements for CFC-12 (and R-500) over a wide variety of applications and conditions without having to add or change out lubricants.

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