

June 12, 2015

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RE: Comments by Honeywell International Inc. on the May 7, 2015 Concept Paper, “Short-Lived Climate Pollutant Reduction Strategy”

Dear Mr. Tollstrup,

Honeywell International Inc. (“Honeywell”) submits these comments in response to the paper issued by the California Air Resources Board (ARB) titled, “Short-Lived Climate Pollutant Reduction Strategy” (“Concept Paper”). We appreciate the opportunity to provide additional input into ARB’s process to craft a strategy to move away from high global warming potential (GWP) products toward more environmentally beneficial alternatives and applaud ARB’s efforts in developing a strategy that will pave the way for low-GWP substitutes across the fluorocarbon industry.

I. OVERVIEW

We commend ARB’s efforts to reduce hydrofluorocarbon (HFC) emissions by at least 80% by 2030. In California and around the globe HFCs are the fastest growing source of greenhouse gas (GHG) emissions. We believe such HFC reduction goals can be achieved via a suite of actions including sector-specific bans and incentive programs to encourage retrofit actions to use low-GWP substitutes where alternatives are technically and economically feasible and commercially available. Honeywell has developed alternatives that meet these criteria and produce overall environmental benefits in all of the sectors addressed by the Concept Paper. We believe that a strategy to reduce reliance on HFCs can succeed due to the availability of these alternatives and we are ready to work with ARB to develop and implement an HFC reduction strategy.

Honeywell is a global leader in providing energy efficient technologies and innovations that can help the world solve its energy and environmental challenges. We are a recognized leading innovator in the development of environmentally preferable fluorocarbons for use as refrigerants, blowing agents, solvents, propellants, and other uses. Since the 1990s, we have helped businesses replace ozone-depleting substances in these applications with alternatives that are non-ozone depleting and in certain cases more energy efficient.

Honeywell is a strong supporter of US EPA’s commitment to reducing the use of substances with a high GWP and the use of its Significant New Alternatives Policy (SNAP) program to transition the industry to low-GWP alternatives. We have been working diligently to

develop and commercialize technologies to further those goals. Honeywell has invested over \$500 million thus far and projects to invest another \$400 million in its new platform of low- and lower-GWP hydrofluoroolefin (HFO) and HFO blend compounds for use by equipment and product manufacturers worldwide.

We continue to work with original equipment manufacturers (OEMs) to evaluate and implement new compounds in their products and equipment. Regulatory incentives and drivers such as ARB's regulations, the US SNAP regulation, Canada's proposed HFC regulations, and the F-gas Regulation in the European Union (EU) have helped lead companies to commercially adopt these new HFO and HFO blend compounds that will yield substantial environmental benefits. We believe ARB's leadership in this area will drive further adoption of these technologies and accelerate the environmental benefits.

For example, due to the implementation in Europe of the MAC (Mobile Air Conditioning) Directive that requires all new cars to use an air conditioning refrigerant with a GWP of less than 150, Honeywell worked cooperatively with the automotive OEMs to develop a solution that meets the EU's climate change objective without sacrificing on energy efficiency or performance. This led to the launch in 2012 of HFO-1234yf, a new refrigerant for motor vehicle air conditioning with a GWP of less than 1—lower than that of carbon dioxide. Today, over 3 million cars are on the road in the EU and the US using HFO-1234yf and that number is expected to grow to over 5 million by the end of 2015. To support the growth in use of this product, in December 2013, Honeywell and its suppliers announced plans to invest \$300 million in building a new facility in Geismar, Louisiana to produce HFO-1234yf. The plant is expected to be operational by the end of 2016. Honeywell estimates that the broad adoption of HFO-1234yf in the United States for use in motor vehicle air conditioning could result in emissions reductions of approximately 10 million metric tons of carbon dioxide equivalent (MtCO₂e) annually.

We have also made great strides in transitioning to low-GWP alternatives in the foam sector. Beginning in January 2014, Whirlpool Corporation announced that it has implemented the use of Honeywell's Solstice® Liquid Blowing Agent (LBA) (HFO-1233zd(E)) into the foam insulation used in its US-made household refrigerators and freezers. This compound has a GWP approximately 1000 times lower than the most common foam blowing agents in use today. It is also nonflammable and exempt from regulation as a volatile organic compound (VOC) by EPA. The conversion resulted in a global warming impact equivalent to removing more than 400,000 cars annually from the road. Since then 12 appliance manufacturers, 6 spray foam system houses, and 3 panel manufacturers have adopted this blowing agent throughout North America, Europe, and Asia. Solstice® LBA has also been commercial in the US for nearly two years in spray foam. Commercialization of Solstice® LBA has also occurred in Japan, EU, and even in China for a variety of foam applications, including appliance, panel, and spray foam. A commercial-scale plant for this compound has been operating in Baton Rouge, LA since 2014.

Honeywell has completed construction of another commercial-scale plant in Baton Rouge, LA to produce HFO-1234ze(E)—a low-GWP compound for use as a refrigerant, extruded polystyrene (XPS) foam blowing agent (Solstice® Gas Blowing Agent (GBA)), and aerosol propellant. HFO-1234ze(E) is nonflammable, VOC-exempt by both US EPA and California, and has a GWP of less than 1. We are working with companies to replace HFC-134a in XPS, consumer, technical, and personal care aerosols, and chillers. In fact, HFO-1234ze(E) has been sold

commercially since 2009 in a variety of consumer and technical aerosol applications in Europe, Asia, and the US, as well as for one-component foams and extruded polystyrene foam applications in Europe. In January 2015, ITW Accessories Marketing, the world's largest seller of aerosol tire inflators, announced that they have selected HFO-1234ze(E) to power new ultra-low-GWP versions of its flagship tire inflator products, which are used to fix flat tires. In addition, over 12 chiller manufacturers around the world have launched lines of air-cooled and liquid-cooled chillers using HFO-1234ze(E).

Providing alternatives to industrial solvents with high ozone depletion potential and high GWP is also a key focus for Honeywell. For example, users of industrial solvents are currently faced with finding a balance between effective cleaning and minimal environmental impact when seeking an alternative to AK-225 (HCFC-225ca), a popular solvent used for cleaning, drying, and deposition applications that was banned from use in the United States as of January 2015. With the commercialization of Solstice® Performance Fluid, Honeywell has introduced a highly effective cleaning solution that is non-flammable, has an ultra-low global warming potential (GWP is 1), and is not a VOC as determined by both California's South Coast Air Quality Management District (SCAQMD) and the US EPA. Customers in California have already begun the successful transition to Solstice® Performance Fluid.

We look forward to supporting ARB's strategy to reduce high-GWP substances. Below we offer suggestions and comments for ARB's consideration as the agency drafts its strategy. A catalogue of low-GWP alternatives available or under development by application and end-use follows our comments in Appendix I. Appendices II-IV provide further detail about specific low-GWP products adopted in specific end-uses.

II. APPROPRIATE CONTROL MEASURES

A. Refrigerants

1. *Motor Vehicle Air Conditioning*

There are three areas of opportunity for ARB to reduce high-GWP HFC emissions in the mobile air conditioning (MAC) sector: (1) light-duty vehicles, (2) heavy-duty vehicles, and (3) transport refrigeration.

We support the phase out of HFC-134a in MAC applications and believe the transition can be completed sooner than the 2021 model year (MY), as has been proposed by US EPA. The transition to low-GWP replacements for HFC-134a in light duty MAC can be implemented as early as MY 2018. We also support phase-out of HFC-134a for heavy-duty vehicle MAC and are prepared to work with industry to demonstrate the success of low-GWP refrigerants in this application.

Eliminating HFC-134a in light-duty vehicle air conditioning applications could result in emissions reductions of greater than 1 million MtCO₂e annually in California. An alternative such as HFO-1234yf, a very low-GWP product, is a near drop-in replacement, which means adoption requires minimal equipment changes and little expense. Further, regulations requiring or incentivizing the use of low-GWP solutions are already in place in many countries and regions

including the US (via the joint EPA and NHTSA CAFÉ program), the EU, Mexico, Japan, and South Korea. Most vehicle manufacturers already offer models with low-GWP refrigerants in other markets.

Honeywell also supports phasing out HFC-134a in heavy-duty vehicle air conditioning applications and is prepared to work with industry to demonstrate this use of low-GWP refrigerants in these applications. The same low-GWP products being used for light-duty automotive applications can be used in this application. For a practical phase-out to occur the heavy-duty OEMs would need to evaluate the safe and effective implementation of low-GWP alternatives, much like the light-duty automotive vehicle manufacturers have done. This could take approximately 2-3 years to complete, plus another 2-3 years for heavy-duty automotive vehicle manufacturers to adopt necessary changes. Therefore, if ARB is targeting to announce proposed HFC reduction strategies in 2016, a potential sector ban of high-GWP refrigerants for use in this application could occur by Model Year 2022 or 2023. If enacted, ARB would be leading the way for the rest of the US and potentially the world to follow. Currently, the lack of regulation surrounding this application has resulted in a lack of development action in this arena. ARB could jump-start the necessary work by heavy-duty automotive manufacturers with an HFC reduction strategy for this sector.

Finally, we support the phase-out of high-GWP refrigerants such as R-404A in transport refrigeration because multiple lower-GWP options exist for this application. We recommend setting a GWP limit of less than 1500 for new and retrofit units by January 1, 2020.

2. Commercial Air Conditioning – Chillers & Rooftops

In the commercial air conditioning sector for chillers, we recommend that ARB's strategy include a sector specific ban on refrigerants with a GWP above 750 by 2021. Today, there are multiple low-GWP solutions (GWP of 1) being adopted that require small equipment redesign and other lower-GWP alternatives (GWP of less than 750) that are near drop-in replacements compared to currently used substances such as HFC-134a (GWP of 1430).¹ A moderate amount of time for transition is necessary because OEMs will need to incorporate equipment modifications across their portfolios to adopt low-GWP alternatives, which in some cases may require the use of mildly flammable low-GWP solutions.

In addition, current building codes do not appropriately provide for the use of mildly flammable refrigerants. Current codes accommodate only highly flammable and non-flammable substances, placing significant safety requirements on the former. ARB should allow time for the building codes to be appropriately updated to accommodate the use of mildly flammable refrigerants, which will require some but fewer safeguards than are currently mandated for highly flammable substances. To allow for use of low-GWP alternatives in the commercial air conditioning sector, the California Fire Code and the California Mechanical Code need to be altered in order to ensure that safe and practical handling of flammable refrigerants can be accommodated. These California codes are based upon national model codes, which are currently being revised for the 2018 edition. In order to make necessary changes to these codes to facilitate the adoption of low-GWP refrigerant alternatives, such changes must be submitted by January 2016

¹ Please see Appendix II for a full listing of chillers commercially available today around the world.

and shepherded through the respective code change processes. The California Building Standards Commission would then amend the California Codes as appropriate to incorporate the updated code. Alternatively, the California Building Standards Commission could choose to reform the California Codes independently of the model code process to facilitate the reduction in GWP products.

Lastly, for commercial rooftop air conditioners we also support a GWP of less than 750 by January 1, 2023, but as these units tend to come in direct contact with occupied space, more time may be needed to address the safe use of mildly flammable, but quite viable, low-GWP solutions. The time would be used for safety evaluation and building code modifications that today are more suited for using highly flammable refrigerants.

3. New Centralized Refrigeration Systems – Commercial and Industrial Refrigeration Central Systems

We support ARB's intention to take early action to reduce emissions from commercial refrigeration. Honeywell suggests a GWP limit of 1500 for new commercial and industrial refrigeration and believes that limit is appropriate as multiple lower-GWP alternatives exist today that can reduce GWP levels by over 2500 (compared to R-404A and R-507) and are more energy efficient by approximately 10%. For new stores we believe that high-GWP refrigerants such as R-404A and R-507 should be eliminated immediately since there are multiple options with a GWP lower than those substances by more than 50%. These lower-GWP alternatives can support a transition by 2017 in new commercial and industrial refrigeration applications.

Multiple replacements have been developed with lower-GWP refrigerant solutions and they are in the early phases of commercialization (e.g., R-448A and R-449A). These alternatives are more energy efficient than the most common refrigerants used today, are near drop-in replacements for widely used HFC blends like R-404A, R-407A, R-407F, and R-507, and would require no major equipment redesigns for new centralized refrigeration systems.

We encourage ARB to consider not just the refrigerants listed in the Concept Paper such as ammonia, carbon dioxide, and hydrocarbons, but to also support adoption of reduced-GWP options such as HFC-HFO blends, which can be used in existing equipment designs, serviced via existing maintenance practices and therefore have the ability to be more rapidly adopted than some of the other refrigerants suggested by the Concept Paper.

4. Retrofitting of Centralized Refrigeration Systems – Commercial and Industrial Refrigeration Central Systems

For retrofit applications, there are multiple lower-GWP and near drop-in replacements for existing widely used higher-GWP HFC blends such as R-404A and R-507. Given that alternatives are available today, the industry could transition quickly, in the 2016-2017 timeframe.

ARB could accelerate the rate of retrofits of centralized refrigeration systems in California compared to the rest of the US by providing incentives for retrofits. While it is true that costly equipment changes are not necessary in order to adopt the available lower-GWP alternatives, an average supermarket may spend \$30,000 in contractor service fees to implement a retrofit. Providing an incentive to lessen the cost of the retrofit would help supermarket store owners make

the transition, especially since adopting lower-GWP solutions offers approximately 10% energy efficiency benefit over currently-used substances, resulting in reduced electricity usage and cost savings.

5. Stand-Alone Refrigeration

Honeywell believes that significant GWP reduction is possible by eliminating the use of R-404A and HFC-134a in stand-alone refrigeration equipment. When crafting its strategy for this sector, ARB should consider that allowing continued use of lower-GWP HFCs and HFO blends in the short-term would offer a quicker path to reduced overall GWP than would an ultra-low GWP limit. Other substitutes, such as CO₂ and hydrocarbons present greater challenges than HFC and HFO blends for stand-alone commercial units. Hydrocarbons are highly flammable and thus have strict charge limits; and CO₂ has high equipment costs and can be less energy efficient than refrigerants currently in use or lower-GWP alternatives.

Since stand-alone units typically have small charges and low leak rates, Honeywell proposes a GWP limit of 650 for medium temperature units and 1500 for low temperature units. HFOs and HFO blends offer an excellent balance of safety, performance, and cost. For example, HFO blend solutions R-448A and R-450A are near drop-in, commercially available, approved by major compressor manufacturers, require minimal design changes, and are being adopted today by stand-alone refrigeration unit manufacturers. By allowing the use of more viable lower-GWP options, it would allow ARB to implement more quickly high GWP refrigerant phase-out, while minimizing unnecessary and costly equipment changes and unnecessary exposure to highly flammable refrigerants.

B. Foam

Honeywell supports ARB's intention to phase out high-GWP HFCs in foam applications. We believe the transition to low-GWP solutions in foam applications such as polyurethane (PU) and extruded polystyrene (XPS) can happen quickly. Multiple alternative solutions have been approved by US EPA under the SNAP program and have been commercially available in both PU and XPS applications for several years. Moreover, transition times in these applications are fast (~12-18 months). Honeywell has commercialized two low-GWP products:

- HFO-1233zd(E) (Solstice® LBA) for PU: HFO-1233zd(E) has a GWP of 1, which is about 1000 times lower in GWP compared to the HFCs it replaces. HFO-1233zd(E) is also more energy efficient than the HFCs it replaces, non-flammable, and not a VOC. HFO-1233zd(E) has been sold commercially globally since 2013. A large-scale plant to manufacture HFO-1233zd(E) commenced operations in May, 2014.
- HFO-1234ze(E) (Solstice® GBA) for XPS: HFO-1234ze(E) has a GWP of less than 1, which is 1000 times lower than the GWP of HFC-134a, which it replaces. It is also equal or higher in energy efficiency than HFC-134a, is non-flammable, and is not a VOC. HFO-1234ze(E) has been sold commercially in XPS applications since 2010. A large-scale plant to manufacture HFO-1234ze(E) started-up in Baton Rouge, LA, in October, 2014.

We believe that California has the opportunity to set the stage to drive conversions away from HFCs in both XPS and spray-foam applications. A summary of Honeywell's recommendations is as follows:²

Phase-Out Dates in Foam Applications

Application	Date of phase-out	Comments
XPS	January 1, 2017	Solutions commercial globally; supply in place
High-pressure spray foam	Jan. 1, 2018	Low-hanging fruit for conversion. Solutions exist globally; quick product development times; supply available
All other foams	Jan. 1, 2018	Solutions exist; supply available

Recently, several customers across many applications have already transitioned from high-GWP to low-GWP foam blowing agents and are selling products with low-GWP foam blowing agents commercially, and reformulation and testing time has not been an issue in their commercialization. Included below is a select list of customers across various foam applications:

- XPS (Jackson, Abriso, Austrotherm, Knauf, Fibran);
- Appliances (Whirlpool, Midea, Haier, Hisense, Festivo);
- Spray foam (Lapolla, West Development, Elastochem, Toyo, Asahi, BIP);
- Panel (Kingspan, All Weather Panel);
- Commercial refrigeration equipment (Porkka, Okamura);
- Refrigerated trailers (CIMC China); and
- One-component foam (Dow, Fomo, Soudal).

Across most applications numerous other customers globally are in various stages of commercial development. Customers have several available options from Honeywell and others that are listed as acceptable under SNAP. According to EPA even more options will become available in the near future. Strong regulatory action will continue to drive conversions away from high-GWP HFCs to products with a much less climate impact. Adoption of Honeywell technologies in the foam sector could have an impact of up to 35 million MtCO₂e by 2020.

C. Aerosol Propellants

Honeywell supports the early actions taken by ARB to limit the use of high-GWP aerosol propellants in certain consumer applications and believes that additional actions can now be taken to further strengthen the existing regulation to include additional applications for which preferable, low-GWP alternatives are already readily available. We encourage ARB to consider extending the existing restrictions on high-GWP (GWP greater than 150) propellants to include all aerosol applications, with very few specific exemptions for sensitive medical applications (such as metered-dose inhalers).

² A summary of currently available products utilizing low-GWP solutions is attached in Appendix III.

History has shown that the aerosols industry can convert quickly to alternatives with very limited equipment changes and capital expenditures, especially when drop-in replacements are available, as they are now.³ Customers have several options from Honeywell and others that are listed as acceptable under the EPA SNAP program and are currently available. Strong regulatory action will continue to drive broad conversion to available low-GWP alternatives.

III. CONCLUSION

Thank you for this opportunity to share our comments on ARB's development of a strategy to reduce high-GWP HFC use. Honeywell strongly supports ARB's efforts. If you have any further questions, please do not hesitate to contact Amy Chiang at Amy.Chiang@honeywell.com or Dave Stirpe at David.Stirpe@honeywell.com.

³ Please see Appendix IV for a list of currently available products utilizing low-GWP solutions.

APPENDIX I

Additional Background on Honeywell Platform of Low-GWP Alternatives

Honeywell International Inc. appreciates the opportunity to provide additional background material that will allow California to transition from high global warming potential (GWP) products to more environmentally beneficial alternatives.

I. INTRODUCTION

Honeywell is a global leader in providing energy efficient technologies and innovations that can help the world solve its energy and environmental challenges. Our Fluorine Products business is a recognized leading innovator in the development of environmentally preferable fluorocarbons for use as refrigerants, foam blowing agents, solvents, propellants, and other uses. Since the 1990s, we have helped businesses replace ozone-depleting substances in these applications with alternatives that are more energy efficient and have less impact on the stratospheric ozone layer and global climate change.

