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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.

White Paper
2018

Stand the Test of Time

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Michael Stratton
Product Engineer

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].

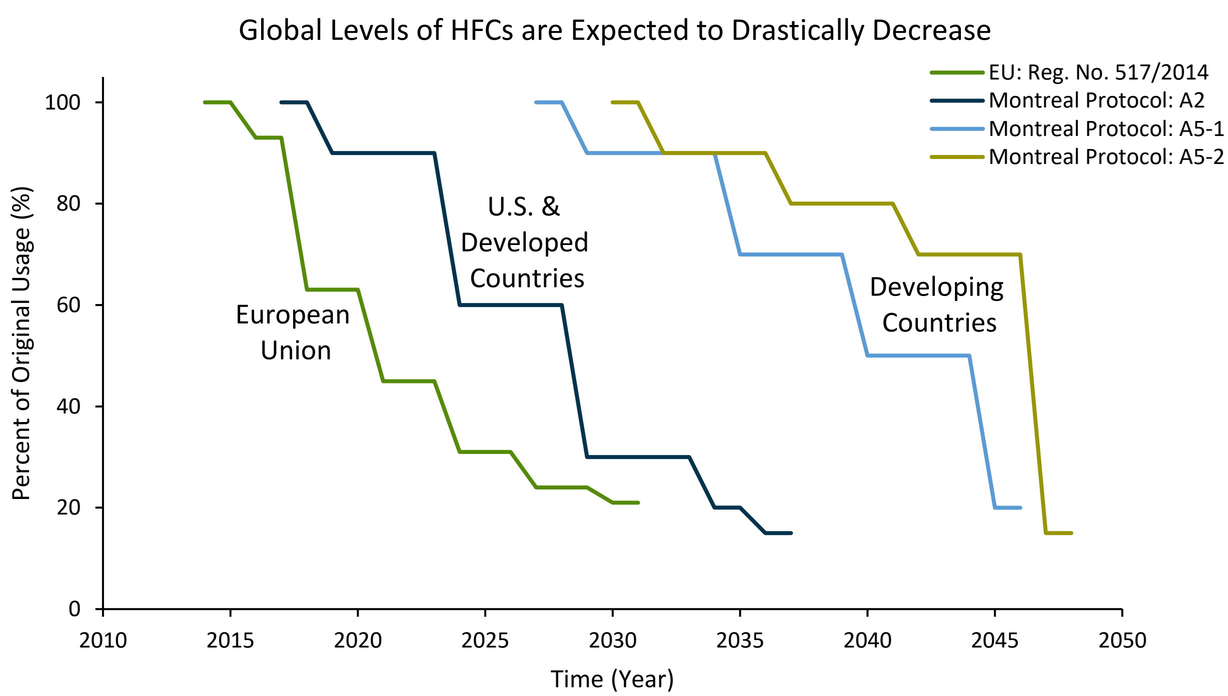


Figure 1: Global HFC Phasedown Timeline[5,6]

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].

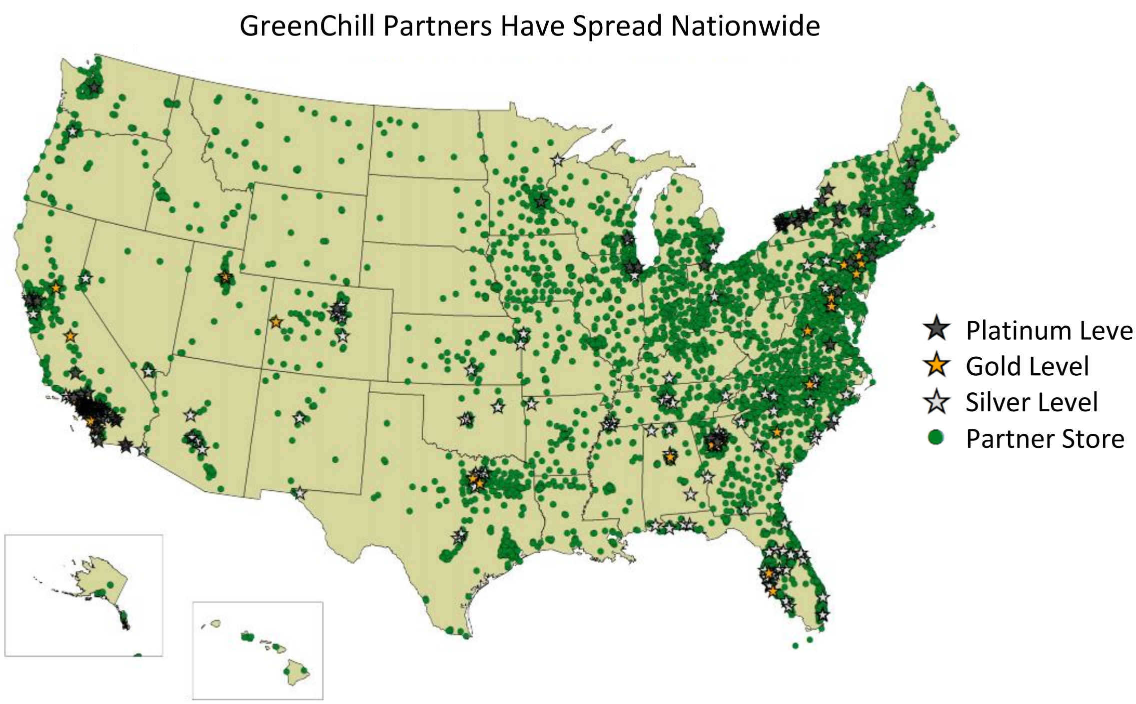


Figure 2: Location of GreenChill Partner Stores[11]

