Honeywell

May 16, 2016

The Honorable Mary Nichols, Chairwoman
California Air Resources Board
1001 I St
PO Box 2815
Sacramento, California 95812
Via online submission

RE: Comments by Honeywell International Inc. on the F-Gas Provisions of the April 2016 Proposed "Short-Lived Climate Pollutant Reduction Strategy"

Dear Chairwoman Nichols,

Honeywell International Inc. ("Honeywell") submits these comments in response to the paper issued by the California Air Resources Board (ARB) titled, "Proposed Short-Lived Climate Pollutant Reduction Strategy" ("Proposed Strategy"). 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 preferable alternatives and applaud ARB's efforts in developing a strategy that will pave the way for low-GWP substitutes across the fluorocarbon industry. Honeywell offers the enclosed views as a supplement to our comments on ARB's May 7, 2015 Concept Paper, which we submitted on June 12, 2015, and on ARB's September 2015 Draft Strategy, which we submitted on October 30, 2015.

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 agrees with ARB that California can and should take additional actions to accelerate implementation of low-GWP measures. The current availability of many suitable and high-performing low-GWP alternatives supports our view that ARB should establish aggressive phase-down targets, an incentive program to drive early action, and the phase-out of high-GWP refrigerants. Honeywell also encourages ARB to take a leadership position by limiting the use of high-GWP HFCs in aerosol and foam applications beyond what the U.S. EPA has required. Honeywell supports the North American proposal to add HFCs to the Montreal Protocol, but ARB is in a position to reduce high-GWP HFCs in the near-term and therefore should not wait for such an amendment to be adopted.

II. COMMENTS

Below is a summary of Honeywell's position with respect to the Proposed Strategy. Our detailed comments follow the table.

Table 1—Summary of Honeywell's Views on the Proposed Strategy

Issue	ARB Proposed Strategy	Honeywell Position
Incentives for adoption of low-GWP refrigerants	Provide incentives for supermarkets to retrofit systems to use low-GWP refrigerants	Support; incentive program should also include replacements of chiller (air-conditioning) equipment
Sale or distribution of very high-GWP refrigerants	Prohibit sale or distribution of refrigerants with GWP of 2500 or greater Jan. 1, 2020	Prohibit use of refrigerants with GWP of 1500 or greater by Jan. 1, 2020 for servicing or retrofitting existing commercial and industrial refrigeration equipment Prohibit use of refrigerants with GWP of 2500 or greater by Jan. 1, 2020 for servicing or retrofitting existing air conditioning equipment
New non-residential refrigeration systems	Prohibit use of refrigerants with GWP of 150 or greater Jan. 1, 2020	Prohibit use of refrigerants with GWP of 1500 or greater Jan. 1, 2018 in new commercial and industrial systems
New domestic refrigerators	Prohibit use of refrigerants with GWP of 150 or greater Jan. 1, 2021	Support
Air-conditioning—new chillers	Prohibit use of refrigerants with GWP of 750 or greater Jan. 1, 2021	Support
Air-conditioning—new residential and rooftops	Prohibit use of refrigerants with GWP of 750 or greater Jan. 1, 2021	Disagree that phase-out date is appropriate at this time

A. Incentives For Conversions To Low-GWP Refrigerant in Commercial Applications

We applaud ARB's leadership on refrigerant management and support extending such efforts to drive adoption of low-GWP refrigerants. A financial incentive program would, as ARB recognizes, help reduce the expense of installing low-GWP refrigeration equipment in new facilities or retrofitting equipment in existing facilities. For example, a program could provide

incentives for supermarkets to retrofit their existing refrigeration systems currently using high-GWP products, such as R-404A and R-507A, which both have a GWP of nearly 4000. These systems can be easily converted to use reduced-GWP refrigerants such as R-448A or R-449A, which both have GWP of less than 1400, resulting in a GWP reduction of approximately 65%. In addition, using R-448A or R-449A typically reduces energy consumption by approximately 10% compared to R-404A or R-507A, which lowers operating costs and reduces indirect emissions related to energy usage. Lower-GWP substitutes such as R-448A and R-449A have been approved by major compressor manufacturers and are currently being used in numerous centralized refrigeration systems in North America and Europe.[1] Use of these substitutes would require no major equipment redesigns to new or existing centralized refrigeration systems.

