Environment global protection on the refrigerants polution

IOAN SÂRBU, OLGA BANCEA
Department of Building Services
"Politehnica" University of Timisoara
Piata Bisericii, no. 4A, 300233 Timisoara
ROMANIA
ioan.sarbu@ct.upt.ro, olga.bancea@ct.upt.ro

Abstract: In this paper are approached principal aspects of the environmental pollution, by working fluids of the refrigeration, air-conditioning and heat-pumping systems and a new utilization strategy of these refrigerants is described, in accordance with the international legislation. The refrigerants will be selected in order to be the best adapted for the desired application, based on few criteria which take into account the thermodynamic and thermophysical properties, the technological behavior, the cost and the use constraints.

Key-Words: working fluids, polution, environment protection, nonecological refrigerants, substitutes.

1 Introduction

The environment pollution represents a major risk for all that means life on our planet (men, flora, fauna), it consist not only in the local noxious effect of different pollutants but in the unbalances produced in a large scale on the whole planet.

The term "pollutant" appoints each solid, liquid or gaseous substance, microorganisms, sounds, vibrations, all kind or combination of radiations, that modifies the natural state of environment.

Environment protection represents the fundamental condition of the society's sustainable development, a priority purpose of national interest that is realized in institutional frame where the legal norms authoresses the development of activities with impact on environment and exert the control upon these.

The purpose of environment protection is to maintain the ecological balance, to maintain and improve the natural factors, to prevent and control pollution, the development of natural values, to assure better life and work condition for the present and future generations and it refers to all actions, means and measures undertaken for these purpose.

The atmosphere represents the surrounding air of earth, excluding the indoor air or the air in underground spaces. One of the minor components of atmosphere, the ozone has a special importance in maintaining the ecological balance. It is distributed in principal between the stratosphere (85…90%) and troposphere. Any perturbation of the atmospheric ozone concentration (it varies between 0 and 10 ppm, in function of the regions) has direct and immediately effect upon life.

The problems of forming and maintaining the earth ozone layer, represents a priority preoccupation of all states. In this context during the last 30 years, the European Union has adopted a great number of laws and regulations concerning environment protection, to correct the pollution effects, frequently by indirect directives, imposing allowable concentrations, asking for government collaboration, programs and projects for regulation of industrial activities and productions. The Alliance for Responsible Atmospheric Policy [11] maintains a brief summary of regulations for some countries.

2 Refrigerants action on the environment

Refrigerants are the working fluids in refrigeration, air-conditioning, and heat-pumping systems. They absorb heat from one area, such as an air-conditioned space, and reject it into another, such as outdoors, usually through evaporation and condensation, respectively. These phase changes occur both in absorption and mechanical vapor compression systems, but not in systems operating on a gas cycle using a fluid such as air. The environmental consequences of refrigerant leaks must also be considered.

Working fluids escaped through leakages from refrigeration equipments, during the normal operating (filling, empting) or accidental (damages), gathers in significant quantities in high levels of the atmosphere (stratosphere). There, through catalytically decompounding they deplete the ozone layer that normally is filtering the ultraviolet sun radiations, dangerous for living creatures and plants on earth. Supplementary, refrigerants contributed to the global warming of atmosphere, as gases with green house effect. Some very stabile substances used as refrigerants have a long period of atmospherically live.

Thus, the negative influences of refrigerants, especially of Freon's upon environment, can be synthesized by the two effects:

– depletion of the ozone layer;

– contribution to global warming at planetary level by the green house effect.

Therefore refrigerants will be select so that the ozone depletion potential (ODP) will be zero and with a reduced atmospheric global warming potential (GWP).

