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20 YEARS ANNIVERSARY

ADVANTAGES OF INFRARED SENSORS FOR REFRIGERANT LEAK DETECTION IN THE COMMERCIAL/INDUSTRIAL HVACR SECTOR

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Nürnberg | 11.10.22

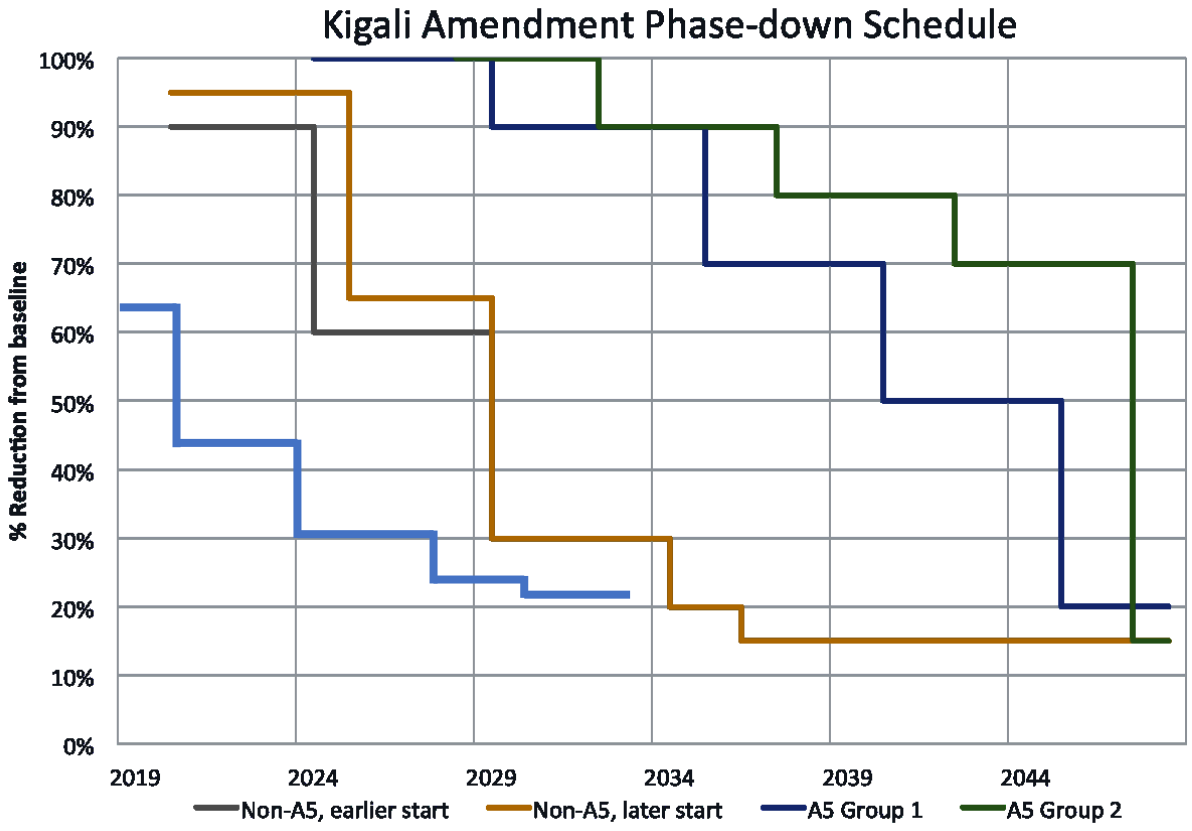
THE DRIVERS BEHIND THE GREAT REFRIGERANT TRANSITION

- Growing concerns about the impact on the environment and climate change of high-GWP refrigerants, particularly Chlorofluorocarbons (CFCs), Hydrochlorofluorocarbons (HCFCs) and Hydrofluorocarbons (HFCs).

- All 197 member countries agreed in 2016 to amend the Kyoto protocol, introducing a scheduled phase-down of HFCs (the so called "**KIGALI AMENDMENT**").

