An Introduction to A2L Refrigerants

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Discussion Topics

- Regulatory Drivers for A2Ls
- Key Enablers of A2Ls
- A2Ls Background & Safety Classes
- A2L Flammability Parameters
- A2L Test Examples
- Q&A

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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)

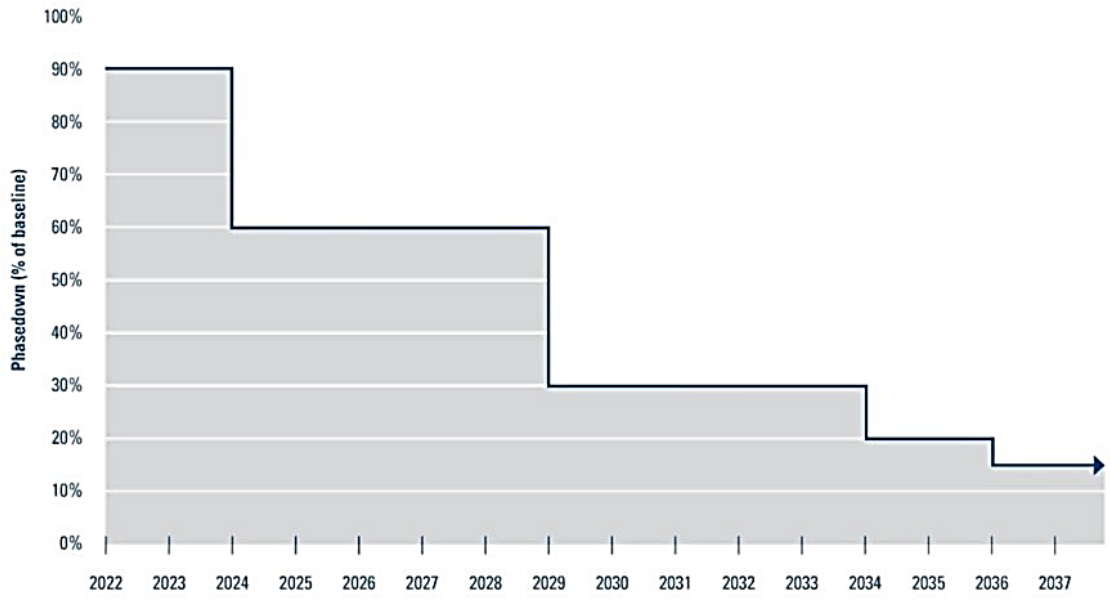
Lower global warming potential (GWP)

Next generation of refrigerants

REFRIGERANT TRANSITION IN THE U.S. – THE AIM ACT

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

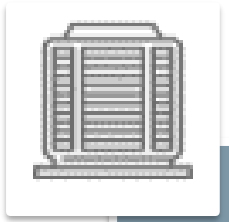


Source: U.S. EPA

THREE AIM REGULATIONS ACCOMPLISH THE U.S. HFC PHASEDOWN

Finalized 2023

ALLOCATION RULE



Finalized 2023

TECHNOLOGY TRANSITION RULE

Draft Rule Proposed

REFRIGERANT MANAGEMENT RULE

First restrictions begin January 1, 2025

Low-GWP Refrigerants Required Soon

EPA Restricted Products by Application (partial list)

Refrigeration, Air Conditioning, and Heat Pump Systems*			
Subsector	**Systems**	**Global Warming Potential Limit or Prohibited Substances**	**Installation Compliance Date[5]**
Stationary air conditioning and heat pumps	Residential and light commercial air conditioning and heat pump systems	700	January 1, 2025[5]
	Variable refrigerant flow systems	700	January 1, 2026
Chillers	Industrial process refrigeration with exiting fluid below -50 °C (-58 °F)	Not covered	Not covered
	Industrial process refrigeration with exiting fluid from -50 °C (-58 °F) to -30 °C (-22 °F)	700	January 1, 2028
	Industrial process refrigeration with exiting fluid above -30 °C (-22 °F)	700	January 1, 2026
	Comfort cooling	700	January 1, 2025
Ice rinks	Ice rinks	700	January 1, 2025