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

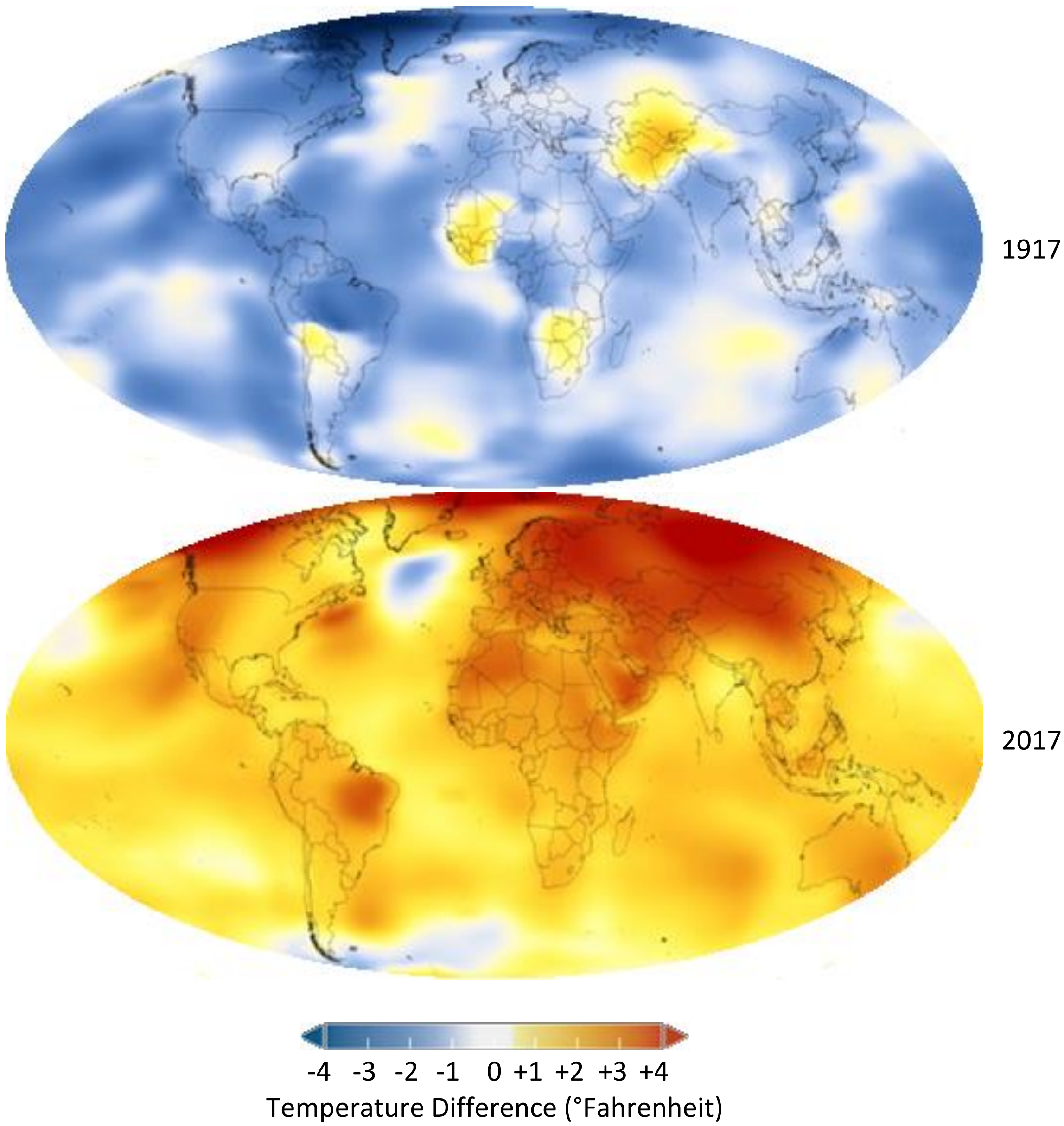


Figure 3: Global Temperature Increase from 1917 to 2017[16]

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%

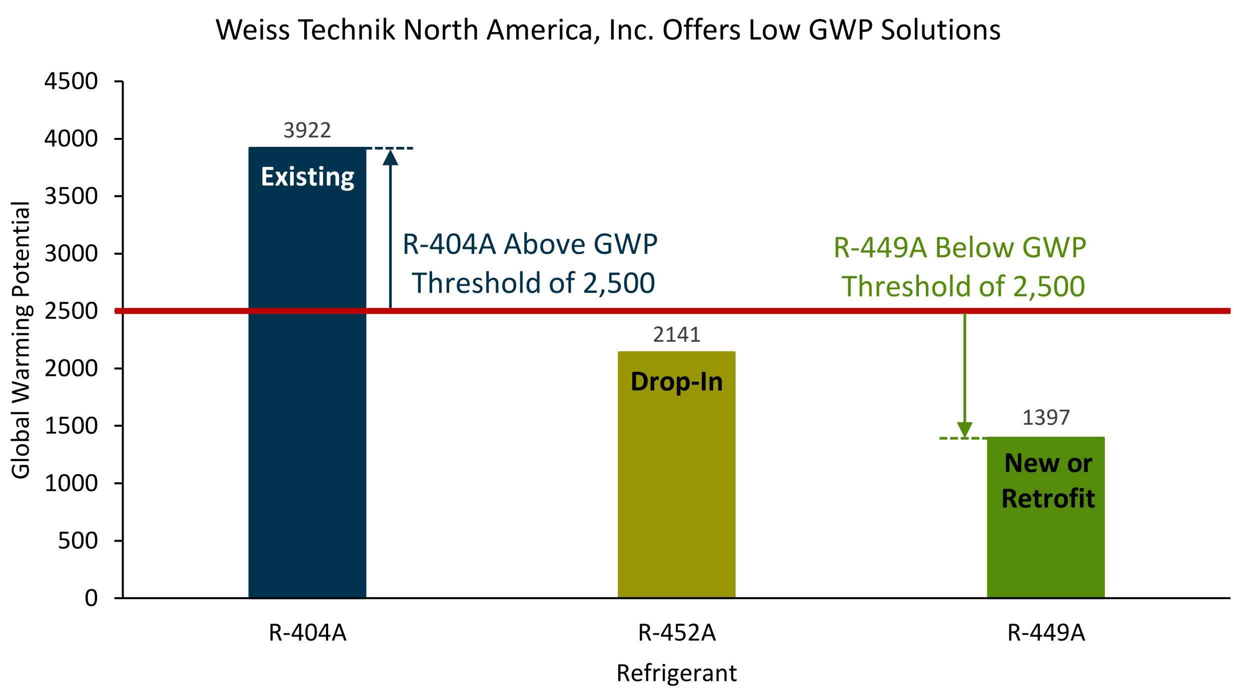


Figure 4: GWP Comparison of R-404A, R-452A, and R-449A[17]

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

References

1) National Aeronautics and Space Administration. *NASA Ozone Watch*.
https://ozonewatch.gsfc.nasa.gov/facts/eesc_SH.html
2018 (Last visited 7/27/2018).

2) United States Department of State. *The Montreal Protocol on Substances That Deplete the Ozone Layer.*
https://www.state.gov/e/oes/eqt/chemicalpollution/83007.htm
2018. (Last visited 7/27/2018).

3) United States Environmental Protection Agency. *Understanding Global Warming Potentials*.
https://www.epa.gov/ghgemissions/understanding-global-warming-potentials
2018 (Last visited 7/27/2018).

4) The Linde Group. *R449A – Opteon® XP40.*
http://www.linde-gas.com/internet.global.lindegas.global/en/images/BAMPG_Refrigerants_R449A17_140677.pdf
2018 (Last visited 7/30/2018).

5) Official Journal of the European Union. *Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014*.
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0517&from=EN
2018 (Last visited 7/27/2018).

6) United States Environmental Protection Agency. *Update on Kigali Amendment to the Montreal Protocol*.
http://www.epa.gov/sites/production/files/2016-11/documents/newberg_kigaliamend_122016.pdf
2018 (Last visited 7/27/2018).

