THE NEED FOR SMARTER STANDARDS AND CODES IN COOLING

EXECUTIVE SUMMARY

Several safety standards and building codes are blocking the uptake of low global warming potential (GWP), energy efficient alternatives to hydrofluorocarbon (HFC)-based cooling around the world. This briefing provides an introduction and overview of some key standards organizations with respect to refrigeration and air conditioning (RAC), how they are impacting the commercialization of low-GWP alternatives, and how these standards can be modified to both allow greater use of natural refrigerants and continue to protect human health and the environment. Smarter standards that allow for safe use of low-GWP alternatives should be based on valid assumptions backed by rigorous research and data and take into account the full range of modern safety technologies and warning systems.

STANDARDS AND CLIMATE AMBITION UNDER AN HFC PHASE-DOWN

Most refrigerants used today are synthetic fluorinated super-greenhouse gases called hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), which are hundreds to thousands of times more damaging to the climate than carbon dioxide (CO_2). In November 2015, the 197 countries of the Montreal Protocol agreed to negotiate an agreement to adopt a global phase-down of HFCs in 2016. An ambitious phase-down could avoid 100 $GtCO_2$-equivalent HFC emissions by 2050 with up to an additional 100 $GtCO_2$ through potential energy efficiency improvements[1] and prevent 0.5 degrees Celsius of warming by 2100.[2] Several developing countries are looking to leapfrog HFC use altogether as they phase-out HCFCs.

Standards and standards-making bodies are a critical link to making low-GWP alternatives available for public and enabling countries to leapfrog HFCs. These standards, developed by industry, not the governments, set the rules for practically every safety and quality aspect of designing, testing, and installing any

