R-449A, A Low Global Warming Potential Refrigerant

A New Option for Environmental Test Chambers That Helps Combat Climate Change

Weiss Technik North America, Inc.

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Stand the Test of Time
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Summary

R-404A and similar refrigerants have been used in environmental simulation test chambers to enable optimum performance. However, it has been determined that they have a high global warming potential, and international agreements and regulations such as European Union Regulation No. 517/2014 and the Kigali Amendment to the Montreal Protocol aim to phase down these types of compounds. It is expected that R-404A will see a global price increase as well as reduced availability over the next few years, which is why customers need an alternative.

Weiss Technik North America, Inc. has been aware of these upcoming changes and is the first environmental simulation test chamber manufacturer to develop a widespread solution for the North American market. Environmental simulation test chambers are now available with Opteon™ XP40 (R-449A), which is a low global warming potential refrigerant, without sacrificing performance or reliability. R-449A meets the requirements of European Union Regulation No. 517/2014 while avoiding the future availability issues of R-404A. Not only is performance preserved, but customers that transition to R-449A help combat climate change by operating an environmental simulation test chamber with a low global warming potential refrigerant.

Introduction

Environmental simulation test chambers (test chambers) are used to test a variety of products across multiple market sectors, including circuit boards, laptops, jet engine components, natural and synthetic fabrics, and even entire hybrid/electric vehicles. The refrigerants responsible for transferring heat out of the test spaces containing these products have been synthesized to deliver optimum results, but some have been determined to have high global warming potential (GWP) values and will soon be impacted by international agreements and regulations. The price and availability are predicted to be heavily influenced by these coming changes, and users will soon need other options. It is important to take these changes into consideration today when purchasing new test chambers because they are often used for 15-20 years.

The purpose of this white paper is to provide background on how refrigerants impact the environment, outline how other industries can increase low GWP refrigerant use, and explain why test chamber users should shift away from high GWP refrigerants, and present a low GWP refrigerant solution they can currently transition to.

Problem Statement

Test chambers use a complex refrigeration cycle to extract heat from a test space into a refrigerant and away from the system. The selected refrigerant greatly impacts the performance of the test chamber, but the refrigerant can be inadvertently released into the atmosphere when the refrigeration system is decommissioned, serviced, or charged. This makes the initial selection of refrigeration crucial because some refrigerants have a high ozone depleting potential (ODP) and/or GWP value, which means some are more harmful to the environment than others.

Refrigerants, in addition to commonly used household substances, used to be made of molecules that contained chlorine. When these gases were released into the atmosphere, the ultraviolet radiation from the sun would break a chlorine atom loose from the rest of the refrigerant molecule. The chlorine atom would separate an ozone molecule (O_3) into diatomic oxygen (O_2) by bonding with one of the oxygen atoms. The amount of O_3 broken down into O_2 by a substance determines its ODP value, with larger values being more harmful. This is referenced against the same amount of trichlorofluoromethane, which has an ODP value of 1[1]. This phenomenon was a substantial contributor to the depletion of the ozone layer, most prevalent above Antarctica.

Once the science of ODP and ozone depleting substances (ODS) was understood, the nations of the world came together and decided ODS needed to be phased out. The collaboration resulted in the Montreal Protocol, which was an international agreement signed by every member of the United Nations. Every member nation agreed to phase out ODS when the agreement was finalized in 1987, and the ozone layer is now showing signs of improvement[2].

The Montreal Protocol was extremely successful in preventing further damage to the ozone layer, but it has been recently discovered that some of the new compounds (including refrigerants) that replaced older ODS over the past few decades have been contributing to the earth's rising temperatures. This is because they have high GWP values.

GWP illustrates how much energy (heat) a gas will absorb, or in other words, how much impact a compound has on Earth's rising temperatures. It is referenced against the same amount of carbon dioxide (CO_2) over a set time frame, usually 100 years[3]. As CO_2 is the reference, it has a GWP value of 1, which means substances with lower GWP values are more environmentally friendly. R-404A is a refrigerant commonly used in compressors for test chambers and has a GWP value of 3,922[4]. When compared with equal amounts of CO_2, R-404A is a larger contributor to global warming because it stores 3,922 times more energy.

