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# Low GWP refrigerant compliance with UL Solutions



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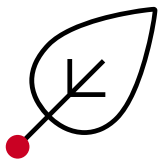
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## Ecofriendly refrigerants bring new challenges to the HVAC/R industry.

Hydrofluorocarbon refrigerants (HFCs) were once believed to be an environmentally friendly alternative to ozone-depleting substances like chlorofluorocarbons (CFCs). However, it was later discovered that HFCs also contribute to global warming because of their potential to produce greenhouse gases. Manufacturers are now working hard to scale back the use of HFCs as they develop systems equipped to safely handle the explosive characteristics of low global warming potential (GWP) refrigerants.

Several regulatory measures introduced worldwide are leading this shift to phase down the consumption and production of HFCs. These include the European Union Climate Target Plan, the American Innovation in Manufacturing (AIM) Act and the Kigali Amendment to the Montreal Protocol. These and other recent legislative and regulatory updates support a range of strategies aligned with the world's mission to fight global warming and reduce greenhouse gas emissions.





Through extensive research activities, we have learned that while low GWP refrigerants reduce greenhouse gas emissions, they come with a higher fire risk due to their mildly flammable nature. Leaks can occur due to many factors, including wear and tear, product defects and other damage, making it possible for nearby hot surfaces or electrical components to ignite escaping gas. This makes flammable refrigerant mitigation planning a critical part of the HVAC/R equipment development, assessment and certification process.

UL Solutions has conducted extensive research on flammable refrigerants, including a [landmark joint study](#) with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) investigating the hazards to fire service personnel when responding to events in occupancies with low GWP refrigerants. Our science-led advocacy for safety throughout the HVAC/R industry gains momentum through relationships with organizations such as [Eurovent](#), the American Society of Heating, Refrigerating and Air-Conditioning Engineers ([ASHRAE](#)), and [AHRI](#). Our leadership on various technical committees allows us to keep pace with emerging refrigerant industry requirements and global demands so we can provide clear guidance to HVAC/R appliance manufacturers.



## Global refrigerant landscape and regulation timeline

Our expertise and insights can help you keep pace with the phase-down of F-gases and the rapidly evolving global regulatory requirements of low GWP refrigerant adoption, such as:

### North America

- Established by the U.S. Environmental Protection Agency (EPA), the Significant New Alternatives Policy (SNAP) identifies ozone-depleting substances (ODS) and their health risks.
- The AIM Act (U.S.) proposes a nationwide phase-down in place of individual states enacting their own policies.
- The California Air Resources Board (CARB) has proposed a global warming potential (GWP) limit of 750 starting Jan. 1, 2023, for HVAC products; Jan. 1, 2024, for chillers; and additional requirements for refrigeration systems that went into effect in 2021.

### China

A direct result of the Montreal Protocol, the HCFC Phaseout Management Plan (HPMP), also called the Chinese Green Cooling Plan, is a program to phase out hydrochlorofluorocarbons (HCFCs).

### European Union

The EU adopted the F-gas Regulation to control emissions from fluorinated greenhouse gases, including hydrofluorocarbons. [Fit for 55](#) is a revision of the initial timeline that requires manufacturers to achieve a 55% reduction in greenhouse gas emissions by 2030 and become climate-neutral by 2050.



## Key elements of F-gases

Fluorinated gases are used in various household appliances and industrial applications. Unfortunately, while easier on the ozone layer, they could potentially contribute to greenhouse gases. F-gases have a [global warming effect](#) of up to 25,000 times greater than carbon dioxide (CO<sub>2</sub>), which is why the EU is taking regulatory action to phase them out. Some of the most common F-gases include:

Trade or common name	Global warming potential (100-year)
Hydrofluorocarbons (HFCs)	Up to 14,800
Perfluorocarbons (PFCs)	Up to 12,200
Sulfur hexafluoride (SF <sub>6</sub> )	22,800
NF <sub>3</sub>	17,200

## Common low GWP refrigerants

On the other side, ammonia (NH<sub>3</sub>), carbon dioxide (CO<sub>2</sub>) and hydrocarbons (propane or isobutane) are a few examples of low GWP refrigerants. These substances occur naturally and have a lower ozone depletion potential (ODP) than traditional F-gases.

