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Varitec Refrigerant Update

June 15, 2022

Bill Dietrich Daikin Applied Americas Director, Chiller Applications

SPEAKERS

- > Bill Dietrich
 - Director of Chiller Applications at Daikin Applied Americas. This includes all air cooled, and water cooled Centrifugal and Positive Displacement machines.
 - He has a deep chiller background and was involved in the transition from CFCs and HCFCs to HFCs and is actively involved in the work and discussions regarding the new low GWP refrigerants.
 - With over 30 years' experience in the industry, Bill has held numerous Engineering, Applications and Marketing positions addressing commercial/industrial HVAC equipment (chillers, AHU, rooftops, cooling towers and evaporative condensers) and systems using these components.
 - Past chair of the ASHRAE Conferences and Exposition Committee (CEC) and TC 8.2, Centrifugal Machines, and a recipient of the ASHRAE distinguished service award. He is currently an active AHRI and ASHRAE member.





Agenda

- > Background
- > Regulatory update
- > Recap What are the alternatives?
- > Market activity



Evolution of Refrigerants





INDUSTRY NEWS

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Breaking Down the EPA's Final Rule to Cut HFCs

ATLMTA-In late September, the U.S. Environmental Protection Agency (EPA) issued a final rule establishing a comprehensive program to cap and phase down the production and consumption of climate-damaging hydrofluorocarbons (HFGs)—potent greenhouse gases commonly used in refrigeration and air-conditioning equipment.

"This means the U.S. will begin the phasedown of HFCs next year in line with the Kigali Amendment to the Montreal Protocol," said Nanette Lockwood, P.E., Member ASHRAE, member-at-large for ASHRAE's Government Affairs Committee, and Steve Kujak, Member ASHRAE, chair of ASHRAE Standing Standard Project Committee 34, Designation and Safety Classification of Refrigerants.

This final rule is set to phase down the U.S. production and consumption of HFCs by 85% over the next 15 years, as mandated by the American Innovation and Manufacturing (AIM) Act that was enacted in December 2020.

The rule specifically reduces production and bulk consumption of high global warming potential (GWP) refrigerants by 10% in 2022 and 2023, according to Kujak and Lockwood.

"This means refrigerant producers will be required to alter the refrigerants produced to reduce the higher GWP refrigerant volumes in favor of those with lower CWP. The next reduction is another 30% and starts in 2024," they said, adding that another rule is anticipated to be developed over the next year to address the restrictions on the use of higher GWP refrigerants beginning in 2024.

As the U.S. is adhering to the schedule for the Kigali Amendment to the Montreal Protocol, the availability of high GWP refrigerants is expected to decrease.

^AAs high GWP HFCs become less available, lower GWP refrigerants will become more available and preferred solutions. It is likely that impacts to the marketplace, as the result of the lo% reduction, will be low given many low GWP refrigerants are already widely available and used in products today," they said.

6 ASHRAE JOURNAL ashrae.org NOVEMBER 2021

In order to be prepared for the next stepdown in 2024, Lockwood and Kujak said ASHRAE members should become more



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educated on nextgeneration lower

GWP refrigerants and associated products. The EPA estimates the total emission reductions as a result from the rule from 2022–2050 could be the equivalent of 4.6 billion metric tons of carbon dioxide (CO₂), which is about equal to three years of U.S. power sector emissions at 2019 levels. In 2036 alone—the year the final reduction step is made—the rule is expected to prevent emissions that are about equal to the annual greenhouse gas emissions from one out of every seven passenger vehicles registered in the U.S. \blacksquare

Demystifying Building Decarbonization

Building decarbonization is an industry trend, talking point and hot topic, But what does it all mean? Donald Colliver, Ph.D., P.E., Presidential/Fellow/Life Member ASHRAE, and Thomas Phoenix, P.E., BEMP, Presidential/Fellow/

Life Member ASHRAE—the co-chairs of ASHRAE's Task Force for Building Decarbonization—define decarbonization, talk about the plausibility of carbon goals and dispel common myth and misconceptions on the latest ASHRAE Journal Podcast episode.

Listen at ashrae.org/podcast or wherever you get your podcasts.