In addition to supermarkets, we would strongly encourage ARB to make incentives available to offset the cost of replacing older chillers. In the commercial air conditioning sector, there are multiple low-GWP refrigerants with a GWP of one or less being adopted for new chillers. Low-GWP chillers are commercially available today from many manufacturers. Replacing older models of chillers that currently use high-GWP and ozone-depleting chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) refrigerants with low-GWP alternatives yields a two-fold benefit for the environment. Low-GWP replacements (1) directly reduce emissions of high-GWP refrigerants, and (2) decrease greenhouse gas emissions by reducing energy consumption by about 50%, compared to the efficiency of many of the oldest chillers in use today, which were installed decades ago. For example, replacing an older 1,000-ton CFC chiller with a new high-efficiency chiller can save up to approximately 900 metric tons of CO_2-equivalent from reduced energy consumption and reduced GWP of the refrigerant. There are also additional reduced-GWP alternatives (GWP of less than 650) that are near drop-in replacements compared to currently used substances such as HFC-134a (GWP of 1430). These products can be used to retrofit existing chillers to reduce the impact of refrigerant leaks from these chillers. ARB can help accelerate the transition to low-GWP substances in chiller applications by providing incentives for manufacturers and users to make the switch.

B. Prohibition on Refrigerants with GWP of at Least 2500

Honeywell strongly agrees with ARB's proposal to prohibit the sale and distribution of very-high GWP refrigerants, defined in the proposal as virgin HFC having a GWP of 2500 or greater. As ARB points out, however, there are several lower-GWP refrigerants, with a GWP of less than 1500, that can be used in existing commercial and industrial refrigeration equipment. Honeywell believes a GWP limit of 1500 for servicing or retrofitting existing commercial and industrial refrigeration equipment is appropriate given the multiple low-GWP alternatives available today. We believe that there are no significant technical barriers or hurdles that would prevent implementation of our proposal. There are hundreds of installations around the world currently using HFO-blend refrigerants with a GWP of less than 1500. They are near drop-in replacements in existing refrigeration systems and provide superior performance as compared to refrigerants such as R-404A or R-507.

[1] Please see the attachment to these comments for a sampling of results of trials using R-448A (Solstice® N-40) in commercial refrigeration applications.

Commercially available replacements, such as R-448A (GWP=1387) and R-449A (GWP=1397), are more energy efficient than currently used R-404A (GWP=3922) and R-507 (GWP=3985) refrigerants, and are near drop-in replacements for these substances. As noted in Section II.A., above, testing by qualified industry experts has demonstrated that R-448A delivers approximately 10% energy savings as compared to R-404A. R-448A has been approved by major compressor manufacturers and is currently being used in numerous centralized refrigeration systems in North America and Europe.

In the case of air conditioning equipment, which often uses R-410A (GWP=2088), no suitable nonflammable refrigerant has been identified to service this equipment. While there are some reduced-GWP, mildly flammable refrigerant options being evaluated for new air conditioning equipment, these should not be used in equipment that was originally designed for nonflammable refrigerants. Therefore we agree with the ARB proposal to prohibit the use of refrigerants with GWP of 2500 or greater for servicing or retrofitting existing air conditioning equipment.

Honeywell thus urges ARB to prohibit the use of refrigerants with a GWP greater than 1500 by January 1, 2020 for servicing or retrofitting commercial and industrial refrigeration applications and to prohibit the use of refrigerants with a GWP of 2500 or greater for servicing or retrofitting existing air conditioning equipment.

C. Prohibition of High-GWP Refrigerants in New Stationary Systems

Honeywell agrees in general with ARB's proposal to prohibit the use of high-GWP refrigerants in new commercial, industrial, and residential stationary refrigeration and air-conditioning equipment since many lower-GWP alternatives are available, as we described at length in our previous comments. However, below we offer recommendations related to ARB's proposals for this segment.