- The European Union (EU) introduced in 2006 and revised in 2014 an environmental law (**F-GAS REGULATION**) to reduce emissions to 70 per cent below 1990 levels by 2030 through a gradual market limitation of the quantities of HFCs, along with prohibitions its use at different points in time.

  - Its compliance is mandatory for all EU members, which are required to implement and enforce rules and penalties for violations.



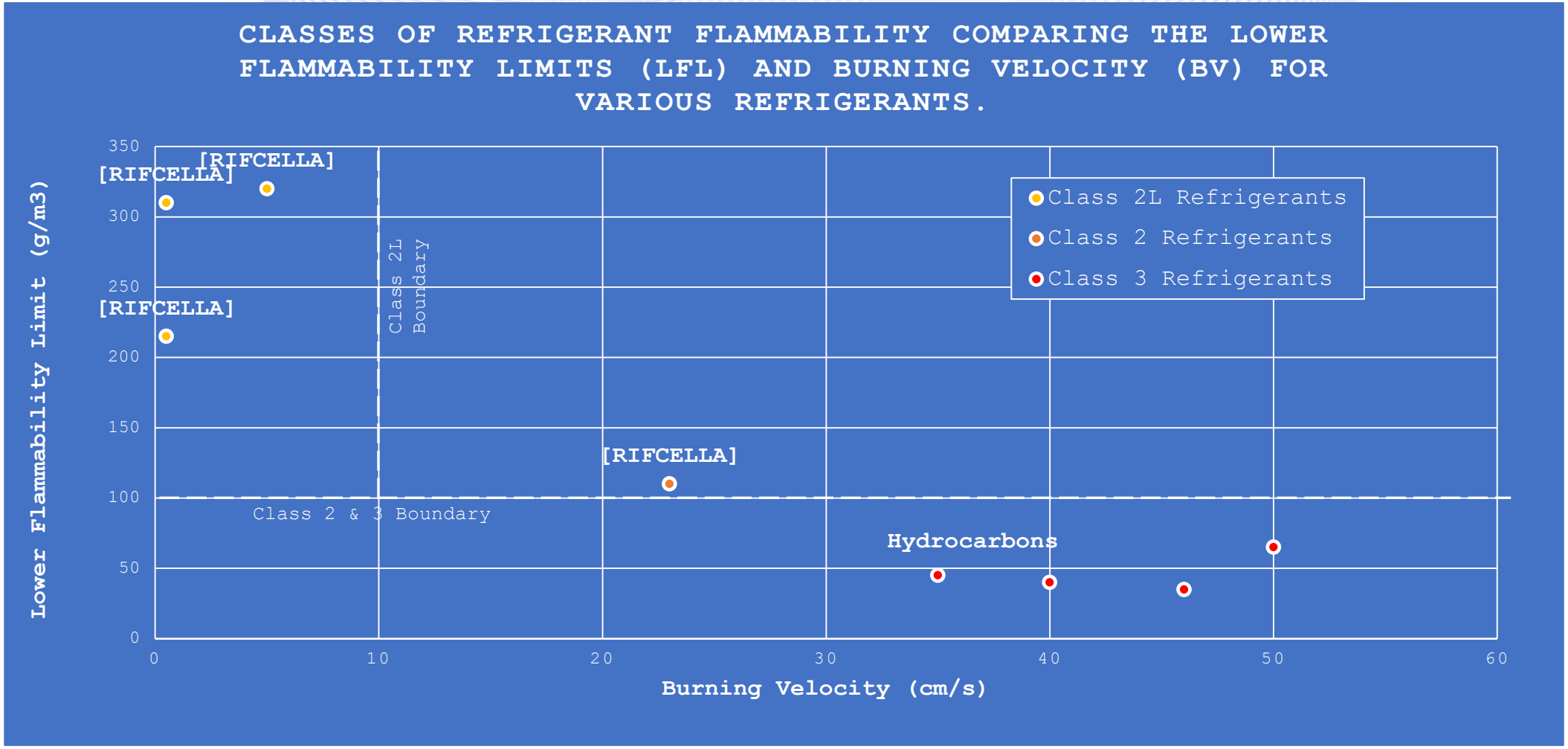
Group 1: Kigali Amendment Article 5 parties not part of Group 2
Group 2: Bahrain, India, the Islamic Republic of Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and the United Arab Emirates

