Lower Global Warming Potential Refrigerants: Frequently Asked Questions

1. **What are A2L refrigerants?**

   A2L refrigerants are a class of refrigerants that have lower toxicity and flammability.

   All common refrigerants are listed through the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) in ASHRAE Standard 34 (2019). The ASHRAE 34 Standard Committee determines toxicity and flammability classification.

   - Class A refrigerants have lower toxicity; Class B refrigerants have higher toxicity.
   - Flammability class is determined by ASTM E681, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases), at a pressure of 101 kPa and temperature of 60°C but at higher temperatures they can become flammable)*.
     - Class 1 refrigerants do not propagate a flame.
     - Class 2L refrigerants have lower flammability (e.g., R-32, HFO-1234yf) and slow flame propagation (burning velocity <10 cm/sec).
     - Class 2 refrigerants (e.g., R-152a) have lower flammability and faster flame propagation (burning velocity >10 cm/sec).
     - Class 3 refrigerants (e.g., propane, butane) have higher flammability and faster flame propagation (burning velocity > 10 cm/sec).

ASHRAE SAFETY CLASSIFICATION OF REFRIGERANTS

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

INCREASING TOXICITY

Toxicity classes are delineated at a concentration of 400 ppm
Flammability is classified based on a lower flammability limit (LFL).
LFL < 0.1 kg/m3 is classified as flammability class 3

2. **Are there any truly non-flammable refrigerants?**

   Yes, there are truly non-flammable refrigerants like carbon dioxide (CO2), but CO2 or R744 operate at a significantly higher pressure than most HFCs and is not suitable as a retrofit refrigerant. A1 refrigerants are identified as having "no flame propagation"[1] but common A1 refrigerants such as R-410A or R-22 in use today can burn under the right conditions.

   Refrigerants are tested to ASTM E681, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases),* at a temperature of 60°C but at higher temperatures they can become flammable. The results of this standard determine the level of combustibility of each refrigerant.

   R-410A, the most common air conditioning refrigerant in use globally today, is not actually "non-flammable." It is ASHRAE-listed as an A1 refrigerant, meaning that it has no flame propagation at 63°C.

   - R-410A is 50% R-125 (a fire suppressant with very high-GWP) and 50% R-32 (an A2L that can be used in AC systems with much lower GWP).

[1] ASHRAE Standard 34 (2019)

- R-410A behaves very similarly to R-32 especially when exposed to higher temperatures (e.g., a fire impacting AC equipment).[2] [3]

3. **Are all refrigerants hazardous? What is a Refrigerant Concentration Limit (RCL)?**
   Even lower toxicity refrigerants (ASHRAE classification A) displace oxygen and can act as an asphyxiant if they are not properly managed. ASHRAE developed an RCL to ensure that equipment and the room design address these risks by ensuring that certain concentrations are not exceeded. The RCL is reduced by a safety factor and mitigation is initiated if this value is exceeded.

   Systems containing larger charge sizes or systems located in a confined space must have mitigation measures like circulation or ventilation which are initiated if the concentration exceeds the safety margin. These same safety measures are required for flammable refrigerants. However, the RCL would likely be dependent on the lower flammability limit (LFL) rather than toxicity.

4. **How safe are A2L refrigerants used in air conditioning systems? Do they burn easily**?
   As confirmed by AHRI research[4], it takes three failures in a system to ignite an A2L refrigerant used in air conditioning equipment. Failures required include the following:
   - **a.** There would have to be a significant refrigerant leak.
   - **b.** The leak would have to be sufficient to reach the lower flammability limit (LFL) concentration. LFL concentrations for A2Ls are above 10%.
   - **c.** There would have to be an open flame or a high energy ignition source where the concentration is sufficient to ignite A2L refrigerants.

   Note: UL60335-2-40 edition 3 and ASHRAE addendums D and H are designed to prevent reaching the LFL concentration, and the charge size is limited for many systems so that the LFL can never be reached when leaked refrigerant fully mixes with air.

5. **Do A2L refrigerants ignite from static sparks or toasters?**
   No, A2L refrigerants must be exposed to an open flame or high energy source to ignite as they have a high Minimum Ignition Energy[5]. Toasters, electric heaters and other common household products will not ignite an A2L.

