INTRODUCTION TO A2L REFRIGERANTS

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REGULATORY LANDSCAPE

U.S. American Innovation AND Manufacturing Act

The bipartisan American Innovation and Manufacturing (AIM) Act was included in the Omnibus spending bill/COVID relief package signed into law December of 2020.

- **The AIM ACT mandates a 15-year phasedown of HFCs at a national level, administered by EPA, and aligned with the Kigali schedule.**

  Three main pillars:

  A. PRODUCTION PHASEDOWN. requires EPA to implement an 85 percent phasedown of the production and consumption of HFCs, so they reach approximately 15 percent of their 2011-2013 average annual levels by 2036.

  B. SECTOR SPECIFIC PROHIBITIONS. Authorizes EPA to adopt sector-specific HFC use restrictions referred to by AIM as "technology transitions."

  C. RECLAIM AND RECOVERY. Lastly, the AIM Act requires EPA to promulgate regulations for purposes of maximizing reclamation and minimizing releases of HFCs from equipment

A – Production Phasedown

In 2021, EPA implemented the first regulations under the AIM act by setting up an allowance allocation program aligned with the International Kigali targets. In July 2023, EPA finalized second rulemaking covering 2024-2028.

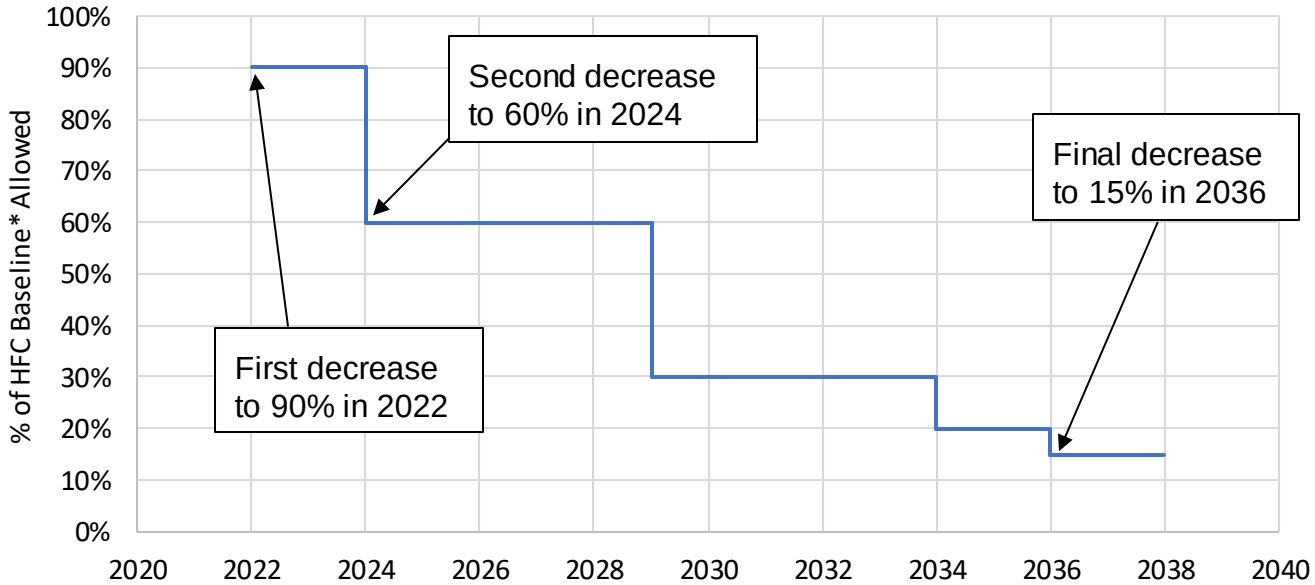
1. **Allowance Allocation & Trading:** EPA gives HFC producers and importers the right to manufacture and sell a limited quantity of HFCs

2. **Phase-Down:** The allocation given to these parties decreases over time to effectively decrease production/sales per the schedule to the right

3. **Compliance:** EPA established strict compliance tools to deter foul play and punish bad actors with hefty penalties

4. **Timing:** Allowance allocation established for 2024 – 2028 via EPA rule finalized in July of 2023

Figure 1: US AIM HFC Phase-down Schedule



**The average annual US HFC production/sales in 2011 – 2013 is used to establish a baseline for the phase-down (100%)*

Enables EPA implementation of Kigali

B – Sector Specific Regulation

On October 6, 2023, EPA finalized the TECHNOLOGY TRANSITION rule to restrict certain HFCs in certain applications using its authority under the AIM Act. Prohibitions largely align or build upon those in SNAP 20/21, adopted by States and CARB.

1. **Context:** Under the AIM Act, EPA can "partially, fully, or on a graduated schedule" restrict HFC use in specific sectors and subsectors.

2. **Finalized Rule:** Restricts HFCs used in refrigeration, aerosols, foams, AC, and heat pump products and equipment by setting GWP thresholds for most sectors.

3. **Scope:** Applies to **new** products, systems, and components only. Does not include retrofit or sale/maintenance of used equipment in the US. Will apply to product imports/exports.

4. **Transition Dates:** In most cases, manufacture/import/install prohibition begins on Jan. 1, 2025, and prohibition of sale, distribution, and export of **products** begins three years after manufacture/import prohibition.