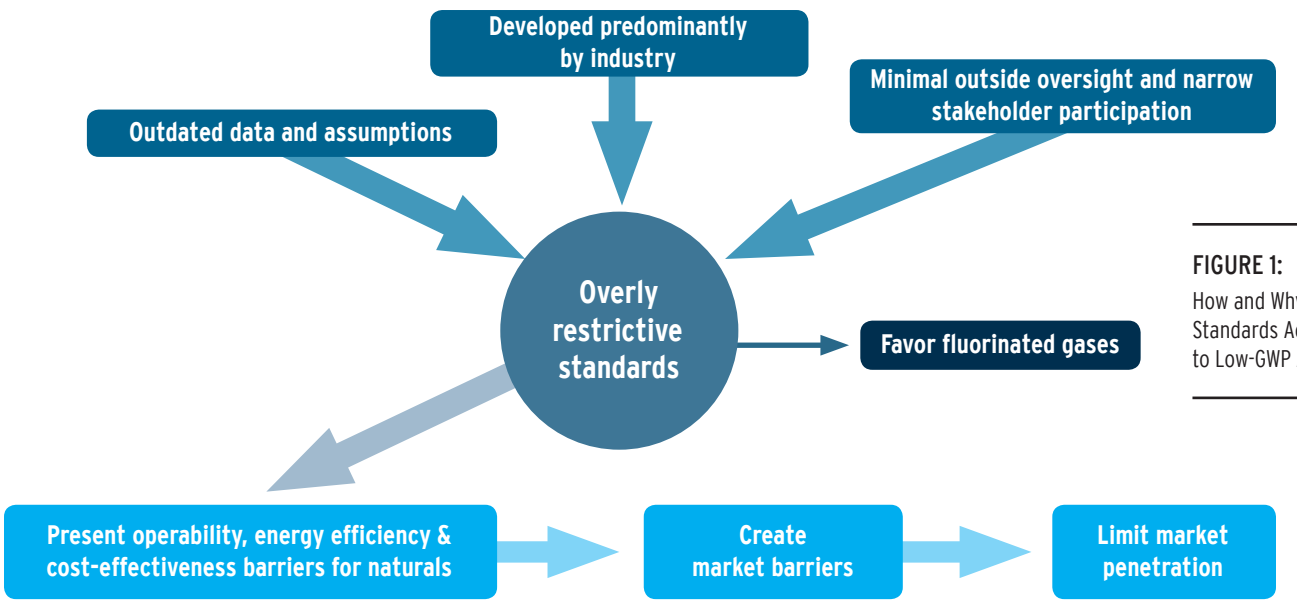


FIGURE 1:
How and Why Many Standards Act as Barriers to Low-GWP Alternatives

product sold. This includes what kind and how much refrigerant can go into any type of domestic, commercial or industrial equipment that uses a refrigerant. Standards are supposed to ensure that the products we buy are safe and do not pose an unreasonable risk to human health or the environment. Yet many current standards governing low-GWP alternatives are outdated and are acting more as false barriers rather than constructive facilitators to an HFC-free world.

Standards can be used as barriers to competition if they impose overly restrictive measures and requirements. Many of the RAC standards are based on outdated assumptions and old technologies that do not take into account advances in technology, safety devices and warning labels. In many cases, safety risks of flammability, toxicity, or high pressure of low-GWP refrigerants have been treated as an insurmountable barrier by narrow stakeholder groups. Narrow participation and outdated data and assumptions have led to standards that prohibit many systems using low-GWP alternative refrigerants, particularly natural alternatives such as hydrocarbons, CO_2, and ammonia from entering the market. Historically though, natural refrigerants have been used in several applications especially refrigeration, for several decades prior to widespread uptake of fluorochemicals.

KEY TECHNICAL ISSUES AND AREAS FOR ADDITIONAL EVALUATION

Charge Size Thresholds and Related Assumptions

Most refrigerants have properties such as flammability or toxicity, which can have certain risks if the refrigerant leaks from a piece of equipment. Certain refrigerants which have the least global warming impact, could be more flammable or toxic when compared as such to climate damaging HFCs. With flammable refrigerants in particular, limiting the amount of refrigerant used in a given type of equipment, or the charge size, is one way that standards seek to mitigate the risk of a fire or explosion. The amount of refrigerant allowed, or allowable charge size, is based on assumptions about how much refrigerant would leak from a given system that would result in it accumulating and becoming concentrated enough that it would ignite in the presence of an ignition source. This concentration is known as the *lower flammability limit (LFL)*.

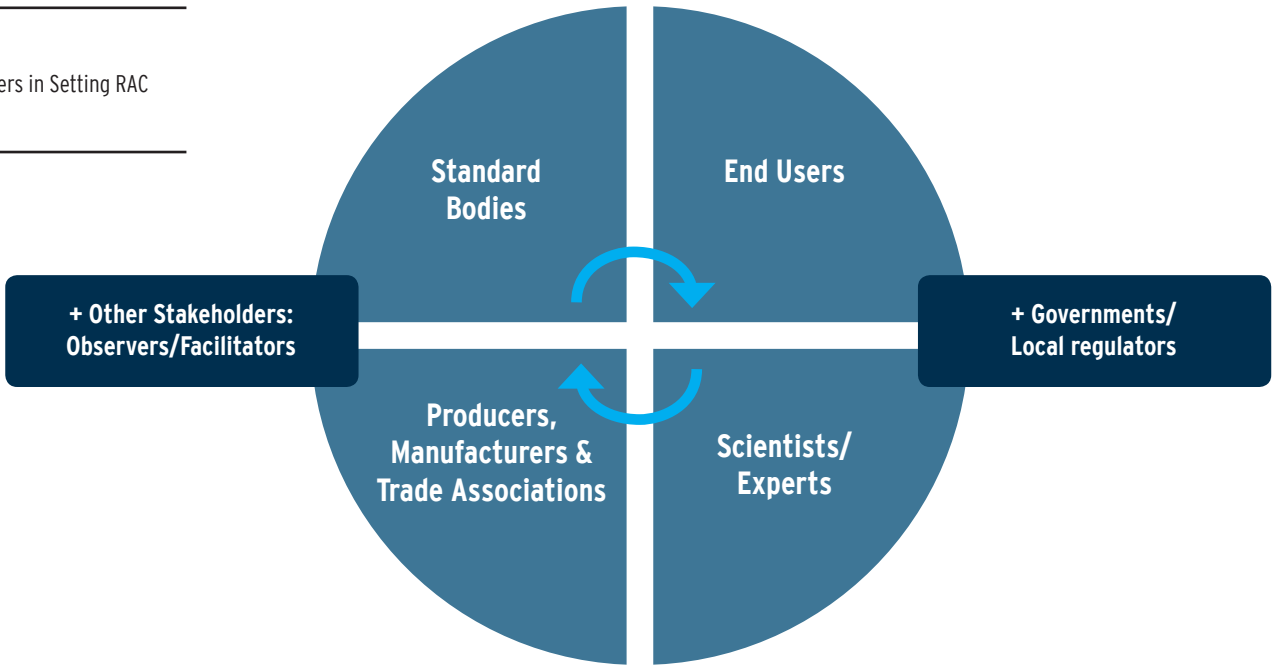
Many assumptions underlie the equation for a charge size threshold that determines the amount of refrigerant considered safe. Some current standards fail to address these assumptions in a rigorous manner, and also fail to take into account other mitigating factors and safety measures that could allow for more refrigerants to be placed in an equipment.