R-404A is not the only refrigerant in the industry, but it is primarily used in test chambers. Gases with similar chemical structures to R-404A are classified as hydrofluorocarbons (HFCs), and now that climate science is better understood and supported, they will soon be regulated because the nations of the world agreed that these high GWP substances should not be used.

The European Union Regulation No. 517/2014 (F-Gas) initiated a mandatory phasedown for HFCs, which began in 2015. In addition to the phase down, it states that new sales of commercial refrigeration equipment in the European Union utilizing refrigerants with GWP values above 2,500 will be banned beginning January 1st, 2020 (excludes low stage compressor refrigerant for cascade systems)[5]. Another HFC phasedown program is the Kigali Amendment to the Montreal Protocol (Kigali Amendment), which was added to the Montreal Protocol in 2016, and set various goals for different global regions[6]. These phasedown programs are shown in Figure 1[5,6].

While F-Gas has a goal to remove 79% of HFCs from the European market by 2030, and the Kigali Amendment is expected to prevent a global temperature increase up to 0.5 degrees Celsius, these programs are predicted to limit the global supply of R-404A and similar refrigerants[5,6]. It can be expected that the price of these refrigerants will increase exponentially as the phasedown programs take effect, especially since Honeywell (large R-404A manufacturer) plans to stop producing R-404A in Europe in 2018[7].

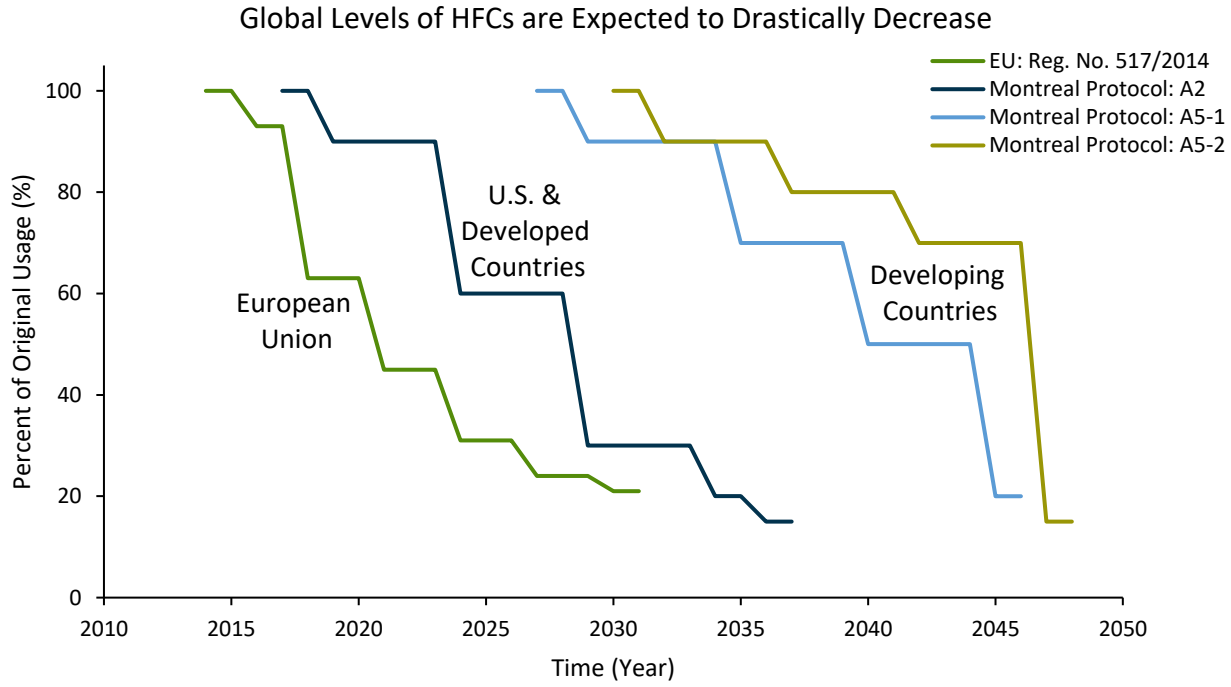

Figure 1: Global HFC Phasedown Timeline[5,6]

While the international phase down agreements are predicted to greatly impact high GWP refrigerants, the GreenChill and Significant New Alternatives Policy (SNAP) Programs are expected to increase the domestic market adoption of low GWP refrigerants, making them more affordable and commercially available.