NEW-GENERATION REFRIGERANTS AND FLAMMABILITY

- There's growing concern about the impact on **environment** and **climate change** of high-GWP refrigerants
- In response, the industry is developing a **new class** of **lower-GWP** refrigerants which in many cases posses some level of flammability.
- Refrigerant flammability is classified by **ISO Standard 817-2014 Refrigerants—Designation and Safety Classification** or by ASHRAE Standard 34-2016.
- To express the flammability properties of the new unsaturated HFCs (referred to as **HFOs**) and other refrigerants with similar properties, ISO 817-2014 made **2L** a **separate class**, characterized by **burning velocities less than or equal to 10 cm/s.**

REFRIGERANT SAFETY GROUPS		
Class 3 – Higher Flammability	**A3**	**B3**
Class 2 – Lower Flammability	**A2**	**B2**
Class 2L – Lower Burning Velocity	**A2L**	**B2L**
Class 1 – No Flame Propagation	**A** **1**	**B** **1**
	Lower Toxicity	Higher Toxicity

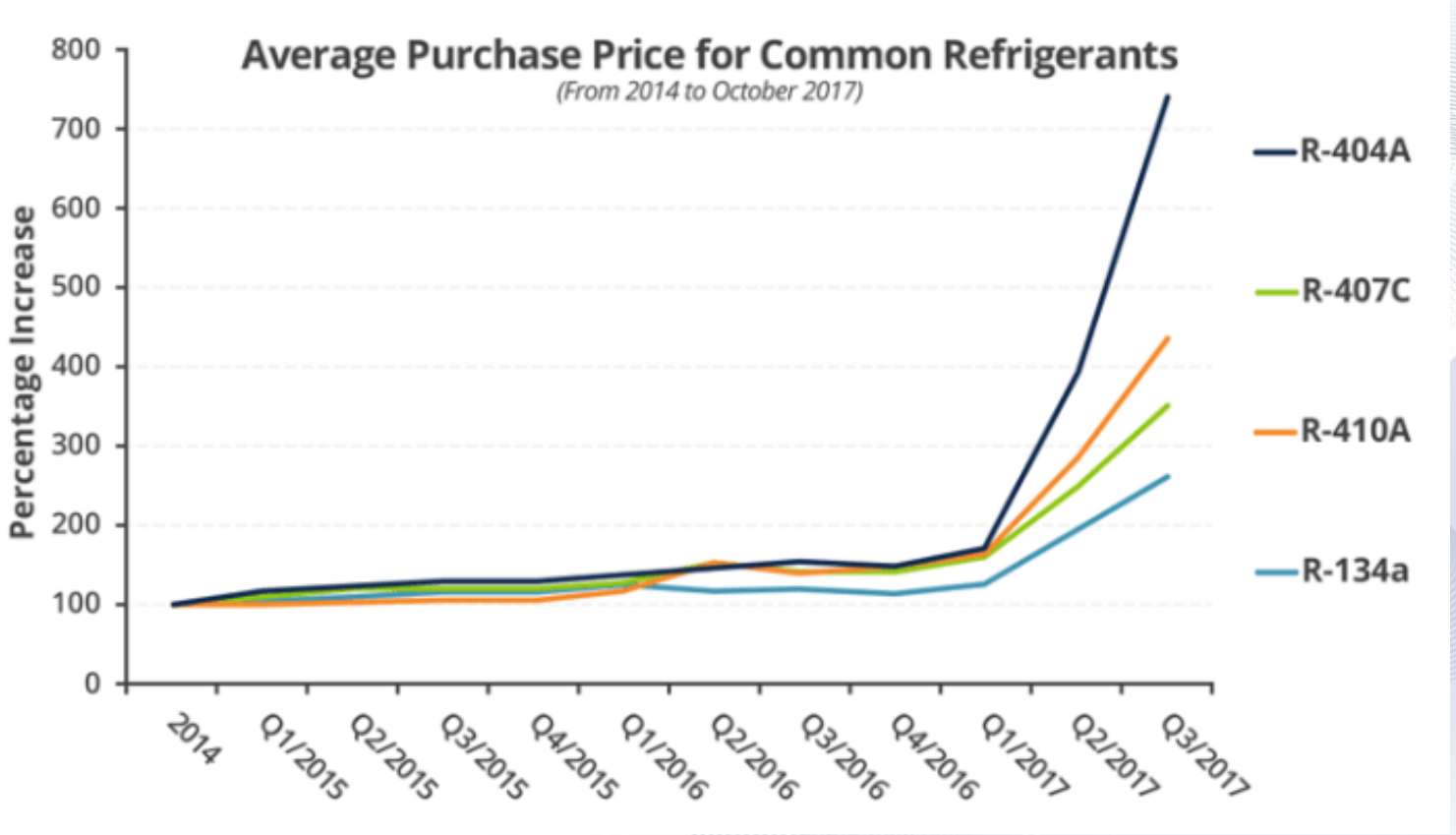
NEW-GENERATION REFRIGERANTS AND FLAMMABILITY



