

192 Aprox.

TECHNICAL NOTE

Use of R290 refrigerant
recommendations

Use of R290 refrigerant gas in hermetic compressors and
commercial refrigeration equipment



HUAYI
COMPRESSOR
BARCELONA

1. HUAYI COMPRESSOR BARCELONA (HCB)

The HCB of today started out with Spanish and French capital in 1962, under the original name of “Unidad Hermetica”. Its goal was to meet the country’s needs for hermetic compressors and refrigeration equipment. Today, the company is corporate parent to the Cubigel Compressors® brand, and employs over 400 employees at its 42,000 m² plant in Barcelona, with a production capacity for 2.5 million compressors a year. While Europe is the main market, the company has a global presence through a network of 70 highly professional distributors in 65 countries. HCB markets compressors for commercial refrigeration under the well-known Cubigel Compressors® brand.

HCB, under the umbrella group Huayi Compressor Co. Ltd., has an annual turnover exceeding 39 million units in sales. Huayi Compressor Co. enjoys the solid backing of the Chinese giant, Sichuan Changhong Electric. Since its founding in 1990, Huayi Compressor Co. has achieved world leadership in the manufacture of hermetic compressors for refrigeration. Its broad portfolio of equipment covers a wide variety of applications in domestic appliances, such as refrigerators, water dispensers, dehumidifiers, etc.

1.1. Objective and Responsibility

Huayi Compressor Barcelona aims to provide quality and environmentally-friendly products using cutting-edge technology,

Huayi Compressor Barcelona is ISO 14001 certified, which confirms the company’s commitment to Total Quality and to sustainable practices. The firm considers that affording equal opportunities to its employees acts as a means to fully optimize their skill sets and performance.

The increasing use of natural refrigerants in commercial applications such as propane (R290) and isobutane (R600a) is a priority, not only owing to the need to replace HFC refrigerants, which have a high impact on the environment, but also because they are more efficient in terms of performance and energy consumption.

2. PRODUCTS

Huayi Compressor Barcelona supplies the most comprehensive range of compressors for the light commercial refrigeration market. It bases its business strategy on the development

of high quality, energy efficient and environmentally sustainable products, which in itself demands a high level of R&D, as well as the most advanced manufacturing technology.

2.1. Compressors

Huayi Compressor Barcelona has an ample portfolio of models with displacement capacities ranging between 2.4 cc and 34.0 cc, working with most refrigerant gases and suitable for virtual-

ly any application in commercial refrigeration. Briefly, the company catalog is organized along the following product lines:



D Range

Characterized by a very compact design, low weight and extremely quiet operation, includes models that work with R134a, R600a and HFO1234yf refrigerants, with cylinder displacement ranging between 2.40 and 4.03 cc. Its main applications are water, can and bottle coolers, as well as small refrigerators and freezers.



U Range

These are the most efficient compressors. They were designed with the most advanced technologies to minimize energy consumption, while retaining maximum cooling capacity. Its shell, more compact and rounded, minimizes noise. This range is available in models with R290, R134a, R600a and HFO1234yf refrigerants.



L Range

It includes the most extensive catalog of models and is classified into three levels of efficiency (standard, high and very high), for practically any application in refrigeration equipment: refrigerators, freezers, bottle and can coolers, freezers for ice cream conservator, vending and ice machines, beer dispensers, etc. This range is available in displacements from 4.56 and 10.7cc, using R134a, R404A, R290, R600a, R507 and HFO1234yf refrigerant gases.



X Range

With displacements from 16.0 to 23.0cc, this series is designed to work in applications where high cooling capacity is required, such as large refrigerators and freezers, display cabinets or islands, supermarket refrigeration equipment, etc. Works with R134a, R404A, R290, R407C, R507 and HFO1234yf refrigerants.



Condensing units

Huayi Compressor Barcelona offers high quality hermetic condensing units, with a wide range of options for most commercial refrigeration applications employing LBP, LMBP and HBP back pressures. Standard as well as customized model versions are available.



