Low Global Warming Potential Refrigerants for Direct HVAC Applications

- Helen Walter-Terrinoni, VP Regulatory Affairs, Air-Conditioning, Heating, and Refrigeration Institute
- Julian DeBullet, Consultant for Carrier Corporation

http://www.ahrinet.org/SafeRefrigerant

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- Please contact Chris Bresee (cbresee@ahrinet.org) if you would like to join the Speakers Bureau to communicate with other stakeholders regarding low global warming potential refrigerants.

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Air Conditioning, Heating and Refrigeration Institute

300 plus cooling & heating equipment manufacturers for residential, commercial & industrial applications:

central AC & heating equipment

components for heating, AC & refrigeration systems

hydronic heating equipment

water heating equipment

commercial & industrial AC, heating & ventilation equipment

commercial & industrial refrigeration equipment

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Overview

- Introduction
- Refrigerant regulatory landscape
- Low global warming potential (GWP) refrigerants, including the new A2L safety category
- Technical research and development informing the standards
- Safety standard upgrades for flammable refrigerants (UL60335-2-40 and ASHRAE 15/15.2)

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Refrigerants Are Changing…

- Ozone depleting refrigerants have been regulated for many decades
  - The ozone layer protects us from harmful radiation that causes skin cancer
  - Ozone depleting R-22 use is now being phased out globally
  - The hole in the ozone layer is shrinking and predicted to fully recover by 2080.
  - Ozone depleting refrigerants are regulated by EPA in compliance with the United Nations (UN) Montreal Protocol on Substances that Deplete the Ozone Layer
- High global warming potential (GWP) refrigerants are now being regulated
  - The Montreal Protocol was amended to regulate high global warming potential refrigerants.
    - Although 92 countries are parties to the amendment, the U.S. has not ratified yet
  - States are implementing regulations regarding appliances, chillers, self-contained commercial refrigeration equipment
  - California is regulating air conditioning refrigerants

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US Climate Alliance States Regulate HFCs

- U.S. submitted formal notice of withdrawal from Paris Climate Agreement on Nov. 4, 2019
- United States Climate Alliance States commit to meet Paris Climate Agreement goals.
- 12 states have now included refrigerants in their greenhouse gas reductions
  - States are adopting EPA SNAP rules for commercial refrigeration and chillers
  - California, Washington, New Jersey, Vermont have adopted regulations
  - Oregon, Colorado, Massachusetts, Connecticut, Delaware, Maryland, New York, Hawaii are developing refrigerant regulations

Bottom Line:

12 States are regulating refrigerants, but only California is regulating air conditioning (AC) refrigerants

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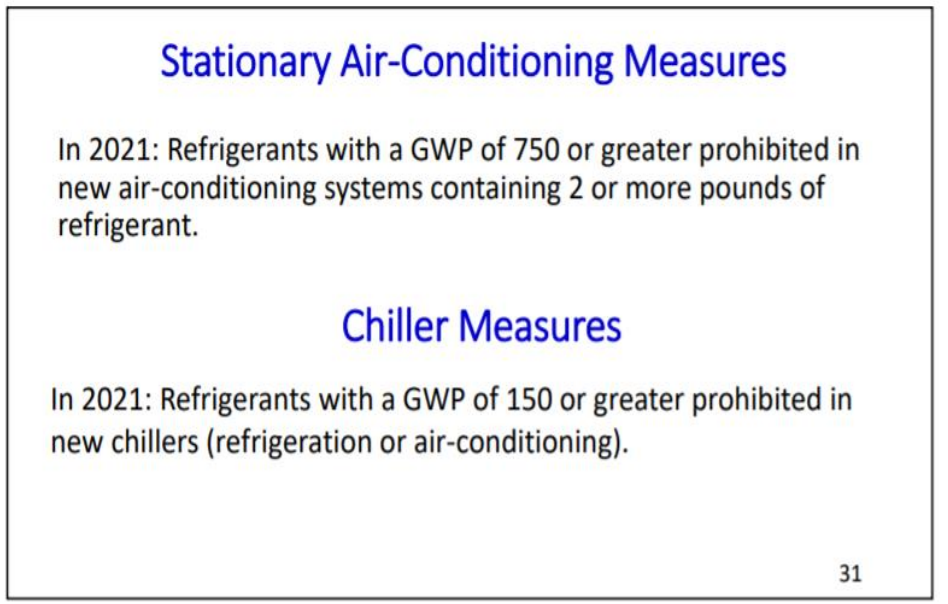
California Air Resources Board (CARB)

In 2017, the CARB proposed high GWP refrigerant bans*

- Chillers: Jan 1, 2021
- Air-Conditioning: Jan 1, 2021
- Commercial Refrigeration: Jan 1, 2022

AHRI counterproposals:

- Chillers 2024 (accepted)
- Air conditioning: 2023
  - Two additional years
  - Harmonize with new minimum energy efficiency standards going into effect in 2023
- Commercial Refrigeration: 2022 medium-GWP (rejected)
- Commercial Refrigeration: 2024 low-GWP (rejected)



* Public Workshop on Rulemaking Proposal: High Global Warming Potential Refrigerant Emissions Reductions California Air Resources Board October 24, 2017
https://ww3.arb.ca.gov/cc/shortlived/meetings/10242017/public_workshop_snap-california_10-24-17_presentation.pdf?_ga=2.182187808.621576105.1573738237-276427812.1565094831

Safe Refrigerant Transition

- Differences in properties of low GWP refrigerants (e.g., low levels of flammability and toxicity) may require changes made to current commercial practices and building codes to minimize risk while meeting climate regulations
- In some cases, these are historic products (e.g. butane) that have not been used in many of these equipment types in some time, if at all.

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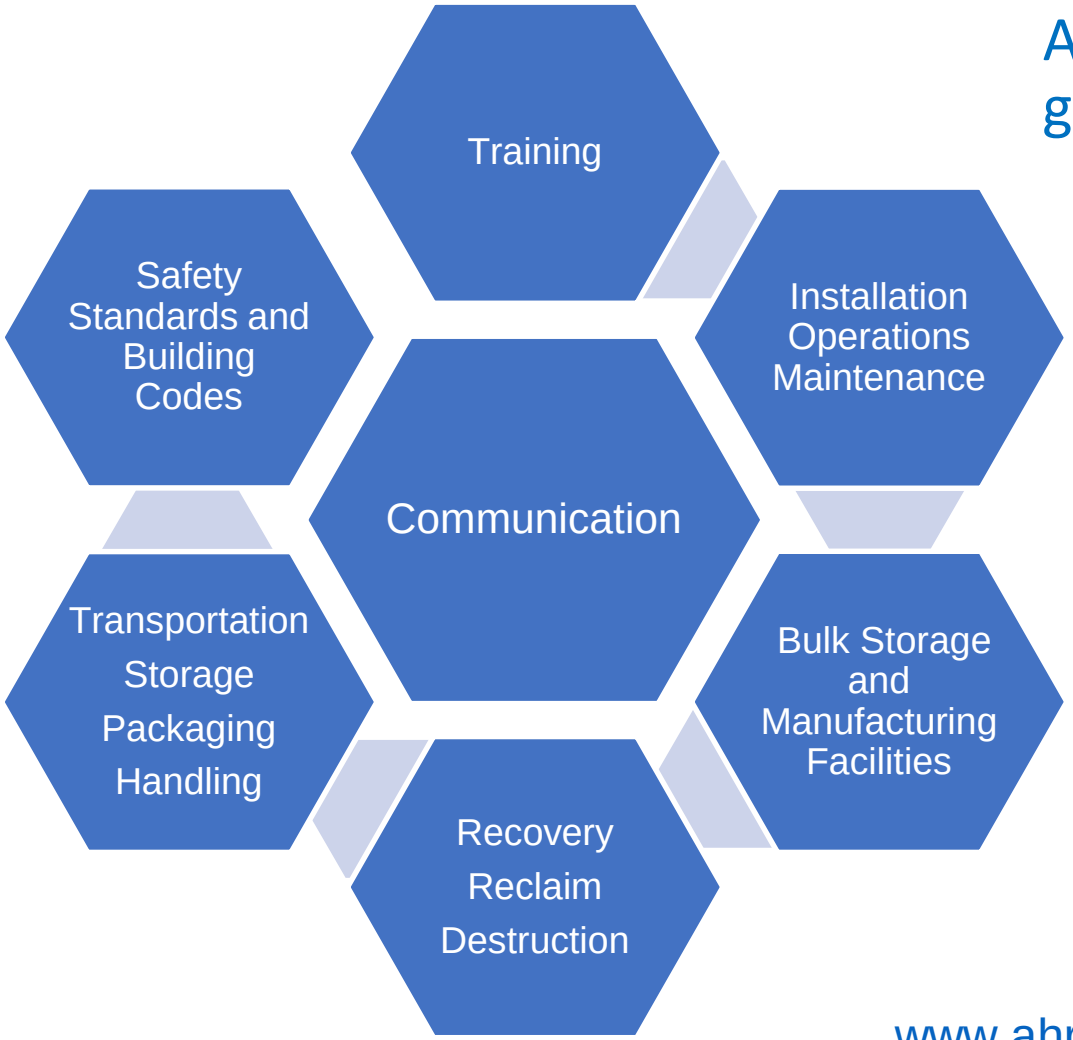
Regulatory Policy "Writing on the Wall" Lead to the Creation of the AHRI Safe Refrigerant Transition Task Force



AHRI Safe Refrigerant Transition Task Force working groups are open to volunteers

- Over 200 members from more than 70 organizations
- Identifies and resolves issues related to transition
- Develops communications, training materials and information to support regulatory compliance and the safe use of low global warming potential (GWP) refrigerants
- Building on refrigerant training programs already in place in Europe, Australia, and Japan; and from several companies who are training in the U.S.

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Transition to Low-GWP Refrigerants

What's the same?

- The majority of the physical and chemical properties of these new Class A2L refrigerants are no different from traditional A1 (CFC, HCFC, and HFC) refrigerants

What's different?

- Low-GWP refrigerants include some lower flammability (Class A2L) and higher toxicity refrigerants

What do I need to do about it?

