Planning and Designing Gas Detection Systems

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Why Do You Need a Gas Detection System?

- There are two primary reasons to implement a Gas Detection System
  - To Protect Human Life
  - To Protect Property

What is the Hazard?

Determining the Hazards that exist at your facility is the first step in planning your gas detection system.

Combustible substances

- There may be considerable damage to installations if the substances ignite and explode, often accompanied by further fires and human casualties.

Toxic Substances

- Toxic substances. These can pose a serious risk to human health, often involving symptoms that manifest themselves only at a later date and are difficult to assess, possibly even leading to premature death.

Three Basic Sets of Questions

- Gases
  - With what objective are the target gases to be monitored?
  - Where are they likely to be released?
  - In what concentrations and quantities? How often?
  - What other non-target gases might be present?
- Gas sensors
  - Which sensing technology is most suitable?
  - How many sensors are needed?
  - Where and how should they be positioned?
  - What levels will activate the alarms?
- Gas Detection System
  - What do you want from the system?
    - Alarms- Lights, Horns, Ventilation Systems, etc.
    - Data Collection - Historical review, calculating TWA and STELs, etc.
    - Communication with an existing Control System such as a DCS

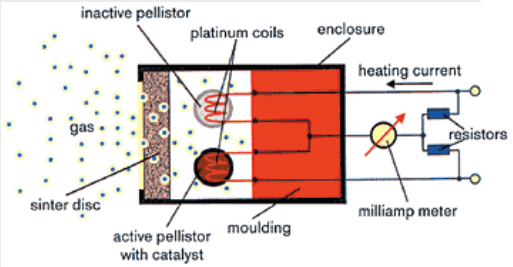
Gases

Answering the first group of questions will give a general outline of the task at hand, clarifying the operational conditions and the intended purpose, i.e., whether toxic gases (or gases that can have a suffocating effect) need to be detected to protect workers or whether combustible gases (or vapors) need to be detected to help prevent explosions.

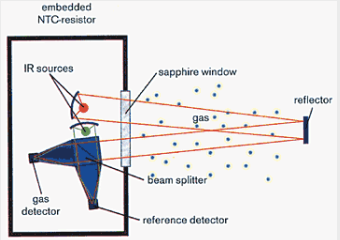
Gas Sensors

The three most common measurement technologies are:

- **Electrochemical**
  - Electrochemical sensors are particularly suited to the detection of toxic gases in the lower ppm range
- **Catalytic**
  - IR and catalytic methods are used to detect combustible substances in concentrations below the lower explosive limit
- **IR** (Infrared)- lel or ppm



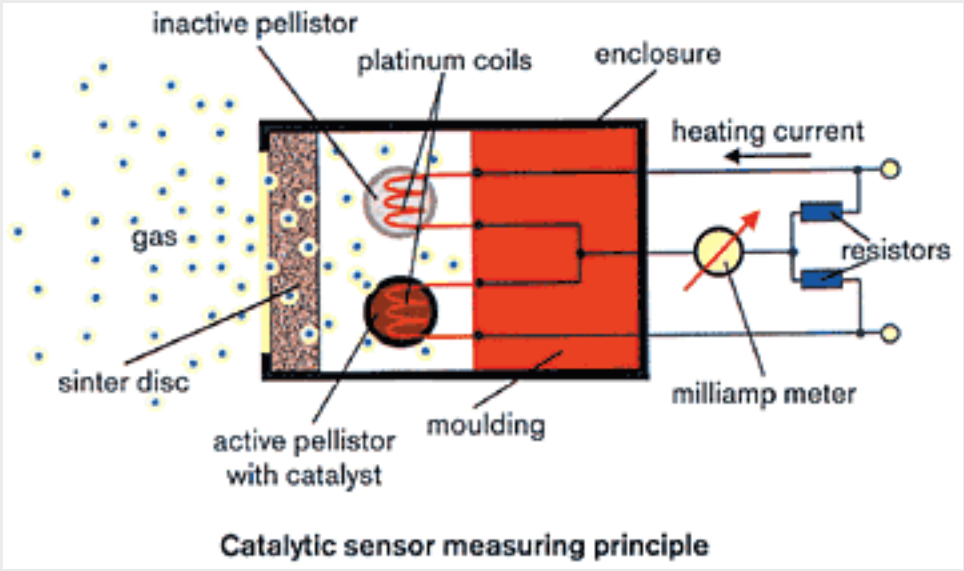
Catalytic sensor measuring principle



Double-compensated infrared measuring principle

Catalytic Bead Sensor

- Two ceramic beads (pellistors) with embedded platinum coils are heated to ~450°C. One pellistor is activated by a catalytic material that, at the given temperature, oxidizes the gas and thus forms additional heat which can be detected by measuring the resistance of the platinum coil. Using a Wheatstone bridge with a second, deactivated pellistor as a reference, the bridge current is approximately proportional to the gas concentration in the 0%–100% range of the lower explosive limit (LEL).