HVACR – STATE OF STANDARDS AND CODES

KEY INTERNATIONAL SAFETY STANDARDS			
STANDARD TYPE	**GROUP / USAGE RESTRICTION**	**PRODUCT / APPLICATION**	**REFRIGERANT CLASSIFICATION**
International standard	**ISO 5149 Standards on refrigerating systems and heat pumps**	**IEC 60335-2 series Household and similar electric appliances**	**ISO 817 Refrigerant Designation & Safety Classification**
US (national standard)	ASHRAE 15 Safety standard for refrigeration systems	UL 60335-2 series UL 250, UL 471, UL 484, UL 1995	ASHRAE 34 Refrigerant Designation & Safety Classification
EU (regional standard)	EN 378 Refrigerating systems and heat pumps	EN 60335-2 series	ISO 817 EN Refrigerant Designation & Safety Classification

SIDE EFFECTS – THE GREAT REFRIGERANT SHORTAGE

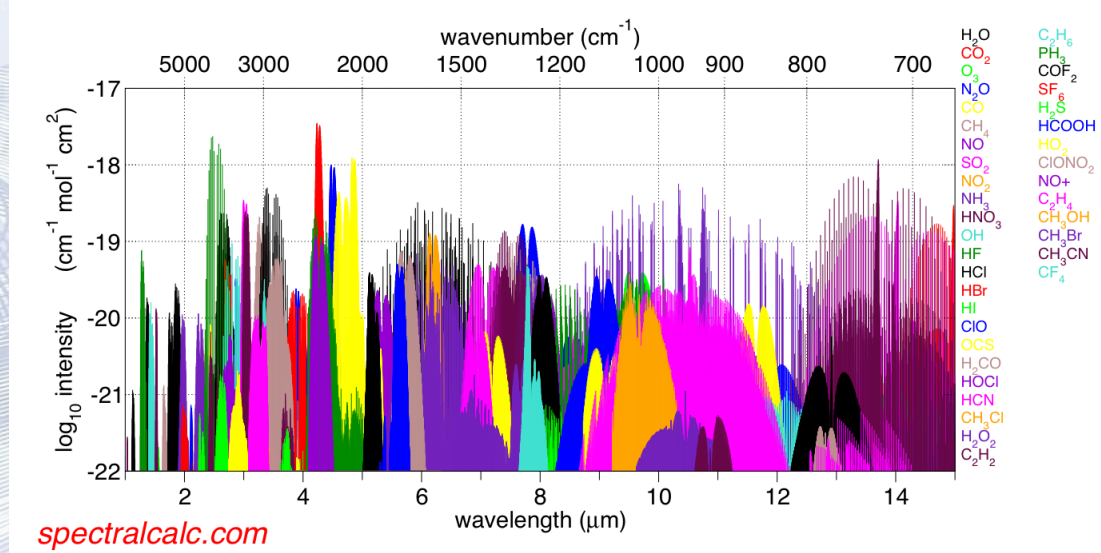


Source: https://refindustry.com

- European markets are experiencing the start of a drastic phase-down in the availability of HFC refrigerants: a reduction from 93% to 63% of the 2015 baseline figure.
- It is estimated that, in many cases, the cost of refrigerant loss is now higher than the cost of a technician's time to repair a leaking refrigeration system.
- Early refrigerant leak detection is increasingly important for financial reasons, especially in big systems.