**A1**  
Not flammable

 **A2L**  
Mildly flammable

 **A3**  
Flammable/explosive

- R32 and R454B are the two leading A2L refrigerant replacements for R410A, which is being phased out.
- Ammonia, CO<sub>2</sub>, and isobutane are only found in some refrigeration applications.
- Propane is an A3 (explosive) refrigerant and can only be used in very small charge amounts.
- Propane is used in some refrigeration applications such as grocery store reach-in coolers.

Refrigerant Name	Trade or common name	Global Warming Potential
R-744	CO <sub>2</sub>	1
R-290	Propane	4
R-600a	Isobutane	5
R-1234yf	HFO-1234yf	4
R-1234ze	HFO-1234ze	<1
R-152a	HFC-152a	124
R-124	HCFC-124	609
R-32	HFC-32	675
R-452B	HFC-45B	675
R-454B	Opteon™ XL41	466

# Key Standards for the HVAC/R industry

To support your compliance when redesigning HVAC and refrigeration systems for use with flammable refrigerants, it's important to understand the key standards and regulations that govern them.



# Access to North America



## UL 60335-2-40 Ed. 4

UL 60335-2-40 describes the requirements for electrical heat pumps, air conditioners and dehumidifiers, and is an ANSI/SCC-accredited U.S./Canada bi-national consensus safety standard. It's based on IEC 60335-2-40, the international standard currently serving as the basis for the evaluation, testing and certification of HVAC equipment designs using low GWP refrigerants in Europe and elsewhere.

After Jan. 1, 2025, the American Innovation and Manufacturing (AIM) Act will prohibit the manufacturing and importing of products containing refrigerants and blends with a GWP of greater than 700. All A2L products shall undergo evaluation to UL 60335-2-40.



## UL 60335-2-89 Ed. 2

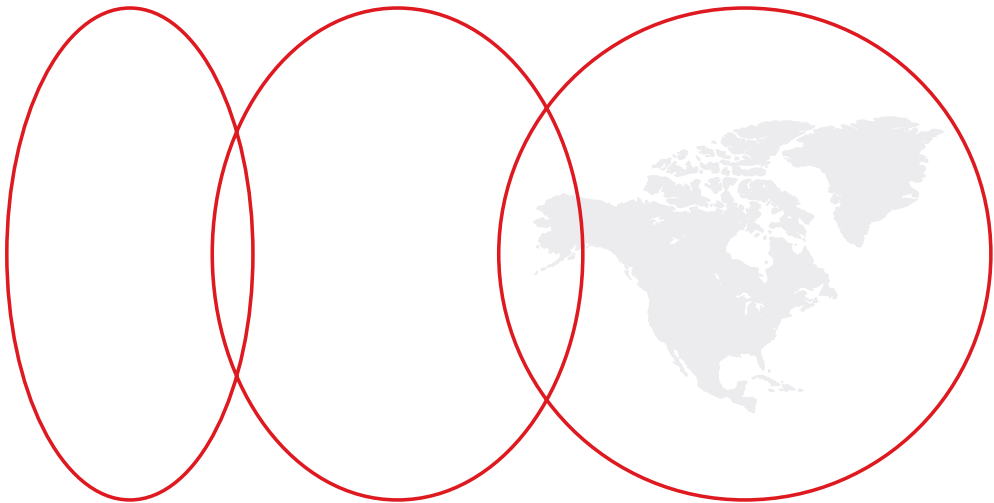
UL Solutions recently transitioned to the new harmonized Standard UL 60335-2-89, the Standard for Safety for Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances and Ice-Makers with an Incorporated or Remote Refrigerant Unit or Motor-Compressor, which covers the following refrigeration Standards:

- UL 412, the Standard for Refrigeration Unit Coolers
- UL 427, the Standard for Refrigerating Units
- UL 563, the Standard for Ice Makers
- UL 471, the Standard for Commercial Refrigerators and Freezers

The latest version of UL 60335-2-89 is harmonized with the International Electrotechnical Commission (IEC) and covers all current market changes, easing global market access and simplifying testing for manufacturers.