[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)

Refrigeration, Air Conditioning, and Heat Pump Systems*			
Subsector	**Systems**	**Global Warming Potential Limit or Prohibited Substances**	**Installation Compliance Date[5]**
Cold storage warehouses	With 200 or more lb refrigerant charge, excluding high temperature side of cascade system	150	January 1, 2026
	With less than 200 lb refrigerant charge	300	January 1, 2026
	High temperature side of cascade system	300	January 1, 2026
Retail food - supermarkets	With 200 or more lb refrigerant charge, excluding high temperature side of cascade system	150	January 1, 2027
	With less than 200 lb refrigerant charge	300	January 1, 2027
	High temperature side of cascade systems	300	January 1, 2027
Retail food - remote condensing units	With 200 or more lb refrigerant charge, excluding high temperature side of cascade system	150	January 1, 2026
	With less than 200 lb refrigerant charge	300	January 1, 2026
	High temperature side of cascade system	300	January 1, 2026

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State building codes must reference updated standards that permit A2L refrigerants

EPA SNAP RULES

SNAP 23

- Final Rule May 2021
- 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

SNAP 25

- Final Rule April 2023
- List 6 refrigerants for use in air conditioning in commercial and industrial buildings (“chillers”) and residential dehumidifiers:
  - HFC-32, HFO-1234yf, R-452B, R-454A, R-454B, R-454C
- Revision of use conditions for HFC-32 in new self-contained room air conditioners

SNAP 26

- Proposed May 2023
- 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

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Standards & Codes Updated for A2Ls

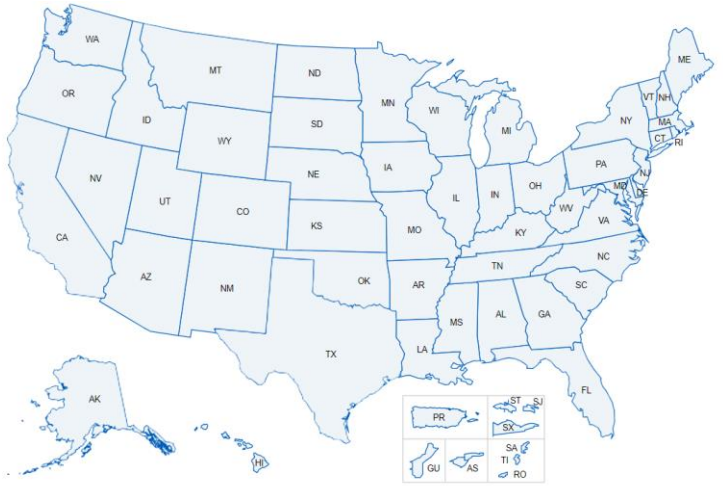
STANDARDS

- EQUIPMENT SAFETY STANDARD:
  - UL-60335-2-40
  - UL-60335-2-89
- APPLICATION SAFETY STANDARDS
  - ASHRAE 15, 15.2

More on this in future sessions

CODES

- NATIONAL MODEL CODES
  - ICC (IRC, IMC, IFC et al)
  - IAPMO (UMC)
- STATE & LOCAL CODES
  - AHRI Interactive Codes Map



