

INTRINSIC SAFETY AND HAZARDOUS LOCATIONS

Portable electrical devices like RAE Systems gas monitors used in potentially flammable environments need to be made safe so that they cannot deliver enough energy (via hot surfaces or a spark) that ignites a flammable mixture of air and gas, vapor, dusts, fibers or flyings. If a device is made safe for a flammable environment, it can be either “intrinsically safe” or “explosion-proof.” Because there are various types and degrees of flammability, due to some substances being more flammable than others, there are various classifications of hazardous areas based upon the characteristics of various flammable substances.

INTRINSICALLY SAFE

If an electrical device is intrinsically safe, it is designed to be certified by an independent approving body, so that if it fails during normal use and operation it will not generate enough energy to ignite a flammable mixture of the hazard classes specified. Both theoretical analysis and real-life testing are used to determine if a device is intrinsically safe. Electrical devices like RAE Systems’ portable gas detectors are certified by outside authorities like Underwriters Laboratories (UL), Canadian Underwriters Laboratories (cUL), and other authorities to be intrinsically safe.

Explosion-Proof

An explosion-proof device is designed so that if a flammable mixture inside the device ignites, the flame will not get outside of the device to ignite a flammable mixture outside of it. An example of an explosion-proof device is a catalytic-bead Wheatstone bridge LEL sensor used to measure flammable gases by gas monitor manufacturers worldwide. Essentially a tiny electric stove, a LEL sensor uses a sintered metal flame arrestor to prevent any flame that might start on the hot sensing bead from getting outside of the sensor itself.

Oxygen Concentration and Intrinsic Safety

Intrinsic safety testing is done with combustible products in mixture with air. Because air is approximately 79% nitrogen and 21% oxygen, all intrinsic safety approvals are based upon a concentration of 21% oxygen. A typical UL approval label on an intrinsically safe instrument might say:

INTRINSICALLY SAFE, CLASS I, DIVISION 1, GROUPS A,B,C,D... This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%.



Testing at 21% oxygen is consistent throughout industry and among different approval agencies. It does not mean that the device is not intrinsically safe at 21.1% oxygen. Agencies only certify instruments as intrinsically safe for normal atmospheric oxygen concentrations. Flammability characteristics can change as oxygen concentrations change. Reduced oxygen levels decrease the risk of flammability, and enriched oxygen concentrations can increase the risk.

HAZARDOUS LOCATION CLASSIFICATION

Hazardous locations are places where the possibility of fire or explosion exists because of flammable gases– vapors or fine dusts are in the air. The National Electric Code (NEC) segregates hazardous environments into classes, divisions and groups:

Class I Locations

Class I locations may have flammable gases or vapors present in quantities sufficient for a fire or explosion. Class I locations are divided into two divisions:

- Class I, Division 1 (CI, D1):** Locations where a flammable atmosphere is expected during normal operations. These may also be locations where the breakdown of processing equipment can lead to the release of a flammable mixture and the simultaneous failure of electrical equipment. An example is the mixing area of a flammable paint manufacturer.
 
- Class I, Division 2 (CI, D2):** Locations where flammable vapors or gases are handled, processed or used. However, these flammables are confined within closed containers or closed systems from which they can escape only in the case of accidental rupture or breakdown. An example is the warehouse area of a flammable paint manufacturer. Flammable paints are normally contained in 55-gallon drums or metal cans, but a forklift could puncture a drum, leading to a flammable atmosphere.
 

