UNDERSTANDING REFRIGERANT REGULATIONS & BASIC SWITCHES

A Honeywell White Paper

Honeywell

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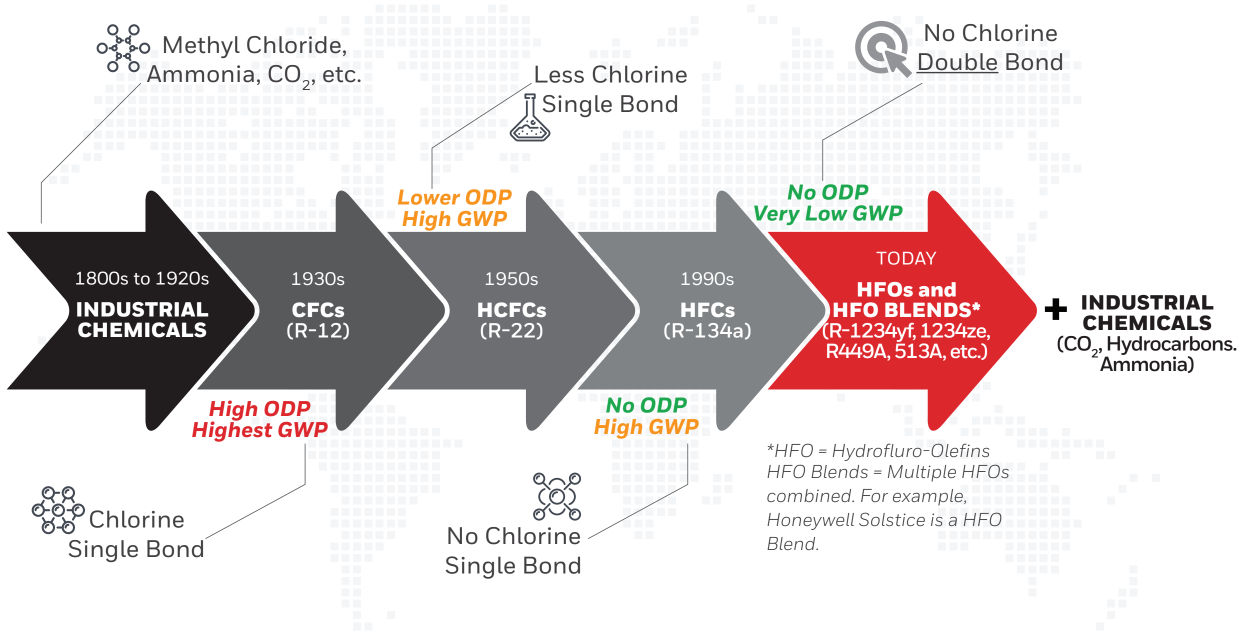
ABSTRACT

Since the early 1950s the evolution of refrigerants in household appliances has driven manufacturers worldwide toward designs that continue to address the new challenges these chemicals bring.

As global warming potential and energy efficiency drive key requirements, designers must find solutions that provide the appropriate balance of performance, safety, sustainability, and total cost of system ownership.

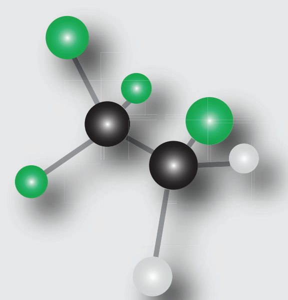
HISTORY OF REFRIGERANT TRANSITIONS



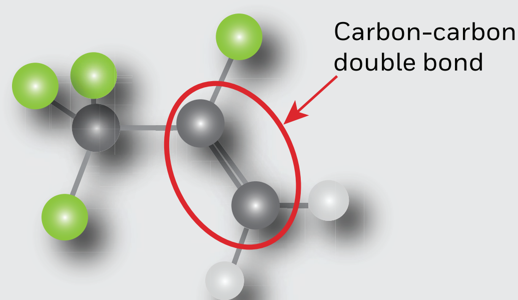
INTRODUCTION

In the past few years, a major market driver and disrupter for the refrigeration and HVAC market has been the ever-evolving Montreal Protocol and Kigali Amendment.