Evaluating Assumptions and Additional Safety Measures

Evaluating some of the fundamental assumptions and safety measures can have a major bearing on the charge size that can be considered safe. These assumptions are related to the

i) refrigerant itself, ii) the frequency, rate, and size of refrigerant leaks, and iii) the design, manufacturing, and installation requirements for the piece equipment. Evaluating these and other assumptions and safety measures in revised standards would help permit larger charge size thresholds that are both safe and allow for greater commercialization of low-GWP refrigerants:

FIGURE 2:
Key Stakeholders in Setting RAC standards



- **Leak rates:** Current formulas based on the assumption of the entire refrigerant charge leaking in under four minutes are overly conservative based on limited outdated knowledge and research. Informal tests with small sized holes typically encountered in normal HVAC servicing and repair have shown that 60-90% of the refrigerant remains in the unit after four minutes. These studies should be replicated under controlled conditions that incorporate more accurate parameters for leak rates and quantities are incorporated into charge size equation parameters.
- **Leak detection and shut-off valves:** The use of leak detection and automatic shut-off valves can be used to limit the amount of refrigerant that leaks from a unit. Under these circumstances a greater charge size of hydrocarbons could be used without risk of flammability.
- **Airflow and fans:** Influence of local airflow in a room, or on the equipment from a fan that turns on as a result of a leak being detected, can significantly reduce the chance that concentration of the refrigerant leaked will reach the LFL.
- **Location of parts and components:** The location of key components such as compressors and evaporator where a leak is more likely to occur can influence likelihood of a leak. Window AC units, for instance may be designed so that certain parts are only exposed to the outside ruling out the risk that a leak in that part would enter the room.
- **Leak tightness testing:** Manufacturing requirements such as strength pressure tests, and tests for impacts of vibration, corrosion, cycling, long-term use and other factors can be used to reduce the chances of leaks.

By making overly conservative assumptions that lack basis in evidence based research and testing, and by not accounting for safety measures and technologies, current standards are setting charge size thresholds that are too small for many flammable refrigerants to be used, thereby preventing wider market uptake of alternatives to HFCs.

KEY STAKEHOLDERS IN STANDARDS SETTING

In case of refrigeration and air conditioning equipment, narrow stakeholder participation and limited external oversight on key standards setting bodies has tended to restrict charge sizes thereby favoring technologies that use synthetic fluorinated refrigerants. Effective standard setting can best be achieved with consistent and active participation from various relevant stakeholders at all stages of the standard-setting lifecycle. Participation, inclusiveness and transparency allow for continuous improvement of standards through incorporation of new scientific research and best practices. Given the need for significant resources and expertise to develop national standards, that many developing countries might find challenging, it is important to allow for broad participation in the standards bodies that exist.