1. Refrigeration

Commercial and Industrial Refrigeration. We do not support ARB's proposal to prohibit the use of refrigerants with a GWP of 150 or greater in new non-residential refrigeration equipment beginning January 1, 2020. Such a proposal would essentially require the use of ammonia, carbon dioxide, or hydrocarbons, which present significant challenges for adoption, as compared to 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 and cost effectively adopted than the other options. A GWP limit of 1500 by January 1, 2018 would reduce GHG emissions in a way that allows for a cost-effective and safe transition to low-GWP refrigerants in new non-residential equipment.

Multiple lower-GWP alternatives exist today that (1) can reduce GWP levels by over 2500 (compared to R-404A and R-507) and (2) are more energy efficient than currently used substances by approximately 10%. For new retail 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 that is lower (by more than 50%) than those substances. These lower-GWP

alternatives can support a transition by 2018 in new commercial and industrial refrigeration applications.

A GWP limit of 150 for new non-residential equipment is too low because it would severely limit the available alternative options, creating a number of undesirable effects. A limit of 150 effectively means that only transcritical CO_2 or CO_2 cascades may be used in large centralized systems. It is widely known that transcritical CO_2 systems consume more energy in high ambient temperature conditions, such as those that are present in certain areas of California. Moreover, the additional electricity consumed by these systems is greatest on the hottest days, when the electricity grid is already strained. Many utilities have tiered pricing structures that charge higher prices for electricity during periods of peak demand.

While it is true that the performance of CO_2 cascades systems is better than transcritical CO_2 at high ambient temperature conditions, their performance is typically comparable only to R-404A systems. As previously mentioned, some of the newer reduced-GWP replacements such as R-448A and R-449A are approximately 10% more efficient than R-404A.

In the case of a CO_2 cascade system, the only refrigerants currently available to meet a GWP limit of 150 are either flammable, toxic, or both.

Imposing a GWP limit of 150 in new non-residential refrigeration applications would also have a much higher cost than a limit of 1500. The purchase price of CO_2 systems and CO_2 cascades is typically at least 25% higher, and often more, than the typical direct expansion systems used today.

In addition, since both of these systems are very different from the typical large direct expansion refrigeration systems that technicians service today, a great deal of technician training would be required if all new stores are required to safely install, operate, and service these types of systems.

Honeywell notes that in ARB's Appendix D: Supporting Documentation for the Economic Assessment of Measures in the Proposed Strategy, ARB has made a number of assumptions related to energy efficiency that we believe are overly optimistic. In the case of large centralized systems, ARB assumed (1) an energy efficiency increase of 7.5% and that (2) 50% of the systems used CO_2, 45% used HFO blends and 5% used ammonia. While it is true that HFO blends have demonstrated approximately 10% higher efficiency than R-404A, the proposed GWP limit of 150 would not allow the use of these HFO blends. Carbon dioxide systems generally have energy efficiency rates that are comparable to today's higher-GWP systems depending on the design of the system and ambient operating conditions.

Similar energy efficiency assumptions were made for cold storage systems and refrigerated condensing units. We believe those analyses to be incorrect for the same reasons as noted above. ARB's economic analysis appears to project an increase in energy efficiency that would offset an increase in the cost of low-GWP systems. However, we do not believe there is sufficient basis for the projected energy efficiency increase, and corresponding offsetting of cost, if HFO blends are not permitted to be used, as they would not be if ARB were to adopt the proposed GWP limit of 150.

For walk-in coolers, special consideration must be given to the feasibility of a GWP limit of 150. Carbon dioxide and cascades are generally not used in these systems due to high cost relative to other options, performance issues, servicing challenges, and lack of available components for this type of equipment. Setting a GWP limit of 150 would therefore require the use of a flammable refrigerant, such as hydrocarbons, for this application. Since these are direct systems, the refrigerant can leak into the walk-in cooler and create a flammable or explosive situation inside the cooler room, which is often occupied by employees. Consequently, it would be extremely difficult and expensive to design the system to safely handle a flammable refrigerant in this segment of the market. Some of the changes required to handle flammable refrigerants safely in this application could include requiring the use of explosion proof electrical components, which would reduce the safety risk, but even these measures do not address ignitions sources, such as lit cigarettes or potential sparks from electrical equipment brought into the walk-in cooler.

