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THE FUTURE OF COMMERCIAL REFRIGERATION IN BRAZIL WITH THE REDUCTION OF HFCS CONSUMPTION

Guilherme Alexandre Eich
Professional College - FAPRO
Curitiba, Paraná
http://lattes.cnpq.br/3718286822804719

Leandro Dornelas Moura
Professional College - FAPRO
Curitiba, Paraná

Eliandro Barbosa de Aguiar
Professional College - FAPRO
Curitiba, Paraná
https://orcid.org/0000-0001-9994-7736

Alexandre Fernandes Santos
Professional College - FAPRO
Curitiba, Paraná
https://orcid.org/0000-0001-5306-6968

Abstract: This article addresses the scenario of commercial refrigeration in Brazil, with a view to reducing the consumption of HFCS in the coming years, proposed in the Kigali Amendment. Due to this amendment, which aims to reduce the impact on the global climate system, there will be a need to seek the use of less aggressive resources in new projects. In this work, the experiences and difficulties present in Brazil were analyzed, with the objective of showing to all those who work in this field, from supermarkets to technicians, what are the challenges that lie ahead in the coming years.
Keywords: HFCS, Natural Fluids, Supermarket, Commercial Refrigeration, Kigali.

INTRODUCTION

Today we live in a world that is constantly evolving, always looking for technological innovations, with the aim of bringing more and more comfort to our lives.

Humanity has been very successful in recent years in developing new technologies and this has positively influenced people's quality of life today. We can cite several examples, such as the ease we have in communication and in the search for information thanks to the internet, or the comfort we have in getting around due to the evolution of automobiles, and this also applies to the topic that is on the agenda in this work, which is the quality of food preservation.

However, unfortunately, there were not only positive points as a result of all this evolution, planet Earth was directly affected and causing high levels of deforestation, pollution, water contamination, death of animals, etc. In the field of refrigeration it was no different, in the search for efficient processes for food preservation, a large amount of synthetic refrigerants is still used for this work and they are part of those responsible for the destruction of the ozone layer and also contribute to global warming.

REFRIGERATION AND THE ENVIRONMENT

MONTREAL PROTOCOL – CONCERN FOR THE OZONE LAYER

In view of all the problems caused to the environment at global levels due to the increase in industrialization, there were specific meetings on each topic, with representatives of the interested countries and several treaties were created with the objective of reducing the negative impact caused on the planet.

One of these meetings was held in 1985 in the city of Vienna, Italy, the meeting resulted in the first debate on the need to protect the ozone layer. This first meeting, in Vienna, served as a reference for establishing international understanding on the importance of the topic.

The ozone layer is a gaseous protection that surrounds the planet Earth, whose purpose is to stop the ultraviolet radiation emitted by the sun's rays. This protection has been destroyed over the years, partly because of the release of synthetic gases (CFCs and HCFCs) used on a large scale in refrigeration and air conditioning systems. The release of these gases has contributed to the increase in holes in the ozone chamber, most of which are located in Antarctica, which are formed when the concentration of ozone gas is below 50%.

Holes in the ozone layer directly affect people's lives, as more radiation from the sun will come into contact with human skin, causing more cases of skin cancer. It is estimated that every 1% of the loss of the ozone layer corresponds to 50,000 new cases of skin cancer, in addition, it is harmful to vision and can stimulate premature aging. Below is Figure 1, which illustrates the levels of ozone in the Earth's stratosphere, recorded in 2020:

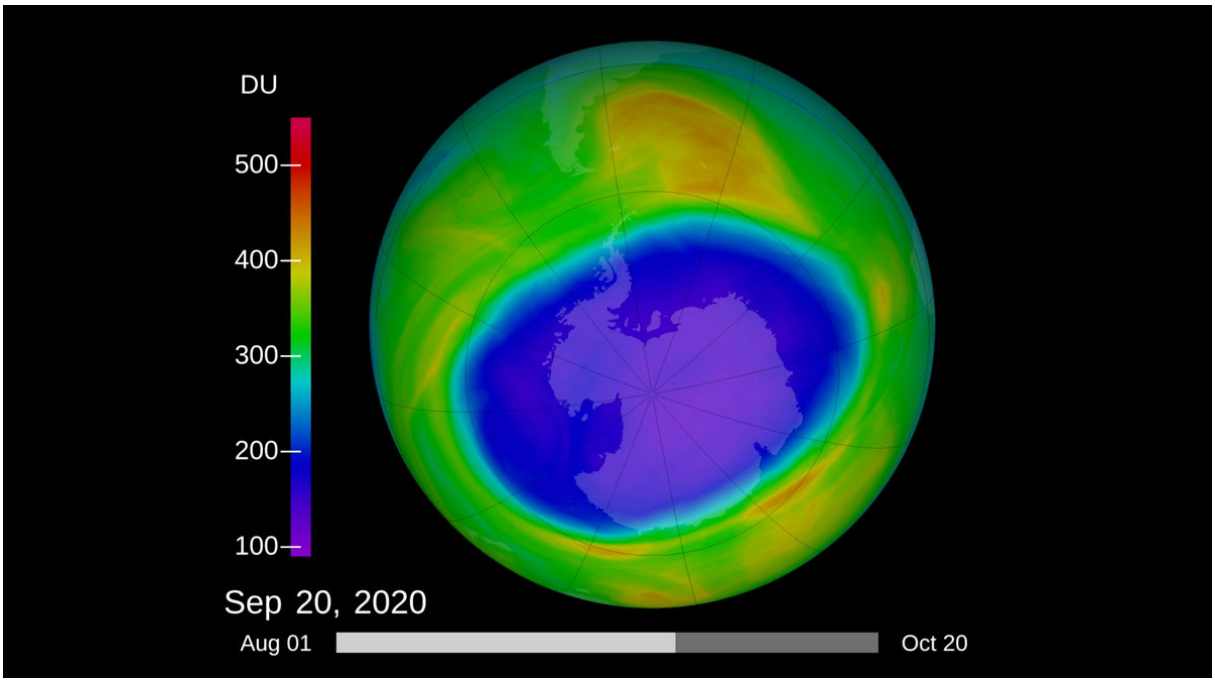

Figure 1. Ozone levels in Dobson units.

Source: NASA, 2020.

Two years after the Convention in Vienna, in 1987 in Montreal, Canada, an international treaty was discussed with the objective of progressively reducing the consumption and production of substances that contribute to the destruction of the ozone layer. This treaty came into force in 1989 and was called the Montreal Protocol, with several amendments in the following years, London in 1990, Nairobi in 1991, Copenhagen in 1992, Bangkok in 1993, Vienna in 1995, Montreal in 1997, Beijing in 1999 and most recently Kigali in October 2016, in order to update the Protocol to include other substances that harm the environment.

The Montreal Protocol was ratified in Brazil in 1990, being considered a great example over the years, as it is one of the countries to fulfill with excellence what was proposed in the treaty, including on its own initiative, the National Plan of elimination of CFCs in 2002.

In the field of refrigeration, until then, synthetic refrigerants known as CFCs (Chlorofluorocarbons) and HCFCs (hydrochlorofluorocarbons) such as R12 and R22 were used, which have excellent thermodynamic properties for heat exchange, however contributing to the destruction of the ozone layer. As an alternative and also to follow the treaty, new options for synthetic fluids have appeared on the market, known as HFCs (hydrofluorocarbons), such as R134a, R404A and R410A, which, unlike those mentioned above, do not affect the ozone layer and have efficient thermodynamic properties. The use of HFCs was a milestone in the HVAC-R industry, widely used even today in refrigeration and air conditioning projects.

Over the years, the use of substances that deplete the ozone layer has been significantly reduced, as NASA scientist Paul A. Newman notes, the Earth's stratosphere has 16% less chlorine and bromine than in the peak year of the problem, in 2000. The hole would be around 1,700,000 square km larger than shown in Figure 1, if this Protocol had not

been understood. As a result, more than two million cases of skin cancer were prevented from reaching the world's population.

One of the goals is that the amount of ozone existing above Antarctica returns to the levels of the 1980s, between the years 2050 and 2075.

In 2009, the Montreal Protocol entered history as the first global treaty on the environment that was ratified by 197 countries. This treaty is a great example to be followed by countries in relation to efficient actions in favor of the environment (Todamatéria, 2018).

KIGALI AMENDMENT – CONCERN ABOUT GLOBAL WARMING

With the issue of ozone depletion under control, attention was given to new problems in relation to synthetic refrigerants used on a large scale in refrigeration. In 2016, in Kigali, Rwanda, a new issue for the Montreal Protocol was brought up on the agenda, the problem of the time was HFCs (hydrofluorocarbons). Previously seen as the solution to control the creation of holes in the ozone layer, now as the main cause of global warming on Earth, related to the greenhouse effect. Although HFCs do not harm the ozone chamber, they have a high rate that contributes to global warming (GWP).

Global warming is caused by the accumulation of polluting gases in the atmosphere and, as a consequence, raises the average terrestrial temperature. There are many discussions about whether this problem exists or not, but it is believed that the main reason behind this problem is a result of pollution caused by human practice. Estimate that in the 20th century the Earth's temperature increased, on average, by 0.7ºC in the last 100 years. Due to the increase in the emission of gases that accumulate in the atmosphere, the greenhouse effect is intensified, which is the protection that the Earth provides us so that the planet is not such a cold place, to the point that many forms of life do not even exist. With the intensification of the greenhouse effect, due to the accumulation of polluting gases in the atmosphere, there is retention of heat on the Earth, which results in several problems for the environment. As well as the gases used in refrigeration, other activities also contribute to global warming, such as the burning of fossil fuels, deforestation, fires and industrial activities. The main consequences are changes in the composition of fauna and flora around the planet, melting of glaciers in the north and south poles, causing sea level rise, increases in cases of natural disasters such as hurricanes, floods and storms, extinction of species, more frequent droughts, disease progression due to high temperatures, etc. (Tomatéria, 2018).