Honeywell strongly supports product-specific controls similar to those that have been proposed by the US EPA and Environment Canada. We support product-specific controls and incentive programs to accelerate retrofit and equipment replacement in favor of equipment using low-GWP substitutes because we believe they have a number of benefits:

- Environmental Benefit. Product-specific controls will yield greater environmental benefits where commercial solutions are available and high-GWP HFCs can be phased out by application because the GWP of those HFCs is permanently eliminated upon phase-out.
- Ease of Implementation. Product-specific controls are easier to implement for producers, manufacturers, and businesses because a phase-out date provides certainty for the market for each particular product.
- Greater Chance For Accelerated Adoption: Incentive programs to encourage retrofit actions to use low-GWP substitutes where alternatives are technically and economically feasible and commercially available would have a material impact to accelerate transition. For example, in commercial refrigeration the average supermarket might spend close to \$30,000 to retrofit a store to adopt a new refrigerant, regardless of its GWP content. Today, there are lower-GWP solutions available that would cut GWP by more than 50% compared to existing high GWP refrigerants and they provide 10% energy benefits. If California provided incentives to reduce the impact of the retrofit cost, it could lead to a cascade of many more retrofits cutting GWP emissions by over 50%.
- Ease of Enforcement. Product-specific controls are easier to enforce. It is clear whether a producer/manufacturer/user is in compliance.
- Clear Market Signal. Product-specific controls provide clear direction to businesses. By contrast, a sector-wide phase-down in applications like foam is difficult because a manufacturer would have to formulate and sell different products (systems)—some with

HFCs and some without HFCs—that would add cost and operational complexity for system houses and downstream users.

II. PRODUCT-SPECIFIC CONTROLS

Honeywell believes that product-specific control measures are preferable to other measures because such controls can drive transition in applications for which alternatives are available. In this section we provide information on product-specific controls by application.

A. Refrigerants

1. Summary of Attainable GWP Caps and Phase-Out Dates By Application

The table below summarizes Honeywell’s position with respect to the GWP thresholds and HFC phase-out dates. Both are provided in the event that policymakers are considering GWP thresholds and phase-out dates.

Table 1. SUMMARY OF HONEYWELL POSITION—REFRIGERANTS

Application	Honeywell Position	Supporting Information
MAC – light duty vehicles	R134a unacceptable by 2018 model year. Alternatives: HFO-1234yf; CO ₂ ; HFC-152a	<ul style="list-style-type: none"> Conversion is already underway with more than 3 million vehicles using low-GWP refrigerants globally. Near drop-in replacements (HFO-1234yf) simplify ability to transition.
MAC- heavy duty vehicles	R134a unacceptable by 2022 or 2023 model year. Alternatives: HFO-1234yf CO ₂ ; HFC-152a	<ul style="list-style-type: none"> Honeywell is prepared to work with auto manufacturers to demonstrate success of HFO-1234yf in this application. Complete transition would take about 4-6 years.
Domestic Refrigeration - Refrigerators	GWP less than 150 by 1/1/2019	<ul style="list-style-type: none"> Most of the world is already using low-GWP for domestic refrigeration, Multiple low-GWP options, such as HFO-1234yf, HFO-1234ze(E), and hydrocarbons, are commercially available.
Domestic A/C – window & portable A/C, PTACs	GWP less than 750 by 1/1/2023	<ul style="list-style-type: none"> Conversion is already underway in Asia. Multiple low-GWP options, such as R-446A, R-447A, and R-32 are currently available.
Commercial A/C – chillers, rooftops	GWP less than 750 by 1/1/2021 for chillers and by 1/1/2023 for commercial rooftops	<ul style="list-style-type: none"> Numerous manufacturers now offering low-GWP chillers. Non-flammable, high-efficiency options available for chillers today, such as HFO-1233zd(E), HFO-1234ze(E), and R-450A.
Mobile Refrigeration – trailers and containers	GWP less than 1500 by 1/1/2020 for new and retrofit units	<ul style="list-style-type: none"> Multiple lower GWP refrigerant options, such as R-450A and R-448A, are available today.
New Centralized Refrigeration Systems – commercial and industrial refrigeration central systems	GWP less than 1500 by 1/1/2017	<ul style="list-style-type: none"> HFO blend solutions R-448A and R-450A are commercially available. R-448A is currently being evaluated in extensive field trials.

Retrofitting of Centralized Refrigeration Systems – commercial and industrial refrigeration central systems	GWP less than 2000 by 1/1/2017	<ul style="list-style-type: none"> Multiple lower-GWP options exist today including R-407F, which have been used successfully in thousand of retrofits. In addition, R-448A has been qualified by leading compressor OEMs and extensive field trials have occurred and are continuing.
Stand-Alone Commercial Refrigeration Systems	GWP less than 650 by 1/1/2017 for medium temp. (HFC-134a systems); GWP less than 1500 by 1/1/2017 for low temp. (R404A systems)	<ul style="list-style-type: none"> HFO blend solutions R-448A and R-450A are commercially available. HFOs could provide optimal balance of safety, performance, and significantly lower GWP.

2. Motor Vehicle Air Conditioning

We support the phase-out of HFC-134a in mobile air conditioning (MAC) applications and believe the transition can be completed sooner than the 2021 model year (MY), as has been proposed by US EPA. The transition to low-GWP replacements for HFC-134a in light-duty MAC can be implemented as early as MY 2018.

Eliminating HFC-134a in this application could result in emissions reductions of approximately of greater than 1 million MtCO₂e annually in California. An alternative such as HFO-1234yf, a very low-GWP product, is a near drop-in replacement, which means adoption requires minimal equipment changes and little expense. Further, regulations requiring or incentivizing the use of low-GWP solutions are already in place in countries and regions including the US (via the joint EPA and NHTSA CAFÉ program), the EU, Mexico, Japan, and South Korea. Most vehicle manufacturers already offer models with low-GWP refrigerants in other markets. Honeywell believes the transition to low-GWP alternatives in California can happen by MY 2018 vehicles based on the following:

- Adoption of low-GWP alternatives in motor vehicle air conditioning applications has been underway since 2012. Major suppliers of mobile air conditioning systems have already developed systems to accommodate alternatives to HFC-134a, including HFO-1234yf, a widely available substitute. Today there are more than 85 different models totaling more 3 million vehicles on the road using low-GWP refrigerants. That number is expected to double by the end of this year.
- In the EU, the Motor Vehicle Air Conditioning Directive prohibits use of HFC-134a in new vehicles by January 1, 2017. In response, increasing numbers of global auto manufacturers have already transitioned, or will soon transition, to non-HFC-134a alternatives.
- Multiple refrigerant solutions exist. Solutions such as, HFO-1234yf, HFC-152a, and CO₂ (R-744) have been approved for use in multiple regions for motor vehicle air conditioning systems and, as noted above, low-GWP motor vehicle systems are currently in widespread use in the U.S. and Europe.
- Commercial quantities of HFO-1234yf exist today and production is growing. There is one production plant operating today in China. A second plant was commissioned in April 2015 in Japan via a strategic supply relationship between Honeywell and Asahi Glass Company Ltd. Honeywell will commission a third world-scale production plant in Geismar, Louisiana by the end of 2016. Other refrigerant options such as CO₂ and HFC-152a have been commercially available for decades.

Some concerns have been raised regarding vehicles that are produced with HFO-1234yf in the U.S. and then subsequently exported to other countries without similar low-GWP requirements. Some allege that these countries appear unprepared to service cars with low-GWP refrigerants. We believe that this is not a valid concern. This issue is not unique to refrigerants; it is the same for other vehicles parts. Regardless of refrigerant choice, if a vehicle is sold in another country, the OEM must ensure there is a vehicle servicing infrastructure available to perform all types of services and repairs and therefore all of the unique parts, including body panels, engine parts, transmissions, refrigerants, etc., must be available. It is the responsibility of the vehicle manufacturer to ensure that their authorized dealers in those countries are able to provide all the necessary service to these exported cars, especially since they will be required to provide warranty service for a period generally ranging from three to seven years after first sale. Thus the parts and servicing infrastructure must already be in place when a new car is launched, regardless of refrigerant choice. In addition, Honeywell has already developed an extensive global network of distributors capable of supplying HFO-1234yf in all corners of the globe from North America and Europe to South America, Australia, North and Southeast Asia, South Africa, and South America. In addition, refrigerant service machines capable of servicing HFO-1234yf are available today via global leading refrigerant service machine manufacturers.

We also support phasing out HFC-134a in heavy-duty vehicle air conditioning applications and are prepared to work with industry to demonstrate this use of low-GWP refrigerants in these applications. The same low-GWP products being used for light-duty automotive applications can be used in this application. For a practical phase out to occur the heavy-duty original equipment manufacturers (OEMs) would need to evaluate the safe and effective implementation of low-GWP alternatives, much like the light-duty automotive vehicle manufacturers have done. This could take approximately 2-3 years to complete, plus another 2-3 years for heavy-duty automotive vehicle manufacturers to adopt necessary changes. A potential sector ban of HFC-134a for use in this application could occur by MY 2022 or 2023.

Finally, we support the phase-out of high-GWP refrigerants such as R-404A in transport refrigeration because multiple lower-GWP option exist for this application. We recommend setting a GWP limit of < 1500 for new and retrofit units by January 1, 2020.

3. Commercial Air Conditioning – Chillers & Rooftops

In the commercial air conditioning sector for chillers, we support a sector specific phase-out of refrigerants with a GWP above 750 by 2021. Today, there are multiple low-GWP solutions (GWP of 1) being adopted that require small equipment redesign and other lower-GWP alternatives (GWP less than 750) that are near drop-in replacements compared to currently used substances like HFC-134a (GWP of 1430). A moderate amount of time for transition is necessary because of OEMs will need some time to incorporate equipment modifications across their portfolios to adopt low-GWP alternatives, which in some cases may be require the use of mildly flammable low-GWP solutions.

Moreover, current building codes do not appropriately provide for the use of mildly flammable refrigerants. Current codes accommodate only highly flammable and non-flammable substances, placing significant safety requirements on the former. Regulators should allow time for

the building codes to be appropriately updated to accommodate the use of mildly flammable refrigerants, which will require some but fewer safeguards than are currently mandated for highly flammable substances.

Currently more than 12 manufacturers globally now offer chillers with low-GWP refrigerants. Trane and Mitsubishi Heavy Industries, global manufacturers of chillers, have recently introduced high efficiency chillers that utilize HFO-1233zd, a non-flammable refrigerant with a GWP of just 1. Another option, HFO-1234ze(E), has a GWP of 1 and matches the energy efficiency of HFC-134a. Commercial supply quantities of HFO-1234ze(E) are available today. Several manufacturers currently offer high-efficiency chillers, air-cooled and water-cooled, using HFO-1234ze(E) in sizes ranging from tens of tons to hundreds of tons. The high efficiency chillers now being offered have largely been commercialized in the EU where the promulgation of the F-gas Regulation has motivated OEMs to allocate the requisite time to develop and commercialize these units. We believe that prohibiting high-GWP substances in this use in other countries would similarly accelerate commercial development in those areas. Also, in recognition of the fact that the cost of this equipment may be slightly higher than existing equipment, consideration should be given to providing consumers purchase rebates/credits in order to incentivize adoption and make these low-GWP solutions comparable in value to existing high-GWP solutions.

Lastly, for commercial rooftop air conditioners we also support a GWP of less than 750 by January 1, 2023, but as these units tend to come in direct contact with occupied space, more time may be needed to address the safe use of mildly flammable, but quite viable, low-GWP solutions. The time would be used for safety evaluation and building code modifications that today are more suited for using highly flammable refrigerants.

4. New Centralized Refrigeration Systems – Commercial and Industrial Refrigeration Central Systems

Honeywell supports a GWP limit of 1500 for new commercial and industrial refrigeration and believes that limit is appropriate as multiple lower-GWP alternatives exist today that can reduce GWP levels by over 2500 (compared to R-404A and R-507) and can deliver approximately 10% higher energy efficiency. For new stores we believe that high-GWP refrigerants such as R-404A and R-507 should be eliminated immediately since there are multiple options with a GWP lower than those substances by more than 50%. These lower-GWP alternatives can support a transition by 2017 in new commercial and industrial refrigeration applications.

Multiple replacements have been developed with lower-GWP refrigerant solutions and they are in the early phases of commercialization (e.g., R-448A and R-449A). These alternatives are more energy efficient than the most common refrigerants used today and are near drop-in replacements for widely used HFC blends like R-404A, R-407A, R-407F, and R-507. Testing by qualified industry experts has demonstrated that R-448A delivers approximately 10% energy savings as compared to R-404A. Low-GWP substitutes such as R-448A have been approved by major compressor manufacturers and are currently being used in centralized refrigeration systems in North America and Europe. These substitutes would require no major equipment redesigns for new centralized refrigeration systems.

Many of these lower-GWP alternatives also reduce energy consumption, providing

additional environmental benefit. We encourage regulators to consider not just alternatives such as ammonia, carbon dioxide, and hydrocarbons, but to also support adoption of reduced-GWP options such as HFC-HFO blends, which can be used in existing equipment designs, serviced via existing maintenance practices and therefore have the ability to be more rapidly adopted than some of the other available refrigerants.

5. Retrofitting of Centralized Refrigeration Systems – Commercial and Industrial Refrigeration Central Systems

For retrofit applications, there are multiple lower-GWP and near drop-in replacements for existing widely used higher-GWP HFC blends such as R-404A and R-507. Given that alternatives are available today the industry could transition quickly to refrigerants with GWP's below 2000, in the 2016-2017 timeframe.

Lower-GWP options, such as R-407F (GWP of 1825), and R-448A (GWP of 1386) are approved by major compressor manufacturers and have been used to retrofit thousands of centralized refrigeration systems globally. These substitutes can deliver approximately 10% energy efficiency compared to the higher-GWP HFC refrigerants that are currently used in centralized refrigeration systems. Qualified industry experts have successfully used R-407F in this application and it is becoming widely adopted. These substitutes would require no major equipment modifications to centralized refrigeration systems during the retrofit process.

6. New Stand-Alone Refrigeration Equipment

Honeywell believes that significant reduction in GWP is possible by eliminating the use of R-404A and HFC-134a in new stand-alone refrigeration equipment. Regulators should consider allowing the use of lower-GWP HFCs and HFO blends, which would offer a quicker path to reduced overall GWP. Other substitutes, such as CO₂ and hydrocarbons present greater challenges than HFC and HFO blends for stand-alone commercial units. Hydrocarbons are highly flammable and thus have strict charge limits and CO₂ has high equipment costs and can be less energy efficient than refrigerants currently in use or lower-GWP alternatives. By allowing the use of more viable lower-GWP options, it would allow ARB to implement more quickly high-GWP refrigerant phase-out, while minimizing unnecessary and costly equipment changes and unnecessary exposure to highly flammable refrigerants.

Due to the charge limitations for larger stand-alone units it is not possible to adopt hydrocarbons (R-290 or R-600a) without completely redesigning the system to accommodate two or more separate refrigeration circuits. This could increase the cost of the refrigeration system by nearly double to accommodate the use of hydrocarbons. Use of highly flammable hydrocarbons also requires changes to the electrical components of the units as well as costly modifications to the manufacturing facilities to safely handle hydrocarbons.

Adopting CO₂ would require a complete redesign of stand-alone refrigeration systems. Overall analysis done by Honeywell and many of its equipment partners indicate that transitioning to R-744 (CO₂) requires a higher equipment cost than transitioning to other alternatives such as an HFO or HFO blends for several reasons. First, CO₂ systems require higher pressure ratings for copper tubing, compressors, valves and heat exchangers. Second, transcritical

CO₂ is inefficient and would require a booster compressor or a two-stage system to reach efficiency levels close to HFC and HFO systems. Lastly, liquid injection may be required in low temperature applications to ensure the compressor remains within the acceptable temperature operating range.

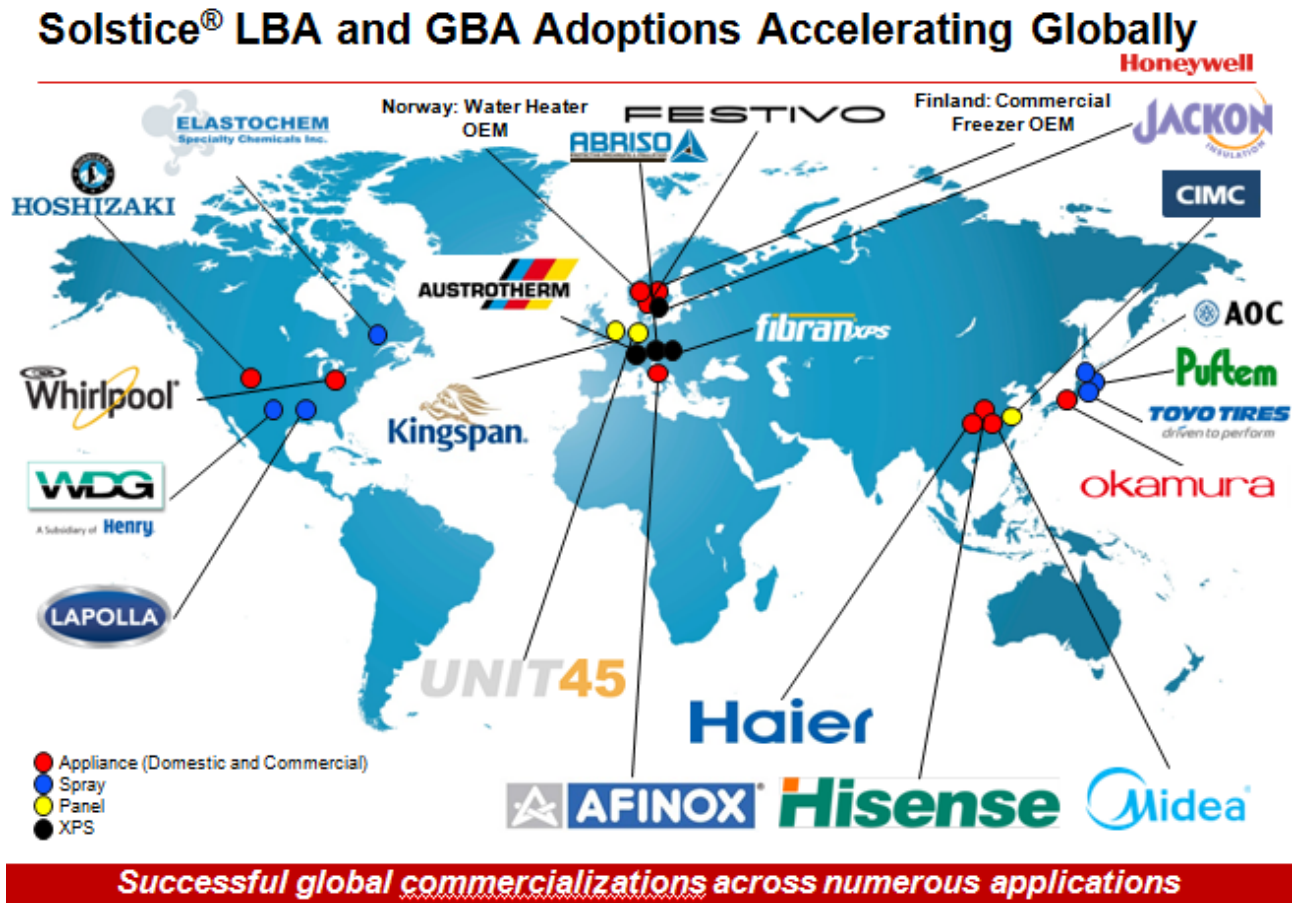
Since stand-alone units typically have small charges and low leak rates, Honeywell proposes a GWP limit of 650 for medium-temperature units and 1500 for low-temperature units. HFOs and HFO blends offer an excellent balance of safety, performance, and cost. For example, HFO blend solutions R-448A and R-450A are near drop-in, commercially available, approved by major compressor manufacturers, require minimal design changes, and are being adopted today by stand-alone refrigeration unit manufacturers. By allowing the use of these non-flammable, reduced GWP refrigerants, we believe the transition out of R-404A and R-134a can be accomplished years sooner and with minimal disruption to the industry. We believe a phase-out date of 404A and 134a in new stand-alone equipment could be by January 1, 2017.

