

Refrigerant Update

THE NEXT TRANSITION HAS BEGUN

W. Ryan Geister

Applied Systems Leader, Chillers
Trane, A Division of Ingersoll-Rand

Chairman of AHRI Chiller Section
Member of IR Refrigerant Council
ASHRAE Member since 1996

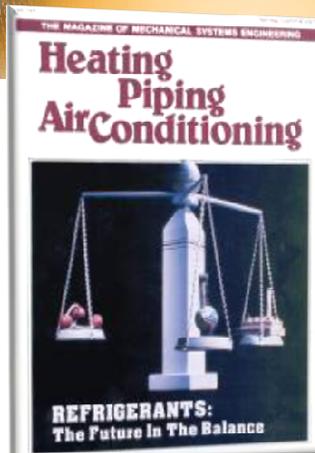
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Trane Refrigerant Message



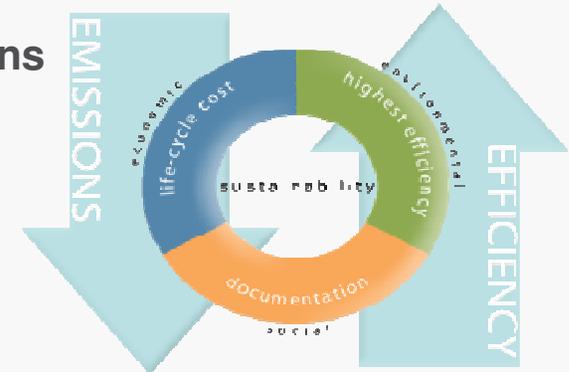
Trane said ozone depletion, global warming, and energy efficiency as all being equally important.

As stated in 1991 Trane Article for HPAC Magazine.



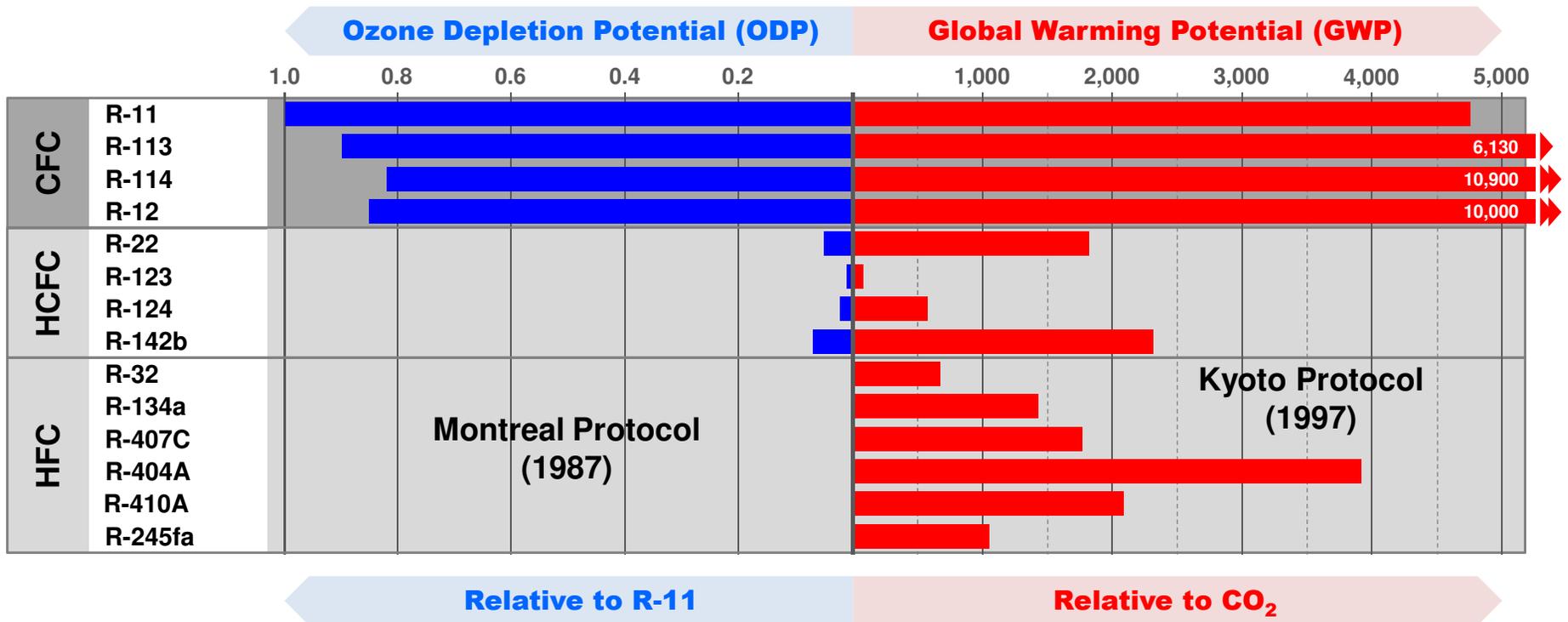
Balanced approach minimizes overall environmental impact:

- Energy efficiency
- Refrigerant emissions
- Ozone depletion
- Global warming
- Atmospheric life



Trane will offer the right product with the right refrigerant at the right time.

ODP versus GWP



Singularly, the answer seems obvious ... together a challenge

J. M. Calm and G. C. Hourahan, "Refrigerant Data Summary," Engineered Systems, 18(11):74-88, November 2001 (1998 WMO and 2001 IPCC assessments)

Understanding the Timeline

Past (CFCs)
R-12, R-11, R-113 more...

17 35,453
Cl
CHLORINE

⇒ **ODP**

Low-ODP
or no ODP

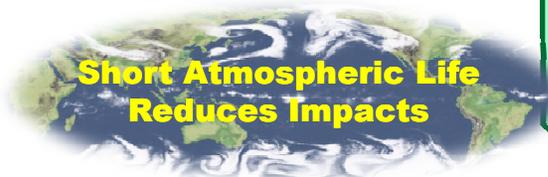
Present (HCFCs & HFCs)

R-22, R-134a, R-410A, R-407C
R-123, R-404A R-245fa more...

9 18,998
F
FLUORINE

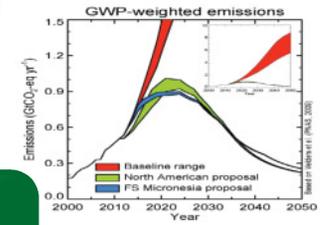
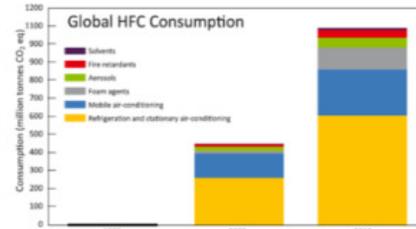
⇒ **GWP**

Reduced
GWP & Deminimus ODP

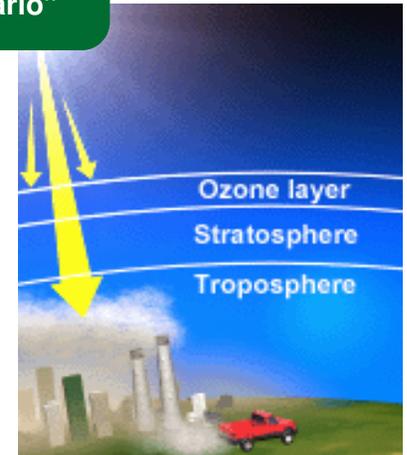


Future (HFO & Blends)

R-1234yf, R-1234ze, R-1233zd,
R-513A, R-1336mzz, more...



“If left unchecked, by 2050, annual HFC emissions could be equivalent to 20% of annual CO₂ emissions under a business-as-usual (BAU) scenario”



There's more to refrigerant selection than just ODP & GWP

Global Pressure on **ALL** Refrigerants



COMMENTARY

Midgley's Legacy

Thomas Midgley meant well. He invented chlorofluorocarbons (CFCs) in 1928 to provide a refrigerant for refrigerators that was safer than ammonia, sulfur dioxide and other toxic gases. Until this time, those who could afford home refrigerators kept them outside. Midgley's work was sponsored by Frigidaire, General Motors and DuPont. His invention of what became known as Freon paid off. By 1935, Frigidaire and its competitors had sold 8 million refrigerators using Freon. In 1932, Carrier Engineering Corporation used Freon in its "Atmosphere Cabinet" the world's first air-conditioned home air.

JULY 26, 2004

HFCs Are On Shaky Ground In Europe

By Peter Powell
Of The News Staff

shaky ground in Europe.

A recent alternative refrigerant conference in Brussels drew 300 people to hear repre-

equipment used in many locations in Europe.

In a statement issued at the time of the conference, environmental group Greenpeace

AUGUST 11, 2008

\$5.00

VISIT US ONLINE AT WWW.ACHRNEWS.COM

A **bnp** PUBLICATION



Price Increase

American Standard (Piscataway, N.J.) increased prices 5 percent for PTAC units, effective immediately for new quotes and Aug. 22 for the rest.

Contractors

TAC (Raleigh, N.C.) relocated its offices

Refrigerant Talk Turns to HFOs

By Peter Powell
Of The NEWS Staff

WEST LAFAYETTE, Ind. — Contractors who have mastered working with CFCs, HCFCs, and HFCs may now want to turn their attention to what is being promoted as the fourth generation of refrigerants — HFOs (Hydro Fluoro Olefins).

