MONITORING AND DETECTION OF HAZARDOUS SUBSTANCES

Determining the presence and concentration of hazardous substances at an incident scene or waste site is essential for protecting response personnel and the general public. Levels of personal protection and the areas where it is needed can be determined when the nature and quantity of the hazardous substances are known. Monitoring allows responders to determine the effectiveness of their preventive or remedial actions and to evaluate the progress of the overall cleanup effort.

INSTRUMENT SELECTION CRITERIA

Field use of monitoring instruments puts some different demands upon these devices than what might be acceptable for use under controlled conditions. Careful evaluation is necessary to ensure that the device is suitable for field work including consideration of the following:

1) Portability - reinforced shells, shock-mounted electronic packages, padded shipping containers, weather-proof packaging, easily carried.
2) Reliability - fast response time, immediately readable data, immediately interpretable data, consistent data.
3) Selectivity and Sensitivity - minimal interferences, distinguishes substance of interest; accurate and repeatable at acceptable low and high concentrations.
4) Inherent Safety - electrical system constructed to eliminate arc from power source or electronics, control of flame or heat sources inherent in the instrument.

Two terms often come up in discussions of monitoring instruments and their safety in ignitable atmospheres - "explosion-proof" and "intrinsically safe". Explosion-proof devices encase their source of ignition in a rigidly constructed container. Should a flammable atmosphere enter the instrument and be ignited, the fire/explosion is contained within the enclosure in the instrument and hot gases are cooled prior to leaving the device. An intrinsically safe device is defined as incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmosphere mixture in its most easily ignitable concentration. Abnormal conditions include accidental damage to any wiring, failure of electrical components, application of over-voltage, adjustment and maintenance operations and other similar conditions.

Underwriters Laboratory (UL) and Factory Mutual Research Corporation (FM) provide testing and certification of many monitoring instruments under procedures established by the National Fire Protection Association and the American National Standards Institute. These approvals are sought by many instrument manufacturers. It is important to look for these approvals on an instrument. It is likewise important to determine what hazardous atmospheres the instrument has been approved for by these groups. An instrument which is rated as intrinsically safe for an ethylene atmosphere would not necessarily be safe in a hydrogen atmosphere. The Class,

Division, and Group of hazardous (flammable) atmosphere(s) for which the instrument has been approved must be marked on a permanently affixed plate on the instrument. What constitutes the various Classes, Divisions, and Groups may be found in the National Electrical Code published by the National Fire Protection Association every three years.

MONITORING INSTRUMENTS

Monitoring instruments are useful in determining the presence and concentration of flammable atmospheres, oxygen, toxic vapors and gases, and ionizing radiation. These instruments are necessary not only for initial surveys and evaluation of the incident or site, but also to enable periodic or continuous monitoring to be done throughout the work period.

COMBUSTIBLE GAS INDICATORS

Combustible gas indicators (CGI) monitor for the presence of combustible gases and vapors. CGIs typically read out the concentration of combustible gases and vapors as a percent of the lower flammable limit of the calibration gas. Most CGIs operate on the "hot wire" principal. A filament, usually platinum, is heated and as the combustible gases or vapors are brought into contact with this filament, they are burned. This burning raises the temperature of the filament and also the filament's electrical resistance. This change in resistance is measured as the ratio of combustible vapor present to that required to reach 100% of the lower flammable limit.

CGIs should be calibrated using a hydrocarbon/air mixture which contains a hydrocarbon similar to that expected to be encountered. Lower flammable limit concentrations can vary widely between different hydrocarbons, and it is important to understand that an instrument calibrated for a 50 percent mixture of propane in air will not read out exactly 50 percent if the mixture encountered is, for example, 50 percent methane in air. Most alarms on CGIs are set at ten percent of the lower flammable limit, so errors resulting from encounters with flammable gases differing from the calibration gas are minimized. In the above example, an alarm set for ten percent (10%) of the lower flammable limit of propane could signal at five percent (5%) of the lower flammable limit for methane.

Two sub-classes of CGIs can be found-those with pumps to bring the sample over the sensor and those which rely on diffusion for sample analysis. Pumps may consist of a manual aspirator bulb arrangement or an automatic system for continuous are intake. Instruments which use an aspirator bulb sample discontinuously and are useful for periodic checks. Continuous pumps can shorten battery life. Sensors which utilize diffusion type cells have a slightly slower response time because the sample must pass through a semi-permeable membrane before it can be analyzed. This is rarely a problem, however.[2] This type monitor is widely used as a personal monitor for tank cleaning and confined space entry.