7) Honeywell Refrigerants. *Think about tomorrow today.*
https://www.honeywell-refrigerants.com/europe/wp-content/uploads/2017/03/honeywell-nomore404A-phase-out-information.pdf
2018 (Last visited 7/27/2018).

8) United States Environmental Protection Agency. *About GreenChill.*
https://www.epa.gov/greenchill/about-greenchill
2018 (Last visited 7/30/2018).

9) United States Environmental Protection Agency. *GreenChill Partners.*
https://www.epa.gov/greenchill/greenchill-partners#retailers
2018 (Last visited 7/30/2018).

10) United States Environmental Protection Agency. *GreenChill Store Certification Trends.* https://www.epa.gov/greenchill/greenchill-store-certification-trends 2018 (Last visited 7/30/2018).

11) United States Environmental Protection Agency. *GreenChill Program as of December 2017.* https://www.epa.gov/sites/production/files/2018-02/documents/gc_map_thru_december_2017.pdf 2018 (Last visited 7/30/2018).

12) United States Environmental Protection Agency. *Profile of an Average U.S. Supermarket's Greenhouse Gas Impacts from Refrigeration Leaks Compared to Electricity Consumption.* https://www.epa.gov/sites/production/files/documents/gc_averagestoreprofile_final_june_2011_revised_1.pdf 2018 (Last visited 7/31/2018).

13) The Chemours Company. *Multi-Year Evaluation of R-449A as a Replacement for R-22 in Low Temperature and Medium Temperature Refrigeration Applications.* https://www.chemours.com/Refrigerants/en_US/products/Opteon/Stationary_Refrigeration/assets/downloads/multi-year-evaluation-of-r-449a-as-a-replacement-for-r-22-in-refrig-apps-paper.pdf 2018 (Last visited 8/13/2018).

14) United States Environmental Protection Agency. *Revised Draft Analysis of U.S. Commercial Supermarket Refrigeration Systems.* https://www.epa.gov/sites/production/files/documents/EPASupermarketReport_PUBLIC_30Nov05.pdf 2018 (Last visited 7/30/2018).

15) United States Environmental Protection Agency. *GreenChill Regulatory Context.* https://www.epa.gov/greenchill/greenchill-regulatory-context 2018 (Last visited 7/30/2018).

16) National Aeronautics and Space Administration. *Global Temperature. Time Series: 1884 to 2017*. https://climate.nasa.gov/vital-signs/global-temperature/ 2018 (Last visited 7/30/2018).

17) Tecumseh. *Guidelines for using R449A/R452A*. http://www.ecr-nederland.nl/files/documentatie_tecumseh_guidelines_r449a_r452a_gb.pdf 2018 (Last visited 7/27/2018).

Opteon™ XP40

Refrigerant (R-449A)

The Optimal Solution for Environmental Test Chambers

Weiss Technik demonstrates how smaller-sized equipment running on R-404A can easily make the switch to a sustainable refrigerant solution.

Replicating the variabilities of Mother Nature is no walk in the park. To reliably simulate a variety of climatic conditions, environmental testing facilities require adaptable systems with precise process control. A key component of these test chambers is the refrigerant. For decades, R-404A has remained the refrigerant of choice in many environmental test chambers. The status quo is changing, however, as regulations drive the market toward alternatives with lower global warming potential (GWP)…without sacrificing performance. Weiss Technik North America, Inc., a leading manufacturer of environmental test chambers, has found a solution: Opteon™ XP40 (R-449A) by Chemours.

Chemours™

LOW GWP

A Global Designer of Environmental Test Chambers

Weiss Technik North America, Inc. (Weiss Technik), as part of the global Schunk Group enterprise, is a leader in the design and manufacture of these state-of-the-art testing systems. Weiss Technik offers environmental test chambers that range from bench-top to drive-in models and accommodate items from as small as laptop computers up to large automobiles. Depending on the scale of the system, the refrigerant charge size is between 3-80 lb. These chambers are designed to mimic a variety of environmental conditions via manipulation of temperature, humidity, air pressure, and other variables. To enable this functionality, Weiss Technik's environmental test chambers must utilize refrigeration systems that meet demanding performance standards, while at the same time providing longevity—from both an operational/durability as well as regulatory standpoint.

"By leading the regulatory shift away from high GWP HFCs, Opteon™ XP40 is enabling Weiss Technik's test chambers to stand the test of time."

Phase-Down of High GWP Refrigerants

For many years, refrigerant R-404A has been commonly used in the environmental test chambers of Weiss Technik and others. R-404A has proven to be a reliable refrigerant that enables test chambers to meet testing protocols quickly, accurately, and precisely. However, as a pure hydrofluorocarbon (HFC) with a relatively high GWP of 3,922,[1] R-404A has been under the spotlight as regulations focus on phasing down high GWP refrigerants.

Regulations Driving Change

A critical international regulatory milestone was the 2016 Kigali Amendment to the Montreal Protocol. Although not yet ratified in the U.S., this agreement has been adopted by over 80 countries as of October 2019 and puts in place the framework to phase down the use of HFC refrigerants by more than 80% over the next 30 years.

European countries have taken steps to ensure compliance through the EU F-gas regulation. A key component of the EU regulation is the prohibition, starting in 2020, of R-404A in new stationary refrigerant systems and "virgin" R-404A for servicing existing systems. In Germany, Weiss Technik's parent company, Weiss Umwelttechnik, identified the R-404A issue early and reacted swiftly to find an alternative refrigerant for their environmental test chambers. After an initial meeting at the Chillventa conference in 2014, Weiss Umwelttechnik worked closely with Chemours in evaluating Opteon™ refrigerants—a portfolio of environmentally sustainable, hydrofluoroolefin (HFO)-based, lower GWP refrigerants as potential solutions.

In Europe, Weiss Umwelttechnik ultimately selected Opteon™ XP40 (R-449A) as its replacement for R-404A in new test chambers and Opteon™ XP44 (R-452A) as a retrofit replacement for R-404A in existing chambers. With GWPs of 1,282 and 1,945 respectively,[1] Opteon™ XP40 and XP44 offer a significant GWP reduction. Furthermore, they have the credibility of being adopted by major transport refrigeration equipment and commercial refrigeration OEMs.

[1]GWP – IPCC Fifth Assessment Report (AR5)

Weiss Technik North America Selects Opteon™ XP40

In North America, measures are also being taken to drive the transition away from high GWP HFC refrigerants. In 2015, the U.S. Environmental Protection Agency (EPA) listed R-404A as "unacceptable" in various end uses under the Significant New Alternatives Policy (SNAP). Even though EPA SNAP rules 20 and 21 were later vacated in a court decision, a number of U.S. states have announced their intention to phase down the use of R-404A and other HFCs. For example, Michigan—the home of Weiss Technik's corporate headquarters—is one of a growing number of states who have joined the U.S. Climate Alliance: a bipartisan coalition committed to, and in the process of, reducing greenhouse gas emissions.

