Sensata Technologies

A2L AND NEW REFRIGERANT STRATEGIES TAKE HOLISTIC VIEW OF ENVIRONMENTAL IMPACTS

NEW TECHNOLOGIES HELP SUPPORT REDUCED GREENHOUSE GAS EMISSIONS

WHITE PAPER

Across nearly every industry worldwide, there has been a continued push for fuel and energy efficiency – along with a reduction in global warming impacts. The heating, ventilation and air conditioning industry has been a focal point of that trend.

The U.S. Energy Information Administration estimates that the energy used to cool residential and commercial buildings accounted for a full 10 percent of total electricity consumption. The latest push in the industry to help reduce electricity use and greenhouse gas emissions is the shift to A2L HVAC systems featuring new refrigerant types designed to be both energy efficient as well as less impactful toward global warming.

The use of advanced A2L refrigerants – and their widespread use – will help drive a continued reduction in greenhouse gas emissions and continue a push for a healthier world.

PUSH FOR A2L - REGULATORY AND HISTORICAL BACKGROUND

The processes which set the stage for the development of A2L refrigerants go back to the late 1970s and early to mid-1980s, when scientists studying the thinning of the ozone layer in Earth's atmosphere discovered the impact man-made chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) were having on the planet.

Those discoveries ultimately led the way to the creation of the Montreal Protocol through the United Nations, which was adopted in September of 1987. To this day, it is the only treaty which that has been ratified every country on Earth - all 198 UN Member States.

That treaty created a phase-down schedule for almost 100 man-made chemicals designated as ozone depleting substances – many of which had been traditionally used in refrigeration and air conditioning contexts. Under that schedule, developed countries completed phased out HCFCs by 2020, and developing countries operating under a timeline of 2030.

Introduced to replace those ozone-depleting chemicals in many cases were another group of substances - hydrofluorocarbons (HFCs). While they did not have the same negative impact on the ozone layer, these chemicals did still have elevated global warming potential (GWP), creating an outsized effect on global warming.

To address that aspect of the dynamic, the United Nations developed the Kigali Amendment in 2016, which would look to phase out HFCs over time, reducing their use by 80 to 85 percent by the late 2040s in developed countries. Many European countries have taken independent actions, and the United States ratified the agreement in September 2022.

Overall, the trend in refrigerant technology and approach over the past 40+ years has been the continued movement toward systems with a reduced GWP and overall lower environmental impact.

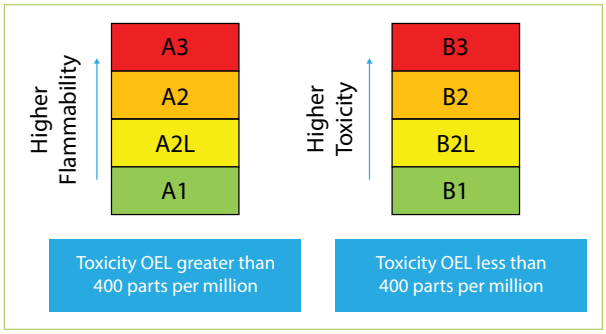
BREAKING DOWN ENVIRONMENTAL IMPACT OF REFRIGERANTS

The environmental impact of refrigerants – and why the A2L category is coming into focus – comes back to the holistic impact those chemicals have on the environment.

In this context, chemicals are generally classified in terms of both flammability and toxicity according to ISO 817.

Chemicals in category A3 are considered less toxic, but highly flammable – such as propane. While chemicals at B1 may not be flammable, they are toxic. A2L chemicals are slightly flammable but are less toxic.

The third factor to consider is how efficient and effective a chemical is for a given purpose. After all – most of the environmental impact of HVAC equipment – about 70 percent – is in their power consumption (and the energy generation processes used to provide it).



Holistically, the goal is to find the balance between a chemical's global warming potential (GWP) and its efficiency in use in an HVAC environment while also considering flammability, toxicity, or other issues.

While legacy hydrofluorocarbons did provide strong efficiency in HVAC systems for their time, they carried extremely high GWP rates, in addition to the ozone depletion issues discussed prior. Many A2L refrigerants developed in the years since deliver stronger HVAC performance without those ozone-depleting or greenhouse gas side effects.

Other chemicals – such as propane, CO2, or ammonia - have also been used in this application, but each of them has issues which stand as barriers to truly widespread use. CO2 systems operate at 5 to 10 times higher pressure than other systems and may not be permitted in some context, propane is extremely flammable, and ammonia has the potential to be highly toxic.

	R12 Freon (Banned CFC)	HFC-134a	HFC-152a	CO2 (R-744)	Propane (R290)	Ammonia
Ozone Depletion Potential (ODP)	1	0	0	0	0	0
Global Warming Potential (GWP)	10,200	1,430	124	1	3	0
Flammability/Toxicity	A1	A2L	A2L	A1	A3	B2L
Operating Pressure Range	2.1 - 11.7 bar	0.6 - 6.7 bar	0.6 - 6.7 bar	10 -150 bar	10 - 50 bar	2.9 -13.5 bar

That concept of finding the right balance between GWP, safety, and cooling efficiency is the genesis behind the A2L category, and its use within the HVAC context.

CODIFYING A2L HVAC SYSTEMS IN BUILDINGS

A2Ls have been used in the European Union, Japan, India, Australia, and the auto industry for some time. But as the advantages of using A2L systems became more clear, regulatory bodies made adjustments to account for their use in commercial and residential HVAC systems, such as ASHRAE 15-2019 and UL 60335-2-40.

In order to burn, A2L gases would need to leak, reaching concentrations above the chemical's lower flammability limit, and then be exposed to an open flame or other ignition source. To prevent this, much of the regulatory focus has been on the preventing and detection of leaks within a given system.

Systems designed to operate with A2L refrigerants must be designed so they cannot operate if leak detection systems are bypassed. Those same leak detection systems must withstand very challenging environmental conditions – high in condensation with significant temperature extremes - without needing additional maintenance or calibration over a planned 15-year equipment life. In addition, many chemicals used in servicing HVAC equipment may use oils or other chemicals which may foul some detection systems.

Those factors put the pressure on HVAC OEMs and their partners to develop solutions for this next generation of equipment.

LOOKING FORWARD WITH REFRIGERANT TECHNOLOGY

Stretching back more than 40 years, the continuing arc of HVAC technologies has been the continued push toward more environmentally friendly technologies and refrigerants – a trend which will likely continue to take shape in the coming decades.

Actions taken under the Kigali Amendment to reduce and eliminate the use of HFCs is expected to prevent more than 100 million tons of carbon dioxide equivalent of greenhouse gases from the atmosphere. By 2100, that effort will have hopefully helped to avoid up to 0.5 degree Celsius of global temperature rise.

Looking ahead, further enhancements in HVAC system design throughout the coming years and decades will continue to take shape, governed by that ongoing focus on safety, environmental impact, and energy efficiency worldwide.