Due to this problem, at the meeting held in Kigali, an amendment called the Kigali Amendment was decided and approved, which consists of including HFCs in the list of controlled substances by the Montreal Protocol. As previously mentioned, the reason for including this item was due to the contribution of fluids to global warming and not due to the destruction of the ozone layer. This amendment defined a schedule for reducing consumption and production of HFCs with a minimum starting value, but increasing over the years. As shown in Table 1 below.

Brazil is part of the A5 Group 1, so it will have to freeze consumption in 2024 and start to reduce it in stages from 2029. More than 100 countries have already ratified the new amendment, which consists of reducing or replacing the gases responsible for contributing to the global warming. In Brazil, the discussion has been stalled for more than a year in the Chamber of Deputies, and the matter is ready to go to

the plenary and be approved by Congress, due to the lack of priority in speeding up this very important matter. The amendment will make Brazil connect to the rest of the world in its environmental legislation and also has positive effects in relation to the modernization of the national industry. The states that are part of the amendment are pressuring Brazil to ratify it as soon as possible, threatening to cut funds.

NATURAL FLUIDS

ALTERNATIVES TO SYNTHETIC FLUIDS

As previously mentioned, really effective strategies were designed to control and also reduce the problems that synthetic fluids, widely used in refrigeration, were causing to the environment. In the Montreal Protocol, a treaty already quite advanced, with the objective of recovering the ozone layer,

		A5 GROUP 1	A5 GROUP 2	A2
Baseline	Year	2020-2022	2024-2026	2011-2013
	HFC component	Average HFC consumption	Average HFC consumption	Average HFC consumption
	HCFC component	65% Baseline	65% Baseline	15% Baseline
Freezing		2024	2028	**
1st step		2029 - 10%	2032 - 10%	2019 - 10%
2nd step		2035 - 30%	2037 - 20%	2024 - 40%
3rd step		2040 - 50%	2042 - 30%	2029 - 70%
4th step		**	**	2034 - 80%
Plateau		2045 - 80%	2047 - 85%	2036 - 85%

Table 1. Schedule for reducing production and consumption of HFCs approved by the Kigali Amendment.

Source: Montreal Protocol, 2017.

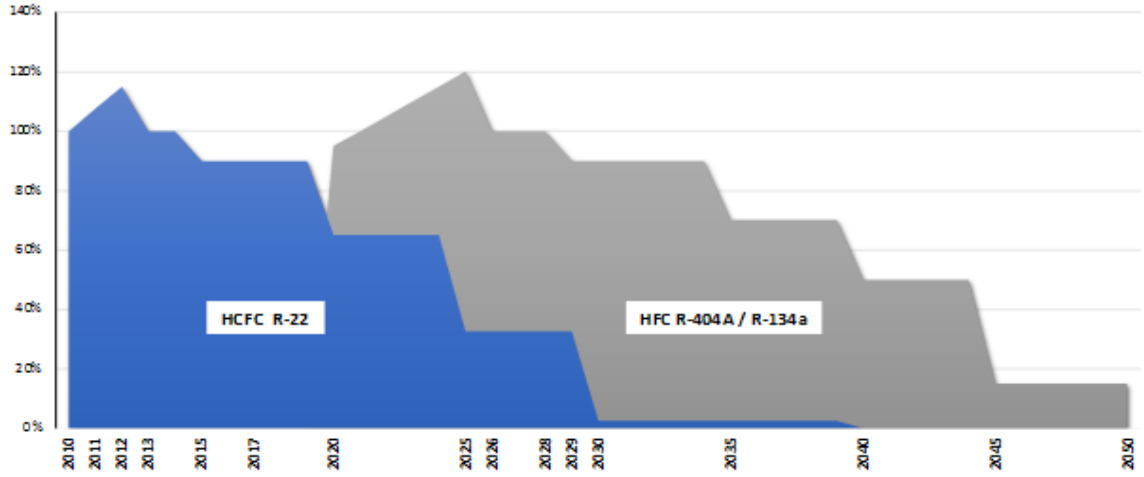

Figure 2. Reduction in the use of synthetic fluids over the years.

Source: Eletrofrio, 2019.

Figure 2 shows the reduction in the use of CFCs and HCFCs over the years, highlighted in blue. In the Kigali Amendment, a treaty still at an early stage, pending ratification by some important countries, such as Brazil, with the aim of reducing the effects of global warming, which is shown in Figure 2 and highlighted in gray, the reduction of the proposed use of HFCs over the years.

