Revisiting Flammable Refrigerants

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This paper explores the ongoing efforts by those who are anticipating the more widespread use of flammable refrigerants in HVAC equipment and appliances, with the principle focus on the use of hydrocarbons as refrigerants. It is hoped that this paper will initiate a dialog among stakeholders, and increase the likelihood that the more widespread use of flammable refrigerants does not result in a decline in safety.

Introduction

Since the 1989 Montreal Protocol and its successor agreements, the world of refrigerants has been marked by change. In the search for more environmentally-preferable refrigerants, technology has moved from chlorofluorocarbons to a host of alternative substances. Many of these substances are serving as interim measures, until the phase-out of ozone-depleting and global-warming refrigerants meets the targets set by the U.S. Clean Air Act. The journey toward compliance has caused the HVAC equipment and appliance industries to revisit the potential use of substances that have good environmental and thermodynamic properties as refrigerants, but which are also, unfortunately, flammable.

Anticipating the Increased Use of Flammable Refrigerants in the U.S.

It may be surprising to learn that the first commercial refrigerant was a flammable refrigerant. In 1850, an ethyl ether vapour compression system for

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ice making was developed. From that humble beginning of freezing a simple pail of water, a robust vapor compression refrigeration industry was developed. Today, ice making alone is a nearly one billion-dollar industry in the U.S. Along the way, scientists, engineers and probably more than a few tinkerers have experimented with numerous potential refrigerants.

Ammonia (R717) was an early choice for breweries and continues to be a popular refrigerant in industrial applications, including food processing, pharmaceutical and, even today, breweries. Noxious but non-flammable sulphur dioxide (R764) became popular for small refrigerating systems, and was in widespread use in the U.S. into the 1940s. Methyl chloride (R40) experienced brief popularity, but its flammability and potential toxicity ultimately made it unsuitable as a refrigerant. Propane (R290) was touted as a replacement for ammonia refrigerant in the 1920s. Isobutane (R600a) was first used as a refrigerant for small systems in the 1920s but, as with other flammable refrigerants (except ammonia), it quickly fell out of use when chlorofluorocarbon (CFC) refrigerants were introduced for commercial use in 1931.

CFCs had a 60 year run as the refrigerants of choice, until they were identified in the late 1970s as ozone depleting substances. The phase-out of CFC refrigerants began a little over 10 years later.

A mature safety system had evolved over the decades, as various industries settled upon refrigerants which were generally non-toxic and non-flammable, which provided consistent performance, and which were relatively inexpensive. Household refrigerators used the CFC R12. Larger commercial refrigerators used another CFC, R502, while air conditioners used R11 (CFC) and R22 (HCFC). Manufacturers ensured that their equipment was appropriately designed and constructed using well-established criteria and standards, chose the correct refrigerant for the application, and then sold the equipment for installation and use in accordance with equally well-established standards and codes.

However, beginning with the phase-out of CFCs, the choice of refrigerant has increasingly become a complicating factor in equipment design, construction, installation and use. In the U.S., the more widespread use of pure hydrocarbon refrigerants, flammable hydrocarbon refrigerant blends, or halo-hydrocarbon blends with flammable hydrocarbons has further complicated matters.

The Challenges Posed by Flammable Refrigerants

Vapor compression refrigeration in appliances is a closed system that circulates a volume of refrigerant and lubricant under pressure. This system typically operates under variable environmental conditions, and often must be capable of adjustment to meet the end use application. From a traditional electrical equipment safety perspective (electric shock, fire and casualty hazards), appliance designers have sought to reliably contain the refrigerant. To accomplish this, they used tubing, vessels and other components with sufficient mechanical strength to handle the developed pressures under expected normal and abnormal operating conditions.

Because the typical HVAC and appliance refrigerant gas (excluding ammonia) was non-toxic in the volumes used and non-flammable, the potential for gas leakage or explosion was not considered to be a safety concern, except under fire conditions. In such cases, the refrigerant system was required to have a means for the controlled venting of refrigerant, before pressure build-up could cause an explosion hazard.

Aside from locations where large quantities of refrigerant might be found (e.g., large commercial / industrial facilities), there has been limited concern for the safety of refrigerant-containing appliances in all manner of occupancies. This would include locations where a number of appliances are stored or used (e.g., warehouses, retail locations) or how the appliances are transported, serviced or disposed of. However, if a flammable refrigerant were to be used in these appliances, it cannot be assumed that safety is adequately assured.