- **AIM Act authorizes EPA to implement sector-specific HFC transitions**

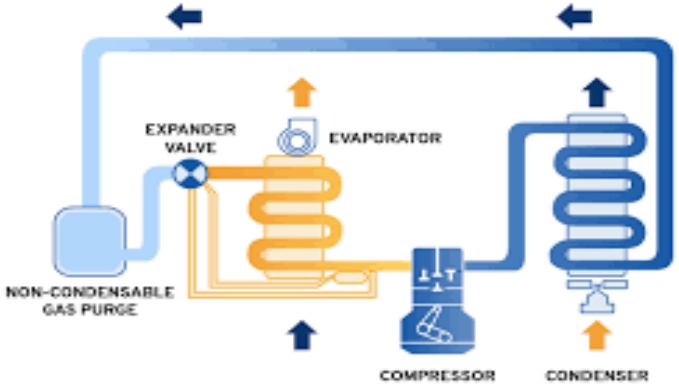
B - Sector-Specific Prohibitions – Key Terms

Products

"Factory-completed appliances"

Examples: Self-contained appliances, foams, fully formulated polyols, aerosols, pressurized dispensers, and wipes

Systems



"Field-assembled equipment"

Examples: Supermarket, industrial process refrigeration, residential split systems

Components

"Major mechanical elements of RACHP systems"

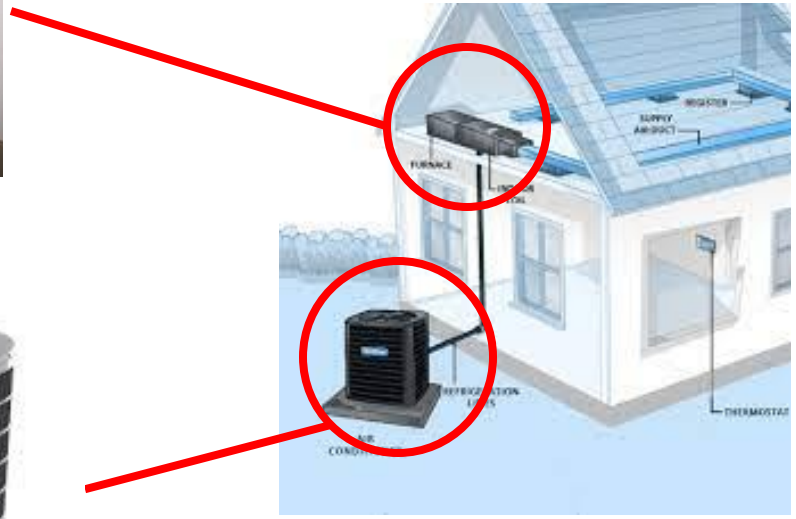
Examples: condensing units, condensers, compressors, evaporator units, and evaporators

1. **No sell through period for systems or components (Modified 12/20/23)**
2. **Components manufactured/import for service and maintenance exempted**

Compliance scenario under current regulation and Industry proposed changes

Example: Components manufactured with or designed for R-410A on December 31, 2024

Gas furnace (contains evaporator)



Condenser

CURRENT Regulation	Industry Proposed Change
Cannot install or sell for **new** residential RACHP systems as of January 1, 2025.	Allow sell and installation in residential RACHP systems through December 31, 2025 **Revised to Jan 1, 2026, on 12/20/23. Using components manufactured prior to Jan 1,2025.**
Can manufacture, import, sell, and install for service or repair indefinitely	Ban manufacture and import of R-410A condensing units, including for service and repair.

- **Industry ask of EPA: Initiate and finalize rulemakings with industry proposed changes**

EPA HFC SECTOR-SPECIFIC PROHIBITIONS RULE

NEW EQUIPMENT ONLY

INDUSTRY SECTOR	GWP LIMIT/RANGE	EXCLUDED PRODUCTS	WHEN	COMPLIANT PRODUCT
Residential & Light Commercial HVAC	700	R-410A	Jan 1, 2025	454B ,R32
VRF	700	R-410A	Jan 1, 2026	454B,R32
Chillers (Excluding IPR with exciting fluid below - 50)	700	R-410A, R-134a	*2028 (-58F -> -22F)* 2026 (>-22F), Comfort Cooling	454B, 454C, L40X 515B, 513A,1234ze, 1233zd, 1234yf,
Data centers	700		Jan 1, 2027	515B, 513A, 454B, 1234ze, 1233zd,
Industrial refrigeration (non-chiller)	150-700		2026-2028	515B, 513A,1234ze, 1234yf, 454C, R455A,
Retail	150-300	**R-448A**, R-404A, R-407's, R-410A, R- 507A, HFC-134A and more	2026 – 2028 (supermarket systems 2027)	R455A, 454C,, 515B, 1234ze, 1234yf
Ice Machines (Batch type w/ harvest rate <=1000 lb/24 hr ice and continuous type w/ harvest rate <=1000 lb/24 hr)	150	R-404A, R-407's, R-410A, R- 507A, HFC-134A and more	Jan 1, Jan 1, 2026	R455A, 454C, 1234yf
Cold Storage	150 - 300		2026	R455A, 454C, 1234ze, 1234yf

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*Honeywell recommended products based on GWP limits and application requirements, list may change

C -Proposed Reclaim and Recovery rule

The AIM Act gave EPA the authority to implement HFC management programs including recovery and reclamation of HFCs. On October 6, 2023 EPA released the first HFC management proposed rule

- Focused on Refrigeration, AC, and Heat Pump sectors, and covers HFCs and HFC-replacements with GWP > 53
- **Includes leak repair requirements** (>15lbs ref. and GWP > 53)
- **Sets reclaim standard**, no more than 15% virgin HFC by weight can be used in reclaim HFC
- **Initial Charge:** Starting Jan. 1, 2028, factory-charged equipment in specific sectors must used reclaimed HFC
- **Servicing/Repair:** Starting Jan. 1, 2028, must use reclaimed refrigerant for servicing/repair in: Stand Alone Retail Refrigeration, Supermarkets, Refrigerated Transport, Automated Commercial Ice Makers sectors
- **Disposable cylinders** must be sent to certified reclaimer for heel removal before disposal starting Jan. 1, 2025

Industry 60-day comment period ended on 12/18/2023

WHY A2Ls?