From the point of view of refrigeration, gases such as R404A and R22, which for many years were the great highlights in supermarket systems, where everyone who works in the field knows how to operate with them, it is really questionable the way forward. As everything is constantly evolving, it is important to keep in mind that everyone must adapt and understand that this moment of transition is essential as a learning experience. As an alternative to synthetic fluids, there are options for HFOs and natural fluids. Due to the feasibility, it is noted that many projects are going in the path of natural fluids, this is explained not by the simplicity of use, but by the low cost of these fluids, by the long useful life, availability in the national market and, finally, the An important reason for this transition is the low impact on the environment that is provided. (ABRAVA, 2018)

Unfortunately, the complexity of applying the concepts of natural fluids in refrigeration projects is quite high, compared to projects with R22, R134a and R404A. More training is needed on the part of professionals, as each natural fluid has its particularity.

Today we have CO_2, (R744) as an option, which has excellent thermodynamic properties, making it possible to work both with the frozen regime and with the refrigerated regime. However, for CO_2 application, it is necessary to work with very high pressures, which requires special installation materials and also to be careful with safety.

Another option is propane (R290), where it also has excellent thermodynamic properties, operates at pressures similar to R22 gas and is very promising for small and medium-sized projects. The application of this fluid requires a lot of concern with safety, as it is highly flammable, making leakage in installations very dangerous.

With a focus on industrial refrigeration, there is ammonia gas (R717) as an option, it is the most dangerous compared to the other two mentioned above, as ammonia is toxic to people, and can lead to death depending on the amount inhaled by a person. Generally, ammonia is used in refrigerator projects that have a certain distance from cities.

It is also important to mention a great ally of the reduction in the use of refrigerants, which is propylene glycol, used in projects as a secondary fluid in medium and high temperature applications, already widely used in small, medium and large supermarket chains.

In the following paragraphs, each of these options is discussed in more detail and some real examples of the application of natural fluids in commercial refrigeration projects in supermarkets are also shown.

PROPYLENE GLYCOL

The use of propylene glycol as a secondary fluid is a very interesting sustainable solution that has been applied in supermarkets throughout Brazil for over 15 years. It is a compound of the alcohol family, with the purpose of reducing the freezing temperature of water, acting as an antifreeze depending on the mixture percentage, shown in Table 2 below. As known, the freezing temperature of water is 0ºC, but if we add 30% of propylene glycol to the mixture, we can lower this temperature to -12.7ºC, making it possible to apply it to medium temperature (cooled) and high temperature systems. (air-conditioned

and air-conditioned preparations). In the common refrigeration process, which is called direct expansion, the refrigerant fluid is pumped in a gaseous state by the rack compressors, with high pressure and temperature, to the remote condenser. Where the heat absorbed in the environments and compressors is rejected in the exchange of heat with the external air, as it travels through the entire condenser piping, carrying out the condensation of the fluid. After that, the fluid in liquid state will go to the expansion valves of the exhibitors and chambers, drastically reducing both the pressure and the temperature, passing through the evaporators with the temperature around -10ºC if cooled or -30ºC if frozen., absorbing heat from the surroundings and changing the fluid state from liquid to gas, due to heat gain, and finally returning to the compressor to start the cycle again.

Percentage of Propylene Glycol in H_2O (by weight)	Solidification Point in °C (1 Atm)
0	0
20	-7.1
25	-9.6
30	-12.7

Table 2. Propylene glycol + water freezing temperature.

Source: Freeart Seral Brasil, 2012.

Cooling using Propylene Glycol is a little different, as it acts as the secondary fluid in the process, called indirect expansion. In the rack there is a heat exchanger that has the function of cooling the glycol, on the one hand the synthetic fluid passes in a liquid state, with a temperature around -10ºC and on the other hand the glycol that returns from the heated store passes. The synthetic fluid after cooling the glycol ends up heating and changing to the gaseous state and then going to the compressor, condenser and expansion valve, being the primary fluid in this process. In other words, there is a direct expansion system in the engine room for the purpose of cooling the glycol.

After being cooled, the secondary fluid is pumped through a motor pump to the store's environments, passing through the expositors and chamber forcing, with a temperature around -4ºC, absorbing the heat from the food and returning to the heat exchanger to start the whole process again. There is no change of physical state, the glycol is liquid throughout. In figures 3 and 4 we can see the diagram of direct and indirect refrigeration cycles.