Hydrocarbon refrigerants (HCs) present a risk of fire and explosion hazard if there is a refrigerant leak. The vapour within the closed refrigeration system is not flammable until oxygen is present at the location of the leak, or in the location(s) where the hydrocarbon gas travels after leaking from the system. If the gas and air mixture is within the upper and lower flammability limits (UFL and LFL respectively) for the particular refrigerant, the mixture is flammable in the presence of an ignition source. Hot surfaces and electrical arcs, such as those present at the contacts of electrical switching contacts (switches, temperature and humidity controls, etc.), are the principle potential ignition sources in HVAC and appliances.

The same concerns hold true for other flammable refrigerants, as well as for refrigerant blends containing flammable refrigerant components. The presence of a flammable gas and air mixture from a leaking refrigerant blend additionally depends upon the properties of the blended gases, and whether they separate into individual component gases (fractionate).

Small quantities of flammable refrigerant discharged into an open area may disperse at a rate that ensures that the LFL is not achieved or is achieved for a very brief time period. However, for larger quantities of refrigerant, or in situations in which the leaked refrigerant is contained in a smaller volume space or in which the leaked refrigerant accumulates (e.g., heavier than air refrigerant), it is more likely that the LFL can be reached and sustained.

Typically, supermarket refrigerated cases and building air conditioning systems have larger quantities of refrigerant. Because these systems are often assembled on-site, they are more often subject to leaks. Indeed, leakage is assumed for field-assembled equipment. The Clean Air Act now requires refrigerant leaks to be repaired for systems containing over 50 pounds of refrigerant if the leakage is determined to be 35%

or greater in a 12 month period for commercial refrigeration, and 15% for comfort cooling and other appliances. Therefore, the use of a flammable refrigerant in such equipment would require improved containment features over those found in non-flammable refrigerant systems. It would also require mechanical ventilation and other mitigation procedures at the installation site to avoid the presence of a flammable gas and air mixture at potential ignition sources, either on the equipment or in the installation environment.

Smaller equipment such as household refrigerators can also leak. Improved containment over non-flammable refrigerant systems is also appropriate, but mechanical ventilation or other means to disperse the refrigerant may not be practical for such appliances. Equipment designers must then look to avoid placing potential ignition sources in locations (e.g., a storage compartment, hollow in a wall, etc.) that could yield a flammable gas and air mixture in the event of a leak. The designer, of course, can often do little about other possible ignition sources in the installed environment.

All equipment is serviced and, ultimately, disposed off. These activities also offer opportunity for leakage. The equipment design must minimize the risk of fire or explosion during servicing, and service personnel must have sufficient knowledge to safely do their job. Upon disposal, the refrigerant should be recovered, though relatively small propane or isobutane refrigerant charges could conceivably be released to the air in a controlled manner. Parties involved in the disposal of HVAC equipment and appliances should also have sufficient knowledge to perform their job safely, and should be able to identify equipment with a flammable refrigerant charge. For their part, equipment designers must anticipate the need to evacuate the refrigerant from equipment upon disposal and to facilitate identification of locations on the equipment intended for this purpose.

Most appliances, room HVAC equipment and split systems are factory charged, and subsequently transported with the charge present, and may be transported multiple additional times throughout the product's useful life. Vehicle transport can jar or vibrate the parts containing refrigerant, increasing the risk of leakage. Designers must account for these concerns in the equipment design, as well as the equipment packaging.

If an individual appliance has a small refrigerant charge, but there are many such appliances at a given location (e.g., a warehouse or tractor-trailer), the aggregate amount of flammable refrigerant may be relatively large. Though it is unlikely under normal circumstance that all of the appliances might simultaneously leak, a warehouse fire or transportation accident could lead to the leakage of large volumes of flammable refrigerant.

