R 410 A

Refrigerant of the Future for Air Conditioning

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The 20th century was an era of rapid technological progress that saw mankind overcome technical barriers that had hindered development for centuries. In the early decades we began to artificially cool our environment to allow more comfortable living and working conditions. Early cooling systems used a variety of refrigerants many of them flammable or explosive and so danger was an ever present reality. In the 1930's a whole new family of synthetic refrigerants emerged that have been applied in the majority of air conditioning and refrigeration systems since that time. Commonly called CFCs and HCFCs, these chemicals made refrigeration safe, reliable and economical.

Like numerous other 20th century inventions all the characteristics and long term implications of refrigerants containing chlorine were not well understood at the time of their invention. In the 1970's suspicions that the earth's ozone layer was being damaged began to emerge. By the mid-1980's there was little doubt that the suspicions were correct and the world as a whole needed to act to reduce ozone damage. The first international agreement to limit CFC usage, the Montreal Protocol, was signed in 1989 and its provisions have provided industry direction since that time. Since 1989 the protocol has been revised several times and each revision has accelerated the phase out of ozone damaging chemicals. Initial industry efforts focused on finding replacements for CFC11, CFC12 and CFC502 since their Ozone Depletion Potential (ODP) was high. These refrigerants were commonly used in domestic and commercial refrigeration and by now they have been effectively phased out. It soon became evident that although the common air-conditioning refrigerant HCFC22 had only 5% of the ODP of CFC12, its long term usage was not sustainable. Consumption of HCFC22 rose rapidly in the 1990's partially as a replacement for CFC and partially as a result of the boom in first time AC buyers in Asia.

Efforts to find a replacement for R22 were less successful than for the CFC refrigerants and different trends developed around the world. Candidate replacement refrigerants emerged at different times and adoption, sometimes forced by legislation, varied from region to region.

R134a was the earliest candidate to replace R22 but it never won wide acceptance in either the residential or commercial AC markets. R134a has many characteristics that are desirable in a refrigerant but its low pressure requires a larger compressor and a subsequent increase in system cost. Today R134a is the dominant refrigerant in automobile air conditioning where lower operating pressures are a real advantage.

About the Author

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In the mid 1990s R407C was proposed as an R22 replacement. The operating pressures and temperatures are fairly similar to R22 but it is a design challenge to match the system efficiency of R22. R407C won widespread adoption in Europe even if it was a less than ideal refrigerant. It offered '0' ODP, low Global Warming Potential and in many cases could be used in R22 systems with a minimum of redesign. Disadvantages included a large "glide", higher discharge pressures and slightly lower efficiency. Japanese manufacturers who are large suppliers to the European market embraced R407C and currently offer a wide R407C AC product range. In the local Japanese market R407C has gained minimum market acceptance and is being superceded by R410A.

The US and European markets reacted differently to the Montreal Protocol. The US will comply with the requirements of the Montreal Protocol and phase out of R22 will be complete in 2020. In Europe R22 has already been consigned to history. The refrigerant transition in the US has been clearer for some time. R407C never gained acceptance and R410A has been accepted as the air conditioning refrigerant of the future. The first R410A units were launched in the US in 1996 and today R410A is used in about 20% of new units. By 2010 this percentage will be close to 100%. After using R407C for the past few years the European market is also moving to R410A.

As the transition to HFC refrigerants progressed the environmental considerations in refrigerant choice shifted from Ozone Depletion to Global Warming Potential. Air conditioning contributes to global warming directly and indirectly. Direct global warming results from release of refrigerant to the atmosphere and its behaviour before it decays. Indirect global warming depends on the efficiency of the air-conditioning unit. Over the life of the normal AC unit, CO_2 emissions from power plants used to generate the electricity to power the unit will far outweigh the impact of release of the refrigerant. Worldwide concern about global warming is acknowledged by the Kyoto Protocol which has recently been ratified. The Kyoto Protocol challenges all countries to limit emissions by improving energy efficiency.

With this background in mind we can see that two major trends are happening at the same time: ozone depleting refrigerants are being replaced and system efficiency is being improved. System efficiency improvements to some extent are being driven by the demands of the market but regulations are driving the improvement like never before. In 2006 the USA will raise the minimum acceptable efficiency for AC units by 30%. China is in the process of introducing an energy efficiency labeling system that will put its most efficient units on a par with the best in the world. The Japanese government raised the minimum AC efficiency levels in 2005 and new European regulations are expected in 2006.

With the two simultaneous trends AC manufacturers have obviously sought to satisfy both at the same time and it is now clear that R410A is the refrigerant of choice around the world. R410A has both advantages and disadvantages but when compared with the alternatives of R134a and R407C the advantages of R410A make it attractive.

R410 Advantages

- R410A is a near azeotrope – the glide is less than 0.2°K - so evaporation temperature changes little at constant suction pressure.
- R410A allows the use of smaller displacement compressor to achieve the same capacity. This could result in some cost savings for compressor manufacturers but this advantage may be offset by higher operating pressures.
- R410A runs slightly cooler than R22 so there is some potential to increase the operating range of the system.
- Heat transfer in R410A heat exchangers is better.

R410A Disadvantages

- The obvious disadvantage of R410A is that it operates at much higher pressures. This has required a total redesign of systems and compressors to guarantee safety.
- Greater skill and attention to cleanliness is required during the installation of an R410A system to prevent moisture entering the system. R410a requires POE oil which is highly hygroscopic.
- The theoretical R410A compression cycle at normal air conditioning system conditions is lower than for R22 and this gets worse as condensing temperatures rise. However this disadvantage is offset by the better heat exchange and lower impact of pressure drops.

Conclusion

R410A is entering the mainstream at a time when energy regulations are forcing higher system efficiencies. The new refrigerant makes a contribution to this goal but advances in heat exchangers, compressors, fan motors and controls have made the major contribution.

The final word in this article is left to Mitsubishi Electric:

"Whilst R410a can provide some small advantages in efficiency, it is technology itself that is the largest contributor towards the steady increase in ever important COPs." ❖