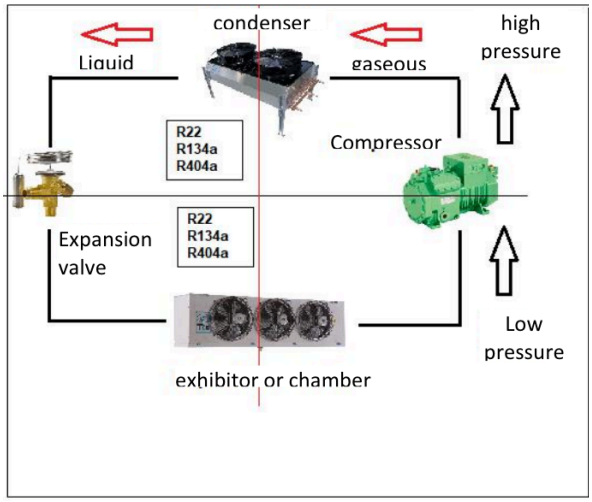

Figure 3. Direct expansion system.

Source: Own Authorship, 2021.

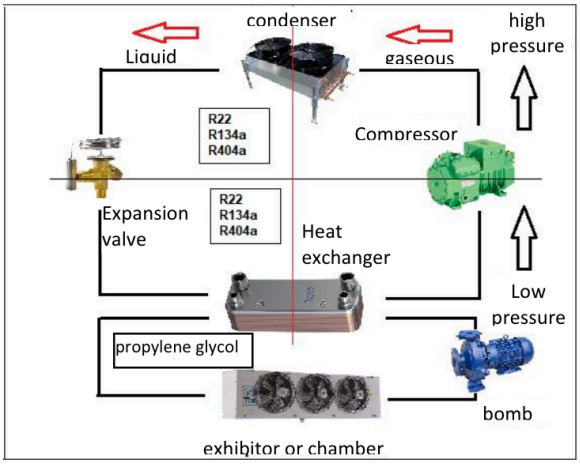

Figure 4. Indirect expansion system.

Source: Own Authorship, 2021.

The great advantage of using this system, from an environmental point of view, is the significant reduction in the amount of synthetic fluid needed in medium and high temperature regimes. As explained earlier, the synthetic fluid is only needed to cool the glycol, where it will circulate only in the section between rack, condenser, expansion valve and heat exchanger, and it is no longer necessary to go to the chambers and displays throughout the store. With the amount of gas reduced, consequently there will be a reduction in the amount of gas that can supposedly leak, due to some problem, from the system to the atmosphere. Many supermarkets have adopted the use of propylene glycol in their stores, which was a great start in reducing the use of HCFCs and HFCs. In addition to ecology, below are some other advantages:

- Easier installation compared to the direct expansion system, due to lower maintenance costs;
- Savings in relation to the cost of installation materials, because unlike direct expansion systems, where copper pipes and connections are usually used due to working pressures, for the indirect expansion system PPR is used, a type of polymer that is ideal in the application, because the working pressures are lower;
- Simplified automation, where temperature controls and defrost programming are not required for medium temperature environments, as solenoid and thermostatic valves are not required in each environment.

To work with an intermediate fluid in the low temperature regime, it is not ideal to work with an aqueous propylene glycol solution, as the concentration must be very high so as not to freeze at temperatures below -25ºC, causing the density to become very high. and consequently requiring very large motor pumps, increasing the cost of the project. As an alternative, there is Tyfoxit, which has also been considered an environmental solution in reducing synthetic fluids. However, due to the high cost of special materials due to corrosion and better alternatives such as CO_2, it ended up being left out in commercial refrigeration projects. Below are some images to illustrate the secondary fluid system with propylene glycol:

Figure 5. PPR and Thermofuser Connections.

Source: Tecnofluidos, 2021.

Figure 6. Piping installed underground.

Source: Eletrofrio, 2021.

CARBON DIOXIDE - CO_2 (R744)

It is always questioned why CO_2 is considered one of the great environmental solutions in refrigeration, as it is one of the main compounds that cause imbalances in the greenhouse effect on Planet Earth.

There is a big difference between producing carbon dioxide from the burning of fossil fuels, as is done in industries and in car engines, releasing this compound that did not exist before in the atmosphere, compared to using it in refrigeration systems, where the gas is taken from nature, used inside the installations' pipes and later returned to nature as a result of a possible leak. In other words, the use of CO_2 in refrigeration systems does not contribute to the increase in global warming, as the compound is taken from nature and not created.

CO_2 or R744 as it is called, is a solution with natural fluid that has been applied in supermarkets in Brazil for 10 years. Being used mainly in the low temperature regime, where it comes each year to take the place of R404A and Tyfoxit.

Unfortunately, the pursuit of 100% sustainable refrigeration, where synthetic fluids are giving way to natural fluids, is not an easy path to take. As previously mentioned, each natural fluid has its particularity, projects with R744 are different from projects with R404A, requiring greater technical qualification. The main difference is the high pressure in the system, with R404A to reach the evaporation temperature of -30ºC it operates with 2 bar of pressure, for R744 it operates with 14.28 bar to reach the same evaporation temperature, that is, 7 times bigger. Due to this condition, the initial cost to apply R744 in refrigeration is much higher, as it is necessary to use materials that are more resistant to breakage, a more reliable automation and also several safety components.