THE HFO A2L ALTERNATIVE

With the adoption of the A2L rating HFO blended solutions are termed **mildly** flammable and with mitigation in place have been deemed safe for use. (standards and codes are being updated)

Blended HFO's have been crafted to closely mimic the performance of the most widely used HFC's while delivering compliant GWP values

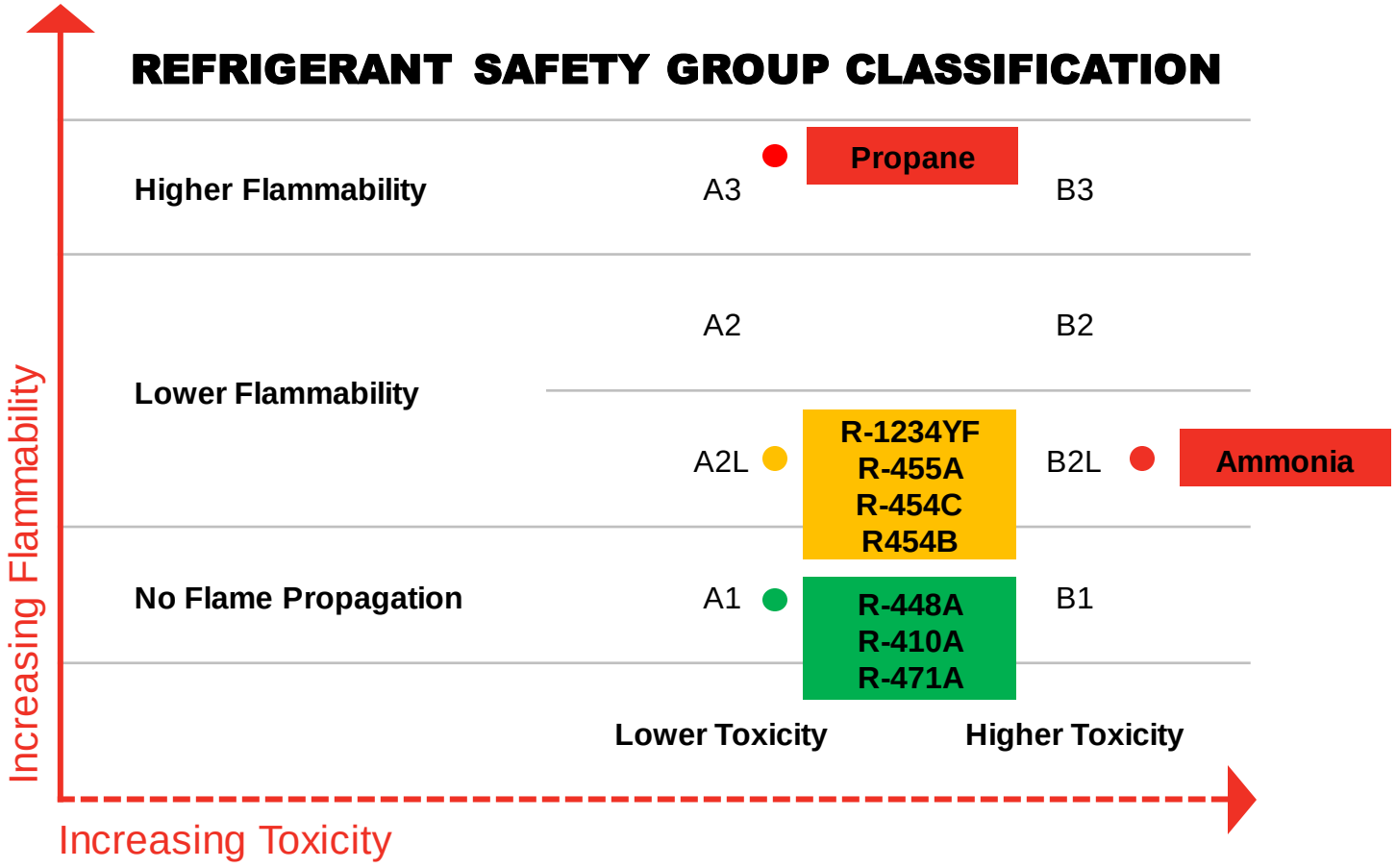
A2L HFO's have allowed OEM's to deliver energy efficient systems and equipment with minimal re-design and charge sizes sufficient for most applications.

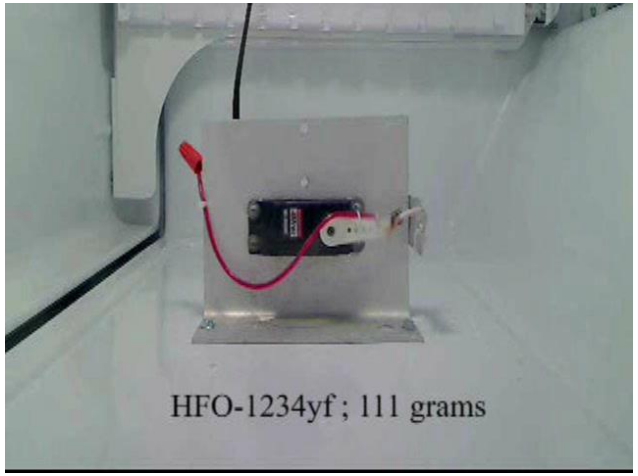
The Air Conditioning segment appears to have settled on R-454B and R32 as the replacement for R-410A in residential and light commercial applications.