On the Way to Decarbonizatio

ASHRA

Covering Virus Transmission Modes and Mitigation COVID-19 Strategies: The Final Installment

REGULATORY UPDATE

- > Recent US Action
- > California Activity
- > Canada





LOW GWP REFRIGERANTS – US FEDERAL ACTION

- The AIM Act (American Innovation and Manufacturing Act) is now law, included within the December 2020 Omnibus spending bill
- Gives EPA authority to phasedown HFCs roughly aligned with Kigali Amendment to Montreal Protocol





What is the AIM Act and the HFC Phasedown?

Congress enacted the American Innovation and Manufacturing (AIM) Act on December 27, 2020. The AIM Act directs the U.S. Environmental Protection Agency (EPA) to address HFCs. Specifically, the AIM Act directs EPA to phase down production and consumption^[1] of HFCs to 15% of their baseline levels in a stepwise manner by 2036 through an allowance allocation and trading program.





https://www.epa.gov/climate-hfcs-reduction/phasedown-hydrofluorocarbons-hfcs-issuing-allowance-allocations



LOW GWP REFRIGERANTS – US FEDERAL ACTION

- Law required EPA to establish the phase-down program and allocate allowances for production and consumption by Oct 1, 2021 - Complete
- Environment groups have petitioned to reinstate SNAP Rules 20 & 21
 - Rule 21 would ban use of R134a and R410A in new chillers January 1, 2024
 - Rule 20 addresses aerosols, foams and MAC (mobile AC, i.e. automobiles)









CHANGE OF LISTING STATUS

End-Uses	Substitutes	Date of Change of Status
Air Conditioning		
Centrifugal chillers (new)	FOR12A, FOR12B, HFC-134a, HFC-227ea, HFC-236fa, HFC- 245fa, R-125/134a/600a (28.1/70/1.9), R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-410A, R-410B, R-417A, R-421A, R-422B, R-422C, R-422D, R-423A, R-424A, R-434A, R- 438A, R-507A, RS-44 (2003 composition), and THR-03	Unacceptable, except as otherwise allowed under a narrowed use limit, as of January 1, 2024
Centrifugal chillers (new)	HFC-134a for military marine vessels	Acceptable, subject to narrowed use limits, as of January 1, 2024
Centrifugal chillers (new)	HFC-134a and R-404A for human-rated spacecraft and related support equipment	Acceptable, subject to narrowed use limits, as of tentiary 1, 2024
Positive displacement chillers (new)	FOR12A, FOR12B, HFC-134a, HFC-227ea, KDD6, R- 125/134a/600a (28.1/70/1.9), R-125/290/134a/600a (55.0/1.0/42.5/1.5), R-404A, R-407C, R-410A, R-410B, R-417A, R-421A, R-422B, R-422C, R-422D, R-424A, R-434A, R-437A, R- 438A, R-507A, RS-44 (2003 composition), SP34E, and THR-03	Unacceptable, except as otherwise allowed under a narrowed use limit, as of January 1, 2024
	1	

What Petitions Has the Agency Received and What is their Status?⁴

On October 7, 2021, the Administrator granted ten petitions in full and partially granted one petition submitted under subsection (i) of the AIM Act, meeting the statutory deadline for the earliest petitions received by EPA. EPA is also issuing a notice in the *Federal Register* to inform stakeholders about these determinations. The status of all petitions received as of October 1, 2021, are summarized in the table below.

Petitioner	Receipt Date	Topic of Petition	Status
Air-Conditioning, Heating, and Refrigeration Institute (AHRI), et al.	April 13, 2021	"Restrict the Use of HFCs in Residential and Light Commercial Air Conditioners"	Granted
Air-Conditioning, Heating, and Refrigeration Institute (AHRI), et al.	April 13, 2021	"Restrict the Use of HFCs in Certain Commercial Refrigeration Equipment"	Granted
Association of Home Appliance Manufacturers (AHAM)	April 13, 2021	"Restrict the Use of HFCs in Certain Air Conditioners and Dehumidifiers"	Granted
Environmental Investigation Agency (EIA), et al.	April 13, 2021	"Restrict the Use of HFCs in Certain Stationary Refrigeration and Air Conditioning End uses"	Granted
Natural Resources Defense Council (NRDC), et al.	April 13, 2021	"Replicate HFC Prohibitions from SNAP Rules 20 & 21"	Granted





special accommodations, please contact James Casey at

The Office of Atmospheric Programs is hosting this sector workshop to provide an additional opportunity for stakeholder input on the Technology Transitions proposed rulemaking. Subsection (i) of the American Innovation and Manufacturing (AIM) Act provides EPA authority to restrict the use of regulated hydrofluorocarbons (HFCs) in sectors or subsectors where they are used. This workshop will focus on the refrigeration and air

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conditioning sectors.