These two regulations together form a list of requirements and timelines that are solely focused on improving the health of the ozone and reducing global warming. Part of these efforts are targeted at finding and adopting lower GWP (global warming potential) refrigerant solutions like R290 and R600a to replace common refrigerants used in the past like R22 (Freon) and R134a. As the composition and chemical properties of the refrigerants change, the electrical designs and certifications needed for these solutions evolves as well.



HFC
Hydrofluorocarbon
HFC- R134a, R22



HFO
Hydrofluoroolefin
HFO- R290, R600a

The weaker double bond in the HFO compound between the two carbons allows for short atmospheric life, while still maintaining stable systems.

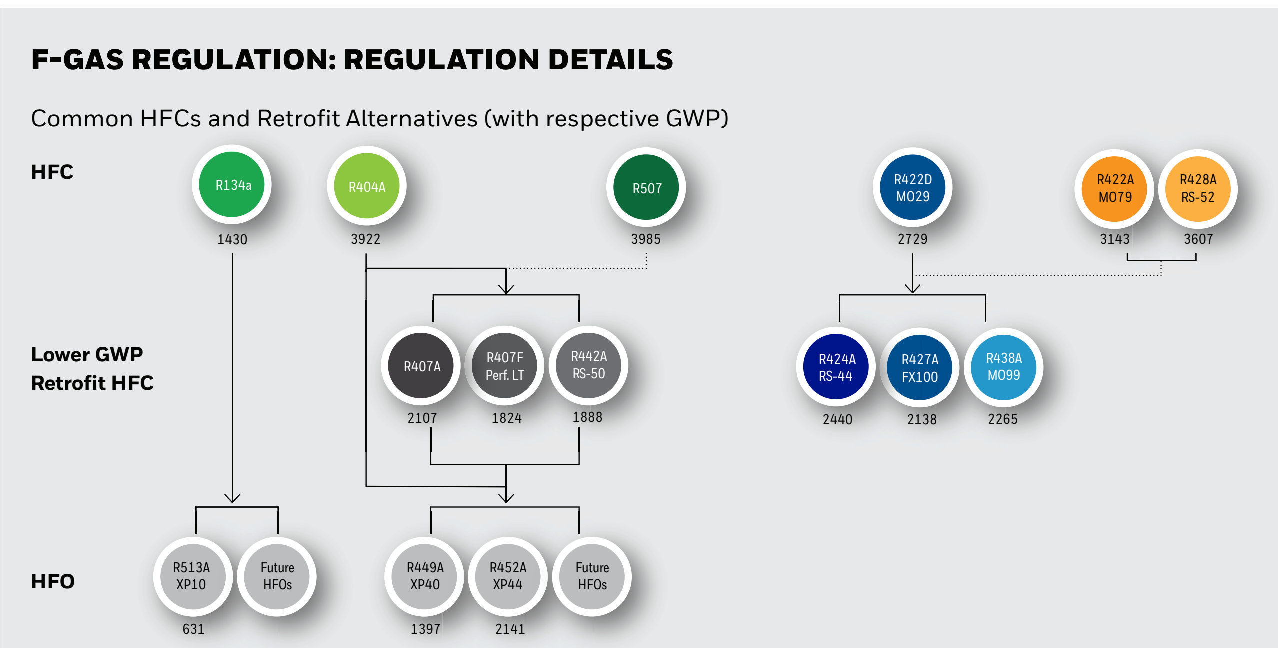
In HFC compounds, more energy is required to break the double bond between the two fluorine molecules than that of the carbon, leading to a higher overall GWP value.

MONTREAL PROTOCOL AND THE KIGALI AMENDMENT DRIVE REGULATION CHANGES

> **Now more than ever, designers need solutions to help enable them to quickly and easily adapt their designs to meet not only the new requirements and regulations but the higher flammable nature of the new refrigerant solutions as well.**

In 1987, the Montreal Protocol was ratified by 197 countries around the world to help create regulations and actions focused on protecting the ozone layer by phasing out the consumption and production of ozone-depleting substances (ODS). Since this time, countries worldwide have taken actions to help reduce the amount of these substances both in production and circulation out in the market. In the original scope of the Montreal Protocol, the ozone-depleting substances that were first targeted for phase-out focused on compounds like chlorofluorocarbon (CFC), Halons (bromine, chlorine or fluorine alkane compounds), and hydrochlorofluorocarbons (HCFC). The outcome of the protocol was a set of guidelines and procedures that clearly outlined the control measure, phase-out timelines (see Figure 1), and handling procedures that each participating country must follow to ensure compliance in the reduction of the target ozone-depleting substances.