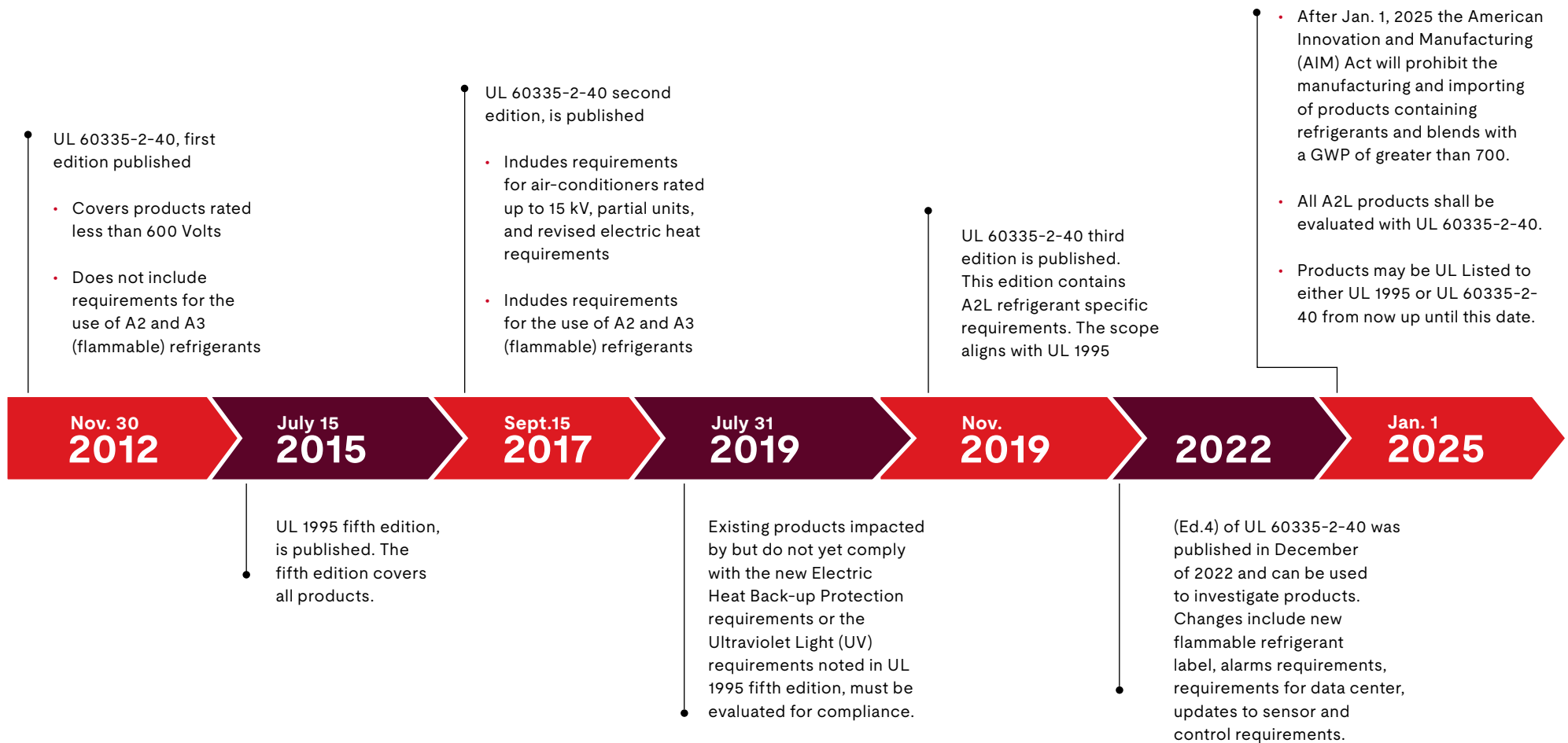
Currently, manufacturers may have UL 412, UL 427, UL 563, and UL 471 certified products evaluated to UL 60335-2-89. UL 412, UL 427, UL 563, and UL 471 remained valid certification Standards through Sept. 29, 2022. Thereafter, they became obsolete and are no longer used to certify new products. This timeline also applies to products currently certified to UL 1995, the Standard for Heating and Cooling Equipment, but are not in the scope of UL 60335-2-40 (such as condensing units for refrigeration or chillers used in non-comfort-cooling applications).

After Jan. 1, 2026, the American Innovation and Manufacturing (AIM) Act will prohibit the manufacturing and importing of products containing refrigerants and blends with a GWP of greater than 300. All A2L products shall undergo evaluation to the latest edition of UL 60335-2-89.



