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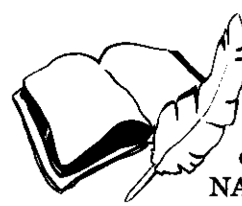
SUMMER 1997

NACAT NEWS

North American Council of Automotive Teachers

From your President:

Good news for NACAT members

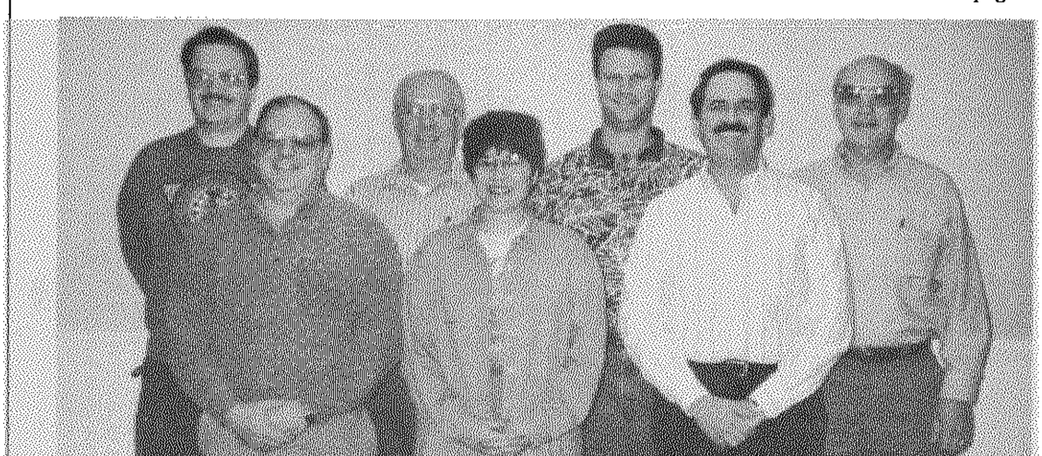


Good things are happening to and for NACAT members. This past winter, NACAT's board, officers, and business manager have been very successful in finding and negotiating new and valuable member benefits. As a result of hard work, and many kind donations of money and effort, NACAT and its membership are coming-up as winners.

The International Mobile Air-Conditioning Association (IMACA) has arranged through NACAT's head office for all NACAT members to receive a free IMACA associate membership. Most of us are well aware of the good work that IMACA has done for the mobile air-conditioning industry. Also, we are aware of their excellent conferences, shows, and publications. I look forward to this new partnership and the benefits our membership shall gain. For more information on this new benefit, please read Al Goodyear's article in this issue of the NACAT News. Thank you very much IMACA.

Thanks to the efforts of Tim Waters and Bumper to Bumper, our members can expect to see more increased value in their NACAT membership. According to Tim, a discount card will soon be issued to all NACAT members in the US and Canada. It will allow members substantial discounts off of their institutional prices for all purchases at Bumper to Bumper parts stores. Through Tim's and Bumper to Bumper's efforts, a Technical phone service for Canadian NACAT members, (similar to the one already available to American Members) will soon be available. Also, Bumper to Bumper is working with NACAT on several other projects that will greatly benefit both organizations. Special thanks to you, Tim, and also to Bumper to Bumper.

Continued on page 2



NACAT BOARD MEMBERS Back row left to right: Randy Paul, Bill Mason, Tim Waters, Henry Barber **Front row left to right:** Bob Thompson, Jessica Levy, John Carleo

Editors Note: I have known George Goble, holder of US patent 5,151,207 and inventor of R-406A / Autofrost, R-414A / Chill-it / GHG-X4, and GHG-HP, prior to his perfecting and patenting R-406A. I was involved (in a minor way) with some aspects of both the early experimental tests and the continuing long term testing. Presently, I have R-406A in all of my personal vehicles as well as a number of experimental cars here at the lab. I can say with confidence, that R-406A as well as some of George's other refrigerant blends perform as promised. In my experience, each vehicle retrofitted with R406A has improved cooling and perhaps some small energy efficiency improvement.

An Alternative to Retrofitting to R-134a

by George Goble

Back in 1990, the demise of CFC-12 was set for the end of the decade. As we all know, the CFC-12 cutoff date was moved up to Jan. 1, 1996 and that has come and gone. During the first part of the decade, frantic efforts were begun to deal with the upcoming phase outs of CFCs, which included CFC-12 (R-12, R-11, etc). Both the stationary refrigeration and automotive air conditioning industries began the move to HFC refrigerants, or mor ecifically R-134a for R-12 replacement.

Several problems quickly became evident:

1) R-134a is not miscible (dissolves in) the mineral oils used in R-12 systems.
2) R-134a has a higher boiling point of -14.9F versus -21.6F for R-12 at atmospheric pressure
3) R-134a has a lower critical temperature of 213.9F versus 233.2F for R-12.