Figure 1. Phase Out Regulation Details



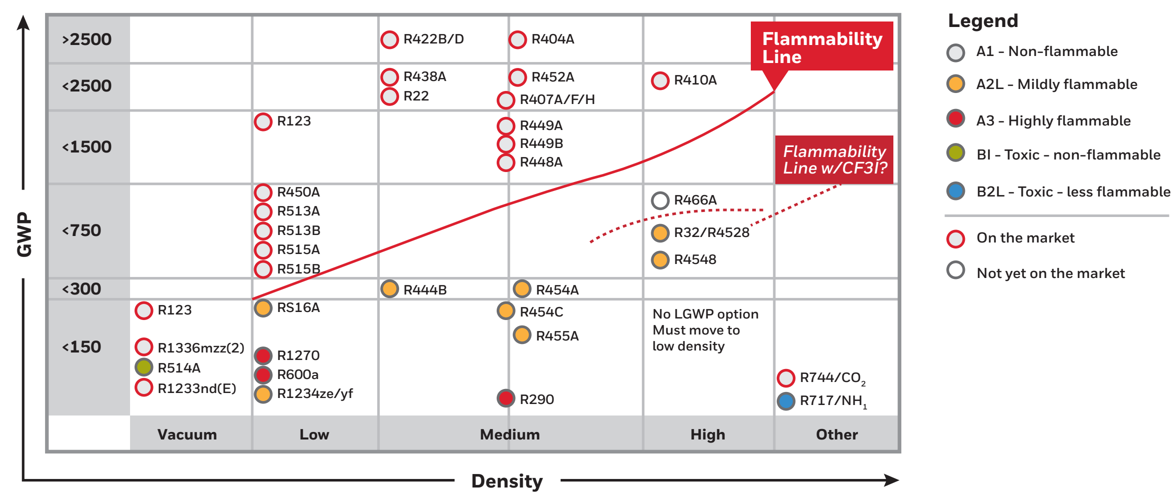
From 1990 to 2016, seven other meetings were held by the same countries that participated in the first Montreal Protocol committee. Each of these subsequent meetings helped to ensure that the regulations around ozone protection evolved and changed over time to reflect the developments and growth experienced in science and technology. The last of these meetings took place in October 2016, where the Kigali Amendment was added to the Montreal Protocol. This amendment brought with it the addition of hydrofluorocarbons (HFCs) to the list of ozone-depleting substances subject to reductions in both production and consumption of the compounds. HFCs are commonly used for refrigerants in applications such as air conditioners, consumer and industrial refrigeration, chiller, and condensers. The target phase-out timeline for these refrigerants calls for at least an 80% reduction in the production and consumption of these substances over the next 30 years, with all major developed countries completely freezing their production and consumption by 2028 as monitored and measured by their respective regulating agencies (see Figure 2).

To ease of adoption of the new regulations, the amendment implementation takes place in three separate phases that span from 2019 to 2028 and pertains to all developed countries. The first stage began in January 2019, and is focused on achieving two main goals. The first, is to drive the adoption of new designs and expedite the phase-out of HFCs in North America refrigeration market. The second is to continue to strengthening previous regional regulations like the “F-Gas Regulations” (EU No 517/2017) in Europe and “Action on Rational Use and Proper Management of Fluorocarbons” in Japan that focus on adoption of ozone friendly refrigeration solutions. The second stage follows in 2024 and will encompass most of the remaining developed countries of China and Brazil, plus the entire continent of Africa in HFC reduction efforts. The final stage is set to complete in 2028, when countries located in the Middle East will be required to discontinue their consumption and use of ozone-depleting substances.