B. Foam

Honeywell supports regulations to transition foam applications to low-GWP substitutes, including high-pressure spray foam, where solutions have been commercial since 2013 globally. We also believe that in some cases the transition can occur relatively quickly yielding significant environmental benefits. History shows that the foam industry can convert quickly to alternatives with very limited equipment changes and capital expenditures, especially when near drop-in solutions are available, as they are now. Globally, manufacturers are choosing low-GWP solutions. Figure 1 shows that HFO-1233zd(E) (Solstice[®] LBA) and HFO-1234ze(E) (Solstice GBA) are commercial across numerous applications worldwide in numerous polyurethane and polystyrene applications. Adoption of Honeywell technologies in the foam sector could have an impact of up to 35 million Mt/CO₂ equivalent by 2020.

Further, in many instances manufacturers are seeing benefits of better performance, energy efficiency, non-flammability, and better product yields (less foam for the same performance) while reducing impact on climate change. For example, refrigerators made with HFO-1233zd(E) are 8-10% more energy efficient than those manufactured from flammable hydrocarbons and 2-4% more efficient than those that use HFC-245fa. Similar energy efficiency benefits are being seen across spray foam and other foam applications as well, offering manufacturers better performance and/or lower cost alternatives across a range of applications. Therefore, in addition to offering direct GWP reduction, several substitutes for HFCs are expected to dramatically reduce the CO₂e emissions on a life-cycle basis as well.

Figure 1. Global Adoption of Low-GWP Alternatives in Foam Applications



1. Summary of Proposed Phase-Out Dates By Application

We believe that an effective phase-out can be achieved with just three categories: extruded polystyrene (XPS), high-pressure spray foam, and all other foam applications. The availability of substitutes justifies a more rapid transition to low-GWP solutions in these applications. Earlier transition dates will greatly increase the environmental benefit of the product-specific control measures.

The table below summarizes Honeywell's position with respect to the HFC phase-out dates or foam.

Table 2. Phase-Out Dates in Foam Applications

Application	Date of phase-out	Comments
XPS	Jan. 1, 2017	Solutions commercial globally; supply in place
High-pressure spray foam	Jan. 1, 2018	Solutions exist globally; quick product development times; supply available
All other foams	Jan. 1, 2018	Solutions exist; supply available

2. High-Pressure Spray Foam – Phase-Out by January 1, 2018

Solutions for spray foam have been commercial in the U.S. and Japan since 2013, and in Canada since 2014. High-pressure spray foam is low-hanging fruit. It is the easiest and quickest application to transition, as demonstrated by successful transitions by several manufacturers, noted below. For example, high-pressure spray foam was one of the last applications that Honeywell started to commercialize with its customers, but the first low-GWP product commercialized in the U.S. was in a spray foam application with West Development Group. Honeywell strongly supports prohibiting HFC-143, HFC-245fa, HFC-365mfc and blends thereof in high-pressure spray foam applications.

Several low-GWP and non-flammable alternatives have been listed as acceptable under U.S. SNAP for use in spray foam applications. Honeywell has been selling HFO-1233zd(E) commercially in this application since March 2013 in the U.S. and globally. HFO-1233zd(E) was also successfully trialed in Philippines by UNIDO in 2012, more than two years ago. Several small businesses such as Lapolla Industries, West Development Group (a subsidiary of Henry Company), and Canadian-based Elastochem, have commercialized low-GWP spray foam formulations containing HFO-1233zd(E). In Japan, spray foam made with HFO-1233zd(E) has been commercialized by numerous customers including Toyo, Asahi, and BIP. There have been several case studies which demonstrate the capabilities of HFO-1233zd(E) in spray foam applications.

In our experience in the U.S., it took just 6-18 months from start of development to a formulated system that was technically and commercially saleable, with all the requisite regulatory approvals. Further, several U.S. companies are close to commercial systems and will be undergoing product certification shortly. We expect the commercialization timelines to continue to shorten. The supply chain of additives (catalysts, surfactants) has also developed substantially so that companies have a wide variety of components to formulate with HFO-1233zd(E). Also, when new materials such as HFC-365mfc blends have come to market, the industry has indicated that it can transition rapidly, typically in less than six months.

Low-GWP alternatives in spray foam applications are high performance, low cost, and in ample supply. Companies that have already commercialized low-GWP spray foam based on HFO-1233zd(E) are seeing benefits of better energy efficiency as well as reduced cost. HFO-1233zd(E) has demonstrated better yields (more foam per pound of liquid component) by as much as 10% to 12%, which results in substantial cost savings. In addition, these foams have shown 4% to 8% improved energy efficiency, which means that companies can either improve the energy efficiency for the same thickness of foam or reduce the thickness to further bring down cost. On a total life-

cycle analysis basis, which includes both direct and indirect GWP, foams with HFO-1233zd(E) are shown to reduce CO₂e life-cycle emissions by up to 90%.¹

These alternatives are available to supply North America. Honeywell's HFO-1233zd(E) large-scale plant started up in May 2014; DuPont announced plans to start its HFO-1336mzzm plant in the second half of 2016.² Given the availability of low-GWP solutions, the ability of the industry to transition easily and quickly, and the benefits that go well beyond low-GWP such as better energy efficiency and lower costs, Honeywell believes that high-GWP compounds such as HFC-143a, HFC-245fa, and HFC-365mfc, and blends thereof, may be prohibited in spray foam applications beginning January 1, 2018.

3. Extruded Polystyrene Foam – Phase-Out January 1, 2017

For XPS users, several solutions are already available and have been in use globally for some time. For example, in Europe, approximately 80% of the industry uses solutions other than HFC-134a, including CO₂, HFC-152a, isobutane, and HFO-1234ze(E). Similarly, in Japan, all XPS is produced with alternatives to HFC-134a, such as isobutane and HFO-1234ze(E). HFO-1234ze(E) has been commercial since 2008, and is being used by companies in Europe and Japan. Honeywell is now running a large, world-scale commercial plant in Baton Rouge, Louisiana, which started operating in September 2014. Honeywell is ready to support a phase-out date of January 1, 2017 for XPS applications.

Energy efficiency and cost are two important factors to consider in evaluating alternatives. First, with respect to energy efficiency, the table below shows that HFO-1234ze(E) is an excellent foam-blowing agent and results in energy efficiency properties that are comparable and in some instances better than HFC-134a. Vo and Fox from The Dow Chemical Company published a peer-reviewed study, which noted, "... [T]hermal insulation performance of foams obtained with HFO-1234ze(E) and co-blowing agents is very similar to those blown with HFC-134a produced today."³ Jackson has been selling boards in the EU with energy efficiency that is better than HFC-134a since mid-2011 and four other EU customers are using HFO-1234ze(E) commercially. A major Japanese producer has also been commercially selling boards made with HFO-1234ze(E).

Table 3. Comparison of Energy Efficiency Performance of Foam Blowing Agents⁴

Blowing Agent	CO₂	HFC-134a	HFO-1234ze(E)
Aged lambda (lower = better)	34-38	29-30	27-30
% improvement over CO ₂	—	~12-15%	~12-20%

¹ Bogdan and Pascual, Environmental assessment of next generation blowing agent technology using Solstice LBA in ccSPF, Polyurethane Magazine, 5 (2012).

² <http://www.gupta-verlag.com/general/news/industry/14939/duPont-fluorochemicals-announces-world-s-first-full-scale-production-of-hfo-1336mzz/pdf>.

³ Vo and Fox, *Assessment of hydrofluoropropenes as insulating blowing agents for extruded polystyrene foams*, JOURNAL OF CELLULAR PLASTICS, 49, 423 (2013).

⁴ Honeywell analysis based on customer information.

In addition to HFO-1234ze(E), which offers comparable or better energy efficiency as HFC-134a in XPS, companies like The Dow Chemical Company have commercialized other solutions to improve energy efficiency with CO₂. For example, Dow's XENERGY technology, according to Dow, is the "[t]hermal insulation of the future. XENERGY™ combines proven features of STYROFOAM™ with up to 20% higher insulating properties made possible by a new manufacturing process using CO₂ and reflecting particles in the foam cells. The result: reduced heating costs—increased efficiency, comfort and sustainability.”⁵

Cost is another important criterion. The economics of boards produced with HFO-1234ze(E) are also reasonable compared with boards produced with HFC-134a. Honeywell estimates that an XPS board made with HFO-1234ze(E) is likely to be less than 10% more expensive than a comparable board made with HFC-134a.

4. Proposed GWP Caps by Application

Honeywell prefers product-specific controls by application versus a GWP-based approach. In foam, it is possible to estimate the GWP in various ways, including other blowing agents (like water) and other components. Therefore, it is important to state that foams “containing” HFCs with the GWP higher than the threshold are phased out.

5. Products and Articles Containing HFCs

Honeywell supports prohibiting HFC foam-blowing agents contained in the cells of closed-cell foams and foams and products containing them, as well as the use of the HFC foam-blowing agent in manufacture of those products.

Refrigerated containers and trailers used to transport food, medicine, and other perishables may be manufactured with products that are classified as acceptable today but unacceptable in the future. These refrigerated containers and trailers travel across country borders and are used in service from 5-10 years, and then sold at the end of their life for use as storage, living, or other applications. Any regulation banning such containers should allow the sale and use of containers already manufactured.

Honeywell supports prohibiting the import of products containing foams blown with banned HFCs and HCFCs, such as HCFC-141b, since doing so will (1) benefit the environment by reducing use of ozone-depleting and high-GWP substances, and (2) improve the competitiveness of companies which will not have to compete with cheaper imports of products made with such substances.

6. Product-Specific Bans By Application

The table below contains our current view of appropriate phase-out dates for each foam end-use.

⁵ <http://www.dow.com/products/market/construction/product-line/xenergy-extruded-polystyrene-insulation/>

Table 4. SUMMARY OF HONEYWELL POSITION—FOAM

End-Use	Product	Honeywell Position	Supporting Information	Supply of Alternatives
Polyurethane Foams (all)	HFC-227ea and blends	Prohibit shortly after promulgation of final regulation	<ul style="list-style-type: none"> Highest GWP of all molecules used in PU foam GWP of HFC-227ea = 3220, which is 225% that of HFC-134a Non-flammable solutions with 3000x lower GWP in use Rule would spur industry to develop low-GWP products Limited use in industry; only recently approved 	<ul style="list-style-type: none"> HFO-1233zd(E) – March 13,⁶ May 2014⁷ HFO-1336mzzm—2nd half 2016² HFC-245fa, HFC-245fa/365 blends²
High-pressure spray polyurethane foams	HFC-143a, HFC-245fa, HFC-365mfc and blends	Prohibit Jan 1, 2018	<ul style="list-style-type: none"> Significantly lower GWP alternatives available Quickest (6-18 months) and easiest application Improved performance (energy efficiency) and lower cost (raw material yields) 	<ul style="list-style-type: none"> Water HFO-1233zd(E) HFO-1336mzzm Hydrocarbons
XPS	HFC-134a and blends	January 1, 2017	<ul style="list-style-type: none"> Numerous alternatives approved by U.S. EPA SNAP and Environment Canada, and in use today EU and Japan largely do not use HFC-134a HFO-1234ze(E) offers both low-GWP and high energy efficiency (even better than 134a) Low cost of transition – less than 10% higher board costs. 	<ul style="list-style-type: none"> CO₂ Butane HFC-152a HFO-1234ze(E) – 2008,¹ August 2014²
Polyurethane (all applications)	HFC-134a and blends	Prohibit Jan 1, 2018	<ul style="list-style-type: none"> Low-GWP one-component foam commercial since 2008 Low-pressure low-GWP two-component pour foam systems commercially available Low-pressure two-component spray foam – technical solutions being developed and optimized 	<ul style="list-style-type: none"> HFO-1234ze(E) HFO-1233zd(E) Methyl formate HFO-1336mzzm
Products containing	All HCFCs, HFCs	Prohibit all products except refrigerator containers/ trailers	<ul style="list-style-type: none"> Allow transit of refrigerated containers/trailers manufactured with prohibited substitutes before phase-out date and sold after the date 	<ul style="list-style-type: none"> All HCFCs, HFCs

⁶ Small scale plant

⁷ Large scale, world-scale plant to supply global needs

C. Aerosols

1. Phase-Out Date

Honeywell supports the near-term phase-out of high-GWP HFCs in aerosol applications as soon as January 1, 2016. Alternatives such as hydrocarbons, HFC-152a, HFO-1234ze(E), and CO₂, are already available for all major aerosols applications and history shows the aerosols industry can convert quickly to alternatives with very limited equipment changes and capital expenditures, especially when drop-in replacements are available, as they are now. Customers have several options from Honeywell and others that are listed as acceptable under SNAP and are currently available.

2. Global Warming Potential Threshold

Honeywell would support a full phase-out of aerosol products that contain an HFC, or a blend containing an HFC, with a GWP greater than 150. Multiple alternatives are readily available to meet this standard in all aerosol applications containing an HFC, or a blend containing an HFC, with the exception of sensitive medical applications (such as metered-dose inhalers), for which we would support an exemption.

3. California-specific Issue

Honeywell agrees that several of the aerosol product classes in which HFC-134a is used continue are both necessary and useful. However, in some categories, such as cleaning products for electronics, sprays for aircraft maintenance, duster sprays for energized electrical equipment, and others, Honeywell does not believe there is sufficient justification to allow continued use of HFC-134a. Honeywell believes that eliminating these uses of HFC-134a is practical because of the commercial availability of dusters containing alternate propellants such as HFC-152a and HFO-1234ze(E). Furthermore, since dusters are often distributed through channels over which the marketer has no control, this special exemption creates a loophole whereby a duster labeled for an exempt use could be purchased and used for other applications.

For example, California regulations allow HFC-134a dusters to be used only on energized electrical equipment, and cans are so labeled. However, it is possible to purchase an HFC-134a duster from an online catalog for delivery to an address in California without any restrictions or questions about the intended end-use.

4. Sell-Through Period

Honeywell believes that any regulation should include a sell-through period to prevent “stranded inventory.” The sell-through period should allow inventory produced prior to the phase-out date to be sold, imported and exported after that date, even if the product is classified as an unacceptable use of HFC-134a. However, the sell-through period should not continue indefinitely since doing so would delay the transition to low-GWP substitutes, and disadvantage small businesses that are unable to carry large inventories. Honeywell believes that a sell-through period should apply only to products that were manufactured prior to the phase-out date and that have entered the distribution channel. Honeywell believes that extending the sell-through period to manufacturers, especially with an open-ended sell-through period, would serve as a disincentive for

the timely conversion to low-GWP substitutes.

5. Summary of Position on Product-Specific Controls

The table below shows achievable phase-out dates for each major category of aerosol end-uses.

Table 5. SUMMARY OF HONEYWELL POSITION—AEROSOLS

End-Use	Product	Honeywell Position	Supporting Information	Supply of Alternatives
Consumer Aerosols	HFC-134a	Prohibit Jan. 1, 2016 for all applications, including tire inflators and novelty aerosols	<ul style="list-style-type: none"> Multiple/wide-ranging low-GWP commercial products and/or shelf-ready prototypes currently available 	<ul style="list-style-type: none"> Large, commercial-scale plants for low-GWP alternatives in operation to supply global demand (Hydrocarbons, HFC-152a, HFO-1234ze(E), CO₂)
Technical Aerosols	HFC-134a	Prohibit Jan. 1, 2016: <ol style="list-style-type: none"> Safety dusters for energized electrical equipment Refrigerant flush Cleaning products for removal of grease, flux, soils from electrical equipment or electronics Sprays for aircraft maintenance Duster sprays for photographic negatives, semiconductor, microscopes Mold release Lubricants for electrical equipment or electronics: no phase-out Lubricants and cleaners for spinnerettes for synthetic fabrics Document preservation sprays Prohibit Jan. 1, 2017: <ol style="list-style-type: none"> Pesticides for use near electrical wires Pesticides for use in an aircraft Pesticides in total release insecticide foggers 	<ul style="list-style-type: none"> Multiple/wide-ranging low-GWP commercial products and/or shelf-ready prototypes currently available (see table of commercial products) It is industry practice to remove flushing agents from lines, etc. by blowing them dry with nitrogen or compressed air after flushing; no risks from residual flushing agents are posed by welding lines after flushing 	<ul style="list-style-type: none"> Large, commercial-scale plants for low-GWP alternatives in operation to supply global demand (Hydrocarbons, HFC-152a, HFO-1234ze(E), CO₂)
All Aerosols	HFC-125	Prohibit Jan. 1, 2016	<ul style="list-style-type: none"> Multiple/wide-ranging low-GWP commercial products and/or shelf-ready prototypes currently available (see table of commercial products) 	<ul style="list-style-type: none"> Large, commercial-scale plants for low-GWP alternatives in operation to supply global demand (Hydrocarbons, HFC-152a, HFO-1234ze(E), CO₂)
All Aerosols	HFC-227ea	Prohibit Jan. 1, 2016, except in metered dose inhalers	<ul style="list-style-type: none"> Multiple/wide-ranging low-GWP commercial products and/or shelf-ready prototypes currently available (see table of commercial products) 	<ul style="list-style-type: none"> Large, commercial-scale plants for low-GWP alternatives in operation to supply global demand (Hydrocarbons, HFC-152a, HFO-1234ze(E), CO₂)

III. CONCLUSION



Honeywell strongly supports efforts to implement a transition to low-GWP compounds. For more information, please contact Amy Chiang at Amy.Chiang@honeywell.com, or Dave Stirpe at David.Stirpe@honeywell.com.

APPENDIX II

Alternative Products for Refrigerant Applications

A. Mobile Air Conditioning (MAC) – Solstice® MAC (HFO-1234yf)



- In use in nearly three million cars globally
- 99.9% reduction in GWP compared to HFC-134a
- More efficient than CO₂
- Automakers have sold approximately 85 different models totaling 3 million vehicles on the road in the world designed to use HFO-1234yf. U.S.-based companies, including Ford, GM, Chrysler, and Tesla are manufacturing more than a dozen models using HFO-1234yf.¹

Company, Product Name	Product Photo
General Motors- Cadillac XTS, others www.gm.com	
Chrysler Corporation- Jeep Cherokee, others www.chrysler.com	

¹ This data is from a list compiled by the Institute for Governance and Sustainable Development (IGSD) (Feb. 27, 2014) (Sources include Deutsche Umwelthilfe, Mobile Air Conditioning Society (9/19/2014), EU Stakeholder Meeting (11/2013) and IGSD communication with MVAC experts.

B. Vending Machines - HFO-1234yf

- In use by two manufacturers in Japan
- 99% reduction in GWP compared to HFC-134a
- More efficient than CO₂, safer than hydrocarbons

Company	Product Photo
Kubota Corporation- www.kubota-global.net/vending/english/	
Fuji Electric- www.fujielectric.com	

C. Commercially Available Chillers Using Solstice®ZD and Solstice®ZE (HFO-1233zd(E) and HFO-1234ze(E))






- Approximately 99% reduction in GWP compared to HFC-134a or HCFC-123

Manufacturer	Product Photo
Trane – 1233zd Centrifugal Chiller http://www.trane.com/commercial/north-america/us/en.html	
Carrier -1234ze Screw Chiller—Water- and Air-Cooled http://www.ahi-carrier.at/wp-content/uploads/2015/02/CB_HFO-screw-units_Jan20151.pdf	
Climaveneta- HFO-1234ze(E) Chiller http://www.climaveneta.com/	
Airedale-HFO-1234ze(E) Chillers www.airedale.com	
Geoclima – HFO-1234ze(E) Chiller www.geoclima.com	
Smardt Chillers http://www.smartd.com	
Star Refrigeration – HFO-1234ze(E) Chiller http://www.star-ref.co.uk	

<p>FrioTherm – HFO-1234ze(E) District Heat Pump</p> <p>http://www.friotherm.com</p>	
<p>Cofely GDF Suez – HFO-12343ze(Z) Chiller</p> <p>https://www.cofely-refrigeration.de/en/products/chillers/quantum/Quantum-G/</p>	
<p>BlueBox – HFO-1234ze(E) Chiller</p> <p>http://www.blueboxcooling.com/</p>	
<p>Multistack – HFO-1234ze(E) Screw chiller</p> <p>https://www.multistack.com</p>	
<p>Mitsubishi Heavy Industries (MHI) -1233zd Chiller</p> <p>www.mhi-global.com/news/story/1506101900.html</p>	

D. Commercial Refrigeration - Solstice® N-40

- GWP of N-40 is 67% lower than R-404a while delivering higher efficiency
- Oak Ridge National Labs testing shows 11.6% increase in the coefficient of performance compared to R-404A

Company, Product Name	Logo or Product Photo
<p>Oak Ridge National Labs</p>   <p>http://www.ornl.gov</p>	<p>Working Fluids: Low Global Warming Potential Refrigerants</p> <p>2014 Building Technologies Office Peer Review</p>  <p>Life Cycle Climate Performance - Supermarket Refrigeration</p>  <p>U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy</p> <p>Omar Abdelaziz, abdelazizoa@ornl.gov Oak Ridge National Laboratory</p>
<p>Copeland – Emerson Climate Technologies</p> <p>http://www.emersonclimate.com/en-us/brands/pages/copeland.aspx</p>	

Genetron Performax® LT



**Sustainability and energy efficiency,
hallmarks of R407F**

Honeywell

Tewis

“After this laboratory test, we are convinced that R407F will contribute decisively in obtaining maximum savings at a minimum cost in refrigeration systems that have been using R404A until now.”