As R-404A is phased down in certain states, production and availability is likely to decline. Taking a proactive approach, Weiss Technik set out to find a suitable low GWP alternative refrigerant for North America. Following the lead of its German parent company, Weiss Technik also selected Opteon™ XP40 as the R-404A replacement for its environmental test chambers.

Opteon™ XP40—A Reliable, Low GWP Refrigerant

With a GWP of 1,282, Opteon™ XP40 offers a greater than 65% reduction in CO_2 equivalent emissions relative to R-404A (GWP = 3,922), meeting the sustainability goal of a GWP under 2,500 to ensure long-term restriction-free testing.

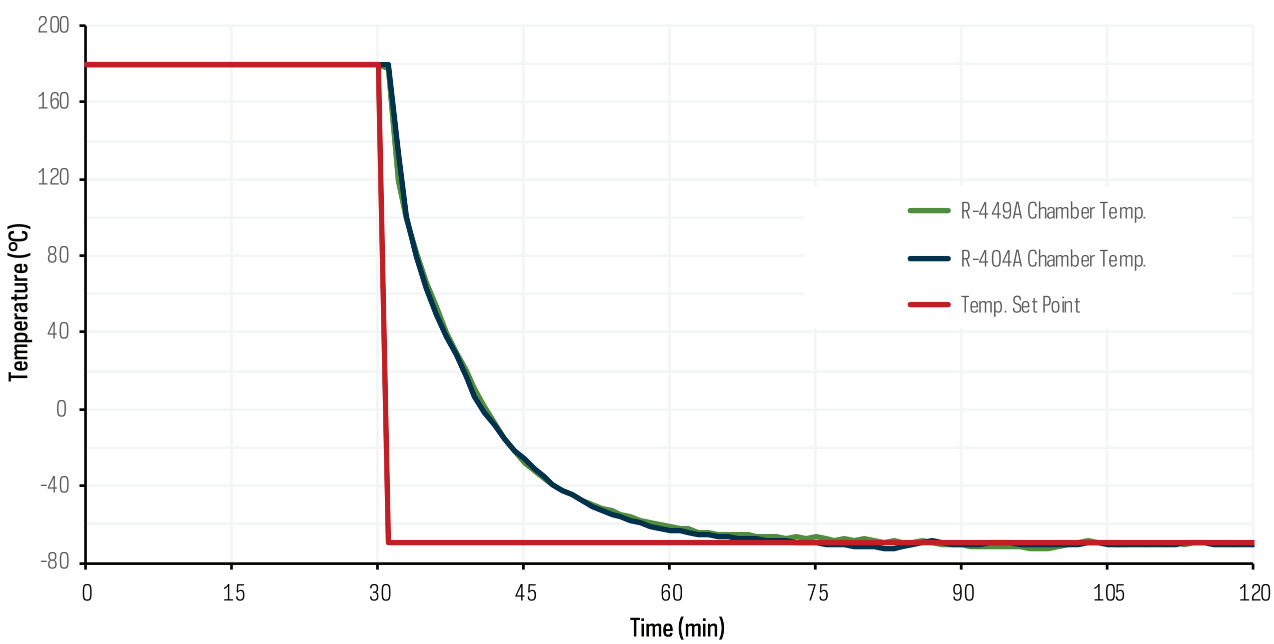
As is the case with any refrigerant replacement, however, it is important to consider not only GWP reduction, but meeting the existing performance standards of the equipment.

Weiss Technik's environmental test chambers are equipped with complex control systems designed to rapidly change temperature and humidity, as well as introduce stressors such as vibration and/or radiation. To accommodate the range of applications in industries that include automotive, electronics, or pharmaceuticals, operating temperatures ranging from 180 to -70°C (355 to -95°F), with rates of change that may exceed 25°C (45°F)/min, are a prerequisite. Chamber systems must be highly responsive to input parameters and able to reproduce climatic conditions precisely and accurately. Therefore, the performance and capability of these refrigeration units is clearly integral to the overall environmental test chamber operation.

One method Weiss Technik uses to assess performance is through temperature profile tests. After developing a system using Opteon™ XP40, Weiss Technik was able to achieve an identical temperature profile to an R-404A chamber with the same test volume and refrigerant charge size, and under the same test parameters,[2] as seen in **Figure 1**. By matching the performance standard of R-404A systems, XP40 is validated as a dependable and sustainable alternative refrigerant for this application.

[2]Industry standard IEC 60068-3-5

Figure 1. Opteon™ XP40 (R-449A) Matches the Performance of R-404A in Environmental Test Chambers Under Standard Conditions



Opteon™ XP40—An Optimal Alternative

Once sustainability and performance goals were confirmed, Weiss Technik needed to ensure Opteon™ XP40 would be readily available to serve their customers. Fortunately, XP40 is already used extensively in stationary commercial and industrial refrigeration systems—both new and converted—throughout the world, with well-established supply and distribution networks. Weiss Technik saw clear additional benefits in both the nonflammability of XP40, as well as cost stability over time as R-404A is phased down. With the optimal balance of sustainability, performance, and cost, Opteon™ XP40 was the ideal candidate to replace R-404A.

Stand the Test of Time

Backed by over 32,000 hours of testing, the conversion from R-404A is complete. Aside from a few exceptions—due to existing contracts or minor application restrictions—all new test chambers leaving the Weiss Technik production line are now equipped with Opteon™ XP40. Weiss Technik's customers take great satisfaction in knowing they are doing their part to combat climate change, as they perform testing with chambers that meet all of their demanding performance and reliability needs. By leading the regulatory shift away from high GWP HFCs, XP40 is enabling Weiss Technik's test chambers to stand the test of time, well into the future. The Weiss Technik Group is proud to be the first environmental test chamber manufacturer to develop and offer a low GWP testing solution, facilitated by Opteon™ XP40.

Scan here to find an Opteon™ XP40 stocking location near you.

For more information on the Opteon™ family of refrigerants, or other refrigerants products, visit opteon.com or call (800) 235-7882.

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LEEF® Technology

The Breakthrough Refrigeration Technology in Environmental Test Chambers That Produces High Energy Efficiency & A Lower Carbon Footprint

Weiss Technik North America, Inc.

White Paper
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Michael Stratton
Product Engineer

Summary

The design of refrigeration systems used by environmental simulation test chamber manufacturers has remained essentially unchanged for many years. However, as testing requirements have evolved, manufacturers have gradually increased compressor horsepower to provide greater cooling capacities. This method has provided reliable results, but refrigeration systems with larger compressor horsepower increase operating expenses by consuming more power. This needs to change because most of the United States' electricity is produced by using non-renewable resources, and any reduction in a company's electricity usage reduces its carbon footprint, in addition to providing cost savings. While a more efficient refrigeration system is needed, the design method of increasing compressor horsepower has become common practice in industry, with no one challenging this concept – until now.

