

The Transition to Low-GWP Refrigerants in the Unitary Market

September 16, 2022

Just as the HVAC industry in the United States transitioned from ozone-depleting hydrochlorofluorocarbon (HCFC) refrigerants to hydrofluorocarbon (HFC) refrigerants, it will now transition from HFC to low-GWP (global warming potential) hydrofluoroolefin (HFO) refrigerants. The specific timing, however, is a hotly debated industry issue.

Parallels for this transition can be drawn from 2010, the last time the U.S. unitary sector implemented a refrigerant transition. In order to comply with the Montreal Protocol and minimize damage to the ozone, the industry transitioned from R-22 refrigerant to R-410A refrigerant. This transition was guided by federal mandates via the Environmental Protection Agency's (EPA's) SNAP¹ program. While some states desired to transition at different times, the EPA's federal authority ensured a single, national transition that was smooth and orderly, preventing price spikes and refrigerant shortages.

While the production of new equipment using R-22 ended in 2010, some production of new R-22 refrigerant was still permitted for another 10 years to support the servicing of existing equipment. On January 1, 2020, production of new R-22 for service applications ended. But, even today, significant quantities of R-22 are still available in the market from numerous refrigerant reclaimers. To meet market needs, reclaimers have been actively reclaiming millions of pounds of R-22 per year (see <https://www.epa.gov/section608/summary-refrigerant-reclamation-trends>). There are currently no bans on the use of reclaimed R-22 for service purposes and none are expected in the foreseeable future.

With the recent passage of the American Innovation and Manufacturing (AIM) Act² as part of the December 2020 COVID stimulus bill, the EPA has now been granted formal authority to regulate substances based on their GWP³. The EPA had previously attempted to regulate substances based on GWP but lost that authority due to a court challenge⁴ that originated in 2015. At that time, the court ruled that the EPA's authority was limited to the regulation of the ozone depletion potential (ODP) of a substance. Today, the AIM Act directs the EPA to phase down U.S. HFC production and use by approximately 85% over the next 15 years. This requires a transition from HFC refrigerants like R-410A to a new generation of low-GWP refrigerants.

HFCs typically have very high GWP levels relative to carbon dioxide (CO₂). The most well-known HFC, R-410A, which is the dominant refrigerant used in today's residential and commercial sector (e.g., unitary), has a GWP of 2,088 (AR4 – 100 yr). The U.S. and Canadian markets last transitioned their unitary sectors from R-22 to R-410A in 2010. The issue with the 2010 transition was that it focused solely on addressing ODP and failed to address GWP. In fact, R-410A has a higher GWP than R-22, which has a GWP of 1,810.

The specific timing for the low-GWP refrigerant transition, and whether it will be a single federal transition or the current "state by state" approach, is still taking shape. While several states like Washington and California have taken up the initiative and adopted the EPA SNAP-approved regulations for product sectors such as chillers, foams and motor vehicles into their respective state regulations, they are still working through the practical aspects of implementing an HFC phase-out in the more controversial unitary equipment sector.

¹ Significant New Alternatives Policy (SNAP) is a program to evaluate and regulate ozone-depleting and high global-warming potential (GWP) chemicals as authorized by the Clean Air Act (CAA)

² On December 27, 2020, the American Innovation and Manufacturing (AIM) Act of 2020 was enacted as section 103 in Division S, Innovation for the Environment, of the Consolidated Appropriations Act, 2021 (H.R. 133 (116th): Consolidated Appropriations Act, 2021 [Including Coronavirus Stimulus & Relief])

³ <http://climatecasechart.com/case/mexichem-fluor-inc-v-epa/?cn-reloaded=1>; Mexichem Fluor Inc. v. EPA in which the court found that some applications of the HFC standards exceeded EPA's authority because they were crafted under a Clean Air Act program focused on eliminating ozone-depleting substances

⁴ <http://climatecasechart.com/climate-change-litigation/case/mexichem-fluor-inc-v-epa/>

Refrigerant Attributes

Fluid	ASHRAE 34	GWP	Component Mix - Ratio %	Exposure Limit	Operating Pressure	LFL	UFL	Burning Velocity	MIE	Auto Ignition	Hot Surface Temperature	Efficiency	Capacity
		CO ₂ e		ppm	psia	% v/v	% v/v	cm/sec	mJ	C	C	vs R-410A	vs R-410A
R-410A	A1	2,088	R-32/R-125 - 50/50	140,000	434	-	-	-	-	> 750	-	-	-
R-454B	A2L	466	R-32/R-1234yf - 69/31	30,000	405	11.8	21.5	5.2	100-300	498	700	=	<
R-32	A2L	675	R-32 - 100%	36,000	444	14.4	29.3	6.7	21-40	648	700	+	+

LFL - lower flammability limit

UFL - upper flammability limit

MIE - minimum ignition energy

Based on the California Air Resources Board (CARB) board meeting held in December of 2020⁵, California is mandating a transition for stationary AC/unitary products on January 1, 2025, with a maximum GWP limit of 750. The Air-conditioning, Heating and Refrigeration Institute (AHRI) submitted a formal petition to the EPA in April 2021 that requested a national, sector-based phase-out of stationary AC/unitary products aligning with California's pending date and GWP limit. It is hoped that such prominent regulatory agencies will prompt other states, and even other countries, to adopt this same timing and GWP level.