As previously mentioned, R744 is widely used in the low temperature regime as one of the best alternatives to synthetic fluids. Due to the high working pressures, the system does not operate in the same way as in direct expansion, as shown in Figure 3 above, it is necessary to exchange heat with a synthetic fluid, similar to what happens with propylene glycol. This system is called subcritical CO_2, two-stage cascade, which works with a synthetic fluid, usually R134a, condensing R744 through the heat exchange that takes place in the heat exchanger. The R134a condenses the CO_2, it is compressed by the compressor, rejecting heat obtained by the heat exchange and also by the compressor in the condenser and then going to the expansion valve to start the cycle again. R744 is compressed by other compressors in parallel and sent to the heat exchanger, where the synthetic fluid with a temperature of around -10ºC passes on the one hand and the heated R744 on the other side, evaporating the synthetic fluid and condensing the CO_2. In direct expansion systems, the designs are made considering that the fluid condenses at a temperature of 45ºC, which is not possible with R744 due to the working pressures. Because of this, the heat exchanger works as the condenser of this cascade system, causing R744, after exchanging heat with R134a, to condense at a temperature of -5ºC. There are projects where this condensation is done by propylene glycol, as an alternative to synthetic fluids. After condensing, the CO_2 goes to the expansion valves and circulates in the evaporators of the environments, removing the heat and returning to the compressor in the gaseous state again, shown in Figure 7 below:

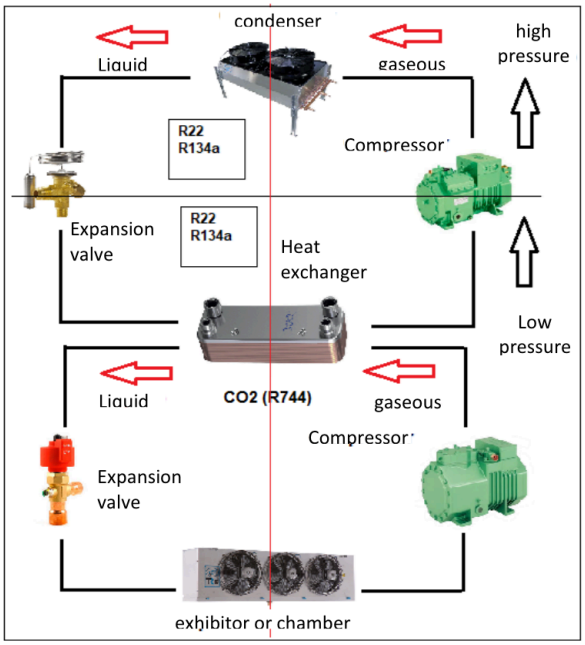

Figure 7. Cascade System - Subcritical CO_2.

Source: Own Authorship, 2021.

Figure 8. Copper connections with 1/16" wall.

Source: Curva e Cobre, 2021.

In commercial refrigeration systems in Brazil, R744 has been applied for 5 years also for the medium temperature regime, which we call CO ₂transcritical. Compared to the other systems discussed in this article, the CO ₂ systemtranscritical is the most complex and also the most expensive of all, because to work with this fluid for cold, the pressure is even higher than compared to the subcritical that is applied on a large scale for frozen. For evaporation at -10ºC, which is the temperature generally used for cooling, the pressure is around 26.5 bar, almost double compared to the subcritical. To work with this even higher pressure, we cannot use the same standards as the subcritical, thicker or stainless steel pipes and K65 copper connections must be considered, which is an alloy of copper and steel that offers greater resistance to rupture.

The great advantage of this system, from an environmental point of view, is that no synthetic fluid is used, it is 100% natural with CO_2. It is a very promising system, but it is still quite expensive to be applied in Brazil, as many items needed in the project are imported, such as the compressor rack and the K65 connections. The expansion of this technology is essential to reduce the emission of HFCs, because despite the high cost, it is one of the 100% ecological options applied in refrigeration worldwide.

There are many cares in working with this natural fluid, due to this high operating pressure. In the event of a power failure, the CO_2 is all purged from the inside of the pipes to the outside, and it is not possible for it to stay still like what happens in other fluids, because without refrigeration connected the temperature will increase and consequently the internal pressure in the pipes as well as being able to break them. There are several items that help to purge the atmosphere. It is necessary that in closed places, such as cold rooms and in the engine room, CO_2 detectors are installed, because in the event of a pipe rupture, the leak will be very fast due to the

working pressure, removing oxygen from the environment and being able to asphyxiate. A person. Automation must also be precise, to be able to control this unstable system. To provide this control, electronic expansion valves are used instead of thermostatic ones, as they offer greater precision and speed in automation. Below are some images of CO_2 application in some supermarket projects:

Figure 9. CO_2.