Online event

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Distribution of HFC Consumption Allowances for 2022, with Entities Receiving <0.5% Aggregated



Entities with <0.5% of Allowances</p>

THE AIM ACT

The following illustrates the HFC production and consumption phasedown schedule as outlined in the AIM Act.



The AIM Act phases down the

consumption and production

KIGALI AMENDMENT TO THE MONTREAL PROTOCOL



- In October 2016 a multinational agreement was reached in Kigali, Rwanda to phase down HFCs by 85% between now and 2047
- Based an AR4 GWP values*
- Phase down will be done on a GWP weighted basis
 - Eliminating higher GWP HFCs such as R404A (GWP=3940) will have more of an impact than reductions in R134a (GWP=1300)



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https://www.unido.org/sites/default/files/files/2020-04/UNIDO-brochure HFC-Phase Down-Complete.pdf

LOW GWP REFRIGERANTS – CALIFORNIA

- California Air Resource Board (December 10, 2020 meeting) voted to approve the staff proposal on its HFC regulation. Key provisions:
 - GWP <u>750</u> ban
 - Room AC and dehumidifiers: January 1, 2023
 - VRF: January 1, 2026
 - Other AC equipment: January 1, 2025
 - <u>Chillers: January 1, 2024</u>
 - Refrigerant Recovery, Recycle, and Reuse (R4) Program
 - 10% use of reclaimed refrigerant by AC manufacturers for 2023 and 2024 shipments into CA
 - Early action credit for low GWP refrigerant use
 - Reclaim rulemaking in 2021. Likely excludes chillers and could source reclaim nationwide, but all TBD



CANADA & MEXICO HAVE RATIFIED THE KIGALI AGREEMENT





September 2021: 125 Countries Ratified



RELEVANT CANADIAN REGULATIONS, STANDARDS, CODES



- > Environment and Climate Change Canada
 - Chillers less than 750 GWP by Jan, 2025
 - No regulations yet for direct HVAC systems
- B52 standard and certification to CSA 22.2 No. 60335-2-40 3rd Edition permits A2Ls restricts to certain charge limits

High probability Canada will follow USA with HFC phasedown regulations, B52 will be revised in 2022, and provincial building codes will fall in line



GWP IS NOT THE FULL MEASURE OF EMISSIONS



— Majority of climate impact from HVAC is electrical power generation over equipment lifetime

- A lower GWP refrigerant with lower efficiency could actually create more global warming!

©2022 Daikin Applied Source: Zhang M., et al. 2011. "Life Cycle Climate Performance Model for Residential Heat Pump Systems." AHRTI Report 09003-01



CO₂ EQ. EMISSIONS MOSTLY FROM ELECTRICITY CONSUMPTION



WHAT ARE THE ALTERNATIVES?





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BASICS

- Refrigerant number designations
- > Toxicity A or B
- > Flammability 1 thru 3

ASHRAE Standard 34





ASHRAE 34-2019

- > Toxicity ASHRAE 34
 - A (lower toxicity) or
 - B (higher toxicity)
- Flammability ASHRAE
 34
 - 1 (no flame propagation)
 - 2L (lower flammability) effect of ignition is not so large, and typically difficult to ignite
 - 2 (lower flammability)
 - 3 (higher flammability)



Figure 6.1.4 Refrigerant safety group classification.