The commercial refrigeration segment has settled on R-454C,R454A and R-455A. These blends mimic R404A performance with a GWP value <150.& 300

A2L'S SHOULD BE INCLUDED IN ANY LONG-TERM SUSTAINABILITY STRATEGY

ASHRAE STANDARD 34 CLASSIFICATIONS





ENERGY OF COMBUSTION IS VASTLY DIFFERENT BETWEEN A3 AND A2L REFRIGERANTS

ASHRAE 34
KEY DEFINITIONS

REFRIGERATION CONCENTRATION LIMIT (RCL)

Concentration limit intended to reduce the risks of toxicity, asphyxiation, and flammability

OCCUPATIONAL EXPOSURE LIMIT (OEL)

Average concentration for a 40 hour workweek to which workers can be exposed without adverse effect

FLAMMABLE CONCENTRATION LIMIT (FCL)

Concentration limit intended to reduce the risk of fire or explosion

LOWER FLAMMABILITY LIMIT (LFL)

Lowest amount of a specific refrigerant in air that allows for flammability

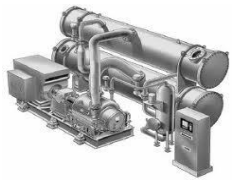
Disclaimer: Refer to Standards and Code for full verbiage

A2L'S IN THE MARKETPLACE

APPLICATIONS

A2L RATED REFRIGERANTS WILL BE UTILIZED IN MULTIPLE SEGMENTS

	HFC (high GWP) products	Equipment Example	Potential Low and Ultra Low GWP Offerings
AIR CONDITIONING	**Unitary, VRF, heat pump, ductless split, packaged rooftop** • R22 (ODS, GWP 1760) • R410A (GWP 1924) • R407C (GWP 1624)	Heat Pump  Ductless Split  Packaged Rooftop 	**Unitary, heat pump, ductless, packaged rooftop** • R454B and R32 (A2L GWP 466) • R455A L40X (A2L GWP 146) • R454C (A2L GWP 146)

CHILLER	**Chiller**
	• 410A(GWP 1924)
	  • High Press
	• 134a(GWP 1300)
	  • Med Press
	• 123(ODS, GWP 79)
	  • Centrifugal
		Chiller  Centrifugal Chiller 	**Chiller**
			• R454B and R32 (A2L GWP 466)
			  • High Press
			• R515B (A1 GWP 293)
			• R1234ze(A2L GWP <1
			  • Med Press
			• R1233zd (A1 GWP <1),
			  • centrifugal

REFRIGERATION	**Commercial** • R404A(GWP 3943) • R507(GWP 3985) **Transport** • 404A(GWP 3943) • 134a(GWP 1300) **Industrial** • R22 (Flooded sys)	Supermarket  Transport  Industrial 	**Commercial** • R455A (A2L GWP 146) • R454C (A2L GWP 146) • R454A (A2L GWP 300) **Transport** • R454A (A2L GWP 300) **Industrial** • R454A (A2L GWP 300)

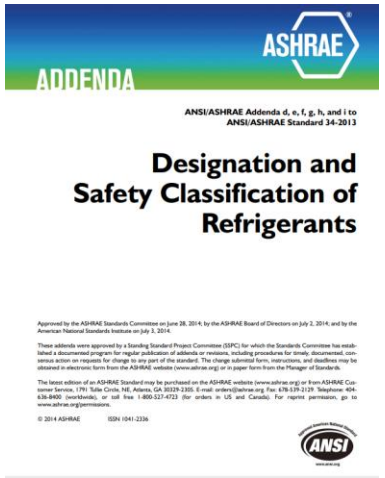
NEW REFRIGERANT INTRODUCTIONS

The application of flammable refrigerants has required the industry to re-write codes and standards to ensure the safe application of A2L's. This is a multi-step process.

UL standard 60335-2-89 published October 2021 applies to commercial refrigeration (2-40 applies to HVAC equipment). [still being modified]

ASHRAE 34 modified to include A2L's as separate class

ASHRAE standard 15- Commercial refrigeration updates is approved for publication



1 – 3+ years

INDUSTRY STANDARDS

ASHRAE 15
(Installation)
UL 60335-2-89
(Refrigeration Equipment)