R-134a oil issues

Since R-134a is not miscible in mineral oils used in R-12 systems, the industry struggled to develop new oils that were miscible in R-134a. In any refrigeration system, a portion of the compressor lubricating oil is circulated with the refrigerant through the system. The pressure and temperature of the oil/refrigerant mixture affect the quantity of oil which will remain in suspension. The cooler lower pressures in the evaporator tend to allow the oil to "condense out." In order for oil to return to the compressor from the evaporator, it must be able to dissolve in the refrigerant being used.

PolyAlkylene Glycol (PAG) oils were developed that were miscible with R-134a at evaporator temperatures. Unfortunately, PAG oils are extremely sensitive to moisture and chlorides (left over from residual CFC-12 in the system and aluminum chloride coatings from the insides of pipes in R-12 systems). PAG oils are in the order of 100 times more sensitive to moisture than are mineral oils. When A/C systems are opened for servicing or have totally lost their charge due to a puncture or broken hose, moisture gets in and contaminates the oil. This causes further damage after servicing, since moisture laden PAG oils are almost impossible to get dry again.

Residual chlorides, from remaining traces of R-12 (or R-11 flush) and chloride coatings (not possible to flush out) inside pipes from previous R-12, are very damaging to most PAG oils. Some of the newest PAG oils are much more tolerant of chlorides and even claim to be able to operated with 100% R-12 charges. When servicing a system, often one does not know what kind of oil it contains. Using R-11 to flush before a retrofit to R-134a and PAG oils was shown in 1991 tests to cause catastrophic compressor failures due to PAG oil breakdown after a week of runtime. R-12 and chloride coatings attack the PAG oils slower than R-11, but nevertheless, after several months the breakdowns often occur. For the moisture and chloride problems, the stationary refrigeration industry abandoned the use of PAG oils for retrofits and new systems in the early 1990s.

The stationary refrigeration industry has gone to Polyol Ester (POE) based oils to run with R-134a and other HFC refrigerants. Some automotive retrofits are also specifying POE based oils as well. POE oils are very expensive and may have chemical stability problems. Steel can cause POE oils to breakdown into their original components of fatty acids and alcohols under high temperature conditions. "Passivators" and other additive packages have to be developed and added to POE oils to inhibit their breakdown. POE oils, in general, do not provide as good lubrication as do the PAG and mineral oils, especially in boundry (sliding surfaces) conditions.Unlike mineral oils, most POE oils do not foam when agitated in compressor crankcases. Some automotive compressor designs rely on foaming oil to reach critical internal parts for needed lubrication. These compressors will probably fail with nonfoaming POE oils.

R-134a boiling point difference

Due to a different boiling point, R-134a will boil 3 or 4 degrees warmer in A/C systems designed for R-12 unless modifications are made to change the evaporator pressures. For systems with a variable displacement compressor, such as the GM V5, it is almost impossible to change evaporator pressures. These compressors are designed to maintain 28 PSIG on the evaporator (R12 systems) and when retrofitted to R-134a will still maintain 28 PSIG. As a result, dash outlet temperatures will be 3 or 4 degrees F warmer than R-12 systems.

R-134a Lower Critical Temperature Problems

The critical temperature of a gas is the temperature at which a gas will not condense to a liquid, no matter how much pressure is put upon it. The critical temperature of R-12 is 233F while R-134a's critical temperature is 213.9F. As condenser temperatures approach the critical temperature of the refrigerant, the head pressures soars. Temperatures of up to 220F are often found in the condenser/radiator area. With normal R-12 sized condensers and air flows, R-134a will offer terrible cooling performance and produce very high head pressures under hot low air flow conditions such as gridlock idle. To get R-134a to produce R-12 temperatures, a much larger condenser or different design and/or much more air flow is needed.

Development of R-406A refrigerant

In August 1990, I invented a blended refrigerant which eventually became known as R-406A. It consists of R-22, R-142b, and a small amount of isobutane (4%). The small amount of isobutane enables the refrigerant to become miscible in the standard mineral oils. No oil change is needed for R-406A. Due to multiple boiling points, R-406A can move more heat than single component refrigerants such as R-12 and R-134a. R-406A often produces 6-10F colder duct temperatures in CCOT type systems and 3-4F colder duct temperatures in expansion valve systems. Single component refrigerants condense (the actual phase change from vapor to liquid) in a relatively small area in the condenser. The rest of the condenser is used to just cool down hot gas (desuperheating) and cooling down (subcooling) the already liquid refrigerant. The desuperheating and subcooling operations reject a small amount of heat compared to the phase change region of the condenser. On the other hand, R-406A has a large phase change region, thus causing it to reject far more heat with a given condenser. Some cars, with marginal radiator systems (plugged and dirty), have had radiator boil overs after R-406A was installed due to more heat being moved.