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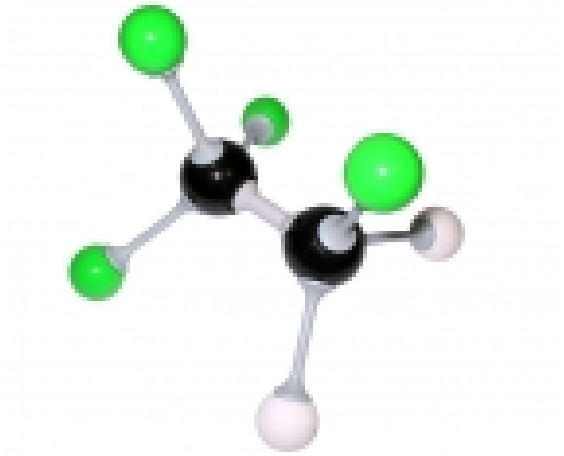
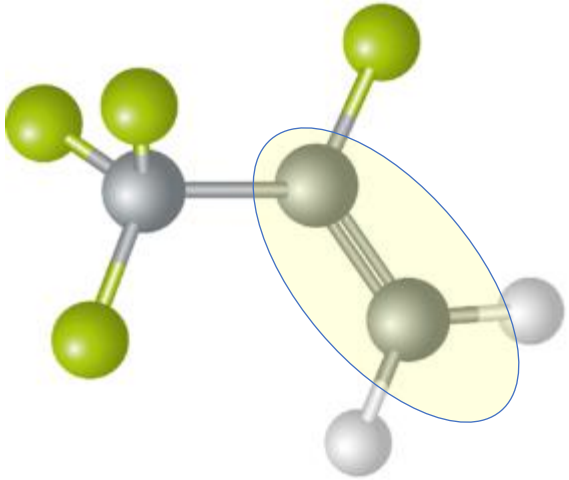
A2Ls Background

How HFOs Work



HFC
Hydro fluorocarbon



HFO
Hydro fluoro olefin

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

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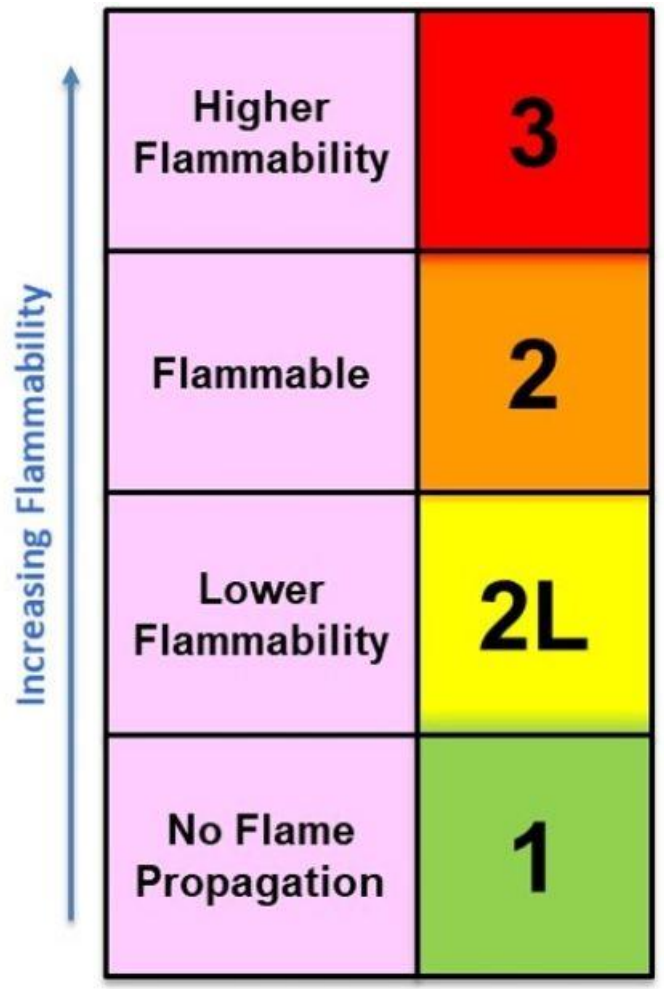
Refrigerant Flammability Classes



Examples

Hydrocarbons
(e.g., Propane, Isobutane)