- Stakeholders must be aware of and properly trained in the mitigation of risks due to the lower flammability or higher toxicity properties associated with the new refrigerants

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Refrigerants: Definitions and Properties

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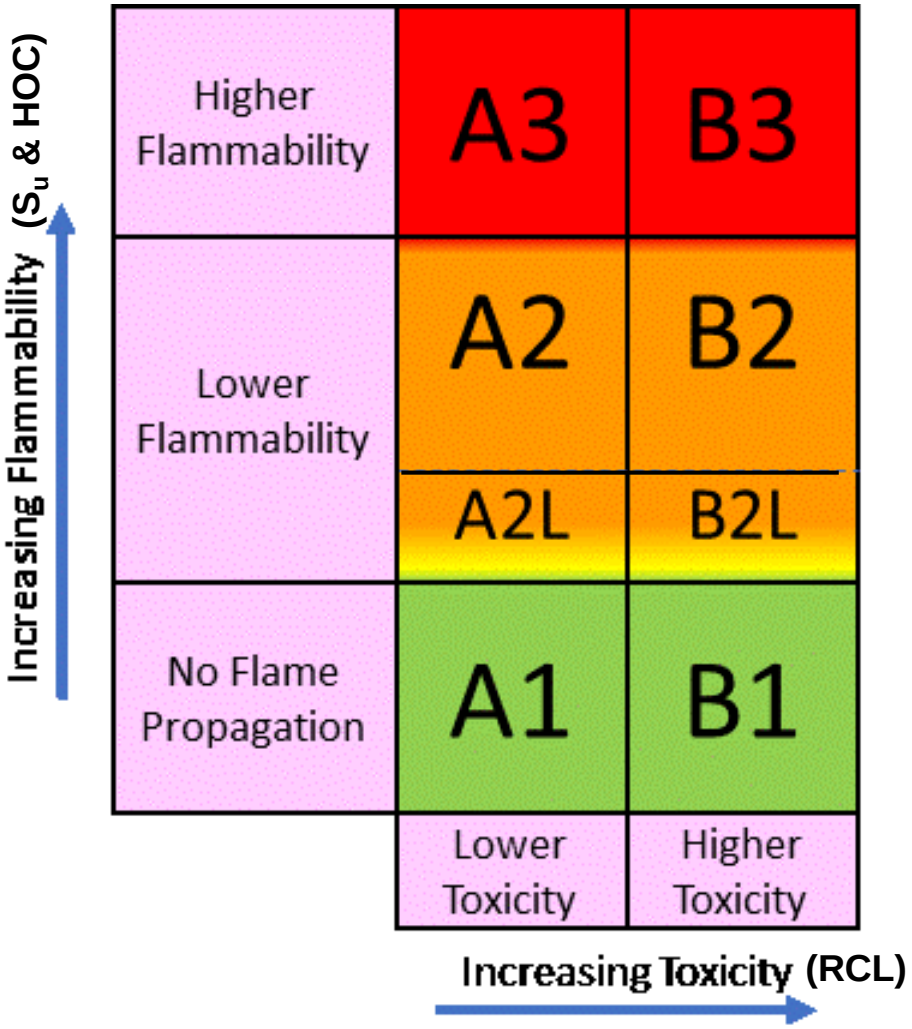
ASHRAE 34 and ISO 817 Refrigerant Classification



Class 3 Requirements

1. Exhibit flame propagation @ 60°C & 101.3 kPa
2. LFL ≤ 0.10 kg/m^3 or HOC ≥ 19,000 kJ/kg

Class 2 Requirements

1. Exhibit flame propagation @ 60°C & 101.3 kPa
2. LFL > 0.10 kg/m^3
3. HOC < 19,000 kJ/kg

Class 2L Requirements

1. Same as Class 2 requirements & S_u ≤ 10 cm/s

Class 1 Requirements

1. No flame propagation @ 60°C & 101.3 kPa

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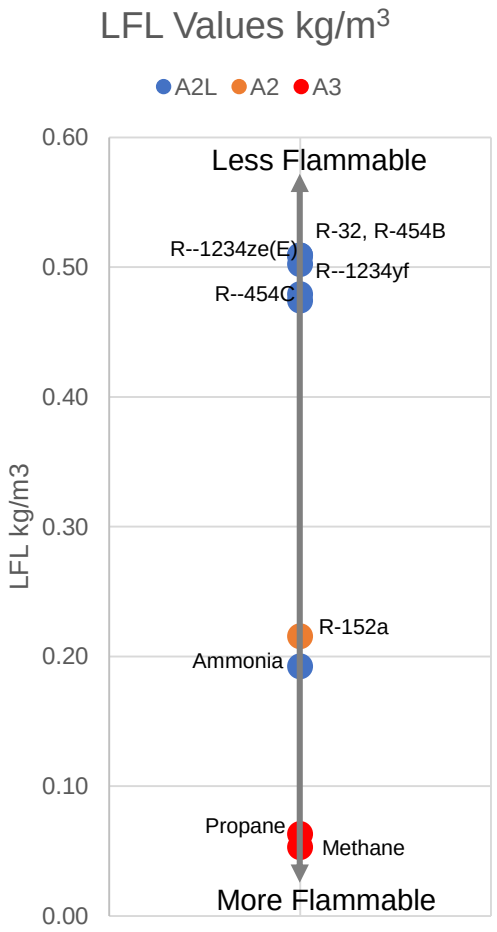
ASHRAE Classification
ASTM E-681: Flammability Limits

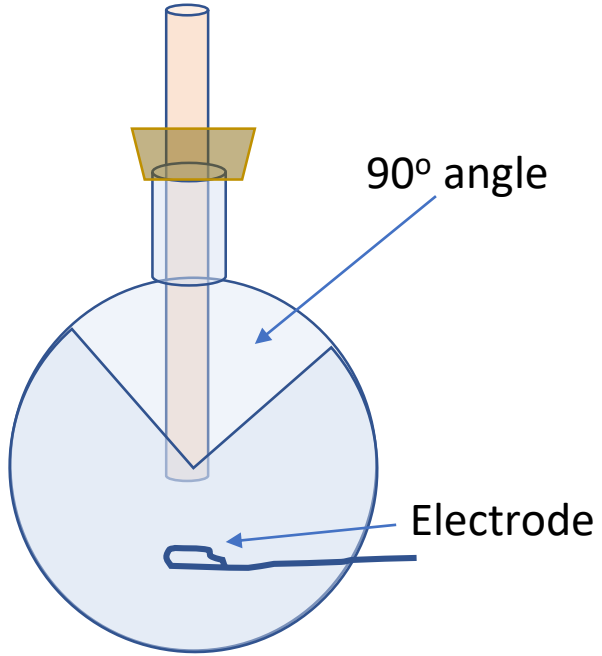


Apparatus

- 12L glass flask
- Ignition- 15 kV/30 ma, 0.4 sec duration

Testing

- 23°C and **at 60°C**, with RH of 50% ± 0.1% at 23.0°C.
- Absolute humidity of air-0.0088 grams H2O/dry air @ 23°C.
- Tested increments of 1 vol % or less of refrigerant in air.



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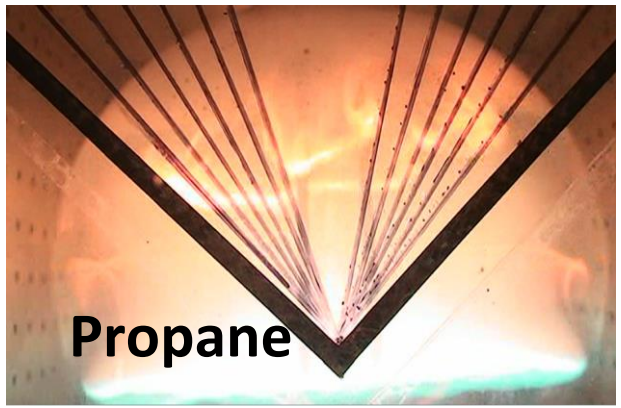
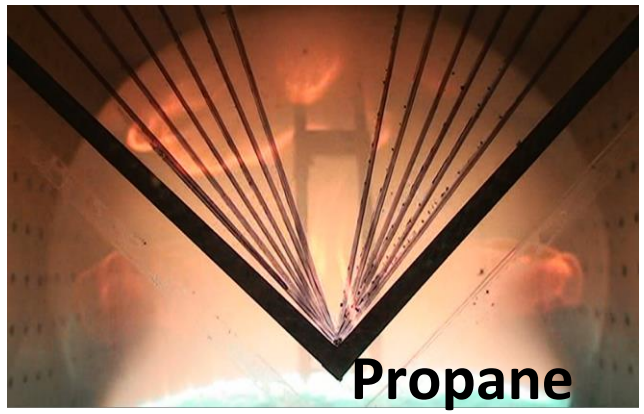
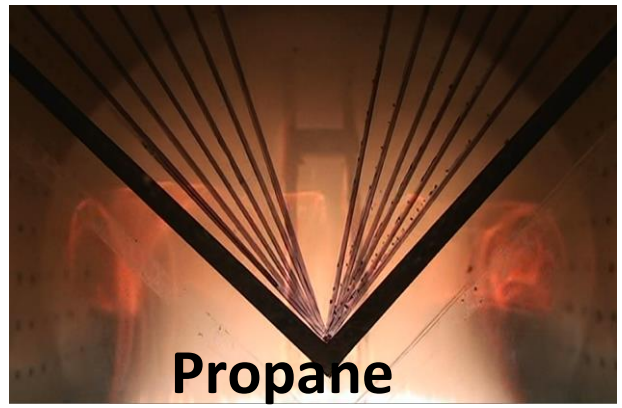
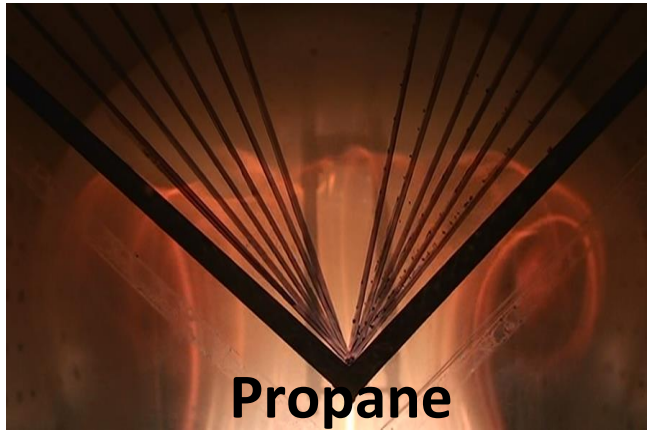
ASTM E681- Class 3 (e.g. propane)