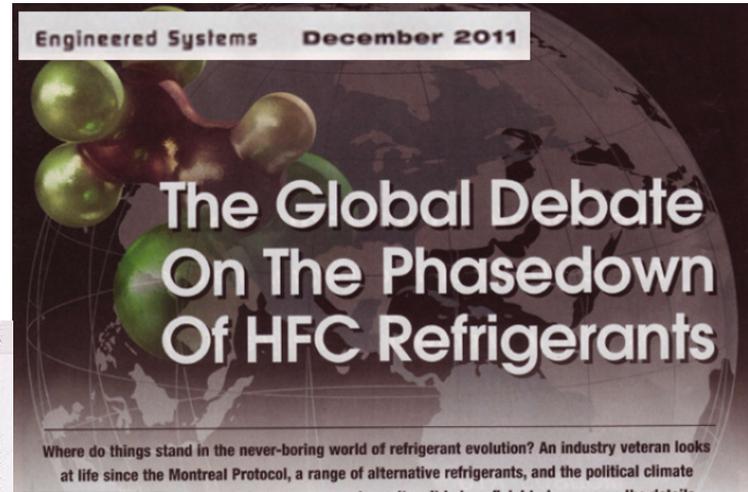
"We are on the verge of a new revolution in refrigerants," said Denis Clodic

in a primary address before 500 engineers from 30 countries at the combined International Compressor Engineering and International Refrigeration/Air Conditioning conferences hosted by Purdue University. He specifically cited research currently underway with HFO-1234yf that is being developed for mobile air conditioning, but may have applications in stationary equipment.

He noted that R-1234yf and the halogen-free natural refrigerant R-744 (CO₂) are being studied closely because



Denis Clodic of the Center for Energy and Process in



For more REFRIGERATION AND AIR CONDITIONING MAGAZINE



15 September 2014

HOME NEWS FEATURES COMMENT

AR CONDITIONING | REFRIGERATION | LEGISLATION | F-GAS | REFRIGERANTS | DATA CENTRE COOLING

Home » News

DuPont has high hopes for new non-flammable refrigerant HFO 1336mzz

15 September 2014 | By Andrew Gaved

The Pressure on HFCs is Not New

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An \$8 Billion Push to Cool the Globe Has Poor Countries Steaming

BloombergBusiness

A quarter-century after the world banned the chemical compounds blamed for chewing a hole in the ozone, the solution to that problem has been tagged as a main instigator of global warming

HFCs, synthetic refrigerants developed in the 1990s as an ozone-friendly alternative, have now emerged as one of the most potent greenhouse gases, a problem unforeseen by their inventors two decades ago. They can be thousands of times stronger than fossil fuel emissions at trapping heat.

Pushed by the U.S., global negotiators are again discussing a phase-out of the chemicals used in refrigerators, cars and air-conditioners worldwide.

In the U.S., President Barack Obama has made retiring HFCs a cornerstone of his climate change strategy. "It makes an enormous amount of sense," said Todd Stern, the U.S. envoy to global climate talks. "HFCs are pretty small in the grand scheme of things right now but they have an explosive growth path."

Obama's effort has gained traction among companies in the cooling business. In September, 19 of them joined a White House pledge to reduce HFCs, including soda makers Coca-Cola Co. and PepsiCo Inc., appliance manufacturer Carrier and Kroger Co., market chain.

**HFCs were introduced as an ozone-friendly alternative...
...but they're far more potent at trapping heat in atmosphere**

US Government Partnership with Industry

Executive action to reduce greenhouse gas emissions and spur a global phasing-out of HFCs



White House statement: "These industry associations and companies are making significant commitments to phase out or phase down their use of HFCs and transition to climate-friendly alternatives, good for the environment and good for business,"

AHRI president and CEO Stephen Yurek stated: "Close to \$2bn has been spent by the industry since 2009 researching energy-efficient equipment and the utilization of low-GWP refrigerants," Yurek stated, "and over the next 10 years, the HVACR industry will invest an additional \$5bn for r&d and capital expenditures to develop and commercialize low-GWP technologies."

22 companies have committed to cutting HFC emissions by 2020

	<p>Carrier, announced that its commitment to pursue the commercialization of HFC-free refrigerants in road transportation refrigeration by 2020.</p>
	<p>Danfoss, announced that it's championing a stakeholder task force to accelerate adoption of standards and building codes for next generation, low-GWP refrigerants.</p>
	<p>Johnson Controls, announced that it commits to using the lowest GWP option for each application that best fits the needs of its customers. It also committed to spend an additional \$50 million over the next three years to develop new products and improve and expand its existing portfolio.</p>
	<p>Goodman Manufacturing Company, commitment to help slash greenhouse gas emissions by developing low-global warming potential (GWP) air conditioners and/or heat pumps. Daikin aims to reduce its greenhouse gas emissions in 2020 to one-quarter of its 2005 emissions.</p>
	<p>Ingersoll Rand, commitment to slashing greenhouse gas emissions at their operations by 35%, reduce GHG associated with our products by 50% (increased unit efficiency and the transition to lower GWP refrigerants) and will invest \$500M in research and development... all by 2020</p>

Big changes in the **NEWS**

Post-HFC-Phaseout Refrigerant Options

August 3, 2015

U.S. Environmental Protection Agency (EPA) that sets forth the timeframes for the phaseout of certain hydrofluorocarbons (HFCs) in specific applications...

...the EPA is using the SNAP program to help transition the industry away from high-GWP products used in refrigeration and air conditioning, aerosols, and foam-blowing sectors where lower- GWP products are available.

Refrigerants Targeted: R-404A, R-507A & R-134a

...as of Jan. 1, 2017, in supermarket systems, and Jan. 1, 2018, in remote condensing units, R-404A, R-507A, and several other high-GWP refrigerants cannot be used in new installations.



EPA using Significant New Alternatives Policy to make the change



Final Rule - Protection of Stratospheric Ozone: Change of Listing Status for Certain Substitutes under the Significant New Alternatives Policy Program

Under this final rule, various HFCs and HFC-containing blends that were previously listed as acceptable alternatives will be listed as unacceptable in various end-uses in the aerosols, foam blowing, and refrigeration and air conditioning sectors where other alternatives are available or potentially available that pose lower overall risk to human health and the environment.



EPA-HFC 7-2015

Final Rule

What?

- Changes the status of certain HFCs now that safer alternatives are available

Which industrial sectors are included?

- Aerosols
- Refrigeration & Air Conditioning
- Foam Blowing

Who is affected?

- Chemical producers and some manufacturers of equipment and products using aerosol propellants, refrigerants, and foam blowing agents

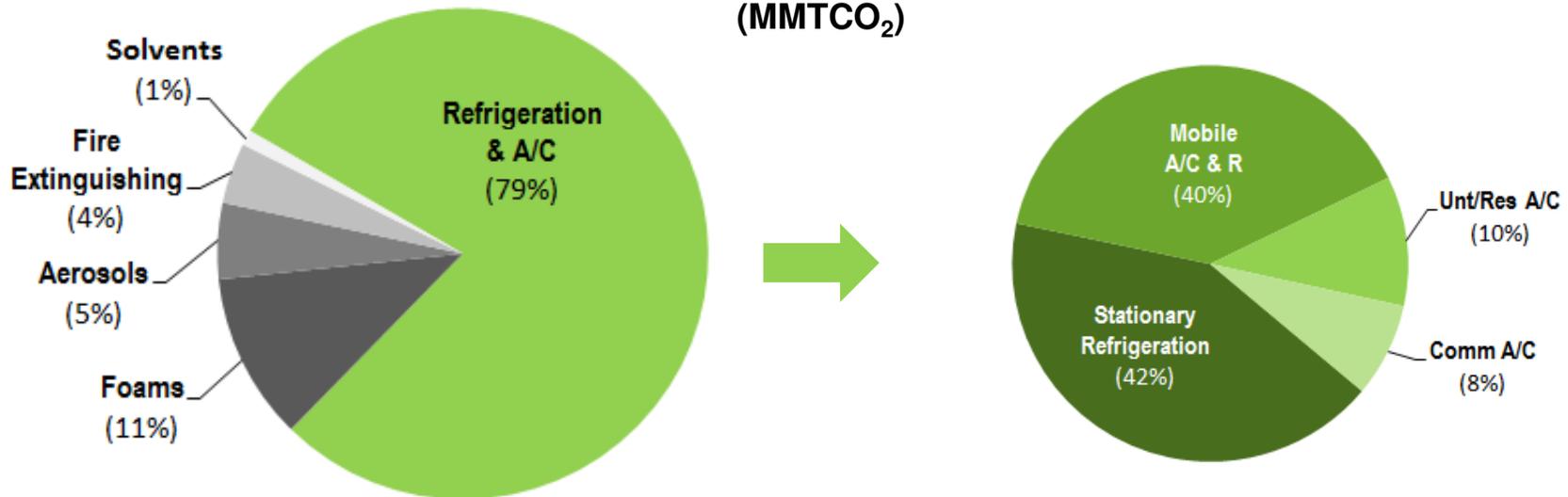
When?

- Starting in January 2016; see table for dates for all affected end-uses

Signature Final Rule put into place on July 2, 2015

Emissions of Fluorinated Gases

Global HFC Consumption 2010 (MMTCO₂)



Global Actions Currently Being Taken

European Union F-Gas Regulations

1-1-2013 de facto ban on R-134a in newly type-approved vehicles per Directive 2006/40/EC on mobile air conditioning (MAC)

HOME
MACS: Chrysler reports R-1234yf results in Jeep Cherokee
BY ELLIOT MARAS, EDITOR ON JAN 20, 2014

SAE finds R1234yf is "safe and effective"

Published: 23 April 2013 - 00:00

USA: The team formed by SAE International to perform an updated engineering safety analysis of R1234yf in car air conditioning systems has found the refrigerant is 'safe and effective' for use. The SAE Cooperative Research Project (CRP) team, which included car manufacturers Chrysler/Fiat, Ford, General Motors, Honda, Hyundai, Jaguar Land Rover, Mazda, PSA, Renault and Toyota, evaluated the extensive testing conducted by its members, was subsequently updated with regard to actual collision scenarios and is now complete pending final review.