R-152a

Ammonia

R-1234yf, R-454B

Most baseline HFCs

CO_2

R-449A, R-513A

Focus on expanding usage

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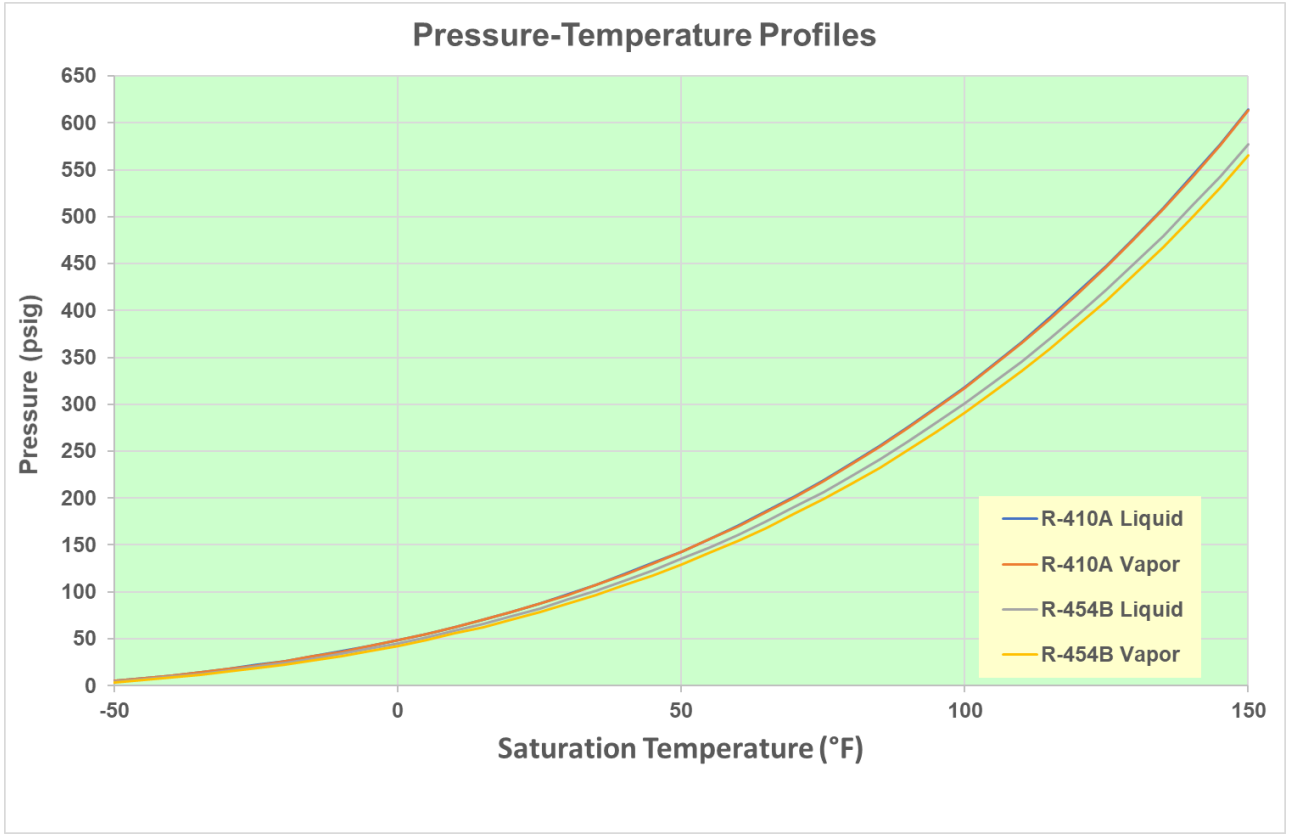
Comparing A1s & A2Ls

- 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



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Comparing A1s & A2Ls*

	R-410A	R-454B
Capacity (%)	100.0	97.4
COP (%)	100.0	102.6
Δ Suction Pressure (psi)	+ 0	- 10
Δ Discharge Pressure (psi)	+ 0	- 39
Δ Discharge Temperature (°F)	+ 0	+ 12

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

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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.