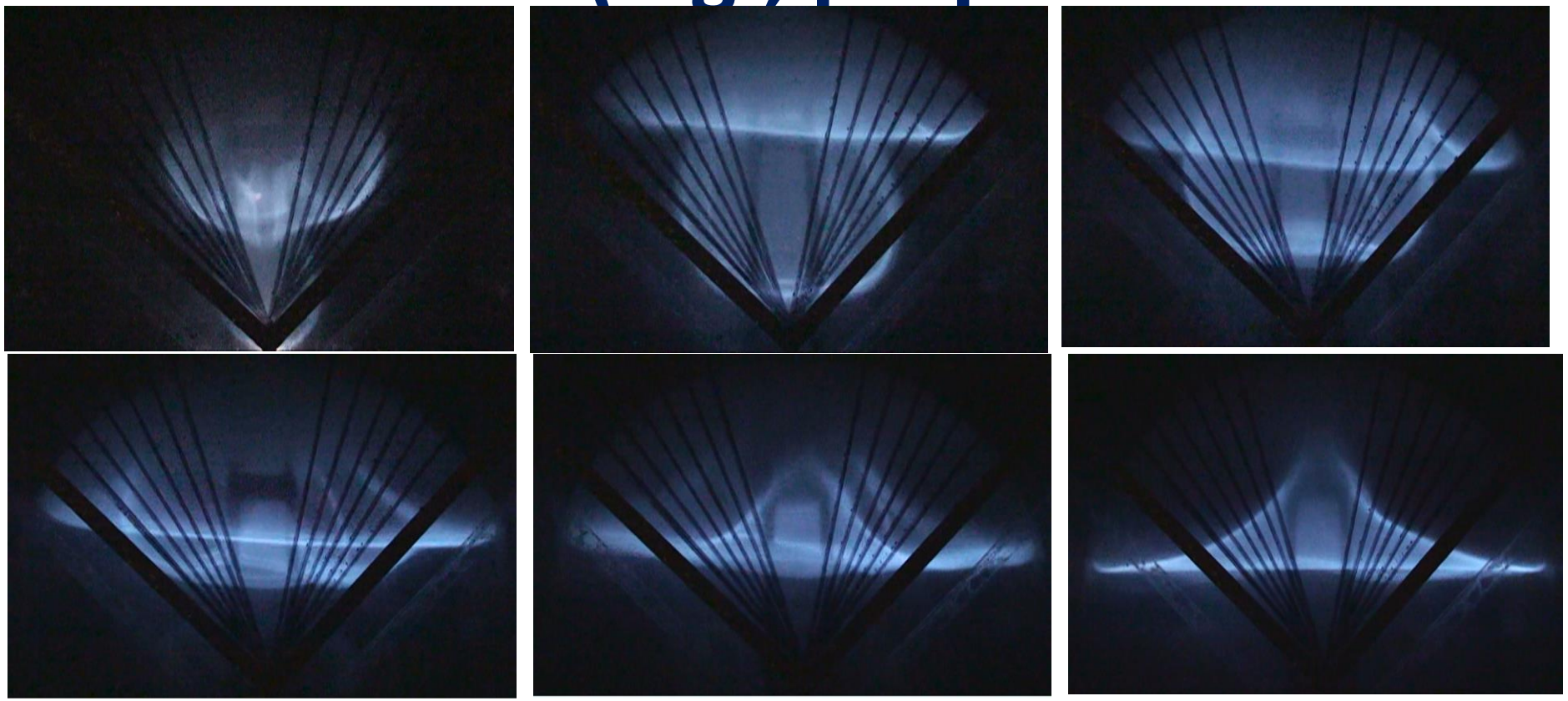




The flame must be a solid flame stretching out over a 90 degree span. If the flame breaks on one side or the other only the largest degree span is counted.

Class 3 has addl. parameters (LFL<0.1kg/m3 and HOC> 19,000kJ/kg)

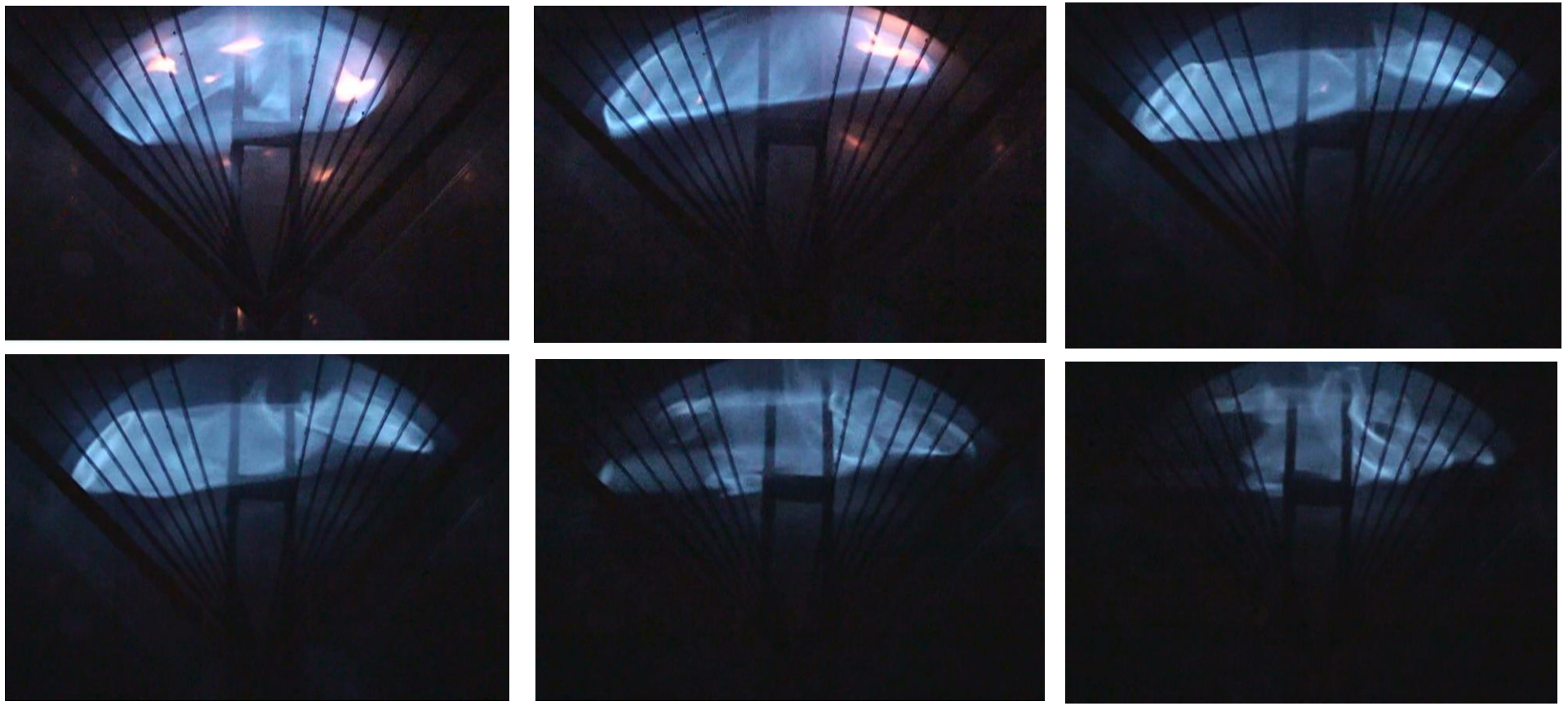
ASTM E681- Class 2 (e.g., propellant in Hairspray)



The flame must be a solid flame stretching out over a 90 degree span. If the flame breaks on one side or the other only the largest degree span is counted.

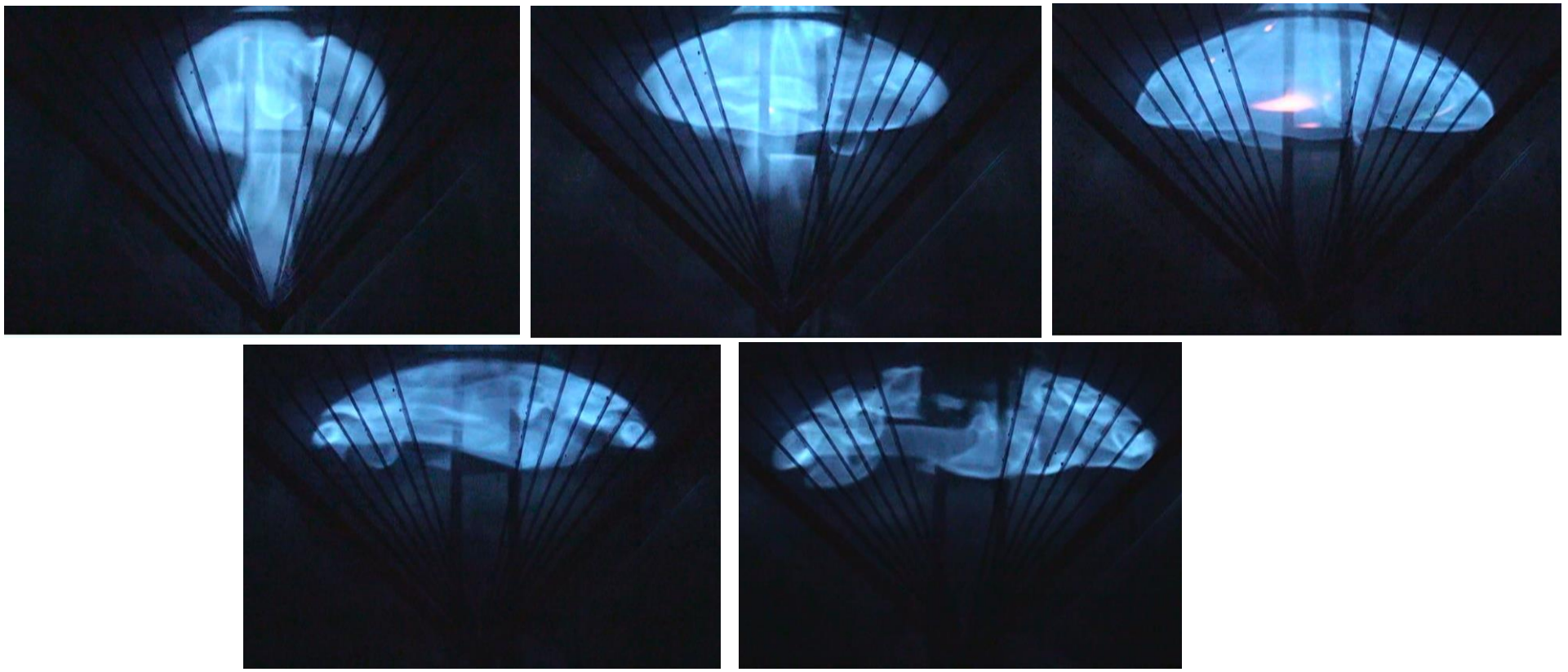
Class 2 has addl parameters (LFL>0.1kg/m3 and HOC <19,000kJ/kg)

ASTM E681- Class 1 – Does Not Propagate Flame



The flame must be a solid flame stretching out over a 90 degree span. If the flame breaks on one side or the other only the largest degree span is counted.

