Direct Reading Instruments

Monitors Intended for One Compound or Group of Compounds

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 1

Introduction

- Direct Reading Instruments are electronic devices that will provide a rapid or continuous detection or measurement of the concentration of the target compound without need for later analysis.
- Examples are:
  - Total hydrocarbon meters
  - Personal alarms and dosimeters
  - Stationary monitors
  - GC and IR Systems

Application of Direct Reading Instruments

- Alarms
- Monitoring Peak Exposures
- Leak Detection
- Locating Emission Sources
- Field Screening
- Emergency Response
- Confined Space Entry

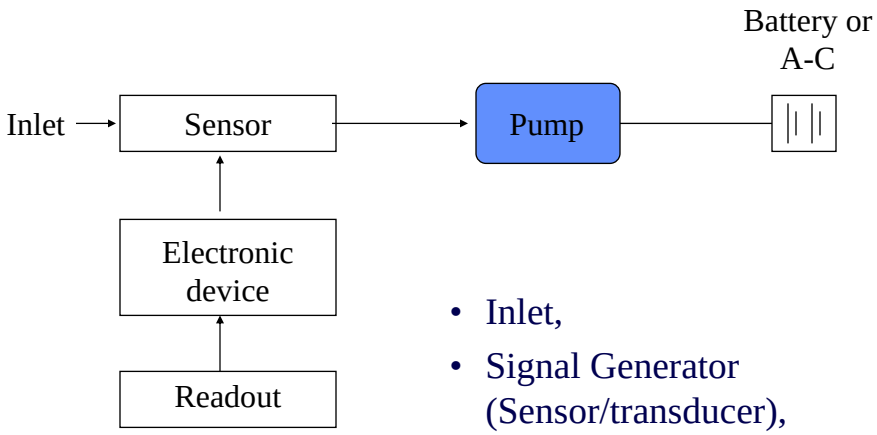
Overview

- Direct reading meters are used by industrial hygienists in the evaluation of occupational exposures.
- Direct meters are applied by numerous other specialists in performance of the previously listed uses.

Principles

- Identify a unique property of the target Compounds
- Convert property to electrical signal
- Convert electric signal to a concentration (compare to the signal of known standards or make a calibration curve)
- Visible reading or audible alarm

Schematic



- Inlet,
- Signal Generator (Sensor/transducer),
- Electrical Processor,
- Air Mover (Pump)

Types of Sensors

- Specific Gas Detectors
  - Electrochemical, IR Absorbance, UV Absorbance, Fluorescence, Chemiluminescence, Other
- Non-Specific Detectors
  - Flame Ionization, Photoionization, Catalytic Combustion, Thermal Conductivity

Detection Sensors: Performance Parameters

- Definitions
  - Accuracy: agreement between reading and true concentration
  - Precision: agreement between repeated measurements
  - Bias: consistant difference between true and measured value
  - Linearity: the fit of concentration/response curve to a straight line

Detection Sensors: Performance Parameters

- Definitions (Continued)
  - Dynamic range: range over which readings change with concentration change
  - Limit of detection (LOD): lowest concentration that the instrument can reliably detect.
  - Limit of Quantitation (LOQ): The lowest concentration of the target compound that the instrument can reliably measure (10xSD).

Specificity & Interference

- Specificity: Quality of responding to only certain compounds in presence of others
- Interference: Inaccuracy caused by compounds other than the target compounds.

Noise & Drift

- Noise: Rapid random fluctuations in signal that are not caused by changes in concentration
- Drift: Slow long term changes in reading that are not caused by changes in concentration

Performance Parameters

- Response Time: Time from the sensors exposure to an increased concentration and when it shows 95% of the total reading.
- Recovery Time: Time from the exposure of the sensor to a decrease in concentration and when the instrument displays 5% of the initial high concentration.

