CASE STUDIE – TECHNOLOGIES THAT AVOID OR REPLACE HCFCs

1. TITLE OF THE CASE STUDY

Application of Ammonia Based Azeotropic Blend in Commercial Refrigeration Systems

2. BACKGROUND ABOUT THE COMPANY

The ILK Dresden is an independent non-profit research company.

With its staff of 120, the ILK Dresden performs industry-related research, development and technology transfer in the wide range of air conditioning, ventilation, refrigeration and cryogenic technologies and their applications including related scientific and technical fields.

The ILK Dresden works as a commercial research & development company for all interested businesses and institutions of the related and applied branches as well as for the supplying industries.

The ILK Dresden has an experimental test area of 3000 m^2 with 60 experimental und test facilities as well as 25 scientific and technical laboratories.

3. PREVIOUS SYSTEM AND REFRIGERANT

An HCFC known as R-22 (chlorodifluoromethane) has been the refrigerant of choice for air-conditioning and residential heat pump systems for more than four decades. Unfortunately for the environment, releases of R-22, such as those from leaks, contribute to ozone depletion.

In addition, R-22 is a greenhouse gas and the synthesis of R-22 results in a by-product (R-23) that contributes significantly to global warming. As the manufacture of R-22 is phased out over the coming years as part of the agreement to end production of HCFCs, manufacturers of residential air conditioning systems are offering equipment that uses ozone-friendly refrigerants.

The application of the azeotropic blend ammonia with dimethyl ether is also an energy efficient alternative in comparison to pure ammonia. In some cases a substitution of cooling systems based of HCFC is possible with systems which works with the refrigerant blend schick®R723.

Institut für Luft- und Kältetechnik gemeinnützige Gesellschaft mbH · Bertolt-Brecht-Allee 20 · 01309 Dresden
Geschäftsführer: Dr. rer. nat. habil. Ralf Herzog · Prokurist: Prof. Dr.-Ing. Uwe Franzke · Amtsgericht Dresden HRB 6118
Telefon (0351) 4081-520 · Telefax (0351) 4081-525 · E-Mail: gf@ilkdresden.de · http://www.ilkdresden.de
Commerzbank Dresden · Kto. 8 000 135 · BLZ 850 400 00 · SWIFT: COBADEFF850 · IBAN DE34 8504 0000 0800 0135 00

4. NEW SYSTEM AND REFRIGERANT

The mixture of 60 weight% ammonia and 40 weight% dimethyl ether was designated schick®R723 after the molecular weight, in accordance with the refrigerant nomenclature for inorganic refrigerants.

In comparison to pure ammonia, the blend has a lot of advantages. With the schick®R723, lower discharge temperatures of approximately 15-25 degrees are possible. The solubility of the refrigerant in conventional oils is improved. An additional characteristic of the blend is the higher heat transfer in evaporator and condenser.
The COP value of the blend is higher than the pure ammonia. Because of the low GWP value and a zero ODP value the blend is an environmentally friendly natural refrigerant.

The azeotropic refrigerant can be used in small and medium size refrigeration systems as a working fluid in a similar way to R717.

If a low GWP and energy efficient refrigerant is necessary, may be in case of a substitution of an old established refrigerating plant, the application of the azeotropic blend is also an alternative to previously used refrigerating plants with HCFC as refrigerant.

5. EXPERIENCE SO FAR

The positive experience of the application of the schick®R723 is illustrating in the following examples:

1. A company in Austria is specialised in the production of organic meat and provides his products in Austria.
For ecological production the use of environmental friendly refrigerant for cooling processes is inalienable. Due to leakage in the old R22 chiller a new energy efficient chiller with a low GWP refrigerant was necessary. The refrigerant schick®R723 was the choice. The new cooling machine works with a quantity of 30 kg refrigerant. Polyethylene glycol is used as cooling brine. The refrigerating capacity is 115 kW in average and the main components of the system are two power controlled reciprocating piston compressors with air cooled condenser.

2. To reach lower temperatures down to -50 °C a cooling cascade is installed in a cooling plant for quick-frozen foods in the region Leipzig/Germany. In the special case, a CO_2 cycle is connected with a schick®R723 refrigerant cycle. The cooling plant works with air-cooled condenser and the cooling capacity is in average 2x45 KW.