There are some important limitations to CGIs which should be noted. Differences between the calibration temperature and the sampling temperature can affect the accuracy of the readings. Because of differences in physical and chemical properties between the gases sampled and the calibration gas the reading may be higher or lower than the actual concentration. These units also can give erroneous readings when oxygen concentrations are higher or lower than normal. Certain substances such as leaded gasoline, sulfur compounds, and halogens (chlorine, bromine, etc.) can foul the filament, decreasing it sensitivity. Silicon containing compounds can actually destroy the filament.

Generally CGIs are easy to operate. Most have low battery alarms or indicators. They should be calibrated immediately prior to use in the field.

OXYGEN SENSORS

Very often oxygen sensors are combined with CGIs in the same instrument. Measurement of oxygen is necessary since this will determine the accuracy of the CGI. Determination of the oxygen level will also indicate the presence of non-flammable gases or vapors which the CGI will not sense. Oxygen sensors measure the percent oxygen concentration in the immediate atmosphere. Normally, this is 20.9 percent. Typically oxygen sensors read out from 0-25% oxygen concentrations and are set to alarm if the level drops below 19.5%.

An electrochemical sensor is used to determine oxygen concentrations with these instruments. Some units have pumps or aspirator bulbs, others rely on diffusion similar to the CGIs. Oxygen molecules diffuse through a membrane into an electrolytic solution. There, the oxygen reacts with electrodes to produce a small electric current which produces a reading on the meter.

Oxygen sensors must be calibrated prior to use to compensate for barometric pressure changes and changes in altitude which affect normal oxygen concentrations. Carbon dioxide in high concentrations (7.5%) shortens the useful life span of the sensors once they are exposed to the ambient air. Units which allow field replacement of the oxygen cells are usually preferred.

PHOTOIONIZATION DETECTORS

Photoionization detectors (PID) can detect the total concentration of many organic and some inorganic vapors and gases. The basic principle of operation is the ionization of contaminant substances with ultra-violet light. Am electrical current is produced by this ionization which is proportional to the number of ionized molecules. These instruments are much more sensitive than CGIs and detect concentrations in the parts per million range. This sensitivity makes PIDs useful for monitoring some toxic substances.

PIDs do not detect methane and will not detect other substances if the particular probe used does not have a higher energy level than the substance's ionization potential (energy in electron volts needed to cause ionization). Mixtures of gases

will not be measured quantitatively, unless their ionization potentials are the same. Radio signals and other voltage sources may interfere with measurements. High humidity can also affect a PIDs response.

The effective use of a PID requires trained operators knowledgeable in the operation, maintenance, and data interpretation of the instrument. For example, although a PID may be capable of measuring concentrations of 0-2000 ppm of benzene, the response is not linear over this entire range. Above 600 ppm, the readings on the PID are lower than the actual concentration. Training and familiarity with the instrument are essential if the data is to be useful.

FLAME IONIZATION DETECTORS

Like the PID, a flame ionization detector (FID) uses the ionization of contaminant molecules as the means of analysis. With the FID, a hydrogen flame rather than ultra-violet light accomplishes the ionization. Flame ionization is useful only for organic vapor gas detection but detection is in the parts per million range.

A pump brings a sample into the detector chamber of the FID where it is exposed to a hydrogen flame. Most organic compounds burn, yielding positively charged carbon ions. These ions are collected which produces an electrical current proportional to the number of ions.

FIDs do not detect inorganic gases or vapors and will not ionize some synthetic organic substances. Sensitivity varies with the compound. For methane, it is 0.1 ppm. At temperatures lower than 40° F, gases and vapors begin to condense in the pump and column leading to inaccurate responses. Oxygen deficient atmospheres and high concentrations of contaminants require modifications to the systems. The FID only provides a true reading for the substance used in calibration, all other readings may be higher or lower than their actual concentrations. Generally manufacturers provide charts or information so that readings can be interpreted or the instrument adjusted to provide true values for the compound being sampled.

Some FIDs can operate in a gas chromatograph (GC) mode, as well as, the survey mode. In the GC mode, hydrogen gas carries an injected sample of ambient air through a packed column. Different contaminants are retained on the column for varying lengths of time and are detected separately by the FID. A strip chart recorder plots the retention times graphically which allows comparison with known chemical substances. This feature allows some compounds to be identified and also allows volatile substances to be quantified.

