

Greening Your Refrigerants — Saving the Ozone Layer and Saving Money

Source: fmlink.com

Published: June 7, 2017



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Chemical refrigerants are the heart of a large majority of building HVAC and refrigeration equipment. These manufactured fluids provide enormous benefits to society, but in recent decades have been found to have harmful consequences when released to the atmosphere: all refrigerants in common use until the 1990s caused significant damage to the protective ozone layer in the earth's upper atmosphere, and most also enhanced the greenhouse effect, leading to accelerated global warming.

The world community has recognized the seriousness of ozone depletion, and 160 countries have signed the Montreal Protocol on Substances that Deplete the Ozone Layer. The United States, as one of the world's largest emitters of ozone-depleting substances, has signed the treaty, which includes a timetable for the phase-out of production and use of ozone depleting substances.

Refrigerant regulation is thus forcing change on the buildings HVAC industry, but on phased schedules that vary with how harmful the refrigerant is and with the phase of the refrigerant life cycle being targeted (i.e., original production vs. on-site usage). Greening your refrigerant practices means changing ahead of the regulated schedule, which may actually save you money.

CFCs: an outdated option

Historically virtually all HVAC&R equipment in buildings used refrigerants containing chlorofluorocarbons (CFCs). CFCs are halogenated substances that, when inevitably released to the atmosphere, cause ozone depletion. The reaction between a CFC and an ozone molecule in the earth's stratosphere destroys the ozone and depletes the Earth's natural shield for incoming ultraviolet radiation. Overexposure to UV rays can lead to skin cancer, cataracts and weakened immune systems.

In addition to their ozone depletion effects, CFCs in the stratosphere also absorb outgoing infrared radiation from the earth, functioning as potent greenhouse gases. Thus, banning the use of CFCs in refrigerants not only slows the depletion of the ozone layer but also reduces the human-caused component of global warming.

Under the Montreal Protocol U.S. CFC production ceased in 1995. Consequently, specification of non-CFC building equipment is now standard and CFC-based refrigerants are no longer available in new equipment. These developments mean CFCs will eventually no longer be used at all in buildings, but phasing CFCs out completely will take time because of the long lifetimes of some existing HVAC equipment. Accelerating this phase-out is an essential green building strategy in the LEED-EB green building rating system: Energy & Atmosphere prerequisite 3 requires that the building either use no CFCs in its base building systems or that an independent economic analysis show that system replacement or conversion is economically infeasible.

HCFCs and Halons: better, but not good enough

A common alternative to CFC refrigerants is their chemical cousin, hydrochlorofluorocarbons (HCFCs). While HCFCs are more environmentally friendly than CFCs, with ozone depletion potentials one-tenth or less than those of CFCs, they still cause significant ozone damage. As a result, all HCFCs will be phased out in the United States by 2030. The most damaging HCFCs began to be phased out first, starting in 2003. Halons are used in fire suppression systems and fire extinguishers. Halon production has been banned in the United States since 1994 because of its very high ozone depletion potential, many times greater than those of CFCs or HCFCs.

HCFCs are still in production in the U.S., and HCFC-based equipment will be available for many years to come until the full phase-out has been accomplished. However, in an effort to accelerate this phase-out LEED-EB offers an optional credit for existing buildings that use no halons or CFCs (no economic feasibility exemption) and also either use no HCFCs or reduce the HCFC leakage to low rates.

Choosing Greener Refrigerants

If CFC refrigerants are bad for the environment and HCFCs are better but still undesirable, what refrigerants are considered sustainable? It turns out no perfect substitute for CFCs yet exists that combines all their desirable properties while avoiding their undesirable properties. Even so, research has led to a new class of refrigerants, the hydrofluorocarbons (HFCs), that are considered "greener" than either CFCs or HCFCs. A key chemical difference is their absence of chlorine atoms, which means their ozone depletion potential is essentially zero. On the downside,

they still have significant global warming potentials (like CFCs) and are somewhat less thermodynamically efficient than their predecessors.