NON DISPERSIVE INFRARED (NDIR) GAS DETECTION WORKING PRINCIPLE

- Gas molecules absorb light at specific **wavelengths** (or "color") that are characteristic of their molecular structure.
- Absorption characteristics are defined as **molecular vibrational energies** associated with stretching, bending or rotations and depends upon the gas molecular structure.
- For IR energy to be absorbed, that is for vibrational energy to be transferred to the molecules, the frequency must match the frequency of the mode of vibration. Thus, **specific molecules absorb IR radiation at precise frequencies** and each gas has a unique and well defined light absorption curve in the infrared spectrum.
- When IR radiation passes through a volume containing a specific gas, only frequencies matching the vibration mode are absorbed, while the rest of the light is transmitted without interference. For this reason, the presence of a particular gas gives rise to characteristic



Infrared absorption bands of all major trace gases
https://commons.wikimedia.org/wiki/File:Spectralcalc_infrared_bands.png

NDIR BENEFIT #1

GAS SELECTIVITY (NO CROSS INTERFERENCE)

MORE BENEFITS OF NON DISPERSIVE INFRARED (NDIR) GAS SENSORS

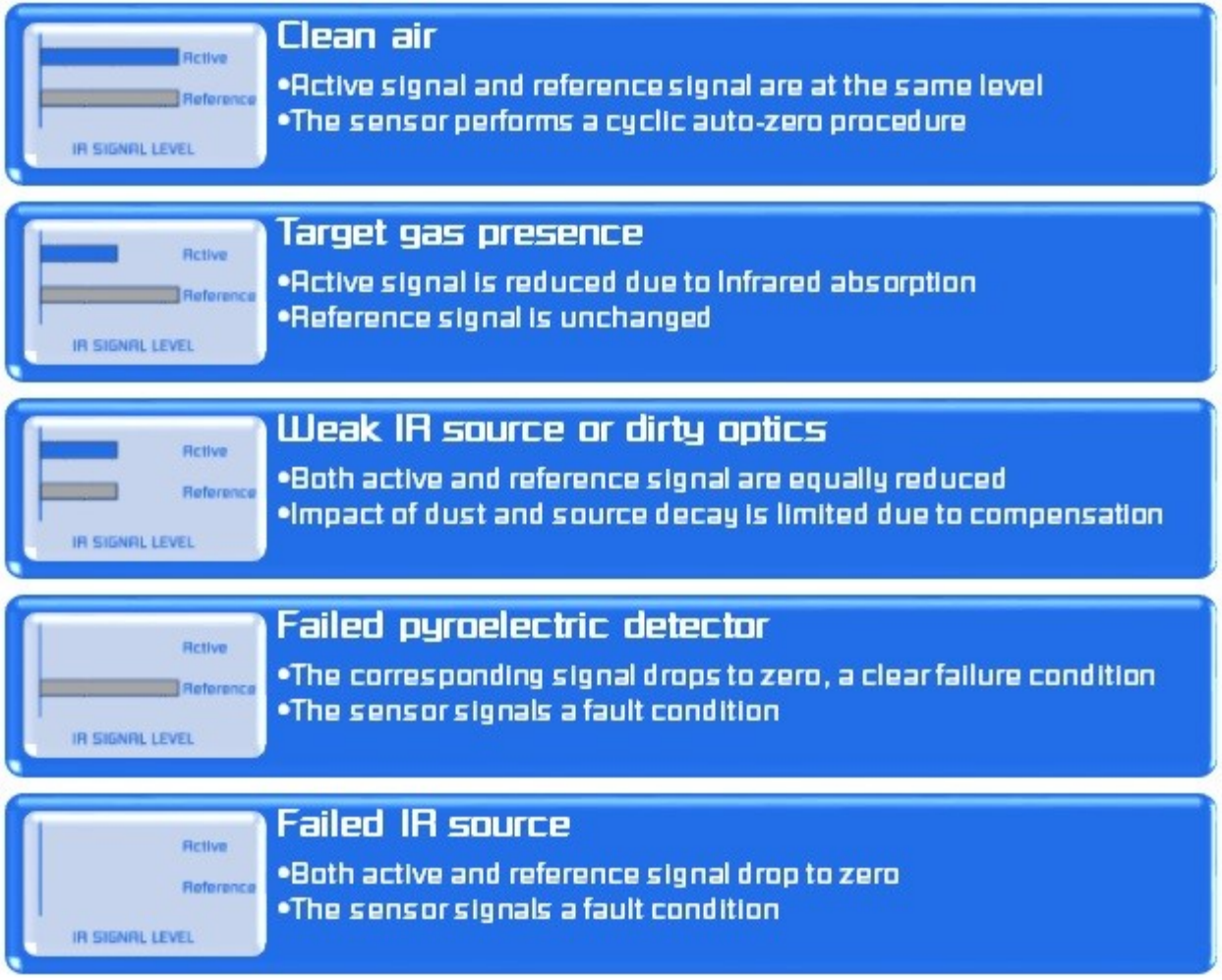
- The most frequent cause of failure on technologies such as Metal Oxide Semiconductor (MOS) and Catalytic (or pellistors), other than progressive wear, is the exposure to inhibitors and poisons causing the sensor to enter a condition unresponsive to the target gases.