Corporate Average Fuel Economy (CAFE)

The 2012-2016 Standards offer credits for using low-GWP refrigerants other than R-134a:

- ~ 3-4 MPG for changing refrigerant
- ~ 5 MPG for overall system changes

Vehicles using R-1234yf refrigerant (North America)



- ✓ **Cadillac** XTS
- ✓ **Chevrolet** Spark EV, Malibu, Trax
- ✓ **Chrysler** 300
- ✓ **Dodge** Challenger & Charger
- ✓ **Honda** Fit EV
- ✓ **Jeep** Cherokee
- ✓ **Range Rover** Sport
- ✓ **Ford** Transit
- ✓ **Hyundai** Santa Fe, i30
- ✓ **Kia** Sorento, Optima, Carenz
- ✓ **Mazda** CX-5
- ✓ **Mitsubishi** Mirage
- ✓ **Infinity** Q50
- ✓ **Subaru** BRZ, Forrester, Impreza

Auto Industry began HFC Phase-down in 2011
USA Phase-down underway, complete by 2017

Environment Canada

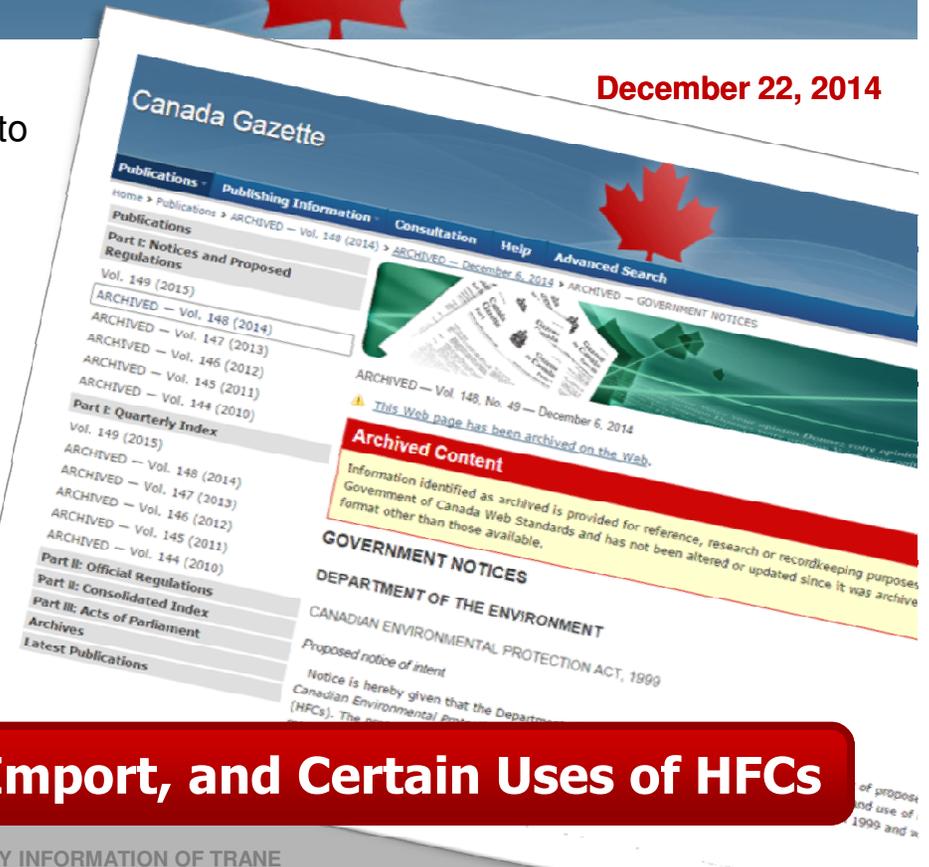
Publishes Notice of Intent to Regulate HFCs



December 22, 2014

Environment Canada has published a Notice of Intent to Regulate HFCs in the Canada Gazette. The proposed regulation includes prohibition of the manufacture and import of specific HFCs (134a and those with a higher global warming potential, i.e. 507 series and 404A) with use being phased out in condensing units and supermarket systems, stand-alone units and vending machines.

These regulations are based on the North American Amendment Proposal to the Montreal Protocol proposed by Canada, United States and Mexico



Measures to Control Manufacture, Import, and Certain Uses of HFCs

Global Actions Currently Being Taken

EU F-Gas Regulation (EC 842/2006)

HFC cap and phase down begins 2015

European Parliament Formally Adopts HFC Phase-Down Regulations

BRUSSELS—The European Parliament this week formally passed legislation calling for a 79% reduction in hydrofluorocarbons (HFCs) used in refrigeration and air conditioning. The "F-Gas" regulation will cap the amount of HFCs that can be placed on the market in the European Union (EU) and will gradually reduce it to 21% of current levels by 2030. The regulations go into effect Jan. 1, 2015. In its "plenary session"—the meeting of the entire Parliament, which culminates the work of committees—the body passed the F-Gas regulations as proposed by 644 votes to 19 (with 16 abstentions). The proposal was made last December (an [article](#) was linked to in the Jan. 2 issue of *The HVAC&R Industry*). The European Parliament is the directly elected parliamentary institution of the 28-nation EU, and acts as its legislative branch.

2015 – Baseline established based on 2009-2012 EU market average

2020 – 37% of bulk supply is removed

2030 – 79% of bulk supply is removed

Higher GWP fluids will be phased down first

The cap and phase down will *not* apply to HFOs (unless they are in a blend w/ HFCs)



EU Phase Down of HFCs Coupled with Bans

Global Actions Currently Being Taken

The White House
Office of the Press Secretary

United States and China Agree to Work Together on Phase Down of HFCs

June 08, 2013

Obama's Climate Action Plan Targets HFC Reduction

By Peter Powell
Of The NEWS Staff

President Barack Obama's recently announced Climate Action Plan specifically references the future of the familiar HFC refrigerants all HVACR contractors work with on a daily basis.

The plan supports a phase down in production and consumption of the refrigerant in the context of the Montreal Protocol over the next 30 years. And it calls for more immediate efforts to steer users away from hydrofluorocarbons (HFCs) and to embrace alternatives.

In a speech given June 25 at Georgetown University in Washington, D.C., the

president said, "Hydrofluorocarbons, which are primarily used for refrigeration and air conditioning, are potent greenhouse gases. In the U.S., emissions of HFCs are expected to nearly triple by 2050, and double from 2010 levels." To reduce these emissions, the

and will lead both through international diplomacy as well as domestic actions."

[International Effort](#)

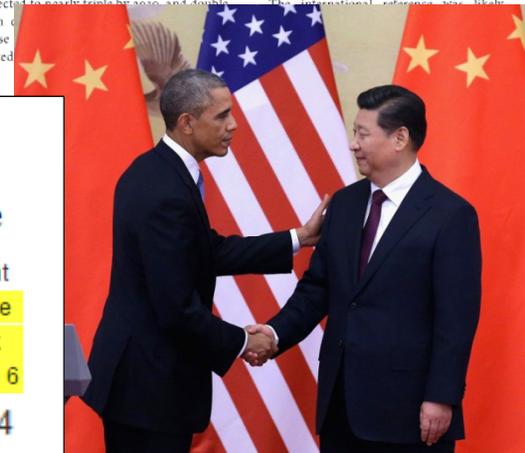
The international reference to HFCs

The White House
Office of the Press Secretary

U.S.-China Joint Announcement on Climate Change

Enhancing Cooperation on HFCs: Building on the historic Sunnylands agreement between President Obama and President Xi regarding HFCs, highly potent greenhouse gases, the two sides will enhance bilateral cooperation to begin phasing-down the use of high global warming potential HFCs and work together in a multilateral context as agreed by the two Presidents at their meeting in St. Petersburg on 6 September 2013;

November 11, 2014



US Legislators and Regulators Begin with Presidential Push

India agree to phase down HFCs

Phase down potent climate-damaging refrigerant HFCs

THE TIMES OF INDIA

Vishwa Mohan, TNN | Apr 17, 2015,

NEW DELHI: Reversing its several years of opposition, India has, in a major decision relating to a global treaty, made a formal proposal to amend the Montreal Protocol to phase down the climate-damaging refrigerant HFCs which are used in air-conditioners, refrigerators and insulating foams.



...The country's amendment proposal is in tune with what the Prime Minister Narendra Modi had promised to the American president Barack Obama during his visit to the US in September last year.

Under the UPA rule, India had been the most vocal opponent to phasing down HFCs under the Montreal Protocol, a strategy first proposed in 2009 by the Federated States of Micronesia, and quickly followed by a proposal by the US, Mexico, and Canada.

"With India emerging as the leader of the HFC phase down, we are moving into position to finish the amendment at the November Meeting of the Parties, and provide a boost to the UN climate negotiations in Paris the following month", said Zaelke. The Africa group of 54 countries had endorsed the HFC amendment last month, and Senegal has requested on their behalf that formal negotiations start on the amendments.

India has reversed its stance on HFC Phase Down...



CLARK'S REMARKS

Lawrence (Larry) Clark



Update on Refrigerants

by Lawrence (Larry) Clark, CEA, GGP, LEED AP O+M in Clark's Remarks

Feb 24, 2015

<http://hpac.com/blog/update-refrigerants>

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There are several factors that must be considered when determining the availability, safety, efficiency, and environmental impact.

In January 2014, I (semi) humorously posted about football and the HVAC industry ("HVAC and ... For the phaseout of hydrochlorofluorocarbon (HCFC) of our local ASHRAE chapter, I was reminded just recall that HCFCs, which have been in use as refrigerants, were required by the Montreal Protocol of 1996. HCFCs were targeted next, but over a much longer period than CFCs. ...