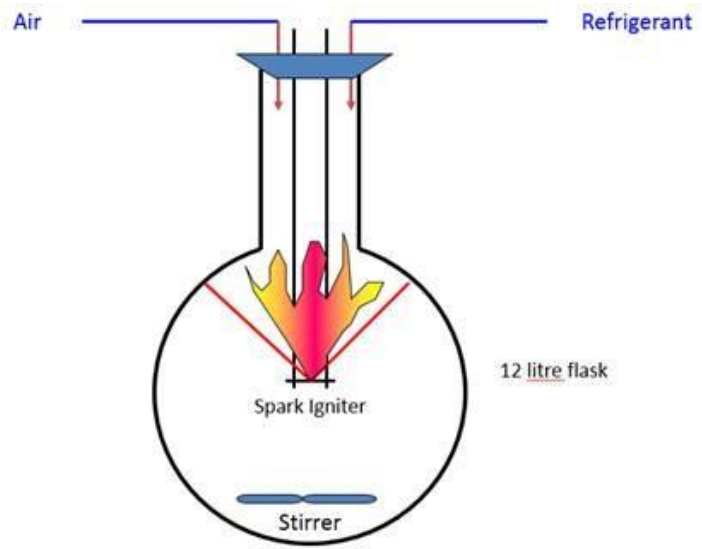
Comparison of Flammability Parameters

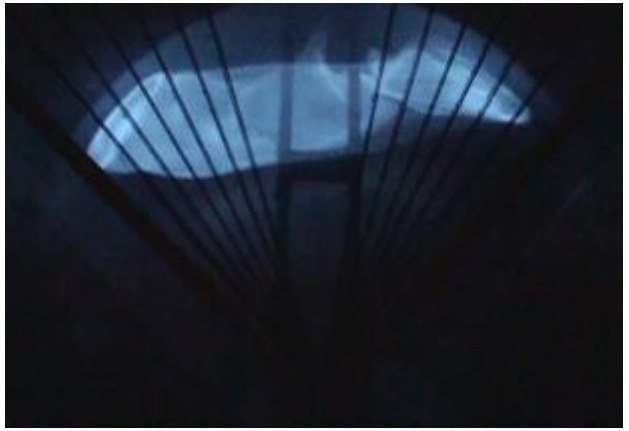
- **More favorable flammability parameters can lead to lower risk!**

ASHRAE #	R-290 (Propane)	R-32	R-1234yf	Risk Trend
Safety Group	A3	A2L	A2L	
LFL (g/m^3)	38	307	289	LFL ↑, Risk ↓
MIE (mJ)	0.25	30 – 100	> 5,000	MIE ↑, Risk ↓
S_u (cm/s)	46	6.7	1.5	S_u ↓, Risk ↓
HOC (kJ /g)	46.3	9.4	10.7	HOC ↓, Risk ↓