While the risk conditions noted above can often be anticipated in the design process, it is much more difficult to anticipate the abuse of equipment in use, and to design appropriate safety features to mitigate that risk. For example, vending machines are checked for the risk of overturning in cases where the equipment is rocked back and forth to dislodge a vended product. But what type of rocking test would adequately assess the risk involving a vending machine with flammable refrigerant? It can also be a challenge to ensure that an installation site doesn't pose an unacceptable risk. For example, how can local building authorities anticipate and address the potential risk posed by having multiple appliances containing flammable refrigerant in a single-family

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Vapor Compression Refrigeration and Air Conditioning End-Uses

- Chillers typically cool water, which is then circulated to provide comfort cooling throughout a building or other location. Chillers can be classified by compressor type, including centrifugal, reciprocating, scroll, screw and r otary.
- Cold storage warehouses are used to store meat, produce, dairy products and other perishable goods. The majority of cold storage warehouses in the United States use ammonia as the refrigerant in a vapor compression cycle, although some rely on other refrigerants.
- Retail Food Refrigeration includes all cold storage cases designed to chill food for commercial sale. In addition to grocery cases, the end-use includes convenience store reach-in cases and restaurant walk-in refrigerators.
- Vending machines are self-contained units that dispense goods that must be kept cold or frozen.
- Water coolers are self-contained units providing chilled water for drinking. They may or may not feature detachable containers of water.
- Commercial ice machines are used in commercial establishments to produce ice for consumer use, e.g., in hotels, restaurants, and convenience stores.
- Household refrigerators and freezers are intended primarily for residential use, although they may be used outside the home. Household freezers only offer storage space at freezing temperatures, unlike household refrigerators. Products with both a refrigerator and freezer in a single unit are most common.
- Residential dehumidifiers are primarily used to remove water vapor from ambient air for comfort or material preservation purposes. While air conditioning systems often combine cooling and dehumidification, this application serves only the latter purpose.
- Residential and light commercial air conditioning and heat pumps includes central air conditioners (unitary equipment), window air conditioners, and other products. Blended HFC 410A has supplanted HCFC-22, a class II substance, as the most common refrigerant for this application.

Table content extracted from EPA web content: http://www.epa.gov/ ozone/snap/refrigerants/index.html

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residence or in a children's play area or classroom? These and similar such concerns involve a number of potential stakeholders, who individually and collectively have a key role in ensuring the safety of HVAC equipment and appliances containing flammable refrigerants. As the publisher of equipment safety standards for HVAC equipment and appliances, Underwriters Laboratories Inc. (UL) has identified stakeholder interests that it believes to be relevant to the total safety system, in which safety standards are an essential element. These areas of interest are depicted in *Figure 1*.

Stakeholder identification is just a first step in undertaking a unified and coordinated review of the potential impact of the wider use of flammable refrigerants in HVAC equipment and appliances. Gaps in codes and standards for installation and use, including the applicable equipment safety standards, need to be identified and addressed. Education and training for installers, service personnel, operators of storage and retail facilities, fire fighters and inspection professionals will also be important.

The remainder of this paper will explore the most important factors that are expected to result in flammable refrigerant HVAC equipment and appliances, the current state of safety standards, and some near-term activities to address gaps.

U.S. Federal Regulatory Environment

CFC and HCFC Phase Out

The phase-out of CFCs began in 1991, a change that drove equipment manufacturers to expand the use of hydrochlorofluorocarbons (HCFCs) where they could, and to use hydrofluorocarbons (HFCs) in applications as diverse as household refrigerators and automotive air conditioning. Manufacturers began to use hydrocarbons (HCs) as well, around this time.

As noted earlier, isobutane (R600a) had long ago been used as a refrigerant. With the phase out of CFCs, isobutene was reintroduced as a refrigerant for household refrigerators and freezers in Japan and Europe, and found widespread use and acceptance. Though ANSI/UL 250, the U.S. safety standard for household refrigerators, anticipated as early as the 1990s the