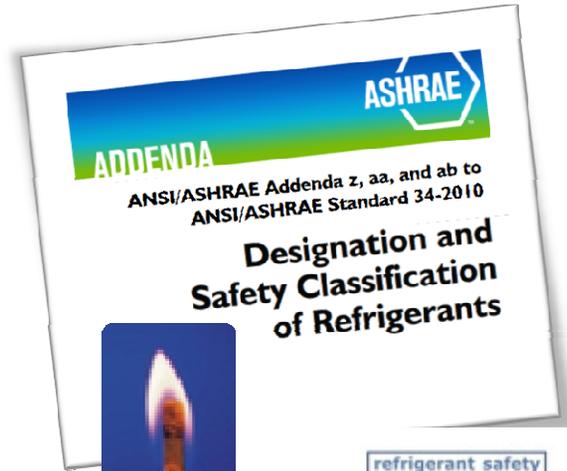
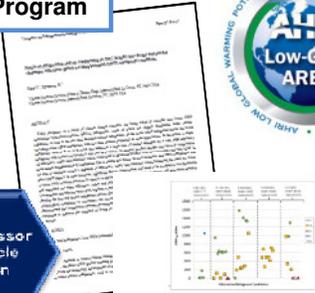
Although it appears HFCs will be around longer than HCFCs, a great deal of pressure is being put on industry to find more environmentally friendly alternatives. And the pressure is not just on the buildings industry. Automobile air conditioning is a huge user of refrigerants; the U.S. Environmental Protection Agency (EPA) has been offering automakers Corporate Average Fuel Economy (CAFE) credits for low-GWP refrigerants other than HFC-134a since 2012. Although only a handful of vehicles, some of them lower-miles-per-gallon (MPG) models, have so far qualified using R-1234yf, those that have can add 3 to 5 MPG to their EPA label. For instance, adding 3 to 5 MPG to a 2014 Dodge Charger with 5.7-L engine represents a 17- to 28-percent improvement of (combined city and highway) fuel efficiency! Last year, the EPA also issued a proposal that could ban HFC-134a in certain other uses as soon as Jan. 1, 2016.

The Message & Position on Next-Generation Refrigerants Emerging

Next-Generation Refrigerants



AHRI Low-GWP Alternative Refrigerant Evaluation Program

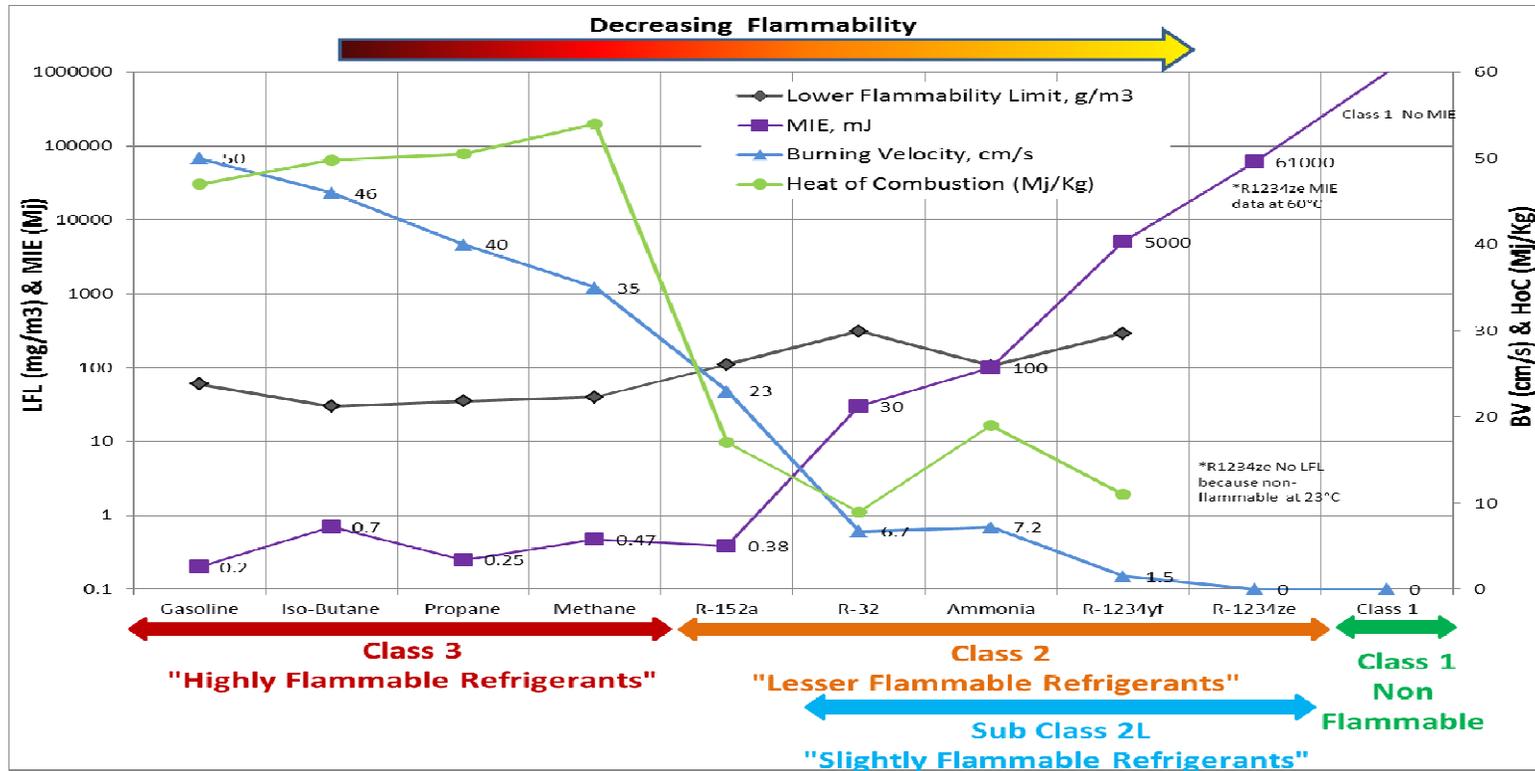


	refrigerant safety groups	
Class 3 Higher Flammability	A3	B3
Class 2 Lower Flammability	A2	B2
Class 2L Difficult to Ignite & Sustain	A2L	B2L
Class 1 No Flame Propagation	A1	B1
	lower toxicity	higher toxicity

In 2010 ASHRAE 34 Development a new class 2L
“Difficult to Ignite & Sustain”
 Not all 2L refrigerant are equal

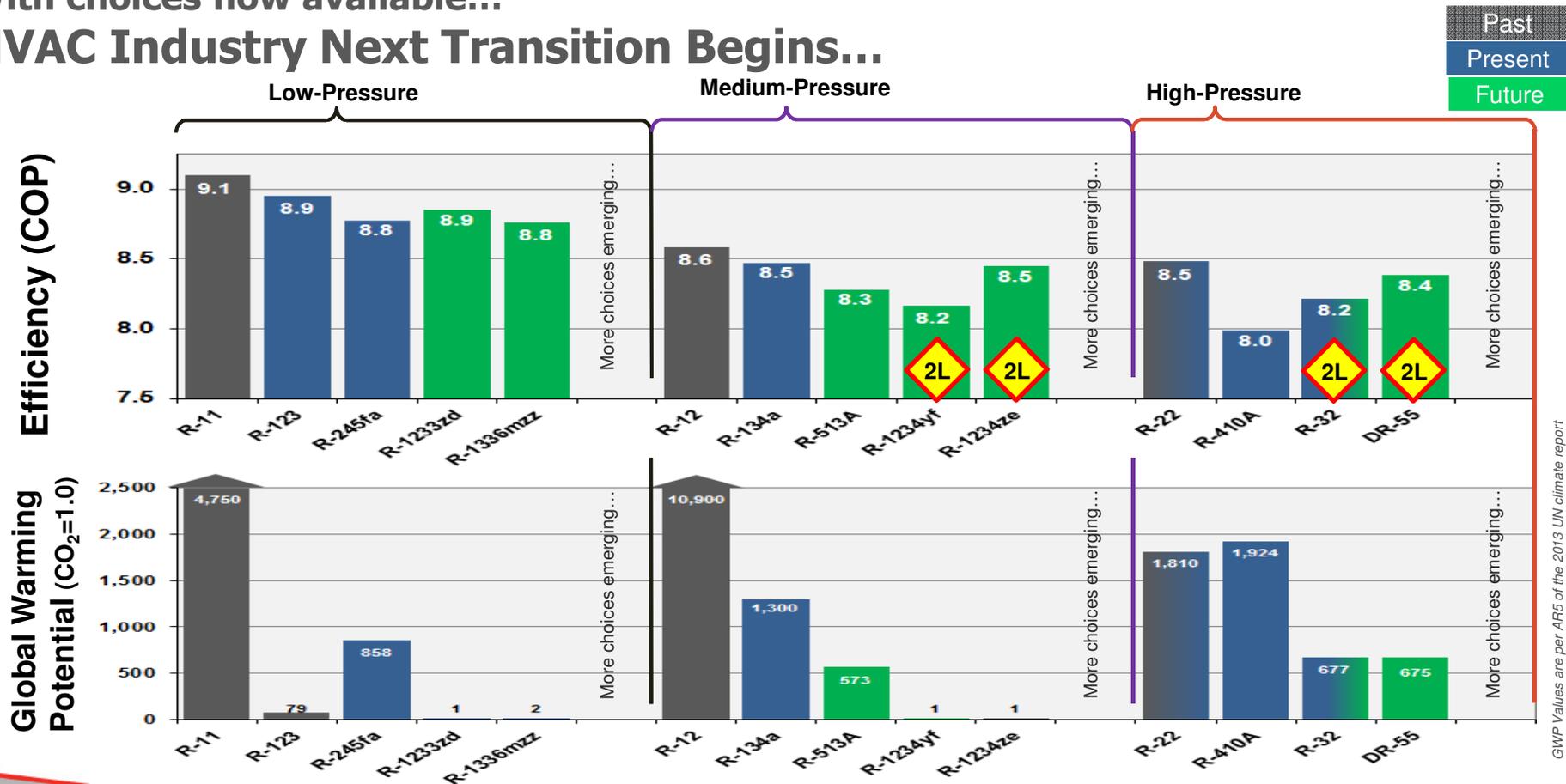
New refrigerants raise new questions...