Figure 2. International, Regional, National and Industry Regulatory Agencies

The timelines and regulations instated by the Kigali Amendment require that all platforms released after January 2020 for stage one countries, January 2024 for stage two countries, and January 2028 for stage three countries must adhere to the HFCs phase out efforts and use only ozone friendly refrigerant solutions instead of the high ozone-depleting substances, like R-22 (Freon) and R-134a (see Figure 3 for a detailed comparison). Due to these platform design deadlines, there is a market need to find new refrigerants that can replace HCFCs and HFCs, while still providing a solution that is equivalent or better than the current refrigerants in areas like performance, safety, sustainability, and total cost of system ownership. Two of the top refrigerant solutions that being adopted by design engineers as replacements for old refrigerants are R290 (propane) and R600a (isobutane).

Figure 3. Refrigerant Relationships with GWP and Density



REFRIGERANT SOLUTIONS AND ELECTRICAL STANDARDS TO ADDRESS NEW REGULATIONS

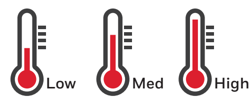
R290 (propane) and R600a (isobutane) have emerged as two of the main replacements that system designers are used in both domestic, commercial, and industrial refrigeration applications.

Both new refrigerants are solely targeted for new platform designs and not suitable for retrofitting older designs due to their mildly flammable properties. The various chemical properties of these two substances also influence several system requirements that designers must meet (EN/IEC 60335-2-24) in their new designs to ensure proper certifications and safety. One of the main chemical properties that drives design differences between R290 and R600a is the total amount of charge each refrigerant can support. This charge level directly correlates to the efficiency and performance of the refrigerant and has led to R600a being a common replacement in the domestic appliance applications due to its lower charge-level of 57 g, where R290 is more commonly used in new commercial and industrial grade solutions due to its higher charge-level of 150 g.

The refrigerant GWP regulations that drive R290 (see Figure 5) and R600a (see Figure 5) toward popularity in new designs also pushes revisions in common electrical design standards like IEC and ISO. The new revisions specifically cover the changes necessary in electrical requirements to ensure that these new designs can safely operate in the potential presence of a flammable gas. An example of one of these standards is IEC 60079, which is a collection of application-specific standards that covers the design considerations that need to be taken for each to ensure compliance. While the IEC standard is an example of a worldwide standard driving design changes, there are still many regional standards (i.e., UL, BSI and DIN) that give further details

Figure 4. R290 Refrigerant Retrofit

TEMPERATURE RANGE



RETROFIT INFORMATION	
Replacement for:	R22, R502
Retrofit gas or design for new equipment?	R290 is suitable for new R290 systems.It is a flammable refrigerant and therefore not suitable for retrofitting existing fluorocarbon refrigerant systems.
Other alternatives/ replacements	R600a, R1270
Compatible lubricants	MO, AB, POE

ENVIRONMENTAL IMPACT	
Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	
Global Warming Potential (GWP)	3
Global Warming Potential (Rating)	

SAFETY INFORMATION	
ASHRAE Safety Group (2013)	A3
ASHRAE Flammability	Yes (Highly flammable)
ASHRAE Toxicity	No

on the new requirements that are more regional specific. Along with adhering to the electrical design standards, there is also a need for these designs and often time components in the designs to have additional explosion-proof ratings. Agencies like UL, ATEX and IEC Ex have various levels of certification based on the Zone and Group of hazardous materials that are present in the system.

DECIPHERING CLASS, DIVISIONS, AND GROUP SYSTEMS FOR EXPLOSIVE ENVIRONMENTS

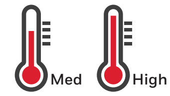
In the EU and most other countries, a class/division/group system is used to classify hazardous materials and is based on Article 500 of the National Electrical Code (NEC). Each hazardous material, whether it is a gas/vapor, dust, or fiber is given a specific class, division, and group classification to appropriately label the materials hazardous nature. For the classes, there are three total categories that correspond directly to the general nature and properties of the hazardous material. Class I is reserved for hazardous gases and vapors, while Class II is specifically for hazardous dusts and the final class, Class III, categorizes hazardous fibers. Once a material has a Class rating it is placed in the appropriate division rating. The division rating given to hazardous materials address the probability of the hazardous material being present in an ignitable concentration in the surrounding atmosphere. There are two division definitions for this material characteristic. The first, Division I, is for substances that have a high probability of causing an explosion if present in the environment, while the second, Division II, classifies substances with a low probability of ignition if present in the surrounding atmosphere. The final element to the classification rating is the Group rating. The Groups, much like the Zones are split by the type of hazardous material they are referring to. There are seven total Groups classified as Group A-Group G. The first four Groups (A,B,C,D) are reserved for flammable gases while the last three groups (E,F,G) are specific to flammable dusts and fibers.