3 - 6+ years

NATIONAL/ INTERNATIONAL CODES

IBC: Int. Bldg Code
IMC: Int. mech Code
UMC: Uniform Mech Code

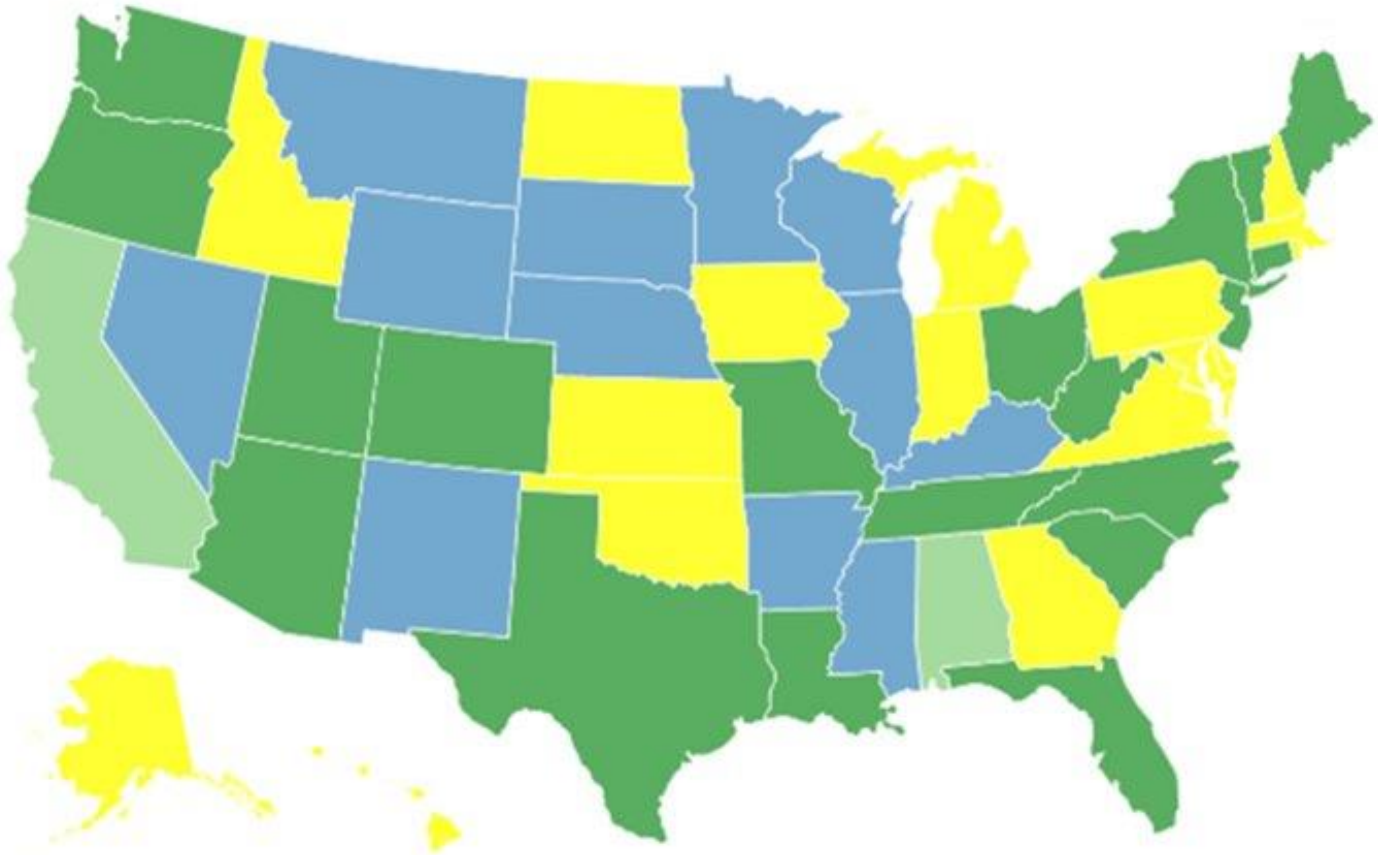
6 – 8+ years

LOCAL AND STATE JURISTICTIONS

THE GRAPHIC IS THE TYPICAL TIMELINE – SOME ENTITIES HAVE ACCELERATED THIS PROCESS

U.S. STATE AND LOCAL CODE A2L ADOPTION STATUS

The dark green states will allow A2L refrigerants. The light green states allow low-GWP refrigerants at some level. States shown in yellow are in the process of enabling low-GWP refrigerants.



- While this data indicates A2L approval on a state level, it is unlikely that local building codes and inspectors are up to speed on A2L adoption and use.
- If assistance is needed on this front Contact Honeywell.
- Each place where UL 2-89 and UL 2-40 is accepted that jurisdiction may enact small tweaks to the UL 2-89 / UL 2-40 before placing it into law.

A2L CHARGE LIMITS

- Charge limits are governed by ASHRAE 15 (safety standard for refrigeration systems) and UL standards 60335-2-40 (HVAC) and 60335-2-89 (Refrigeration)
- For commercial systems like supermarkets the UL codes are more restrictive and therefore drive the limits. For industrial systems the ASHRAE limits apply.
- For the ASHRAE limits the volume of the room is used in a calculation of the charge limit. These numbers can be quite substantial. A 10x15 room could have hundreds of pounds allowed.
- For UL the usage is driven by the LFL value and the level of leak mitigation utilized.
- Masses of m_1, m_2, and m_3 are calculated based on the LFL (Refrigeration values below, HVAC is similar)
  - $m_1 = 13 \times LFL$
  - $m_2 = 52 \times LFL$
  - $m_3 = 260 \times LFL$
- Mitigation measures vary from nothing (m_1) to combinations of leak detection, isolation valves, circulation, and ventilation (m_2, m_3).
- Larger than m_3 not allowed in commercial
- These values and applications are still in flux in the UL committees. Changes are expected but it is clear that max charge limits of 260xLFL will be allowed and possibly more depending on final definition of “releasable charge”.

Refrigerant	Safety Classification	LFL (kg/m^3)	Max Charge Size pounds (lbs.)
R-290 (Propane)	A3	0.038	1.1
R-454B	A2L	0.352	201
R-454C	A2L	0.291	167
R-455A	A2L	0.43	247

*Maximum charge size based on UL guidelines

Refrigerant	m_1 (lb)	m_2 (lb)	m_3 (lb)
R-290 (Propane)	1.1	NA	NA
R-454B	10.1	40.4	201
R-454C	8.3	33.4	166.8
R-455A	12.4	49.4	247.1

Note: Codes and regulations are in flux. These interpretations are Honeywell’s best assessment as of this publication. Expect to see modifications to codes and their interpretation.

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A2L SERVICING
TRANSPORTING STORAGE

SERVICING

Systems built to utilize A2L refrigerants operate very similar to A1 systems but leak management and an increased focus on safety is required.