Flammability Properties Vary



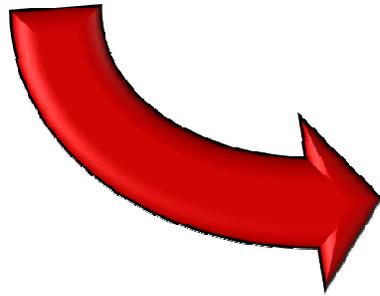
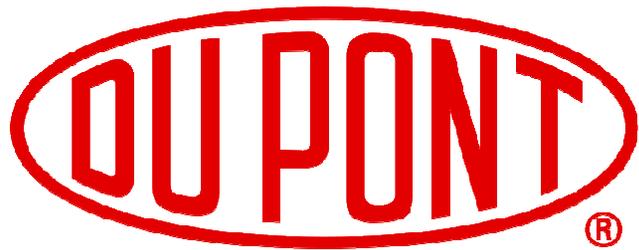
2L Definition Being Evaluated

With choices now available... HVAC Industry Next Transition Begins...



Industry commitments and available options are increasing

Changes in the Industry



“DuPont” has spinoff of its performance chemicals division... which is now called “Chemours”



What is the Next Refrigerant?

Cryogenics and Refrigeration Proceedings of ICCR2013

Page ID: 2-4-10

Future of refrigeration and air conditioning in 2032; insights into design and market challenges with lower global warming potential (GWP) refrigerant candidates

Kujak S.¹, Thompson M.²

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²Climate Solutions Division, Ingersoll Rand, Division, NC, 28034, USA

ABSTRACT

Today designers, as a result of climate change concerns, are being asked to consider new lower GWP (global warming potential) refrigerants, some of which are highly flammable under certain conditions, as well as the less than desirable natural refrigerants. In the lower GWP refrigerant future, the world will adopt lower GWP refrigerants with less than optimal properties in some applications. For a safe, high efficiency refrigerant, such as R-32 or R-410A that addresses a large area of market demands for a safe, high efficiency refrigerant with lower cost products may not be available. In general, product design may have to compromise on efficiency, safety and reliability which could lead to increased product cost for consumers and may result in more safety suggestions by refrigerant type to enable this future. In most instances, new HFO refrigerants will be able to maintain society's demands of efficiency, safety and reliability while balancing the need for lower direct GWP impact. In other instances, significant design compromises will need to be accepted to use flammable or more costly solutions because of capacity and efficiency constraints. Natural refrigerants will gain more attention as expanded use where efficiency, safety and reliability can be delivered at a reasonable cost to consumers. Government and industry must work together to enable low GWP refrigerant future. A cooperative effort to develop the best and lowest refrigerant options that cover the widest range of applications to minimize cost and technological complexity to consumers can succeed. The safety transition from CFCs to HCFCs and HFCs demonstrated that cooperation between government and industry can achieve great environmental benefits while continuing to improve the standard of living in developing countries and minimize the societal impact for everyone.

KEYWORDS

Alternative Refrigerants, Low GWP, Flammability, Efficiency, Safety, Reliability, HFOs

INTRODUCTION

Societal demands to control climate change are driving the development of new regulatory policies to restrict and lower the direct GWP (global warming potential) impact of Fluorocarbons (F-gases). These regulations have spurred both the technology development of alternative lower GWP F-gas alternatives and renewed consideration of natural refrigerants, such as water (R-718), ammonia (R-717), hydrocarbons and carbon dioxide

Future of refrigeration and air conditioning in 2032; insights into design and market challenges with lower global warming potential (GWP) refrigerant candidates

Kujak S.¹, Thompson, M.²

¹Climate Solutions Division (Trane & Thermo King), Ingersoll Rand, La Crosse, WI, 54601, USA

²Climate Solutions

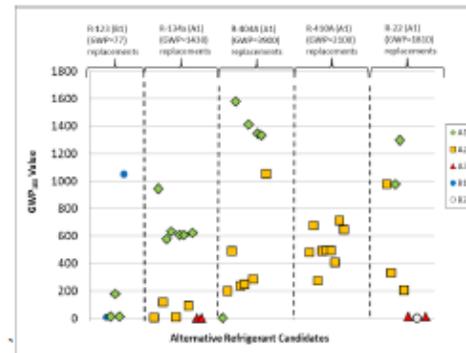
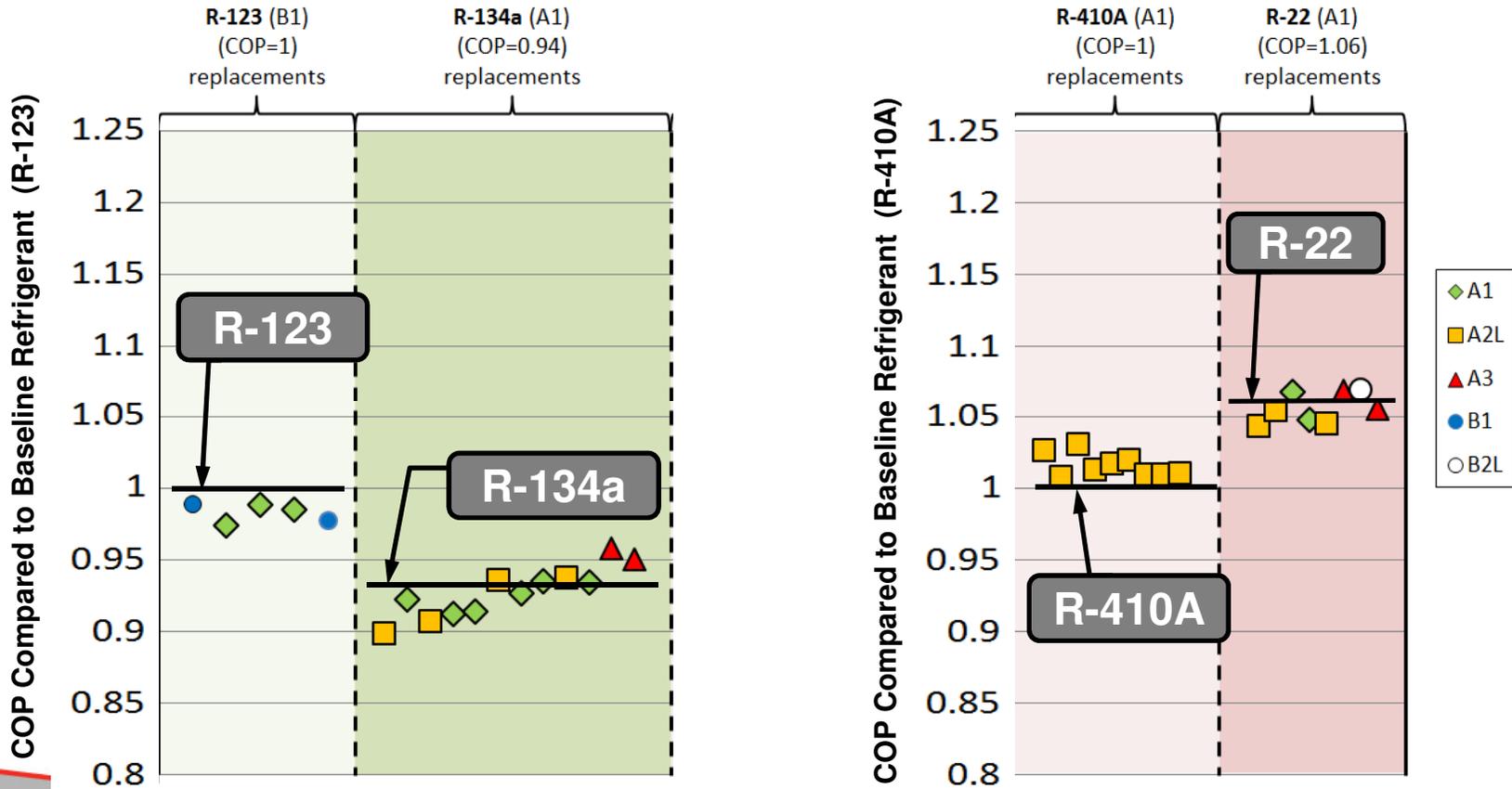


Figure 3 Summary Next Generation Refrigerants by GWP and Safety Classification by Application