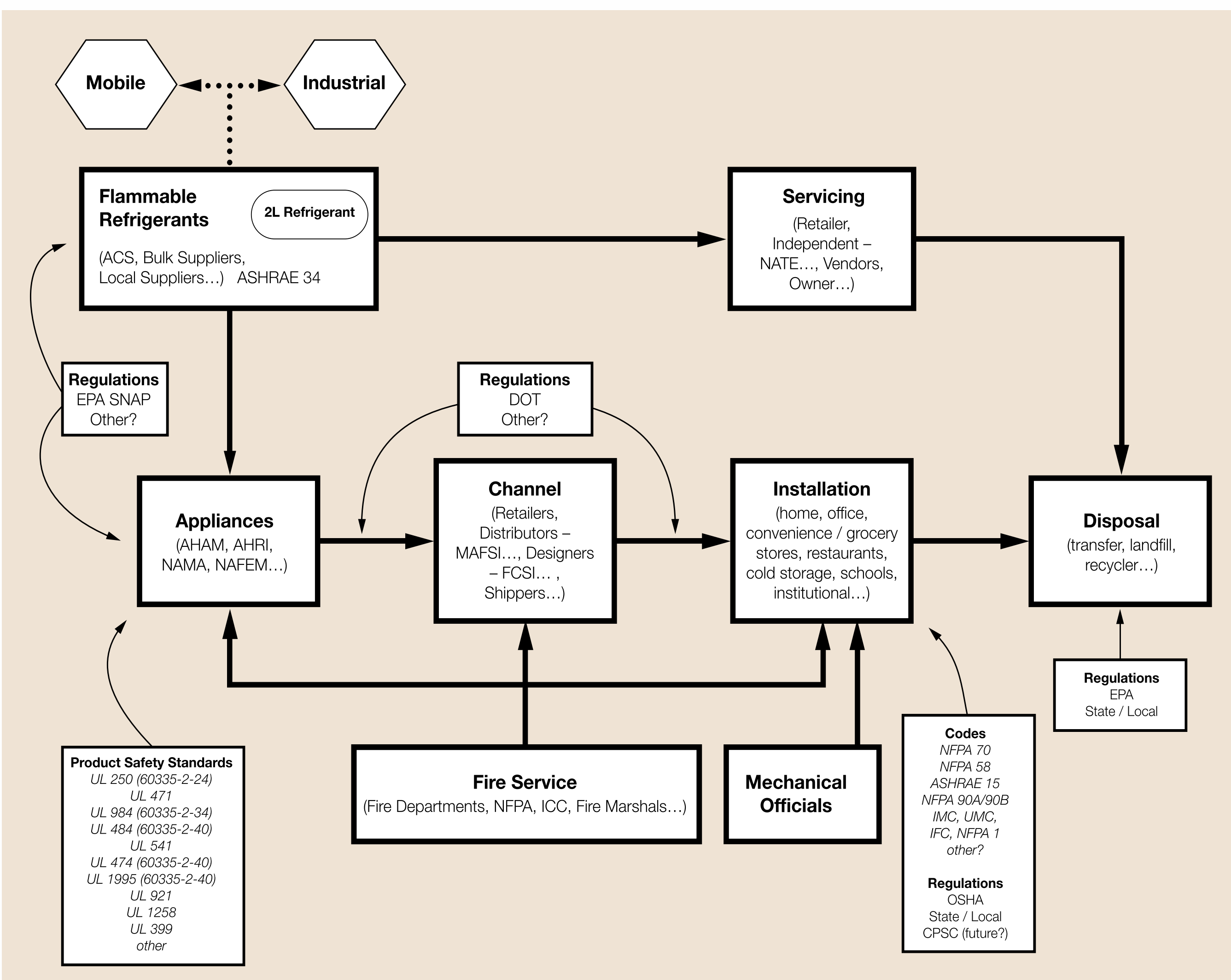

Figure 1: Stakeholder interest areas

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Table 1: Phase-out of HCFC's in US

Year	% Reduction Consumption and Production#	Implementation of HCFC Phase-out Per Clean Air Act
2010	75.0%	No production or importing of HCFC 142b and HCFC 22, except for use in equipment manufactured before 2010.
2015	90.0%	No production or importing of any HCFCs, except for use in equipment manufactured before 2020.
2020	99.5%	No production or importing of HCFC 142b and HCFC 22.
2030	100.0%	No production or importing of any HCFCs.

 # Using prior cap as baseline

Table 2: Comparison of refrigerant GWP and ODP

Refrigerant	Global Warming Potential (GWP)	Ozone Depleting Potential (ODP)
R 134a	1430	0
R290	3.3	0
R600	3	0
R600a	3	0
R1234 yf	4	0
R717	0	0

possible use of flammable refrigerants in the U.S., they were not introduced in U.S. appliances until 2008.

An interim solution, HCFCs are also ozone-depleting substances and were subject to a longer-term phase out than CFCs. In September 2007, the signatories of the Montreal Protocol agreed to a more aggressive phase-out of HCFCs. *Table 1* describes the phase-out timetable under the U.S. Clean Air Act. The imminent HCFC phase-out, coupled with recent efforts to improve energy efficiency of certain appliances as well as experience outside of the U.S. market, has substantially renewed interest in the U.S. toward flammable refrigerants, isobutane and propane in particular, along with blends using these substances.