Javier Atencia, Tewis Smart Solutions International



Background, context and issues

Industrial and commercial installations of all types must comply with increasingly strict standards of sustainability, environmental impact and energy efficiency.

In the majority of the more developed countries in the world - regulation, legislation and the potential application of fines involved, result in constant adaptation on the part of these installations to meet these high standards.

Furthermore, industry itself is gradually taking on a commitment to reduce possible harmful effects to the environment, such as by establishing green or sustainable agendas that set goals to reduce the impact of their activity.

There is one clear strategic factor in this scenario that fully affects refrigeration systems, which are vital, in preserving dairy, fresh and frozen products in supermarkets, as well as in many other sectors. The efficient operation of a refrigeration system largely depends on the properties of the refrigerant used.

The characteristics of this fluid, essential for maintaining a variety of perishable products in perfect condition, are being increasingly valued by businesses in the industry. Hence, some firms like Honeywell have research and development departments that are continuously working on replacing refrigerant gases that have been used until now with others that are safer, harmless to the environment and efficient; and other companies, such as Tewis Smart Solutions International, are focusing their technological research on designs and systems that result in the lowest possible TEWI (Total Environmental Warming Impact) through savings in energy consumption and environmental properties. It is in this context that Tewis has undertaken this test for the purpose of estimating the energy saving potential of the refrigerant R407F (Genetron Performax® LT).



An optimal refrigeration system largely depends on the properties of the refrigerant used”

Tewis Smart Solutions International: committed to energy efficiency

Tewis Smart Solutions International, one of the leading energy consulting firms with operations in five countries on three continents, decided to undertake a rigorous and meticulous comparative assessment of the properties of the refrigerant R407F (Genetron Performax® LT) compared to other gases that it could substitute (R404A, in this case).

Tewis has focused its business on continuous development and concern for research and identification of new solutions and controls for refrigeration, directed toward the implementation of more efficient, less energy consuming systems. This goal has led them to open their own laboratory at their Valencia facilities, a pioneering step in this field in Spain.



A conclusive trial with an added seal of accuracy

The Tewis team has set up a controlled laboratory trial with a well-defined objective: to analyse the energy consumption of a medium temperature refrigeration installation with two different refrigerants – R407F and R404A – under similar weather conditions and with a short time difference.

The data resulting from the study must allow evaluation of possible energy savings based on the use of refrigerant R407F in comparison with its predecessor, R404A, with the same compatibility characteristics for the existing installation as with the former (an additional added value for Genetron Performax® LT).

To provide the greatest possible accuracy, consistency and reliability for the entire trial, which was conducted in the Tewis laboratory, certification and monitoring by the *Instituto Tecnológico de la Energía* (ITE) of Valencia (Spain) was required.

The ITE is a support centre for innovation and business competitiveness created 15 years ago by the Generalitat Valenciana (Spanish Regional Government). It is primarily devoted to supporting projects of companies in the energy sector.

In this particular case, **the ITE supervised and confirmed the protocols and calibration of all components, equipment and systems installed**, certifying the validity and accuracy of the results obtained.

After two 70-hour operational cycles of a compressor pack connected to a series of refrigerated display cases, each using one of the two refrigerants for comparison, the results demonstrated the energy saving potential of R407F.

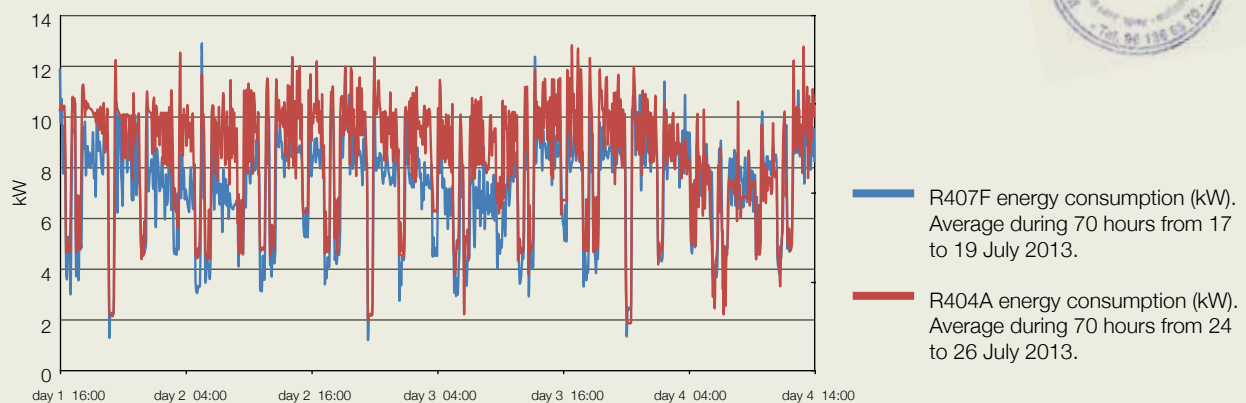
The new refrigerant developed by Honeywell showed a reduction in energy consumption of about 8% kilowatts/

hour than when the system ran on R404A. It should be noted that the initial trial indicators showed an even greater saving in favour of Genetron Performax® LT – specifically, 11% - but given that there was a slight variation in the outside temperature (less than one degree) in the two periods during which the tests were run, a correction factor was applied that provides even greater precision in the final results.

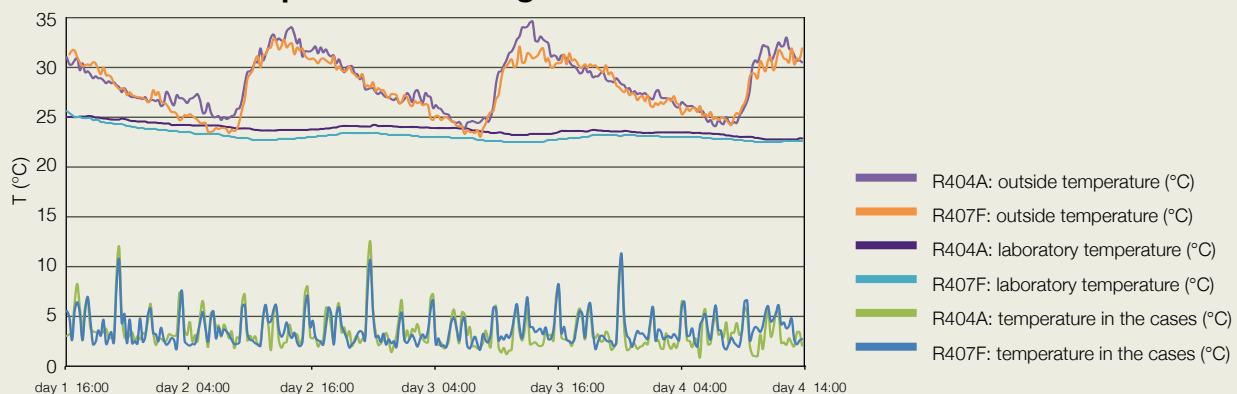
The conclusion is that the potential for reduction in energy consumption that R407F provides, combined with the improved capacity and with lower CO₂ emissions compared with its competitors, makes it the most suitable replacement for the more common refrigerants used in Commercial Refrigeration today. The potential for improving overall profitability of operations involving refrigeration makes it a key product for increasingly sustainable industries.

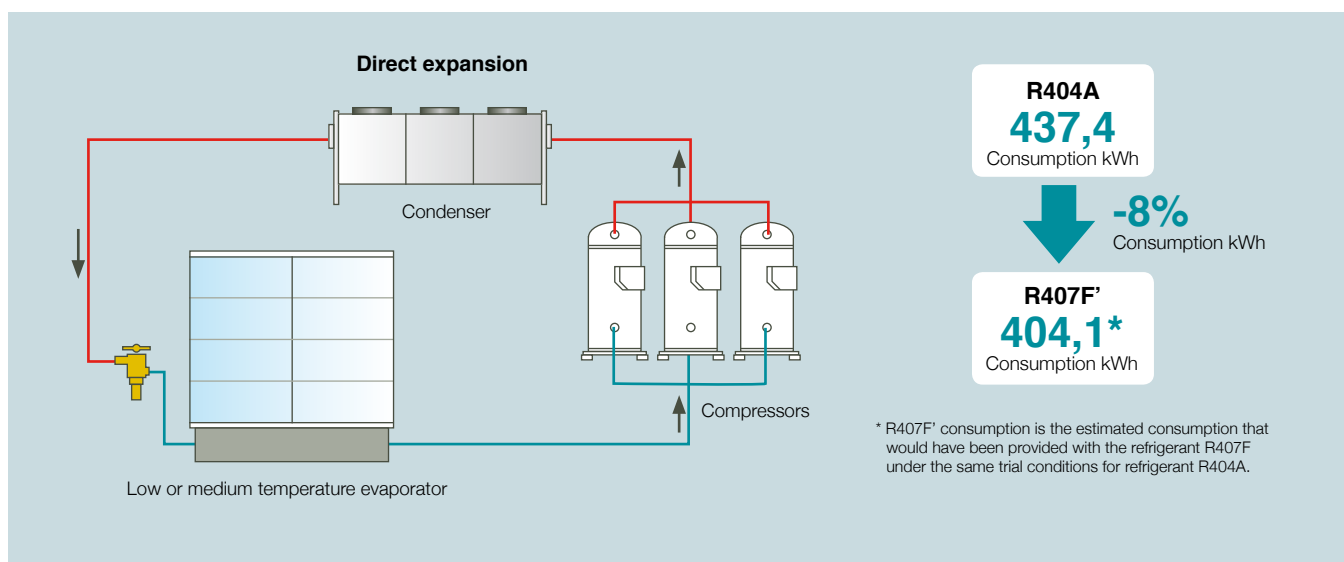


Energy consumption



Temperatures during the trial





The solid advantages of R407F:

1. Reduction of carbon emissions.

Previously conducted tests have already made it possible to establish the better performance of R407F gas compared with other gases that it is gradually replacing, such as R404A and R407A; its global warming potential (1,824) is about 50% less than refrigerant R404A (3,922), and lower than any other alternative used in commercial refrigeration.

2. Savings on energy bills. In terms of energy consumption, the 8% savings indicated in the Tewis trial (savings due strictly to the refrigerant and under the worst conditions and with very restrictive criteria regarding the influence of differences in ambient temperature) confirms the savings in other field trials performed by Honeywell with savings of up to 15% compared to systems operating on R404A.

3. Application in already existing installations.

There is no need to replace refrigeration systems in order to use R407F. With a series of minor adjustments, Genetron Performax® LT or R407F can be used with no problem in existing systems. In this way, the necessary remodelling of gas refrigeration installation groups that commercial and industrial establishments face has a major ally in this new refrigerant.

4. Approved by major manufacturers of components, and can be handled by technicians and installers. R407F is approved by major manufacturers of compressors, valves and other components, and there is no significant difference in its handling for regular technicians and contractors, so that it can be handled safely and with no major changes.

A rigorous methodology endorsed by the ITE (Energy Technological Institute, Valencia, Spain)

- The refrigeration system in the Tewis laboratory was charged with 80 kg of R407F refrigerant and run uninterruptedly for 70 hours from July 17 to 19, 2013.
- The same schedule was repeated a week later (from July 24 to 26) with R404A.
- The key parameters were recorded in both cases: average power (every 5 minutes); outdoor ambient temperature (every 15 minutes); temperature in the refrigerated cases (every 15 minutes) and laboratory temperature (every 15 minutes).
- The main parameter, electricity consumption in the compressor pack, was measured with a calibrated network analyser owned by ITE.
- The tested parameters were measured for the average time of both tests (48 hours) to eliminate transients effects in the system. The two tests were conducted during two consecutive weeks so temperature conditions were practically the same. As the temperature was not exactly the same despite all efforts, a series of corrections were applied based on the thermal difference between the temperatures of the refrigerated case and the outside.
- The conditions for the regulation and operation of the installation were as follows for both tests:
 - Compressor suction setting: **-10°C**
 - Compressor discharge setting: **40°C**
 - Temperature setting at cases: **1°C**
 - Case loading: **Operating empty (without foodproducts)**

Component	Brand	Model
Compressors	Frascold	S 7 33Y
Condensers	Siarco	CN 523H
MT refrigerated cases	Frost-Trol	HMC-4/3750/465
Electronic control	Eliwell	EWCM9100 eo
Individual electronic control	Eliwell	ID985/E LX
Expansion valves	Eliwell	PXVB0AR8000
Network analyser	Darnetz Power Xplorer	Serial no. PX502A510

Methodology used to correct the effect of variation in the external temperature

Bearing in mind that the two testing periods were conducted with a sufficiently close time period, linear and proportional performance of energy consumption in relation to temperature is assumed; the thermal jump existing between the case and the ambient temperature within the laboratory where the test was conducted was considered the variable key of reference. This thermal difference could be considered, in a simplified manner, proportional to the heat extracted by the unit.

In this way, ITE considered the increase in this thermal difference, as a simplified approximation, to be proportional to the increase in energy consumption*.

By establishing a simple formula, it is, hence possible to even more rigorously establish the power consumption measured with R407F under the temperature conditions that the refrigerant R404A was tested with.

$$\text{Consumption}_{R407F'} = \frac{\Delta T_{R407F'}}{\Delta T_{R407F}} \cdot \text{Consumption}_{R407F}$$

Refrigerant	Consumption (kWh)	Temperature gradient (°C)	Laboratory Temp. (°C)	Case Temp. (°C)
R-407F	388,8	19,4	23,0	3,6
R-407F'	404,1	20,2	23,7	3,5

* This approximation may be considered to be excessively rigorous, as the thermal difference is less than one degree and this difference could be within the tolerance of the temperature measuring devices.

A considerable saving

Regarding the increase in regulatory control mentioned, the economic impact resulting from the new tax in Spain on fluorinated greenhouse gases that will become effective in January 2014 on all industries that use commercial refrigeration (supermarkets, hypermarkets, convenience stores, the food industry, vending machines, etc.) should be noted.

This tax sets a new rate for industry, with the new amount to be determined by the type of refrigerant or blend, the charge and the global warming potential (GWP) of the gas used in each case. The tax seeks to stimulate the use of gases with lower environmental impact, levied especially on those with higher GWP.

In this context, the suitability of Genetron Performax® LT is even more obvious. This refrigerant has potential global warming credentials that make it an option that is difficult to beat: its GWP is 53% lower than R404A, the gas that it will be replacing in most cases, and less than any other alternative used in commercial refrigeration. The potential for reduction of direct and indirect emissions that R407F (Performax) provides, aside from its environmental benefits, economic advantages that are far from insignificant.

	GWP*	2014 - €/kg	2015 - €/kg	2016 - €/kg
R-134a	1,300	8,58	17,16	26,00
R-407C	1,653	10,91	21,81	33,05
R-407F	1,705	11,25	22,51	34,10
R-442A	1,793	11,83	23,67	35,86
R-410A	1,975	13,04	26,07	39,50
R-407A	1,990	13,13	26,27	39,80
R-438A	2,151	14,20	28,40	43,03
R-422D	2,623	17,31	34,62	52,46
R-507	3,850	25,41	50,82	77,00
R-404A	3,784	24,97	49,95	75,68

* Global Warming Potential according to the IPCC (International Panel of Climate Change), revision 3.

More information about R407F

You can find all the information about Genetron Performax® LT at:

<http://www.honeywell-refrigerants.com/europe/applications/commercial-refrigeration-supermarkets/>

More information about Tewis

www.tewis.com

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Download the free software from Honeywell Genetron Properties Suite at:

<https://www.honeywell-refrigerants.com>

Download the PT calculation retrofit calculator applications for iOS and Android free



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Honeywell Genetron® Performax™ LT



CUSTOMER INSIGHT:
ASDA SUPERMARKETS (UK)

**Innovative Refrigerant Reduces
Emissions, Enhances Energy
Efficiency and Supports Sustainability**

Honeywell

“The benefits we are seeing are very much a combination of ASDA system optimisation and favourable properties of the refrigerant. I feel the most important aspect of this conversion to Performax will be its unparalleled efficiency and lower GWP versus R404A, which will enable us to reduce both direct and indirect emissions. I am impressed by the energy improvement.”

Brian Churchyard, Head of Refrigeration at ASDA.



The new Genetron® Performax™ LT is the best performing, cost saving and lowest GWP refrigerant for supermarket installations.

Summary: Creating a Sustainable Future

Supermarkets around the world are coming under intense scrutiny to prove their credentials when it comes to environmental impact and sustainability. Honeywell has responded by developing a new refrigerant blend – Genetron Performax LT – which is delivering outstanding results across key metrics linked to energy efficiency, carbon footprint reduction and running costs.

In the latest field test – completed with ASDA, one of the foremost supermarket chains in the UK – the new Honeywell refrigerant was assessed against the commonly-used R-404A and R-407A.

The results proved Genetron Performax LT to be the best performing refrigerant currently available for supermarket installations.

Unlike R407A, Genetron Performax LT can be used in both low temperature and medium temperature applications. The refrigerant delivered impressive results due to its higher capacity and efficiency and a GWP that is nearly 50% lower than R-404A and 15% lower than R-407A.

The Honeywell Genetron Performax LT advantage created for ASDA included:

- Up to 15 % saving in system energy bills
- Up to 40 % reduction in system CO₂ emissions
- Up to 10 % improvement in system running costs

Background: Contributing to ASDA's Carbon Reduction Goals

ASDA has made a public commitment through its Sustainability 2.0 agenda to reduce the environmental impact both of its own operations and those of its supply chain. The ambitious goals for 2015 (compared to 2005 levels) include:

- Reducing energy consumption in existing stores by 35 %
- Reducing new store carbon emissions by 60 %

- Reducing overall carbon footprint by 10 %
 - Removing 20 million metric tons of CO₂ from its global supply chain
 - Reducing 60 % of emissions from its transport fleet
- A key contributor to these targets for ASDA is the identification and application of eco-friendly refrigerants used to preserve meat and dairy products, with a particular focus on

reducing energy consumption (and cost) and lowering carbon emissions through improved GWP.

Following a successful laboratory test of Genetron® Performax™ LT, ASDA embarked on a full-scale field test of the Honeywell refrigerant at its new Hunts Cross store in Liverpool (UK).