ASHRAE Standard 34-2016 Addendum g

Work underway to recognize 2L category in North America building codes



CODE ADOPTION PROCESS OF NEW REFRIGERANTS

ASHRAE Standard 3 Designation and Safety Classification	A Ready A2L Qu U.S. EP	u <mark>ick Fact</mark> A SNAP-Lis	ted Lower I	Flammabili	ty Refriger	ants	llers, can use A2Ls already s revised codes to permit A2L revised their National Code
EPA SNAP Approval Significant Ne		UNITED ST.		Ther EPA flam use equi R45 R45 R45 <u>has</u> <u>thes</u>	e are already SNAP-listed lo mability refrige in air condition pment, includi 2B, R454A, R- 4C and R-457, set use conditi e refrigerants.	six U.S. ower erants for ng R-32, -454B, A. <u>The EPA</u> ions for	State and Local Codes
Alternatives Policy Prograr	n						Contract States Environmental Protection
2016	5 2017	2018	2019	2020	2021	2022+	

UMC, Uniform Mechanical Code IMC/IRC, International Mechanical Code/International Residential Code



BASICS – FLAMMABILITY AND TOXICITY

			Safety Group		
1	ability	Higher Flammability	Propane (R290) A3	B3	
	g Flamm	Lower	A2	B2	
	asin	Πατιπιπασιπτγ	A2L	Ammonia (R717) B2L	
lncr€	lncr€	No Flame Propogation	R134a ^{R410A} A1 R22	^{R123} B1	
			Increasin	g Toxicity	









Refrigerant	ASHRAE 34 Classification	GWP ₁₀₀ (AR5)	Composition	Efficiency	Capacity
R134a	A1	1300			
R513A	A1	572	44% R134a / 56% R1234yf		
R515A	A1	392	88% R1234ze / 12% R227ea		
R515B	A1	292	91.1% R1234ze / 8.90% R227ea		
R1234yf	A2L	1			
R1234ze	A2L	1			

R134a is the best choice today for A1 applications

R1234ze is the best long-term choice

- Requires new compressors and code changes
- ➢ R515 is the non-flammable option for R1234ze
- > Lower GWP and better efficiency than R513A



WHAT ABOUT NON-FLAMMABLE NO FLAME PROPAGATION R513A?



- Less efficient than R134a
- > More expensive
- > 44% R134a with 573 GWP
- Achieves goal of lower GWP than R134a but may not have lower climate impact



R134A AVAILABILITY

- Likely will be more R134a available for servicing in 20 years than R513A
- > HFC phase-down does not go to zero
- > Large reclaim / recycle market

HUDSON 1 Blue Hill Plaza, 14th Floor PHONE 800-953-2244 Suite 1541 845-735-6000 ECHNOLOGIES Pearl River, NY 10965 FAX 845-512-6070 WEB www.hudsontech.com April 22, 2019 William E. Dietrich Product General Manager, Chillers Daikin Applied PO Box 2510 Staunton, VA 24402 Re: Availability of R134a Dear Mr. Dietrich: As per our telephone conversation today, Hudson Technologies Company will guarantee the continued availability of R134a for your customer's servicing needs for the next twenty years at prices based upon the existing market pricing at the time of supply. This guarantee is based upon current US laws, rules and regulations including, without limitation, those governing the production and supply of HFC refrigerants. Please feel free to call if you have any questions. Yours very truly, Kevin J. Zugibo CEO



R515B AND **R1234**ZE

- European products have been for sale with R1234ze already
 - In most cases as a dropin to existing R134a designs
 - R515B (91% R1234ze) is very similar to R1234ze from a performance standpoint
 - GWP goes from 1 to 292
 but is now a nonflammable refrigerant

R1234ze chiller is the best medicine

9 JAN 2022



AUSTRIA: Daikin has supplied two screw inverter chillers operating on Low GWP HFO refrigerant R1234ze to a major pharmaceutical company's facility in Vienna, Austria.



1/18/2021 Carrier adopts lower GWP refrigerant R515B (Europe)

Carrier has become one of the first manufacturers to adopt the lower GWP A1 refrigerant R515B in its water-cooled chillers and heat pumps.

The refrigerant, introduced by Honeywell last year as Solstice N15, is now offered in Carrier's AquaForce 30XW(H)PZE and 30XW(H)VZE water-cooled liquid screw chillers.



Developed as a replacement for R134a in new medium temperature commercial refrigeration, chillers and heat pumps, R515B is an A1, non-flammable refrigerant blend with a GWP of just 293 under AR4. It is a blend of R1234ze (91.1%) and R227ea (8.9%), is said to have zero glide and combines low discharge temperatures with an efficiency to match R134a.