Residential Refrigeration. For new residential refrigerators and freezers, Honeywell supports ARB's proposal to prohibit the use of refrigerants with GWP of 150 or greater beginning January 1, 2021. Domestic refrigerators around the world already use low-GWP refrigerants. There are many commercially available low-GWP options, such as HFO-1234yf, HFO-1234ze(E), and industrial gases such as hydrocarbons.

2. Air-Conditioning

Chillers. We support ARB's proposal to prohibit the use of refrigerants with a GWP of 750 or greater in new air-conditioning equipment as of January 1, 2021 for certain segments of the market. As ARB notes, chiller equipment exists today that uses refrigerants that have a GWP of 1 or less. These refrigerants are HFO-1233zd(E) and HFO-1234ze(E). With the EU F-Gas regulation as a driver, there are over a dozen new chillers that have been launched by manufacturers using HFO-1234ze(E) and HFO-1233zd(E). In addition to the ultra-low-GWP HFOs, there are a number of blends with GWPs below 750 that can be used in medium- and high-pressure chillers, some of which are nonflammable.

Residential Air-Conditioning and Rooftops. In the case of residential air-conditioning and rooftop applications, we do not support the proposed phase-out date of January 1, 2021 because the industry, with the U.S. Department of Energy, is in the midst of a multi-million dollar research effort to identify appropriate alternative refrigerants for these systems. Unlike chillers, which are indirect systems where the refrigerant is contained in an equipment room or installed outside, residential and rooftop units are direct systems where the refrigerants circulates in the occupied space of the house or building. Consequently, direct systems require additional considerations to be used safely in these applications. The industry is working together to evaluate the flammability characteristics of mildly flammable refrigerants with GWPs below 750, but that work is not yet complete. The U.S. Department of Energy is working with the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) and the Air-Conditioning, Heating and Refrigeration Institute (AHRI) in a comprehensive $5 million research program to investigate the flammability- and safety-related concerns presented by the use of flammable refrigerants in this application. This research is not expected to be completed for nearly two years. After the research is completed, time will be needed to develop and

incorporate the necessary equipment changes and procedures to safely handle flammable refrigerants in these applications. Changes will also have to be made to the air conditioning equipment manufacturing facilities to safely handle flammable refrigerants in the manufacturing environment. These facility changes can be extremely expensive and may require manufacturers to shut down facilities for an extended period of time in order to make the necessary changes.

In addition to the research program mentioned above, building codes and standards will need to be changed to allow the safe use of mildly flammable refrigerants. These changes will be based on the results of the aforementioned research projects. Finally, while there are many U.S. EPA SNAP-approved low-GWP options for chillers, there are no SNAP-approved refrigerants for residential air-conditioning and rooftop applications that are below the GWP threshold of 750 that ARB has proposed.

D. Foam Applications

The Proposed Strategy would, at this time, leave the phase-out schedule for certain foam applications up to U.S. EPA regulations. This approach forgoes an opportunity for significant additional GHG emission reductions. Instead, ARB can and should continue to be a leader in driving GHG reductions and prohibit the use of high-GWP HFCs in polyurethane (PU) and extruded polystyrene (XPS) foam applications as of January 1, 2018.[2]

Multiple alternative solutions have been approved by U.S. EPA under the SNAP program and have been commercially available in both PU and XPS applications for several years. And, as we stated in our previous comments, transition times in these applications are fast, about 12-18 months.

1. PU Spray Foam

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 higher 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 greenhouse gas emissions, foams with HFO-1233zd(E) are shown to reduce life-cycle CO_2e emissions by up to 90%.[3]

More than one-third of North American high-pressure spray foam companies now use

[2] In our previous comments to ARB, we suggested that January 1, 2017 would be an appropriate phase-out date for HFCs in XPS applications. Given that almost a year has passed since those comments were submitted, we have adjusted our position accordingly. We continue to believe that an HFC phase-out by January 1, 2018 is still achievable for PU applications.

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

commercial low-GWP foam systems. Honeywell's HFO-1233zd(E) large-scale plant started up in May 2014, and Chemours announced plans to start its HFO-1336mzzm plant in the second half of 2016.[4] Given the availability of low-GWP solutions, the industry has been transitioning easily and quickly, with resulting benefits that go well beyond reducing GWP, including better energy efficiency and lower overall costs.