Finally, in September 2008, ice-cream maker Ben and Jerry's introduced a commercial ice cream case into the U.S. market, representing the first U.S. use of a hydrocarbon refrigerant in a conventional commercial food serving and display application in over 50 years. The self-contained freezer case, made by Unilever, was of a cold wall construction that used propane refrigerant.

Notwithstanding the movement toward HC refrigerants, HFCs currently remain the predominant choice to replace HCFCs. However, under the European Climate Change Programme (ECCP), a 2006 regulation for all F-gases (fluorinated gases) "makes it mandatory to contain via the control of systems via leakage detection systems that are regularly checked, to recover and recycle, to monitor and archive, to label, to train and certificate servicing personnel, to restrict marketing of F-gases for emissive uses, etc."

Automobile manufacturers selling in the European market must also contend with the EU's directive relating to emissions from air-conditioning systems in motor vehicles (2006/40/EC), also known as the MAC Directive. The MAC Directive will eliminate the major mobile air conditioning market for the popular HFC 134a, and has led manufacturers to explore a "lower flammability" refrigerant (HFO 1234 yf), as well as CO_2 and other options. Somewhat related is the move toward "natural refrigerants." Looking to avoid altogether the transition to HFCs, which have high global warming potential (GWP), a consortia of equipment manufacturers and retailers have included HC refrigerants in their plans to meet energy regulations.

See *Table 2* for some examples of the GWP for flammable refrigerants. Over time, these various initiatives can be expected to contribute to a reduction in use of HFCs as an alternative to HCFCs, and lead to increased use of HCs.

Energy Efficiency

In addition to being affected by the phase-out of ozone-depleting refrigerants, HVAC equipment and appliances employing refrigerants are subject to a variety of regulations in the U.S. Such equipment must meet the appropriate electrical, mechanical, fire and public health requirements of state and local jurisdictions. Increasingly, such equipment must also meet state and federal energy efficiency goals (e.g., Energy Policy and Conservation Act) that can be expected to drive the search for new and more efficient technologies, including the types of refrigerant used.

As recently of September 2010, the U.S. Department of Energy has proposed standards for residential refrigerators and freezers that are expected to lower energy use by as much as 25%. The energy efficiency appeal of flammable refrigerants in refrigeration equipment and air conditioners may also lead to its use in other appliances. For example, a storage tank water heater could potentially be more efficient if a reverse-cycle (heat pump) system with a relatively small flammable refrigerant charge were used instead of a large resistance-heating element to maintain the temperature of the water. A similar technology could be used in a clothes dryer to dehumidify clothing, instead of drying solely by resistance heat or heat of combustion.

U.S. EPA SNAP

It is only logical that the transition toward more environmentally preferable refrigerants and energy savings has renewed interest in HC refrigerants in appliances. And arguably, the most significant regulation affecting the use of flammable refrigerants in appliances is the Clean Air Act, administered by the U.S. Environmental Protection Agency (EPA), under its Significant New Alternatives Policy (SNAP).

According to the EPA, the purpose of its SNAP program is "to allow a safe, smooth transition away from ozone-depleting compounds by identifying substitutes that offer lower overall

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risks to human health and the environment." SNAP specifically identifies the use of refrigerants used in HVAC equipment and appliances as a focus of the policy, including chillers, cold storage warehouses, retail food refrigeration, vending machines, water coolers, commercial ice machines, household refrigerators and freezers, residential dehumidifiers and residential and light commercial air conditioning and heat pumps.

EPA's SNAP has authorized HCs (propane, butane and blends) as alternative refrigerants for industrial process refrigeration only. For all other applications, such refrigerants are not yet authorized as substitutes for refrigerants employed today. However, there are exemptions to this restriction for small volume producers of substitutes, and in cases where end-use equipment is being test-marketed or deployed for research and development.

In response to the increased interest in HC refrigerants, the EPA issued a Notice of Proposed Rulemaking (NPRM) in the U.S. Federal Register in May 2010. The NPRM recommends that "isobutane, propane, HCR–188C28 and HCR–188C1 be acceptable, subject to use conditions, as substitutes for R–12 and R–22 in household refrigerators, freezers, and combination refrigerator and freezers and commercial refrigeration (retail food refrigerators and freezers – stand-alone units only").