The Environmental Protection Agency's (EPA) GreenChill Program is a partnership with supermarkets and grocery stores, which encourages retailers to become more sustainable[8]. Some of the current GreenChill Partners include Aldi, Jewel-Osco, Kroger, Meijer, Price Chopper, Publix, Target, and Whole Foods, and the overall number of silver, gold, and platinum certifications has been steadily increasing since the program's start in 2008[9,10]. This trend is crucial to both test chamber manufacturers and users because supermarkets and grocery stores consume large amounts of refrigerant and have the power to set precedence on how and what refrigerants are used. Figure 2 shows a map of partner stores as of December 2017[11].

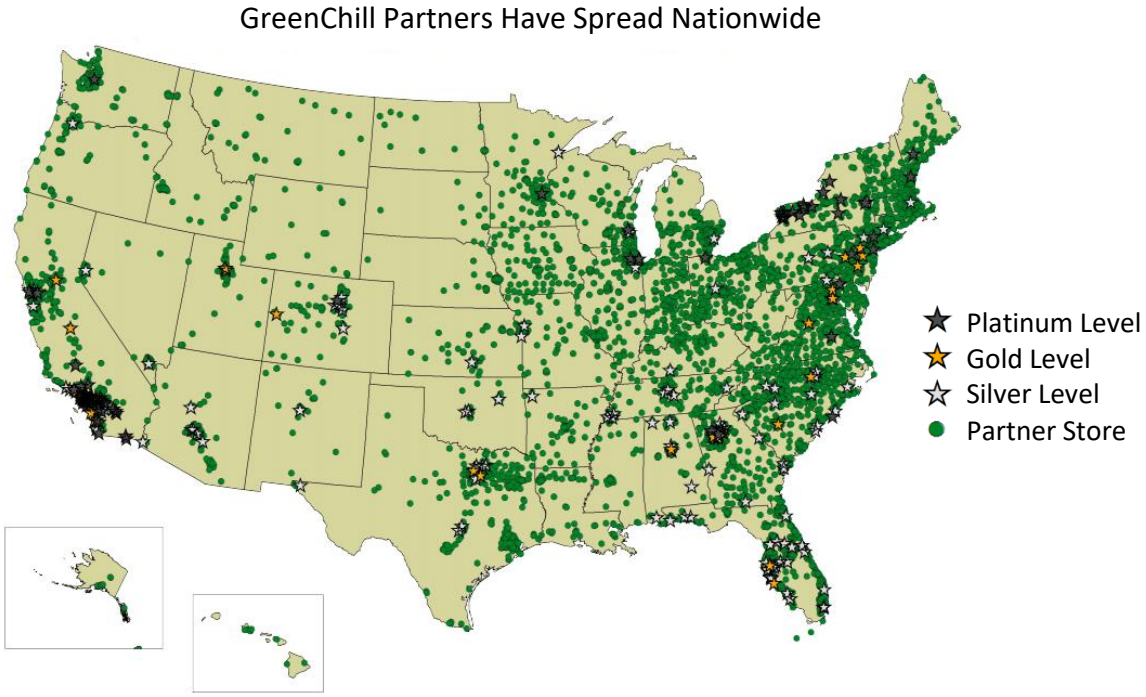

Figure 2: Location of GreenChill Partner Stores[11]

Considering the typical supermarket in the United States utilizes R-404A and contributes more CO_2 equivalent emissions from leaked refrigerant than from electricity consumption, the increase in certifications shows a positive trend of companies wanting refrigeration systems that impact the environment less, and retailers can drastically reduce their CO_2 equivalent emissions by transitioning to a low GWP refrigerant[12].