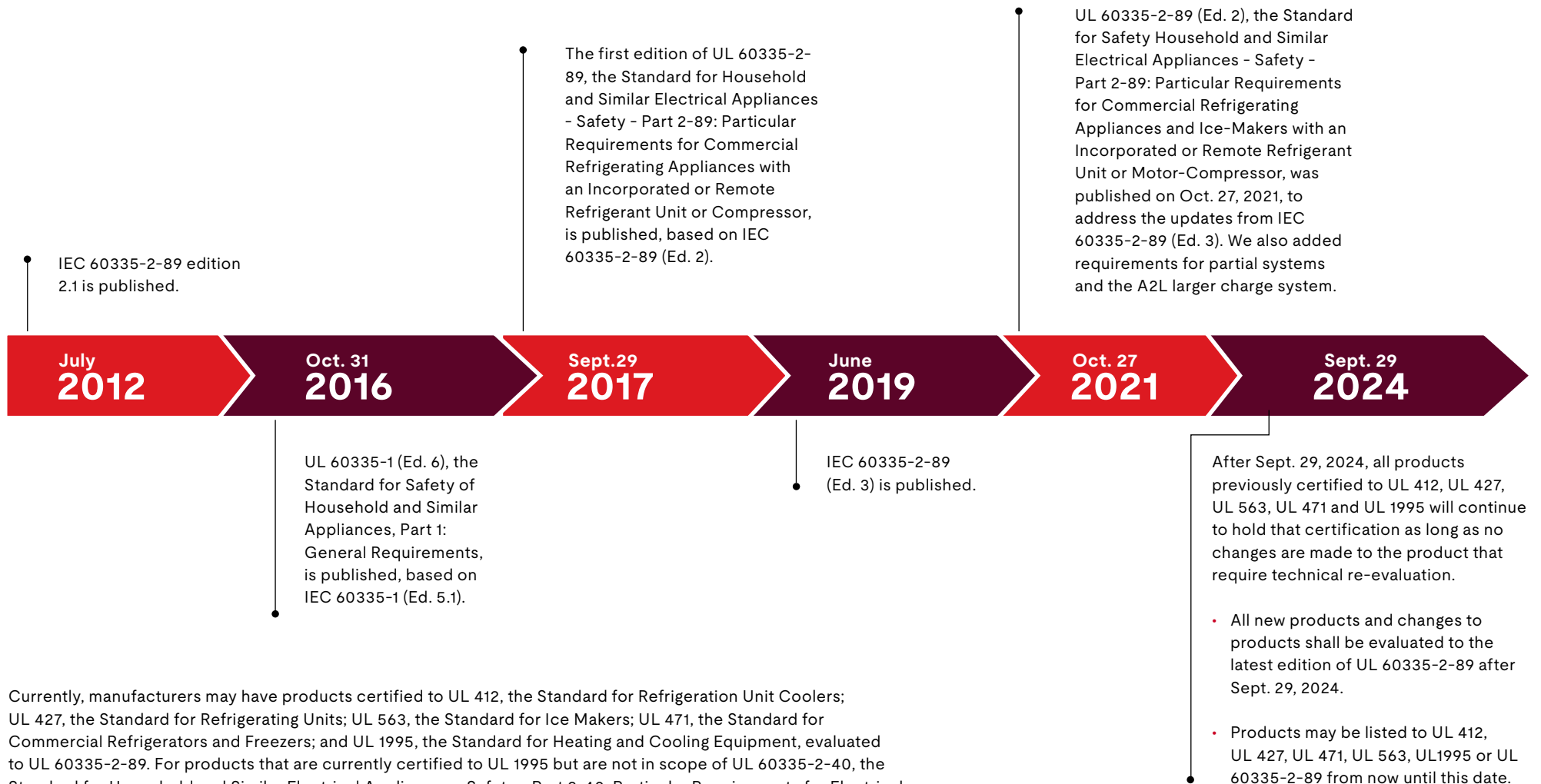


# UL 1995 Transition to UL 60335-2-40



Currently, manufacturers may have UL 1995 Certified products evaluated to UL 60335-2-40. UL 1995 will remain a valid certification standard through January 1, 2025. At that time, UL 1995 will no longer be used to certify new products.