P Range

Along with the L series, these are the most commonly used compressors. They also offer three levels of efficiency, as well as solutions for all types of refrigeration applications, such as: refrigerators, freezers, bottle and can coolers, ice cream freezers, vending machines, beer dispensers, beverage dispensers, ice machines, heat pumps, etc. The cylinder capacities range from 12.10 a 18cc, with R134a, R404A, R290, R600a, R507 and HFO1234yf refrigerant gases.



S Range

This collection of models includes the top of the ranges of Cubigel Compressors®, with displacement ranging between 18.0 and 34.4cc. This line offers an optimized design to reduce vibration, and there are models that work with R134a, R404A, R407C, R507 and HFO1234yf refrigerants for applications such as large freezers and refrigerators, supermarket refrigeration equipment, heat pumps, etc.



Compressors for Mobile Applications

Reliable and versatile, the DC line of Cubigel Compressors® operates at voltages of 12-42 V. These are for use in recreational vehicles, boats, caravans and vehicles equipped with refrigerators and freezers, as well as trucks and transport vehicles with air-conditioning equipment.



Variable Speed Compressors

These compressors allow the possibility of adapting its speed to the cooling needs at any given moment, which is a huge advantage, because this leads to a drastic reduction in energy use.

2.2. Green Cooling

The advanced design of the 'Green Cooling' series under the Cubigel Compressors® brand is intended to minimize operating costs for refrigeration equipment in supermarkets, shops, restaurants, etc., where energy conservation is a main requirement. Moreover, this equipment can work with R134a and R404A gases or natural refrigerants, such as propane (R290) and isobutane (R600a).

The progressive introduction of natural refrigerants in these applications is required not only by increasing legislative pressure towards replacing HFCs, but also because they are more efficient in terms of energy consumption and performance.

These high-efficiency units can reduce energy consumption between 20% and 40% compared to the usual standards. They are equipped with engines designed according to the concept: "Run Capacitor Optional" which allows the compressor to work with maximum efficiency at all times. In addition, variable speed motors add extra efficiency by adapting their speed to application requirements, improving the Coefficient Of Performance (COP) up to 50%.

3. ENVIRONMENT AND SUSTAINABILITY

There is broad scientific consensus on the beginning of a climate change cycle on Earth. Unlike other similar phenomena occurring repeatedly throughout the history of our planet, this time it is human intervention that is causing the increase of greenhouse gases in the atmosphere. The burning of fossil fuels, many industrial processes of all kinds, transportation systems, agricultural production, deforestation, etc. are just some examples of how human activity is having an impact on the problem decisively.

In fact, an increase of 30% since the last century in the concentration of greenhouse gases in the atmosphere can only be explained by taking into account our production and energy consumption habits. In addition, the scientific consensus is definitive in finding that global climate disruption will cause serious impacts on the Earth, including social and economic systems, health, drinking water supply, etc.

3.1. Fluorinated Refrigerants

Artificially created for industrial purposes, these represent approximately 15% of greenhouse gas emissions in industrialized countries. Compounds such as sulfur hexafluoride (SF₆) or perfluorocarbons (PFCs) used in various industrial processes are especially damaging because they can trap heat in the atmosphere up to 22,000 times more effectively than CO₂ and pollute for thousands of years.

The industry has been using significant quantities of fluorinated greenhouse gases for refrigerators, air conditioning, the

production of aerosols and fire extinguishers, etc. In the European Union (27) alone, it is estimated the region exceeded 850 million tons of CO₂-eq emissions in 2010. The best known of these gases, chlorofluorocarbons (CFCs), led to a global debate over the final two decades of the previous century owing to its destructive properties regarding the ozone layer. Its gradual market withdrawal since the signing of the Montreal Protocol of 1987 and replacement by hydrofluorocarbons (HFCs), has only provided a solution to the ozone problem, but not for climate change.