R-406A's critical temperature is 238.1F, much higher than R-134a (213.9F) and a little higher than R-12's (233.2F).

Other substitutes out on the market

There are now a number of "EPA acceptable" R-12 replacements out on the market. The EPA does not evaluate performance or steps needed (such as oil changes) needed for each particular substitute.

Years of testing have shown that in order to operate correctly with R-12 mineral oils at at least 3 or 4% of a hydrocarbon, such as isobutane is needed. I discovered that about 15% or more of R-142b is needed along with the isobutane to properly return mineral to the compressor in all systems. Once, I tested 5% isobutane in 95% R-134a in mineral oil, and it still did not return oil properly.

Many systems will still operate correctly with refrigerants with poor or non-existent oil return capabilities (e.g. R-134a in 100% mineral oil), provided their suction line runs downhill, or is short, or has enough gas velocity to forcibly "drag" the oil back. The trick is to know WHICH ONES will operate and which ones will fail. Often a system will operate for a month or two with poor oil return, until the compressor runs dry, and then it fails.

Hydrocarbons, such as isobutane and butane, along with R-12 have excellent miscibility in mineral oils. Due to flammability limitations, hydrocarbons must be kept below 4 or 5% of the total blend (weight %) in order for it to remain nonflammable. R-22 only has "mediocre" miscibility in mineral oil with R-142b being only slightly better. Sometimes, they will carry oil in

Continued on page 14

continued from page 14

some systems, sometimes not. Early R-22 stationary systems had numerous failures from poor mineral oil return, until the suction lines were downsized to increase gas velocity to "drag" the oil back. R-12 systems may not have "downsized" suction lines. R-124 has almost no miscibility in mineral oils, while R-134a has ZERO mineral oil miscibility. Changing some or all of the compressor oil to alkylbenzene (AB) will cause it to have excellent miscibility in R-22, R-142b, R-124, and of course R-12 and the hydocarbons. AB oil is a highly refined form of mineral oil and may be mixed with it, unlike unstable POE or PAG oils.

Some Compositions listed on the US EPA web page (weight %)

http://www.epa.gov/ozone/title6/snap/macssubs.html

R406A/Autofrost-
X3HCFC-22 55% / HCFC-142b 41% /Isobutane 4%

R414A/Chill-it/Autofrost-
X4/GHG-X4HCFC-22 51% / HCFC-124 28.5% / HCFC-142b 16.5% / Isobutane 4%

GHG-HP-
HCFC-22 65% / HCFC-142b 31% /Isobutane 4%

FRIGC FR-12-
HFC-134a 59% / HCFC-124 39% /Butane 2%

FREE ZONE RB-276-
HFC-134a 79% / HCFC-142b 19% /lubricant 2%

Freeze 12-
HFC-134a 80% / HCFC-142b 20%

HOTSHOT/R-414B
HCFC-22 50% / HCFC-124 39% / HCFC-142b 9.5% / Isobutane 1.5%

I have seen all of the above refrigerants, at one time or another, as being claimed to not need an oil change and to operate with no system changes. Sometimes, a given refrigerant is claimed to not needing oil changes by one sales group, and another group admits to having to add some POE oil, there is lots of false information out there. As you can see, only three refrigerants do a good job with mineral oil return: R-406A, R-414A, and GHG-HP.

Some refrigerant boiling points (degrees F)

R-22	-44
R-12	-21.6
R-134a	-15
R-124	+10
R-142b	+14.4

Some of the blends are just about 60 to 80% R-134a and are "cut" with even higher (warmer) boiling components such as R-124 and R-142b with no lower (colder) boiling components present to "balance" the pressure-temperature curve. R-134a is about 5F warmer than than R-12 before adding 20-40% of something which boils at +10 or +14.4F. The final refrigerant is about 10F warmer than R-12.

R-406A and R-414A use 55% and 51% R-22 to balance the pressure-temperature curve, and with the performance improvements from the glide, deliver colder air than R-12, especially in startup conditions. Another refrigerant, "GHG-HP," although not marketed yet, but EPA acceptable (with use conditions) can deliver duct temperatures of 25F on a 100F hot humid day. GHG-HP requires high pressure cutouts switches in good working order and a "defrost" timer if a variable displacement compressor is used to prevent evaporator freeze up.

R-406A is EPA SNAP acceptable (with use restrictions, such as unique threaded fittings and barrier hoses) for automotive use as well as for stationary and transport refrigerations (no special fittings/hoses needed for non-automotive use). R-406A is marketed under trade names as Autofrost and McCool-406A. For more information, contact Monroe Air Tech, 1-800-424-3836 or see the information on the World Wide Web at *http://worldserver.com/Autofrost*