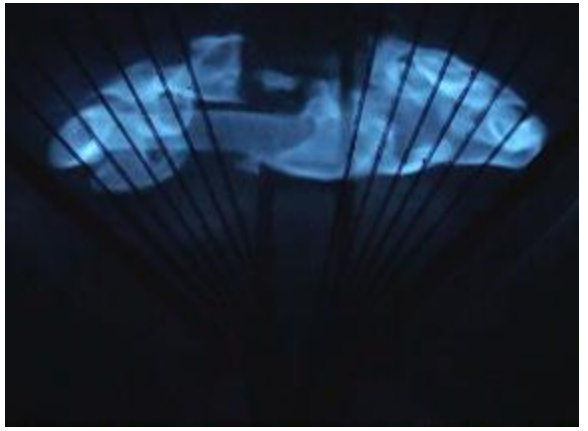
ASTM E681 Test Examples

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

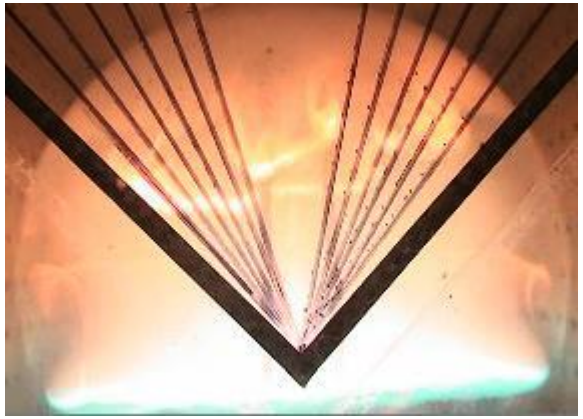




Class 1



Class 2L



Class 3

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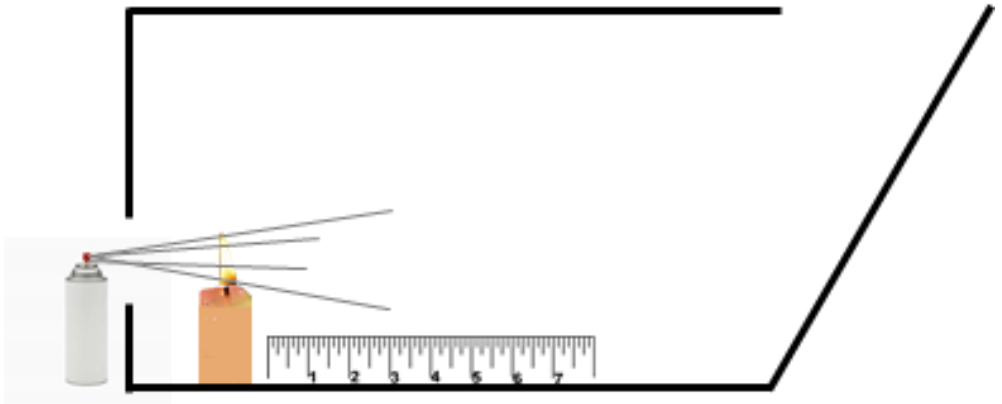
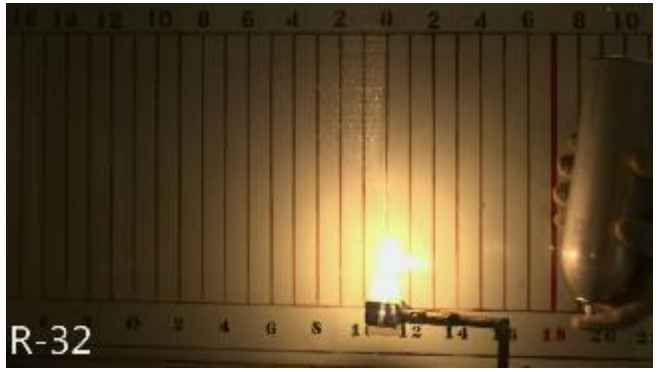
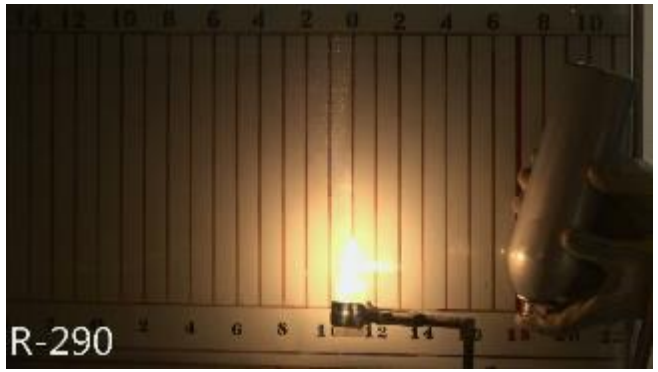
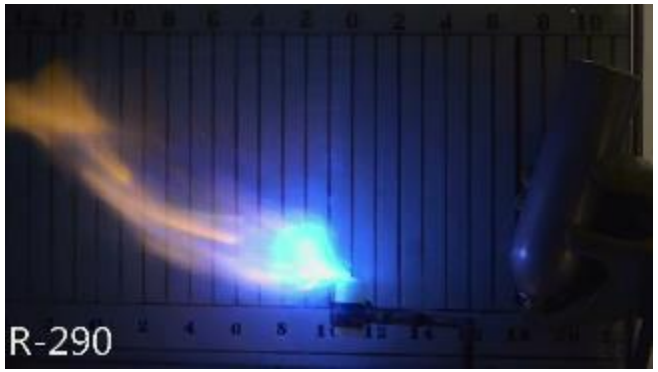
ASTM D3065 Test Examples

- Measures flame projection of aerosols
- Open flame ignition source (candle)
- Liquid spray used to create “refrigerant rich” region