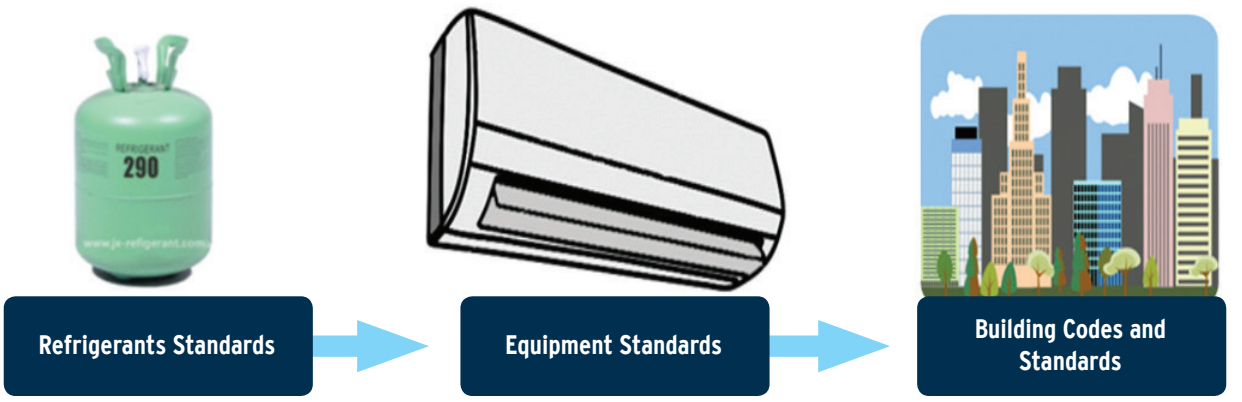
KEY TYPES OF STANDARDS AND CODES

Three key types of standards and codes most relevant to commercialization of low-GWP alternatives are:

i) Refrigerant standards are typically required for a refrigerant to be made commercially available and include an evaluation and classification of the refrigerant based on its properties, such as flammability and toxicity.

FIGURE 3:

Key Types of Standards and Codes (Includes key types of standards pertinent to this briefing. Additional standards and codes relevant to production, manufacturing, containers, transport and storage exist that are outside the scope of this briefing.)



ii) Equipment standards are those where charge size thresholds and other safety requirements are specified for a given type of equipment such as a window air conditioner, a domestic refrigerator, or even an industrial chiller.

iii) Building codes and standards include building codes, fire codes, and electrical codes and place requirements on where and how certain equipment (using a flammable or toxic refrigerant) can be installed and used. For instance, a code may require systems over a certain capacity or size using a toxic or flammable refrigerant be placed in a machinery room, a confined space to be accessed by trained technicians and which must meet certain requirements such as proper ventilation and leak detection equipment.

All three types are interlinked and rely on many of the assumptions made in the others. The following section on specific standards setting bodies focuses primarily on equipment standards where most charge size limitations are enshrined, however other important standard and codes bodies exist that are not fully covered in the scope of this briefing.

OVERVIEW OF RELEVANT STANDARDS SETTING BODIES AND PROGRESS

This section provides an overview of key global, regional, and national standards setting bodies, their internal structure and governance. Due to lack of formal connections between and within international, regional and national standardization bodies, how these standards and groups are impacting low-GWP alternatives varies and is summarized individually. For a broader list of relevant standards bodies refer **annex 1**.