2. XPS

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 CO_2, 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). All of the above solutions are available to California companies. 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.

As noted in our previous comments, foam manufacturers are using HFO-1234ze(E) in part because of its significant advantages over CO_2 and HFC-134a in terms of energy efficiency and cost. Since mid-2011 Jackon has been selling boards in the EU with energy efficiency that is better than HFC-134a, and four other EU companies are using HFO-1234ze(E) commercially. A major Japanese producer has also been commercially selling boards made with HFO-1234ze(E).

For the above reasons, Honeywell urges California to lead the transition out of high-GWP HFCs and adopt a phase-out date of January 1, 2018 for PU and XPS applications. Adoption of Honeywell technologies in the foam sector, which can be driven further by ARB's actions, could have an impact of reducing greenhouse gas emissions by up to 35 million MtCO2e by 2020—the equivalent of removing more than 7.3 million passenger vehicles from the road for one year.[5]

E. Aerosol Applications

ARB's Proposed Strategy states that, "ARB will continue to work with the U.S. EPA on reducing HFC emissions from [certain applications], and may pursue state-level measures if progress is not made on the Federal level."[6] The Proposed Strategy omits, however, mention of the industrial aerosols sector, where replacing HFC-134a could reduce CO_2e emissions by 3 million MtCO2e when manufacturers and other states follow California's lead.

EPA's final rule listing certain high-GWP HFCs as unacceptable under SNAP prohibits the use of HFC-134a in a number of consumer and specialty aerosol applications (e.g. tire inflators) and subjects others to use limitations. However, neither the final rule nor EPA's April

[4] http://www.gupta-verlag.com/general/news/industry/14939/dupont-fluorochemicals-announces-world-s-first-full-scale-production-of-hfo-1336mzz/pdf.
[5] Source: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
[6] Proposed Strategy at 89.

18, 2016 proposed second status change rule would prohibit the use of HFC-134a in industrial aerosols, which account for about 50% of all aerosol applications.

ARB thus has an opportunity to take a leadership position in an area where low-GWP technology alternatives are commercially available and technically proven. One such alternative in this application is HFO-1234ze(E), which has a GWP of less than 1, is nonflammable per ASTM E681 and ISO 10156:2010 testing, has zero ozone-depletion potential, and is not a volatile organic compound (VOC), as determined by the U.S. EPA and ARB. There are numerous examples of currently available products that contain alternative low-GWP propellants, including hydrocarbons, HFC-152a, and non-flammable propellants such as CO_2 and HFO-1234ze(E).

Honeywell strongly encourages ARB to consider prohibiting the use of HFC-134a (or any propellant with a GWP greater than 75) in industrial aerosol applications by January 1, 2018.

III. CONCLUSION

Thank you for this opportunity to share our comments on ARB's development of a strategy to reduce the use of high-GWP HFCs. Honeywell 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.

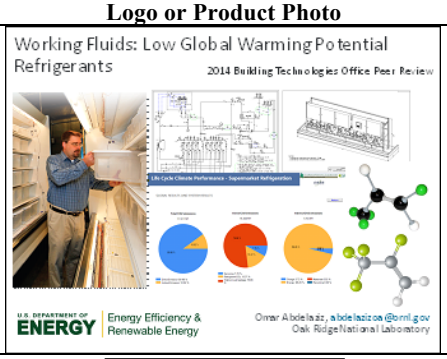
Sincerely,

Ken Gayer
Vice President and General Manager
Honeywell Fluorine Products

Honeywell

ATTACHMENT
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
Oak Ridge National Labs http://www.ornl.gov	
Copeland – Emerson Climate Technologies http://www.emersonclimate.com/en-us/brands/pages/copeland.aspx	
Hussmann – Lowe's – Case Study http://supermarketnews.com/webinar/lowes-market-retrofit-success-story-r-404a-solstice-n40-r-448a	
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Hiper Simply - Case Study http://www.honeywell-refrigerants.com/europe/wp-content/uploads/2015/09/Honeywell-Solstice-N40-case-study-Simply-supermarketJune-2015.pdf	
Tops Supermarket - Case Study https://www.honeywell-refrigerants.com/americas/?document=solstice-n40-r-404a-retrofit-at-tops-supermarkets&download=1