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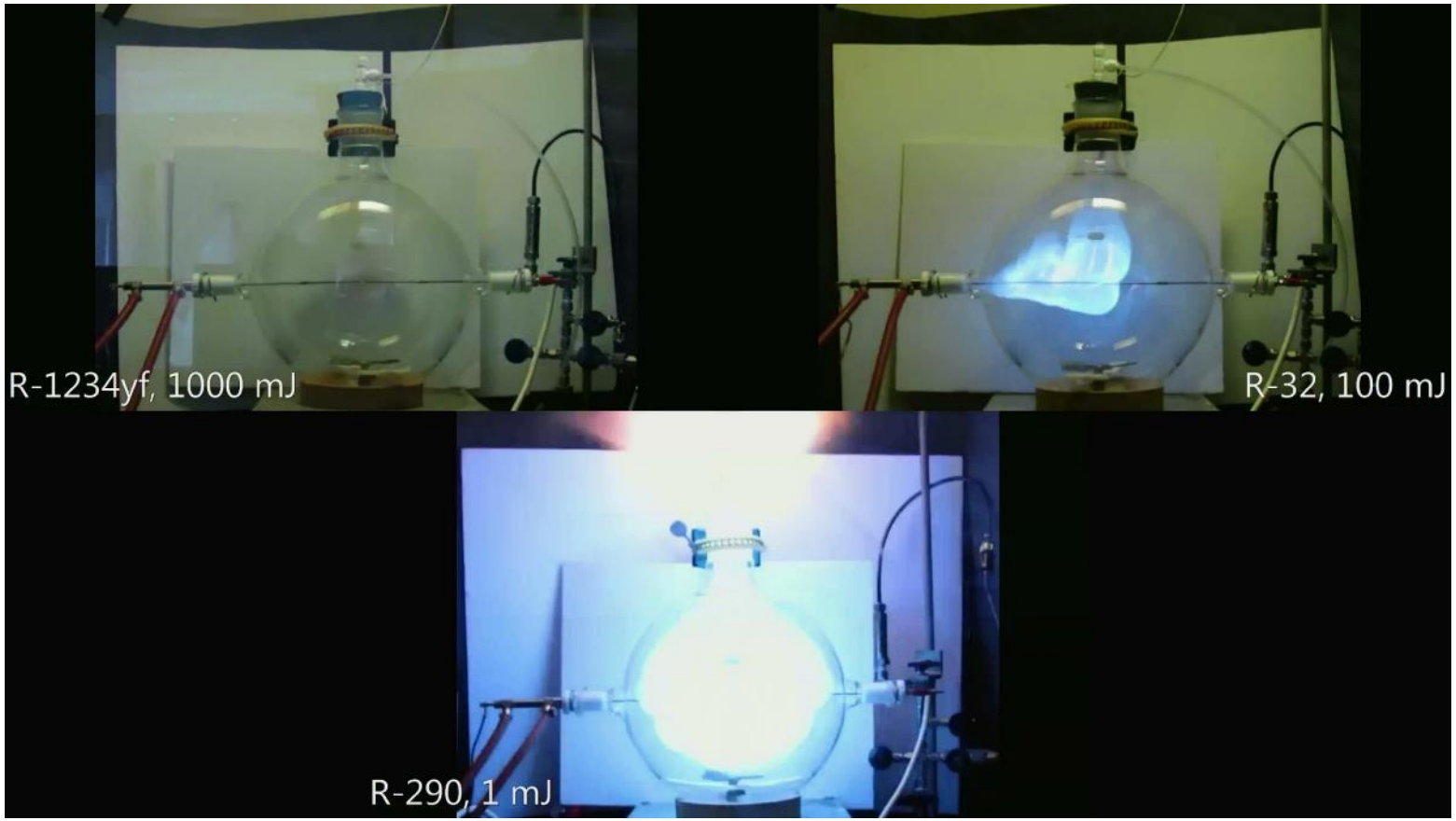
ASTM E582 Test Examples

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



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Residential Ignition Sources Research

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Final Report

AHRI Report No. 8017

Investigation of Energy Produced by Potential Ignition Sources in Residential Application