Catalytic sensor measuring principle

CATALYTIC BEAD SENSOR CAUTIONS

Because the sensor works by comparing the current change between a reference and an active (coated) pellistor, if the active pellistor is not working (for example it is coated or poisoned) the sensor can read zero but not actually be working.

Poisoning Compounds

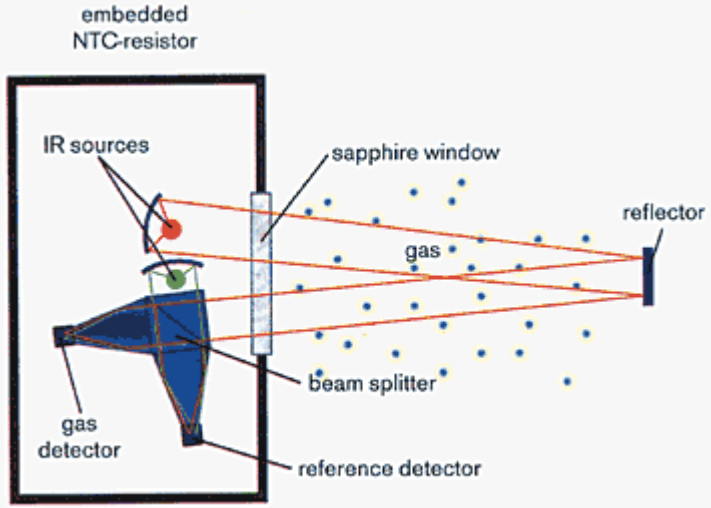
Sulfur-bearing compounds (H2S, SO2, etc.)
Halogenated (CL2, F2, etc.) Hydrocarbons

Inhibiting Agents

Heavy-Metals Containing Compounds
Leaded Gasoline (Pb)
Silicone-bearing (Si) Compounds
Long-Chained Polymers
High Concentrations of Combustible Gases

IR (Infrared)

- In an IR gas sensor, one IR light beam is of a wavelength that excites a particular type of gas molecule and thus loses part of its energy to the resultant molecular vibrations. The intensity of that beam is compared to a second beam of the original energy, and the differential is used to measure the gas concentration.

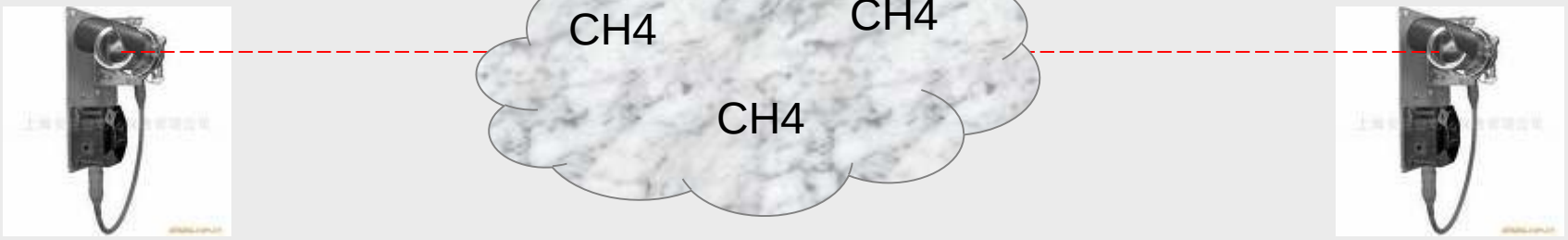


Double-compensated infrared measuring principle

- Other Considerations for IR Sensors
  - Most Flamable Gases with HC Bonds will be detected by IR. However, Diatomic molecules, such as Hydrogen, cannot be detected by IR.
- Reliability through Positive Indication of Operation and Double Compensation Optics. No poisoning issues, zero reading is the full energy being read between source and detector.

Open Path Monitoring

- Based on IR Technology, this system allows the source to be placed in one area and the detector in another, thus shooting a source of IR energy across a very long distance. Any gas that crosses through the path is detected.



Sensor Positioning Strategies

- Three basic sensor positioning strategies, it may be necessary to combine or adapt the strategies to suit a particular application.
  - **Spot Monitoring** Potential sources of leakage (e.g., valves, filling nozzles, flanges, bellows) are known and their position can be pinpointed. This means that sensors can be positioned in such a way as to ensure that gas leaks can be reliably detected in plenty of time.
  - **Area Monitoring** Potential sources of leakage cannot be pinpointed and are spread across a large area, with the result that sensors must be distributed over this entire area. ** Typical Coverage for one sensor is 500-1000 ft^2 **
  - **Fence line Monitoring** Potential sources of leakage cannot be pinpointed, so the outer limits of the installation are monitored to check whether hazardous gas concentrations are crossing into or coming from neighboring areas

**Dependant upon obstructions, air flow, room design, etc. this figure is based on homogenous air mixing and open, unobstructed area.

Considerations When Positioning a Sensor

- Whether monitoring combustible or Toxic Vapors, the molecular weight of the substance must be considered. Most vapors emanating from combustible liquids are heavier than air. Sensors must therefore be positioned very near the ground (though they must nevertheless remain accessible for calibration purposes).