# UL 412, UL 427, UL 471, UL 563, UL 1995 transition to UL 60335-2-89



Currently, manufacturers may have products certified to UL 412, the Standard for Refrigeration Unit Coolers; UL 427, the Standard for Refrigerating Units; UL 563, the Standard for Ice Makers; UL 471, the Standard for Commercial Refrigerators and Freezers; and UL 1995, the Standard for Heating and Cooling Equipment, evaluated to UL 60335-2-89. For products that are currently certified to UL 1995 but are not in scope of UL 60335-2-40, the Standard for Household and Similar Electrical Appliances - Safety - Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers, such as condensing units for refrigeration or chillers used for process applications (e.g., non-comfort cooling), this timeline also applies.

# Access to Europe and the U.K.

## European directives and CE marking

### CE marking

Special precautions are required when using flammable or mildly flammable refrigerants. The following directives are the most common requirements for HVAC/R products:

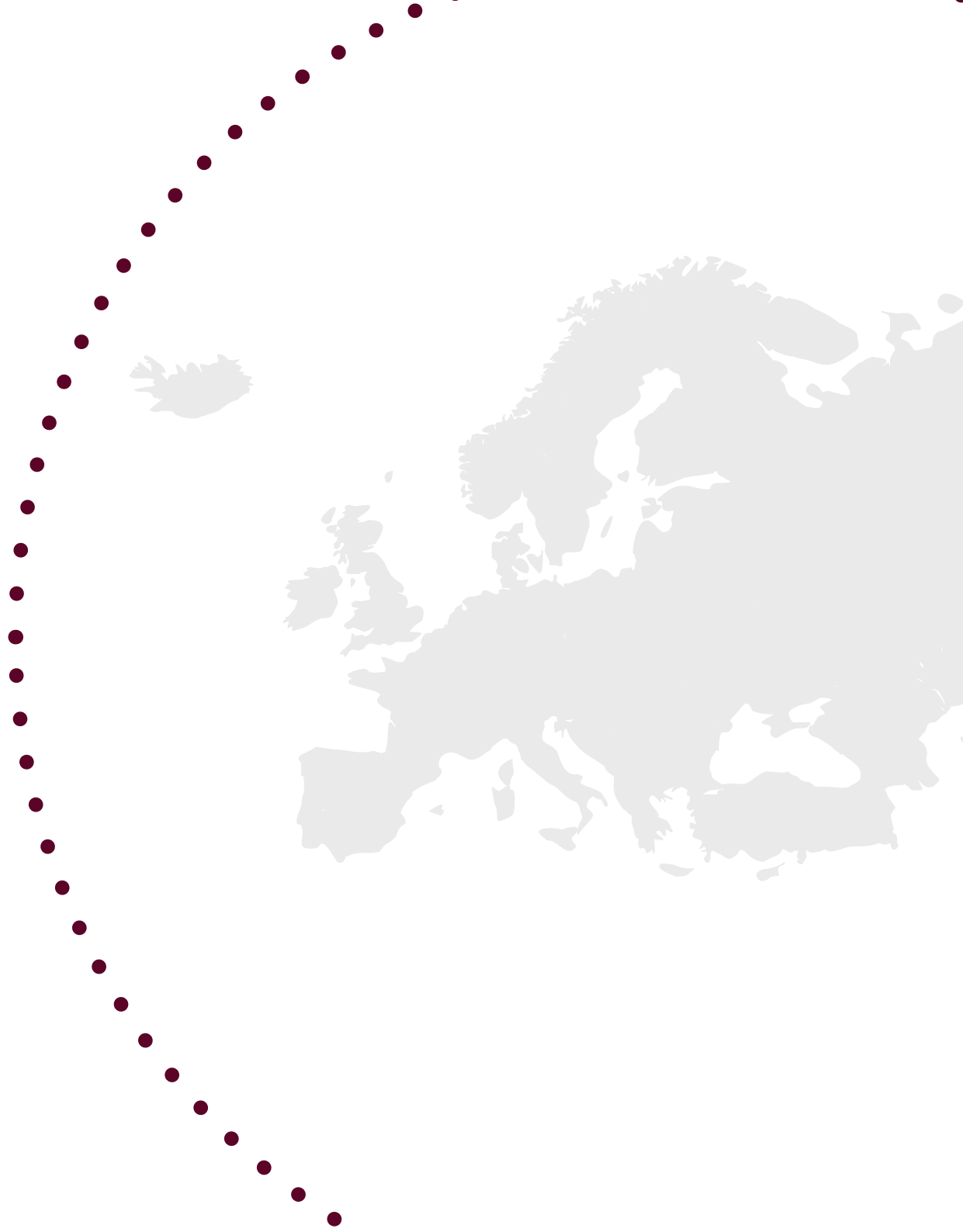
- Low Voltage Directive (LVD 2014/35/EU)
- Machinery Directive (MD 2006/42/EC)
- Equipment for potentially explosive atmospheres (ATEX 2014/34/EU)
- Pressure Equipment Directive (PED 2014/68/EU)