If retailers were to switch their refrigeration systems to R-449A, which is a low GWP refrigerant (designed to replace R-404A) with an ODP value of 0, CO_2 equivalent emissions originating from leaked refrigerant could be reduced by ~65% as R-449A has a GWP value of 1,397 and R-404A has a GWP value of 3,922[13,4].

In addition to R-404A, R-22 is another commonly used refrigerant, but the EPA's SNAP program is banning all new production of R-22 beginning January 1st, 2020 because the goal of the program is to promote safe replacements for ODS[14,15]. Even though R-449A was designed to replace R-404A, The Chemours Company (manufacturer of R-449A) published a multi-year study to determine if it was a suitable replacement for R-22. The study concluded that R-449A was in fact a viable alternative to R-22 for low and medium temperature applications[13].

The test chamber market needs a low GWP alternative that delivers the same performance and reliability as R-404A because F-Gas and the Kigali Amendment are expected to limit the supply of high GWP refrigerants, and the GreenChill and SNAP Programs show potential widespread use of R-449A domestically. An alternative would not only help avoid the expected price increases, but more importantly, would contribute to the global movement of environmental sustainability. Figure 3 shows 2 global temperature snapshots and reveals how quickly the earth is heating up[16]. Any transition from a high to low GWP refrigerant would help combat climate change by bringing the world's population a step closer to reaching the goals set by F-Gas and the Kigali Amendment.

Weiss Technik North America, Inc. tasked itself with delivering a solution. Years of collaborated research was conducted with Weiss Umwelttechnik, GmbH, to fully understand low GWP refrigerants. The data guided the design and construction of prototypes, which were then optimized for industrial use. After all testing was completed, the result was successfully changing a refrigeration system's refrigerant from R-404A to R-449A, which is a low GWP refrigerant, without sacrificing performance or reliability.