Experienced operators are needed, especially if the GC mode is used. The hydrogen fuel supply must be monitored. The batteries should be checked regularly and operating procedures should be carefully followed.

INFRARED SPECTROPHOTOMETERS

IR spectrophotometers operate on the principle that the frequencies and intensity of IR absorbed are specific for a compound and its concentration. By measuring the frequency and how much IR is absorbed a measurement in parts per million can be given for a particular substance.

These units have limited field application because the identity of contaminants may not be known. The IR spectrophotometer has also not been recognized as being safe in a flammable atmosphere. Extensive experience is required for reliable analysis.

SPECIFIC CHEMICAL INSTRUMENTS

For a limited number of substances, specific instruments are available for detection which utilize electrochemical cells. The principle of operation is similar to that for oxygen sensors. Carbon monoxide, hydrogen sulfide, chlorine, hydrogen cyanide, and nitrogen dioxide all have specific sensors which can be used for monitoring and detection. Some manufacturers use one of these sensors in combination with a CGI and an oxygen sensor for a multi-purpose instrument. Interferences can be a problem and should be considered when determining the specific application of the instrument.

COLORIMETRIC INDICATOR TUBE SAMPLERS

Colorimetric indicator tubes allow quick and easy measurement of specific gases and vapors. Tubes are available for a much wider range of chemical substances than specific electronic detection devices and are in wide use in industry. Colorimetric indicator tubes are made of glass and filled with a chemical reagent. For detection, the ends of the tube are broken off, and the tube is inserted into a bellows or piston type pump. The pump is then used to draw a specific volume of air through the tube at a pre-determined rate. If specific contaminant substances are present in the air sample, a color change or stain-develops in the reagent in the tube. The length of the stain is measured against a scale, usually marked on the glass tube, and the concentration is read in parts per million.

Tubes are generally chemical specific, that is, each tube is manufactured to detect only a specific chemical. Some manufacturers have developed tubes which detect groups of chemicals. By using a variety of tubes for different groups, it could be possible to narrow down the identity of an unknown compound.

There are some important limitations to colorimetric indicator tubes as a monitoring device. Samples are discontinuous and only a very small area is actually sampled. Most types of tubes have a number of substances which will act as interferences, giving false readings. Determining the actual length of the stain in the tube is subjective and different users may report different values. Tubes have a limited shelf-life, typically two years and should be refrigerated to better maintain the reagents over this period.

Different manufacturers use different reagents to test for the compounds and also may use different size tubes and pump types. NIOSH certifies the pump, detector tube and accessories, and this certification implies that the tube will be accurate to within (+) or (-) 35% at 1/2 the permissible exposure limit. From the accuracy which qualifies these tubes for certification, one can deduct that this method of monitoring is not precise. In standard usage, colorimetric indicator tubes should be used to verify that a substance is present and to determine its approximate concentration.

AIR MONITORING

Initial assessment and surveys should be used to set the priorities for on-going are monitoring. When conditions are found which are IDLH (immediately dangerous to life and health) such as flammable atmospheres, oxygen deficiencies, and toxic substances, extreme caution should be used by personnel entering the area and appropriate personal protective equipment should be worn.

Open areas generally receive the lowest priority for monitoring because natural dispersal forces tend to be able to dilute atmospheric contaminants very readily from these areas. Low lying areas, confined spaces, and containers can allow hazardous concentrations of substances to persist for extended periods of time and thus merit a higher priority for monitoring.

Sampling should be planned and done with specific objectives in mind. To define a contaminant plume, sampling would begin downwind from the source working along the axis of the wind toward the source until the source is reached, or safety becomes a factor. Next, sample crossaxis to determine the width of the plume.

There is very limited capability to detect and quantify unknown inorganic vapors and gases in the field. Colorimetric indicator tubes may have some application in this area and PIDs can monitor a few inorganic materials. Unknown organic compounds can be quantified by PIDs or FIDs when used in the survey mode and identified to a limited degree when the gas chromatograph mode is used. Combustible gas indicators will detect the presence of many combustible gases and vapors at relatively high concentrations.

PERSONAL MONITORING

Personnel working in areas where conditions might become hazardous due to unexpected changes or events can use a personal monitor as a warning device. In other cases, it may be desirable or necessary to monitor the exposure of a worker to various contaminants during a normal work period and obtain a time weighted average of the exposure.