## UK regulations and UKCA marking

### UKCA marking

Special precautions are required when using flammable or mildly flammable refrigerants. The following directives are the most common requirements for HVAC/R products:

- Pressure Equipment (Safety) Regulation 2016
- Supply of Machinery (Safety) Regulations 2008
- Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 UKSI 1107:2016



# Access to Europe and the U.K.

CE marking 

## Machinery Directive

### Key points:

- When a potentially explosive atmosphere is present, machinery must comply with ATEX and the provisions of specific community directives.
- Machinery must be designed and constructed to avoid the risks of overheating and fire.
- Gases, liquids, dust, vapors and other substances produced or used by the machine can cause an explosion without proper safeguards.

## ATEX Directive

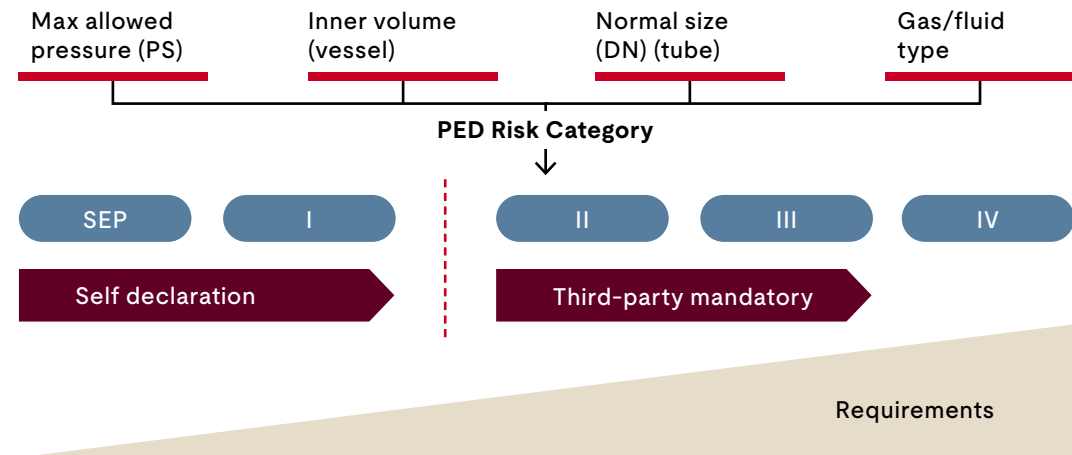
### Key points:

- Under the ATEX Directive, equipment, protective systems and components intended for use in potentially explosive atmospheres must comply with specific product requirements.
- Protective systems and equipment intended for use in potentially explosive atmospheres can still explode. While rare, these accidents usually result from fuel leakage.
- As a rule, potentially flammable equipment should not be used in potentially explosive atmospheres.

## PED Directive

### Key points:

- The Pressure Equipment Directive (PED) is a mandatory European Union (EU) regulation covering conformity assessments for the design and manufacturing of pressure equipment and assemblies with a maximum allowable pressure greater than 0.5 bar or 7.25 pounds per square inch.
- PED compliance is part of EU CE conformity, and access to the European Economic Area (EEA) requires both.
- UL Solutions is an accredited notified body that provides conformity assessment services and UKCA accreditation support.





# International Standards



## IEC 60335-2-40 Ed. 7.0

Revised to accommodate the use of A2L refrigerants, this standard covers electrical heat pumps, air conditioners and dehumidifiers. The latest update includes limits on the amount of refrigerant each type of appliance may contain, reducing the risk to workers and consumers.