6. **What happens to air conditioning systems containing A2L refrigerants during a wildfire?**

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[2] Boussouf, Adam; Lecoustre, Vivien R.; Li, Hao; By, Robert; and Sunderland, Peter B., "Autoignition of R32 and R410 Refrigerant Mixtures with Lubricating Oil" (2014). International Refrigeration and Air Conditioning Conference. Paper 1555. http://docs.lib.purdue.edu/iracc/1555.

According to Boussouf, et al., the auto-ignition temperature of R-410A and R-32 are 790°C and 764°C, respectively.

3 MSDSs indicate that R-410A vapors may form explosive mixtures with air that may travel to ignition sources. Fire or intense heat may cause violent rupture of packages. The 2017 Honeywell MSDS indicates that this material can ignite when mixed with air under pressure and exposed to strong ignition sources and that containers may rupture on heating. https://msds-resource.honeywell.com/ehswww/hon/result/result_single_main.jsp?P_LANGU=E&P_SYS=1&C001=MSDS&C997=C100;E%2BC101;SDS_GB%2BC102;GB%2B1000&C100=E&C101=SDS_GB&C102=GB&C005=000000009881&C008=&C006=HON&C013=&

[4] A significant body of research into A2Ls and other flammable fluids including that completed by AHRI and NFPA. http://ahrinet.org/Resources/Research/AHRI-Flammable-Refrigerants-Research-Initiative

[5] Minimum Ignition Energy is the energy required to ignite a fluid. A low minimum ignition energy indicates that less energy is required.

Wildfires impact a refrigerant system on the outside of a building; typically, a condenser unit with a compressor containing oil and refrigerant. It has been estimated that wildfires burn at approximately 800° C to 1200° C or more. When exposed to this temperature range, the internal system pressure will rise and must be mitigated by a relief device to avoid a significant pressure rise. All air conditioning systems (AC) are required to have over-pressure protection for safety, thus refrigerant and oil will be released into the atmosphere and into the wildfire.

While not flammable at 60° C, even A1 refrigerants are combustible at these higher temperatures. R-410A (classified as A1) hot surface ignition temperature has been estimated at 790±10° C, and R-32 (classified as A2L) has been estimated at 764±10° C[6]. When just 1% oil is added, as found in all such AC systems, the same study determined that hot surface ignition temperatures are reduced by more than 120 Δ° C. The presence of oil in the refrigerant dominates the hot surface ignition temperature, so A2L refrigerants behave similarly to A1 refrigerants during a wildfire.

If R-32 were to burn in a fire, a 15 lb. charge would add the fuel equivalent of three pounds of dry firewood to the fire. Most homes would contain smaller charge sizes than 15 lbs.

7. **What are detectors and sensors?** In the UL 60335-2-40 safety standard, detectors and sensors describe the control systems located inside the equipment.[7] Compliance with the standard, approved in August 2019, requires specific control logic, testing and certification of the product if the refrigerant charge exceeds a certain threshold. If a specific concentration (less than 25% of the lower flammability limit or LFL) is detected, it triggers the mitigation system. For example, safety standards require that ventilation or other mitigation measures be initiated.

   More detail on the UL 60335-2-40 detector requirements can be found at this link: https://www.ul.com/news/understanding-ul-60335-2-40-refrigerant-detector-requirements

   a. Will homeowners have to respond to an alarm?
   There will be no alarm for building occupants to respond to. The term "detector" for refrigerants is not meant to be the same as a smoke detector which would alarm in a household. "Detector and sensor" refer to the control system inside the equipment.

   b. Are detectors and sensors available for manufacturers?
   There are many refrigerant detectors listed in UL standards. Some equipment manufacturers have made them available for display.

   c. How do you have confidence that the control system in the equipment is functioning properly?
   Detectors are required to have a self-test routine that runs every hour to ensure that they are functional and are "fail safe," meaning that if detectors are not functioning correctly, the mitigation is initiated (e.g., turn on circulation and may require closing valves or other measures).

8. **Do A2L refrigerants give off more harmful chemicals than A1 refrigerants when they burn?**
   No, hydrofluoric acid (HF) is produced during combustion of all fluorocarbon refrigerants (including R-410A, R-22 and A2L refrigerants). They will all produce similar amounts of HF.