Personal monitoring instruments for detection of acute hazards such as flammable vapors, low oxygen concentrations, and toxic gases should be small and compact and easily carried by the worker. Audible, as well as, visual alarm signals are desirable,

with accessories such as ear plug attachments if work is to be conducted in high noise environments. The power supply (batteries) should last for the entire work period. Calibration adjustment knobs should be positioned or designed so that they cannot be knocked out of position or easily "readjusted" by the workers. Generally, these instruments operate by the same mechanisms described earlier for monitoring instruments (hot wires) but are more compact. Many devices can serve as both an area monitor and a personal monitor.

Obtaining the time-weighted average exposure for certain contaminants can be done by instruments equipped with microprocessing electronics systems. These personal monitors eliminate the need for sending samples to a laboratory for analysis. More commonly, time-weighted average exposure is measured by collecting the contaminants of interest in an absorbent medium, then doing a laboratory analysis to measure the concentration. The badge or tube containing the absorbent is worn by the worker around the breathing zone. With some devices, a pump draws a continuous flow of air through the sampler. Other devices such as passive dosimeter badges, rely on the process of diffusion or, in some cases, permeation to bring the contaminant into contact with the absorbent. Some types of passive dosimeters can be read directly, similar to colorimetric tube samplers.

REFERENCES

1. *Continuous Monitoring of Air Quality with Portable Analyzers*, J. B. Cumbus, from a paper presented at the 1982 Industrial Safety Seminar, Texas Chemical Council.
2. *Hazardous Materials Incident Response Training Program*, U.S. EPA.

Monitoring Vinyl Chloride

Any time Vinyl Chloride has been released, whether caused by a train derailment or incidents in Vinyl Chloride producing plants, it is important to know that personnel are not exposed beyond exposure limits established by OSHA. These are 1.0 PPM Vinyl Chloride by volume TWA (time weighted average concentrations over an eight hour period), or a 5 PPM.

The first seven pages of this section explained seven monitoring instruments, their selection criteria, assessment surveys, and personal monitoring programs. The next section that follows will discuss two monitors - the Photoionization instrument commonly called the H.Nu meter and the Calorimetric indicator commonly called Draeger Tubes or detector tubes. These two are discussed because of their wide spread availability and their ability to measure below one part per million Vinyl Chloride. Other brands of PHOTOIONIZATION instruments and detector tubes are available, specific discussion here is not an endorsement of any particular product but is for illustration purposes only.

PHOTOIONIZATION DETECTOR-HNu BRAND

Its main and most important feature is its instant indication of Vinyl Chloride in air. A brief summary of its operation follows so you can better appreciate its use in actual situations. If you would reference copied information about this instrument in the appendix of this section, the following statements will be easier to understand:

The instrument is delicate and as a rule cannot be used unprotected in rainy weather. The indication is by needle movement across a calibrated scale as opposed to digital readout. On the instrument face:

A. Switch from OFF position to BATT. The needle must advance past the BATT. indication on the scale for a properly charged battery.

B. Next select knob to STANDBY. This places the instrument in sample mode but does not turn on the Photoionization lamp. It is a battery saving feature.

   1. The needle indicator should drop to "0".
   2. Place the detector head next to your ear. You should hear the sample motor running.

      NOTE: Instruments used frequently will have shorts in the power cord. This is a good time to check.

C. Switch from STANDBY to either of three scales:
   1. Range from 0 to 20.
   2. Range from 0 to 200.
   3. Range from 0 to 2000.

SL 086711

D. Begin sampling the atmosphere for Vinyl Chloride and refer to the manufacturers operation manual for complete operating instructions.

Although this instrument gives instant detection of Vinyl Chloride it has disadvantages which you must know and recognize to separate false from real indications. When reading the appendix information on the unit, a partial list of chemicals in addition to Vinyl Chloride is given that it will also detect. A note of technical information: The lamp usually installed in H.Nu meters will be the 10.2 eV lamp. All chemicals having ionization energy equal to 10.2 or less will also be detected. Because of this you should be aware of other products as suspect in giving false readings. Common items we encounter are: Aerosol spray, gasoline having benzene, liquid chalk, toilet bowl odor crystals; etc. Also note Nitrogen or inert gas, moisture like that from ones breath, and high winds impacting the sample inlet will cause small deviations.