Groups

Since vapors and gases have varying properties after Class and Division there are four groups of chemicals from the most volatile and explosive to the least (Groups A,B,C, and D):

| | |
|---|--------------------------------|
| Group A: | |
| Acetylene (is combustible w/o the presence of oxygen) | |
| Group B: | |
| Acrolein | Gases containing >30% hydrogen |
| Butadiene | Hydrogen |
| Ethylene Oxide | Propylene oxide |
| Group C: | |
| Acetaldehyde | Epichlorohydrin |
| Allyl Alcohol | Ethylene |
| n-Butyraldehyde | Ethylenemine |
| Carbon Monoxide | Hydrogen sulfide |
| Croton Aldehyde | Morpholine |
| Cyclopropane | 2-Nitropropane |
| Diethyl Ether | Tetrahydrofuran |
| Diethylamine | UDMH (1,1-dimethyl hydrazine) |
| Group D: | |
| Acetic Acid | Isopropyl ether |
| Acetone | Mesityl oxide |
| Acrylonitrile | Methane |
| Ammonia | Methanol |
| Benzene | 3-methyl-1-butanol |
| Butane | Methyl ethyl ketone |
| 1-Butanol | Methyl isobutyl ketone |
| 2-Butanol | 2-Methyl-1-propanol |
| n-Butyl Acetate | 2-Methyl-2-propanol |
| Isobutyl Acetate | Pryidine |
| Sec-butyl Acetate | Octanes |
| Di-isobutylene | Pentanes |
| Ethane | 1-Penanol |
| Ethanol | Propane |
| Ethyl Acetate | 1-Propanol |
| Ethyl Acrylate | 2-Propanol |
| Ethylene Diamine | Propylene |
| Ethylene Dichloride | Styrene |

| | |
|----------|----------------|
| Gasoline | Toluene |
| Heptanes | Vinyl acetate |
| Hexanes | Vinyl chloride |
| Isoprene | Xylenes |

Temperature Codes

Not all combustible gases are found in the NEC Groups A,B,C, and D. For the combustible gases and vapors falling outside of those listed in NEC Groups, we must reference the approval's temperature code. For above ground, non-volatile dust areas, the temperature code is the maximum hazard temperature that an instrument could produce. Temperature codes are indicated as T1 to T6. T6 rating means that a device generates a lower temperature than one with a T1 rating, so a T6 device would be safe for use on more easily ignitable substances than a T1 device. If a gas has an ignition temperature of 400°F, then an instrument with T3 to T6 temperature codes are safe for use in the presence of that chemical. For example, cumene is not on the NEC Group listing. Its ignition temperature is 795°F (424°C), so instruments with T2 to T6 temperature codes are safe for use in environments with cumene vapors in the air. Decane has an ignition temperature of 410°F (210°C), so instruments with T2D to T6 temperature codes are safe for use in environments with decane vapors in the air. This table shows temperature codes and their temperatures.

| Temperature Code | Maximum Surface Temp °F | Maximum Surface Temp °C |
|------------------|-------------------------|-------------------------|
| T1 | 842 | 450 |
| T2 | 572 | 300 |
| T2A | 536 | 280 |
| T2B | 500 | 260 |
| T2C | 446 | 230 |
| T2D | 419 | 215 |
| T3 | 392 | 200 |
| T3A | 356 | 180 |
| T3B | 329 | 165 |
| T3C | 320 | 160 |
| T4 | 275 | 125 |
| T4A | 248 | 120 |
| T5 | 212 | 100 |
| T6 | 185 | 85 |

Class II Locations:

Class II locations are flammable due to the presence of combustible dust. Class II locations are also divided into two divisions:

- **Class II, Division 1 (CII, D1):**

Combustible dust may be in suspension in air in sufficient quantities to produce a flammable or explosive mixture under normal conditions. The inside of a grain silo is an example.



- **Class II, Division 2 (CII, D2):**

Locations where combustible dusts are not normally suspended in air and normal operations do not put dust into suspension.

Class III Locations

These are flammable, due to the presence of easily ignitable fibers and flyings, but the fibers and flyings are not likely to be suspended in the air in quantities sufficient to produce an ignitable mixture. Examples include woodworking facilities and textile mills. Class III locations are also divided into two divisions.

- **Class III, Division 1 (CIII,D1):** Locations in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured or used.
- **Class III, Division 2 (CIII,D2):** Locations where easily ignitable fibers are stored or handled.

REFERENCES

NFPA 325: Guide to Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids 1994 Edition.

NFPA 70 National Electric Code (NEC).