- Dual-beam/dual detector Infrared sensors provide instead a **fail-safe** means to detect when a fault condition arises. The possible cause of failure in IR technology is the failure of either the transmitter or the receiver component.

- As IR detectors cannot be poisoned, only a physically blocked gas inlet would prevent the sensor from indicating a problem.

NDIR BENEFIT #3

FAIL-SAFE DETECTION

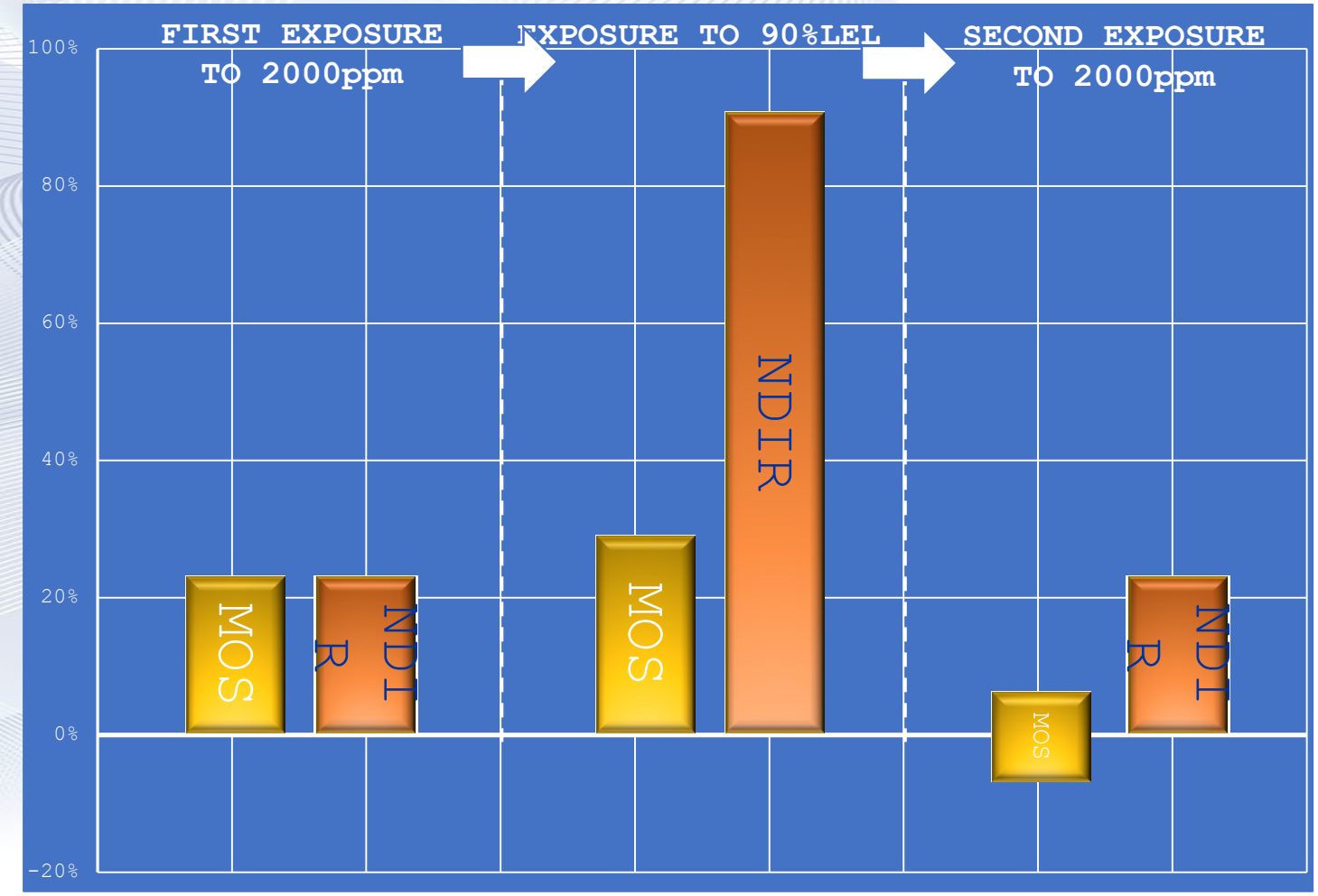


MORE BENEFITS OF NON DISPERSIVE INFRARED (NDIR) GAS SENSORS

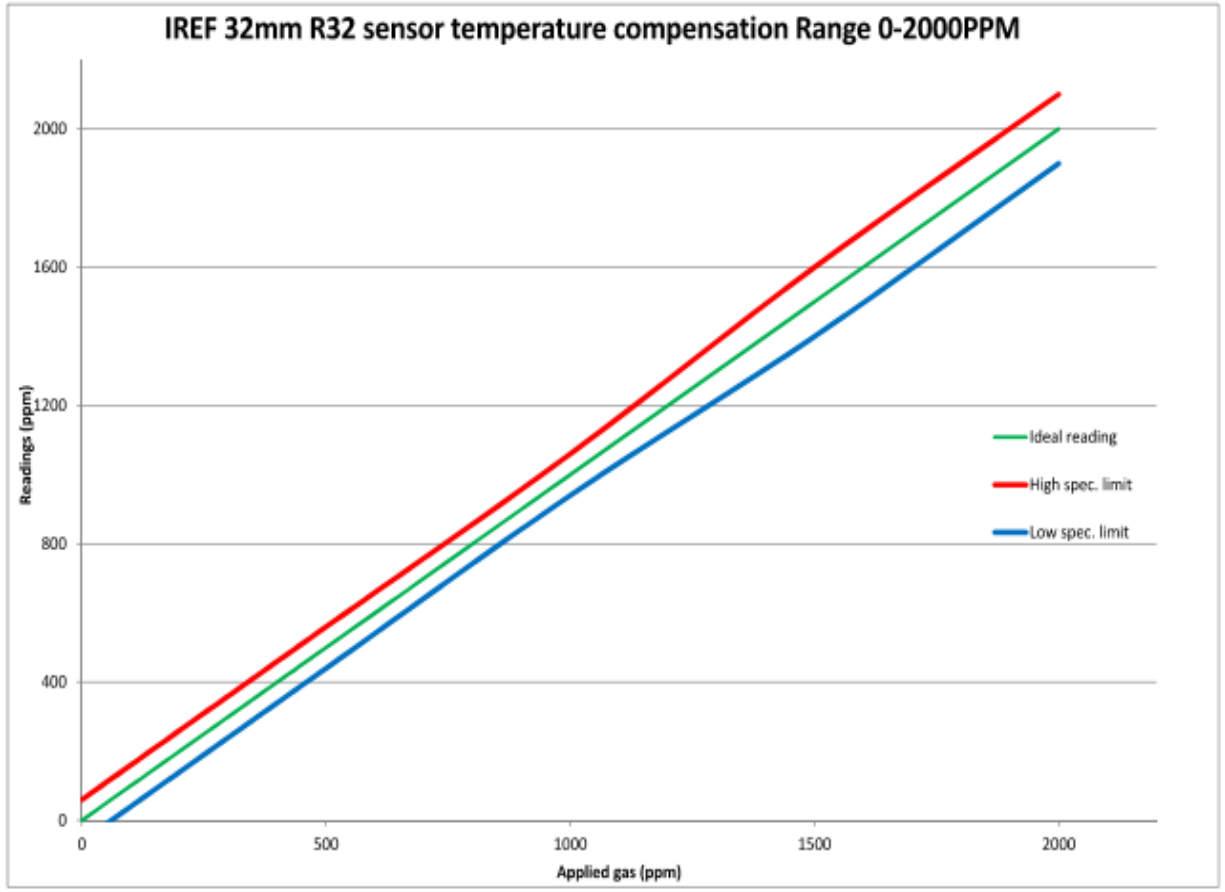
- Technologies such as Metal Oxide Semiconductor (MOS) and Catalytic and EC cells can be deteriorated or "burned-out" when exposed to high concentrations of the target gas, significantly reducing their ability to detect future leaks.
- After high exposures, MOS, EC cells and Catalytic sensors should normally be recalibrated or substituted.
- As NDIR detection does not involve chemical reactions on the sensor, exposure to high concentrations does not alter its characteristics and its ability to correctly detect future leaks is unaffected.