Global Temperatures are Rapidly Increasing

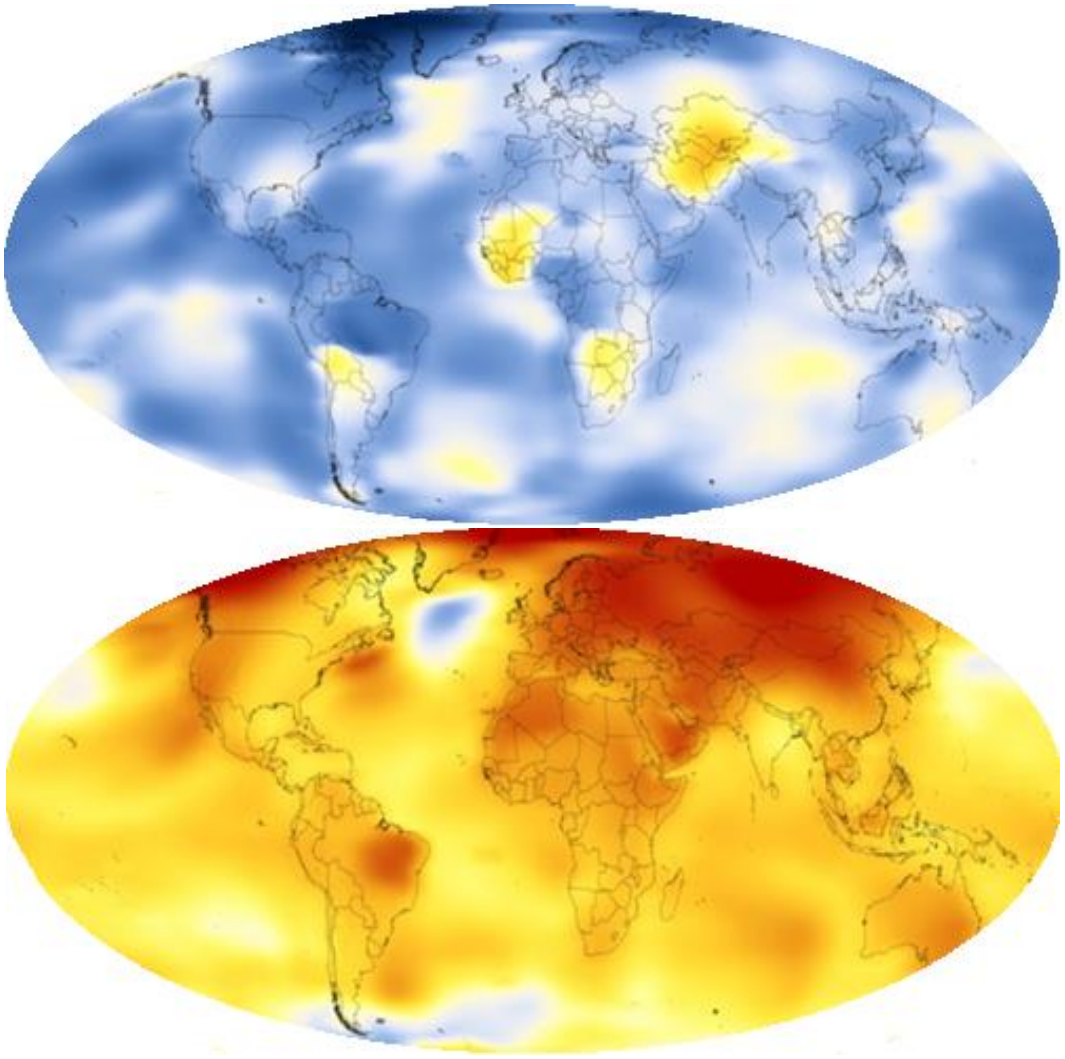

Figure 3: Global Temperature Increase from 1917 to 2017[16]

Solution

R-449A is now available in new Weiss Technik North America, Inc. test chambers in place of R-404A without a reduction in performance, backed by over 32,000 testing hours by the Weiss Group. Table 1 shows the compositional breakdown between R-404A and R-449A, and the new composition of R-449A results in a GWP value that is almost 3 times lower than R-404A (1,397 and 3,922, respectively)[4,17]. Not only is R-449A's GWP value lower, it also has an ODP value of 0, as well as the same non-toxic and non-flammable ratings as R-404A[4]. While the environmental benefits are considerable, users need to have access to R-449A for maintenance and servicing purposes. Weiss Technik North America, Inc. has confirmed with The Chemours Company that an authorized distribution network has been established which covers the United States, Canada, and Mexico, and most distributors have been increasingly adding stocks of R-449A for the past few years. If customers have any trouble locating a supply of R-449A, they should contact Chemours Customer Service at 1-800-441-9407.

For users that have an existing Weiss Technik North America, Inc. test chamber, there are 2 upgrades currently available featuring low GWP refrigerants. The first is a drop-in replacement, Opteon™ XP44 (R-452A) with a GWP value of 2,141, shown in Figure 4[17]. While the change out is not complicated, internal tests have shown approximately a 10% reduction in performance. The second option utilizes R-449A. Performance is preserved, but only after specifically engineered mechanical modifications are made to the refrigeration system. Users will need to conduct a cost-benefit analysis to determine if the cost savings of R-452A outweighs the expected performance losses. Given the international agreements and regulations (and similar to the European market), it is reasonable to expect that the price of higher GWP HFCs will increase over time, making low GWP solutions even more cost-effective.

If users want to benefit from a test chamber that utilizes a low GWP refrigerant, Weiss Technik North America, Inc. recommends purchasing a new test chamber equipped with R-449A. Not only would R-449A support individual companies' initiatives to become more sustainable, it would help companies avoid future refrigerant availability issues as well as avoid future modification costs. Companies with international presence would also be able to ship chambers into Europe because R-449A has a GWP value below the 2,500 F-Gas limit, shown in Figure 4[17].