Global Standards Organizations

International Electrotechnical Commission (IEC)

The International Electrotechnical Commission (IEC) is the most important international forum for setting safety standards that are widely followed and adopted by many countries' national standards organizations. While IEC standards are still too conservative with regard to hydrocarbons for many equipment types, key bodies described below are beginning to address the issue of flammability by re-evaluating many assumptions and incorporating additional safety technologies. The key IEC bodies are:

i) Technical committees (TC) and Sub-committees (SC): TCs are organized by type of equipment and are the primary bodies that carry out the work of reviewing and approving new standards by way of a vote. If TCs find their scope of work is too broad, they can form sub-committees (SCs) to focus on specific areas.[3]

ii) Working Groups (WG): WGs are formed under TCs and SCs to address specialized technical challenges or issues. Specialized experts are tasked with reaching consensus on proposals to the TC or SC for modifying standards to address the topic assigned to them.

iii) National Committees: The IEC's standard-setting process allows for broad and equal representation of countries to participate through their own self-appointed representatives of their National Committees on the key bodies that proposed and approve new standards.

Status of Key IEC Standards and Working Groups

IEC's sub-committees (SCs) on both refrigeration and air conditioning have dedicated working groups on both air conditioning and refrigeration that are evaluating the issue of flammability, charge size limitations, and additional safety technologies and measures. Following is a summary of the key working groups and their progress:

TC61: Household and similar electrical appliances

i) SC61C: Refrigeration

TABLE 1:
Summary Table of Relevant International Standards-making Organizations

Standard	Technical Committee	Area Covered
International Electrotechnical Commission (IEC)		
IEC 60335-2-40	IEC SC 61D WG9 WG16	AC - Appliances for air conditioning for household and similar purposes Amendment for A2L refrigerants Amendment for A2 and A3 refrigerants
IEC 60335-2-24	IEC SC 61C	Domestic refrigerators
IEC 60335-2-89	IEC SC 61C WG4	Commercial Refrigeration Amendment for flammable refrigerants
International Organization for Standardization (ISO)		
ISO 5149	ISO TC86 SC1 WG1	Refrigeration & AC – safety Revision of ISO 5149

Working Group 4: Particular requirements for commercial refrigerating appliances[4]

This working group is tasked with defining the maximum flammable refrigerant amount (or charge size) for commercial refrigerating appliances under Part 2 -89 of the IEC standard: IEC 60335-2-89. Currently, the standard allows up to 150 grams of flammable refrigerants, but several proposals have been made under this working group to increase the charge size limit to between 300 grams to up to 1 kilogram, when equipment is installed and designed according to certain requirements. These proposals are being evaluated and compared with the goal of reaching a consensus to modify the standard in 2017. These proposals, if passed, would allow use of flammable low-GWP alternatives such as hydrocarbons in a much wider range of commercial refrigeration system capacities and configurations and make these systems more cost-effective.

ii) SC61D: Air Conditioning

Working Group 16: Address A2 and A3 refrigerants

This WG is tasked with addressing and developing additional requirements for A2 and A3 refrigerants (flammable refrigerants) taking into account charge limits, dilution, circulation, ventilation requirements and additional mitigation measures. WG16 was formed in 2015 and is expected to complete its work within two to three years to develop a proposal to modify the standard to allow for larger charge sizes and broader use of flammable refrigerants in residential and light commercial air conditioning systems such as self-contained and split air conditioning units.

Regional Standards Organizations

The European Committee for Standardisation (CEN) and the European Committee for Electrotechnical Standardization (CENELEC)

National Standardization Bodies of 33 European countries come together under CEN to develop European Standards and other technical documents on various types of products, materials, services, and processes. CENELEC prepares voluntary standards and closely collaborates with the IEC.

Technical Committee CEN TC 182 on Refrigerating systems, safety and environmental requirements: is the primary body responsible for RAC standards.[5]

Council for Harmonization of Electrotechnical Standards of the Nations in the Americas (CANENA)

As a regional standards body, CANENA is the primary organization responsible for ensuring that harmonized standards are adopted in the United States, Canada, and Mexico. CANENA also establishes complimentary relationships with the IEC National Committees in these countries.[6] CANENA bodies also work closely with the key standards bodies and trade associations in member countries including the Canadian Standards Association (CSA), Underwriters Laboratories (UL), Association of Standardization and Certification (ANCE).[7]

The Technical Harmonization Committee: is the primary body responsible for technical work on harmonizing standards and initiating new standards development.[8]