Resources Available to Help Better Understand Various Options

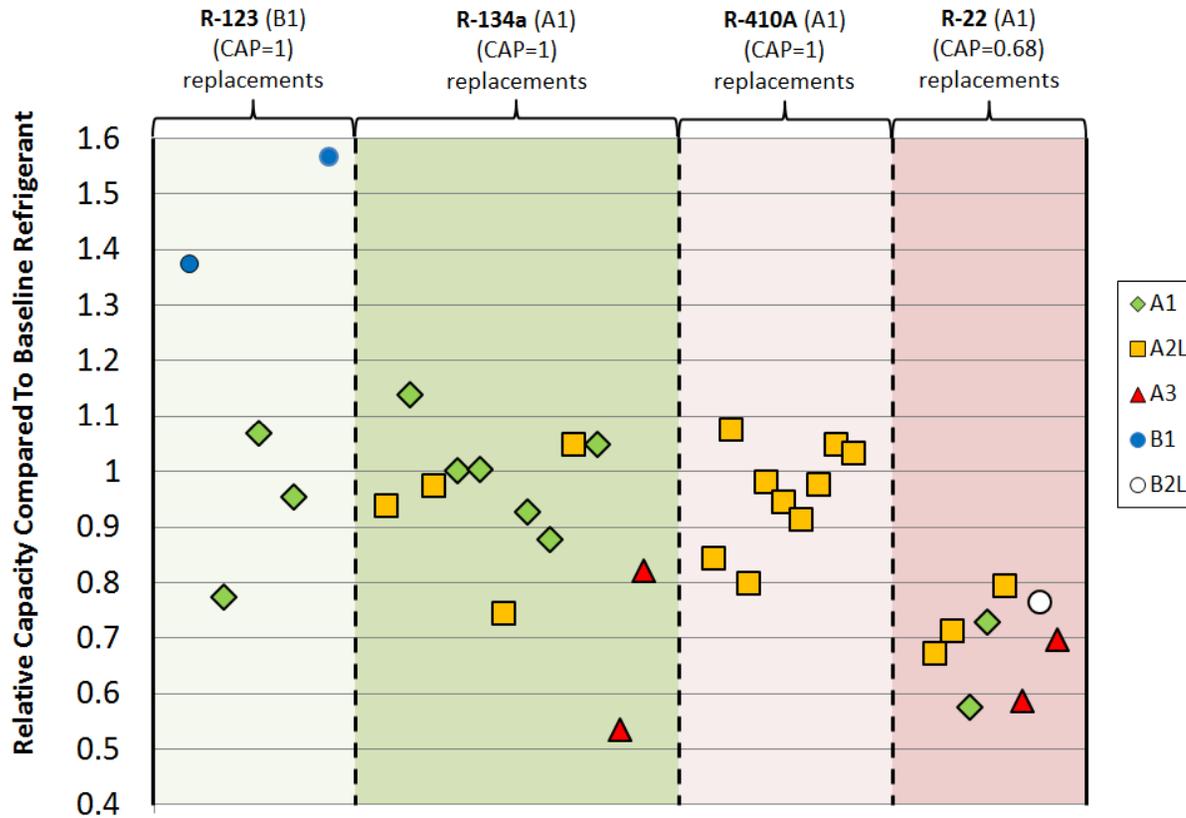
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What is the Next Refrigerant?



Considering COP

What is the Next Refrigerant?



Considering Capacity

High Pressure Refrigerant Replacements

HCFC



R-22



HFC



R-410A

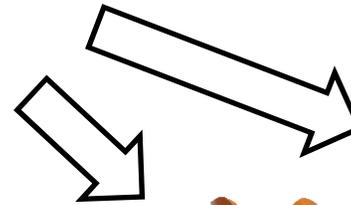


R-32

Low GWP

Driving Factors

- Performance
- Safety



DR-55
R-452B



R-454B

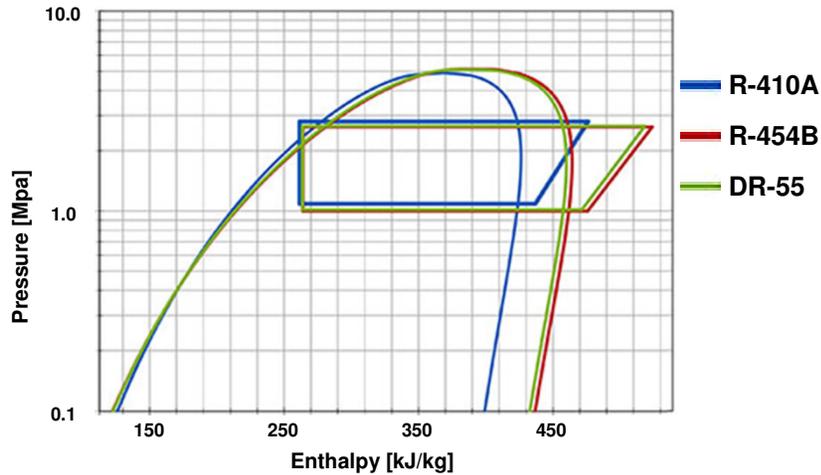


R-32

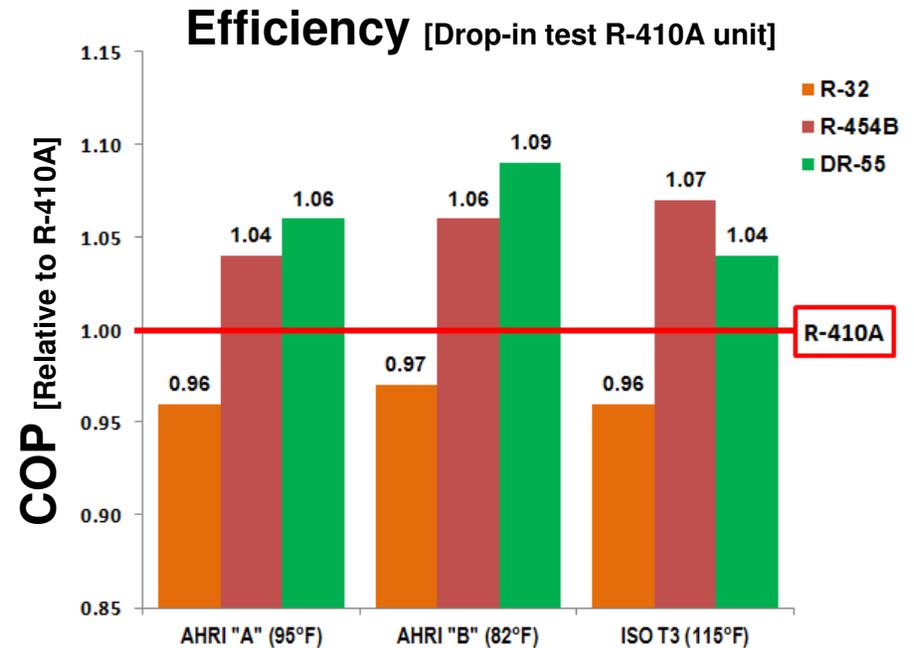
Next transition with High Pressure Refrigerants

High Pressure Refrigerant Replacements

Drop-in Tests – Performance Results



5% Improvement on efficiency
10% Reduction on unit charge



<http://www.coolingpost.com/world-news/is-dr-55-best-option-to-replace-r410a/>

DR-55 provides better performance than current generation R-410A

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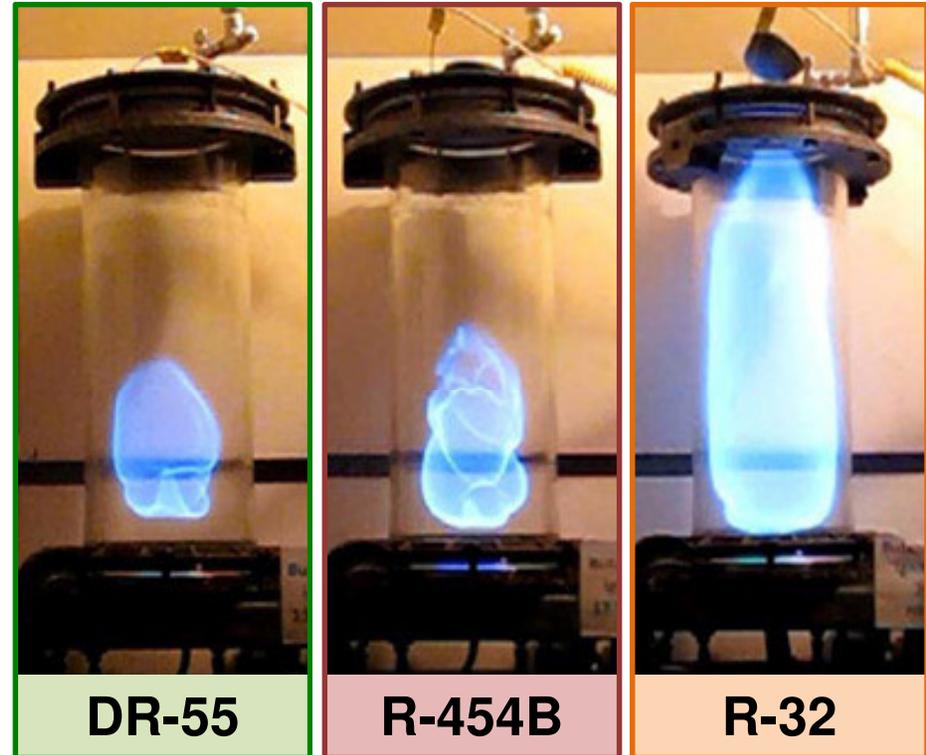
High Pressure Refrigerant Replacements

Review of Safety

Tests are said to have shown that DR-55 also exhibits a slower burning velocity and higher minimum ignition energy requirement when compared to R32.

Although DR-55 has the same A2L “mildly flammable” classification as R32, Chemours maintains that some global OEMs have indicated that the lower flammability properties of XL55 are compelling and are likely to be an important consideration in product selection, especially for larger charge size equipment.

Almost 70% reduction in GWP over R-410A



Not all 2L refrigerants are the same...