A Patent Pending refrigeration system has been developed which offers the same cooling capacities as current market designs but can provide up to 40% energy savings on cooling requirements while simultaneously providing faster pull down rates and improved set point accuracy. This system was the result of collaboration between engineers in the United States and Germany after completing a rigorous analysis of their respective refrigeration systems. This innovation has been named "LEEF®", an acronym for "Leading Energy Efficiency Footprint®", which acknowledges the importance of environmental sustainability and corporate responsibility.

Introduction

Environmental simulation test chambers (test chambers) are used to test a variety of products across multiple market sectors, including server racks and cell phones, aircraft and spacecraft components, military equipment, textiles, and even entire automobiles. Over time, as test requirements and product specifications have evolved, users have adapted and updated their procedures and facilities to keep up with these changes, but the refrigeration systems responsible for their results have remained unchanged.

The purpose of this white paper is to explain why the current design surrounding test chamber refrigeration systems needs to change, as well as present a solution to the need for a lower operating cost refrigeration system.

Problem Statement

A widespread procedure for test chamber users is to load the product, decrease the temperature from ambient to cold, soak at the cold temperature, increase the temperature from cold to hot, soak at the hot temperature, and repeat the cycle. The product can be inspected at various points in the cycle or tested after all cycles have completed. The inspections can be focused on finding defects or meeting specific requirements, such as national or international regulatory standards, to ensure the product will not fail during its life cycle.

A common, overall temperature range for test chambers equipped with cascade refrigeration systems is -73° Celsius (C) to +180°C, and the test profile that users adhere to dictates how quickly the test chamber must change the test space conditions. The test profile could be an industry standard, written by in-house engineers, or commercially adopted from the military, to name a few possibilities.

Regardless of origin, test profiles have changed and will continue to change to keep pace with technology, market demands, and the latest safety requirements. A test profile that previously dictated a change rate of 1°C per minute may now demand a change rate of 2°C per minute, which requires an increase in cooling capacity within the same test space.

Test chamber manufacturers have achieved increased cooling capacities by increasing the size of the refrigeration system, and by default, compressor horsepower. While this method has been proven to provide reliable and sufficient results, it has a drawback – larger refrigeration systems require more power.

Figure 1 shows a near perfect linear relationship between cooling capacities and power needed to operate the system[1]. The trendline approximation shows that approximately twice as much power is required to operate a classic refrigeration system with twice as much cooling capacity. (The data and assumptions can be found in Appendix I.)

As users purchase test chambers with increased cooling capacities to meet new testing specifications and requirements, they are spending more capital on a new test chamber with a larger refrigeration system. Many users run their test chambers continuously to maximize throughput, so they are also significantly increasing their operating expenses by operating a test chamber with a larger refrigeration system. Figure 2 shows the average electricity prices in the United States since 2001[2]. These steadily increasing prices only add to the already increased operating expenses incurred by test chamber users, especially between July and September with the consistent spikes. The design of the classic refrigeration system for test chambers needs to change because current practices only produce more power-hungry equipment for users.

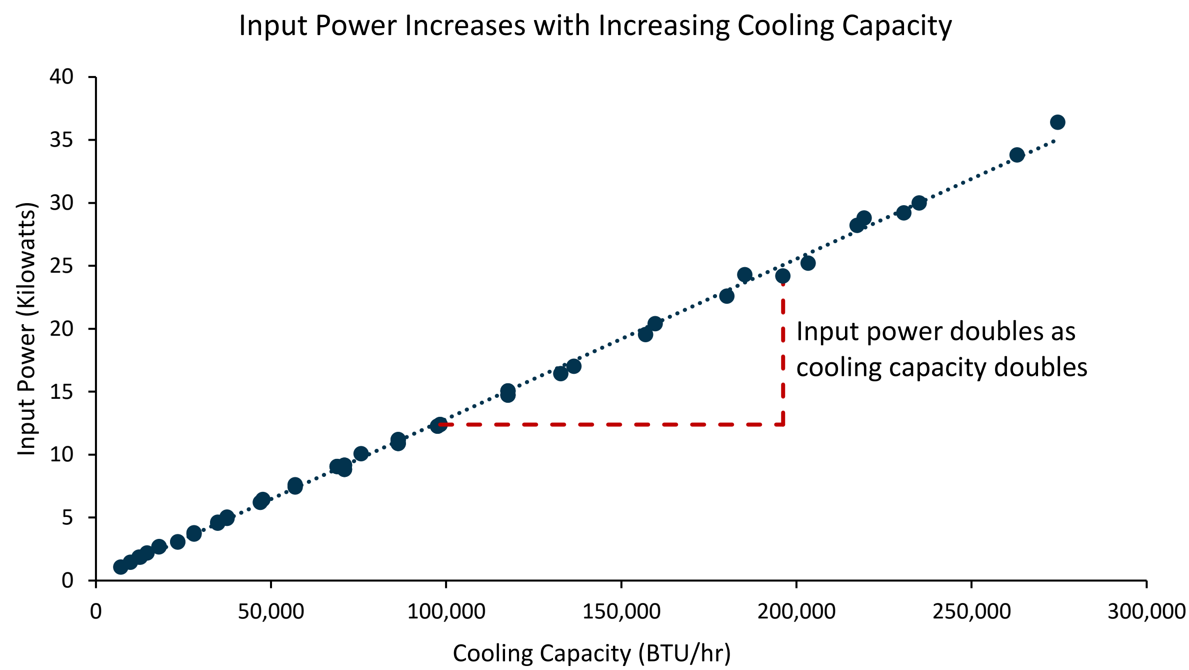

Figure 1: Relationship Between Input Power and Cooling Capacities[1]