Source: ENEX, 2021.

figure 10. K65 copper connections.

Source: Conex Bänninger, 2021.

PROPANE (R290)

HCs (hydrocarbons) have been widely used in white goods and light-duty refrigeration systems. Among them, we can highlight R600a (isobutane), which is present in refrigerators in our homes and also R290 (propane), which is widely used in supermarket self-displays (Revistado-frio, 2018).

For commercial refrigeration, it is more interesting to work with R290, as it has thermodynamic characteristics very similar to R22. This fluid is an excellent alternative for replacing HFCs, however, as previously mentioned, it is a flammable product. Because of this problem, the maximum limit allowed for the use of this fluid is 150 grams, according to the current international iEC standard (ABNT NBR 16667, 2017).

Along with R744, R290 has been considered, from an environmental point of view, one of the most revolutionary solutions in relation to commercial refrigeration, as it offers almost zero risk to the ozone layer and global warming. Due to the fact that the use of up to 150 grams of propane in refrigeration systems is allowed, without posing risks of explosion, the use is almost exclusive of self-displayers, such as the frozen islands that exist in several supermarkets, mainly in cash and carry stores, below in Figure 11 and 12.

Figure 11. Self R290 Island - Electrofrio.

Source: Eletrofrio, 2021.

Figure 12. Self Island R290 - Arneg.

Source: Arneg, 2021.

The operation is very simple, each module of the island has a direct expansion system, where it has a capillary to expand, the evaporator, the compressor and the condenser through which the propane passes, the heat is rejected into the supermarket, thus, warming up the store. Stores that have many of these displays usually have high electricity bills, because the supermarket's air conditioning system has to remove this rejected heat from the self islands.

With all the knowledge obtained, after some years of applying R290 in light-duty refrigeration projects, it is under discussion in several countries to increase the limit of propane to cover systems of greater capacity. In Brazil, the Ministry of the Environment has been encouraging supermarkets and manufacturers of refrigeration equipment to develop and apply new projects with greater amounts of propane.

The rule of allowing the use of a maximum of 150 grams of propane applies to common access areas, such as the supermarket sales hall, where a lot of people circulate. For the use of R290 in greater quantity, it is necessary that this area be of restricted access, where only qualified professionals can access, without putting people at risk.

It was seen earlier in this article that projects with propylene glycol and subcritical CO_2 reduced the use of synthetic fluids in high and low temperature regimes by a large amount, but not by 100%. In these solutions, R134a is still required circulating between the engine room and condensers to cool the glycol or condense the CO_2. With this problem in mind, an innovative solution was thought where R290 can replace R134a in the cooling of propylene glycol, and the cooled glycol itself condenses the CO_2 present in the low temperature regime.

This project works as follows, the rack has a certain number of compressors for propane, and each compressor is isolated inside a module. Inside this module, there is the compressor that compresses the R290, electronic expansion valve and a heat exchanger, all interconnected within this module. The propane cools the propylene glycol, where it goes to the displays and chambers in the store. The condensation of the propane is done through a water system, where the heat that the glycol brought from the store plus the heat rejected from the compressor exchanges heat with the water at room temperature, the heated water releases the heat in an air cooler that It is installed in a ventilated place. R290 goes from liquid to gas when it exchanges heat with glycol and goes from gas to liquid when it exchanges heat with water. In 2019, the first supermarket in Latin America to use this technology was installed in the city of Curitiba. As of this year, the expansion of this 100% sustainable solution has been studied.

Figure 13. Engine room.

Source: Eletrofrio, 2019.

Figure 14. Propane modules.

Source: Eletrofrio, 2019.

However, to work with propane, several precautions must be taken, as it is a flammable fluid. For this reason, this system cannot have leaks, as propane is denser than air and if there are leaks, the gas will be circulating on the floor, having a very high risk of igniting with any material that can cause an ignition.

To avoid leakage, the R290 cannot go to the displays and chambers as in a direct expansion system, which is why this project consists of keeping it only in the engine room, where only authorized and technically prepared people can enter.

Just as working with CO_2 requires a greater investment on the part of the buyer, propane is no exception to this, because although the fluid circulates only inside the modules in the engine room, several safety items are necessary so that accidents do not occur. We can cite as an example the propane modules, they are fully sealed boxes so that there is no leakage, but if there is a leak, the engine room must have an exhaust system to throw all the propane out. To load propane in this module that has leaked, it must be removed from the engine room and taken to a company specialized in this service, as it is not allowed to load it in the place where it is installed. In this store in Curitiba, each module has a load of 1.9 kg of propane, a very considerable amount. In addition, all electrical components must be special, where they cannot produce any kind of spark, further increasing the cost of the project.

The use of this natural fluid in the engine room for glycol cooling is something new in the market, it is very likely that in the coming years the demand will increase more and more, due to the urgency of migrating from synthetic to natural fluids.