[6] Boussouf et al *Ignition of R-32 and R-410A Refrigerant Mixtures with Lubricating Oil* https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2554&context=iracc

[7] UL 60335-2-40, 3rd Edition. The 3rd Edition is currently undergoing a final editorial review as part of the CSA standards process and is scheduled for joint publication with CSA on November 1, 2019. https://www.ul.com/news/update-air-conditioning-safety-standards-hvac-equipment

Hydrochloric acid is produced during combustion for previous generations of A1 refrigerants with ozone depletion potential, such as R22, but it is not produced during combustion of HFCs like 410A or A2L refrigerants like R-32 which do not contain chlorine.

9. **Will the safety standard ASHRAE 15 allow hundreds of pounds of A2L refrigerant be located in a residence?**
   No, a typical charge of a residential air conditioning system is less than 15 pounds. ASHRAE 34 limits the amount of all refrigerant, including A1s and A2Ls, to the refrigerant concentration limits (RCL) based on its flammability and toxicity characteristics. Further, ASHRAE 15 requires products (equipment) to be listed.

10. **Are A2L refrigerants just a phase? Will newer A1 refrigerants be made available and will the industry need to wait?**
    Today, over 80% of new vehicles sold in the United States contain an A2L refrigerant.[8] Just like the AC industry, the automotive industry worked to ensure that safety issues were addressed and to make the transition seamless to end-users.

    They are used in window, room and automotive air conditioners in the U.S., as well as in mini splits, variable refrigerant flow, chillers, hot water heaters and other products around the world. In 2018, 26 million A2L HVAC-R units were sold throughout the world in homes and businesses.[9]

    Refrigerant molecules with reduced numbers of fluorine atoms generally have lower GWP, however, that leaves more hydrogen atoms, which increases flammability. There are no feasible options, other than A2Ls that are ASHRAE-listed, for products that use refrigerants like R-410A that have low toxicity, are non-corrosive and have high efficiencies.

11. **Is training ready for the use of A2L refrigerants?**
    Yes, some equipment manufacturers report that they have training ready for technicians. Other countries have also made A2L refrigerant training available. For example, Australia has an extensive program.
    Since new A2L systems are not commercially available in some systems within the U.S., many contractors have not received training.

    Finally, building codes need to be upgraded and approved so that those building code requirements can be incorporated into training for the installation industry. This will also encourage contractors and installers to participate in training and certification classes.

    a. **What compelling evidence shows that technicians can install and maintain systems using A2L refrigerants?**

    Plumbers and HVACR technicians install millions of systems using propane and natural gas every year. Boilers, water heaters, gas stoves, dryers and generators have been installed in millions of homes around the country. These skilled tradesmen have proven that they are highly capable at installing and maintaining systems using highly flammable fluids for many years.

[8] The Chemours Company *Service demand for R-1234yf is growing rapidly. Are you prepared?* https://www.chemours.com/Refrigerants/en_US/uses_apps/automotive_ac/SmartAutoAC/assets/downloads/opteon-yf-infographic.pdf

[9] E-Jarn *The Global R32 AC Market – 2018 Overview* 7/1/19 https://www.ejarn.com/detail.php?id=58679&l_id=

Also, it should be noted that training and licensing have already been implemented internationally. In Australia, the transition to A2Ls occurred quickly due to the carbon tax. Over half of the air conditioning equipment has transitioned to A2Ls in Australia within six years, with no reported safety incidents including 35 models like those used in the U.S.[10]

The AHRI Safe Refrigerant Transition Task Force (Task Force) conducted an analysis of topics that should be included in the training program for technicians. The Task Force found no gaps in the information available needed to create training programs. However, the Task Force concluded that it would be helpful if the information were compiled with a uniform format for ease of use.

b. **Do technicians need "spark-proof tools"[11] to work on systems containing A2L refrigerants?**
No, the installation of A2L equipment uses the same types of tools as the installation of A1 refrigerants. Spark-proof tools are not required because the minimum ignition energy (MIE) for A2L refrigerants is considerably higher than the energy of a static spark. An open flame or high energy source is required to ignite an A2L.

c. Will these new low GWP refrigerants require the use of complicated new lubricating oils?
Although the oil is specific to the refrigerant, as it is today, in most cases these new refrigerants use polyolester oils like R-410A.

d. Will I able to retrofit my old R-410A/R-22 units with these new A2L refrigerants?
No. 2L or any flammable refrigerant should not be used in the equipment that was not designed for that use.