Status of Key CANENA Standards

i) THC 61C Safety Requirements for Household Refrigerators & Freezers

The CANENA THC 61C on household refrigerators and freezers met in May 2016 to discuss the issue of increasing charge sizes for flammable refrigerants from 57grams under U.S., Canadian, and Mexico standards to harmonize with the IEC standard of 150 grams. This discussion was prompted following a vote of the standards technical panel of the U.S. standard UL250 to vote down a harmonization proposal that did not include charge sizes. No formal proposal to harmonize charge sizes with the IEC has yet been made to date to EIA's knowledge.

National Standards Organizations

Although many countries have their own national standardization bodies, the nature of such bodies varies greatly in terms of composition, linkages to national government, linkages to international standards bodies and level of modifications done when adopting international standards. We focus on the UL standards below, as manufacturers in several countries outside the United States follow these standards for market access.

Underwriters Laboratories (UL)

Underwriting Laboratories (UL) is an American based safety consulting and certification company that maintains offices in 46 countries. UL sets the standards followed by U.S. governmental agencies and the U.S. market. When approving new low-GWP substitute refrigerants, the U.S. Environmental

DEVELOPING COUNTRIES SEEK TO MODERNIZE RAC STANDARDS: A CASE STUDY FROM INDIA

In the absence of an established national safety standard for refrigerating systems, the Bureau of Indian Standards (BIS) committee had proposed the adoption of "ISO 5149: Refrigerating systems and heat pumps–Safety and environmental requirements" in 2015 as it was followed by Indian RAC manufacturers to meet requirements in the EU market. Stakeholders in India petitioned for a change in the standard that would allow Indian manufacturers to expand their production line to hydrocarbon air conditioning systems with higher cooling capacity than the restrictive ISO 5149. The BIS refrigeration and air conditioning committee consequently formed a panel which is now considering amendments to refrigerant standards suited to Indian conditions developed nationally.

Protection Agency frequently references and incorporates UL standards in the technical basis of its risk evaluations on flammability and other safety issues. UL standards are more conservative than their IEC equivalents and are significantly impeding U.S. market competition of low-GWP alternatives, and hydrocarbons in particular.

The key bodies under UL are:

i) Standards Technical Panel (STP): The primary body responsible for development and revision of a standard for a certain equipment type. STPs allow voting representation of different interest categories including producers, supply chain, local regulators and code officials (AHJ), government representatives, consumers, commercial or industrial users, international delegates, and general interest members such as academics, scientists, trade associations and non-governmental organizations.[9]

ii) Task Group: A group appointed by UL to address a specific topic of problem.[10]

Status of Key Relevant UL Standards

UL 250: Domestic Refrigeration

The current UL250 standard allows only 57grams of flammable refrigerant which is preventing uptake of hydrocarbon refrigerants in the U.S. market. Hydrocarbon refrigerators are proven around the world, and currently proposed regulation by the EPA and California Air Resources Board (CARB) are targeting a 2021 phase-out date for HFC-134a in this use. A harmonization proposal that excluded charge sizes was voted down by a majority of STP members who support addressing the charge size limitation in May 2016.

UL 471: Commercial Refrigeration

UL471 covers commercial refrigerators and freezers up to 600 volts, including display cases, merchandisers, soda fountain units, and ice cream cabinets. This standard currently allows for up to 150 grams of flammable refrigerant. This restricts the cost-effectiveness of low-GWP alternatives in some types of commercial refrigerating applications and certain stakeholders support charge sizes in this end use of up to 1kg provided best practices around installation and servicing are followed.