### Latest updates:

- Annex GG sets charge limits and requirements for ventilation and secondary circuits, including A2L refrigerants. In particular, it provides guidance on applying these criteria when calculating how much ventilation is necessary according to the installation space and refrigerant charge used.
- Clause 22 makes charge limit exceptions for appliances with multiple refrigerating systems. It also revises the requirements for avoiding ignition sources, leak detection systems, safety shut-off valves and particle foam material.
- Annex LL requires refrigerant leak detection systems to have pressure sensors and control logic electronics that activate the evaporator fans and disperse refrigerant in the event of a leak.
- Annex MM mandates a refrigerant sensor location confirmation test to demonstrate its ability to detect refrigerant leaks in the location specified by the equipment manufacturer.
- Annex P intends the verification of the entire detection system (not only the sensor location) and it measures the time from the start of the leak to the mitigation.



## IEC 60335-2-89 Ed. 3.0

This standard applies to commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor. The latest revision fully enables the use of A2L refrigerants and increases the maximum charge limit for A3 refrigerants (R290) without adding additional safety measures from 150 g to 500 g.

### Latest updates:

- Clause 22.110 removes charge limits for appliances with multiple refrigerating systems and revised requirements for avoiding ignition sources, leak detection systems, safety shut-off valves and particle foam material.
- Annex CC is a test method for determining gas concentration beyond the boundary of the appliance. Aging motors and appliances must pass Annex CC testing, and in cases of doors/drawers, it includes a door opening test.



## How UL Solutions can help

Testing by a third-party like UL Solutions plays a critical role in minimizing life and property risks. Our expertise integrates and advances sustainability broadly across our customers' business portfolios, helping to deliver on ESG goals and meet growing consumer demand for safer, more sustainable products and practices.

Flammable refrigerant testing and certification with an independent third-party helps evaluate whether or not products meet applicable safety and public use requirements. Learn how to comply with the latest regulations and get training on critical standards, all in a laboratory environment with risk assessment support.

Third-party testing helps manufacturers keep pace with the current requirements and supports adherence to warranties and other contractual obligations. UL Solutions provides a full range of services for HVAC/R products, including expertise in refrigerants and facility certification. We can help you choose the ideal alternative refrigerants for your specific application so that you can meet current regulations and compete in the global marketplace.



# How UL Solutions can help

## Product testing and certification services

**We can provide advisory, testing and certification services according to the following standards:**

- UL/IEC 60335-2-24, the Standard for Household and Similar Electrical Appliances – Safety – Part 2-24: Particular Requirements for Refrigerating Appliances, Ice-Cream Appliances and Ice-Makers
- UL/IEC 60335-2-34, the Standard for Household and Similar Electrical Appliances – Safety – Part 2-34: Particular Requirements for Motor-Compressors
- UL/IEC 60335-2-40, the Standard for Household and Similar Electrical Appliances – Safety – Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers
- UL/IEC 60335-2-89, the Standard for Safety for Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances and Ice-Makers with an Incorporated or Remote Refrigerant Unit or Motor-Compressor

## Regulatory training and advisory

**Our low GWP advisory and training services include:**

- Flammable refrigerant basics and mitigation techniques
- Component qualification
- Recent adaptations of flammable refrigerant requirements
- Pressure Equipment Directive (PED) for compressors and refrigeration pressure vessels
- Training for laboratory technicians on proper use and hazards of flammable refrigerants
- Global regulatory advisory for systems containing flammable refrigerants