According to the polluting action upon environment, for atmospheric ozone view through the Montreal protocol (1987) and the further amendments, and for the green house effect according to the Kyoto protocol (1997), refrigerants can be classified as follows:

– with strong destructive action upon the ozone layer and with significant amplification of the green house effect upon earth (Chlorofluorocarbons-CFCs);

– with reduced action upon the ozone layer and with moderate amplification of the green house effect (Hydrochlorofluorocarbons-HCFCs);

– non harmless upon the ozone layer, with less influence on green house effect (Hydrofluorocarbons-HFCs);

– non harmless upon the ozone layer, with less influence on green house effect (ammonia-NH_3, carbon dioxide-CO_2, natural hydrocarbons)

The second influence of refrigerants upon the environment, preciously mentioned, guided to a new classification of refrigerants according to there contribution to the atmosphere warming. Comparison of this specific contribution to the green house effect is realized even for R-11 (the most noxious even from point of view of ozone layer depletion) as well as for CO_2.

Freon's placed on the undesirable position 3 (14%) between the gases with green house effect, could be explained by there great absorption capacity of infrared radiation.

In case of the refrigerating systems, supplementary with direct action to the green house effect, because of the refrigerants leakage in the atmosphere, it must be considered even the indirect action to global warming by the CO_2 quantity released in atmosphere during the transport of energy produced by the installation, obviously greater then the associated direct action. While the refrigerant quantity increases in the installation, the effect of direct action rises.

In Table 1 is presented the refrigerants effect upon the environment.

Table 1. Effect of refrigerants upon environment

Group	Fluid	ODP	GWP (basis R-11)	GWP (CO_2=1)	Atmospherically lifetime (years)
0	1	2	3	4	5
CFC	R-11	1	1	4000	50…60
	R-12	1	2.1…3.05	10600	102…130
	R-113	0.8…1.07	1.3	4200	90…110
	R-114	0.7…1	4.15	6900	130…220
	R-12B_1	3…13	-	1300	11…25
	R13-B_1	10…16	1.65	6900	65…110
HCFC	R-21	0.05	0.1	-	<10
	R-22	0.055	0.34	1900	11.8
	R-123	0.02	0.02	120	1.4…2
	R-142b	0.065	0.3…0.46	2000	19…22.4
HFC	R-23	0	6	14800	24.3
	R-32	0	0.14	580	6…7.3
	R-125	0	0.58…0.85	3200	32.6
	R-134a	0	0.28	1600	14…15.6
	R-143a	0	0.75…1.2	3900	55…64.2
	R-152a	0	0.03…0.04	140	1.5…8
Azeotropic blends	R500(R12/R152a)	0.63…0.75	2.2	6000	-
	R501(R12/R22)	0.53	1.7	4200	-
	R502(R22/R115)	0.3…0.34	4.01…5.1	5600	>100
	R507(R125/R143a)	0	0.68	3800	-
Cvasiazeotrope blends	R404A(0.44R125/0.52R143a/ 0.04R134a)	0	0.6…0.94	3750	-
	R410A(0.5R32/0.5R125)	0	0.5	1890	-
	FX40(0.1R32/0.45R125/ 0.45R143)	0	0.6	3350	-

0	1	2	3	4	5
Zeotropic blends	R407A(0.2R32/0.4R125/ 0.4 R134a)	0	0.14…0.45	1920	-
	R407B(0.1R32/R0.7R125/ 0.2R134a)	0	0.1…0.5	2560	-
	R407C(0.23R32/0.25R125/ 0.52R134a)	0	0.29…0.37	1610	-

3 Replacement of nonecological refrigerants

After the finding that CFCs, HCFCs and some other human-produced compounds deplete the ozone layer, most countries agreed to the Montreal protocol. This protocol is an international treaty, administered by the United Nations Environment Programme (UNEP) that controls consumption and production of ozone-depleting substances, including CFCs and HCFCs [9]. Hydrofluorocarbons (HFCs) do not deplete the ozone layer and have many of the desirable properties of CFCs and HCFCs. They are being widely adopted as substitute refrigerants for CFCs and HCFCs. However, HFCs are also associated with an environmental issue; they contribute to global warming if released into the atmosphere [10]. Countries, trade associations and companies are increasingly adopting regulations and voluntary programs to minimize these releases and, hence, minimize potential environmental effect while continuing to allow use of these refrigerants.