It is well-publicized that unitary equipment manufacturers in the United States and Canada have been testing and evaluating low-GWP alternatives to R-410A for several years. When evaluating new refrigerants, manufacturers must consider various performance and market metrics in addition to GWP. These factors include safety, capacity, efficiency, reliability, availability and longevity. Among the EPA SNAP-approved alternatives, the two leading candidates to replace R-410A in the North American unitary market are R-32 and R-454B.

R-32 is a long-established, pure compound widely used in Asia and other parts of the world in small charge applications, such as window units and ductless equipment. Because of the refrigerant's established use outside the U.S., some manufacturers are promoting it as their preferred replacement for R-410A in the United States in order to leverage their intellectual property and the scale of their investments. R-32 has the potential for improvements in energy efficiency and capacity relative to R-410A. Yet, its higher GWP of 675 makes R-32 more susceptible to a second, near-term transition⁶, and its higher discharge temperatures must be specifically accounted for in equipment design and application.

AIM Act Step-Down Scenario for R-410A

Years	0	2019	2024	2029	2034	2036
AIM Act % Reduction	0%	10%	40%	70%	80%	85%
R410A (GWP)*	2,088	1,879	1,253	626	418	313

⁵ <https://ww3.arb.ca.gov/board/books/2020/121020/20-13-4pres.pdf>

⁶ * - Using only R410A as a proxy for all 18 AIM Act HFC's, the actual GWP limits will likely vary

⁷ <https://www.epa.gov/snap/snap-regulations>

⁸ American Society of Heating, Refrigerating and Air-Conditioning Engineers

⁹ Based on currently approve EPA SNAP listed alternatives for high pressure systems

¹⁰ https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-2-f&chapter=27&clang=_en

R-454B, a relatively new compound, is a blend of R-32 (68.9%) and R-1234yf (31.1%). With the lowest, EPA SNAP⁷-approved GWP of all ASHRAE⁸ 34 classified A2L (low-toxicity, mild flammability) refrigerants on the market, R-454B has a best-in-class⁹ GWP of 466 and offers the best outlook for long-term viability as phase-down regulations continue. It also has very similar operating pressures and temperatures to R-410A, which shortens the learning curve for equipment designers and service technicians.

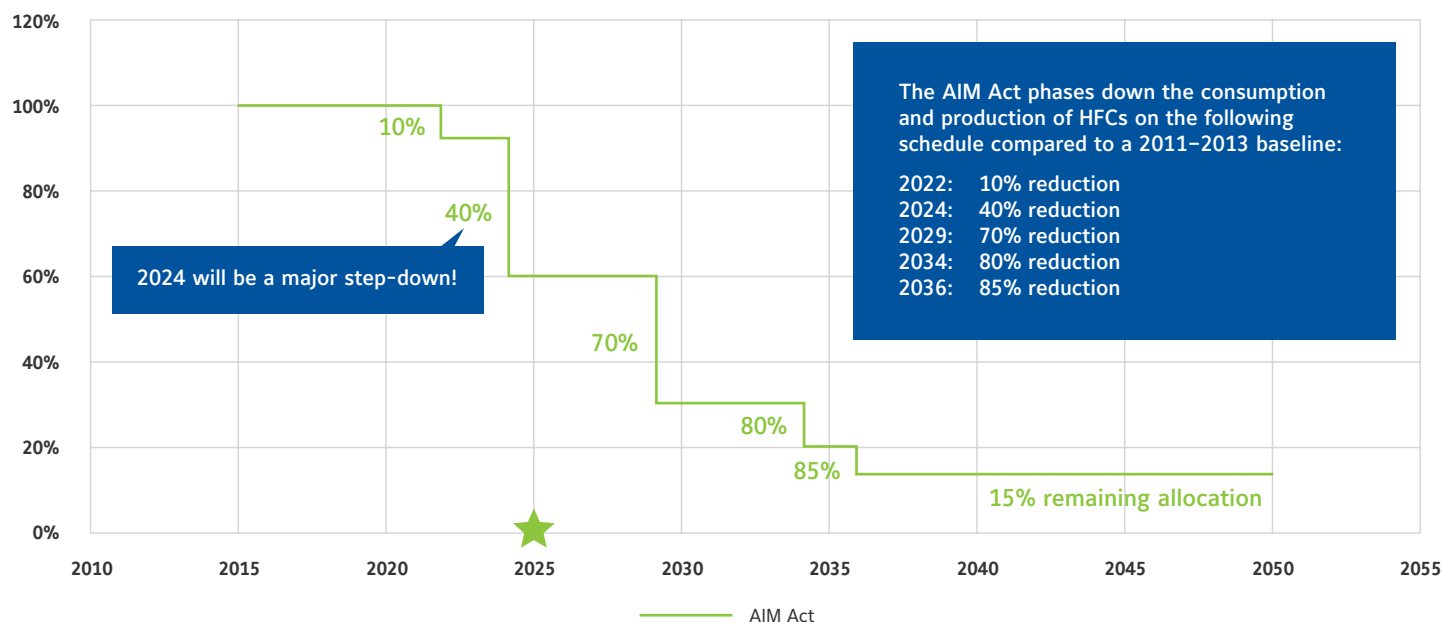
While R-454B and R-32 fall below California's proposed 750 GWP maximum limit, both refrigerants are classified by ASHRAE 34 as nontoxic and mildly flammable A2L refrigerants. This is different from R-410A, which, conversely, is classified as a no flame propagation A1 refrigerant. Because of this A2L flammability designation, R-454B and R-32 cannot be used as drop-in replacements for existing R-410A equipment. As of this article's publication date, there are no known drop-in replacements for R-410A available.