Calibration (Why, How, Considerations)

- Establishing the relationship between the instrument reading and the known (true) concentration.
- Instruments change response and must be corrected back to the correct relationship.
- Compare to prepared standard concentrations

Testing

- Zeroing of the Instrument
  - Zero Gas
  - Interferences
- Testing Alarm
  - Response time and accuracy
- Battery Testing

Maintenance

- Cell/Detector/Sensor Replacement
  - Finite Lifetime
- Cleaning Detector
- Check Electronics
- Pump Maintenance and Repair
- Column Replacement
- Battery Maintenance

Types and Kinds for Specific Contaminants

- Non-Dispersive Infra Red
- PhotoIonization
- Hydrogen Flame Detection
- Dispersive Infra Red
- Electrochemical Sensors

Direct Reading Instruments II

- Examples
  - Horiba Carbon dioxide Monitor
  - Organic Vapor Monitor
  - MicroTIP
  - MIRAN
  - Interscan Carbon Monoxide Monitor

Horiba Carbon dioxide Monitor

- Single gas carbon dioxide monitor
- Infra red absorption (non-dispersive) Principle
- Direct meter
- Multiple ranges
- Zero and span calibration
- Recorder or data-logger output

Organic Vapor Monitor (OVA)

- **Multiple gas and vapor analyzer**
- **Based on flame ionization principle**
  - **Hydrogen flame burns the analytes**
  - **detects hydrogen/carbon vapors/combustibles**
  - **Highly sensitive to most combustibles**
- **Direct meter display (recorder output possible)**

Organic Vapor Monitor (OVA) (Cont'd)

- **Three ranges**
- **Zero and span adjustable calibration**
- **Can be used as a field portable gas chromatograph**
- **Requires supply of hydrogen and refills**

MicroTip

- **Multiple gas monitor**
- **Based on the photoionization principle**
  - **Detects all ionizable molecules ionized by 10.2 electro volt probe**
  - **Response factor depends on ease of ionization**
  - **Can discriminate some classes of compounds**
- **Direct meter or digital display**
- **Select range**

MicroTip (Cont'd)

- **Select calibration scheme**
- **Internal data logger**
- **Digital output and computer output**
- **Highly sensitive to some compounds and insensitive to others.**

MIRAN

- Multiple gas analyzer
- Based on dispersive infra red spectrophotometry
  - Can get characteristic spectra for individual compounds
  - Can discern and quantify individual peaks in mixtures

MIRAN (Cont'd)

- Direct meter: recorder output or digital display
- Select the wavelength for specific classes of compounds
- Select the ranges of pathlength and densitivity
- Moderately sensitive for a great variety of compounds

Interscan Carbon Monoxide Monitor

- Single gas carbon monoxide monitor
- Electrochemical cell principle
- Direct meter
- Multi-range
- Zero and span calibration
- Recorder or data-logger output
- Similar electrochemical monitors for other gasses and vapors such as formaldehyde

Summary

- The general principles of using direct reading instruments have been discussed.
- Examples of specific types of sensors have been applied to the measrement of appropriate compounds
- The lab class gave the students the opportunity to use example instruments

References

- Perkins, J, Modern Industrial Hygiene, pages 603-666.
- Air Sampling Instruments, Chapter 19, Editors B.S.Cohen, S.V.Hering, American Conference of Governmental Industrial Hygienists, 8th Edition, 1995.

Where to get more information

- Other training sessions
  - By Associations and by Vendors
- Articles, Trade Journals
- Electronic sources, Web Pages
- Consulting services, other sources

Practical Exercise

- Carry out the following measurements with each example of the Direct Reading Instruments.
  - **1. Examine the instrument looking for the following:**
    - **a. readout,**
    - **b. Control knobs (zero and span)**
  - **2. Note the type sensor and for what type contaminants**

Practical Exercise (Cont'd)

- **3. Turn-on, check batteries, warm-up.**
- **4. Check the Zero of the Meter**
- **5. Check the Span**
- **6. Read the concentration of the unknown gas.**
- **7. Record all observations on chart.**

Direct Reading Instruments- Part II

Go to next PPT file

 31