Consequently a new orientation appeared upon the utilization of working fluids. Thus, CFC refrigerants as R-11 and R-12 where substituted by simply compound refrigerants R-123 (HCFC) and R-134 (HFC) with a reduced even zero action upon the depletion of the ozone layer. This alternative is attractive because the substitutes have similar proprieties (temperature, pressure) with the replaced one, and the changes that took place directly on the existent installations will be realized with minimum of investments.

For other refrigerants it were not found simply compound fluids as for example for R-502 that could be replaced with a mixture of R-115 (CFC) and R-22 (HCFC) or in some cases only with R-22, that is a fluid for temporary replacement, conform with the international legislation.

By blending two or three pure Freon's we obtain new substances, better adaptable for desired cooling application. The first blends are named azeotropes while the others are named zeotropes. The use of blends could generate undesired aspects, especially by leakages of the working fluid, accidentally or during the installations filling.

Figure 1 presents the strategy concerning the refrigerants.

The substitutes for refrigerant R-22 could be R-134a, R-290, R-1270 and R-744, the HFC blends (R-407C, R-410A, R-417A, FX 90) and the ammonia (R-717).

None of these substances can efficiently substitute R-22, presenting a specific cooling power or a different saturation pressure, restricted application and specially demands in the installation design.

In new installations, for certain applications, R-143a is a good substitute, having a reduced delivering compressor pressure and temperature, but also an inferior specific cooling power being necessary a greater cylinder of the compressor.

The HFC zeotropic blends are considered substitutes for a short period. Between the natural fluids, the ammonia is the best substitute for R-22, having favorable thermodynamic proprieties, high heat transfer coefficient (3…4 times superior to R-22) and a performance coefficient similarly good for many applications, especially industrial one, with great cooling powers. It is cheap and ecological (ODP=0, GWP=0).

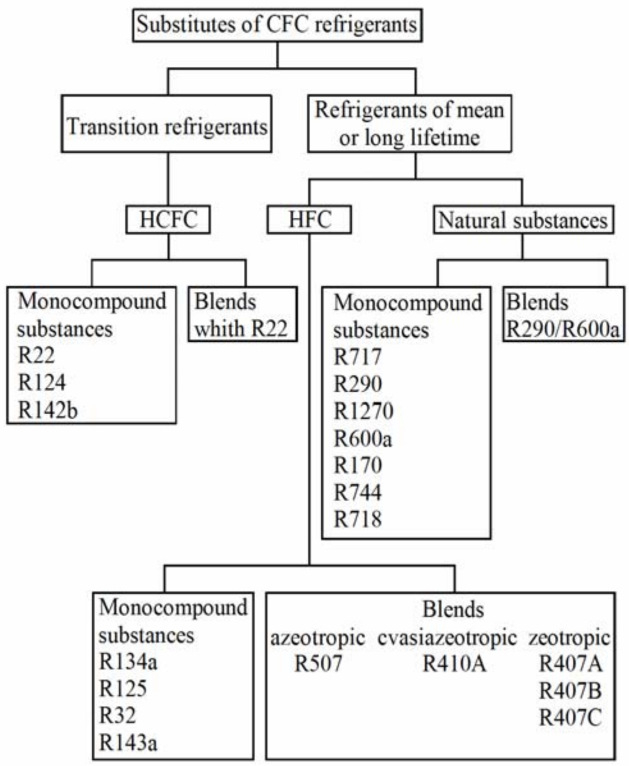

Fig. 1 Strategy concerning the refrigerants

Carbon dioxide (R-744) is a possible substitute for all refrigerants, being used even by low and high temperatures (cascade system, commercial cooling and air-conditioning). It is accessible, has a low cost and doesn't impact upon ozone, while his heating potential is negligible. His low critical temperature involves the use in supercritical cycles. The high saturation pressure and isotherm compression coefficient are considered as inconvenient.