Field Test Implementation: Monitoring and Assessing Data

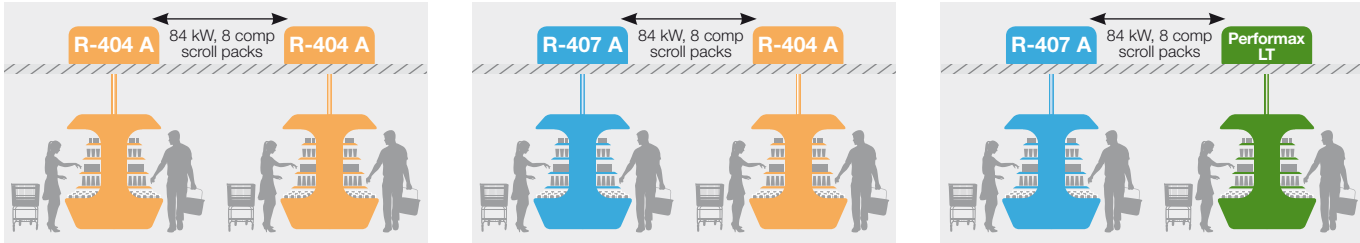
To ensure the robustness of the project, a dedicated team of professionals was set up to run the trial. In addition to the involvement of ASDA's Head of Refrigeration and Energy Manager, the team included representatives from Honeywell Refrigerants Technical Management, Emerson Climate Technologies (Copeland scroll compressors), AGas, BJA Consulting, CBES Constructive

Solutions and City Holdings. The Hunts Cross store was chosen because it had two identical MT (medium temperature) systems, which would allow for accurate comparisons of Genetron Performax LT alongside R-404A and R-407A (see Fig. 1). The MT systems comprised:

- Identical connected loads
- Identical pipe work design and layout

- 8 compressors pack ZB45 (Copeland scroll)
- In order to ensure like-for-like comparisons between all three refrigerants, System 1 was converted from R-404A to R-407A and performance and energy consumption measured over a 12 months period. System 2 was then converted from R-404A to Honeywell Genetron Performax LT and operated over an extended

Figure 1: Original system and two-steps transformation



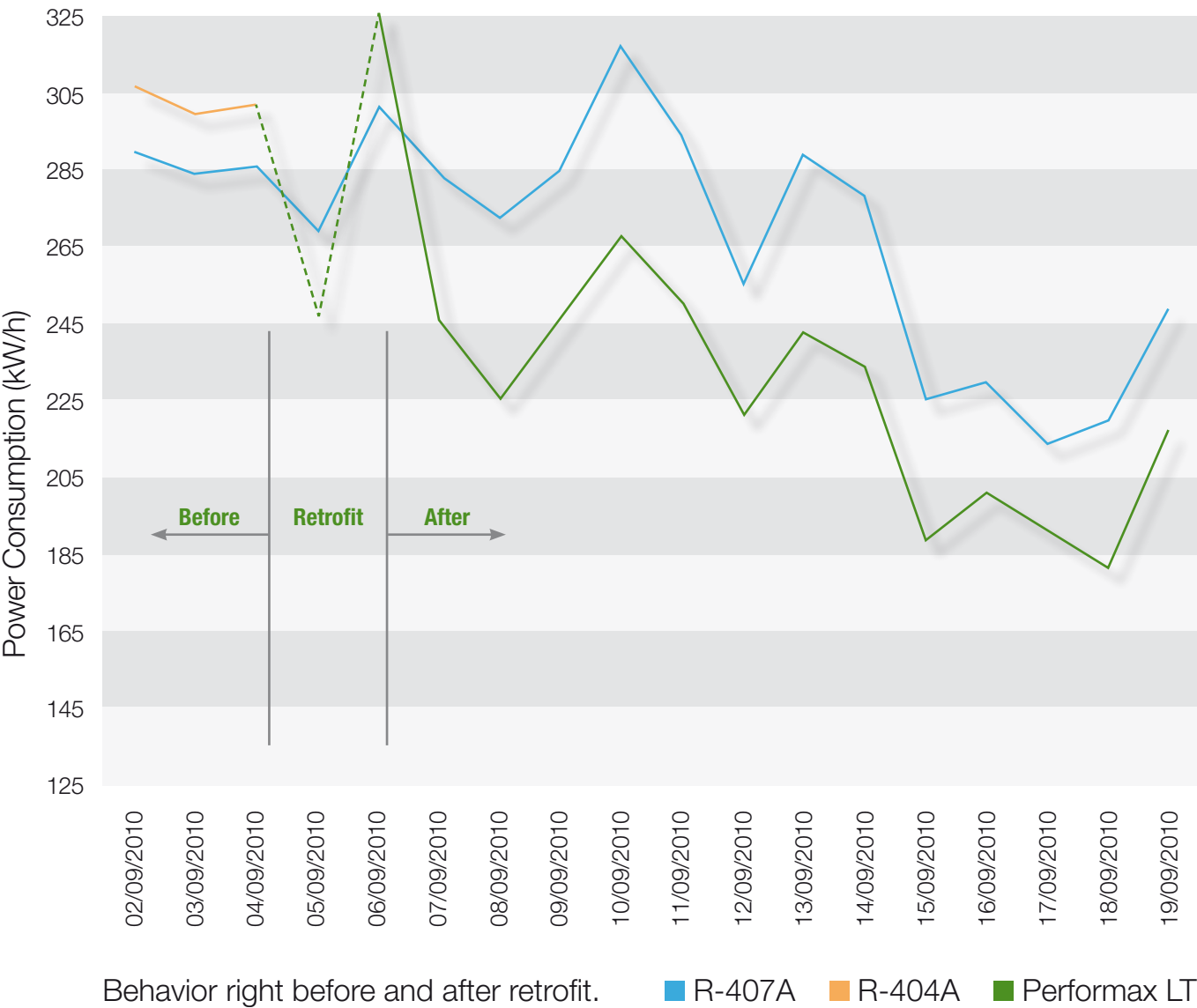
Field Test Results: Proving the Value of Genetron® Performax™ LT

A thorough evaluation of the results by the entire project team confirmed for the Hunts-Cross store the power consumption shown in (Fig. 2).

- Energy Consumption:
- The R-404A system consumed 5% more energy vs. the R-407A system.
 - The Honeywell Genetron Performax LT system consumed 13% less

power than the R-407A system and around 20 % less than the original R-404A system. The figures below show the energy consumption of the retrofitted pack.

Figure 2: ASDA Hunts Cross Energy Savings



Carbon Footprint and Operating Costs

The analysis (Fig. 3) below shows the impact of refrigerants on a standard store similar to the Hunts Cross store carbon footprint and on the system operating costs, based on a 15 year life-cycle assumption and taking account of compressor energy consumption only. All other energy usage is assumed to be the same for all refrigerants. The results show significant emissions and cost advantages in using Honeywell Genetron® Performax™ LT over R-404A and R-407A across a range of operating conditions. The cost of retrofitting is not included.

Figure 3: Results table - Technical case study Performax - Asda Hunts Cross

	MT			LT		Total system		
Refrigerant	R-404A	R-407A	Performax	R-404A	Performax	R-404A	R-407A	Performax
Refrigerant Charge	250	250	250	150	150	400	400	400
Average relative COP ¹	100%	105%	115%	100%	109%	100%	99%	112%
TEWI (Tonne CO ₂) Direct	2.255	1.212	1.049	1.353	629	3.608	2.565	1.678
TEWI (Tonne CO ₂) Indirect	1.390	1.324	1.209	1.006	875	2.396	2.330	2.084
TEWI (Tonne CO ₂) Total	3.645	2.536	2.258	2.359	1.504	6.004	4.895	3.762
Savings CO _{2eq}		30%	38%		36%		18%	37%
Yearly Operating Cost from compressor (€)	23.800	22.667	20.696	17.220	14.974	41.020	39.887	35.670
Savings compressor energy cost vs 404A	95%		87%	87%		97%		87%

Data & Criteria	
Annual leak rate ²	15 %
System operational lifetime (years)	15
Recovery efficiency	95 %
Electricity price (€/kWh) ³	0,14
CO ₂ emission factor (kg CO ₂ /kWh) ⁴	0,54522

ASDA Savings			
Direct emissions tons CO _{2eq}	1.930	* Life time	
Indirect emissions tons CO _{2eq}	264	* Life time	
Total reduction emissions; tons CO _{2eq}	2.194	* Life time	

¹Performax vs 404A: CoP for MT from Asda field test; CoP for LT from Honeywell Research Lab bench test. R407A cannot be used for LT applications

²15 % leak rate is the industry average. Asda's current leak rate is 2 %.

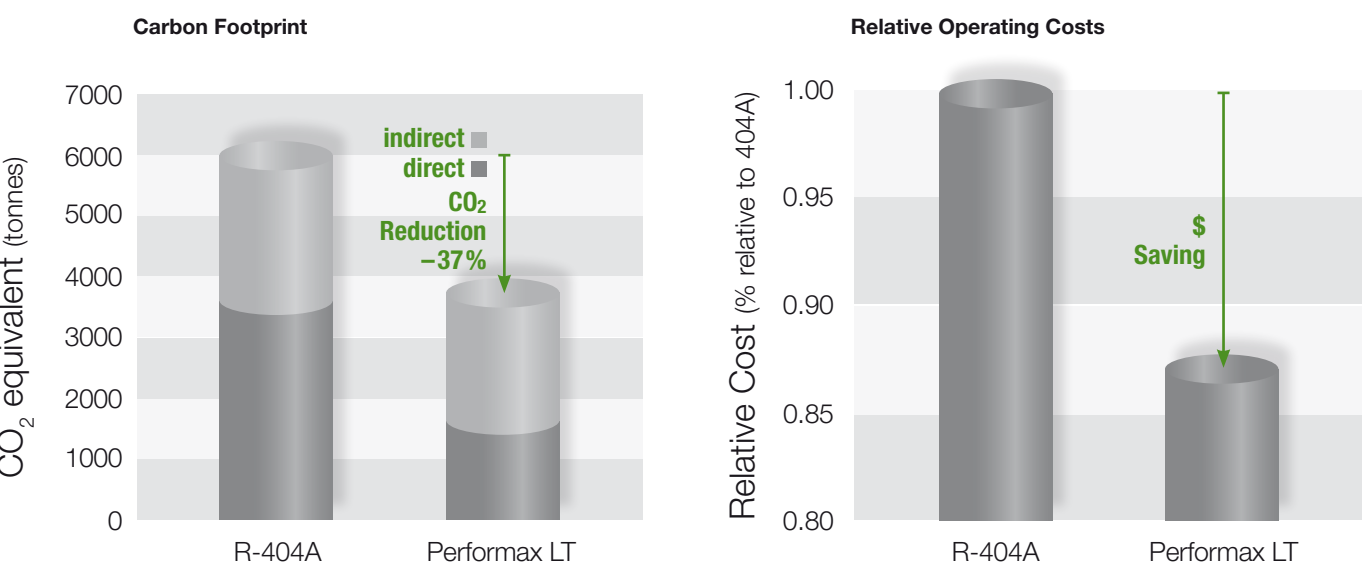
³Source: <http://www.energysavingtrust.org.uk>

⁴Units kg CO_{2e} per unit, source Carbon Trust, conversion factor 2010

Feedback: A Win-Win Result for ASDA

“The benefits we are seeing are very much a combination of ASDA system optimisation and favourable properties of the refrigerant. I feel the most important aspect of this conversion to Performax will be its unparalleled efficiency and lower GWP versus R404A, which will enable us to reduce both direct and indirect emissions. We have killed two birds with one stone; I am impressed by the energy improvement; this will bring us great opportunities when rolling-out this conversion also to LT packages and other stores”.

Brian Churchyard, Head of Refrigeration at Asda: ASDA will extend this program to the rest of refrigeration packs (MT and LT) in Hunts-Cross and use this experience for the further roll-out of conversion to Performax in other stores in the UK.



Sector Perspective: Rolling Out the Benefits of Performax LT Around the World

The ASDA Field Test confirms the excellent performance and energy efficiency of Genetron Performax LT and the potential for significant energy savings and carbon footprint reductions among supermarket operators. Genetron® Performax™ LT outperforms alternative refrigerants across all ambient conditions – a benefit confirmed by subsequent retro-fit projects in the supermarket sector – creating potential for extended application into storage and packaging areas. The efficiency of the Honeywell refrigerant also provides potential for enhancing overall profitability – a true win-win situation when emissions reduction is factored in. Industry-indicative results confirm the ASDA experience, with Genetron Performax contributing up to 15 % savings in energy bills, a 40 % reduction in CO₂ emissions and 10 % lower running costs .

For more information on Genetron Performax LT visit www.genetronperformaxlt.co.uk

Genetron Performax LT is a non-flammable blend commercially available from Honeywell. Complete guidance for use (new and retrofit) can be found in the brochure "Genetron® Performax™ LT Refrigerant - Properties, Guidelines and Retrofits".

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Honeywell

Genetron Performax® LT (R-407F) “Makes Sense” for New Supermarkets

“In some cases, R-407F allows a compressor to cycle off, which saves energy. The supermarket as a whole averaged 3.8% lower energy usage with Genetron Performax® LT vs. R-407A. The payback is short enough to justify using R-407F over R-407A.”

Charlie Lowe

Director of Refrigeration/HVAC/Lighting/Food Equipment Services, K-VA-T Food Stores, Inc.



The Challenge

With R-22 only a few years from phaseout, Charlie Lowe knew his company would look to him to recommend a retrofit refrigerant for their 100+ supermarkets that would perform as well as R-22 without disrupting their business.

The Solution

After testing Honeywell's Genetron Performax LT (R-407F), Charlie Lowe uses it exclusively for all supermarket retrofits as well as new supermarket refrigeration systems.

In 2012, R-22 prices skyrocketed and Charlie Lowe, Director of Refrigeration / HVAC / Lighting / Food Equipment Services, K-VA-T Food Stores, Inc., expected it to happen again. Along with the rest of his team at Food City, Charlie started to look at potential alternatives due to the impending phaseout of (R-22). “I had tried some others, but was not pleased with the outcome,” said Lowe.

First Store Success Sets the Pace

Lowe's first supermarket retrofit with R-407F in Kingsport, Tennessee yielded promising results. “Genetron Performax LT is the refrigerant that most closely resembles R-22, so it makes for a fairly pain-free retrofit process,” Lowe said. “In the last 18 months, we've retrofitted 22 of our supermarkets and one cold storage warehouse with Performax LT, and they are all running well. We plan to retrofit one store every four to six weeks with Performax LT.”

Genetron Performax LT Outperforms R-407A in Energy Savings in New Supermarket

“Honeywell had been telling me for a long time that R-407F

outperformed R-407A in energy benefits, but I wanted to see it for myself,” said Lowe.

“In summer 2013, we took a brand new store that was designed to run R-407A, and set up a product comparison.” Lowe controlled for operating conditions such as humidity and ambient temperature, and ran the two products with three parallel refrigerant racks to compare energy performance.

“We monitored all the systems, including condensers. In some cases, R-407F allows a compressor to cycle off, which saves energy,” according to Lowe. “The energy savings ranged from 1.22% on one rack to a high of 8.3% on another. The store as a whole averaged 3.8% lower energy usage with Performax LT vs. R-407A. The payback is short enough to justify using R-407F over R-407A.”

Making the R-22 Phaseout Work for You

Before embarking on his monumental retrofit project, Lowe purchased the equipment to reclaim, recover and clean the used R-22, to reuse in refrigeration and A/C applications in other stores. “We do all our retrofits in house, so this was a much more economical solution for us,” he said. He is proud to say that they haven't had to purchase any R-22 since they started making the conversions.

Headquartered in Abingdon, Virginia, K-VA-T owns over 100 stores that are located in southwest Virginia, eastern Tennessee and Kentucky. At this pace they will complete their retrofits well before the targeted 2020 R-22 phaseout.



[Cold Storage Case Study Video](#)

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APPENDIX III

Alternative Products for HFC-134a, HFC-245fa and HFC-365mfc Foam Applications

A. One Component Foam

- HFO-1234ze(E) in one-component foam, replacing HFC-134a
- Commercial in EU since 2008

Company, Product Name	Logo or Product Photo
<div data-bbox="342 806 805 1018">  </div> <p data-bbox="337 1056 518 1083">Product Name:</p> <div data-bbox="362 1169 574 1430">  </div>	<div data-bbox="833 806 1190 1253">  </div> <div data-bbox="833 1253 1190 1472"> <p>Handi-Stick® Polystyrene Construction Adhesives were formulated for compatibility with all polystyrene applications including ICFs, architectural foam shapes and foam boards.</p> </div>

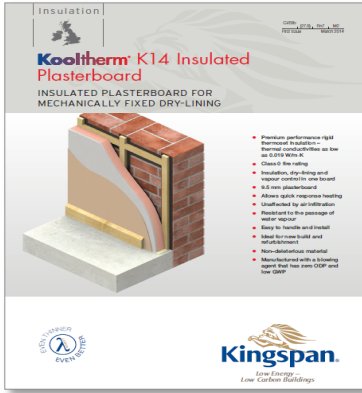
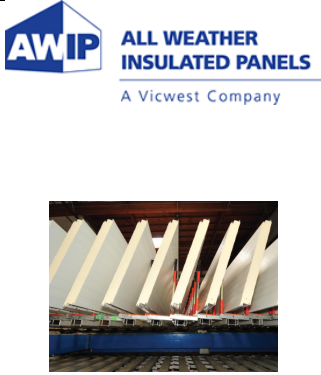
B. Extruded Polystyrene (XPS)

- HFO-1234ze(E) in extruded polystyrene foam, replacing HFC-134a and HFC-152a
- Commercial in EU since 2010 and Australia, Japan since 2014

Company, Product Name	Logo or Product Photo
 <p>Product Name:</p> 	






C. Continuous Panels

- HFO-1234ze(E) and HFO-1233zd(E) replacing HFC-134a, HFC-245fa, HFC-365mfc, and hydrocarbons
- Commercial in EU since early 2014, commercialization imminent in US

Company, Product Name	Logo or Product Photo
<p>Kingspan (EU)</p> <ul style="list-style-type: none"> • phenolic boards for residential insulation 	 <p>The image shows a product brochure for Kingspan Kooltherm K14 Insulated Plasterboard. It features a cross-section diagram of the product being applied to a brick wall. The text on the brochure includes 'Insulation', 'Kooltherm K14 Insulated Plasterboard', 'INSULATED PLASTERBOARD FOR MECHANICALLY FIXED DRY-LINING', and a list of benefits such as 'Excellent fire rating', 'Insulation, dry-lining and vapour protection in one board', and '5.5 mm plasterboard'. The Kingspan logo is at the bottom right.</p>
<p>All Weather Insulated Panels (US)</p> <ul style="list-style-type: none"> • Insulated metal panels for industrial construction and cold storage. 	 <p>The image shows the logo for AWIP All Weather Insulated Panels, which is a blue and white logo with the text 'AWIP ALL WEATHER INSULATED PANELS A Vicwest Company'. Below the logo is a photograph of a large industrial building with a curved roof made of insulated metal panels.</p>


D. Domestic Appliances

- HFO-1234ze(E) and HFO-1233zd(E) replacing HFC-134a, HFC-245fa and HFC-365mfc/227ea
- Commercial in US, Mexico, China; imminent in EU

Company, Product Name	Logo or Product Photo
Adoption complete / underway: Whirlpool (US / Mex), Midea (China), Festivo (Finland), Haier (China)	    






E. Commercial Appliances

- HFO-1234ze(E) and HFO-1233zd(E) replacing HFC-134a, HFC-245fa and HFC-365mfc/227ea
- Commercial in EU, Japan; imminent in US, Mexico

Company, Product Name	Logo or Product Photo
<p>Adoption complete / underway: Porka (Finland), Okamura (Japan)</p> <p>Trials Nearing Completion: (company names confidential) US / Mex, US, Japan</p>	 <p>PORKKA</p> <p>okamura</p>

F. Spray Foam

- HFO-1234ze(E) and HFO-1233zd(E) replacing HFC-134a, HFC-245fa and HFC-365mfc/227ea
- Commercial in US, Japan; imminent in EU

Company, Product Name	Logo or Product Photo
Lapolla (US), West Development Group (US), Soflanwiz (Japan), Nihon Puftem (Japan), BIP (Japan)	<p>Cleveland Airport (Company: West Development Group)</p>  <p>Purdue house (Company: Lapolla industries)</p>  <p>Philadelphia Water Treatment Facility (Company: West Development Group)</p>  <p>Toyo Tire (Soflanwiz) Announcement</p>  <p>Nihon Puftem Announcement</p> 

Commitment to Sustainability and R&D Leads to Breakthrough Solution for Midea

“Midea is a global leader in the manufacture of energy-efficient appliances. Our planned use of a blend of HFC-245fa and Honeywell Solstice® LBA will provide us with the lowest-cost route to meet current and future energy standards.”