ASTM E681- Class 2L (Lower Flammability)



The flame must be a solid flame stretching out over a 90 degree span. If the flame breaks on one side or the other only the largest degree span is counted.

Class 2 has addl parameters (BV<10cm/sec, LFL>0.1kg/m3 and HOC 19,000kJ/kg)

Selection of Lower GWP Refrigerants

Selection of new lower GWP refrigerants is a complex process and includes;

- **Direct** Global Warming Potential (**GWP**) (EPA focus)
- **Indirect** Global Warming – **Energy Efficiency** (power plant emissions) (DOE focus)
- **Toxicity**
- **Flammability** (safety classification 2L, 2, 3)
- **Material compatibility** and stability
- Compressor, heat exchanger, and **line sizing**
- Heat Transfer
- Refrigerant cycle characteristics for cooling, heating, and extreme operating conditions
- Operating pressures and glide for mixtures
- Product application type (residential, commercial packaged, VRF, chillers, refrigeration, etc.)
- Applied Cost

- Extensive work has been done by the refrigerant manufacturers and equipment manufacturers. For example, one company alone has evaluated 431 refrigerants for 20 different system types
  - This included A1, A2L, A2, A3, B1, and B2L safety category (ASHRAE 34)
  - Many of the new refrigerant options are blends (ASHRAE 34 “400” and “500” series)

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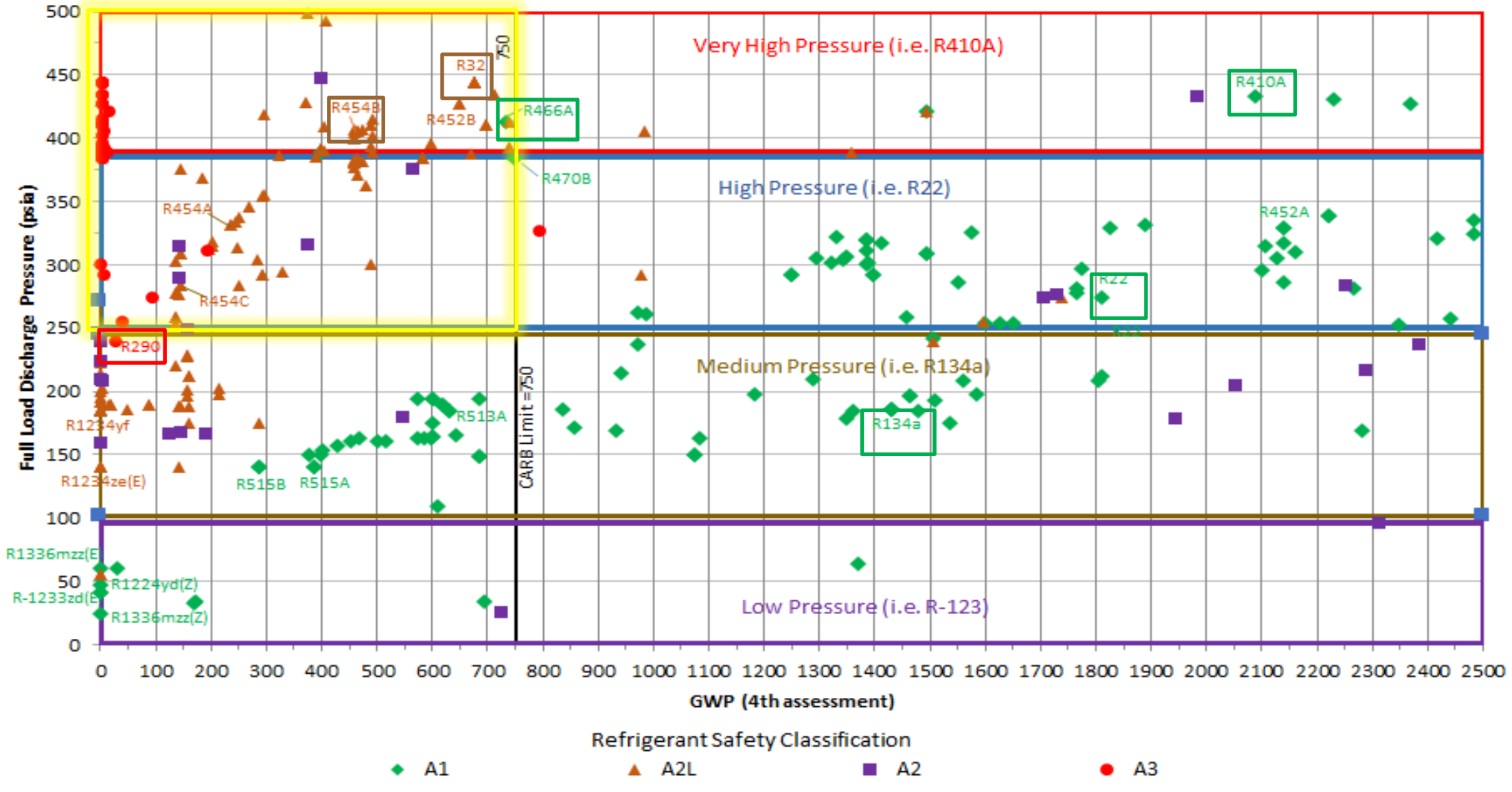
Possible Refrigerant Options for Residential and Light Commercial



Refrigerant Concentration Limit (RCL)

Refrigerant Concentration Limits are used to determine the maximum concentration limit allowed in an occupied space of a refrigerant

- RCL is based on toxicity and / or flammability

What's the same?

- RCLs are still used to determine allowed concentrations in occupied spaces
- Mitigation is required when concentrations exceed RCL

What's different?

- R-410A has an RCL of 140,000 ppm
- Low GWP A1 and A2L refrigerants have RCLs between 16,000 and 50,000 ppm.

What do I need to know?

- Mitigation will be needed before RCL concentration is reached
- Refrigerants with RCLs based on toxicity limits may require similar mitigation

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Air Conditioning Refrigerants

- A1: Current AC refrigerant R-410A (GWP 2088)
  - 50% HFC-32 (A2L) + 50% HFC-125 (fire suppressant)
  - HFC-125 has a high global warming potential (GWP) of 3500 (RCL 75,000 ppm)

- A2Ls: HFC-32 (R-32) and HFO-1234yf are pure refrigerants
  - R-32 is used in home AC (GWP 675) (RCL 36,000)
  - HFO-1234yf (or YF) is used in automobiles and could be used in some chillers in machine rooms (GWP 2) (RCL 16,000)

- A2L: R-454B is a blend of 68.9% HFC-32 and 31.1% HFC-1234yf (GWP 465)

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Air Conditioning Refrigerants – Ongoing Research

- A1: R-466A (GWP 733)
  - Blend of 49% HFC-32 and 11.5% HFC-125 and 39.5% CF3I (fire suppressants)
  - RCL = 30,000ppm
- CF3I is a fire suppressant
  - Approved by EPA as a flooding agent for use only in unoccupied spaces
  - CF3I has low GWP, some Ozone Depletion Potential
  - RCL = 2,200 ppm

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Some Fluorocarbon Refrigerant Safety…

When working with refrigerants, similar to other compressed gases…

- Potential for frost bite
- Displace oxygen (RCL basis)

Hydrogen fluoride (HF) is a combustion product of old A1 refrigerants (in use for 90 years) and new A2L refrigerants

- HF forms when any fluorocarbon refrigerant, including those used today, undergoes combustion, partial combustion, or thermal decomposition
- HF gas is a lung irritant and HF acid, depending on concentration, is a skin irritant

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Some Fluorocarbon Refrigerant Safety…

What do I need to know?

- Personal protective equipment should be worn by technicians and first responders regardless of refrigerant when there is potential for exposure until decontamination is complete
  - Neoprene gloves should be used for acid clean-up
  - Leather gloves should be used with liquid refrigerants (frost bite)
- Machine rooms with special controls are required for large refrigerant quantities due to hazards associated with large charge sizes of compressed gases
- Safety Data Sheet (SDS) requirements for handling should be followed for all chemicals including refrigerants

