Water Chiller Life Extension

Refrigerant Gas Conversion

Service Discussion Document

November 2005

Overview

Under the implementation of the Montreal Protocol and early application of legislation across the European Union, Refrigerant R22 (an HCFC) will be gradually phased out of service over the next few years. Although a final use date of 2015 has been agreed under the Protocol, it is likely use in service may be prohibited from 2009. This was the case with CFC's R12 and R502, which ceased to be legally used for service in 1995. Presently a review of the regulations is expected in 2008 so the final situation will only be known about one year before possible implementation. Presently R22 shall only be available as recycled product from 2009.

<u>A salutary tale - do you remember R12 & R502 ?</u>

It may be worthwhile noting that until just before 1995 it was expected R12 / R502 (CFCs) would remain useable whilst redundant and recovered stocks were used up. However, due to slow up take of the available replacement refrigerants the Government forced the issue by banning the charging of any R12 / R502 into any system after 1st January 1995. Whereas this meant R12 / R502 systems could still be used, it was simply impractical to continue use of <u>ANY</u> system that leaked or required the gas to be removed for any service reason.

At that time the available gases were either HFC replacement refrigerants, such as R134a (a single component gas to replace R12) & R404a (a blend of HFCs to replace R502), requiring a completely different lubricating oil. This presents a significant technical problem because the existing oil will be entrained around the entire system. The traditional Mineral based lubricants suffer oil transportation problems resultant from lack of miscibility with the newer HFC gases, hence a raft of blended gases, largely based upon R22, were offered by the refrigerant manufacturers. Numerous secondary problems also arose particularly when users attempted to replace CFC Mineral oil base systems with HFC gases requiring Polyolester base oils. The problems this caused the then users and service firms were simply legion and many important lessons were learnt in the worse possible way.

R22 has had a far longer technical development period to enable a long term solution to be developed. Firstly the reasons for not simply dumping this gas in favour of an HFC version must be considered.

1. Apparently the Ozone depleting effect of R22 on atmospheric ozone is far less than CFC's such as R12 & R502 (0.1 compared to R12 @ factor 1). I do not know where this 'Fact' came from.

2. R22 is a single molecule gas and not a compound or blend of several other simpler components. The means the relationship between pressure and temperature is fairly linear. No HFC refrigerant as a single component offering a generally similar performance to R22 has as yet been discovered.

3. The present design technology, particularly of compressors, has been optimised to R22 over the past three decades, in favour of the previously dominant, but less efficient CFC R12. R22 particularly lent itself to requirements of higher relative operating temperature but high specific energy movement demanded of air cooling systems. R502 was developed to provide similar heat rejection characteristics as R22 but a lower effective operating range.

4. Several blends of gases have been developed and the HFC refrigerant blend providing the closest performance match to R22 is widely accepted to be R407c, a blend of base gases R134a, R32 & R125. More recently R410a has also come to the fore, but this has a far higher effective operating pressure and this has limited it's usage to smaller systems such as split type air-conditioners.

5. All these gases are HFC family and all require a Polyolester based lubricant to allow proper system oil circulation to occur (it is technically almost

impossible to design an efficient compressor that does not cause oil to mix with the gas passing through the (hot !) compressor hence effective oil movement around the system is paramount, particularly through the colder regions).

6. As a result of the blend the actual pressure / temperature relationship is not strictly linear and the actual evaporation temperature is not a fixed point. Instead the components flash off (boil) at slightly varying temperatures for any given pressure. The term 'Glide' has been adopted to describe this effect. This results in a compromise between optimum operating efficiency and lowest safe operating superheat (of the lowest boiling component).

7. The heat transfer characteristics of R407c require a greater surface area for the same heat transfer available in the evaporator of an R22 system. This means attempting to upgrade an existing system is likely to have insufficient heat transfer causing the possibility of reduced superheat which is dangerous to the compressor, and results in a less efficient system (reduced duty).

8. Use of Polyolester oils causes leech out problems upon any rubber based seals around the system, this leads to the seals failing and leaking in service. However, this effect is a slow insidious problem and has led to many leaks occurring on otherwise properly operating equipment.

9. Polyolester oils have been found to have a tremendous cleaning effect on the interior surfaces of older systems and tend to loosen time bound contaminants and then shift them around the system, commonly to dump them at the compressor sump, which can have another deadly effect for the poor compressor.