Given the instrument was calibrated in a purified air gas, you can get a base reading before going into suspect areas. As a rule deflections up scale will be Vinyl Chloride. You should make every effort to identify other chemicals that may be in the wreck which could give error indications.

As discussed in the first seven pages of this section, you should approach a derailment from a downwind side entrance. Continue to go down wind to determine the plume cloud for purposes of isolation. Investigation of the wreck itself is best done by selecting the high 0 to 2000 range scale, using a long probe and drop sample hoses into low places, jacket tears, tank car dome housings, etc for zeroing in on the leak source.

DETECTOR TUBES-DRAEGER AND/OR SENSIDYNE.

These pencil like tubes are more selective to Vinyl Chloride. They will backup the reading by the H.Nu meter when the atmosphere is sampled with detector tubes. Detector tube sample pumps and tubes are relatively inexpensive. Complete kits with tubes can be purchased for less than $1,000 where Photoionization units can exceed $5,000. Vinyl Chloride detectors use a dual tube assembly: the PRIMARY TUBE AND THE ANALYZER TUBE. Again a little technical information: The primary tube conditions the gas sample. It contains an alkali to remove Chlorine or Hydrogen Chloride which may be in the air from burning Vinyl Chloride. The analyzer tube or second tube contains the detection crystal that changes color. Vinyl Chloride is broken down onto Hydrogen Chloride which causes change on the analyzer to be crystals.

The detector tube's principle of operation is to pass known volumes of air across the indicator crystals. A brown color will form on the indicator crystals depending on the concentration of Vinyl Chloride. This is done by drawing 100 ml air samples across the analyzer tube crystals. The degree of color change is determined by the concentration of Vinyl Chlorid and the volume of air drawn across the crystals. One minute sample times are needed. Because of this,

detector tubes are best used to confirm Vinyl Chloride is present or to sample a closed vessel or stagnant air such as buildings, etc.

Detector tubes can also be affected by interfering chemicals. For example, any compound containing the Chlorine atom such as some paint stripers with Methylene Chloride, refrigerants and electrical contact cleaner containing trichloroethylene, will interfere with detection. Generally any of these chemicals in concentrations you can smell or that would be hazardous to you without personal protection will interfere in detection.

Their use in train derailments should be in conjunction with the H.Nu to confirm positive identification of Vinyl Chloride and to detect approximate concentrations. As already stated before they have a + or - 35% indication error. However, if you had to determine Vinyl Chloride concentrations downwind in a burning cloud plume, the detector tube is preferred instrument and would backup the H.Nu readings. Directions for use are always in the detector tube box. Shelf life is normally two years.

In the appendix is a copied description of Sensidyne's detector tube NO. 131La for Vinyl Chloride. A few comments: Its detection concentration range changes based on the (N=) strokes of the sample pump. Insure the tubes are aligned and don't forget to keep count of the number of pump strokes. Chemical interference is given, but note the concentrations are quite high.

SL 086713

trace gas analysis by photoionization

HNU Model PI-101.
The photoionizer.

SL 086714

APPROVED FOR CLASS I, DIV II, GROUPS A, B, C & D HAZARDOUS LOCATIONS

the ph to-i nizer is a portable trace gas analyzer that can be used to measure a wide variety of organic vapors including chlorinated hydrocarbons, heterocyclics and aromatics, aldehydes and ketones as well as several inorganic gases including hydrogen sulfide and ammonia.

The instrument uses the principle of photoionization as the analytical technique and overcomes many of the problems inherent in current trace gas analysis instrumentation. These problems presently include poor limits of detection, slow and sluggish time response, background electronic noise or drift and a lengthy series of precise technical operations necessary to properly use the instrumentation. In addition, many of today's portable analyzers remain heavy, cumbersome instruments that require additional portable equipment such as sample pumps or compressed fuel and zero gases or bulky power packs for operation.

The advanced technology employed in the photo-ionizer successfully overcomes these disadvantages. For example, the limit of detection for most species is extended down to 0.1 ppm—an increase of 10–100 fold over many conventional instruments—while still maintaining a wide dynamic operating range (0.2 to 2000 ppm). This improved sensitivity allows industrial hygienists to make measurements at or below the TLV's (threshold limit values) established by OSHA.

