An Introduction to A2L Refrigerants
Disclaimer

The opinions expressed in this presentation and on the following slides are solely those of the presenters and not necessarily those of the Air-Conditioning, Heating, and Refrigeration Institute (AHRI). AHRI does not guarantee the accuracy or reliability of the information provided herein. This presentation is for general informational purposes only and does not constitute legal or professional advice. Confer with your own legal counsel.
Discussion Topics

- Regulatory Drivers for A2Ls
- Key Enablers of A2Ls
- A2Ls Background & Safety Classes
- A2L Flammability Parameters
- A2L Test Examples
- Q&A
THE REGULATIONS DRIVING A2L REFRIGERANTS
Market adoption of A2L refrigerants requires 3 things:

1. **Regulatory Driver**
   - HFC regulations by EPA and states

2. **SNAP Approval**
   - Refrigerant alternatives require approval by EPA SNAP office

3. **Updated Codes**
   - State building codes must reference updated standards that permit A2L refrigerants
Global phasedown of hydrofluorocarbons (HFCs)

Lower global warming potential (GWP)

Next generation of refrigerants
American Innovation and Manufacturing (AIM) Act

- Signed into law in December 2020
- Gives U.S. EPA the authority to regulate HFC production and use
- HFC production and consumption allowances will decrease to 15% of historic baseline levels by 2036

Source: U.S. EPA
Three AIM regulations accomplish the U.S. HFC phasedown:

1. ALLOCATION RULE (Finalized 2023)
2. TECHNOLOGY TRANSITION RULE (Finalized 2023)
3. REFRIGERANT MANAGEMENT RULE (Draft Rule Proposed)

First restrictions begin January 1, 2025.
## Low-GWP Refrigerants Required Soon

### EPA Restricted Products by Application (partial list)

<table>
<thead>
<tr>
<th>Subsector</th>
<th>Systems</th>
<th>Global Warming Potential Limit or Prohibited Substances</th>
<th>Installation Compliance Date(^5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stationary air conditioning and heat pumps</td>
<td>Residential and light commercial air conditioning and heat pump systems</td>
<td>700</td>
<td>January 1, 2025(^6)</td>
</tr>
<tr>
<td></td>
<td>Variable refrigerant flow systems</td>
<td>700</td>
<td>January 1, 2026</td>
</tr>
<tr>
<td>Chillers</td>
<td>Industrial process refrigeration with exiting fluid below -50 °C (-58 °F)</td>
<td>Not covered</td>
<td>Not covered</td>
</tr>
<tr>
<td></td>
<td>Industrial process refrigeration with exiting fluid from -50 °C (-58 °F) to -30 °C (-22 °F)</td>
<td>700</td>
<td>January 1, 2028</td>
</tr>
<tr>
<td></td>
<td>Industrial process refrigeration with exiting fluid above -30 °C (-22 °F)</td>
<td>700</td>
<td>January 1, 2026</td>
</tr>
<tr>
<td>Ice rinks</td>
<td>Comfort cooling</td>
<td>700</td>
<td>January 1, 2025</td>
</tr>
<tr>
<td></td>
<td>Ice rinks</td>
<td>700</td>
<td>January 1, 2025</td>
</tr>
</tbody>
</table>

\(^5\)EPA is restricting the installation of new field-assembled systems. Components used to repair existing systems are not subject to these restrictions.
## Low-GWP Refrigerants Required Soon

### EPA Restricted Products by Application (partial list)

<table>
<thead>
<tr>
<th>Subsector</th>
<th>Systems</th>
<th>Global Warming Potential Limit or Prohibited Substances</th>
<th>Installation Compliance Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold storage warehouses</td>
<td>With 200 or more lb refrigerant charge, excluding high temperature side of cascade system</td>
<td>150</td>
<td>January 1, 2026</td>
</tr>
<tr>
<td></td>
<td>With less than 200 lb refrigerant charge</td>
<td>300</td>
<td>January 1, 2026</td>
</tr>
<tr>
<td></td>
<td>High temperature side of cascade system</td>
<td>300</td>
<td>January 1, 2026</td>
</tr>
<tr>
<td>Retail food - supermarkets</td>
<td>With 200 or more lb refrigerant charge, excluding high temperature side of cascade system</td>
<td>150</td>
<td>January 1, 2027</td>
</tr>
<tr>
<td></td>
<td>With less than 200 lb refrigerant charge</td>
<td>300</td>
<td>January 1, 2027</td>
</tr>
<tr>
<td></td>
<td>High temperature side of cascade systems</td>
<td>300</td>
<td>January 1, 2027</td>
</tr>
<tr>
<td>Retail food - remote condensing units</td>
<td>With 200 or more lb refrigerant charge, excluding high temperature side of cascade system</td>
<td>150</td>
<td>January 1, 2026</td>
</tr>
<tr>
<td></td>
<td>With less than 200 lb refrigerant charge</td>
<td>300</td>
<td>January 1, 2026</td>
</tr>
<tr>
<td></td>
<td>High temperature side of cascade system</td>
<td>300</td>
<td>January 1, 2026</td>
</tr>
</tbody>
</table>
Market adoption of A2L refrigerants requires 3 things:

1. **REGULATORY DRIVER**
   - HFC regulations by EPA and states

2. **SNAP APPROVAL**
   - Refrigerant alternatives require approval by EPA SNAP office

3. **UPDATED CODES**
   - State building codes must reference updated standards that permit A2L refrigerants
### EPA SNAP RULES

<table>
<thead>
<tr>
<th>SNAP 23</th>
<th>SNAP 25</th>
<th>SNAP 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Final Rule May 2021</td>
<td>• Final Rule April 2023</td>
<td>• Proposed May 2023</td>
</tr>
</tbody>
</table>
| • Lists 9 substitutes for refrigeration and air conditioning, including R-32 as acceptable, subject to use conditions, for use in residential and light commercial AC and heat pumps, for new equipment | • List 6 refrigerants for use in air conditioning in commercial and industrial buildings (“chillers”) and residential dehumidifiers:  
  • Revision of use conditions for HFC-32 in new self-contained room air conditioners | • Proposes to list 10 refrigerants as acceptable, for refrigeration and air conditioning  
  • Necessary to meet 300/150 GWP limits in Technology Transition Rule for refrigeration  
  • EPA likely to finalize this year |
Market adoption of A2L refrigerants requires 3 things:

1. **Regulatory Driver**
   - HFC regulations by EPA and states

2. **SNAP Approval**
   - Refrigerant alternatives require approval by EPA SNAP office

3. **Updated Codes**
   - State building codes must reference updated standards that permit A2L refrigerants
# Standards & Codes Updated for A2Ls

## Standards

<table>
<thead>
<tr>
<th>Standards</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• EQUIPMENT SAFETY STANDARD:</td>
<td>• NATIONAL MODEL CODES</td>
</tr>
<tr>
<td>– UL-60335-2-40</td>
<td>– ICC (IRC, IMC, IFC et al)</td>
</tr>
<tr>
<td>– UL-60335-2-89</td>
<td>– IAPMO (UMC)</td>
</tr>
<tr>
<td>• APPLICATION SAFETY STANDARDS</td>
<td>• STATE &amp; LOCAL CODES</td>
</tr>
<tr>
<td>– ASHRAE 15, 15.2</td>
<td>– AHRI Interactive Codes Map</td>
</tr>
</tbody>
</table>

More on this in future sessions
How HFOs Work

Weaker double bond in HFOs allows for short atmospheric life, while maintaining stability in systems.
## Refrigerant Flammability Classes

<table>
<thead>
<tr>
<th>Flammability</th>
<th>Class</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher</td>
<td>3</td>
<td>Hydrocarbons (e.g., Propane, Isobutane)</td>
</tr>
<tr>
<td>Flammable</td>
<td>2</td>
<td>R-152a</td>
</tr>
<tr>
<td>Lower</td>
<td>2L</td>
<td>Ammonia</td>
</tr>
<tr>
<td>No Flame Propagation</td>
<td>1</td>
<td>R-1234yf, R-454B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Most baseline HFCs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CO$_2$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R-449A, R-513A</td>
</tr>
</tbody>
</table>

Focus on expanding usage.
Comparing A1s & A2Ls

• Replacement A2L refrigerants have many similarities to A1 refrigerants
  • Similar Pressure-Temperature profiles
  • Similar thermodynamic properties
  • Similar material compatibility
  • Similar oil types / compatibility
  • Similar system architectures

• How are A2Ls different?
  • A1s – No flame propagation
    • Can combust and burn
  • A2Ls – Lower flammability
## Comparing A1s & A2Ls*

<table>
<thead>
<tr>
<th></th>
<th>R-410A</th>
<th>R-454B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capacity (%)</strong></td>
<td>100.0</td>
<td>97.4</td>
</tr>
<tr>
<td><strong>COP (%)</strong></td>
<td>100.0</td>
<td>102.6</td>
</tr>
<tr>
<td><strong>Δ Suction Pressure (psi)</strong></td>
<td>+ 0</td>
<td>- 10</td>
</tr>
<tr>
<td><strong>Δ Discharge Pressure (psi)</strong></td>
<td>+ 0</td>
<td>- 39</td>
</tr>
<tr>
<td><strong>Δ Discharge Temperature (°F)</strong></td>
<td>+ 0</td>
<td>+ 12</td>
</tr>
</tbody>
</table>

*Standard Cycle: 120 °F Condenser, 45 °F Evaporator, 10 °F Superheat & Subcooling
Primary Flammability Parameters

Flammability Limits (LFL / UFL)
• Minimum / Maximum concentrations of a substance in air that exhibit flame propagation (usually shown as volume % in air).

Minimum Ignition Energy (MIE)
• Minimum energy required to ignite a flammable gas / air mixture. Sources with energy levels below this value will not result in an ignition.

Burning Velocity ($S_u$)
• The velocity of a laminar flame under given values of composition, temperature and pressure.

Heat Of Combustion (HOC)
• Heat per unit mass (or mole) released by the combustion of a substance.
Comparison of Flammability Parameters

- More favorable flammability parameters can lead to lower risk!