NDIR BENEFIT #4

IMMUNITY TO POISONING



MORE BENEFITS OF NON DISPERSIVE INFRARED (NDIR) GAS SENSORS



- A properly designed NDIR detector can be operated between -40°C to 60°C without being susceptible to ambient temperature fluctuations.
- Sudden temperature variations typically require 10 to 20 minutes for NDIR sensors to achieve temperature equilibrium.
- Normal environmental humidity has very little effect (H_2O absorption bands do not interfere with the target gases).
- Due to self-heating from the lamp and the electronics, NDIR sensors always operate at a temperature of about 15°C more than the actual ambient temperature, thus systematically above dew point
- Consistent high humidity could promote corrosion and contamination in presence of corrosive gases.

NDIR BENEFIT #5

RESISTANCE TO ENVIRONMENTAL CONDITIONS

MORE BENEFITS OF NON DISPERSIVE INFRARED (NDIR) GAS SENSORS

- Most nowadays NDIR sensors are microprocessor-based units, smart sensors with many advantages:
  - The sensor has a high-level interface, with a standardized, linear output. This eliminates the time and complexity required to deal with low-level signals, calculations and calibrations.
  - Communication with the sensor is bidirectional via digital protocols (Modbus and UART). The user can not only get readings, warnings and alarms but also change communication parameters and input updated calibration values.
  - Fail-safe operation and dependability are enhanced by several self-checks routines and consistency controls continuously performed by the sensor.
  - Faster response time, with accelerator algorithm.

NDIR BENEFIT #6

EASE OF INTEGRATION

CONCLUSIONS

- Infrared technology, already widely used in industrial and commercial settings, satisfy many of the proposed required criteria for A2L sensors.
- IR main advantages lies in greater gas selectivity and accuracy, low humidity and temperature dependence and long stability and expected lifetime, when compared to other available technologies.
- They are believed to be more than capable of detecting leaks within the anticipated alarm ranges without falsely-triggering on typical pollutants present in residential and commercial/industrial environments.
- IR sensors are also not anticipated to be susceptible to many failure modes in both residential and commercial/industrial applications.
- Their cost is however the major inhibitor to use and the industry is in fact in a drive to reduce them.

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THANK YOU FOR YOUR ATTENTION

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