Time response is greatly improved by several design advances. The location of the sensing chamber at the sampling point in the hand-held probe, the fabrication of all sample contact areas with inert fluorocarbon materials and a rapid sample flow through a small analyzing chamber liminate sample hang up (adsorption) and minimize sample transit time in the instrument. The problems of delayed time response and instrument sluggishness are liminated. Total time response to 90% of a full scale concentration change (0–2000 ppm) is less than five seconds—a significant feature when the instrument is used to locate plant "hot spots" or to detect leaks.

All solid state electronics and state-of-the-art circuit design have virtually eliminated conventional instrument drift and background noise. Zero drift is less than 1% over 10 hours. The excellent stability and drift free electronics allow accurate measurements, even at very low concentrations.

The Model PI 101 is one of the simplest analytical instruments to use since it has only three operating controls and unskilled personnel are easily and quickly trained to operate it. An easy to read 4½" *linear* scale provides a readout directly in units of concentration (ppm). Other features include an electronic zero that eliminates the use of a zero gas, and instrument calibrations that hold for weeks. The elimination of a flame, igniters and compressed hydrogen fuel make the photo-ionizer simpler to use than a flame ionization analyzer while providing an unusually safe instrument.

This lightweight (less than nine pounds) instrument was designed primarily as a portable analyzer for survey work and leak detection. However, the unit can also be set up as a continuous stationary monitor powered by 110V through its battery recharger/converter system. A strip chart recorder can be attached to the outputs (0–5V) provided.

Further details about the principle of operation and the significant technical advances this instrument provides are described in the following pages. Additional technical literature regarding your particular application and the photo-ionizer's response and sensitivity to the particular species of interest is available upon request.

Write, call, or use the attached postage paid reply card for further information.

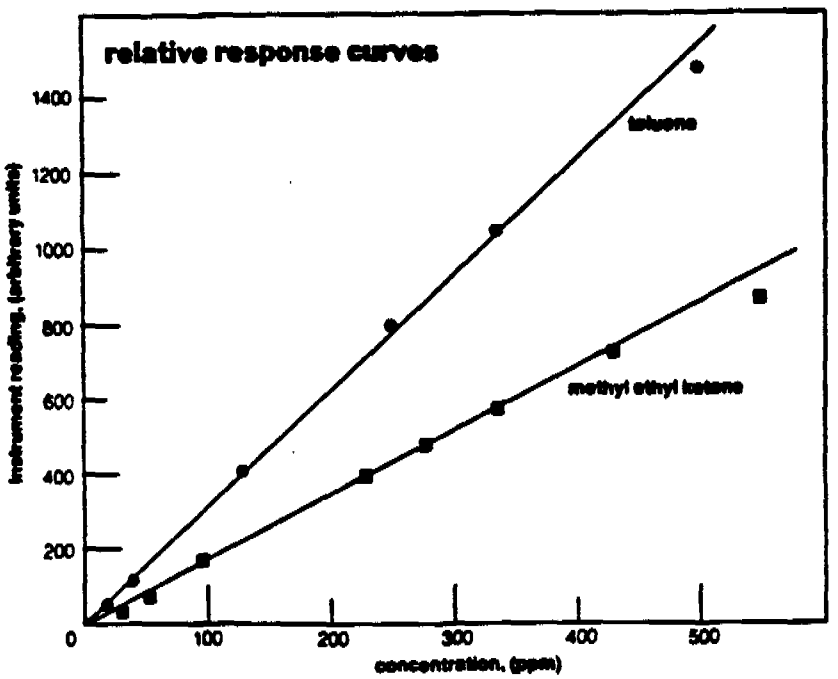
SL 086715

principle of operation

The photo-ionizer is a trace gas analyzer used to measure the concentration of a wide variety of species in industrial atmospheres. The analyzer employs the principle of photoionization for detection. The process is termed photoionization since the absorption of ultraviolet light by a molecule leads to ionization via: $R + h\nu \rightarrow R^+ + e^-$ where R^+ is the ionized species and $h\nu$ represents a photon which has an energy ≥ the ionization potential of the species.

The sensor consists of a sealed ultraviolet light source that emits photons which are energetic enough to ionize many trace species (particularly organics) but do not ionize the major components of air such as O_2, N_2, CO, CO_2, or H_2O. A chamber adjacent to the ultraviolet source contains a pair of electrodes. When a positive potential is applied to one electrode the field created drives any ions formed by the absorption of UV light to the collector electrode where the current (proportional to the concentration) is measured. Typical calibration curves showing the relative response of toluene and methyl ethyl ketone (at the same gain setting) are shown below.