3.2. Europe Slows Use of HFCs

Regulation 842/2006 of the European Union initiated a protracted legislative voyage towards greater oversight of fluorinated greenhouse gases. That text included a package of measures designed to contain emissions, as well as requirements to force gas recovery at the end of the useful life of equipment, to label equipment, and various prohibitions and restrictions on the market. The failure of the results led just eight years later to the issue of the new Regulation, 517/2014, currently in force.

The highlight of this latest European regulation is the progressive reduction scheme (phase down), which provides for

reducing the amount of HFC that producers and importers may market in the Union. The goal takes as a baseline the volume traded in 2015, reducing it to 21% by 2030 under Regulation 517/2014, while the European Commission can recalculate the schedule every three years starting in 2017. The legislators also established a schedule of restrictions on the use of HFCs in new equipment, as well as expanding the scope of containment measures and new labeling requirements. Overall, it is estimated that a reduction in the emission of these greenhouse gases of about 70-80% in the EU 27 will result.

4. INDUSTRY RESPONSE

Society has further realized that climate change is not only an environmental phenomenon, but extends its impact to potential health and economic issues as well as to many other areas previously unsuspected. Although uncertainties do not allow calibrating with sufficient accuracy its exact future scope, the data collected and scientifically analyzed are sufficient to warrant taking immediate action, at least according to the “precautionary principle” which is already contained in the 1992 United Nations Framework Convention On Climate Change.

Industry, ever since first Thomas Midgley announced the first CFC for use in refrigeration in 1930, R-12 (dichlorodifluoromethane, commercially known as Freon-12), has always been sensitive to the pressure of public opinion and has not ceased in the collective search for more energy efficient, better performing, and safer - and undoubtedly also more environmentally friendly - compounds.

4.1. Commitment to the Environment

In the case of light commercial equipment and that for domestic application, once HCFCs have been discarded due to their damage to the ozone layer, and HFCs, due to their high contribution to global warming, the trend towards the use of environmentally friendly refrigerants will continue to grow in the coming years. The case is to find compounds with zero ODP (Ozone Depletion Potential, or potential destruction of the ozone layer) and low GWP (*Global Warming Potential* or GWP).

The first factor indicates on a scale of 0 to 1 the damage it can cause to the ozone layer. The second factor measures the heat

which a gas can trap - generally in comparison to CO₂, or carbon dioxide, for a period usually calculated over 100 years. Thus, the 100-year GWP for methane is 25, which means that the issuance of one million tons of methane is equivalent to emitting 25 million tons of CO₂-eq. Other gases currently used in refrigeration have significantly GWP higher rates: R134a (1,300 GWP), R404A (3260 GWP) and R507 (3,300 GWP).

The best choices among natural refrigerants, which are already on the market, include CO₂ itself (R744), ammonia (R717), air (R729) and hydrocarbons such as propane (R290) or isobutane (R600a).

4.2. Sustainable Hydrocarbons

From a strictly technical point of view, the use of these hydrocarbon refrigerants is a great solution because of their physical and chemical properties. In fact, their use can be considered fairly consolidated in large parts of the world, especially in developed countries. In addition, both R600a and R290 have a 3 GWP and zero ODP indices, which makes them even more attractive. The first is recommended for home appliances and small business applications, and is already being used to replace R134a. For its part, R290, or propane, is a good alternative for light commercial applications, successfully replacing R134a, R404A and even R22 in certain cases.

Some media organizations have expressed reservations regarding the use of these hydrocarbons in domestic and commercial applications where there is no professional oversight over possible leaks or environmental accidents. However, the limitation to less than 150 grams of refrigerant gas per machine should remove any doubt, given that for decades butane and propane canisters of more than twelve kilograms have been stored in homes without significant issues. In addition, the isolation of electrical circuits in these devices to prevent sparks is can be done in adequate manner.