<table>
<thead>
<tr>
<th>ASHRAE #</th>
<th>R-290 (Propane)</th>
<th>R-32</th>
<th>R-1234yf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Group</td>
<td>A3</td>
<td>A2L</td>
<td>A2L</td>
</tr>
<tr>
<td>LFL (g/m³)</td>
<td>38</td>
<td>307</td>
<td>289</td>
</tr>
<tr>
<td>MIE (mJ)</td>
<td>0.25</td>
<td>30 – 100</td>
<td>&gt; 5,000</td>
</tr>
<tr>
<td>S_u (cm/s)</td>
<td>46</td>
<td>6.7</td>
<td>1.5</td>
</tr>
<tr>
<td>HOC (kJ /g)</td>
<td>46.3</td>
<td>9.4</td>
<td>10.7</td>
</tr>
</tbody>
</table>
ASTM E681 Test Examples

- Used to determine flammability limits
- High energy electrical source for ignition
- Flame spread > 90° indicates flammability
ASTM D3065 Test Examples

• Measures flame projection of aerosols

• Open flame ignition source (candle)

• Liquid spray used to create “refrigerant rich” region
ASTM E582 Test Examples

- Used to measure MIEs of flammable gases
- High energy electrical ignition source
- Energy level increased until ignition achieved
Residential Ignition Sources Research

Final Report

AHRI Report No. 8017

Investigation of Energy Produced by Potential Ignition Sources in Residential Application

Table 19.1 Test matrix and result summary.

<table>
<thead>
<tr>
<th></th>
<th>R-32</th>
<th>R-452B</th>
<th>R-1234yf</th>
<th>R-1234ze</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot wire</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Safety match</td>
<td>D</td>
<td>D</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Lighter flame insertion</td>
<td>D</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Leak impinging on candle</td>
<td>L</td>
<td>N</td>
<td>N</td>
<td>L</td>
</tr>
<tr>
<td>Cigarette insertion</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Barbeque lighter</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Plug and receptacle</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Light switch</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Hand mixer</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Cordless drill</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Friction sparks</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Hair dryer</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Toaster</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Hot plate insertion</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Space heater insertion</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Legend:

D - Deflagration
L - Localized flame
N - No refrigerant combustion
Ignition Testing of A2Ls vs. A3s

1,200 g of R-454C*

500 g of R-290*

*Charge levels based on current limits from the IEC 60335-2-89, 3rd Edition
**Overall Flammability Takeaways (A2L vs. A3)**

- **A2L are less likely to form flammable concentrations**
  - Lower / Upper Flammability Limits (LFL / UFL) - ASTM E681

- **A2L are harder to ignite**
  - Minimum Ignition Energy (MIE) - ASTM E582

- **A2L are less reactive & have lower combustion energy**
  - Burning Velocity ($S_u$)

---

Allowing larger charge sizes for larger applications

Making them safe to use with many commonly used electrical components

Hence, A2L’s generate lower severity ignition events

---

Going Forward
Safe Use of Flammable Refrigerants

• Flammable Refrigerants –
  • Can only be used in new equipment specifically designed for flammables
  • Must be in compliance with relevant safety standard and building code requirements
  • Are never to be used to replace nonflammable refrigerants in retrofit situations*

• Installers / Servicers –
  • Must follow installation/use instructions of OEMs
  • Must ensure service equipment, tools, and working conditions suitable for flammable refrigerants
  • Revisit “Best Practices”

* Without a full risk assessment and necessary equipment/building modifications
Standards Updates for Flammables

- Standards focus on ignition prevention
  - Requirements for an ignition event
- Sources of Ignition
- Piping
- Refrigerant charge limits / minimum room area
- Refrigerant detection / mitigation
- Labeling
- Service training & literature
Odorless Flammable Refrigerants

- Stenching is **NOT** used in flammable refrigerants
  - Corrosion / compatibility concerns
  - Absorption in oil / desiccant / non-condensable concerns

- Technicians should use appropriate leak detection
  - Hand-held sniffers / fixed detectors
  - Soap bubbles
  - **NEVER** an open flame
Fire Safety Research Institute Training

• UL developed FSRI training for firefighters
  • UL FSRI Fire Safety Academy (ulfirefightersafety.org)
  • Collaboration between UL, AHRI, and Fire Service
  • Based on AHRI 8028 Research Project
    • Compared A2L & A1 refrigerants
    • Found A2Ls are difficult to ignite
    • Found similar behaviors for A1s and A2Ls in fire scenarios
Join us for our upcoming sessions!

- Friday, May 31st, 1:00 pm – 2:00 pm Eastern
  - A2L Refrigerants Webinar Series – Part 2: Updates to Standards and Model Codes

- Wednesday, June 12th, 3:00 pm – 4:00 pm Eastern
  - A2L Refrigerants – Part 3: State and Local Codes and Available Resources
A2L Refrigerants Building Codes Map
Thank you!

**Contact information**

- Tom Deary
- tdeary@ahrinet.org
- (703) 600-0338