Final Report

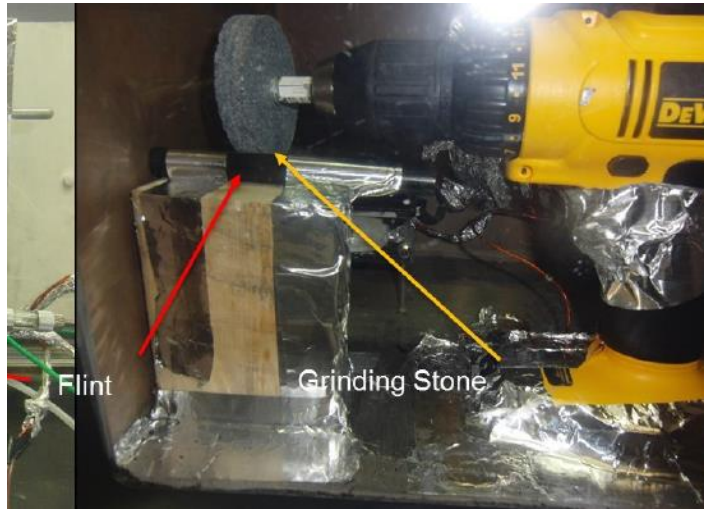

Table 19.1. Test matrix and result summary.

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

Legend:

D - Deflagration
L - Localized flame

N - No refrigerant combustion

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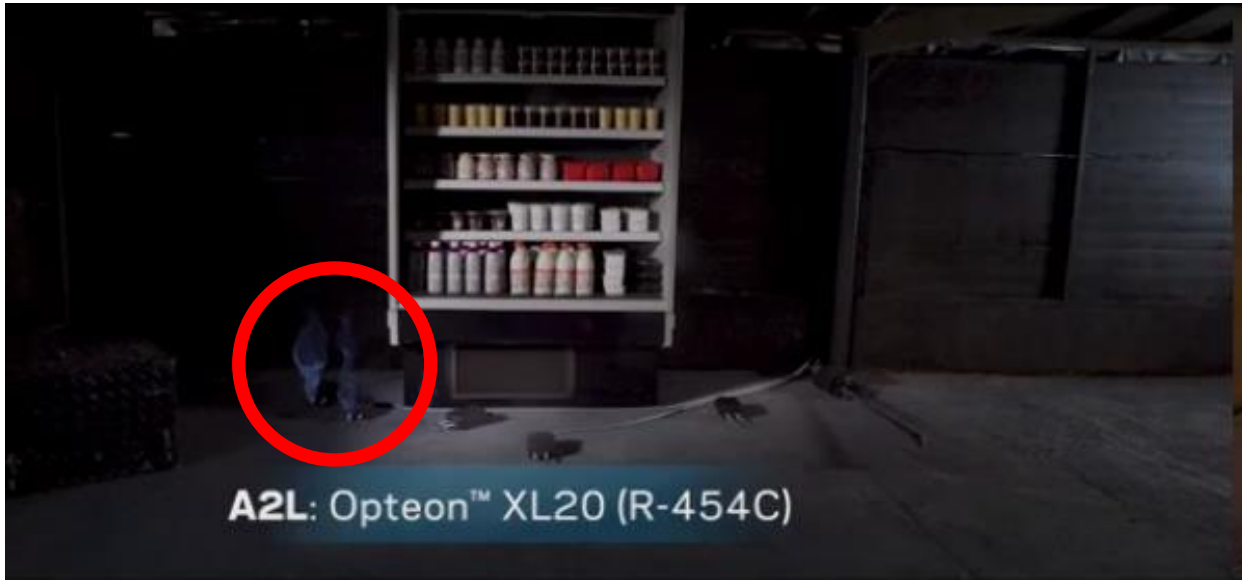
Ignition Testing of A2Ls vs. A3s



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**

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Overall Flammability Takeaways (A2L vs. A3)

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

→ Allowing larger charge sizes for larger applications

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

→ Making them safe to use with many commonly used electrical components

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

→ Hence, A2L's generate lower severity ignition events

https://pages.chemours.com/20-OPTEO-50TheBurningTruthFlammabilityCampaign_TY_EN.html

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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**

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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

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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

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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

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A2L Refrigerants Building Codes Map

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Thank you!

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