Using Figure 6 as an example, all products with hazardous approvals must be clearly marked using the following format. ATEX indicates the approvals for the European Union, where as IEC Ex has global jurisdiction. Products are marked with their ATEX and IEC Ex classifications per the nomenclature shown in Figure 6. To learn more about these designations, review the Honeywell Guide to Hazardous Area Approvals.

In North America, a slightly different system of classification is used that only encompasses a Zone/Group system for hazardous materials and adheres to Article 505 and Article 506 of the NEC and follows the international method of area classification as described by IEC. In this system of material classification, a zone rating defines the general nature of the hazardous material. For gases and dusts, this

Figure 5. R600a Refrigerant Retrofit

TEMPERATURE RANGE

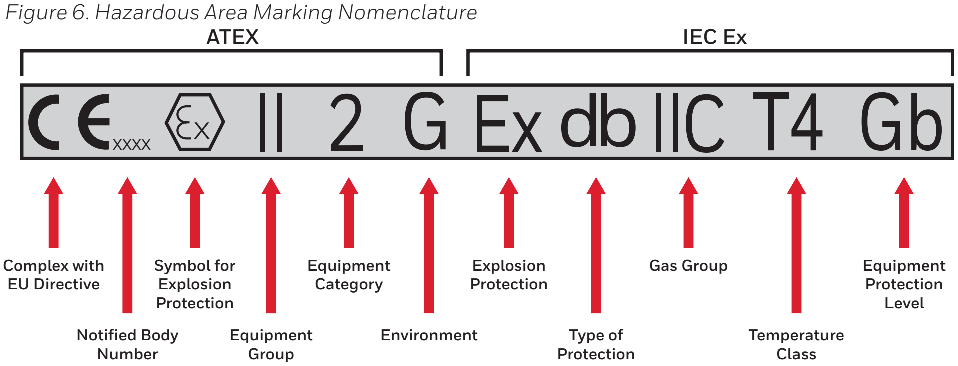


RETROFIT INFORMATION	
Replacement for:	R12, R134a
Retrofit gas or design for new equipment?	R600a is suitable for new R600a systems. It is a flammable refrigerant and therefore not suitable for retrofitting existing fluorocarbon refrigerant systems.
Other alternatives/ replacements	R290, R1270, R134a
Compatible lubricants	MO, AB, POE

ENVIRONMENTAL IMPACT	
Ozone Depletion Potential (ODP)	0
Ozone Depletion Potential (Rating)	
Global Warming Potential (GWP)	3
Global Warming Potential (Rating)	

SAFETY INFORMATION	
ASHRAE Safety Group (2013)	A3
ASHRAE Flammability	Yes (Highly flammable)
ASHRAE Toxicity	No