ASHRAE 34 Flammability Classifications

Higher Flammability	A3	B3
Flammable	A2	B2
Lower Flammability	A2L	B2L
No Flame Propagation	A1	B1
	Lower Toxicity	Higher Toxicity

Since there are no drop-in replacements and the alternatives are A2L refrigerants, it is important that contractors and equipment owners quickly establish proper refrigerant management practices, invest in flammable refrigerant training and establish sources of both virgin and reclaimed R-410A before the AIM Act phase-down on virgin refrigerant occurs. As mentioned, the AIM Act (in alignment with the Kigali Amendment¹⁰) stipulates a 40% step-down in 2024, which could prove disruptive to those without secured, long-term sources.

AIM Act/Kigali HFC Phase-Down Schedule as % of Baseline



In summary, Johnson Controls chose R-454B as its low-GWP refrigerant to replace R-410A in all unitary (residential, light commercial/applied) products. The decision is based on the refrigerant's best-in-class, EPA SNAP-approved GWP of 466 and its similarity to R-410A, which will facilitate an easier transition for contractors and distributors. Other considerations include:

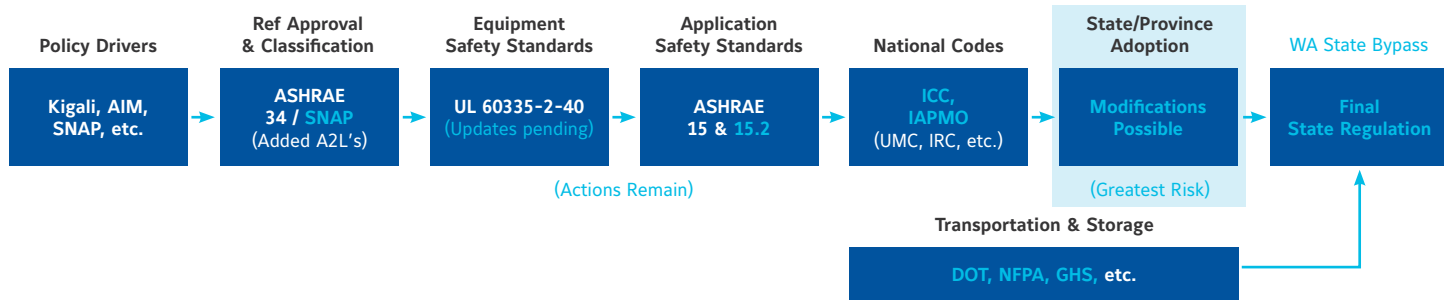
- **Greater environmental/sustainability benefits and credits:** the GWP of R-454B is far lower than the pending 750 GWP limits being proposed, and R-454B has the potential to reduce HVAC energy use by up to 5%
- **Best long-term, low-GWP solution:** the low GWP of R-454B offers the best outlook for long-term viability as phase-down regulations continue
- **Closest performance to R-410A:** the compatibility of R-454B allows the use of many existing R-410A system components, which leverages R-410A production scale, improves availability and minimizes system cost
- **Shortest learning curve for contractors:** very similar pressures and temperatures to R-410A will make for a smoother transition to R-454B
- **Lower discharge pressures versus R-32:** the improved system performance with R-454B doesn't require special designs and components (e.g., compressors, oils, etc.)
- **Slower burning velocity rate versus R-32:** a slower flame propagation rate makes R-454B less flammable
- **Superior heat pump heating:** the broader operating envelope of R-454B at low evaporating temperatures better enables the transition to heat pumps driven by the electrification trend
- **Endorsement by other leading OEMs:** unified backing significantly improves scale and availability