Information on the relative response factors for other species is available upon request.



SL 086716

th ph to-ionizer—accurate measurements, easily obtained

sensitivity A maximum sensitivity of 0-2 ppm, full scale, can be obtained for many species. This scale is readable to 1% (100 division scale).

limits of detection Typical limits of detection are 0.2 ppm. In many cases these lower limits represent a 10-100 fold improvement over conventional portable analyzers.

operating range The linear range for most compounds is from 0.1 ppm to 600 ppm while the useful range typically extends to 2000 ppm.

stability Zero drift is extremely low, normally 1% or less over 10 hours, on battery operation On AC operation, zero drift is less than 1% over 24 hours. Semiweekly span calibrations (100 ppm toluene) over a one month period give a relative standard deviation of ±4.5%. This long term stability of both zero and span is due to the solid state electronics and stable ultraviolet light source.

specificity Specificity in photoionization analysis depends on the sensitivity of the detector to the species being measured, the number of interfering species present, and the concentration of the species being measured relative to interferences. The optimum specificity can be obtained by choosing the light source (9.5 eV, 10.2 eV, 11.7 eV) to suit the application, maximizing sensitivity to the species being analyzed and minimizing any possible interference. Return the postcard for details on your application.

rapid response Response to changes in concentration is extremely rapid. A 90% of full scale change (0-2000 ppm) takes less than five seconds. In addition, the sensor is located at the sampling point rather than inside the instrument. This eliminates the problems of hydrocarbon adsorption and transit time through a sampling tube, all of which can delay the real time response by 30-45 seconds or more

AC/DC operation—The instrument power is supplied from a 12 VDC rechargeable battery which gives a *minimum* of 10 operating hours before recharging is necessary. The AC recharger provides the option of operating the unit continuously from 110V AC so that the instrument can be used either as a portable unit for industrial hygiene surveys and leak detection work or as a continuous stationary monitor. An optional HNU Recorder can also be operated with the 101 battery.

The instrument is equipped with an automatic solid state battery protection circuit to prolong battery life by preventing deep discharging. Both the analyzer and the recorder can be operated during the recharge cycle.

portability The instrument is truly portable, with a total weight of less than 9 pounds (4.1 Kg) complete. No additional bulky power packs, sample pumps or cylinders of fuel gas or zero gas are needed. When not in use, the hand-held sensor is stored in the instrument cover and the total package measures 21 cm wide 24 cm high.

SL 086717

direct reading Concentration (ppm) is read out directly on an easy to read 4.5" (11.3 cm) *linear* scale.

three simple operating controls

Function and Range Switch This switch puts the instrument into the STANDBY, BATTERY CHECK, MEASUREMENT modes or OFF position. The MEASUREMENT position allows the choice of a 0–2 ppm, 0–20 ppm, 0–200 ppm or 0–2000 ppm full scale range. The STANDBY mode reduces power consumption between measurements. The BATTERY CHECK allows a manual power check before use while an LED (red indicator light) adjacent to the function switch provides an automatic battery check indicator during operation.

Zero Adjust The zero control allows electronic calibration of the instrument at the zero concentration point without requiring the use of a zero gas.

Span To calibrate the instrument for a particular gas, this control is adjusted to the gain setting which will match the value of a calibration gas to that same reading on the instrument scale. This control also provides the 10 fold increase in gain that allows the 0–2 ppm full scale range.

recorder outputs A signal output of 0—5V full scale is provided on the front panel for the attachment of a strip chart recorder.

lly Safe (IS-101), 's Waste (HW-101), ral Purpose (GP-101) lso available.

electronic zero Zero calibration is done completely electronically. The instrument is switched to the STANDBY mode where the UV light source is turned off but the other electronics remain on. The zero control is adjusted until the meter indication is zero. No zero gas or regulators are needed; no further adjustments are required. Verification tests for this technique against hydrocarbon-free zero gas show perfect agreement.

safety *The photo-ionizer is extremely safe to use, requiring no flames, igniters, or hydrogen fuel. Versions are available for use in General Purpose, Hazardous Waste; Class I, Division II and Class I, Division I, Group ABCD areas.*

instant warmup Solid state electronics produce stable readings within 20 seconds after turning the instrument on.