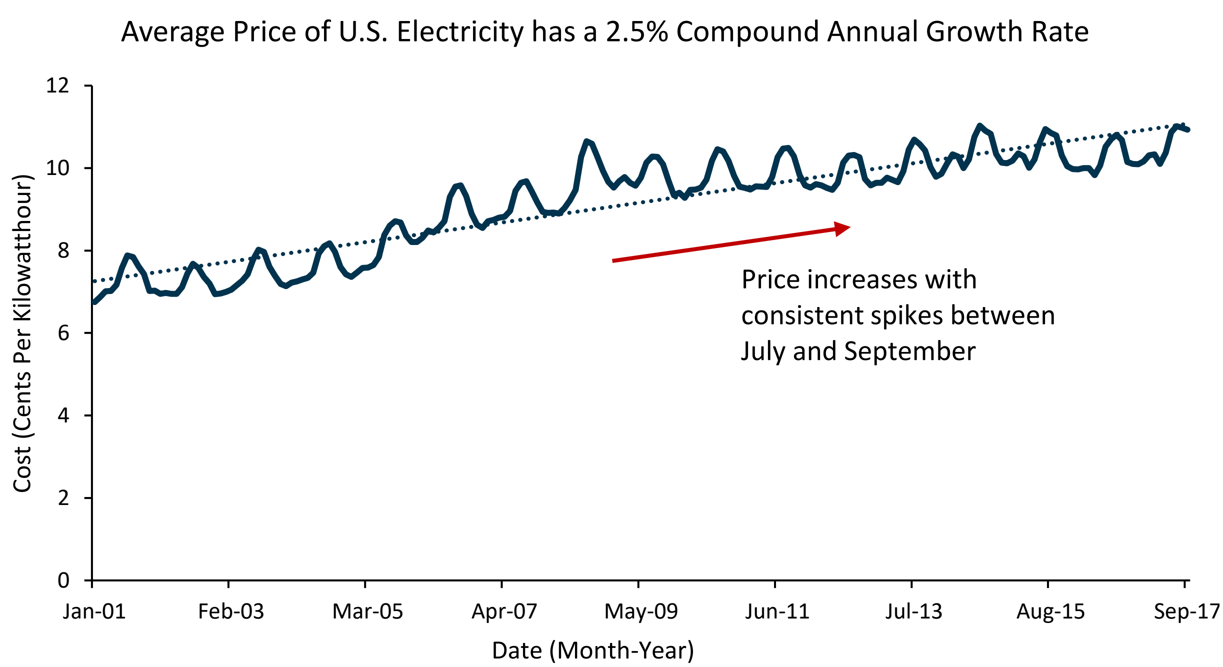

Figure 2: Average U.S. Electricity Price Since 2001[2]

The market needs a test chamber that has a more energy efficient refrigeration system. An energy efficient test chamber would reduce operating costs and, more importantly, would reduce carbon emissions in the electricity generation process.

Figure 3 shows the sources of the United States' electricity generation for 2016[3]. This shows how important it is to make improvements in energy efficiency. Any reduction in a company's electricity usage helps reduce the overall dependency on non-renewable resources.

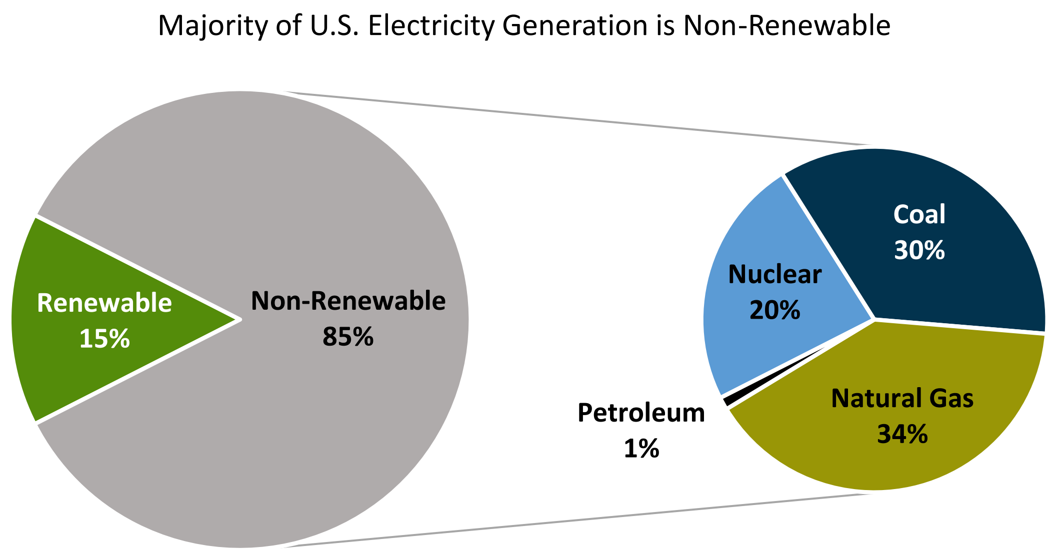

Figure 3: Sources of U.S. Electricity Generation, 2016[3]

Weiss Technik North America, Inc. tasked itself with delivering a solution. After 3 years of extensive research and development, collaborating with the German engineers of Weiss Umwelttechnik, GmbH, and rigorously analyzing the 2 companies' respective existing refrigeration systems, a new type of refrigeration system was developed. This system has been named "LEEF®", an acronym for "Leading Energy Efficiency Footprint®", which acknowledges the importance of environmental sustainability and corporate responsibility.

Solution

Figure 4 presents the LEEF® Technology (LEEF®) logo. Seeing this logo on a test chamber ensures users are doing their part to reduce the dependency of non-renewable resources by conducting tests with a refrigeration system that is up to 40% more efficient during cooling and provides faster change rates. In addition to helping users decrease their carbon footprint, LEEF® was also designed to obtain a smaller physical footprint, allowing users to better utilize their workspace.

Figure 4: LEEF® Technology Logo

The benchmark was an existing Weiss Technik North America, Inc. test chamber, which used a classic refrigeration system. It had a comparable test space volume and cooling capacity, and the comparisons were run using empty chambers and the same temperature set points.

The following figures are a few of the results from the final stages of in-house testing. The solid red lines are the temperature set points, solid green lines are real-time LEEF® data, solid blue lines are real-time classic refrigeration data, and dashed green and blue lines signify either averages or 1 standard deviation (σ) for the respective refrigeration systems.

An example of the improved energy efficiency is shown in Figure 5. It displays the results from a power profile test comparing LEEF® to a classic refrigeration system. This test was chosen to demonstrate power consumption differences at soak temperatures of +85°C, -40°C, and ambient, and to show differences during hot and cold change rates. In this example, LEEF® was 34% more energy efficient on average. While there was no significant difference during the +85°C soak, there were noticeable savings during the ambient soak, and the greatest energy savings occurred during the -40°C soak. Users can see up to 40% energy savings by soaking at colder temperatures for longer periods of time.