5. THE HUAYI ALTERNATIVE

Huayi Compressor Barcelona, in line with the rest of the industrial refrigeration industry, is aware of the need to adapt its technology regarding refrigerant gases. The goal is to not only to comply with legislative requirements, but go a step further and also be exquisitely environmentally friendly.

The advanced design of the Green Cooling ranges from Cubigel Compressors® represents a significant advance in terms of efficiency and sustainability. These compressors are suitable for working with refrigerants such as R290 and R600a in light commercial refrigeration applications and home appliances. Among the most significant advantages are the energy savings, which translates into an important reduction in operating costs and the reduction of CO₂ emissions into the atmosphere.

5.1. R290 Refrigerant in Practice

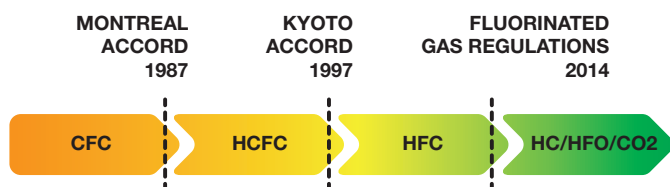
To demonstrate the advantages in terms of energy savings and operating costs of the Cubigel Compressors® Green Cooling ranges, several studies were conducted, among which we would like to highlight a practical analysis, using a variable speed compressor such as the NLT60FSN, loaded with R290, as compared to a standard model, such as the NL60TB, also loaded with propane. The analysis showed a significant savings yield of 39% in energy consumption by the system. This reduction in consumption always translates into lower CO₂ emissions into the atmosphere, while realizing significant savings on the energy bill for the end user.

In conclusion, R290 is definitely the best option among natural refrigerants for light commercial applications. With an excellent global-warming potential, its use does not require drastic changes in the design of equipment currently loaded with other HFC gases, compared to other equally environmentally friendly alternatives such as CO₂. Also, R290 can work with compressors with smaller displacements than those required for R134a and R1234yf, while obtaining a similar cooling capacity. Even the current load limitation to 150 grams per unit, which partially covers the needs of the commercial light refrigeration market, is under discussion and is likely to be modified upward in the future. Finally, we must not forget that R290 has been used without incident in recent years in thousands of applications across Europe.

6. USE OF R290 REFRIGERANT

Climate change is a real concern in our society and the regulations for fluorinated greenhouse gases, issued by the European Parliament in 2014, are a good indicator of the degree of public awareness reached. The aim of legislators for 2030 is to gradually reduce by two thirds the volume of gas discharges into the atmosphere as compared to those released in 2005. This directly affects most HFCs or hydrofluorocarbons commonly used in light and commercial refrigeration systems.

In this context, hydrocarbons and especially R290 refrigerant, are gradually being introduced as substitutes for other less environmentally-friendly refrigerants for the environment, such as R134a and R404a (CFC, H-HCFC and HFC refrigerants).



6.1 Attributes of Refrigerant Gases

Attribute	R134a	R404A/R507	R290
Group Name	HFC	HFC	HC
GWP	1300	3260	3
ODP	0	0	0
Inherent COP	Medium	Medium	High
T (1 bar) °C	-26,1	-46,5	-42,1
T (25 bar) °C	77	54	68
P (-35°C) Bar	0,67	1,66	1,36
P (-10°C) Bar	2	4,33	3,42
P (45°C) Bar	11,6	20,45	15,31
P (60°C) Bar	16,81	28,7	21,18
Critical point	101°C 40,67 Bar	72°C 37,31 Bar	97°C 42,36 Bar
Security classification	A1	A1	A3
Oils	POE	POE	MINERAL POE