- New Equipment built to accommodate A2L's may incorporate mitigation devices such as leak detection, forced fan modes and automatic isolation valves.
- A2L's fall under EPA 608, handling and transport. A2L's must be recovered, not vented.
- Only **original** OEM components can be used in repair and installation. These mechanical and electrical components have been designed for use in a potentially flammable atmosphere.
- Only tools **certified** for use with A2L's must be used.
- Follow the manufacturers recommendations and refer to the SDS for specific hazards and mitigation issues.
- The **charge size** and the **location** of the equipment will dictate the level of mitigation required.
- A2L charge size restrictions are **not** uniform, it is based on the lower flame limit (LFL) of the refrigerant. Contractors must be aware of these restrictions, **equipment OEM's are required to provide detailed service and installation guidelines.**

A2L SERVICE PORTS
AHRI GUIDLINE M

UL designates A2L service ports be colored RED

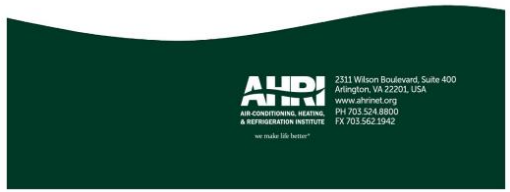
FITTINGS/ SERVICE PORTS FOR EQUIPMENT[1]

Current Fitting for Equipment with Class A1 Refrigerant	Recommended A2L Fittings	Recommended A2/A3 Fittings
3/16 in SAE Flare RH Thread 3/8-24	3/16 in SAE Flare RH Thread 3/8-24	3/16 in SAE Flare LH Thread 3/8-24
1/4 in SAE Flare RH Thread 7/16-20	1/4 in SAE Flare RH Thread 7/16-20	1/4 in SAE Flare LH Thread 7/16-20
5/16 in SAE Flare RH Thread 1/2-20	5/16 in SAE Flare RH Thread 1/2-20	5/16 in SAE Flare LH Thread 1/2-20
3/8 in SAE Flare RH Thread 3/16-24	3/8 in SAE Flare RH Thread 3/16-24	3/8 in SAE Flare LH Thread 3/16-24
1/2 in SAE Flare RH Thread 5/16-20	1/2 in SAE Flare RH Thread 5/16-20	1/2 in SAE Flare LH Thread 5/16-20
3/4 in SAE Flare RH Thread 1/2-16	3/4 in SAE Flare RH Thread 1/2-16	3/4 in SAE Flare LH Thread 1/2-16

Notes: 1. SAE Flare is 45°, per SAE Standard J513.

2020 Guideline for

Unique Fittings and Service Ports for Flammable Refrigerant Use



RECOMMENDED A2L EQUIPMENT CONNECTIONS REMAIN RIGHT HAND

A2L REFRIGERANT CYLINDER VALVING

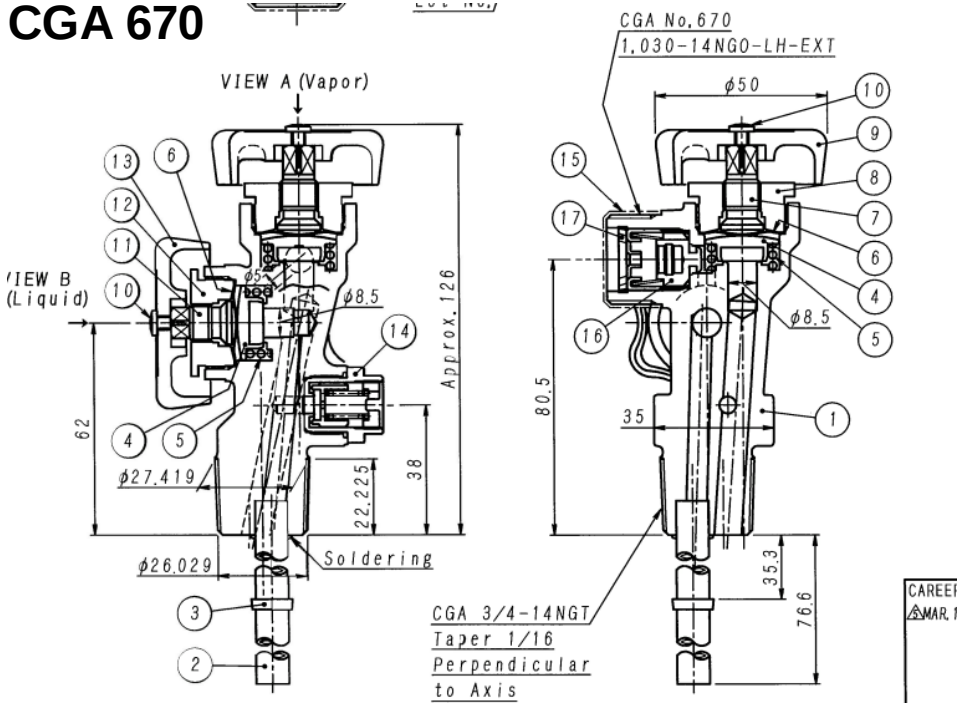
FITTINGS FOR REFRIGERANT CYLINDERS AND TON TANKS

Container Type Net Product Weight (W), lb	Refrigerant Classification	
	A2L	A2/A3
W < 2	CGA 164 (LH)	Consult refrigerant manufacture
2 ≤ W < 50 – Disposable	CGA 164 (LH)	CGA 510
50 ≤ W < 240 Returnable	CGA 670 (LH)	CGA 510
240 ≤ W < 1000 Returnable	CGA 670 (LH)	Consult refrigerant manufacture

https://www.ahrinet.org/system/files/2023-06/AHRI_Guideline_M_2020.pdf

Specifications for bulk cylinders is under development

CGA 670



AHRI A2L CYLINDER CONNECTIONS ARE DESIGNATED LEFT HAND

REFRIGERANT TRANSPORTING

- A2L's May be transported in the same manner as other **flammable** gases.
- DOT and local codes should be consulted. Additional vehicle placarding and other measures may be required. DOT requires a class B fire extinguisher and a written inventory when transporting flammable products.
- Cylinders must be transported in an **upright** position to keep relief device exposed to vapor.(**There is the possibility of change to this restriction)**
- "Empty" A2L cylinders that have a heel must be handled as though full. A2L cylinders are only considered to be empty after being evacuated.
- Other conditions are evolving.
- The EPA is considering the return of **all** disposables (A1 & A2L) to a refrigerant reclamation facility

SPECIFICATIONS FOR A2L RECOVERY CYLINDERS IS IN DEVELOPMENT, ARI GUIDELINE K IS BEING REVISED.