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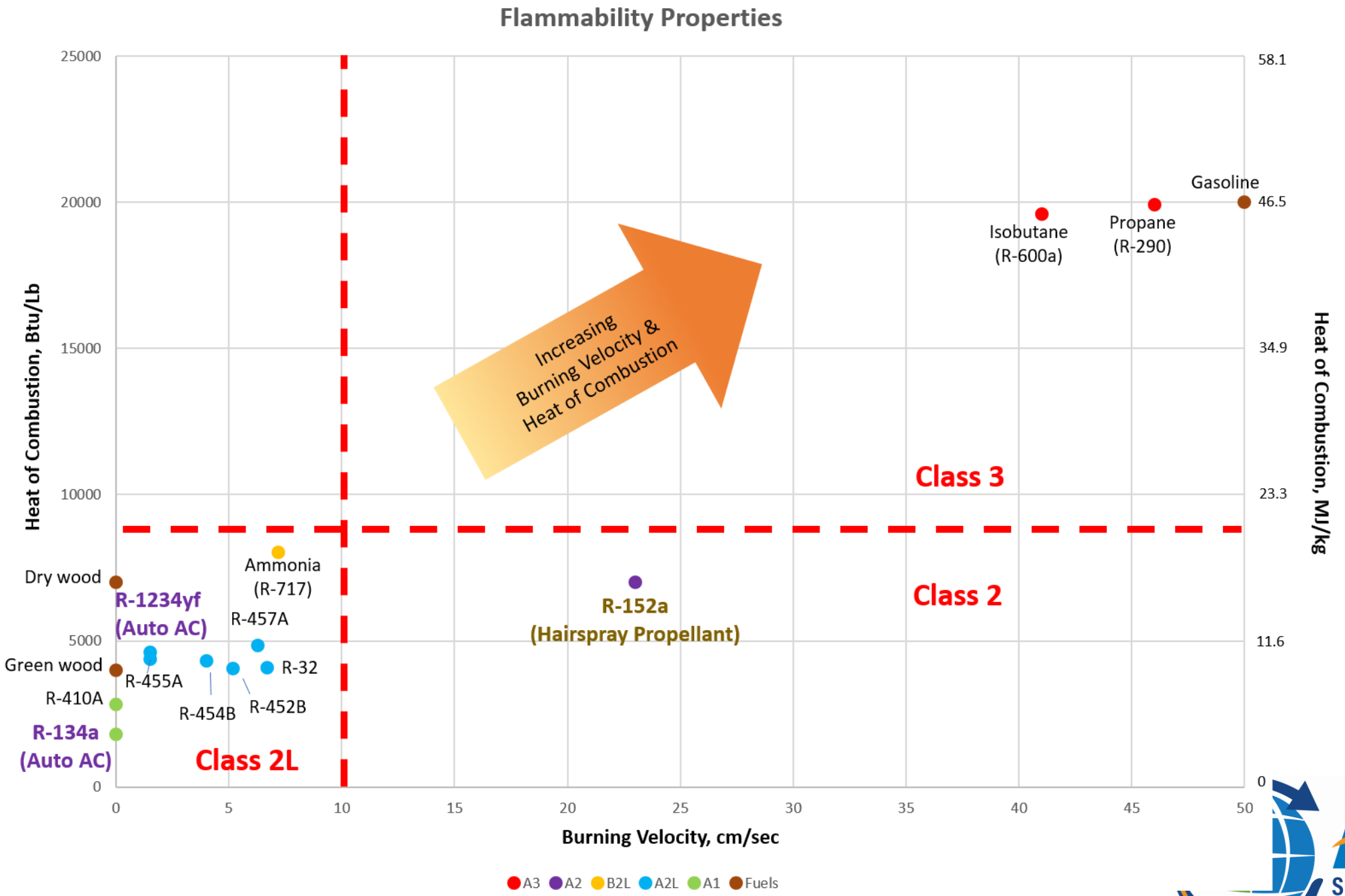

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AHRTI – 8017 A2L Potential Residential Ignition Sources

Competent Ignition Sources

1. hot wire,
2. safety match
3. lighter flame insertion,
4. leak impinging on candle,

No Ignition

- cigarette insertion
- barbeque lighter, plug & receptacle
- light switch
- hand mixer
- cordless drill
- friction sparks
- hair dryer
- toaster
- hot plate insertion
- space heater insertion.

Bottom Line: Live flames are competent ignition sources for A2L refrigerants.

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A2L Refrigerant Ignition Properties

A2L Refrigerants are difficult to ignite

- Require high ignition energy to ignite
- Require high levels of concentration to be flammable

They also have lower flammability characteristics

- Low burning velocities
- Low heat of combustion
- Do not always fully combust

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Storage

- National Fire Safety Storage Requirements
  - Permit from fire code official
    - Hazardous Materials Management Plan
    - Hazardous Material Inventory Statement
  - Requires visible hazard identification signs (NFPA 704 sign)
  - No smoking signs
  - No open flames or high temperature devices (could include warehouse heaters)
- Empty tanks/cylinders (Heels)
  - Must be free of residual material and vapor before storage for reuse
- Safety Data Sheets
  - SDS must be available on site
- Upright storage
  - Exception for nonflammable gases secured to a pallet

Sample NFPA 704 Sign

Key Points About the Transition

- Low GWP refrigerants are already being used safely
  - 80% of new cars sold in the US contain a low GWP refrigerant
  - Nearly all new European cars contain low GWP refrigerant
  - Air conditioning and refrigeration equipment in the European Union, Australia, Japan, Thailand and other countries contain low GWP refrigerants
  - Small appliances in the US as approved by the Environmental Protection Agency (EPA) contain low GWP refrigerants
- Low GWP refrigerants will only be used in new systems/applications that are designed to mitigate risks, and where allowed by appropriate codes and standards

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Research and the Safety Standards: Ignition Source Protection

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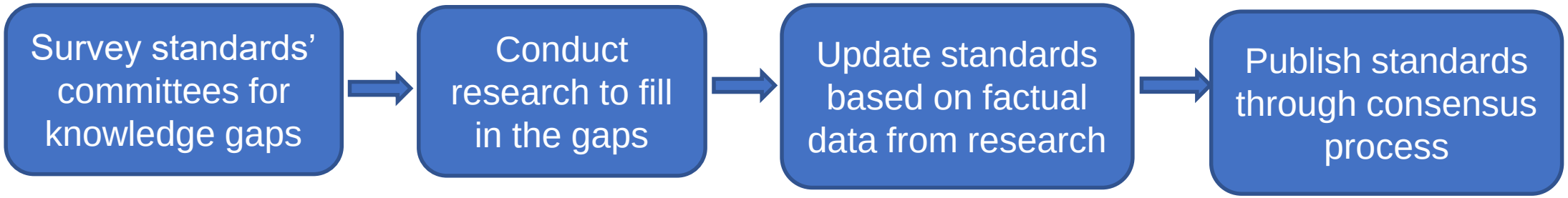
Safety Standards Updated Based on Extensive Research



- Significant research is available through third party testing
  - More than a decade of research is available from testing for Japan and Europe
  - Nearly $7 million has been invested in the U.S. to understand low-GWP refrigerants plus additional research conducted by refrigerant and equipment manufacturers
  - Objective: produce technical results to support code revisions related to use of flammable refrigerants

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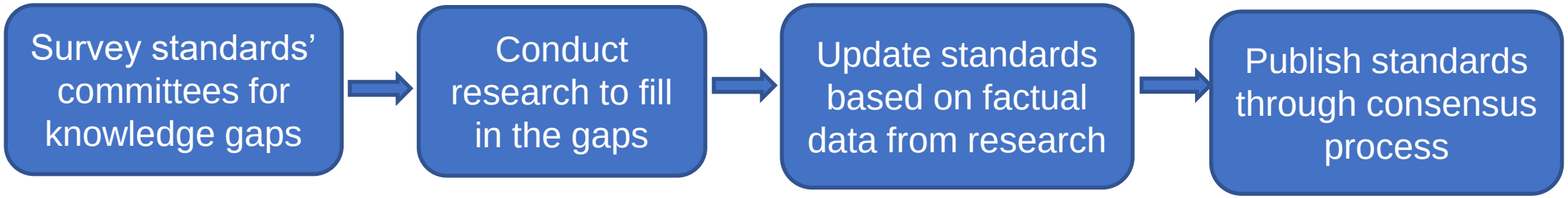
Safety Standards Updated Based on Extensive Research



- Research informed conservative modifications to safety standards. For example:
  - A detector trip time of 30 seconds was not fast enough, so a shorter response time is required in the standard
  - Propane charge reduced to 114 g compared to Europe which just approved 500 g
  - Research also showed that potential common household ignition sources do not ignite A2Ls
  - The charge size for cord-connected equipment was not relaxed
  - 4x safety factor used for room exposure levels
- Current research all over the world will support optimization for future products

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Extensive Research Completed on Flammable Refrigerants

- Testing
  - AHRTI-9007: Benchmarking Risk by Whole Room Scale Leaks and Ignitions Testing
  - AHRTI-9013: A2L Consequence Study
  - AHRTI-9012/Oak Ridge National Laboratory (ORNL): Real-world Leak Assessments of Alternative Flammable Refrigerants
  - AHRTI-9008: Investigation of Hot surface Ignition Temperature (HSIT) for A2L Refrigerants
  - AHRI-8017: Investigation of Energy Produced by Potential Ignition Sources in Residential Application
- Modeling
  - ASHRAE-1806: Flammable Refrigerants Post-Ignition Simulation and Risk Assessment Update
  - ORNL: Investigate the Proper Basis for Setting Charge Limits of A2L, A2, and A3 for Various Types of Products
  - NIST: Modeling tools for low-GWP Refrigerant Blends Flammability
- Servicing
  - ASHRAE-1807:Guidelines for Flammable Refrigerant Handling, Transporting, Storing and Equipment Servicing, Installation and Dismantling
  - ASHRAE-1808: Servicing and Installing Equipment using Flammable Refrigerants: Assessment of Field-made Mechanical Joints
- Detection
  - AHRTI-9009: Leak Detection of A2L Refrigerants in HVACR Equipment

*This is not a comprehensive list (excludes NFPA, Japan, Europe, Manufacturers etc)

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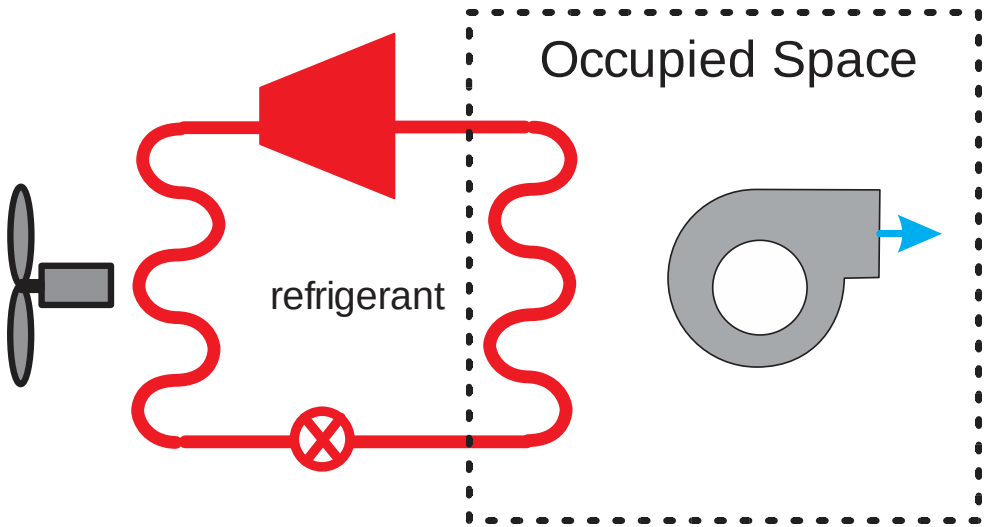
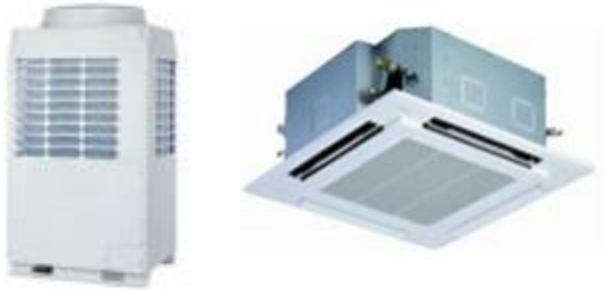
Safety Standard Application Classifications





Ductless

Ducted

Small Chiller

Direct System

Refrigerant piping circuit in occupied space

Comfort Cooling Product Safety Standard

Product standard requirements are followed in manufacturing equipment for "listing" and are labeled by Underwriters Laboratories LLC (UL).