The NRPM also references product safety standards ANSI/UL 250 and ANSI/UL 471, indicating that equipment must meet the requirements of these standards to use one of the specified flammable refrigerants. The proposal also specifies that hoses and piping be color coded to identify the presence of flammable refrigerants in these appliances, and that unique fittings and service ports be provided to avoid accidental connection of inappropriate service equipment while facilitating recovery of refrigerant during service or disposal of the appliances.

Finally, the NPRM proposes that technicians working with equipment using flammable refrigerants be "specifically trained in handling flammable refrigerants service or dispose of refrigerators and freezers containing these refrigerants" to minimize the risk of fire.

U.S. DOT

The U.S. Department of Transportation (DOT) publishes requirements for "packaging" which apply to cylinders that may contain liquefied petroleum gas (LP-Gas). These requirements describe the types and sizes, construction, testing, inspection and markings of these cylinders, often simply referred to as "DOT cylinders". The requirements are well established for the transport of LP-Gas cylinders for combustion equipment and, together with regulations from the U.S. Occupational Safety and Health Administration (OSHA) associated with workplace handling of LP-Gas, thoroughly cover transportation of flammable gas in cylinders.

HVAC equipment and appliances containing flammable refrigerant could be identified as hazardous material cargo due to the presence of flammable gas. CFR Part 177.834 (Packages secured in a motor vehicle) states:

"Any package containing any hazardous material, not permanently attached to a motor vehicle, must be secured against shifting, including relative motion between packages, within the vehicle on which it is being transported, under conditions normally incident to transportation. Packages having valves or other fittings must be loaded in a manner to minimize the likelihood of damage during transportation."

Fortunately, the Federal Motor Carrier Safety Administration (an agency of the DOT) reports that "crashes involving large trucks–those with a gross vehicle weight rating of more than 10,000 pounds-carrying hazardous materials (hazmat) are relatively rare."

U.S. OSHA

OSHA publishes regulations intended to protect the safety or health of those employees working in federally-regulated workplaces. National consensus standards are frequently referenced for this purpose and, in accordance with 29 CFR 1910.7(c), ANSI/UL standards for refrigerators and freezers, heating and air conditioning equipment, associated components and appliances fulfill the requirements. Such products, once listed by a nationally recognized testing laboratory (NRTL) using the accepted standards, may be used in the workplace.

OSHA regulations addressing storage and handling of LP-Gases are documented in 29 CFR 1910.110. While these regulations do not anticipate LP-Gas refrigerants, they do cite compliance with DOT container requirements and location of containers in buildings.

Of particular relevance for the servicing of HVAC equipment and appliances in-place is 1910.110 c) 5, which states that "when operational requirements make portable use of containers

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Disposal

"Refrigeration and air-conditioning equipment that is typically dismantled on-site before disposal (e.g., retail food refrigeration, central residential air conditioning, chillers, and industrial process refrigeration) has to have the refrigerant recovered in accordance with EPA's requirements for servicing prior to their disposal. However, equipment that typically enters the waste stream with the charge intact (e.g., motor vehicle air conditioners, household refrigerators and freezers, and room air conditioners) are subject to special safe disposal requirements. Under these requirements, the final person in the disposal chain (e.g., a scrap metal recycler or landfill owner) is responsible for ensuring that refrigerant is recovered from equipment before the final disposal of the equipment. If the final person in the disposal chain accepts appliances that no longer hold a refrigerant charge, that person is responsible for maintaining a signed statement from whom the appliance/s is being accepted. The signed statement must include the name and address of the person who recovered the refrigerant, and the date that the refrigerant was recovered, or a copy of a contract stating that the refrigerant will be removed prior to delivery."

Content taken from EPA web site fact sheet: *http://www.epa.gov/ ozone/title6/608/608fact.html*

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necessary and their location outside of buildings or structure is impracticable, containers and equipment are permitted to be used inside of buildings or structures…." There are also caveats to this allowance and they are comparable to the requirements of NFPA 58 (Liquefied Petroleum Gas Code).

Installation Requirements and Equipment Safety Standards Environment

Fulfilling government regulations is only part of the compliance landscape for HVAC equipment and appliance manufacturers. Equipment must also comply with safety standards in order to be installed in a workplace or (depending upon the local jurisdiction) in other occupancies. Retailers, insurers and other parties may also require evidence of compliance with safety standards.