- Three common combustible gases are significantly lighter than air: hydrogen, **ammonia**, and methane. Unless they are extremely cold, these gases rise and can gather together close to the ceiling, forming so-called gas nests.

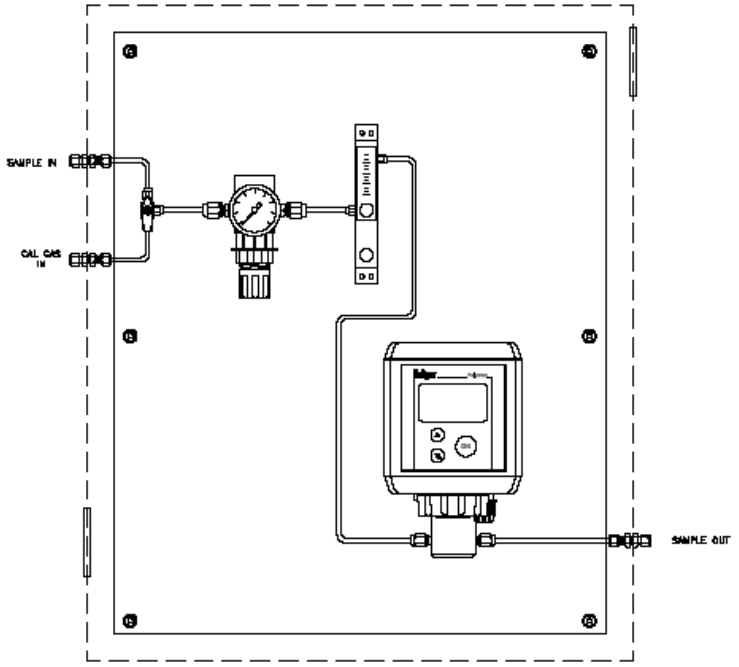
- Toxic gases, though heavier than air and present in the air only in low concentrations (e.g., <1% by volume), should be monitored at around head height (in the breathing area), as their distribution is mainly dependent on convection and thermal currents.

- When detecting combustible gases or vapors, the sensor must be positioned between the leak and the source of ignition. Furthermore, the safety concept must take into account both the reaction time and the time needed for the intended countermeasure to take effect (e.g., start-up time of additional ventilation systems).

Sample Draw

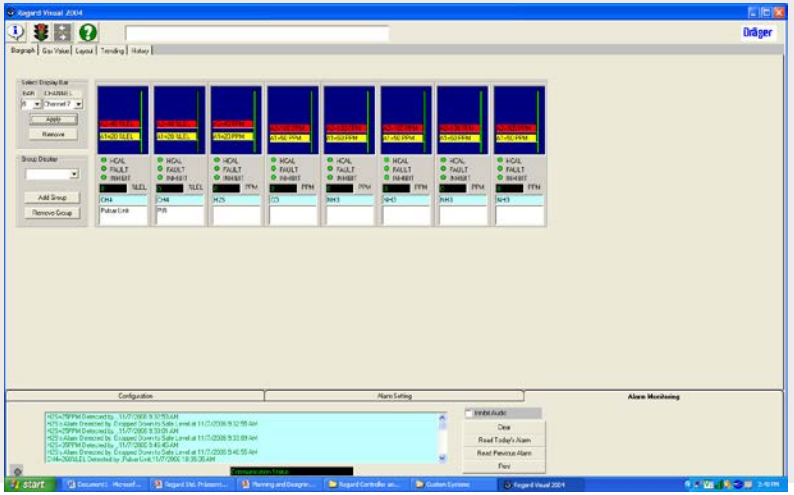
- If for whatever reason a gas sensor cannot be placed in the immediate area of interest, it is possible to draw a sample from the area and direct it to a remotely mounted gas detection device.

- Care must be taken and considerations have to be given with respect to the possibility of condensate forming in the sample transport line. Also, if the gas of interest is a reactive gas such as CL2 or **NH3,** special design considerations have to be met so that the gas does not react or absorb in the transport line.



Gas Detection Systems

- Once you have chosen the Sensor types and quantities, you must decide what to do with the information.
- Gas Detection Systems are capable of handling hundreds of points of detection. With today's advancements in communications, the possibilities are only limited by your imagination.
- Alarms, Historical Data Archiving, Calculating TWA and STEL, etc. are all possibilities.
- Custom Software Packages are also available so that you can have a graphical display of your facility and/or floor plan on a computer with each gas detection point displayed in it’s exact location.



Alarm Levels

- **Alarm Levels.** Two alarms have been demonstrated sufficient in gas detection systems.
  - The pre-alarm (or low alarm) provokes a reaction, either a prearranged set of responsive actions or the issuance of instructions appropriate to the particular event.
  - Should the alarm condition persist, the main (or second or high) alarm is triggered and more aggressive actions are taken, such as switching off machinery and clearing the area.
- Ideally, the main alarm will rarely—preferably never—be necessary.

- Thank You!!