- Building codes or application standards generally require that a product standard is followed
- Adopted into Washington State building code

UL/CSA 60335-2-40 3rd edition (approved, published)

- Based on IEC60335-2-40 6th edition and is a modification of UL60335-2-40 2nd edition
  - ANSI process
  - Two public reviews with comments and modifications
- More conservative than the global IEC60335-2-40 6th edition source standard
  - Reflects the results of research and the conservative approach to insure the safe use of A2L refrigerants
- Replaces UL 1995 on 1/1/2024 and covers all safety for HVAC products and not just low GWP refrigerants
- Users guides and installation instructions under development by equipment manufacturers are reviewed and required for UL certification

Comfort Cooling Application Safety Standards

Application safety standards inform the safe installation of equipment in buildings.

- Building codes generally require that an application standard is followed
- Application standards often require that a product is “listed” which means that it complies to a product standard
- Adopted into Washington State building code

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) 15-2019 (approved)

- Updated for use with A2L refrigerants in direct systems thru addendum d and for machine rooms thru addendum h (published September 2018)
- The complete standard was republished as the 2019 version on 7/30/2019 along with an updated version of ASHRAE 34
- Reflects the results of research and the conservative approach to insure the safe application of A2L refrigerants.

Application Safety Standards

ASHRAE 15.2 (proposed)

- Includes the requirements from ASHRAE 15 and UL 6-335-2-40 for residential systems only
- Combines requirements from product and application standards into a single document
  - Everything in the proposed ASHRAE 15.2 standard is included in UL 60335-2-40 and ASHRAE 15
- ASHRAE 15.2 was created to align with the International Residential Code for residential products

Safe Application of A2L Refrigerant

Fundamental Approach is to prevent ignition and combustion

1. Control of competent ignition sources and isolation from flammable refrigerants
2. Refrigerant Charge limits (m1, m2, m3) combined with item 7
3. Minimum occupied area (A_{min}) combined with charge limits in item 2
4. Factory Installed UL60335-2-40 application approved Refrigerant Detectors in all units above m1 charge
5. Active mitigation using circulation and dilution
6. Refrigerant Piping Design qualification and protection
7. Labeling and Literature
8. Service Training and Education

Goal of Standards: Prevent Ignition

- In order for a refrigerant ignition to occur, there must be 2 failures:
  - The refrigerant leak must exceed the lower flammability limit (LFL)
    - 10 to 14% LFL concentration
    - Large refrigerant release
  - There must be a “competent” ignition source (minimum ignition energy) in an area that exceed LFL
    - Open flame or very high energy ignition source
- Goal of the standard:
  - Prevent the LFL concentration from being reached
    - Refrigerant charge limits or mitigation requirements
    - Mitigation may include circulation or ventilation to reduce refrigerant concentration
  - Remove “competent” ignition sources

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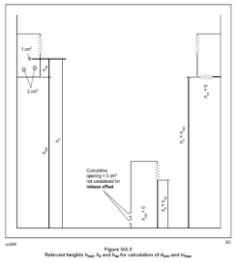
Safe Application of A2L Refrigerants Summary

UL60335-2-40 3rd Edition Summary for a **Residential Ducted Unit (direct system)** A2L Refrigerant Requirements

Minimum Area Check (A_{min})
- Safety factor of 4
- Or safety factor of 2 with additional measures
- Per Annex GG



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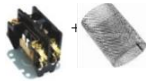
Service Training
and Education Annex DD, Annex HH

8

Ignition Source Isolation
Per UL 60335-2-40
Annex FF



1

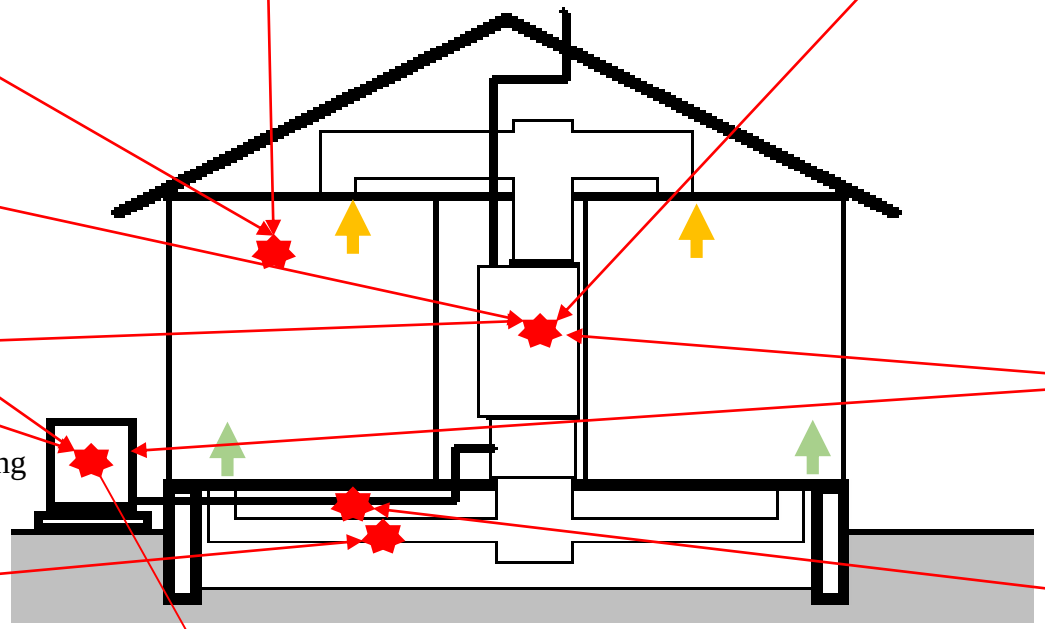
No Competent Ignition
Sources in unit and ducts
Per 22.116, Annex KK, 22,117

1

5

Active mitigation for leaks
detect, circulate an dilute
Annex GG

Residential Down Flow
Air Conditioners with Gas Heat



4 **Factory Installed Refrigerant Detector**
- UL60335-2-40, IEC60079-29-1 and Annex LL, Annex MM
- UL qualification testing
- UL approved
- Safety Circuit approved
- Factory Calibrated
- Self Test Routine (one time/hr.)
- Fail safe mode with fan on
- Field inspection enable feature

7 **Labeling and Literature**
Per UL60335-2-40
Per 101, Annex DD

6 **Refrigerant Piping** (UL60335-2-40)
Per 22.116, 101.DVG
- Protected lines
- Qualified joints (ISO 14903)
- Field pressure test
- Additional requirements for VRF

2 **Refrigerant Charge Limits** (UL60335-2-40)
m1, m2, m3 per Annex GG1.2
R-32 m1=4.1 lbs., m2=26.8 lbs., m3=134.1 lbs.
R-454B m1= 4.0 lbs., m2= 26.0, m3=130.2 lbs.

Service and Training Requirements: UL 60335-2-40 annexes DD and HH

Product standard requirements are followed by manufacturers for equipment listing.

- Standard requires that the service and installation instructions include requirements of Annex DD.
  - Annex DD is an outline of the service and installation requirements.
  - Annex HH defines requirements for competent service personnel
- Although there are no regulatory requirements for transition for air conditioning in North America yet,
  - Some manufacturers have developed training and started training technicians (in-person hands-on and internet-based courses)
  - A North American Training Excellence (NATE) Exam is in development.
  - There is significant training material available around the world where low GWP technologies have been adopted.
  - Additional organizations are developing training material.

https://www.myskills.gov.au/registeredtrainers/search?CourseCode=UEE32211

https://www.ashrae.org/professional-development/ashrae-unep-portal

UL60335-2-40 DD.9 Servicing Refrigerant System Summary - Example

Requirement	A1	A2L	A2&A3	Comment
Safely Remove Refrigerant following local and national codes	Required	Required	Required	EPA Rule 608, which requires recovery except for Natural refrigerants
Purge Circuit with Inert gas (i.e. oxygen free nitrogen)	Not required	**Required**	Required	Repeat as necessary
Evacuate	Not required	**Required**	Required	Insure outlet of pump is not near an ignition source
Purge with Inert Gas for 5 min	Not required	Optional	Required	Second purge
Evacuate again	Not required	Optional	Required	Included in Annex HH
Open the circuit by cutting or brazing	Final step	Final step	Final step	Final repair preparation. Should also state not to leave the system open for long periods
Repair the systems and for brazing purge with nitrogen during brazing	Required	Required	Required	Included in Annex HH
Leak Test and Pressure Test the unit	Not required	**Required**	Required	Part of DD.10
Evacuate the system	required	required	required	Follow industry practices for evacuation
Charge the system (See DD.10)	required	required	required	See DD-10 and mfg. charging procedures

HOW STAKEHOLDERS WORK TOGETHER

Refrigerant Producers:

Continuous **Research** to offer better cost-effective refrigerant solutions

Equipment Manufacturers:

Test and evaluate new refrigerants making sure basic safety, toxicity and efficiencies are not compromised

Mechanical Design Consultants:

Provide sustainable, occupant friendly, affordable building **designs** to owners

Owner/Operators:

Maintain good stewardship of a building system that meet codes and regulations

Maintenance/Service contractors:

Provide **TRAINING** and "as needed" continuous **service** to maintain a healthy building system

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Summary

- World is transitioning to low-GWP refrigerants, including A2L lower flammability refrigerants.
  - 12 U.S. states are regulating HFC refrigerants
  - California proposed regulation for 2023
- AHRI Safe Refrigerant Transition Task Force working to help ensure a safe North American transition to A2L refrigerants.
- Extensive research on A2L flammability has been completed.
  - Results of this research has now been incorporated into approved standards: UL 60335-2-40, 3rd ed. and ASHRAE 15.
- Training materials are already available from some manufacturers in US even though transition is still years away.