Sangjo Suk - Vice President, Refrigerator Division, Midea

The Challenge:

Midea is facing the challenge of meeting increasing energy efficiency requirements and environmental regulations globally.

The Solution:

Midea has developed a blended foam system using cyclopentane, HFC-245fa and Solstice® Liquid Blowing Agent, and is confident this blend will meet the changing global energy standards and regulations on GWP.

Midea Faced New Challenges With Each Generation of Blowing Agent Technology

There are many factors that impact a refrigerator's efficiency and environmental footprint, but one of the most critical is having the best insulation performance so that OEMs can meet increasingly stringent energy standards while maintaining or reducing the cost of doing so. When it comes to the foam insulation's thermal performance (the energy efficiency of the finished refrigerator / freezer), the key component is the foam blowing agent.



Ruling Out VIPs and Changes to Compressors

When Midea was exploring the factors needed to balance cost effectiveness and energy efficiency, they first tried optimizing the compressor, to improve the efficiency of the fixed frequency compressor (i.e., improve capacity), or changing to an inverter compressor, which could contribute 10-15 percent improvement in energy efficiency. However, the cost increase was around 100-150RMB per unit.

Then they tried installing vacuum insulated panels (VIPs), which can also provide a 10-15 percent energy improvement. However, the added cost was 300RMB per unit. Also, the fiberglass in today's VIPs cannot readily be recycled and must be extracted from the unit before incineration adding an additional environmental consideration to their manufacture if proper disposal cannot be assured.

Environmental Drivers: Midea Moves to Mitigate Ozone Depletion and Global Warming

When it became apparent that CFCs depleted the ozone layer, the foam blowing agent industry started work on replacement technology.

When HCFC-141b (the 2nd generation of foam blowing agents) was introduced, Midea developed a polyol system with high degree of functionality to improve the foam strength in their refrigerators. However, when Midea switched to ABS liners, they experienced some compatibility issues and needed to further innovate to work successfully with the new formulation.

Then, due to 141b's ozone depletion potential, Midea's next move was to develop a cyclopentane (Cp) system. Cp has a higher boiling point so the flowability was not as good as with HCFCs, but Midea developed a high functionality polyol with lower viscosity and silicone oil with better flowability.

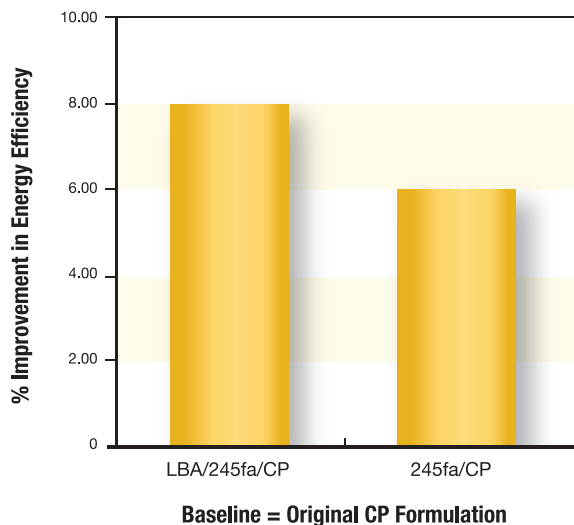
Another disadvantage of the Cp system is lower insulation performance. Although the GWP of Cp is lower than 141b, it negatively impacts the total GWP due to higher energy consumption over the life of the product.

Midea's New Blended System Includes Solstice Liquid Blowing Agent

Since Midea sells appliances in more than 200 countries, they knew they needed to consider global energy standards. They liked the efficiency of HFC-245fa, but its GWP is 858. HFCs are also coming under regulatory pressure in many countries around the world and are being targeted for phaseout. With Solstice LBA, Midea saw not only an improvement in efficiency over 245fa, but also a product with a GWP of only one, helping them prepare for emerging HFC regulations.

Midea finally explored improvements to the foaming system, which they had been studying for several years. When they switched from straight Cp to a Cp / 245fa blended system, the unit cost increased only slightly but they saw significant energy efficiency improvements of 5-7%. Then, by adding Solstice LBA, they were able to improve the insulation performance even further. Midea's new Cp / 245fa / Solstice LBA blend system is now in mass production, and Midea is confident that their refrigerators will meet the changing global energy standards and regulations on GWP.

**ENERGY EFFICIENCY IMPROVEMENT OF
BLENDED BLOWING AGENT SOLUTIONS**



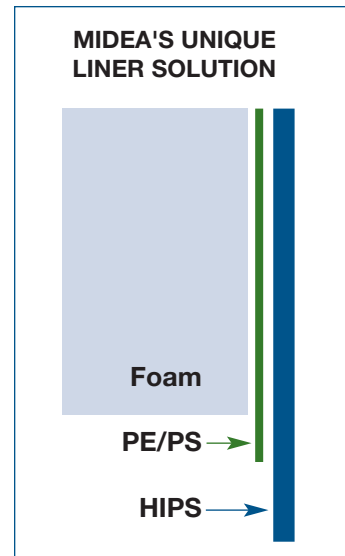
Identical refrigerator models using different foam blowing agent systems were compared in recent production trials at Midea. The test showed that, compared to a pure Cp solution, when 245fa was blended with Cp, the energy efficiency of the finished unit improved by 5-7%. When Solstice LBA was blended with Cp and 245fa, the energy efficiency improved by 8%.

Unique Liner Solution

With the new foam blowing agent system determined, Midea then spent more than a year working with their plastic supplier to develop an innovative new polyethylene and HIPS alloy material with a polyethylene/polystyrene barrier layer to offer the performance Midea was looking for with the new system. Liners were free of blisters, cracks or any visual degradation, and provided the glossy look that the market requires, comparable to ABS.

With this unique three-layer HIPS solution, Midea achieved:

- Optimized cost, performance and product quality/gloss
- Excellent compatibility with the foam containing HFC-245fa and Solstice LBA
- Improved gloss compared with ABS



What's Next for Midea?

In late 2013, Midea started researching a pure Solstice LBA system. The cost increase was significantly lower than changing to inverter compressors or VIPs, with a corresponding energy efficiency improvement of 10-12% over Cp, mainly because of the excellent insulation performance at low temperatures. Meanwhile, the Solstice LBA system has:

- Ultra-low GWP of 1, compared to a GWP of 858 for 245fa
- Better flowability than Cp

Midea also has a visible commitment to sustainability. They are continuing to work with Honeywell under a grant from the U.S. Trade and Development Agency (USTDA) to further the development of Solstice LBA-based solutions for China and beyond.

At a recent supplier event, Mr. Wang, president of Midea's Refrigerator business unit, noted their commitment to sustainability and the environment, and said, "The adoption of Solstice LBA fits perfectly with that commitment."

In the next three years, Midea's strategic vision is to become 'the leader of the Chinese home appliance industry, and in the top three global white goods manufacturers. Midea continues to deepen transformation, improve management quality, focus on customer orientation, technology innovation, quality improvement and lean management to achieve the leading products and advanced strategy needed to support the company growth.

About Midea

Midea is a leading Chinese appliance manufacturer with total sales of \$19.7B in 2013, including \$7.4B overseas sales revenue. Midea's products are sold in more than 200 countries.



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Honeywell

MMA Champ Dan Henderson's New Spray Foam Roof Using Honeywell Solstice® LBA is a Knock-Out

Spray foam roof delivers toughness and low global warming potential for California fitness center

"I've had spray foam in my home gym for a long time. I know it is very tough and durable. I may be able to punch through it but it might take me a while (jokingly). As far as Mother Nature goes, I am absolutely confident that this roof will withstand everything that it throws at it."

Dan "Hendo" Henderson — former Olympic wrestler, UFC, Pride FC and Strikeforce champion



The Challenge:

Dan Henderson's Athletic Fitness Center had a single-ply membrane system installed over a built-up roof (BUR) that was leaking. The approximately 28,000 square foot roof, estimated to be about 30 years old, had been patched multiple times but was deteriorating and not energy efficient.

The Solution:

A new closed-cell spray polyurethane foam (ccSPF) roof system developed by West Development Group*, formulated with Honeywell's ultra-low global warming potential Solstice® Liquid Blowing Agent (LBA), was installed by Western Pacific Roofing.

*Subsidiary of the Henry Company

With more major titles than any other athlete in mixed martial arts (MMA) history, Dan Henderson is one tough customer – literally. As he works with upcoming fighters at his training facility in Temecula, California, he expects the very best. Henderson understands what it means to be resilient and durable. Therefore, a ccSPF roof formulated with Honeywell Solstice LBA was the obvious choice for his facility's roof repair.

Having purchased the building about a year and half ago, Henderson knew upgrades were needed. "I've had spray foam in my home gym for a long time and have been pleased with it," said Henderson. "I chose a foam roofing system with Solstice LBA because it's very durable and can increase energy efficiency. Not only do I want to prevent leaks, I'm excited to see what we save every month in our utility bills."



Round 1: Safety Emphasized During Challenging Installation

"With many skylights and a variety of roof surfaces, this installation was the ultimate challenge for a roofer," said Mary Bogdan, senior principal scientist at Honeywell, who provided on-site technical support. Bogdan gave top marks to Western Pacific Roofing for their focus on safety throughout the entire installation. "The application areas were roped off, each of the skylights was barricaded to ensure adequate fall protection, and ventilation systems were shut down and sealed. Roof access was carefully controlled and clear signage posted. The installation



Installers wore proper protective equipment and followed safety procedures throughout the installation.

crew used proper protective equipment (PPE) and ensured that everyone else remained outside of the work area.”



Round 2: Solstice LBA Gives CcSPF an Edge

Bogdan also underscored the many advantages of Solstice LBA, an ideal blowing agent replacement for HFC-245fa and other HFC alternatives. Some of these key advantages include:

- Ultra-low global warming potential (GWP) of 1 (99.9% better than HFC alternatives)
- A slightly lower molecular weight so less material can be used in a system
- A lower vapor pressure, which improves handling and delivers smoother foam surfaces (smooth surfaces require less coating)
- Improved thermal performance (improves energy efficiency, which allows air conditioning units to run less)

Other benefits for this project included a reduction in construction debris sent to the landfill. After removing the old layer of single-ply membrane, the ccSPF system was applied directly over the original BUR roof. This allowed the roof to be sealed and repaired rather than completely torn off and replaced. Also, the spray foam and acrylic coating are light-colored, which offer reflective benefits by keeping the surface cooler than darker materials. In addition, Solstice LBA is:

- A nonflammable liquid (ASTM E-681)
- Listed under the U.S. EPA’s Significant New Alternatives Policy (SNAP) program to replace ozone depleting substances
- Listed on the TSCA inventory
- Not a volatile organic compound (VOC) as determined by the U.S. EPA



Round 3: CcSPF System Exceeds Performance Expectations

Along with its nonflammability and ultra-low GWP, Solstice LBA in the foam formulation offered other performance advantages as well. “The installation went very well today,” said Richard Brunelle, supervisor, Western Pacific Roofing. “This foam is a lot smoother and looks really nice. The knit lines appear to be very tight and the product laid down really well. It also seemed to clog the spray guns a lot less than normal applications.” He added, “I would use Solstice LBA again. It’s a good product.”

Bogdan concurred, “The spray foam system went down beautifully today. We saw a wide temperature range during application from a rooftop temperature of 59° F to 120° F and the system performed well. The surface finish was excellent and the installation crew had no issues.” Some additional performance benefits of ccSPF systems formulated with Solstice LBA include:

- Increased yields (8-10%)¹
- Improved thermal performance
- Outstanding foam adhesion
- Higher compressive strengths
- Consistency during application (minimal temperature adjustments)



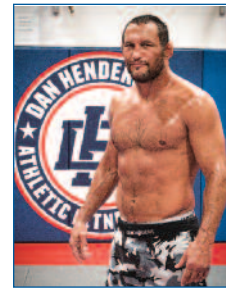
The single-ply membrane on the original BUR roof had been patched many times but was deteriorating and leaking.



CcSPF's unique ability to contour and seal around skylights and the many other rooftop protrusions made it an ideal solution.

Henderson: Winner by Unanimous Decision for Using Solstice LBA

In summing up the experience of having a new ccSPF roof installed, Henderson said, "I am very happy with the installation. It was completed quickly and was pain-free. For anybody considering a new roof, I would absolutely point them in the direction of a spray foam roof. It will stop leaks and last a long time. On the environmental side, it can lower your power usage and if it's made with Solstice LBA, it has a low global warming impact. I'm excited to see what it does for my building."



Dan Henderson



As Henderson works with athletes at his fitness training center, he expects the very best.

Contact Honeywell to Learn More

To learn more about the benefits of Solstice LBA
call Honeywell at **1-800-631-8138**
or visit **www.honeywell-blowingagents.com**

1 Reported by Jack Moore, West Roofing, in Cleveland Hopkins International Airport case study.

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Honeywell

Cottage Comfort Improved with Elastochem Spray Foam Insulation Using Honeywell Solstice® Liquid Blowing Agent

"I would certainly recommend this type of insulation. It has worked really well in our cottage. It provides a high degree of warmth and it will help seal the cottage effectively underneath, which also provides protection against mice and insects."

Linda Luffman - cottage owner, Muskoka, Ontario



The Challenge:

This picturesque A-frame cottage located in Muskoka, Ontario is used seasonally from early Spring through late Fall. With no insulation underneath the raised structure and minimal insulation elsewhere, the Luffman family often experienced uncomfortable temperatures, cold floors, and occasionally mice and insects in their cottage.

The Solution:

A new closed-cell spray polyurethane foam (ccSPF) insulation system developed by Elastochem Specialty Chemicals, Inc., formulated with Honeywell Solstice® Liquid Blowing Agent (LBA) was applied between the joists underneath the floor of the crawl space.

"When we bought the cottage, it was partially insulated but not to a high degree because it wasn't really winterized," said Bill Luffman, who has owned the cottage with his wife Linda for about 16 years. "For under our floor, we looked at a number of different types of insulation – batt insulation and board insulation – but we found they required a lot of labor and weren't suited to being exposed to the elements. It had to be something that was resilient." Linda Luffman added, "In our cottage, like many cottages,

we tend to get mice and some insects. Anything that would help prevent that was also an important consideration. Spray foam was by far the best choice."

Reduced Global Warming Potential

The Luffmans chose Elastochem's new ccSPF wall system, Insulthane® Extreme, which is formulated with Honeywell Solstice LBA. "With the big push in the U.S. and Canada to move towards products with a lower global warming potential, ccSPF made with Solstice LBA is a perfect solution," said Laura Reinhard, global business manager, Spray Foam for Honeywell. "Solstice LBA has an ultra-low global warming potential of one, which is about 1000 times better than HFC alternative products. So not only is it better for the environment than HFC alternatives, it is also demonstrating superior overall foam performance comparatively."



Enjoying spectacular cottage views, Bill and Linda Luffman share a deep appreciation for nature.



The applicator wore proper protective equipment and followed safety procedures throughout the installation.

Like many of the lakefront cottage owners in the Muskoka region, Bill and Linda Luffman share a common appreciation for nature and recognize the importance of environmental preservation. That was an important consideration as they evaluated insulation options. “At the end of the day, it’s good to know that we chose a product that is safe to use, that allows us to use less energy and has improved environmental impact,” said Linda Luffman.

Exceptional Performance and Ease of Installation

Marc Kast, director of sales and marketing, Elastochem, was on-site during the installation. He was pleased with how the new ccSPF system performed and Honeywell’s support throughout its development. “Working with Honeywell has been an absolute pleasure. It’s been a seamless transition from the old blowing agent technology to the new one. The foam is reacting beautifully. We are getting a nice, smooth and even surface with no issues whatsoever. It’s just a consistent, easy to use, contractor-friendly product.”

Muhammed Alibashev, an experienced contractor from Toronto-based FOAMIT, agreed with Kast’s observations after spraying the foam. “I was in a crawl space where it is often difficult to see the foam. This foam was very visible with minimal dripping or leakage anywhere since it adhered to the cavity so well. I was able to maximize my spraying time with much less cleaning needed for the tip of my spray gun chamber.”

Alibashev noted other benefits including:

- a consistent spray pattern
- improved yields
- minimal temperature adjustments required
- lower odor during installation

Mary Bogdan, senior principal scientist, Honeywell Fluorine Products, added, “This was a particularly challenging job. It proved to be an extreme application environment due to the weather, the temperature, and the humidity. The spray foam system worked very well and looks wonderful.”

Safety: A Top Priority

Throughout the installation, safety guidelines were closely followed. Bogdan said, “Safety is always of key importance. The spray areas were taped off with plastic and well ventilated. Only the applicator, who wore full protective equipment which included a full-face respirator with supplied air, was allowed in the spray area during installation. The contractor did a great job.”





The new wall system sprayed flawlessly, adhered well and had a smooth finish.

A Winning Solution

From a contractor perspective, Alibashev summed up his experience, “From the beginning to the end of the spray foam job, everything was consistent and smooth. The material worked in my favor the whole way.” Bill Luffman added, “We’ve been back to the cottage since the insulation was installed and we find, as the weather has gotten colder, the floors are much warmer. It is a great benefit and we would recommend closed-cell foam to other home and cottage owners.” That is a winning solution.

SOLSTICE LBA – Ideal Replacement for HFC Foam Blowing Agents

With a new manufacturing facility that started up in May 2014, Solstice LBA is an ideal replacement for HFC-245fa and HFC-365 because of these key advantages:

- Ultra-low global warming potential (GWP) of 1 (99.9% better than HFC alternatives)
- A slightly lower molecular weight so less material can be used in a system
- A higher boiling point and lower vapor pressure, which improves handling and yields smoother foam surfaces
- Improved thermal performance

In addition, Solstice LBA is:

- Nonflammable (ASTM E-681)
- Listed under the U.S. EPA’s Significant New Alternatives Policy (SNAP) program to replace ozone depleting substances
- Listed on the TSCA inventory
- Not a volatile organic compound (VOC) as determined by the U.S. EPA



Not only is the ccSPF insulation providing warmth and comfort to the family inside, it's helping keep severe weather and pests outside.

Contact Honeywell to Learn More

To learn more about the benefits of Solstice LBA
in new residential construction or retrofits,
call Honeywell at **1-800-631-8138**
or visit **www.honeywell-blowingagents.com**

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Honeywell

Honeywell Solstice® Liquid Blowing Agent: An Insulation Retrofit From the Outside-In

"We are clearly seeing an 8-10 percent increased value in both yield and thermal performance which, in turn, is very beneficial not only for the installer, but for the consumer."

-Doug Kramer, President and CEO, Lapolla Industries

The Challenge: Provide an insulation solution to meet aggressive energy goals for a 2800 sq. ft. home, built in 1928 in West Lafayette, Ind. The home is being transformed into a net-zero energy, waste and water home, sponsored by Whirlpool Corporation and Purdue University.

The Solution: A new closed-cell spray polyurethane foam (ccSPF) system for wall insulation developed by Lapolla Industries, formulated with Honeywell Solstice® Liquid Blowing Agent (LBA).

When Whirlpool Corporation embarked on their search for a supplier to provide world-class spray foam insulation for a sustainable living project near the campus of Purdue University, they knew exactly where to start.