Available Chiller Transition Choices

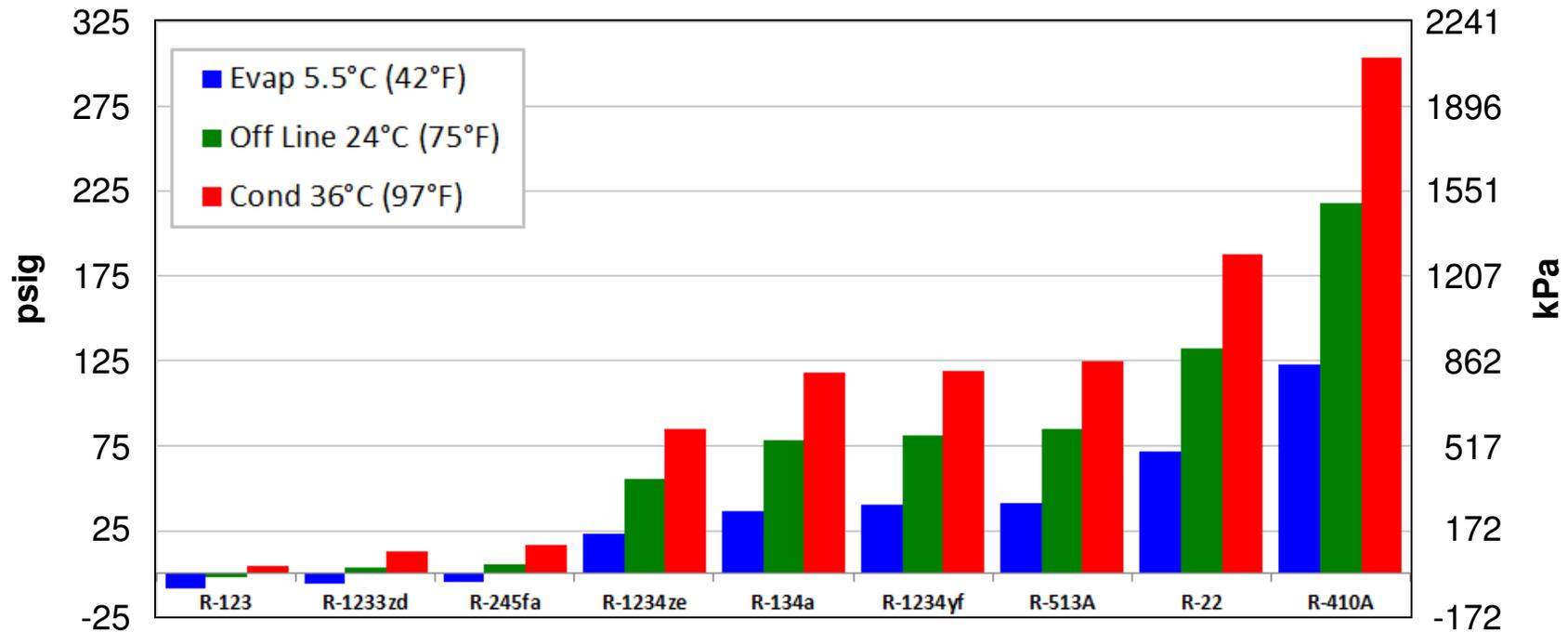
Medium & Low Pressure Designs offer New Challenges

	Low Pressure		Medium Pressure			
	R-123	R-1233zd(E)	R-134a	R-513A	R-1234yf	R-1234ze(E)
Flammability	Non (1)	Non (1)	Non (1)	Non (1)	Slight (2L)	Slight (2L)
Toxicity	Higher (B)	Lower (A)	Lower (A)	Lower (A)	Lower (A)	Lower (A)
Fluid Efficiency	9.4 COP	9.3 COP	8.5 COP	8.3 COP	8.2 COP	8.5 COP
Capacity Change	1	35% Gain	1	Same	5% Loss	25% Loss
GWP	79	1	1300	572	<1	<1
Industry Products available today						

Convertible & Compatible Solutions Also Being Investigated

Centrifugal Chiller Comparison

Operating Pressure by Refrigerant



Many Customers Enjoy the First Charge as the Last Charge

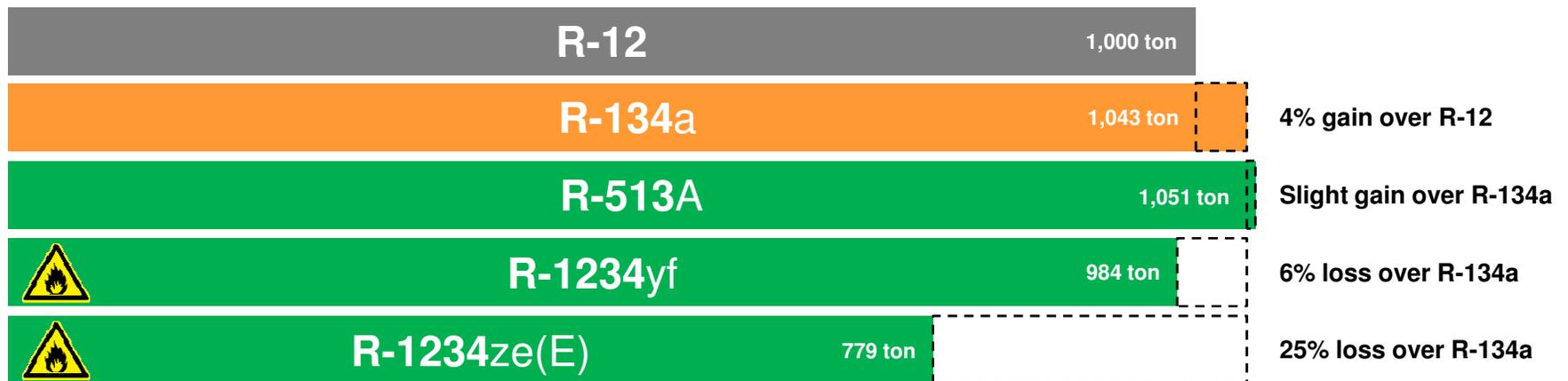
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Capacity Change with New Alternatives

Low Pressure



Medium Pressure



Capacity gap to be covered with additional units or size

Emerson Climate Technologies Approves Refrigerants R-449A and R-513A

**CONTRACTING
BUSINESS**
HELPING HVACR MANAGERS RUN BETTER BUSINESSES SINCE 1944

“It is critical that our customers have tested, proven and more sustainable alternatives to refrigerants that have been targeted for delisting,” said Rajan Rajendran, vice president, Systems Innovation Center and Sustainability for Emerson Climate Technologies, in reference to the EPA proposal...

Honeywell's R450A (N13) and DuPont's R513A (XP10) are replacements for R134a.

Emerson Climate Technologies has approved DuPont Opteon XP40 (R-449A) and XP10 (R-513A) for use in a wide range of their scroll and semi-hermetic compressors. This approval represents a significant milestone for Opteon refrigerants as it paves the way for use in new and existing compressors for a wide range of refrigeration applications.

Opteon XP40 is a new low global warming potential (GWP), non-flammable replacement for R-404A and R-507 refrigerants, which have been identified in a proposal by the U.S. Environmental Protection Agency (EPA) to be banned in specific new and retrofit applications by Jan. 1, 2016. XP40 has more than 60% lower GWP and significantly increased energy efficiency compared to R-404A and R-507. Opteon XP10 is an optimized new low GWP, azeotropic, non-flammable replacement for R-134a with more than 55% lower GWP and comparable properties and performance.

More Manufacturers Moving to HFO and HFO Blends

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Voices of Upcoming Change

An International HFC Phasedown is Coming

August 31, 2015



AUTHOR NOTES



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It's looking more likely that there will be a global agreement to phase down HFCs, and it could come as early as this year or possibly next...

Not waiting for a global agreement, the U.S. is already moving in that direction. The EPA, through its Significant New Alternatives Policy (SNAP) program, has announced the phaseout of some high-GWP refrigerants...

- Supermarkets
- Stand-alone refrigeration units & vending machines
- Foam Blowing
- Motor Vehicle Air Conditioning

The ban on usage of those high-GWP refrigerants will begin as early as July 1, 2016.

International Refrigeration Community... Global Phasedown of HFCs

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What the Industry is **Doing...**



Danfoss Turbocor releases TG310 compressor running with HFO-1234ze

25 September 2013

Tallahassee, FL - Danfoss Turbocor Compressors Inc. announces the production and sales release of the new TG310 compressor, which utilizes the ultra-low Global Warming Potential (GWP) refrigerant HFO -1234ze(E).

The TG310 compressor is available for air-cooled, outdoor mounted chiller applications and will carry the CE mark and CE PED mark. It ranges from 310 - 65kW. It is suitable for use with 400 volt, 50 Hz power supplies. Similar to the current TT series compressors, the TG310 models are oil-free, variable-speed, magnetic bearing centrifugal compressors. The products provide outstanding full and part load energy efficiency and feature a small footprint, light weight, low vibration, very low sound, intelligent controls, and soft starting characteristics.

The ultra-low Global Warming Potential (GWP), zero Ozone Depletion Potential (ODP) refrigerant HFO-1234ze(E) was developed and commercialized by Honeywell, and is trade named Solstice™ L13. While the refrigerant was initially assigned a GWP value of 6, it was recently announced by Honeywell that the GWP value is actually less than 1. The refrigerant exhibits improved energy efficiency compared to the current model using HFC-134a. When combined with the extraordinary environmental metrics for GWP and ODP, the TG310 offers customers a new benchmark in overall operational sustainability.