7. SYSTEM DESIGN

7.1. Performances and Displacement

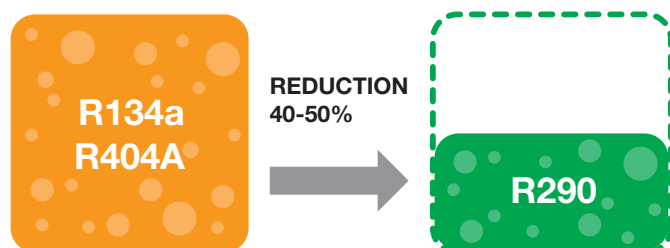
Refrigerant	R134a	R404A	R290
Model	GLY90RAa	MLY90RAa	NLY90RAa
Displacement (cm ³)	9,09	9,09	9,09
Cooling capacity (kCal/h)	770	1220	1080
COP (W/W)	2,37	2,13	2,56

The table shows the performances achieved by three different models of compressors, with equal displacements, but loaded with the three reference refrigerants. Compared to R134a, the R290 gets about 40% more cooling capacity, while compared to R404a it gets 10% less.

7.2. Refrigerant Load

While the amount of refrigerant always depends on the type of system and component, R290 requires loading about 40-50% less refrigerant compared to R404A and R134a.

According to EN 60335-2-24, the maximum load of refrigerant in the case of R290 is 150 g for light commercial equipment and domestic applications.



7.3. Capillary Tube

With R290, the same capillary tube as with R404A can be used, although usually it will be twice as long as that employed with R134a.

The following link leads to tables for selecting the capillary tube for a given cooling capacity:

<http://www.huayicompressor.es/index.php/technical-information/technical-notes/file/44-technical-note-capillary-tube-size>

These tables are intended to assist at the start of laboratory tests, with a view toward minimizing the number of tests.

7.4. Condenser and Evaporator

It is possible to use condensers and evaporators with R290, with typologies and dimensions similar to those used for HFC refrigerants, provided that the working pressures are similar.

7.6. Drying Filters

The following table shows the recommended drying filters for cooling systems loaded with the reference refrigerant gases.

Refrigerant	Molecular sieves
R134a	XH-5 or XH-6
R404A	XH-7
R290	XH-9 and XH-11

7.5. Lubricants

Both R290 and R600a are miscible and soluble in mineral and synthetic oils (POE) used with HCFC refrigerants (R134a and R404A). However, lubricants containing silicone or silicates are not compatible with HC refrigerants and therefore should not be used.

Refrigerant	Mineral oil	POE oil
R134a	Incompatible	Compatible
R404A	Incompatible	Compatible
R290	Compatible	Compatible
R600a	Compatible	Compatible

8. SAFETY RECOMMENDATIONS

8.1. Inflammability

Due to the high flammability of R290, it is necessary to establish security measures both for the equipment itself and on production lines. The use of the R290 is only allowed in devices designed to meet the requirements according to the following standards:

Europe	North America
IEC/EN 60335-2-24	UL 60335-2-24
IEC/EN 60335-2-89	UL 471
IEC/EN 60335-2-34	UL 60335-2-34

Compressors from Huayi Compressors Barcelona enjoy VDE and UL certifications, which comply with the regulations mentioned above.

On the other hand, equipment from Cubigel Compressors® for R290 are equipped with starting devices like PTC, current re-



lays and overload protectors, according to EN60079-15:2010 regulations (ref. ATEX), to prevent electrical sparks from occurring within the machine's environment.

Also, the compressors must bear a warning label alerting to the presence of flammable refrigerant.

Due to the flammability of this refrigerant, for proper repair or maintenance of the system one must take into account the fact that:

- There should be no risk of sparks near the work area.
- Good ventilation in the work area is necessary.
- The coolant should not penetrate into basements or low areas, as HC gases are heavier than air.
- Risk situations in which the R290 can be mixed with air and acquire a high temperature should be avoided.

8.2. Maximum Refrigerant Load

According to EN 60335-2-24 international safety standards, the maximum load of flammable refrigerants in equipment for light commercial and domestic application is limited to 150 g

per unit. In addition, the refrigerant load may be either liquid or gaseous, as it is a pure fluid.

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