Figure 6. Hazardous Area Marking Nomenclature



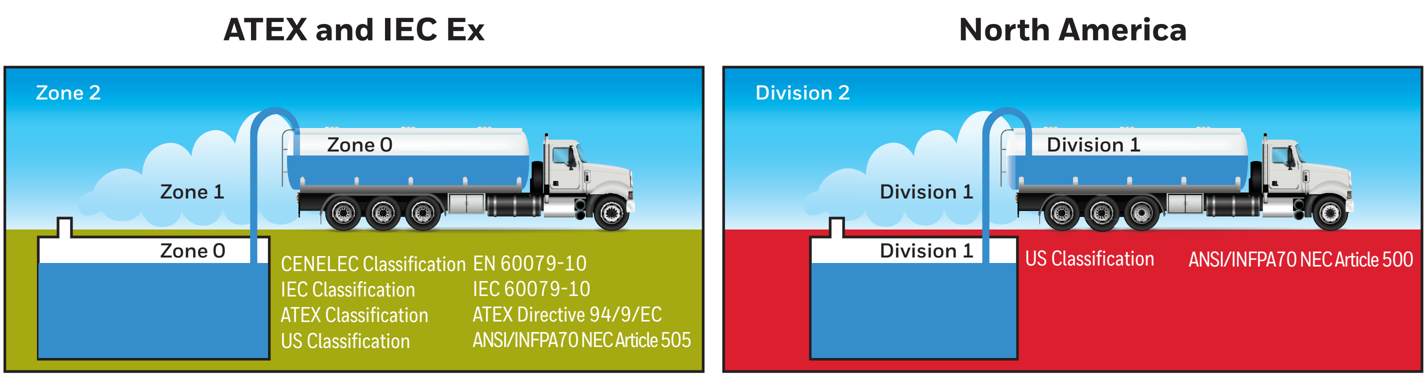
classification also covers the concentration levels of these materials in the surround atmosphere. There are six different zone classifications, and three specific categories reserved for gases and dust alone. The sole difference between the various zones is varying concentration levels of the flammable material that is present (see Table 1). The next portion of the classification, the Group, helps define the type of hazardous material and the location of where the hazardous material can be found in the open environment. There are three total groups in this classification with Group I being solely reserved for mining locations. The remaining two groups, Group II and III, are reserved for explosive gases and matches the corresponding Zone ratings and explosive dusts and their corresponding zone ratings respectively.

Table 1. Europe vs. North America Zone/Division Classification

European and IEC Classification	Definition of Zone or Division	North American Classification
Zone 0 (gases)	An area in which an explosive mixture is continuously present or present for long periods	Class I, Division 1 (gases)
Zone 20 (dust)		Class II, Division 1 (dust)
Zone 1 (gases)	An area in which an explosive mixture is likely to occur in normal operation	Class I, Division 1 (gases)
Zone 21 (dust)		Class II, Division 1 (dust)
Zone 2 (gases)	An area in which an explosive mixture is not likely to occur in normal operation and if it occurs it will exist only for a short time	Class I, Division 2 (gases)
Zone 22 (dust)		Class II, Division 1 (dust)
		Class III, Division 1 (fibers)
		Class III, Division 2 (fibers)

As a visual comparision of the various Classifications, Figure 7 shows a gas tanker truck with ATEX/IEC Ex approvals, as compared with one with North American Approvals. Using the content of Table 1, the atmosphere surrounding the truck can be considered Zone 2/Zone 1 (ATEX/IEC Ex) or Division1/Division 2 (North America) to show the difference in the classification designations.

Figure 7. Comparision 1: Flammable Dust & Liquid Zones



V15W2
DESIGN ENGINEER'S ANSWER FOR A FULLY CERTIFIED SWITCH

Honeywell's V15W2 miniature basic switch provides a fully certified basic switch for Zone 2 hazardous locations.

This makes this switch an ideal solution to help enable manufacturers working with the new, flammable refrigerants, to hit their design and certification goals. The V15W2 basic switch achieves Zone 2 certifications due to the use of an enclosed break protection type which contains any spark or electrical event inside of the switch casing. Internal flame paths are also present inside the switch to aid in cooling any hot gases that ignite inside of the switch cavity to ensure it doesn't spread to the outside atmosphere and ignite more flammable gas.

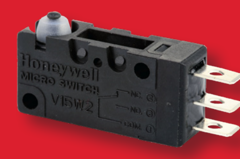
Applications suitable for solutions like the V15W2 basic are appliances, freezers, air-conditioning, condensers, chillers, Zone 2 HVAC, valve actuators and liquid/gas valves. Inside these designs are several subsystems that utilize basic switches like presence detection, on/off function, function monitoring and end-of-travel functionality.

Because there is potential for a flammable gas to be present in these systems, appropriate certifications for the new designs being introduced to the market are needed.