The mild flammability aspect of R-454B and other A2L refrigerants requires that safety standards and individual state building codes be updated prior to their introduction to the market. The process to update codes and standards is well underway. The primary safety standards (U.L. 60335-2-40 – 3rd edition or later, ASHRAE 15 and 15.2) that impact direct systems, such as unitary equipment, have been updated to accommodate the larger charge volumes found in typical U.S. style splits systems and packaged units.

Yet, individual states, cities and even individual municipalities must adopt these standards into their building codes, and the cycle for updating these building codes can greatly vary by jurisdiction, with some being 5 to 10 years. Since there is no widespread mechanism for simultaneously updating the thousands of necessary codes, this presents a challenge to a single, national transition on January 1, 2025. To prepare for the transition from R-410A, it's important to support the adoption of A2L codes at the local and state levels.

It is also important to ensure adherence to ASHRAE 15.2, which specifically addresses residential applications, is adopted into the pertinent national (model) codes.

Codes and Standards Process



Because the AIM Act is now signed into law, it's reasonable to assume the EPA can mandate a national transition for a given sector, such as stationary AC for January 1, 2025, and a GWP limit of 750, which would make the transition very straightforward. It is true that the AIM Act grants the EPA specific authority for such sector-based phase-outs and that states must comply (states can strengthen the regulation but they cannot ignore or weaken it). However, the EPA does not have authority to update a given state's building codes, which means existing codes are prioritized over EPA authority. Because low-GWP alternatives are classified as A2L, mildly flammable refrigerants, safety requirements outweigh environmental mandates.

Much research and testing has been conducted to ensure A2L refrigerants can be safely introduced into direct systems such as residential applications, and the training and licensing of installing contractors is critical. Organizations such as AHRI and their research arm AHRTI (Air-conditioning, Heating and Refrigeration Technology Institute)¹¹ have led the way in research and testing of A2L refrigerants in multiple real-life scenarios, including joint testing performed with the fire service. The results of this ongoing testing and research have helped drive the development of safety and application standards as well as recent training materials. The Air Conditioning Contractors of America (ACCA) was one of the first contractor organizations to offer an A2L training curriculum¹² online, which addresses unitary systems and specifically includes residential applications. ACCA has indicated they will update their training once ASHRAE 15.2 is formally published.

Based on the lessons learned from the R-22 refrigerant phase-out in 2010, as well as the reluctance to strand viable legacy equipment, it is reasonable to believe R-410A will similarly be available for service beyond any mandated phase-out. However, the phase-down schedule outlined in the AIM Act could force the EPA into shortening the traditionally long (~10 year) service tail. Because the AIM Act phase-down schedule applies broadly to HFCs and not just R-410A, a comprehensive, sector-by-sector phase-out schedule has not been established for the stationary AC (unitary) sector. For example, the EPA could be forced to mandate the use of reclaimed R-410A for servicing existing equipment much earlier than any previous transition in order to stay on schedule.

The EPA also has other options it can consider, such as mandatory leak checks for existing equipment, which is already part of the existing Clean Air Act Section 608¹³ rules for ozone depleting substances (ODSs). The existing inspection requirements only apply to systems with greater than 50 lbs of charge, but the EPA could revise the requirements to lower charge levels. As part of the implementation of the AIM Act, the EPA is expected to begin specifically addressing reclamation and service this year; however, completion is unlikely until late 2022 or later. The EPA has stated that there will be additional opportunities for stakeholders to engage.

What's clear is that this transition will be more complex than past transitions due to the mild flammability of the new low-GWP alternatives, as well as the possibility of more than one definitive solution. This transition also coincides with the established 2023 DOE efficiency transition, which means new R-410A equipment developed specifically for 2023 efficiency compliance will only have a very short, two-year life if the pending January 1, 2025, low-GWP transition holds. This is, unfortunately, just part of the ever-increasing frequency of regulatory change that is likely to continue.

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¹¹ <https://www.ahrinet.org/analytics/research/ahri-flammable-refrigerants-research-initiative>

¹² <https://www.acca.org/education/a2l-refrigerants>

¹³ <https://www.epa.gov/section608/managing-refrigerant-stationary-refrigeration-and-air-conditioning-equipment>

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