even A1 refrigerants, when released, can cause death due to asphyxiation or injury such as frostbite.

Product safety standards used to approve listed and labeled equipment impose design requirements that minimize the chance of equipment failure or damage causing a rapid release of the refrigerant that could create a flammable cloud. It is extremely unlikely that slow refrigerant leaks, such as those due to corrosion pin holes or permeability of seals, pose a fire hazard because the refrigerant has sufficient time to disperse and remain below the LFL. However, it is likely that in some air conditioner somewhere, at some point in time, refrigerant will be rapidly released for one reason or another — whether due to defective component failure, accidental damage, or a structural fire from another cause. When that happens, following safety standards minimizes the probability of a refrigerant ignition event. These standards remove ignition sources in the equipment near the source of the refrigerant, require adequate room size to allow for dispersion and dilution, or require mechanical ventilation triggered by a refrigerant sensor when room size alone is not enough.

The air conditioner safety standards recognize that there are uncontrollable factors, such as potential ignition sources in the conditioned space. Many items commonly found inside buildings that are potential ignition sources like Class 2 or Class 3 refrigerants are not ignition sources for Class 2L refrigerants due to their higher MIE values, thereby significantly reducing the probability side of the equation.

RESEARCH

Several organizations have collaborated to conduct peer research how to safely use A2L refrigerants, with the aim of providing technical justification for requirements in standards and codes. AHRI, ASHRAE, and U.S. DOE have collaborated to publish numerous reports with the results, and additional work continues to further explore more detailed issues. One focal area has been refrigerant charge quantity limits, which directly impact the available fuel in the event of a release and the potential worst-case event severity. The charge quantity limits are based on:

- the available space to which released refrigerant can disperse,
- the elevation from which refrigerant could be released,
- presence of ventilation system to supply and exhaust air in the space.

Heavier-than-air refrigerant released near the ceiling will mix and dilute as it falls, while refrigerant released near the floor will pool if the air is still and will take much longer to diffuse into the room. The risk mitigation concepts are to use recirculation fans to mix the refrigerant and air so that the concentration at all locations in the space is quickly brought below the LFL and cannot ignite. Above certain charge quantity limits, a refrigerant sensor is required to be part of the equipment design and used to trigger recirculation air flow, and in some cases, additional ventilation air flow is needed for further dilution.

SAFETY STANDARDS

Figure 6 shows the refrigerant charge limits and relationships to safety measure concepts common to ASHRAE Standard 15-2019 (published) and UL 60335 2 40 edition 3 (proposed changes to edition 2), the two relevant consensus-based national standards. There are some differences in the details between these two standards, though the installation will always need to comply with the more restrictive of the applicable standards. The UL 60335-2-40 requirements will be both inherent to the product design and a mandatory part of the manufacturer’s installation instructions. The ASHRAE 15 requirements will typically be invoked by building code requirements for commercial and industrial applications, but not for smaller residential applications, with restrictions on the application and installation of the equipment.

There are clear limits for refrigerant charge quantity to ensure safety, with a maximum allowable quantity under any circumstances designated as m1, in the UL standard. For smaller-scale equipment below a charge quantity designated as m2, no additional safety measures are required for the product or the installation. For larger-scale equipment with refrigerant charge quantity above m2, the basic concept is use of a refrigerant sensor to detect a leak and trigger recirculation of air to dilute the refrigerant below the LFL. Above a threshold defined in the safety standard, higher levels of refrigerant for a given size of the conditioned space will also require mechanical ventilation to further dilute released refrigerant.

In both approaches, the use of airflow to mix and disperse the released refrigerant is designed to keep the average concentration below 25% of the LFL, and to quickly disperse any local concentration near the source of the release that may be above 25% of LFL. Note that while smoke detectors and carbon monoxide detectors sound an alarm to trigger occupant response, and in applicable cases to also notify emergency response, air conditioners using flammable refrigerants will proactively trigger equipment response to mitigate the hazard.

SITUATIONAL AWARENESS

When implementing any change or transition, there is a need to communicate and educate. With new refrigerants, there are a few issues that require attention. Equipment installers, authorities having jurisdiction (AHJs), service technicians, and fire service personnel need to be aware of the changes. The installation process for air conditioners and heat pumps will remain largely the same but must follow the manufacturer’s instructions, including confirmation that the room size is adequate for the refrigerant charge quantity. Installers and service technicians will be trained on the new requirements through several programs to be offered by air conditioner manufacturers and other associations such as NATE and ACCA.

Fire officials will need to know when periodic inspection of refrigerant sensors is required. Firefighting procedures and personal protective equipment will remain the same, as will training on the hazards of combustion byproducts from halogenated refrigerants (CFCs, HCFCs, HFCs, and HF0s). Structural fires have generated dangerous combustion byproducts from refrigerants in the past, as air conditioners and heat pumps were consumed in the fire along with many other hazardous materials. Post-fire cleanup measures will always need to be appropriate for the event.

CONCLUSION

Cooling and heating are an essential part of life, and due to environmental impact, existing A1 refrigerants will transition to A2L refrigerants in air conditioners and heat pumps. It is in the best interest of all stakeholders to understand how to safely work with A2L refrigerant as they are adopted into use. While there are some new considerations with A2L refrigerants, the changes are incremental in nature.