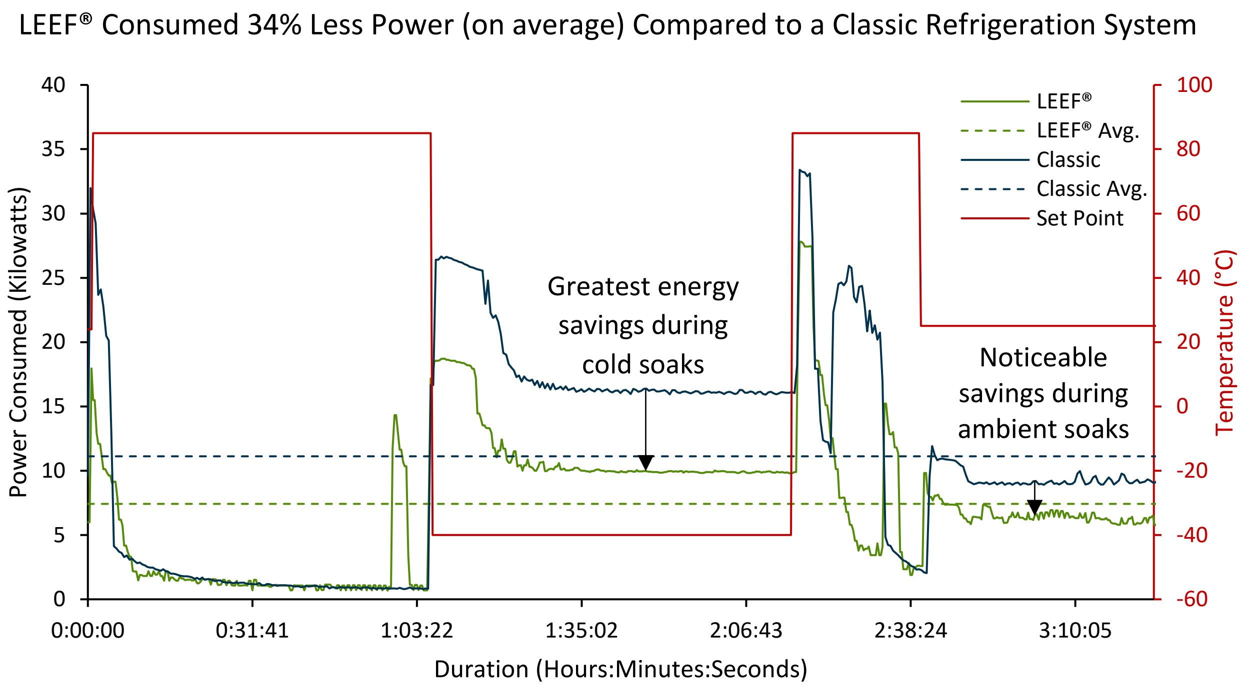

Figure 5: Power Profile Test Comparing LEEF® and Classic Refrigeration Systems

In addition to increased energy efficiencies, LEEF® delivers improved performance. An example is shown in Figure 6. It shows the same +85°C to -40°C pull down near the 1:03:22 mark of Figure 5, except measured temperature is displayed instead of power consumption. The test was measured per IEC 60068-3-5 (illustrated by dashed red lines), and LEEF® reached the lower -27.5°C IEC 60068-3-5 limit 63 seconds faster than the classic refrigeration system. Most test profiles demand multiple thermal cycles, and by reaching the set points faster, LEEF® can reduce overall testing time. The shortened testing time also contributes to lower operating expenses and reduced electricity usage.

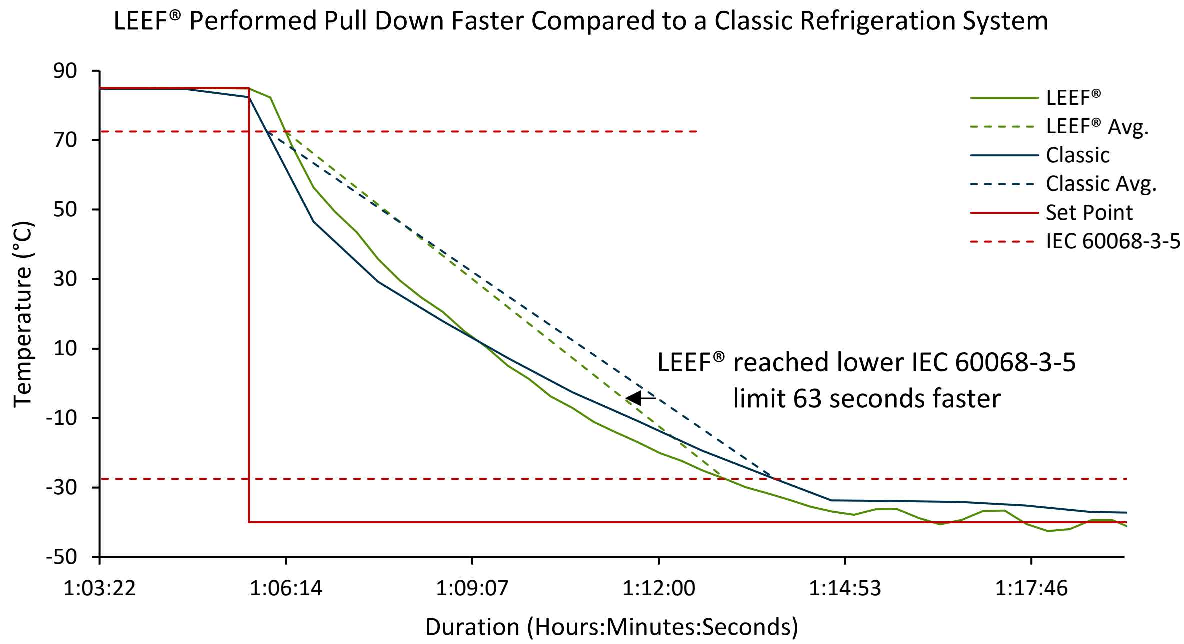

Figure 6: +85°C to -40°C Pull Down Comparing LEEF® and Classic Refrigeration Systems

Table 1 further analyzes the pull down from +85°C to -40°C in Figure 6. Despite having a slightly larger test space volume than the benchmark chamber with a classic refrigeration system, LEEF® had a 15.7% faster pull down rate and consumed 35.7% less power (on average) in the process.

Users will also see improved set point accuracy with LEEF®. While it was tested against the classic refrigeration system over a wide range of conditions, Figure 7 shows the improved accuracy at 2 common soak temperatures (+85°C and -40°C), after temperatures had stabilized for both systems. In each case, the control with LEEF®, was more accurate than the classic refrigeration system. It was also concluded that at the +85°C soak temperature, the standard deviation of LEEF® is less than the classic refrigeration system at a 95% confidence level.

Table 1: +85°C to -40°C Comparison Between LEEF® and Classic Refrigeration Systems

	LEEF®	**Classic**
Empty Test Space Volume (Cubic feet)	40.8	36.7
IEC 60068-3-5 Change Rate (°C per minute)	14.7 **(15.7% faster)**	12.7
Average Power Consumed (Kilowatts)	16.2 **(35.7% lower)**	25.2