Three key features of the V15W2 basic switch that enable designers to have a solution that hits all their system-level requirements are:

1. World-wide certifications for explosion-proof, Zone 2 hazardous locations (UL, ATEX, IEC Ex) enables designers to have compliance in all key regions for their product
2. Configurable options for circuitry, levers, termination and contacts materials to enable switch selection that fits the subsystem design requirements and needs
3. Utilizes the industry-standard footprint for miniature switches to enable drop-in replacements for current basic switch solutions

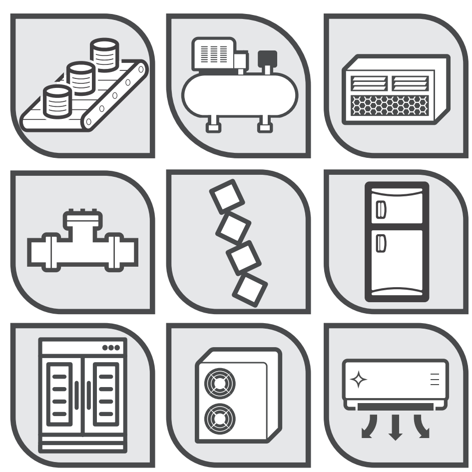
The V15W2 basic switch enables designers to have a drop-in replacement solution that is not only a sealed switch, but is fully certified for use in Zone 2 hazardous locations world-wide. This not only aids in creating a robust design, but also enables designers to not have to worry about the cost or time that is associated with certifying their basic switch to be explosion proof. This means that design engineers now have more time to focus on other areas of their design that also need to be updated to match these new regulations and standards.



V15W2

Hazardous Location Basic Switch

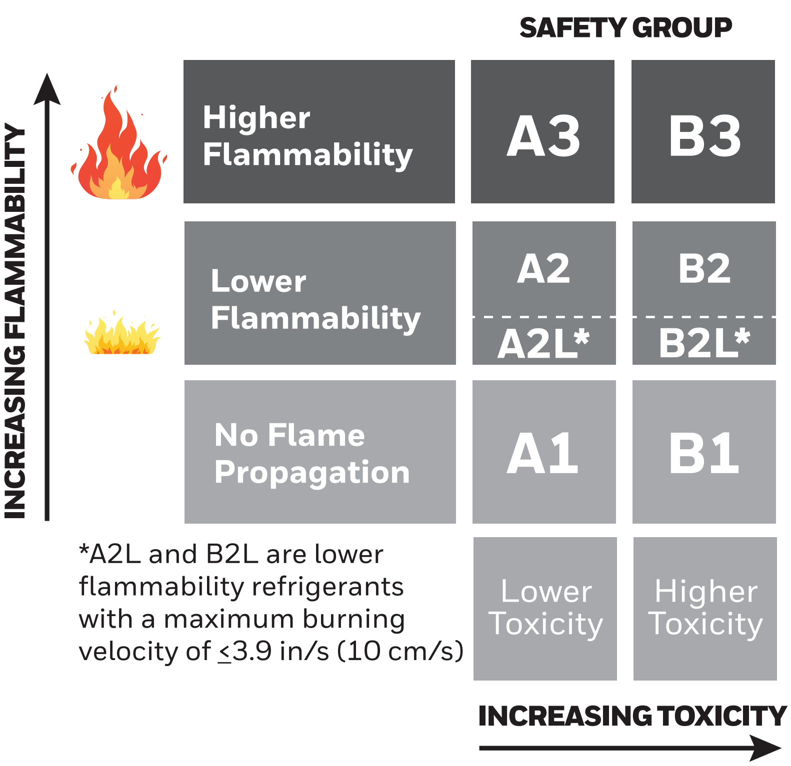
- Approved for use in Zone 2 hazardous locations; ATEX and IEC Ex certifications
- IP67 equivalent
- UL, cUL, ENEC, and CQC certifications for ordinary (non-hazardous) locations
- Longer service life: over one million mechanical operations
- Global package size acceptance



CONCLUSION

By 2028, all developed countries will only be able to release platforms that use new, GWP friendly refrigerant solutions due to the Montreal Protocol and Kigali Amendment.

R290 and R600a are two low GWP refrigerants that have been largely adopted by the industry as new solutions to replace the R-22 and R-134a during their global phase out. Both refrigerants, due to their chemical properties, are mildly flammable and therefore require designers to update both the design of the system and the level of certifications to meet the new electrical standards. The MICRO SWITCH V15W2 basic switch enables designers to easily address the revised requirements of IEC 60079 by providing a fully configurable, worldwide certified (UL, ATEX, IEC Ex), industry standard footprint switch to aid in expedited testing and drop-in replacement opportunities for new refrigeration and HVAC designs.



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THE FUTURE IS WHAT WE MAKE IT

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