AHRI Safe Refrigerant Transition Task Force

- AHRI has formed a **Safe Transition Task Force** which has 7 working groups that are open to interested participants
- Goals are to **evaluate end-to-end supply chain to enable the safe commercialization of low GWP refrigerants** in a timely manner and support the effort to reverse the **global warming trend**.
  - Communications
  - Safety Training
  - Codes and Standards
  - Transportation/Storage/Packaging/Handling
  - Bulk Storage and Manufacturing Facilities
  - Installation/Operation/Maintenance
  - Recovery/Reclaim/Destruction
- Establish structure to ensure continuous improvement
  - Incident investigation
  - Continuous maintenance standards
  - Training upgrades
- Leverage learnings around the world
  - **Widespread use of A2L refrigerants already in global HVAC&R industry** in European Union, Japan, India and Australia and auto industry (including US and Canada)

http://www.ahrinet.org/SafeRefrigerant

Contact one of the following people if interested in the Safe Refrigerant Transition Task Force

Helen Water-Terrinoni HWalter-Terrinoni@ahrinet.org
Christophe Bresee CBresee@ahrinet.org

AHRI SAFE REFRIGERANT TRANSITION TASK FORCE

Thank-you!

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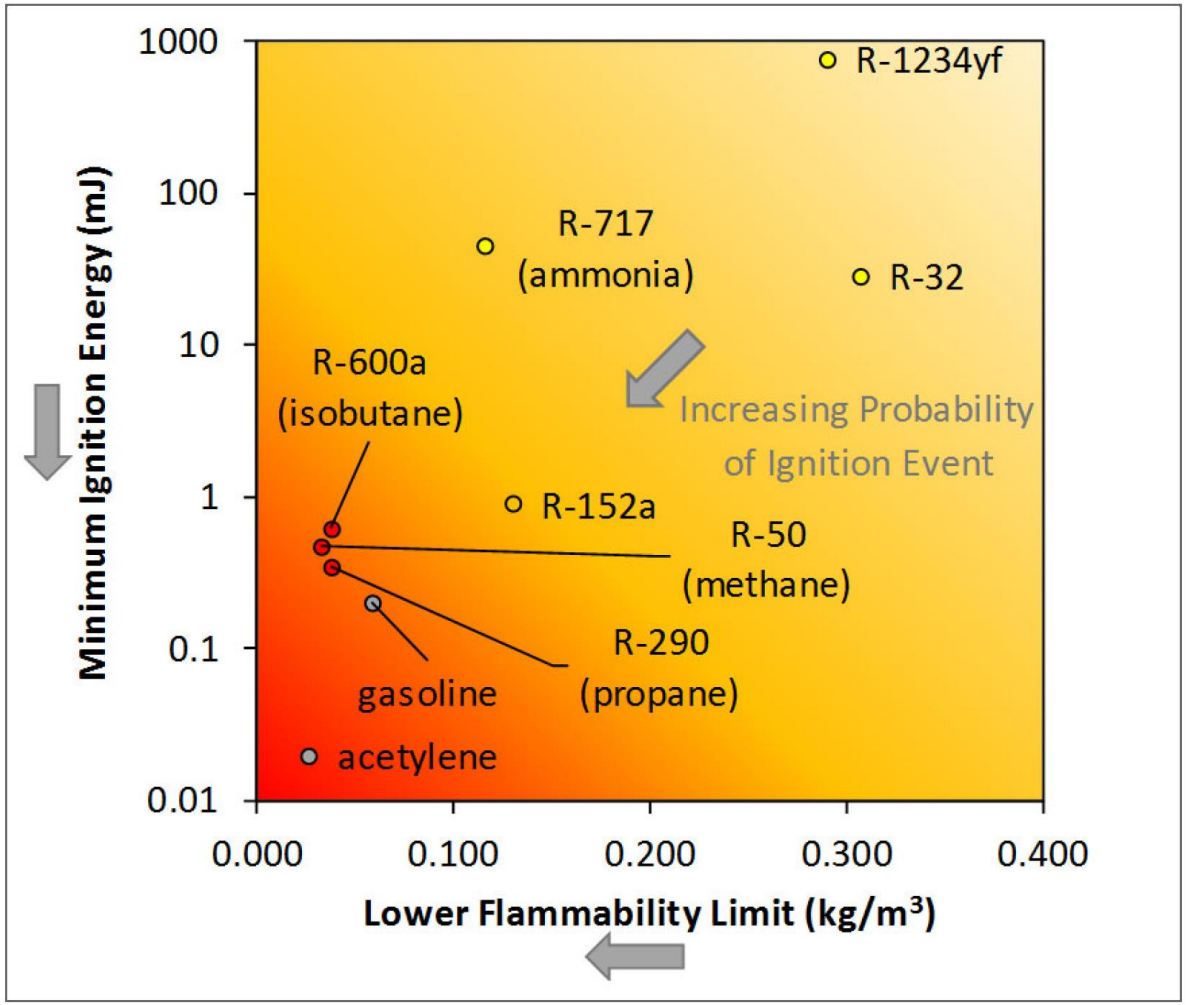
SAFE REFRIGERANT
TRANSITION TASK FORCE

Flammability – Minimum Ignition Energy (MIE)

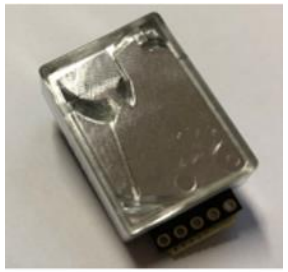


- Hydrocarbons require relatively low energy levels to ignite
- MIEs of A2Ls are much higher than hydrocarbons
- Many potential ignition sources for hydrocarbons (e.g., static spark) will not ignite A2Ls
- Many common household items (toasters, electric heaters, etc.) will not ignite A2Ls

AHRI
SAFE REFRIGERANT
TRANSITION TASK FORCE

Refrigerant Sensors/Detectors

- UL60335-2-40 as well as ASHRAE 15 have developed new comprehensive requirements for sensors and detectors which require new qualification and certification, but the basic sensor technology is the same as used in machine rooms and other industrial application and are being used in Japan and Europe
  - The **Sensor technology** is the basic sensor that is used to measure refrigerants and other gases like CO in homes
  - **Detector** is the new hardware containing the logic and controls that have been developed and defined as part of the new UL60335-2-40 requirements.



Refrigerant Sensor

Refrigerant Detector

- Key features of the detector package are;
  1. Detectors must be **factory installed** on all direct system units with a charge above m_1
  2. Unlike a smoke detector that sound a passive alarm, the UL60335-2-40 standard requires detectors to have **active mitigation** by turning on the indoor fans, to mitigate refrigerant leaks via dilution and in some cases ventilation
  3. The standard requires, at a minimum, indicating sensors that detect and take action, but do not have to have readouts and alarms.
  4. The detector and mitigation will be **inspected and tested per the requirements of, IEC60079-29-1, as modified by annex LL and annex MM** for HVAC applications (IEC60079-29-1 is mine safety standard).
  5. Refrigerant-specific setpoint is **factory set and sealed**, with no field adjustment permitted but internal calibration software routines are allowed.
  6. Setpoint and location are **validated by UL60335-2-40 testing**

AHRI SAFE REFRIGERANT TRANSITION TASK FORCE

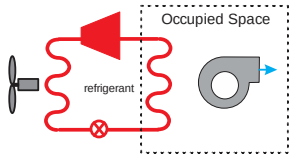
Refrigerant Sensors/Detectors

Key features of the detector systems (continued):

7. Must **respond in 10 second** when exposed to 100% of LFL.
8. Must comply with annex MM simulated leak test for set point confirmation and demonstrate measured LFL below set point in less than 90 sec for the enabled mitigation system
9. **Self-test protocols** are requested that run every hour to ensure proper operation and function.
10. Detector software and fan system is considered part of a **Protective Electronic Circuit** and will be evaluated as a safety circuit as part of the listing of the equipment per UL60335-2-40
11. In the event of **detector failure, indoor fan activates** and maintain a required airflow to prevent flammable concentrations forming is initiated. As noted earlier once there is airflow it is not possible to get to a flammable concentration level. This fail-safe mode is maintained until the detector is replaced.
12. **Routine factory inspections** will be conducted by UL as part of the listing requirements.
13. Detector markings identify the manufacturer and refrigerants used.
14. Testing is required to determine sensor/detector accuracy vibration, range, setpoint verification, and response time
15. Sensors and detectors must pass **long term durability, stability and reliability requirements**,
16. **Poisoning test exposure** required for common fluids, as defined in UL60335-2-40 annex LL, seen in buildings.
17. If the detector has a defined life and requires replacement after a given period, the detection system shall initiate an alarm or indication that replacement is required.

It is **3 years** before new UL60335-2-40 detectors will be needed but field trials and qualification are already underway

A2L Refrigerant Requirements - Direct Systems



Product and Application Requirements (UL60335-2-40/CSA 22.2, ASHRAE 15.2, ASHRAE 15, B52, EPA)

Application
Refrigerant Charge Limits/circuit
A3 limits to 114 g (m1)

Limit	Equation	R--32	R-452B
<m1	=3 or 6*LFL	2 or 4.1lb	2 or 4.0 lbs
<m2	=52*LFL	35.1 lb	34.7 lbs
<2 x m2	=104*LFL	70.1	69.5 lbs
>m3	=260*LFL	175.4	173.7 lbs

All Systems → No sensor requirements or area check, but other requirements still apply

Appliances → A_{min} = (mc / (2.5 x (LFL)5/4 x ho)^2 , not less than A = mc / (SF x LFL x ho)

Ductless → $A_{min} = m_c/(0.25 \times LFL \times h_o)$

Ductless<35kW Multisplit → *sensor and* $A_{min} = m_c/(0.50 \times LFL \times h_{ra})$

Ducted → *sensor and* $TA_{min} = m_c/(0.25 \times LFL \times H)$

Ducted/Ductless → Sensor External Mechanical ventilation

Check A_{min}
Validation Testing
Labeling of h_o
Room connection

(New Cylinder colors AHRI Guideline N and AHRI Guideline G for fittings left hand threads for flammable)

New Reclaim

LH Threads (being discussed)

Refrigerant detector above m1 for ducted and circulation m2 or <Amin VRF in unit

Indoor airflow verification for electric heat (only if no refrigerant detector)

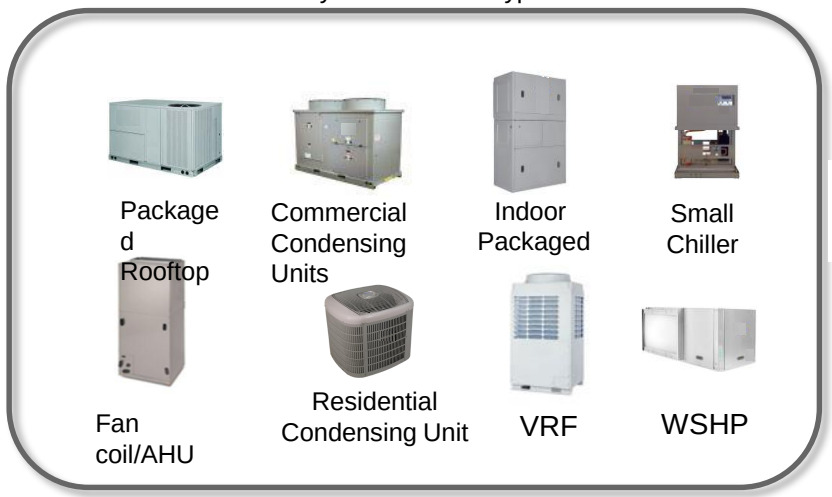
Hot surface limit of <700 C Except for heat with sensor or airflow verification

Tubing protection for exposed piping greater than 6.6 ft (ASHRAE 15).