FINAL CONSIDERATIONS

We live in a time when those who manufacture more, with fewer natural resources and with processes that focus on sustainability, gain an advantage over the competition.

This happens in all branches of the industry, from the automotive industry, which today produces electric vehicles to minimize the effects of pollution, to the home appliance industry, where it aims to produce equipment that consumes less energy, and also to the cosmetics industry, where year by reducing testing of products on animals. These are the effects of industry 4.0, which emerged as a result of preserving the world we live in, which was highly harmed due to the evolution of technology, due to the need of the human being.

In the refrigeration business it is no different, over the years, increasingly efficient technologies have emerged, linked to sustainability at the same time. In the early days of refrigeration, the natural fluids that were so much discussed in this article were responsible for the first food preservation systems. Due to the technology not being as advanced as it is today, there was a lot of difficulty in working with them, resulting in the need to create new synthetic fluids. That's how CFCs and HCFCs like R22 and HFCS like R404A and R134a came about, which for

many years were treated as the solution for heat transfer, and then discovered that they were harming the environment by destroying the ozone and also promoting global warming. Therefore, measures were created to protect the environment, such as the Montreal Protocol, where we saw an excellent fluid for refrigeration, which is R22, each time being left out in projects, being replaced by R404A and R134a, which are doomed to the same fate, due to the Kigali Amendment.

The solution is the return to the use of natural fluids in refrigeration and air conditioning systems, which despite all the difficulties of working with them, today the technology is advanced enough for this purpose. There is a lot of resistance in this change, due to the simplicity of working with synthetic fluids compared to CO_2, for example, breaking paradigms is inevitable. There is a need to seek learning to work with natural fluids. After all, the days of HFCs are numbered. From 2029, there will be 10% fewer projects with HFCs, so there will be 10% more projects with natural fluids, with growth each year.

Figure 15 illustrates the change in fluids in a supermarket system, as a result of the sustainable measures mentioned in this article.

The message this article aims to convey is the need to think differently and simply. With the growth of projects that use natural fluids for the entire HVAC-R branch, it is essential that there are professionals who are able to work with refrigeration systems with natural fluids. This change is just beginning in Brazil, there are few projects where this concept was applied, compared to projects with synthetic fluids. Therefore, it is extremely important to invest in knowledge in the coming years, because as previously mentioned, those who work sustainably will always be one step ahead.

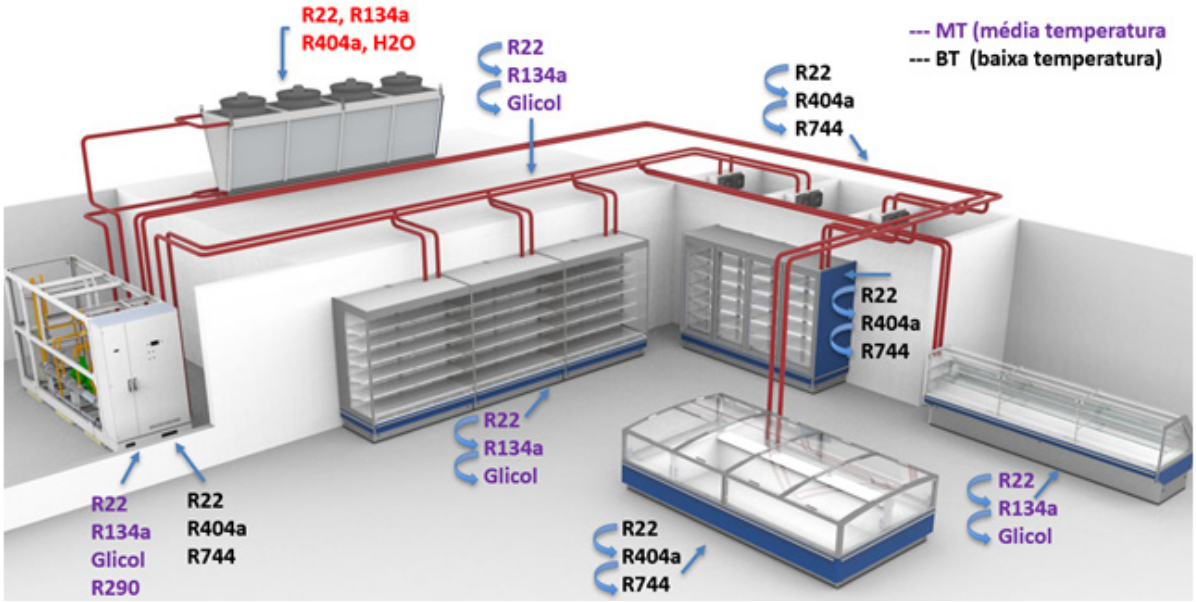

Figure 15. Refrigeration system in a supermarket.

Source: Eletrofrio, 2020.

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