10. Removal of the existing Mineral oil is far from straightforward and it should be noted a typical chiller may have up to 50% of the sump content spread around the remainder of the system as oil in transit. The only possible means of getting this out is by a series of oil changes over a period of time 'Diluting' the old mineral oil out. However, Polyolester oils are anything but cheap and using the expensive oil as a form of flushing agent does little to offer an economic procedure.

R22 Drop In Blend

Development of a drop in for R22, but with no CFC / HCFC gas has proved technically difficult. However, Rhodia (formerly Rhone Poulenc but recently acquired by Du Pont) have developed two blends that offer a reasonable solution. The essential qualities are …

1. Low glide at useable range.
2. Ability to retain original lubricant type.
3. Close performance match to R22.

The first product offered is Isceon 59 (now ASHRAE listed as R417a), however although this worked well in many applications, it was found to be less efficient in water chiller evaporators. Thus Rhodia have now developed Isceon 29 (ASHRAE R no. in application), which is a similar blend optimised for use upon water chiller applications.

The refrigerant is somewhat similar blend of to R407c, using similar base components, but with the significant addition of R600 (Isobutane) which provides the refrigerant gas blend with the essential miscibility required to maintain oil circulation with the traditional mineral based oils.

The above advice is based upon our close working knowledge of current refrigerant technology and available replacements for R22. Gas upgrades do not take account of individual system idiosyncrasies and it is possible certain systems may not respond as well or efficiently with replacement refrigerants. Advice we have given is passed on in good faith, but is not a guarantee of success of otherwise of any particular project.

Field feedback is always welcomed.

A specific Project Consideration is available separately (below)

Specific Project Consideration

Refrigerant Gas Conversion Project

Hitachi RCU240SY1 Chiller
City of London site

Project description

The chiller units concerned are four circuit water-cooled package water chillers currently operating upon R22, with four screw type compressors, 1 per circuit. All compressors are of the same model Hitachi 6002SC-H. The compressors are the largest capacity from the well proven SRM range by Hitachi, Japan. As common range most parts and service exchange units are readily available. Later variants are still in current new production.

The proposal below includes the recommended base procedure for conversion from R22 to Isceon 29 as suggested by Rhodia, with additional options suggested by ourselves to take account of the chiller age and present service set up.

Outline Procedure

1. Recover refrigerant charge and weigh removed gas and compare to plated weight. If less than 90% of expected weight is recovered then system leaks must be suspected and the attention to the leak test procedure (below) becomes essential.

2. Drain oil from compressor and renew with fresh oil of the appropriate grade.

3. Renew system driers (including provision of DCR type 2 core drier).

4. Renew any seals suspected as likely to leak, however it is not specifically necessary to renew seals perse. Hitachi specific: Strip down and refresh all seals on compressor terminal plate.

5. Once all system works are concluded the system should be pressure tested progressively to 12 bar with Oxygen Free Nitrogen, possibly with

the inclusion of Helium. Subject to suitable isolations the high side should be squeezed to 25 bar, but caution should be exercised that excessive pressure is not allowed to build up in the low side of older chillers, otherwise secondary (& possibly disastrous) leaks can be created.

6 Once the final pressure is achieved the system should be left for a 6 hour drop test during which time no appreciable pressure loss should occur.

7 Vent the Nitrogen pressure then evacuate the system to < 4 torr.

8 Charge the system to the condenser preferably in the liquid phase or by charging complete cylinders in the gas phase. DO NOT LIQUID CHARGE THE COMPRESSOR SUCTION.

The weight of Isceon 29 is 5% lighter per equivalent volume than R22, however if a drier is added then the system charge should be increased to account for the added liquid volume. We allow 26kg per circuit (this project).

9 Set system to work, ensuring a Refrigerant Comparator specifically scaled for Isceon 29 is used to verify suction superheat and liquid sub-cooling levels.

10 Effect final system leak check, and complete system operating log.

Other System Specific Considerations: Hitachi RCU240SY1 Chiller

a Renew TEVv power assy & internal orifice

b Install proper DCR type drier (included above)

c Effect compressor bearing overhaul

d Strip down & reseal compressor terminals

e Renew compressor contactors

The above items (a - d) require opening of the refrigeration system. By combining these operations within the scope of the conversion works considerable savings can be achieved by reducing aspects of a project that would otherwise be repetitive (system procedures). Item b is regarded as mandatory to comply with the Rhodia procedure.