Table 1: Compositional Breakdown Between R-404A and R-449A[17]

Base Compound	R-404A	R-449A
R-143A	52%	0%
R-32	0%	24%
R-125	44%	25%
R-134A	4%	26%
R-1234YF	0%	25%

Weiss Technik North America, Inc. Offers Low GWP Solutions

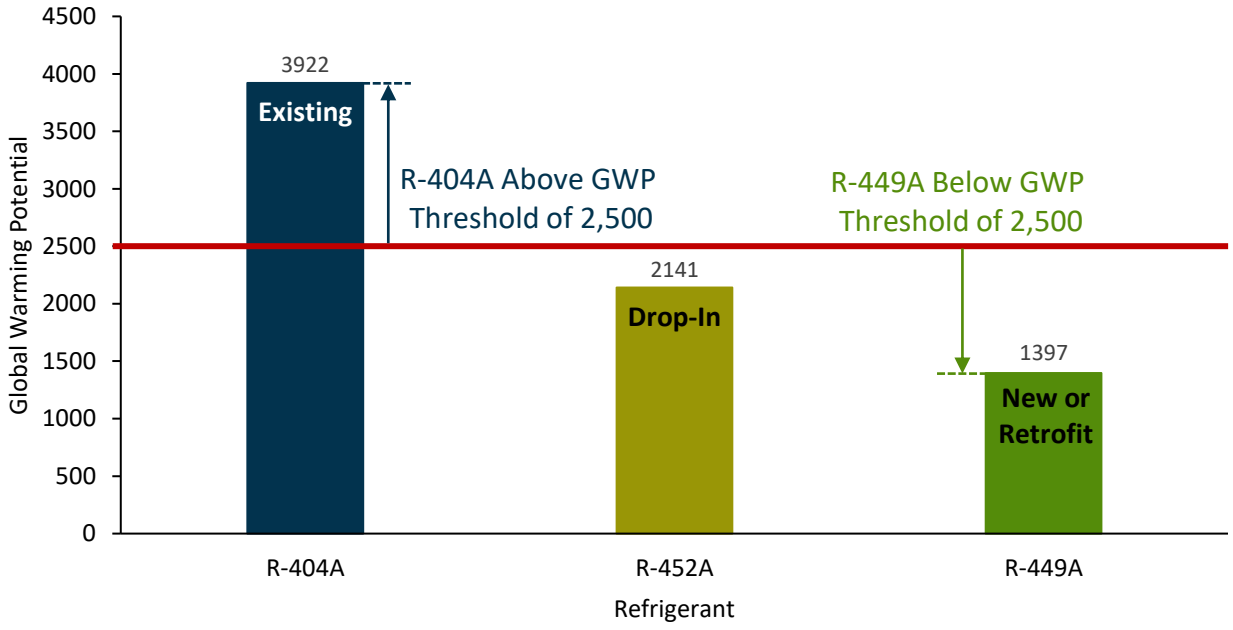

Figure 4: GWP Comparison of R-404A, R-452A, and R-449A[17]

Conclusion

F-Gas and the Kigali Amendment prove that the nations of the world have agreed the practice of using and consuming high GWP refrigerants needs to stop, and the SNAP and GreenChill Programs show a domestic trend of wanting refrigeration systems that impact the environment less. R-449A has been determined to be more environmentally friendly because of its lower GWP value, and after thorough testing, it was confirmed to be a viable alternative for R-404A in test chambers. Weiss Technik North America, Inc. is proud and confident to offer its customers this option and to help lower the overall carbon footprint of environmental simulation test chambers.

Future Projects & Additional Information

R-449A, a low GWP refrigerant, is a more environmentally friendly alternative to R-404A for test chambers, without resulting in reductions in performance. Weiss Technik North America, Inc. is continuing to research various refrigeration topics to further understand the capabilities and limitations of low GWP refrigerants. More announcements will be made as projects are completed and released.

LEEF® Technology is now available with R-449A. For more information, please see the white paper posted online:
https://weiss-na.com/wp-content/uploads/LEEF™-Technology-White-Paper.pdf

For any questions, please visit the Weiss Technik North America, Inc. website at:
www.weiss-na.com or call 616-554-5020.

List of Abbreviations and Acronyms

CO_2	Carbon Dioxide
EPA	Environmental Protection Agency
F-Gas	European Union Regulation No. 517/2014
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
Kigali Amendment	Kigali Amendment to the Montreal Protocol
O_2	Diatomic Oxygen
O_3	Ozone
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substance
R-449A	Opteon™ XP40
R-452A	Opteon™ XP44
SNAP	Significant New Alternatives Policy
Test Chamber	Environmental Simulation Test Chamber

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