UL 484: Room Air Conditioning

The last edition of UL484 (Edition 8) allowed a charge size equation that was based on the size of the room an AC unit was designed to be used in, a formula also used under the equivalent IEC standard. Higher capacity units for larger rooms were allowed to use more of a flammable refrigerant in a larger room, since more would have to leak from a unit in order to reach a flammable concentration. The EPA based its 2015 rulemaking approving hydrocarbon refrigerants for room AC on the charge size equations in Edition 8 of the standard, allowing up to 1 kilogram of refrigerant for some types of units installed in larger rooms.[11] In 2015, following the recommendations of a UL Joint Task Group (UL JTG WG1) on flammable refrigerants in HVAC Products, the STP484 passed a new edition of the standard, Edition9, which reduced maximum allowable charge sizes to be based on a fixed room size the size of a closet ($3m^3$).[12] This resulted in a maximum charge limit of 102 to 114 grams for hydrocarbon refrigerants R-441A and R-290, an amount too small for the technology to be commercially viable. The final report of the UL JTG WG1 were qualified as limited in scope and open to modification given further research and testing.

CONCLUSIONS & RECOMMENDATIONS

Timely and comprehensive modifications to many RAC safety standards are urgently needed in order to allow for greater uptake and commercialization of low-GWP refrigerants. EIA recommends that:

- All standards bodies pertaining to RAC sector update evaluations of assumptions underlying charge size equations, based on realistic data and incorporate safety technologies and measures available to mitigate risks.
- Global standards bodies such as IEC work in a coordinated manner to advance timely evaluations and updates to global standards that serve as best practices for regional and national bodies.
- Regional and national standards bodies harmonize quickly and efficiently with emerging global best practices, or conduct separate evaluations to advance timely updates in countries and regions.
- All standard bodies allow for broad participation by all relevant stakeholders in private, public, and non-profit sectors to ensure a transparent and timely process for modifying and harmonizing regional and national standards with emerging best practices.
- Developing countries leapfrogging HFCs should immediately assess which standards and codes are necessary to ensuring low-GWP technologies can be made safely available and initiate technical working groups on these issues.

ANNEX 1: NON-EXHAUSTIVE LIST OF RELEVANT RAC STANDARDS

Global	Regional	National
1. ISO 5149:2014 Mechanical refrigerating systems used for cooling and heating – Safety requirements	1. CEN: EN 378:2008 Refrigerating systems and heat pumps - Safety and environmental requirements	1. ANSI/ASHRAE 34Designation and Safety Classification of Refrigerants
2. ISO 817:2014 Refrigerants – Designation and Safety Classification	2. CEN: EN 13313:2010 Refrigerating systems and heat pumps – competence of Personnel	2. ANSI/ASHRAE 15 Safety Standard for Refrigeration Systems
3. ISO 17584:2005 Refrigerant properties	3. CENELEC: EN 60335-1:2012 Household and similar electrical appliances – Safety, general requirements	3. AHRI 700-2015: Specifications for Refrigerants
4. ISO 11650:1999 Performance of refrigerant recovery and/or recycling equipment	4. BS EN60335-2-40: Household and similar electrical appliances. Safety. Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers	4. UL 207: Refrigerant-Containing Components and Accessories, Nonelectrical
5. IEC 60335-1:2012 Household and similar electrical appliances – Safety, general requirements	5. BS EN60335-2-89: Household and similar electrical appliances. Safety. Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor	5. UL 250: Household Refrigerators and Freezers
6. IEC 60335-2-40: the safety of electric heat pumps, their maximum rated voltages being not more than 250 V for single phase appliances and 600 V for all other appliances.	6. CENELEC: EN 60079 Electrical Apparatus for Explosive Gas Atmospheres	6. UL 471: Standard for Commercial Refrigerators and Freezers
7. IEC 60335-2-89: electrically operated commercial refrigerating appliances that have an incorporated compressor or that are supplied in two units for assembly as a single appliance in accordance with the manufacturer's instructions (split system).	7. UL 60335-2-40 Safety of Household and Similar Electrical Appliances Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers	7. UL 484: Standard for Room Air Conditioners
	8. UL 60335-2-40: Safety of Household and Similar Electrical Appliances, Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers	8. UL 984: Hermetic Refrigerant Motor-Compressors
		9. UL 1995: Heating and Cooling Equipment

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