Most new HVAC systems without CFCs and fire suppression systems without halons are cost-competitive. As an interim step, many owners are converting to HCFCs while eliminating the use of CFCs. However, since HCFCs face a full ban in 2030, it may be cost-effective to fully migrate to HFC-based equipment now, rather than relying on HCFCs as an interim step. Be sure to consider both approaches if your aging equipment needs to be replaced.

Finally, some HVAC equipment is available that uses “natural” refrigerants such as water, carbon dioxide, or ammonia. These naturally occurring compounds have far lower potential for atmospheric damage than manufactured chemical refrigerants.

Accelerated Equipment Replacement and Retrofit

Many existing buildings still have medium-age, well-functioning chillers containing CFCs, and CFC replacement or conversion per se offers no direct financial benefit to the facility owner. Any such facility would seem to have no reasonable option for greening their refrigerants. How does a facility manager in this position make a business case to go green in this area?

The financial benefit comes from modernization: refrigeration technology has improved dramatically in the past 10-15 years, and the ongoing energy and maintenance cost savings resulting from upgrading to modern equipment may offset the cost of converting or replacing these existing systems. For example, replacing a 500-ton CFC chiller (0.85 kW/ton efficiency) with an efficient (0.56 kW/ton) non-CFC chiller can save \$17,000/year, assuming an electricity rate of \$0.06/kWh. Simple payback times for this sort of chiller replacement can be only a few years in some cases.

For conversion or replacement systems, carefully consider the tradeoffs among the various CFC substitutes. Refrigerants have varying atmospheric lifetimes, ozone depletion potentials and global warming potentials. It is more sustainable to choose refrigerants with low atmospheric lifetimes as well as low ozone depletion and global warming potentials, since the longer a compound is present in the atmosphere, the more damage it can cause. This strategy, in addition to being a greener approach outright, also hedges against the risk of possible future environmental regulations.

Refrigerant Management

Refrigerants cannot damage the atmosphere if they are contained and are never released to the environment. Unfortunately, in real world applications some or all refrigerant provided for HVAC equipment is leaked to the environment during installation, operation, servicing, and decommissioning of equipment. Because of this, Section 608 of the Clean Air Act of 1990 requires some basic management of these refrigerants and defines specific methods for refrigerant handling and reporting.

If replacing all equipment containing CFCs, HCFCs, and halons is economically infeasible, you can implement a program to minimize refrigerant leakage that goes beyond the minimum federal requirements. The program should specify loss minimization procedures and systems to meet annual loss minimization standards and reporting requirements. For LEED-EB purposes, the best practice in this area is reducing total refrigerant emissions to less than 3% of charge per year while also reducing leakage over the remainder of unit life to below 25% of charge.

Conclusion

Changes in building equipment refrigerant have already happened because of environmental concerns, and more are coming. It's really not a question of whether facilities managers will upgrade their HVAC equipment, but when and in what way. Fully evaluating the benefits of using new refrigerant technology before it's absolutely required can get you ahead of the curve and give you a competitive edge for years to come.

Resources

U.S. Green Building Council (www.usgbc.org/leed)

The USGBC's LEED for Existing Buildings program addresses green refrigerants in its requirements and credits.

EPA's Significant New Alternatives Policy (SNAP)

(<http://www.epa.gov/ozone/snap/index.html>)

SNAP is an EPA program to identify alternatives to ozone-depleting substances. The program maintains up-to-date lists of environmentally friendly substitutes for refrigeration and air conditioning equipment, solvents, fire suppression systems, adhesives, coatings and other substances.

Stratospheric Ozone Protection: Moving to Alternative Refrigerants

(<http://www.epa.gov/ozone/snap/refrigerants/refcases.html>)

This EPA document includes 10 case histories on buildings that have been converted to accommodate non-CFC refrigerants.