REFRIGERANT STORAGE

The RCL (refrigerant concentration limit), size of the storage area, classification and what mitigation is in place will determine the allowable amount of refrigerant in storage.

Standards and codes are in place for the storage of gases.

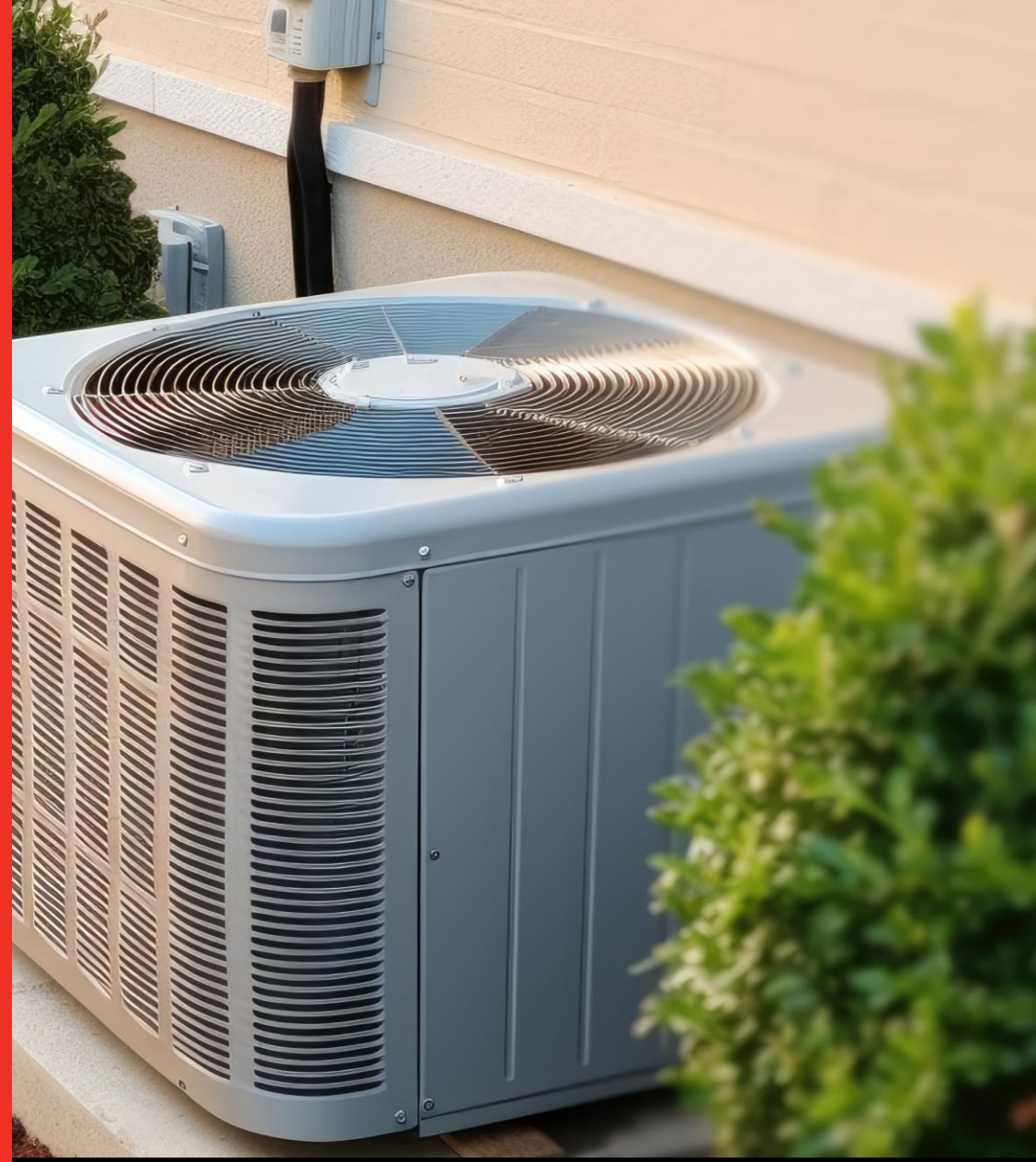
- Refer to the Occupational Safety and Health Administration (OSHA) for requirements.
- Refer to the National Fire Protection Association (NFPA)
- Consult the local authority having jurisdiction (AHJ) for guidance.
- AHRI has produced a guide for A2L cylinder storage – verify these guidelines with your AHJ.

Some examples of requirements dictated by the above entities may include:

- Mitigation in the form of leak detection either passive or active. Active detection will trigger ventilation or other control measures
- Storage limits based on storage area and the presence of fire protection systems
- The RCL of the A2L and other products
- Cylinders must be stored in an upright position
- Have permits on file
- Appropriate signage, accurate inventory, SDS for each product
- Designated storage area-may include fire rated wall systems

THIS IS A BRIEF RECAP OF POSSIBLE REQUIREMENTS- CONSULT YOUR AHJ!