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3. A cooling tunnel was installed in a big farm cooperative with more than 3000 employers. It's located in Spittal in Austria. About 76 million kilogram row milk are processed to yoghurt, cheese and other milk products per annum. The cooling plant works with schick®R723 refrigerant. The system was projected by an Austrian company and works with an amount of 2x47 Kg refrigerant. The cooling brine is propylene glycol. The main parts of the chiller are two power controlled reciprocation piston compressors with air cooled condensers. The refrigerating capacity is in maximum 230 KW.

6. ENERGY EFFICIENCY ADVANTAGE (IF ANY)

The azeotropic blend can be used in small and medium size refrigeration systems as a working fluid in the similar way to R717. But it is advisable to test the material compatibility of the elastomeric parts with the dimethyl ether before.

Because the adiabatic exponent of the refrigerant mixture is smaller due to the higher average molecular mass (23 g/mol for schickR723® in comparison of 17 g/mol for R717), a lower compression temperature can to be expected as well.

In practice the discharge temperature of the compressor can be reduced by about 15 to 25 K compared to pure ammonia, permitting the use of air-cooled condensers for example, instead of cylinder head cooling fans or water-cooled cylinder heads. Figure 6 shows experimental results of the discharge temperature on the compressor outlet in comparison to the use of pure ammonia (Lippold and Schenk, ILK, 1999).

In addition, the lower temperature on the high pressure side avoids the thermal loads for the materials and refrigerating machine oils. At the same time, there are decisive improvements in the oil solubility for mineral oils which can also be extended into the low temperature range, while preserving miscibility with synthetic oils. Uncomplicated oil recovery is thus possible so that separate oil recovery systems are not needed.
For various reasons most properties of the azeotropic refrigerant mixture are better than the properties of the pure ammonia.

The solubility for mineral oils is considerably improved and can be extended the area of very low temperatures. The blend can still be mixed with synthetic lubricants. A good recirculation of lubricant is therefore always easily achieved and there is no need for additional oil recirculation systems. Summarizing these three features, also from this point of view, it can be clearly seen, that schick®R723 has its preferred utilisation in commercial applications, especially in water chillers respectively in small and medium refrigeration systems.

The following table illustrate some selected properties of the refrigerant:

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Properties of schick®R723

ODP	0
GWP	8
Colour	colourless
Odour	characteristic pungent
Mol mass	23 kg/kmol
Boiling point	-36.6 ºC
Melting point	< -90 °C
Ignition temperature	440 ºC
Ignition energy	0.18 up to 0.28 mJ
Vapour pressure	(20 ºC) 9.22 bar (30 ºC) 12.42 bar (50 ºC) 21.27 bar
Critical pressure	110 bar
Critical temperature	131 °C
Lower explosion limit (in air)	6.0 Vol.-% up to 32.2 Vol.-%
Specific enthalpy	200 kJ/kg (liquid at 0°C) 1123.3 kJ/kg (gaseous at 0°C)
Specific volume	(-34 ºC) 1,428 dm³/kg liquid (0 ºC) 0,1977 m³/kg gaseous (4,735 bar)
Specific heat capacity	3657 J/kgK (liquid at 0°C) 1937 J/kgK (gaseous at 0°C)
Solubility in water (18 ºC)	Ammonia: 0.517 kg/l water Dimethyl ether: 0.070 kg/l water
pH-value in aqueous solution (17 g/l, 20 ºC)	11.6
Dynamic viscosity	0.166 mPas (liquid at 0 ºC and 4,908 bar) 9.3 E-3 mPas (gaseous at 0 ºC)
Surface tension	22.1 mN/m (at 0°C)
Thermal conductivity	392 mW/Km (liquid at 0°C) 20.0 mW/Km (gaseous at 0°C)

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7. CONTACT INFORMATION

Institut für Luft- und Kältetechnik gGmbH
Department of New Technologies
Bertolt-Brecht-Allee 20
01309 Dresden
Germany

Internet: www.ilkdresden.de

Dr.-Ing. Siegfried Römer
Head of the department
Email: siegfried.roemer@ilkdresden.de
Phone: +49 351-4081-750
Fax: +49 351-4081-755

Dr. Joachim Germanus
Head of the group analytics
Email: joachim.germanus@ilkdresden.de
Phone: +49 351-4081-777
Fax +49 351-4081-755

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