In addition, it is said that chillers and heat pumps operating on R515B will be capable of being retrofitted to operate on the ultra-low GWP refrigerant R-1234ze in the future.

AquaForce 30XW(H)PZE fixed speed chillers are available in nominal cooling capacities from 275 to 1,100kW and use a variable capacity valve to match cooling capacity to load. AquaForce 30XW(H)VZE units are available in nominal cooling capacities from 450 to 1,300 kW and use a variable speed drive to precisely match output to load.

https://www.coolingpost.com/world-news/carrier-adopts-lower-gwp-refrigerant-r515b/

Source: Cooling Post on 1/18/2021

MARKET ACTIVITY

Home / Features / Daikin supplies R1234ze chillers to Large Hadron Collider

Daikin supplies R1234ze chillers to Large Hadron Collider

• 13 FEB 2022



SWITZERLAND: Daikin has supplied two air-cooled chiller units running on low GWP HFO refrigerant R1234ze to CERN, the European Organisation for Nuclear Research, for the Large Hadron Collider (LHC).



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The two EWAH-TZ chillers with a total cooling capacity of 1312kW were for linear accelerator 4, also known as Linac4.

LOW PRESSURE CENTRIFUGAL CHILLERS



LCCP : Life Cycle Climate Performance, LCA: Life Cycle Analysis

	Refrigerant	ASHRAE 34 Classification	GWP ₁₀₀ (AR5)	Composition	Efficiency	Capacity	Toxicity
	R123	B1	77				
ſ	R1233zd	A1	1				
	R514A	B1	~2	74.7% R1336mzz/ 25.3% R1130			

R1233zd available now. Will be the most used low-pressure refrigerant



R410A ALTERNATIVES



Refrigerant	ASHRAE 34 Classification	GWP ₁₀₀ (AR5)	Composition	Efficiency	Capacity
R410A	A1	1924	50% R32 / 50% R125		
R32	A2L	677 -A			
R454B	A2L	466	68.9% R32 /31.1% R1234yf		
R466A	A1	697 -8	49% R32 /39.5% CF3I /11.5% R125		

*R*410A is the best choice today for A1 applications*▶* R466 under evaluation for new designs as well

R32 appears to be the best long-term choice➢ Requires new compressors and code changes



REFRIGERANT SUMMARY

Refrigerant	ASHRAE 34 Classification	GWP ₁₀₀ (AR5)	Glide (°F)	Composition
R134a	A1	1300	0.0	
R513A	A1	572	0.0	44% R134a / 56% R1234yf
R1234ze	A2L	1	0.0	
R515A	A1	392	0.0	88% R1234ze / 12% R227ea
R515B	A1	292	0.0	91.1% R1234ze / 8.90% R227ea
R450A	A1	547	1.2	42% R134a / 58% R1234ze
R1234yf	A2L	1	0.0	
R410A	A1	1924	0.2	50% R32 / 50% R125
R32	A2L	677	0.0	
R452B	A2L	675	2.1	67% R32/26% R1234yf / 7% R125
R454B	A2L	466	2.4	68.9% R32/31.1% R1234yf
R466A	A1	697	2.7	49% R32 /39.5% CF3I /11.5% R125
R1233zd	A1	1	0.0	
R514A	B1	~2	0.0	74.7% R1336mzz/ 25.3% R1130
R125	A1	3170	0.0	



MARKET ACTIVITY



MARKET ACTIONS – REFRIGERANTS

- > R32 use continues to grow
- New centrifugal chiller introductions using R1233zd
- > Increasing use of R1234ze in Europe
 - Both screws and centrifugals



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We are pleased to formally announce our intent to adopt R-32 as Daikin's low GWP refrigerant of choice for a range of applied, light commercial and residential products in North America. In conjunction with other Daikin Group companies in North America, we issued a <u>press release</u> today.







SUMMARY

- > What are the best choices for new equipment today?
 - R134a, 410A and R1233zd
- > Refrigerant alternatives should focus on:
 - Efficiency and containment
- As codes and testing are completed for 2L refrigerants, R32 and 1234ze will offer more solutions













QUESTIONS?

Bill Dietrich Dakin Applied <u>william.dietrich@daikinapplied.com</u>