A2L OPTIONS



A2L PRODUCTS
COMMERCIAL REFRIGERATION

	R-454C	R-455A
Benefits	• < 150 GWP • Slightly reduced glide vs. R-455A • CARB & AIM Compliant for new equipment	• < 150 GWP • Close capacity match to R-404A • CARB & AIM Compliant for new equipment • ~50% increased charge size allowance vs. other SNAP approved < 150GWP A2Ls driving up to 20% equipment CAPEX reduction
Optimal Equipment Uses	• CDUs • Plug-ins • Food service	• Centralized Rack Systems • Distributed Rack Systems • Plug-ins • Food service
End-use Applications	• Supermarkets • Cold Storage Warehouses • Industrial Process Refrigeration • Convenience & Drug Stores • Transport Refrigeration	• Supermarkets • Cold Storage Warehouses • Industrial Process Refrigeration • Convenience & Drug Stores • Transport Refrigeration

		GWP (AR5)	Boiling point (°F)	Compressor Displacement	COP	ΔT Discharge (°F)	Mass Flow Rate	Discharge Pressure (psig)	Evaporator Glide (°F)	LFL	Charge Size Allowance M3 (lbs.)
404A Baseline	**R-404A**	3943	-51	100%	100%	0	100%	253	1	-	-
	R-448A	1273	-51	93%	108%	27	73%	246	7	-	-
	R-455A	146	-62	96%	107%	23	75%	244	12	0.43	247
	R-454C	146	-50	105%	108%	16	78%	219	9	0.29	165

25lb. Nonreturnable Cylinders; 100lb. Code 210; ½- ton cylinders; 1-ton cylinders

454B COMFORT COOLING

	454B
Features	• GWP: 466 (AR4) • ASHRAE Classification: A2L
Benefits	• Matching capacity vs. R410A • Improved efficiency vs. R410A • 78% lower GWP vs. HFC R410A • Compliant with EPA's AIM Act Technology Transition ruling and CARB regulations • Minimal design changes enabling lower CAPEX and easier conversion from R410A • Outperforms other refrigerant alternatives due to higher critical temperature and broader operating envelope in low evaporating temperatures in normal and high ambient condition
Equipment	• Residential/light commercial AC • High pressure heat pumps • DX Chillers • Packaged systems
End-Use Applications	• Residential and Light Commercial Air Conditioning and Heating • Chillers for comfort cooling and reversible heating
Package Sizes	• Ton Tank (1300 lbs.) • Half Ton Tank (800 lbs.) • 100 lbs. Ret. Cylinder • 20 lbs. disposable jug

454B PERFORMANCE VS. R410A

Refrigerant	GWP (AR4)	Cooling		Heating		Diff. Td (ºF)	$P_{dish.}$	Comp. Ratio	Flow	Evap. Glide (ºF)	LFL (Vol %)	ASHRAE Class
		CAPACITY	COP	CAPACITY	COP							
R410A	2088	100%	100%	100%	100%	0.0	100%	100%	100%	0.2	N/A	A1
R454B R32/R1234yf (68.9%/31.1%)	466	98%	102%	98%	102%	6.7	93%	98%	84%	1.8	11.25	A2L

454B OFFERS IMPROVED EFFICIENCY AND MATCHING CAPACITY VS. R410A

RESOURCES

RESOURCES

ESCO Low GWP e-learning course:
https://hvacr.elearn.network/courses/low-gwp-refrigerant-safety-flammable-and-mildly-flammable-refrigerants

ESCO Low GWP Refrigerant Safety book:
https://www.escogroup.org/shop/itemdetail.aspx?ID=4168

AHRI Safe Refrigerant Transition Taskforce website:
https://www.ahrinet.org/saferefrigerant

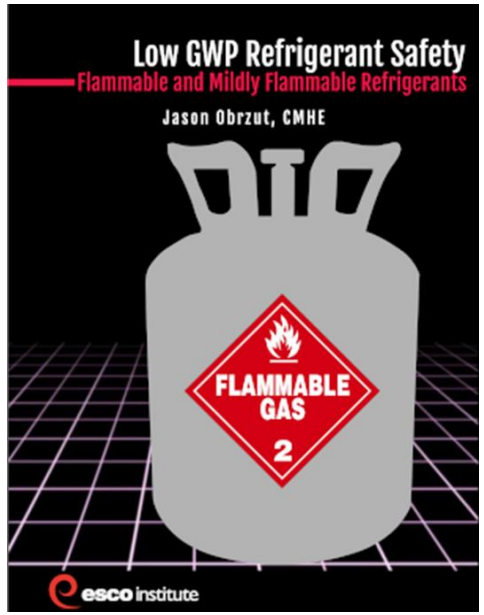
Yellow Jacket tools
https://yellowjacket.com/product/a2l-compatible-service-tools/

Fieldpiece
https://www.fieldpiece.com/a2l-compatibility-fieldpiece-has-you-covered/

JB industries
http://www.westerncomponentsales.com/cms_uploads/A2L_Hydrocarbon_Products_Flyer_0423_(2).pdf

Copeland
https://www.copeland.com/en-us/products/refrigeration/low-gwp-refrigeration/a2l-refrigerants
https://www.ahrinet.org/system/files/2023-06/AHRI_Guideline_M_2020.pdf

For more details on Honeywell Solstice® suite of A2Ls
hwll.co/A2L



RESOURCES ARE AVAILABLE FOR THE SAFE APPLICATION/ SERVICING OF A2L'S

Questions?

THANK YOU!

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EPA Sector-Specific Prohibitions – high level summary

Industry Sector	GWP Limit/Range	Key Prohibited Substance	Manufacture/Import/Install Prohibition Dates		Compliant HON Products
HVACR	150-700	R-404A, R-410A, R-507A, and R-134a	1/1/2025-2028		N71, 455A, N13 N15, R-454B, R-454C
Foams	150	HFC 43-10mee, HFC-245fa, R-134a	1/1/2025		1233zd, 1234yf, and 1234ze, and more
Aerosols	150	HFC 43-10mee, HFC-245fa, R-134a	Consumer Aerosols	1/1/2025	1233zd, 1234yf, and 1234ze, and more
			Technical Aerosols	1/1/2028	
			Products using HFC 43-10mee and HFC-245fa as solvents	1/1/2028	
Mobile AC	150	R-134a	Light-duty	MY 2025	1234yf
			Medium-duty	MY 2028	
			Non-road	1/1/2028	

- **Three-year sell through period (sale, distribution, export) for new products.**