****Danfoss is a competitor of Ingersoll Rand, Trane and Thermo King. Danfoss's published position is presented without their consent.*

First Commercially Available Centrifugal Chiller with R-1234ze

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Trane Debuts R410A Replacement

Showcased at the IIR International Congress on Refrigeration

°COOLING POST

Testing done by two independent teams

- University of California at Davis
- Oak Ridge National Laboratory

Findings

- 5% improved efficiency
- 10% lower refrigerant charge
- 70% reduction in direct GWP (over R-410A)

The Trane AquaTrine demonstration chiller is using DR-55, a Chemours development refrigerant that it will market as Opteon XL55. An A2L, "mildly flammable", HFO-blend, DR-55 is currently being evaluated for use in unitary and residential equipment.

The AquaTrine is said to be designed for up-market apartments, luxury villas, office buildings, small restaurants, retail stores and hotels.

"We expect high performance hvac systems to be available with next generation refrigerants like DR-55 within the next 12-18 months pending regulatory approval," said Randal Newton, vice president of enterprise engineering for Ingersoll Rand.

"This project is one way that we are committed to developing technologies that are safe, increase efficiency and

Trane Announces Demonstration Chiller using DR-55

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Ingersoll-Rand Commitment

Reducing Greenhouse Gas Emissions




Our Products

50% reduction in GHG via:
 1) increased energy-efficient products; 2) use of next generation refrigerants with lower GWP in refrigerant-based products by 2020

50%



Our Operations

35% GHG reductions in our office buildings, manufacturing facilities and fleet by 2020

35%



Market Leadership and Convening

\$500M in research to promote energy efficiency & solve refrigerant gaps via innovation, research, testing, policy over the next 5 years

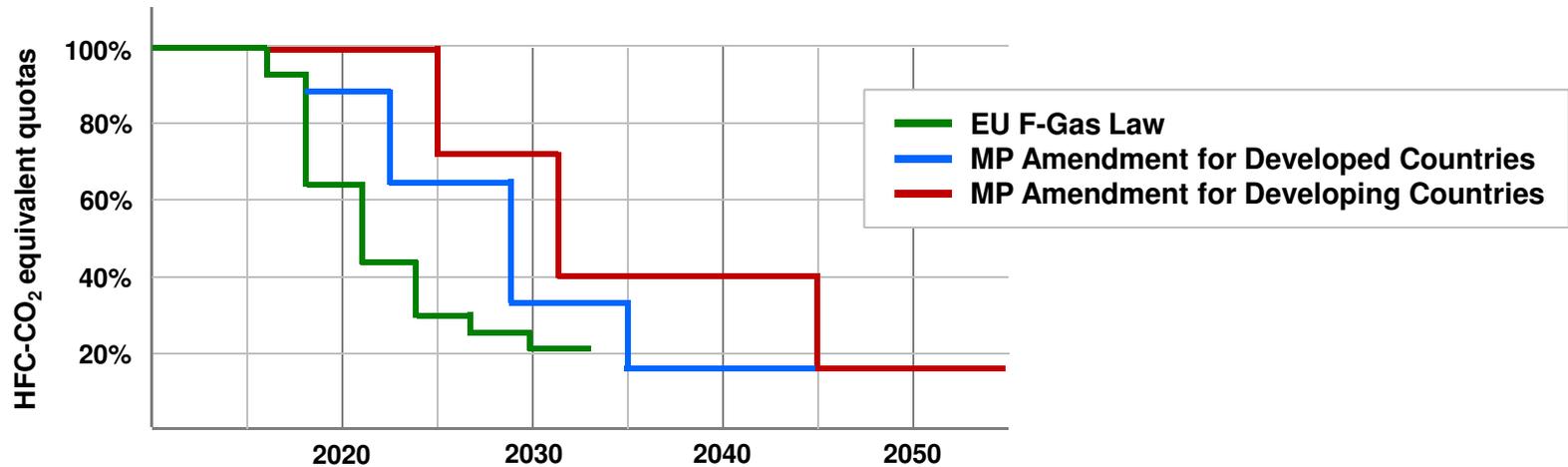
\$500M



Designed to lower environmental impact with next generation, low global warming potential refrigerants and high efficiency operation

Ingersoll-Rand committed & focused, all aspects of the business

HFC Phase-downs will Impact our Products



Potential Timing of Impact

2015 - 2020
(R-404A – 3700 GWP)
Transport Refrigeration

2020 - 2025
(R-134a – 1430 GWP)
Chillers, Transport Cooling
& Refrigerated Dryers

2020 - 2025
(R-410A – 2100 GWP)
Chillers, Unitary
& Residential

Industry responses, producer allocations, cost increases and trade barriers will create transition pressure

How Can I Protect My Investment?



- There are **no** perfect refrigerants
- Take a balanced approach
Safety, Environmental Impact, Efficiency
- R-123, R-134a, R-410A, R-404A, R-407C are all responsible HVAC refrigerant choices...**Today**
- Leak tightness is key!
Means lower emissions, higher efficiencies, lower cost

Understand the Facts

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How Can I Protect My Investment?

All refrigerants we use today are – and will be – available for the life of the equipment.

Focus on reliable, efficient designs.
Let us worry about the refrigerant!

Lifetime of Electricity Cost (88.51%)

Lifetime of Service Cost (6.53%)

“First Cost” (Chiller & Refrigerant) Cost (4.92%)

Lifetime Refrigerant Supply Cost (0.04%)

A Balanced Approach, with a Focus on Efficiency

How do I Find Out More?

http://www.epa.gov/ozone/downloads/HFC_Amendment_2013-Summary.pdf

(Nice summary of North American proposal to Montreal Protocol)

<http://www.achrnews.com/articles/122923-the-future-of-hfcs-in-montreal-protocol>

(April 2013, quotes from other HVAC companies)

<http://www.epa.gov/ozone/intpol/mpagreement.html>

(Sept 2013, fact sheets on the right side of page – focuses on refrigeration, but shows next refrigerants)

<http://www.argusmedia.com/pages/NewsBody.aspx?id=863805&menu=yes>

(Sep 2013, G20 nations sign agreement to curtail HFCs)

http://articles.economictimes.indiatimes.com/2013-10-02/news/42617384_1_hfcs-montreal-protocol-climate-change

(Oct 2013, U.S. and India joint agreement on HFC phasedown)

http://www.hydrocarbons21.com/articles/european_parliament_formally_backs_eu_f-gas_regulation_deal

(Mar 2014, New EU F-gas regulation passed)

<http://www.alliancepolicy.org/index.php>

(Learn more about The Alliance for Responsible Atmospheric Policy)

<http://www.bna.com/epa-proposes-prohibit-n17179892134/>

(Jul 2014, Article on proposed EPA bans/reductions on HFC refrigerants through SNAP)

Additional References, Learn More About Impending Transitions

New Article Now Available:

Considerations for Next-Generation HVAC Refrigerants

ENV-APN001A-EN



Considerations for Next Generation HVAC Refrigerants

A 2011 Engineers Newsletter discussed the need for a balanced approach between environmental impact and efficiency when selecting replacement refrigerants for HVAC equipment.

Non-fluorinated refrigerants. When considering next generation refrigerant alternatives it is recommended that policy makers, the public, and manufacturers balance environmental concerns (e.g. ODP, GWP, leak rates), indirect environmental concerns (energy efficiency), safety and performance.

Policy Drivers

Over the past few decades, refrigerants in the HVAC industry have been under constant regulatory pressure. Whether the focus is ozone depletion or global warming, our industry strives to discover the right balance of efficiency and safety while minimizing the impact on the



As we move beyond HFCs and HCFCs, manufactured chemicals like fluorocarbons, and non-fluorinated refrigerants, such as CO₂, ammonia, or hydrocarbons are being considered.

While non-fluorinated refrigerants (sometimes called "natural" refrigerants) have some desirable characteristics in

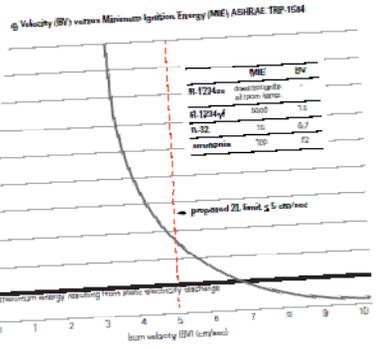
... refrigerants are difficult or unable to ignite at room temperature, and may be able to be used with similar existing uses that are used today.

... simple subject such as safety is actually quite nuanced and can be expressed with nuance. The two most common safety concerns are the minimum flash point, and the burning

... Energy (MIE). The MIE indicates the energy needed to ignite a refrigerant. The more difficult it is to ignite, the lower the risk.

Figure 2: ASHRAE Standard 34-2012 4 safety classifications

Safety Group	Safety Groups	
	A1, A2, A3	B1, B2, B3
Class 1: Lower burning velocity (less than 10 cm/s)	A1, A2, A3	B1, B2, B3
Class 2: Lower burning velocity (less than 10 cm/s)	A1, A2, A3	B1, B2, B3
Class 3: Higher flammability	A1, A2, A3	B1, B2, B3

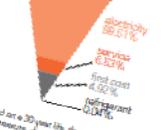


Managing Risk in a Changing Refrigerant Environment

In a constantly changing regulatory environment, a perceived risk surrounds the selection of the right refrigerant. Understanding the risk involved in refrigerant selection is a crucial first step in minimizing that risk.

When compared to the overall life cycle cost of a chiller, refrigerant cost is one of the smallest expenditure items. With a little effort, that expenditure can be reduced to practically zero.

Figure 3: Cost over the life of a chiller



Based on a 20-year life, the energy consumed by the compressor, condenser, evaporator, and other auxiliary equipment is the largest cost. Refrigerant cost is a very small fraction of the total cost. When you evaluate cost over the operational lifetime of a chiller, the magnitude of the risk is reduced.

Industry is yet again bracing for the next wave of refrigerant regulation. The last major ODS regulation resulted in a new wave of options, viable and affordable. I move away from both sides. Gaining some while others, there is

Offering customers insights into the next transition