In the U.S., UL is the principal standards developer addressing electrical appliance and HVAC equipment safety. UL standards are part of an overall safety system of coordinated standards and codes to facilitate safe installation and use of equipment. They complement the electrical installation requirements of the National Fire Protection Association (NFPA), notably the National Electrical Code® (NFPA 70), and mechanical refrigeration requirements of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Standards 15 and 34.

Installation codes for HVAC and refrigeration equipment are published by International Codes Council (ICC International Mechanical Code, Chapter 11) and the International Association of Plumbing and Mechanical Officials (IAPMO Uniform Mechanical Code, Chapter 11). Both codes reference ASHRAE 15 and 34 with additional requirements.

In addition, requirements for the storage, use and handling of refrigerants are published by ICC (International Fire Code, Section 606) and the NFPA (NFPA 1, Chapter 53). These model fire codes impose safety requirements for occupancy based on the volume and safety group of the refrigerant. As with any of the model codes (electrical, mechanical, fire, etc.), local jurisdictions can implement variations and additional requirements for equipment, and may elect to do so for HVAC equipment and appliances employing flammable refrigerants, especially in densely populated areas.

The standards and codes relevant to flammable refrigerants are as follows:

- ANSI/ASHRAE Standard 34, Designation and Safety Classification of Refrigerants
- ANSI/UL 2182, Standard for Safety for Refrigerants
- ANSI/NFPA 58, Liquefied Petroleum Gas Code
- ANSI/ASHRAE Standard 15, Safety Standard for Refrigeration Systems
- ANSI/UL 207, Standard for Safety for Refrigerant-Containing Components and Accessories, Non-electrical
- ANSI/UL 250, Standard for Safety for Household Refrigerators and Freezers
- ANSI/UL 471, Standard for Safety for Commercial Refrigerators and Freezers
- ANSI/UL 1995, Standard for Safety for Heating and Cooling Equipment
- ANSI/UL 484, Standard for Safety for Heating and Cooling Equipment
- ANSI/UL 474, Standard for Safety for Heating and Cooling Equipment
- UL 984, Standard for Safety for Refrigerant Motor Compressors
- ANSI/UL 60335-2-34, Standard for Household and Similar Electrical Appliances, Part 2: Particular Requirements for Motor-Compressors

The first three standards listed above are applicable to refrigerants, while the remainder are applicable to equipment and components. These and other standards also address ammonia, but that refrigerant is outside the scope of this paper.

Other Appliance Standards

Other standards potentially affected by the introduction of flammable refrigerants are ANSI/UL 412, Standard for Safety for Refrigeration Unit Coolers, ANSI/UL 399, Standard for Safety for Drinking Water Coolers, and ANSI/UL 541, Standard for Safety for Refrigerated Vending Machines.

"Reverse-cycle" heating, long the staple of heat pumps, is also making an appearance in products such as clothes dryers and water heaters. With their experience in the use of HC refrigerants in household refrigerators and freezers, European manufacturers have expanded the application to these newer energy saving technologies (e.g., clothes dryers). The water heater application is currently covered by ANSI/UL 1995 for conventional refrigerants. There is no current mechanism within that standard to address a flammable refrigerant. Similarly, clothes dryer requirements (ANSI/UL 2158, Standard for Electric Clothes Dryers) do not anticipate the heat pump technology (conventional or flammable refrigerants). For this reason, there is an effort underway at UL to re-purpose an existing Standard for Refrigerating Units, ANSI/UL 427, to be a general source for refrigeration circuits employed in appliances where the relevant appliance standard does not already include such requirements.

Conclusion

In the 1990s, the U.S. market was not ready for the introduction of flammable refrigerants in many HVAC and appliance applications when CFC phase-out began to take effect. However, much experience with equipment using HC refrigerants has been gained around the world in the intervening years. As the drive toward more environmentally-friendly refrigerants and greater energy efficiency continues, it's time to revisit the use of flammable refrigerants in the U.S. Anticipating that these refrigerants can very quickly attain more widespread use, it is important that the stakeholders of the U.S. safety system take a holistic look at the potential impact of such use, and take the necessary steps to ensure the continued safety track record of HVAC equipment and appliances. UL believes that raising awareness and facilitating dialogue among stakeholders is an important first step in this direction. ❖