Red pantone service port (EPA Requirement)

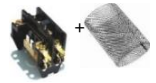
Field Piping Design, (joints, protection) & Pressure proof test

Direct System Product Type



A2L

Safety / circulation control and unit interlock (UL Safety Circuit)



Ignition Source Flame arrestors or control box qualification

New Warming labels on units and packaging

Amin, h_o and charge tracking on unit nameplate

Isolation valves for multiple evaporator systems (VRF) Also additional requirements options per 101 DVG.2

Refrigerant relief requirements and venting

New service requirements and procedures

Training, Literature and Technician Certification? (Nate, HRAI, ACCA)

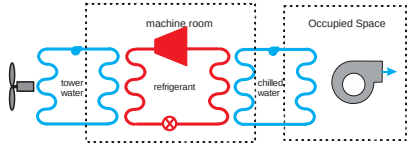
Laboratory Upgrades (Manufacturers and Certification)

Production Processes

Warehouse and Shipping (DOT/GHS)

AHRI SAFE REFRIGERANT TRANSITION TASK FORCE

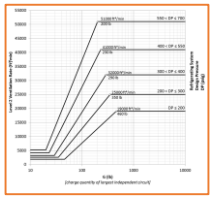
A2L Requirements Indoor Indirect Systems



Product and Application Requirements (UL60335-2-40/CSA 22.2, ASHRAE 15, B52, EPA)

Revised/Increased machine Room Ventilation as a function of charge

ASHRAE 15-2019



ASHRAE 15 addendum h increased ventilation as a function of charge

Safety / ventilation control interface and Inspection

Machine room requirements access controls, alarms, ventilation

Refrigerant sensor (already required for A1)

Hot surface limit of <700 C

New Warming labels on units and packaging

A2L

Flame arrestors or control box qualification for units and machine room

+

Machine Room Indoor Indirect Product Types

Routine inspection & Leak checking, CARB EPA Rule 608 >50 lbs.

Laboratory Upgrades

LH Threads (being discussed)

New Reclaim

(New Cylinder colors AHRI Guideline N and AHRI Guideline G for fittings left hand threads for flammable)

Red pantone service port (EPA Requirement)

No open flame combustion

Machine Room Electrical Protection

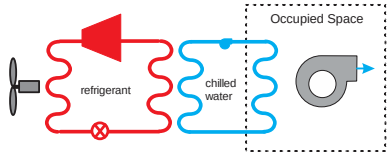
Relief valves vented outdoors And refrigerant relief on waterside

Production Processes

New service requirements and procedures

Training, Literature and Technician Certification? (Nate, HRAI, ACCA)

A2L Requirements Outdoor Indirect Systems



Likely Product Impacts (UL60335-2-40/CSA 22.2, ASHRAE 15, B52, EPA)

No charge limits

(New Cylinder colors AHRI Guideline N and AHRI Guideline G for fittings left hand threads for flammable)

New Reclaim

LH Threads (being discussed)

No ventilation requirements

Refrigerant sensor (not required)

Hot surface limit of <700 C

New Warming labels on units and packaging

A2L

refrigerant relief sizing for waterside to be able to handle refrigerant and ASHRAE 15 requirements for refrigerants

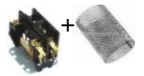
Outdoor Indirect Systems

Routine Inspection & Leak checking Section 608 and CARB

Laboratory Upgrades

Located 20 ft from building intake (ASHRAE 15)

Red pantone service port (EPA Requirement)



Flame arrestors or control box qualification for units

Production Processes

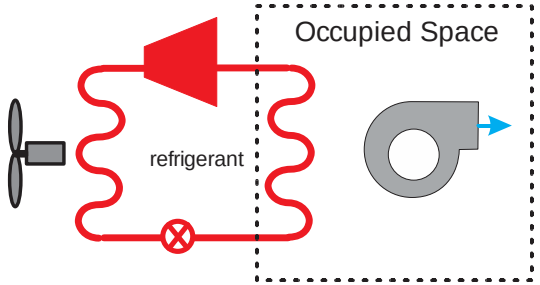
New service requirements and procedures

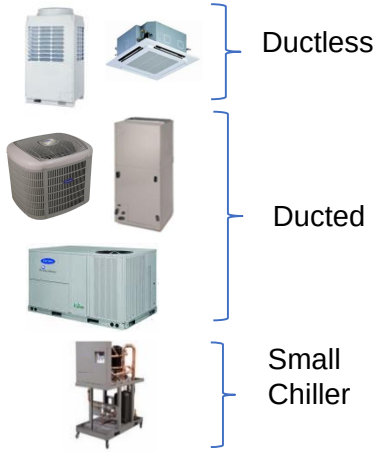
Training and Literature & Machine Room Guidelines (NATE, ACCA, HRAI)

AHRI SAFE REFRIGERANT TRANSITION TASK FORCE

Safety Standard Application Classifications

Direct System
Refrigerant can leak into the occupied space

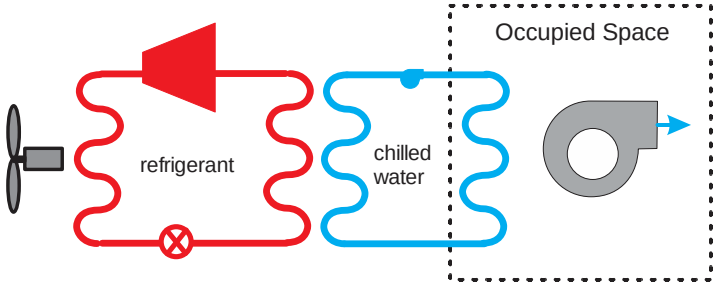


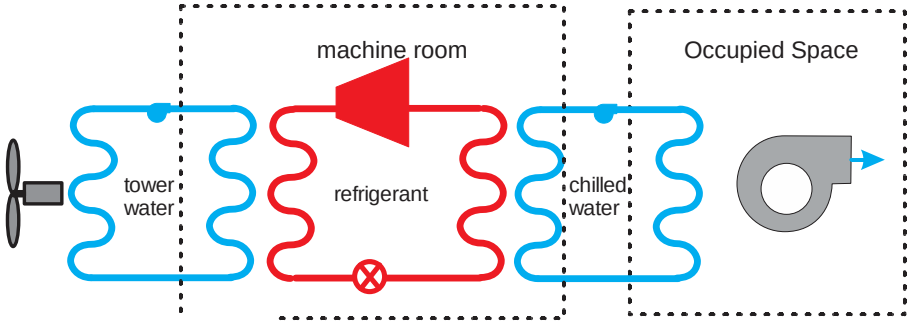


Indirect Systems

Refrigerant Leak Isolated by secondary loop

Equipment outdoors or in a machine room





Refrigerant Safety Classifications Properties

Refrigerant	Components Composition%	Safety Classification ASHRAE 34	Exposure Limit (RCL)	GWP (4th)	Applied GWP relative to R-410A	Operating Pressure @ 120 F SDT	LFL nominal composition	UFL nominal composition	Burning Velocity (Su)	Minimum Ignition Energy (MIE)	Heat of Combustion (HOC)	Auto Ignition Temperature (AIT)	Hot Surface Temperature (HOC)
			ppm	CO_2e	CO_2e	psia	% v/v	% v/v	cm/sec	mJ	KJg	°C	°C
R-410A	R-32/R-125 50/50	A1	140,000	2,088	2,088	433.6	-	-	-	-	5.91	>750	-
R-134a	1,1,1,2-tetrafluoroethane 10000%	A1	50,000	1,430	1,632	185.9	-	-	-	-	?	>750	-
R-404A	R-125/R-134a/R-143a 44/4/52	A1	126,000	3,922	3,878	325.8	-	-	-	-	?	<750	
R-466A	R-32/R-125/CF3I 49/11.5/39.5	A1	30,000	733	855	412.6	-	-	-	-	?	?	
R-513A	R-134a/R-1234yf 44/56	A1	72,000	629	679	184.98	-	-	-	-	?	?	
R-1234yf	2,3,3,3-tetrafluoropropene 100%	A2L	16,000*	0.31	0.32	185.0	6.20%	12.30%	1.5	8000	10.7	405	700
R-32	difuoroemethane 100%	A2L	36,000*	675	612	444.0	14.4%	29.30%	6.7	21-24	9.38	648	700
R-452B	R32/R125/R1234yf 67/7/26	A2L	30,000*	697	612	410.1	11.9%	21.60%	3.3	100-300	9.45	?	700
R-454B	R-32/R-1234yf 68.9/31.1	A2L	30,000*	465	433	405.5	11.8%	21.50%	5.2	100-300	10.3	?	700
R-152a	1,1 difluoroethane 100%	A2	12,000*	124	106	166.1	4.80%	8.0%	23	0.38	16.3	455	355
R-290	propane 100%	A3	5,300*	3.30	1.55	242.5	2.10%	9.5%	46	0.25	46.3	470	370

LFL = Lower Flammability Limit (%v/v)
UFL = Upper Flammability Limit (%v/v)
Su = Laminar Burning Velocity (cm/sec)
HOC = Heat of Combustion (KJ/g)
AIT = Auto Ignition Temperature (°C)
HST = Host Surface Temperature (°C)
RCL = refrigerant concentration limit doe roxicity risk reduction, * = 25% of LFL for flammable refrigerants