12. **Does additional research need to be completed before safety standards are adopted into building codes? Why is there additional research for A2L refrigerants?**
Sufficient research has been completed to update safety standards. Over the last decade, nearly $7 million dollars in research investment has been funded by AHRI, ASHRAE, Department of Energy, and the California Air Resources Board, working together to research low-GWP refrigerants with respect to safety. Just like smoke detectors which have been in use for decades, the science and engineering community will continue to research ways to improve systems related to A2Ls. Some of the additional research for A2L refrigerants will provide more detailed information (especially for smaller companies) to optimize their systems. For example, although there are control systems available, it may be helpful to compare differences between them to assist in the selection and design process.

Other research is underway to summarize available data regarding combustion products to better respond to requests for that data.

13. **Is the standard for testing and listing A2L equipment complete?**
Yes, there are multiple standards used for testing and listing A2L equipment. The 3rd edition of the safety standards, UL/CSA 60335-2-40, containing many safety requirements for A2L refrigerants, was approved on August 26, 2019 by a vote of the UL Standard Technical Panel.[12] The standard will be published on

[10] Refrigerants Australia. https://www.refrigerantsaustralia.org/
[11] "Spark-proof tools" are used with highly flammable refrigerants like propane. They are made of metals such as brass, bronze and other materials to reduce the risk of ignition.
[12] Update on the Air-Conditioning Safety Standards for HVAC Equipment, September 20, 2019. https://www.ul.com/news/update-air-conditioning-safety-standards-hvac-equipment.

November 1, 2019.[13] It is based on the International Electrotechnical Commission (IEC) Standard, IEC 60335-2-40, 6th edition that was updated in 2018. The IEC standard is in wide use in Europe where the conversion to low-GWP refrigerants is moving faster due to their refrigerant regulations.

a. Was the addition of A2L refrigerant requirements to ASHRAE 15 rushed?

The ASHRAE SSPC 15 took more than 10 years to complete the update of the standard to address A2L refrigerants. The committee was very diligent in addressing all of the issues regarding A2L refrigerants. There were multiple public reviews of the requirements before they were approved. Consensus was achieved for the updated 2019 edition of the standard.

b. Will there be any opportunity to make any additional changes?

Yes, ASHRAE 15 and UL60335-2-40 can be modified through the continuous maintenance processes. Even the suggested transition timing by the California Air Resources Board for year 2023 leaves time for additional modifications.

14. **Will R-410A still be available in California after the regulation goes into effect or will all refrigerant systems have to switch to lower GWP refrigerants?**

    In numerous stakeholder meetings with AHRI, the California Air Resources Board has stated that it is not their intention to make existing equipment obsolete by making R-410A unavailable for service in California. Parts for existing systems will still also be available. The proposed lower GWP limit would only apply to new installations.

15. **What are AHRI and HRAI doing to support this transition?**

    AHRI spent millions of dollars in research and leads the AHRI Safe Refrigerant Transition Task Force (Task Force), a body to assess readiness for the transition and address issues identified through that effort. The Task Force membership includes unions, fire service members, regulators, equipment manufacturers, refrigerant producers, training, contractor and technician organizations, standards setting bodies, environmental organizations and others.

    a. Is it too late to make changes to safety standards or regulations?

    No, the earliest transition in the U.S. is still years away. However, we can learn from the experiences of Australia and Europe, and about international air conditioning and refrigeration units and products that use flammable fluids like boilers, automobiles (A2L refrigerants), water heaters, and so on.

    b. How do I get involved in the AHRI Safe Refrigerant Transition Task Force?

    Visit the AHRI Safe Refrigerant Transition Task Force website at http://ahrinet.org/SafeRefrigerant.

The UL Standard Technical Panel is an ANSI consensus process; see more information on this process at www.UL.com/standards.

[13] Ibid.