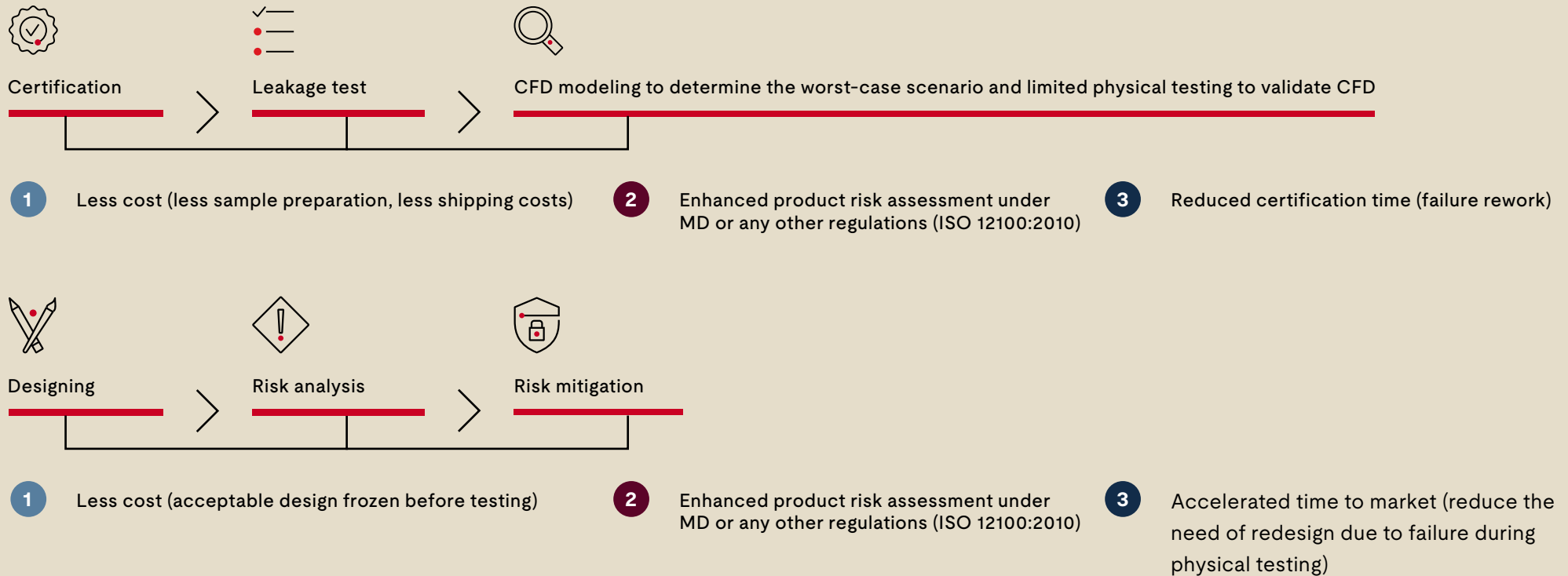


# How UL Solutions can help

## Computational fluid dynamics (CFD) modeling

Flammable refrigerant modeling supports physical testing and gives you a more complete picture of potential risk. CFD evaluates all possible scenarios and quantifies the fire risk due to combustible refrigerant gas leakage in a confined space. It involves tracking the volume of gas between the upper and lower flammability limits, then applying CFD software to demonstrate how the risk metric changes depending on differences in the details.

### Benefits:





# How UL Solutions can help

## A2L refrigerant system components certification

The use of A2L hydrofluoroolefin (HFO) blends and the introduction of flammability risk requires care in the selection of components to help ensure that the components are Flame Arrest-Protected.

To help ease the burden of safety compliance, we've developed a new category for certified refrigerant components called Flame Arrest Protected Components for Use in Refrigeration and Air-Conditioning Equipment Employing A2L Refrigerants.

This offering specifically addresses the need for a balanced approach to certification, provides critical material/design traceability without the need for full hazardous location (HazLoc) certification, and is more robust than a letter of test results. This approach is quicker, more cost effective and helps keep intellectual property private.

[Learn more](#)

## Performance services

**We can also provide HVAC/R benchmarking services when transitioning to low GWP refrigerants:**

- Advisory services
- Preliminary refrigerant leak testing
- Component testing
- Full-scale release testing
- Evaluation of mitigation techniques in the presence of refrigerant
- Fatigue pressure test





## Summary

### **We work at the cutting edge of technology**

Working with innovations across industries means we know how to adapt our services to novel products, emerging fields and evolving regulations. Our independent safety science leadership, technical expertise and international network of testing laboratories help manufacturers in the HVAC/R industry demonstrate compliance with the latest regional safety standards for low GWP refrigerants in their target markets.

We are constantly advancing testing that keeps up with the fast pace of technological innovation. With our command of emerging safety risks, we help enable businesses of all kinds to increase the interconnectivity of products, services and people — safely and securely.





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