"Whirlpool and Honeywell had already established an excellent working relationship when we sought to improve our refrigerator insulation," said Ron Voglewede, global sustainability lead at Whirlpool Corporation. "We had just completed the conversion of our Amana, Iowa refrigerator manufacturing plant to foam insulation formulated with Honeywell Solstice LBA, and we knew this product was also slated to be used in residential wall insulation."



The timing was perfect. Lapolla Industries, based in Houston, Texas, had just completed the final phases of testing on their new wall spray foam system, which included Solstice LBA. "One of the reasons we started work with Solstice LBA is the recent pressure in the industry to find climate-friendly products," said Doug Kramer, president and CEO, Lapolla Industries. "Lapolla wanted to be first in the market with a wall foam system that included Honeywell's new low-global-warming blowing agent."

Closed-cell Spray Foam Insulation: An Easy Choice

Even with so many options for residential insulation available on the market today, the decision to use spray foam insulation for this project was an easy one for general contractor Grant Giese, president, Green Goose Homes.

"We have used spray foam in our homes for a number of years now. We use it largely to stop air infiltration and provide great R-value, and we're doing the same thing here," said Giese. "We're trying to bring this home from being an energy hog to net-zero, and the spray foam is going to play a huge part in that."

“Closed-cell spray foam insulation seals gaps, cracks and holes as it is applied, making it one of the most energy-efficient insulation products available today,” said Laura Reinhard, global business manager, Spray Foam for Honeywell. “Now that Solstice LBA is commercially available, it is exciting to have it be earmarked for sustainability projects such as this one at Purdue.”

Unique Insulation Application Creates More Potential for Spray Foam Retrofits

For many, the thought of retrofitting a home’s insulation brings to mind a messy, disruptive process that involves removing the interior walls down to the studs, but Giese had a different process in mind.

“We primarily use ccSPF in new home construction, but a lot of people don’t realize how easy it is to retrofit,” said Giese.

“This home has all plaster and lath on the inside, which is nasty to work with and remove, and harder to repair and replace. So it made a lot more sense for us, with the siding in the state it was in, to just remove the siding and spray from the outside. It’s really turning out quite well.”

- Grant Giese, President, Green Goose Homes

New Spray Foam Insulation Exceeds Contractor Expectations

Lapolla’s new spray foam system received high marks from the spray foam installer as well.

“My expectations were exceeded. The yields were about 10 percent higher than we expected, which is fantastic,” said Brian Eustis, manager, ThermaSeal / Lakeside Insulation, an Installed Building Products Company. “The [application] guys liked it better because it rose later. The front end was a little slower, the back end was a little faster, so they could control it better. Overall, the product looked fantastic and the finished product looked great.”



Before ▲

After ▼



Before ▲

After ▼





Mary Bogdan, senior principal scientist, Honeywell Fluorine Products, agreed. “The applicators did an excellent job of applying it. We had a broad temperature range from morning to afternoon, and it performed equivalently well across all the temperature conditions we experienced.”

Solstice LBA is Commercially Available

“Honeywell started up its manufacturing facility for Solstice LBA in May 2014,” said Bogdan. She further stated that Solstice LBA is a key replacement for HFC-245fa and other HFC blowing agents because of these key advantages:

- Ultra-low global warming potential (GWP) of 1 (compared to a GWP of 858 for 245fa)
- A slightly lower molecular weight so less material can be used in a system
- A higher boiling point and lower vapor pressure, which improves handling and yields smoother foam surfaces
- Improved R-values

In addition, Solstice LBA is:

- Nonflammable
- Listed under the U.S. EPA's Significant New Alternatives Policy (SNAP) program to replace ozone depleting substances
- Listed on the TSCA inventory
- Not a volatile organic compound (VOC) as determined by the U.S. EPA

Net-zero Energy, Waste and Water Home: What's Next?

With the deep energy retrofit complete, Whirlpool and Purdue are installing a world-class research laboratory in the home, which will provide continuous monitoring of all the products and systems that use the home's energy, to provide valuable insights on technologies that enable sustainable living. To follow the project's progress, visit:

www.renewhouse.org

Contact Honeywell to Learn More

To learn more about the benefits of Solstice LBA in new residential construction or retrofits, call Honeywell at 1-800-631-8138 or visit **www.honeywell-blowingagents.com**



Removing existing cellulose insulation that can slip down the stud cavity, reducing effectiveness over time



After spray foam insulation installation

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REDUCING GLOBAL WARMING IMPACT BY 1300 TIMES VS. 134A

**A blowing agent to improve
insulation to $27\text{mW}/(\text{m}\cdot\text{K})$**

JACKON Insulation

A Low Global Warming Gas Blowing Agent to Improve Thermal Conductivity in XPS Production

Extruded polystyrene (XPS) is a rigid board insulation produced by a continuous extrusion process. XPS boards are used commonly in various insulation applications for their long-term reliability and have unique properties such as extreme compressive strength, water resistance and very good thermal insulation for buildings.

Under F-GAS Regulations, manufacturers of XPS are required to adopt solutions with low Global Warming Potential (GWP) and zero effect on ozone depletion.

The challenge for manufacturers has been to source a blowing agent that meets these criteria while also maintaining thermal conductivity (i.e. Lambda). In the case of JACKON Insulation, this meant working with Honeywell to assess the performance of Solstice® GBA (HFO-1234ze) in comparison to CO₂ and HFC-152a blowing agents.

Background: Opening up market opportunities through technology

JACKON Insulation GmbH has been successfully manufacturing top quality insulation materials and construction boards in extruded polystyrene foam (XPS) for more than 25 years, and is seen as the innovative industry leader. JACKON now employs around 300 people across Europe. The company's headquarters are in Mechau, Saxony-Anhalt, with subsidiaries in Steinhagen, North Rhine-Westphalia, and in Olen in Belgium. Besides the two locations in Germany, JACKON leads further subsidiaries in Belgium, France and in Switzerland.

The company's traditional focus has been on developing XPS boards using CO₂ or HFC-152a as blowing agents, but neither gas stays in the foam – thereby negatively impacting on thermal properties.

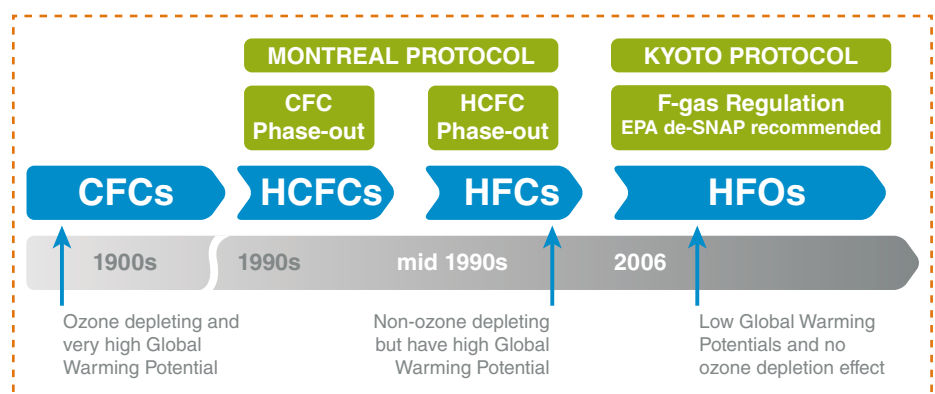
Hence the company's search for a gas blowing agent (GBA) that would help improve on Lambda levels of 34-37 mW/(m·K) using CO₂ (JACKODUR KF) or HFC-152a (JACKODUR CFR). XPS produced using HFC-134a exhibited better thermal conductivity (29-31 mW/(m·K)) but at a high global warming potential (GWP) of 1,300*1.



Inverted roof insulation with JACKODUR Plus for University of Applied Sciences in Lemgo

Headline results

- Solstice® GBA enabled JACKON Insulation to produce XPS with Lambda values of 25-27 mW/(mK) – a first for the XPS boards and some 20%+ better than CO₂
- The Lambda values achieved using Solstice GBA created potential for JACKON to enter the high insulation market
- Solstice GBA supports JACKON's sustainability objectives through its GWP of less than 1
- Replacing all 134a globally with Solstice GBA is equivalent to eliminating 4.5 million cars from the world's roads.



Application: Proving the Performance of XPS using Solstice® GBA

Working with Honeywell, JACKON Insulation started to test the performance of Solstice GBA on its XPS production line. The company was particularly focused on using a low GWP blowing agent that would deliver insulation performance comparable to or even better than XPS produced with HFC 134a.

This would enable the company to target fabrication markets (storage containers, mobile homes, fabrication homes) and building insulation markets where lowest thermal conductivity is a requirement. The blowing agent would also need to demonstrate good solubility in polystyrene (PS) melt, perform under typical pressures and temperatures, remain in the PS foam to achieve a low lambda XPS foam and not make the XPS foam flammable.

Sector Perspective: Supporting a Sustainable XPS Industry

Solstice Gas Blowing Agent (GBA) (HFO – 1234ze) offers the XPS industry improved energy performance and superior environmental properties.

Solstice GBA has no impact on the ozone layer, and possesses a low global warming potential (GWP) of less than 1, which has the effect of minimizing the climate change impact of the finished product. The HFO molecule retains all the positive attributes of HFCs: superior energy efficiency, good processability to improve foam performance; and non-flammability properties.

Today over 15,000 tonnes of HFC 134a is used globally in manufacture of XPS annually. Replacing all 134a globally with Solstice GBA is equivalent to eliminating 4.5 million cars from the world's roads.

Outcome: Successful Application of JACKODUR Plus

Using Solstice GBA, JACKON was able to produce its range of **JACKODUR Plus boards with Lambda 27 mW/(m-K) for building insulation and 25 mW/(m-K) for the fabrication market.**

The company achieved improved thermal conductivity (even better than when using HFC-134a) using Solstice GBA with a GWP of less than 1 – an important factor given JACKON's commitment to sustainability.

JACKON recently completed a project for the University of Applied Sciences in Lemgo with 2,500 m² XPS on a inverted roof using Jackodur Plus boards of 140mm thickness. The University of Applied Sciences in Lemgo chose to use Jackodur Plus boards due to its superior insulation and water resistance properties and low GWP.

JACKON is now optimising production of JACKODUR Plus and is focused on attaining application certification in different countries. In addition an EPD (environmental product declaration) of JACKODUR Plus is in preparation – this will ensure that the material is accredited within different sustainability building systems, such as LEED and DGNB.

“The success of using Solstice GBA in the production of extruded polystyrene is enabling us to enter markets where high insulation performance is required, while simultaneously supporting our sustainability credentials as a manufacturer.”

Dr Anton Klotz
Managing Director,
JACKON Insulation GmbH

Physical properties

Molecular Weight	114
Boiling Point	-19°C
Vapour Thermal Conductivity	13.0 mW/(m-K)
Global Warming Potential (GWP)	<1
Non-Flammable	ASTM E-681 and EU A11



University of Applied Sciences in Lemgo



RESPONSIBLE CARE®
OUR COMMITMENT TO SUSTAINABILITY

RESPONSIBLE CARE

Honeywell Performance Materials and Technologies, as a member of the American Chemistry Council, has adopted Responsible Care® as the foundation of health, safety, and environmental (HS&E) excellence in our business. Responsible Care is the chemical industry's global voluntary initiative under which companies, through their national associations, work together to continuously improve their health, safety and environmental performance, and to communicate with stakeholders about their products and processes.

Our commitments:

The safety of our employees
The quality of our products
Being responsible stewards for the protection of the environment, the communities in which we operate and our customers

*1 GWP as per IPCC AR5

*2 EPA Greenhouse Gas equivalencies
calculator (<http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>)

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Honeywell

Solstice® Liquid Blowing Agent



LOW GWP HYDROFLUOROOLEFINS (HFO)

Energy efficient insulation that is kinder to the planet

Honeywell



Solstice® Liquid Blowing Agent

Energy efficient insulation that is kinder to the planet

Afinox is one of the leading manufacturers of high quality professional catering equipment – frozen food storage and retail display cases. The company places environmental responsibility at the heart of its design and manufacturing process and is rigorous in the way it pursues a greener way of working.

It recently introduced Honeywell's fourth generation blowing agent – Solstice LBA – in their range of commercial cabinets in partnership with polyurethane insulation specialists Europoliuretani srl – and the results have proven the new blowing agent containing foam to offer both environmental and energy efficiency benefits.

Situation

The cold chain sector is increasingly demanding higher energy efficient commercial cabinets to reduce energy costs and CO₂ footprint. In order to help achieve this, cabinet producers are looking at Solstice Liquid Blowing Agent (LBA) to improve polyurethane insulation performance while meeting environmental regulations.

At the same time over the last 10 years, the focus for regulatory authorities and increasingly for customers is on the production of foams with zero Ozone Depletion Potential (ODP) and with ultra-low Global Warming Potential (GWP) blowing agents. Manufacturers face several challenges when considering alternative blowing agents to produce the insulating foam:

- Water-based foams provide less insulation since its initial thermal conductivity is higher and deteriorates at higher degree over time. Operations costs are higher since molds have to be heated in order to guarantee acceptable adhesion to the liner; mixing and processing is more difficult since the polyol has a higher viscosity.
- The transition to pentane needs to take into account the high costs associated with safety equipment to mitigate the flammability risk. A safety operation requires a constant monitoring of the working areas and use of specialized detection equipment and powerful ventilation systems.

- HFCs provide good insulation capabilities thanks to their low thermal conductivity. However, regulations in the European Union will limit their use in the future due to their high global warming potential (GWP).

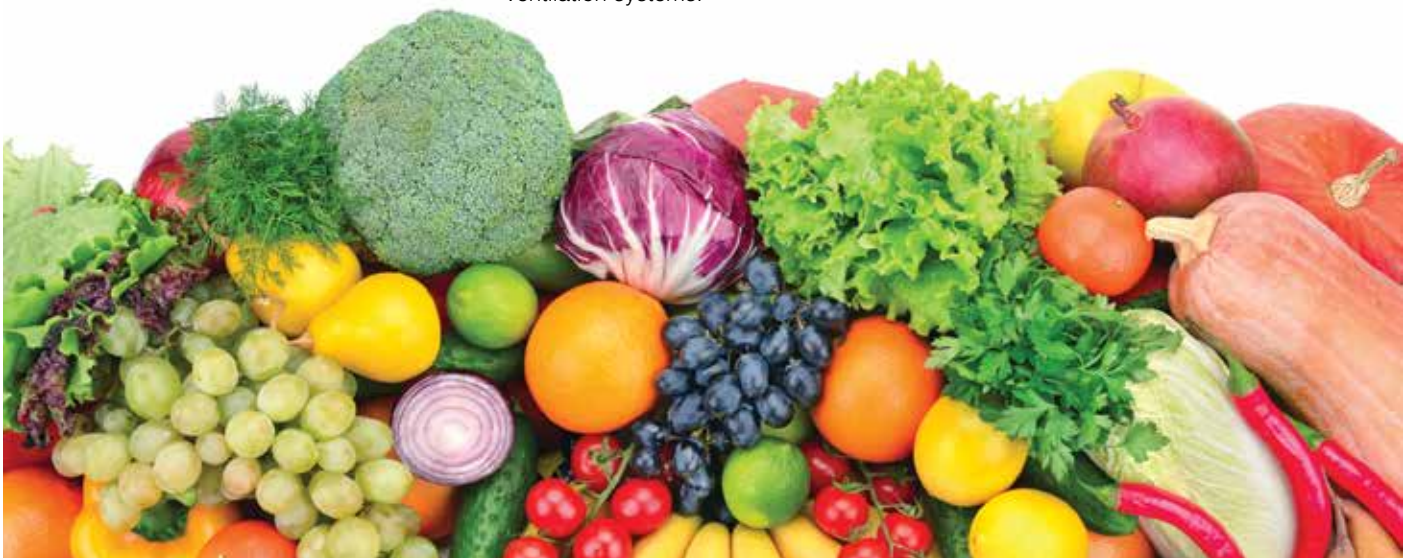
So when Honeywell introduced its innovative low GWP HFO-based Solstice LBA into the market, it provided an opportunity for polyurethane foam producer Europoliuretani to offer a suitable alternative to reduce energy consumption and provide good environmental properties to its customer and cabinet producer Afinox.

As a first step, Europoliuretani compared the insulation performance of the foam systems made with three different blowing agents: water, HFC and Solstice LBA.

Outcomes

The test programme using Solstice LBA exhibited the following results:

- The insulation made with Solstice LBA used in Afinox equipment offered a 17% improvement in comparison with water based systems
- With Solstice LBA, Afinox equipment delivered 3% energy efficiency gain over HFC-blown foam



Putting Solstice® LBA to the test

The trial conducted by Europoliuretani and Afinox compared the relative performances of manufacturing a polyurethane panel using a water-based system, an HFC 245fa blown system, and Solstice LBA.

The results of the test were as below:

The panel made with Solstice LBA showed a 17% improvement in lambda over a 180 day period compared to water based foam.

Immediately after obtaining these results, trials were conducted in Afinox to evaluate the actual energy efficiency. Mekano BT 700 cabinets produced with two type of foams were tested side by side.

Cabinets using Solstice LBA were able to maintain a lower temperature than those made with HFC-245fa.

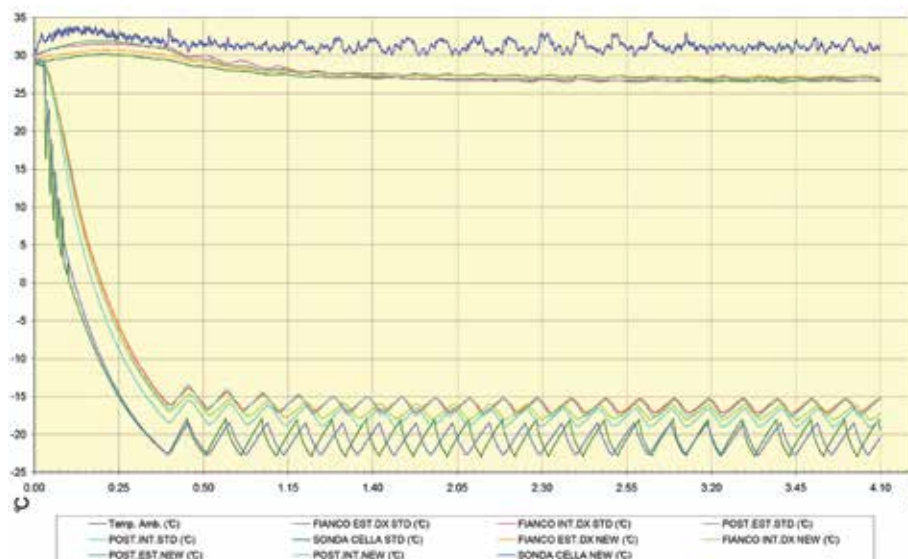
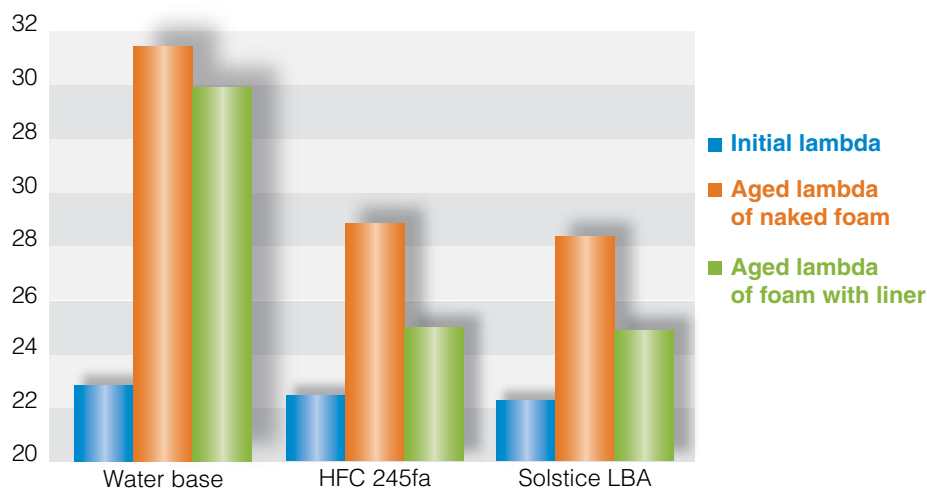


Fig. 1 Maintenance of temperatures in the two refrigerating cabinets

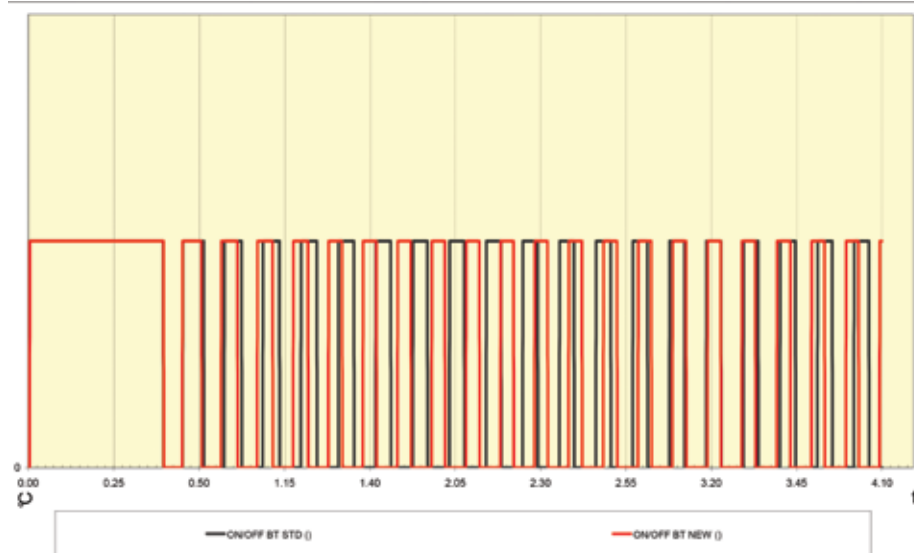


Fig. 2 On/off cycles of the 2 refrigerating cabinets

“The use of Honeywell’s Solstice LBA in the foam is helping us improve the energy efficiency of our refrigerators, which is beneficial not only to customers and manufacturers, but to society as a whole.”