4 Conclusions

Scientific research based on monocompound substances or mixtures, will lead to find adequate substitutes for cooling applications, that will be ecological (ODP = 0, reduced GWP), nonflammable and nonpoisonous, but also with favorable thermo-dynamic proprieties.

A possible solution is the use of inorganic refrigerants (NH_3, CO_2) and hydrocarbon refrigerants (propane, isobutene, ethylene, propylene) for industrial applications, in air-conditioning or food and household cooling. Because the hydrocarbon refrigerants presentes a high risk of flammability and explosion, this substances will not be often used as refrigerants comparative with CO_2 or NH_3. On other advantage of these two substances represents the fact that they were used for a long time as refrigerants.

The European Partnership for Energy and Environment considers the HFC refrigerants as the best alternative for the refrigerant CFC and HCFC in most of the applications. The HFC refrigerants allowes the use energetically efficient applications, offering significant benefits comparing with the existent alternatives. In average over 80% of the gases with green house effect used in cooling equipments have the indirect emissions as sources. The high energy efficiency resulted by the use of HFC refrigerants balances in a great measure the global warming potential.

The replacement of some refrigerants with other nonpolluting influences the operating conditions of the cooling installations, by a rapid degradation of components made from elastomers [1] or plastic materials [3], or it is necessary to replace mineral oils with some other oils adequate to the new refri-gerants. There are cases with more options for an alternative refrigerant and the problem is to choose the economical variant. Some problems of materials endurance and compatibility can be solved only during many testing, but the estimation of energetical performances and expenses that results by modi-fication of operational characteristics when replacing the refrigerant can be solved with numerical modeling.

It is imposed a new conception in execution the refrigerating systems: it must be realized very tight, with refrigerants having a reduced atmospheric warming potential, but as possible efficient energetically.

References:

[1] ASHRAE, *Fundamentals Handbook*, American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, 2005.

[2] Cavallini, A. and Steinle, F. Natural working fluids in a historic perspective, *Fluides actifs naturels*, *Conference de l'IIF*, Gustav Lorent-zen, Oslo, 1998, pp. 37-42.

[3] Cavestri, R.C. Compatibility of refrigerants and lubricants with engineering plastics, *Air-Condi-tioning and Refrigeration Technology Institute Report*, Arlington, 1993.

[4] Gheorghe, F. Înlocuirea agentului frigorific R22 în echipamentele de aer condiționat şi probleme asociate, *Instalatorul*, nr. 4, 2002, pp. 8-9.

[5] Hera D., Drughean, L. and Ivan, G. Confirmări şi incertitudini în strategia privind substituirea agenților frigorifici, *Conferința „Instalații pen-tru Construcții şi Confortul Ambiental*", Timi-soara, 2002, pp. 340-353.

[6] Hera, D. Ivan, G. Pîrvan, A. Utilizarea ames-tecurilor azeotrope şi zeotrope ca substituenți ai R22, *Simpozionul „Ştiința Modernă şi Energia*", Cluj Napoca, 2001, pp. 120-126.

[7] Popescu, M. Hera, D. Chiriac, F. Impactul freonilor asupra mediului înconjurător, *ECO-Clima*, nr. 1-2, 1999.

[8] * * * *Proprietes thermodinamiques des fluides frigorigenes*, Dehon Service, 1977.

[9] * * * UNEP, *Handbook for the international treaties for the protection of the ozone layer*, United Nations Environment Programme, Nairobi, Kenya, 2003.

[10] * * * U.N. *Report of the refrigeration, air con-ditioning, and heat pumps technical options committee*, United Nations Environment Programme, Nairobi, Kenya, 1994.

[11] * * * http://www.arap.org/