LEEF® Provided Improved Accuracy Compared to a Classic Refrigeration System

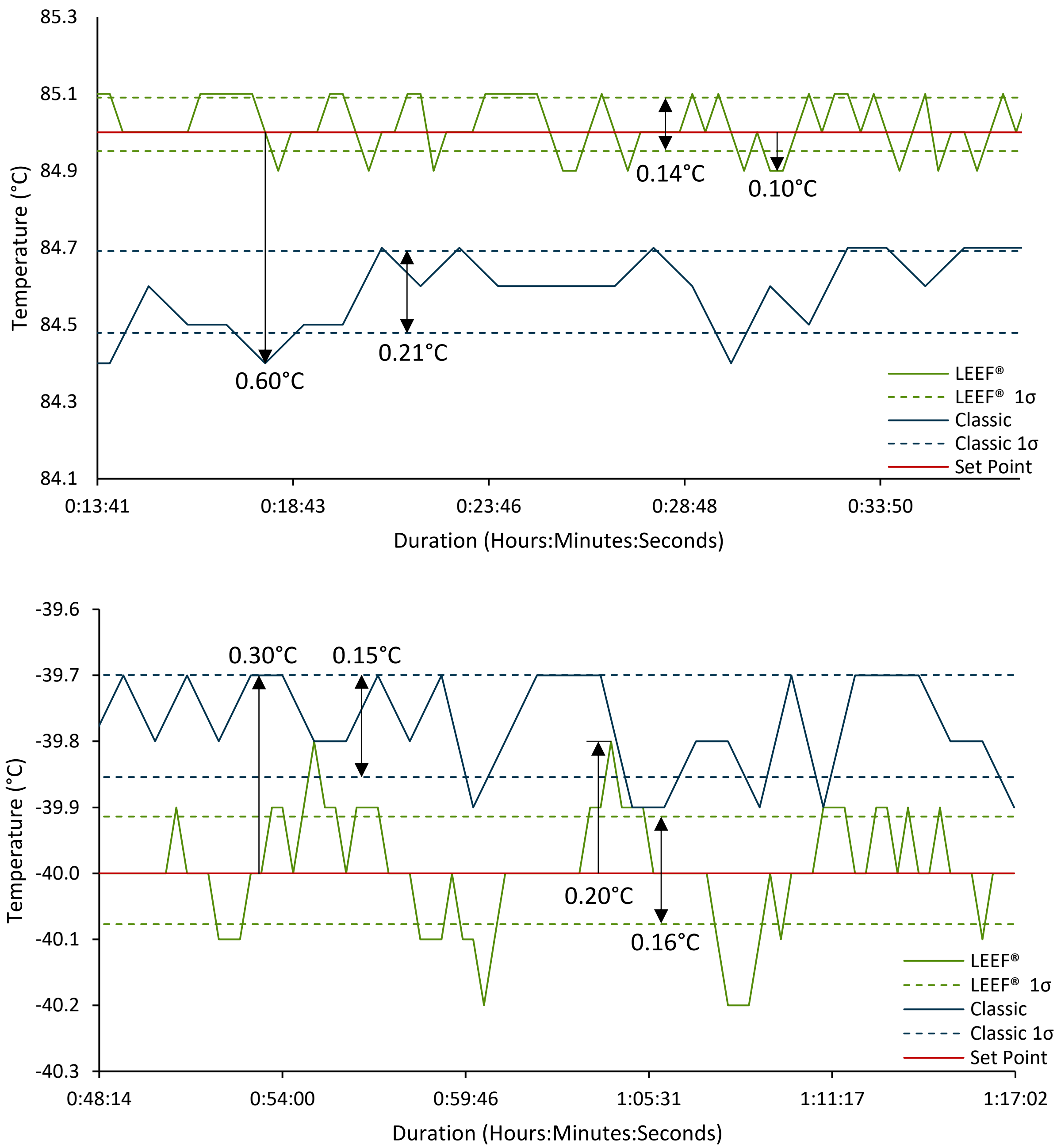

Figure 7: Temperature Fluctuation Comparison Between LEEF® and Classic Refrigeration Systems

Conclusion

After years of refrigeration systems growing larger and more expensive, Weiss Technik North America, Inc. has developed a solution to stop this negative trend. LEEF® Technology provides improved performance and set point accuracy at a lower operating cost compared to a classic refrigeration system. Test chambers with this technology will allow users to perform their needed tests and contribute to the movement of environmental sustainability by operating a refrigeration system that offers the same cooling capacities as current market designs but can provide up to 40% energy savings on cooling requirements.

Future Projects & Additional Information

The improved performance and energy efficiency of LEEF® has been proven, and Weiss Technik North America, Inc. is currently working on expanding the capabilities of LEEF® Technology so it can be incorporated into existing product lines that currently use classic cascade refrigeration systems. This will result in higher quality products, reduced operating costs for test chamber users, and it will contribute to the movement of environmental sustainability. More announcements will be made as projects are completed and released.

LEEF® Technology is also available with R-449A. Please consult your sales representative for more information.

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

References

1) Bitzer. *Software v6.7.0 rev1879.*
   https://www.bitzer.de/websoftware/Calculate.aspx?cid=1513776958699&mod=HHK
   2017 (Last visited 12/20/2017).

2) U.S. Energy Information Administration. *Electricity Data Browser.*
   https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0,1&geo=g&endsec=vg&linechart=ELEC.PRICE.US-ALL.M~~~~~&columnchart=ELEC.PRICE.US-ALL.M~ELEC.PRICE.US-RES.M~ELEC.PRICE.US-COM.M~ELEC.PRICE.US-IND.M&map=ELEC.PRICE.US-ALL.M&freq=M&start=200101&end=201709&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0
   2017 (Last visited 12/29/2017).

3) U.S. Energy Information Administration. *Electricity in the United States.*
   https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states
   2017 (Last visited 12/29/2017).

Appendix I: Raw Data for Figure 1 - Relationship Between Input Power and Cooling Capacities

The following data was obtained using Bitzer's online software[1]. The following assumptions were made:

- Compressors: Semi-hermetic reciprocating
- Refrigerant: R404A
- Reference Temperature: Dew Point
- Single compressor
- Evaporating Saturated Suction Temperature: -10°C
- Condensing Saturated Discharge Temperature: 45°C
- Voltage: 460 V
- Frequency: 60 Hz
- Suction gas temperature: 20°C
- Liquid Subcooling Temperature: 0 K
- Operating Mode: Auto
- Capacity Control: Without
- 1 kW = 3,412.142 BTU/hr
- Only compressor model was changed
- Compressors with similar capacities and input power were excluded from this list but were included in Figure 1

Represented Model	Cooling Capacity (kW)	Cooling Capacity (BTU/hr)	Input Power (kW)
2KES-05Y	2.08	7,097	1.06
2JES-07Y	2.88	9,827	1.45
2HES-1Y	3.62	12,352	1.86
2GES-2Y	4.29	14,638	2.18
2FES-2Y	5.29	18,050	2.71
2EES-2Y	6.85	23,373	3.09
2DES-2Y	8.22	28,048	3.78
2CES-3Y	10.19	34,770	4.64
4FES-3Y	10.99	37,499	5.04
4EES-4Y	13.97	47,668	6.44
4DES-5Y	16.69	56,949	7.60
4CES-6Y	20.2	68,925	9.06
4BES-9Y	22.2	75,750	10.08
4TES-9Y	25.3	86,327	11.19
4PES-12Y	28.8	98,270	12.39
4NES-14Y	34.5	117,719	15.06
4JE-15Y	40	136,486	17.03
4JE-22Y	38.9	132,732	16.43
4HE-18Y	46.8	159,688	20.40
4GE-23Y	54.3	185,279	24.30
4GE-30Y	52.8	180,161	22.60
4FE-28Y	64.3	219,401	28.80
4FE-35Y	63.7	217,353	28.20
6JE-25Y	59.6	203,364	25.20
6HE-28Y	68.9	235,097	30.00
6GE-34Y	80.5	274,677	36.40
6GE-40Y	77.1	263,076	33.80