Civiero Karim,
R&D Manager, Afinox Srl.

More than 3% energy efficiency improvement

Since the temperature in the cabinet made with Solstice LBA is always lower thanks to the improved insulation, the compressor needs to run with less frequency compared to the one made with HFC-245fa resulting in lower energy consumption. Further improvement in energy efficiency is expected compared to pentane and water based foams.

Industry-wide Application

Following the test results Afinox srl has substituted completely the HFC-245fa expanded polyurethane foam system with Solstice® LBA. Moreover Europoliuretani has started to promote Solstice LBA as an energy efficient and environmental compliant blowing agent to its customers.

Solstice LBA

Honeywell Solstice Liquid Blowing Agent is the latest advance in blowing agent technology. It has an ultra low global warming potential (GWP) of 1, it is non-flammable, energy-efficient blowing agent for chilled and freezer cabinet applications, and it does not require platform design changes or manufacturing equipment modifications.

It offers up to 10-12% better performance than cyclopentane; 2% better than HFC-245fa (unoptimized), while delivering better energy efficiency at low temperatures. With a GWP of less than 1, its widespread

adoption could save about 60 million metric tonnes per year of CO₂ equivalent, comparable to eliminating carbon dioxide emissions from more than 11.8 million cars every year.*

Solstice LBA will be more cost-effective than other solutions to meet ever-increasing energy standards globally. It is a near drop-in replacement for liquid HCFC, HFC, hydrocarbons and other non-fluorocarbon blowing agents. It does not require costly hydrocarbon storage and handling or risk mitigation equipment. Solstice LBA is non-flammable, unlike hydrocarbon alternatives, which require explosion-proof handling.



References

*(Source: GHG Equivalencies Calculator: <http://www.epa.gov/cleanenergy/energyresources/calculator.html>)

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The quality of our products
Being responsible stewards for the protection of the environment, the communities in which we operate and our customers

Honeywell



Fresh, Cold & Iced

Ty Pennington Selects Lapolla Spray Foam Insulation with Honeywell Solstice® LBA for His NextGen Home

"When considering insulation for my new home, I chose Lapolla's closed-cell spray foam made with Honeywell Solstice® LBA for its outstanding performance and low global warming potential."

Ty Pennington – television host, designer and carpenter

The Challenge:

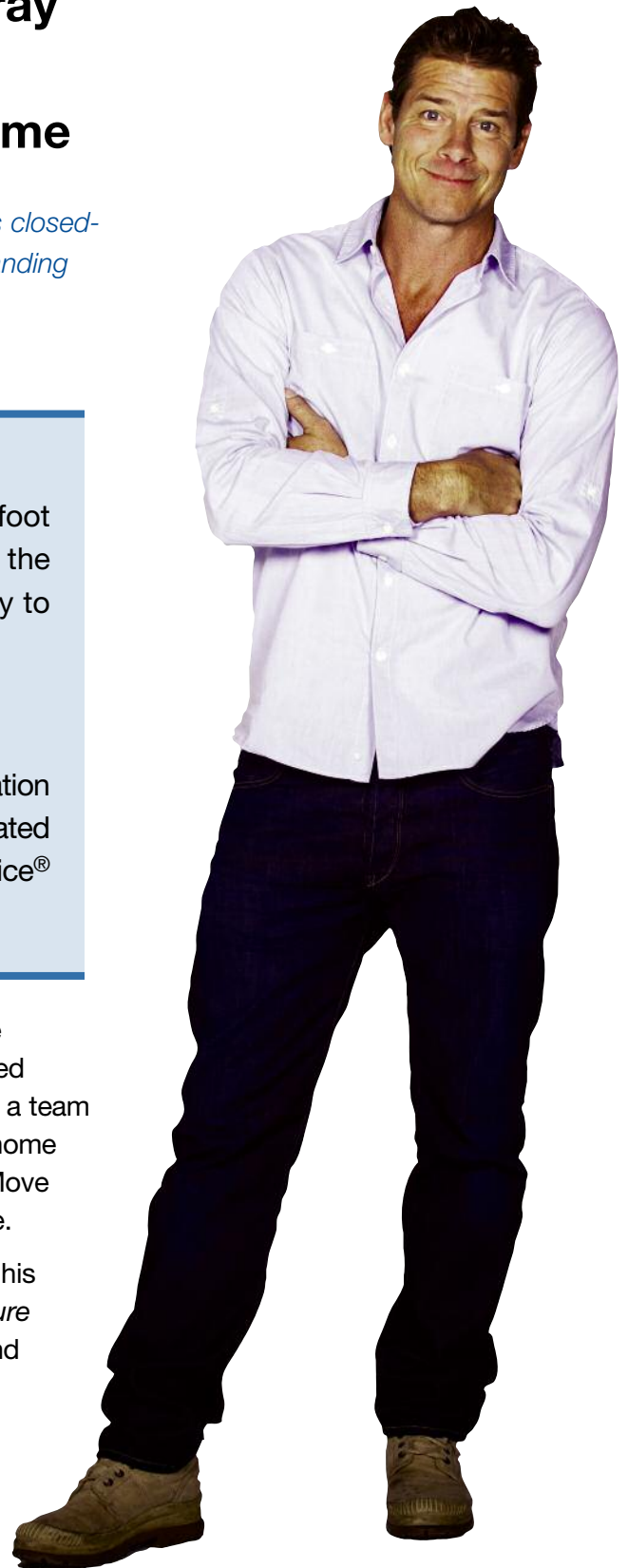
When selecting insulation for his new 6,500 square foot residence in Palm Coast, Florida, Ty Pennington wanted the latest in energy-efficient technology and a proven ability to withstand severe coastal weather.

The Solution:

A new closed-cell spray polyurethane foam (ccSPF) insulation wall system developed by Lapolla Industries, Inc., formulated with Honeywell's ultra-low global warming potential Solstice® Liquid Blowing Agent (LBA).

As the Emmy-award winning host of ABC's hit program, *Extreme Makeover: Home Edition* from 2003 to 2012, Ty Pennington helped rebuild more than 200 homes for deserving families working with a team of skilled contractors and community volunteers. Each extreme home transformation culminated with him belting out his famed line, "Move that bus!" followed by the family touring their beautiful new home.

More recently, Pennington has been showcasing construction of his Florida residence in a series called, *The NextGen First to the Future Project* aired on NextGenHomeTV.com. He shares information and advice about next generation building techniques and materials. In Episode 4, Pennington describes the importance of air sealing and insulation, "The spray foam insulation, along with the vapor barrier house wrap, will reduce the loads on your HVAC system and will also keep the moisture out to stop the growth of mildew, mold and other allergens.¹"





The applicator wore proper protective equipment and followed safety procedures throughout the installation.

Exceeding Performance Expectations

Pennington selected Lapolla's new Foam-Lok™ 2000 4G insulation featuring Solstice LBA for the home and is actively helping promote its benefits, "Lapolla's spray foam insulation creates an air tight barrier around the envelope of your home and this keeps the unwanted external air out and the comfortable air in, creating lower energy costs for you," says Pennington.² Given his focus on using leading-edge materials with positive environmental attributes, Lapolla's ccSPF wall insulation was an ideal solution.

"When formulating our new ccSPF wall system, we chose Solstice LBA because of its better thermal properties and better yield," said Justin Strombeck, technical services manager, Lapolla, who was on-site during installation. "It's performing well beyond what we were expecting. The enhanced attributes, as a near drop-in blowing agent, are tremendous. We didn't have to change much in our system and we get a lower global warming potential by a big factor. We are seeing a lot of other benefits with its workability." Some of the additional benefits being seen by Lapolla include:

- Increased yield (8-10% over previous generation products)³
- Improved thermal performance by up to 10%³
- Outstanding foam adhesion
- Consistency during application (minimal temperature adjustments)

Peter Scharf, a technician at BMP Spray Foam, sprayed the new ccSPF system in Pennington's home and commented on the foam's even consistency and overall sprayability. "It sprayed the same way from the first pull of the spray gun trigger all the way through to the end," said Scharf. "Because it expands a little slower than some other systems, it's easier to control and worked really well on the framed walls. Our crew liked it and we didn't have any problems. We'll definitely spray a Solstice foam system again."

Solstice LBA – An Ideal Replacement for HFC Foam Blowing Agents

Lapolla was the first to launch a next generation spray foam wall insulation containing Solstice LBA technology. According to Strombeck, "We were using HFC-245fa in our system. Because of its low global warming potential, we decided to skip all the other processes and go with the best blowing agent we can get – Solstice." Some key advantages of Solstice LBA include:

- Ultra-low global warming potential (GWP) of 1 (99.9% better than HFC alternatives)
- A slightly lower molecular weight so less material can be used in a system
- A higher boiling point and lower vapor pressure, which improves handling and yields smoother foam surfaces
- Improved thermal performance

In addition, Solstice LBA is:

- Nonflammable (ASTM E-681)
- Listed under the U.S. EPA's Significant New Alternatives Policy (SNAP) program to replace ozone depleting substances
- Listed on the TSCA inventory
- Not a volatile organic compound (VOC) as determined by the U.S. EPA



Lapolla's new ccSPF insulation formulated with Solstice LBA performed flawlessly throughout the installation.

Solstice LBA— A Star in the Making

Bruce Alkire, Honeywell account manager, summed up the installation and overall project experience, “The system performed very well. The contractor, the subcontractor and everyone involved was very well organized, operated very safely, efficiently and did a tremendous job.” When it comes to high-performance foam blowing agents, Solstice LBA is clearly a “star in the making.”



Ty Pennington

Photo courtesy of Lapolla Industries



Not only was ccSPF insulation installed in Ty's home for its energy efficiency, it can help the structure withstand severe coastal weather while providing comfort inside.

Contact Honeywell to Learn More

To learn more about the benefits of Solstice LBA in
new residential/commercial construction or retrofits,
call Honeywell at **1-800-631-8138**
or visit **www.honeywell-blowingagents.com**

1 www.nextgenhometv.com – NextGen First to the Future Home Series, Episode 4

2 www.lapolla.com - Ty Pennington video on website home page. Courtesy of Lapolla Industries.

3 www.lapolla.com/foam-lok-2000-4g

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APPENDIX IV

Alternative Aerosol Products For HFC-134a Applications



A. Tire Inflators

- HFO-1234ze(E) based tire inflator
- 100% of the manufacturers have shelf-ready products or are currently evaluating formulations

Company, Product Name	Logo or Product Photo
<p>ITW Accessories Marketing</p> <p>Slime® brand tire inflators</p> <p>Fix-a-Flat® brand tire inflators</p> <p>http://honeywell.com/News/Pages/Honeywells-Low-Global-Warming-Propellant-Powers-New-Fix-A-Flat-And-Slime-Tire-Inflator-Products.aspx</p>	
<p>Technical Chemical Corporation, Tire Inflator</p>	

B. Dusters

- All non-flammable and recommended for use on electronics
- Over 90% of the manufacturers in the market have a commercialized product

Company, Product Name	Logo or Product Photo
Miller Stephenson, Aero Duster, http://www.miller-stephenson.com/low-global-warming-products/	
Falcon, Dust-Off ECO, http://www.amazon.com/industrial-scientific/dp/B009L9A2X6	
MicroCare, Big Blast EU, https://www.microcare.com/product-detail.html?xRefId=1&xRefItemId=46&product_id=18	 <p>These two products are the latest innovation in freeze sprays and precision dusters. They are the first electronics cleaners in the world to feature tetrafluoropropene, an innovative new</p>
ITW Chemtronics, Typhoon Blast, Typhoon Blast All the Way, Typhoon Duster and Typhoon Surge, http://www.chemtronics.com/products/product.asp?id=598	
Techspray, ECO-Duster, http://www.newark.com/techspray/1580-10s/eco-duster-spray-bottle-253ml/dp/88T4950	


C. Safety Horns

- HFO-1234ze(E) based non-flammable safety and marine horns
- Over 90% of the manufacturers in the market have a commercialized product

Company, Product Name	Logo or Product Photo
ECO Sonic Safety: For Marine as well, https://www.falconsignal.com/shop/category/eco-sonic-safety-horn	
ECO Sound Signal Horn: For Marine as well, https://www.falconsignal.com/shop/eco-sonic-horn	

D. Party Streamers

- Non-flammable option propelled by HFO-1234ze(E), available in Europe

Company, Product Name	Logo or Product Photo
Solchim, Party String	
Xiomara, Party String, Snow Spray	

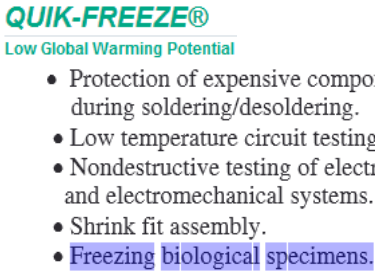
E. Smoke Alarm Testers

- Non-flammable option propelled by HFO-1234ze(E)
- Major manufacturers are either currently evaluating or have commercialized product

Company, Product Name	Logo or Product Photo
HomeSafe Guard, PurCheck, http://www.homesafeguard.com/pur_check.html	





F. Freeze Sprays for Tissue

- Non-flammable option propelled by HFO-1234ze(E)
- Many manufacturers have shelf-ready products or commercialized products



Company, Product Name	Logo or Product Photo
Miller Stephenson, Quick Freeze, http://www.miller-stephenson.com/low-global-warming-products/	 <p>QUIK-FREEZE® Low Global Warming Potential</p> <ul style="list-style-type: none">• Protection of expensive compo during soldering/desoldering.• Low temperature circuit testing• Nondestructive testing of elect and electromechanical systems.• Shrink fit assembly.• Freezing biological specimens.

G. Freeze Sprays for Electronics





- Non-flammable with HFO-1234ze(E)
- At least 90% of the manufacturers have a commercialized product

Company, Product Name, Link	Logo or Product Photo
Miller Stephenson, Quick Freeze, http://www.miller-stephenson.com/low-global-warming-products/	
MicroCare, Circuit Chiller, https://www.microcare.com/product-detail.html?xRefId=1&xRefItemId=49&product_id=58	
Techspray, Freeze Spray, https://www.techspray.com/p-158-eco-freezer.aspx	
ITW Chemtronics, Freeze Spray, http://www.mcmelectronics.com/product/CHEMTRONICS-ES1054-/20-5130	

H. Additional: Industrial Cleaners and Rust Inhibitors

Company, Product Name, Link	Logo or Product Photo
<p>Miller Stephenson, Dry Lubricant, Precision Cleaning, Heavy Duty Solvent, Rust Inhibitor, http://www.miller-stephenson.com/low-global-warming-products/</p>	 <p>En-Rust™</p> <p>Contact Re-Nu®</p> <p>K0103A (14 oz Aerosol)</p> <p>Nonflammable LGW Low Global Warming</p>
<p>Microcare, Flux Remover, https://www.microcare.com/product-detail.html?xRefId=1&xRefItemId=47&product_id=44</p>	

I. Additional: Other Products

Company, Product Name	Logo or Product Photo
Mission Pharmacal, Diaper Rash line of products, http://www.adultbarrierspray.com	
Dental Ceramic Spray	 <p>We feature a range of environmentally friendly aerosol propellants, including the newest technology in non VOC and non-flammable propellants.</p>
Radio Systems Corp: Pet Training/Bark Control Product (Australia), http://intl.petsafe.net/intl/ch/products/bark-control/spray	
MTi Mining Safety: Blast Bag (Australia), http://www.zero.mtigroup.com.au/	
Fumakilla: Bug Control Product (Japan), http://www.fumakilla.co.jp	
Earth Chemical: Bug Control Product (Japan), http://www.earth-chem.co.jp/english/company/group/	

J. Additional: Press Releases/Case Studies

Company	Application	Date	Headline
Accessories Marketing	Tire Inflator	29 January 2015	Honeywell's Low-Global-Warming Propellant Powers New Fix-A-Flat® And Slime® Tire Inflator Products
Mission Pharmacal	Personal Care	17 September 2014	Dr. Smith's® Goes to Washington to Participate in White House HFC Industry Leadership Roundtable
Home Safeguard Industries (HSI)	Smoke Alarm Tester	December 2013	Home Safeguard Industries Chooses Solstice® Propellant for Fire Safety Testing
Microcare	Dusters	28 May 2009	Honeywell's New Propellant Reduces Global Warming Impact of Aerosol Cleaners in Europe by 99 Percent
Falcon Safety	Dusters	28 February 2011	Dust-Off® Non-Flammable ECO Duster Set for U.S. Launch
Solchim S.p.A.	Novelty Aerosols	2009	Solchim S.p.A., Specialty Aerosols Company, Replaces R-134a with Solstice® Propellant
HK Wentworth Group	Dusters / Freezer Sprays	January 2012	HK Wentworth Group, an industrial products company selling to markets around the world, leverages the low carbon benefits of Solstice® Propellant in its air-dusters and freezer sprays
Produits Sanitaires Aeronefs (PSA)	Airplane On-Board Insecticide	May 2012	Solstice® Takes Flight
MTi Group	Mining Products	August 2013	MTi Group Chooses Honeywell Solstice® Propellant for Inflatable Mining Products
Electrolube	Duster Spray for Electrical and Electronic Equipment	21 July 2011	Electrolube Exhibits "Green Products" at AATE

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3. http://www.homesafeguard.com/pdfs/2014/PurCheck_Case_Study.pdf
4. <http://honeywell.com/News/Pages/05.28.09HFO1234zePropellant.aspx>
5. <http://www.falconsafety.com/dust-off-non-flammable-eco-duster-set-for-u-s-launch>
6. <http://www.honeywell-solstice-propellants.com/ResourceCenter/Pages/Details.aspx?ItemID=1>
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(b) http://zero.mtigroup.com.au/uploads/2/1/5/9/21593220/mti_announcement_1213_final.pdf
10. <http://www.ecnmag.com/products/2011/07/materials/electrolube-green-products-AATE/>