selected list of speci s detected

NR: no response
H: high response
L: low response

class / species	photoionization response 9.5 eV lamp	10.2 eV lamp	11.7 eV lamp
paraffins and unsaturated hydrocarbons			
methane	NR	NR	NR
ethylene	NR	L	H
acetylene	NR	NR	H
1-butene	H	H	H
hexane	NR	L	H
chlorinated hydrocarbons			
methyl chloride	NR	NR	H
carbon tetrachloride	NR	NR	H
chloroform	NR	NR	H
dichloroethane	NR	NR	H
vinylidene chloride	L	H	H
vinyl chloride	L	H	H
trichloroethylene	H	H	H
heterocyclics & aromatics			
phenol	H	H	H
pyridine	H	H	H
benzene	H	H	H
toluene	H	H	H
xylene	H	H	H
styrene	H	H	H
aniline	H	H	H
chlorobenzene	H	H	H
nitrobenzene	NR	L	H
nitrogen compounds			
formamide	NR	H	H
ammonia	NR	L	H
hydrazine	H	H	H
methyl amine	H	H	H
acetonitrile	NR	NR	NR
acrylonitrile	NR	NR	H
sulfur compounds			
sulfur dioxide	NR	NR	NR
hydrogen sulfide	NR	H	H
carbonyl sulfide	NR	NR	H
carbon disulfide	H	H	H
methyl mercaptan	H	H	H
dimethyl sulfide	H	H	H
dimethyl disulfide	H	H	H
aldehydes, ketones, alcohols, acids, esters			
formaldehyde	NR	NR	H
acetaldehyde	NR	H	H
propionaldehyde	L	H	H
acrolein	L	H	H
crotonaldehyde	L	H	H
acetone	L	H	H
methanol	NR	NR	H
ethanol	NR	L	H
formic acid	NR	NR	H
acetic acid	NR	L	H
methyl methacrylate	L	H	H
others			
ethylene dibromide	NR	H	H
ethylene oxide	NR	L	H
tetraethyl lead	H	H	H
phosphine	NR	H	H
arsine	NR	H	H
iodine	H	H	H

specifications

performance (benzene related)
- range 0.2 to 2000 ppm
- detection limit 0.2 ppm
- sensitivity (max) 0–2 ppm FSD over 100 division meter scale
- repeatability ±1% of FSD
- linear range 0.1 to 600 ppm
- useful range 0.1 to 2000 ppm
- response time <5 sec to 90% of full scale

physical
- size: probe 6.3 DIA x 28.5L (cm) (2½" x 11¼")
  - readout 21W x 13D x 16.5H (cm) (8¼" x 5⅛" x 6½")
  - stowed 21W x 13D x 24H (cm) (8¼" x 5⅛" x 9½")
  - cable 80 cm long (32")
- weight probe .55kg (20 ounces)
  - readout 3.2kg (7 pounds)
  - total (shipping) 5.4 kg (12 pounds)

controls and functions
- mode switch Off, Battery check, Standby (zero) 0–2000, 0–200, 0–20 ppm
- low battery indicator light
- zero (10 turn ±300% FSD max)
- span (10 turn counting dial 1.0 to 10 times nominal sensitivity)
- readout 4½" (11.3 cm) meter Taut Band movement graduated 0–5–10–15–20, divisions
- outputs recorder 0–5 VDC

power requirements of operating times
- continuous use with battery > 10 hours
- with HNU Recorder > 6 hours
- recharge time, max < 14 hours, 3 hours to 90% of full charge
- recharge current, max .4 amps @ 115 VAC

construction Designed to withstand the shock and abuse to which portable instruments are often subjected. The readout is housed in a two piece aluminum case, and finished with a solvent resistant baked acrylic textured paint. The probe is fabricated from extruded aluminum sections and machined plastic.

serviceability The probe and readout are of a modular design allowing rapid servicing and/or replacement of mechanical and electrical components. All module interwiring includes quick disconnects.

maintenance The instrument contains only one moving part, and consumes no gases or reagents. The only routine maintenance procedure is cleaning the light source window every several weeks.

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applications

industrial hygiene surveys of toxic gases for OSHA (TLV) compliance can be rapidly accomplished with this portable, direct reading instrument. Hood ventilation rates can also be measured accurately because of the sensitivity and wide operating range of the unit.

leak detection is facilitated by the rapid instrument response and extreme sensitivity. This enables the user to locate even small leaks very rapidly.

residual solvent vapors such as trichloroethylene in decaffeinated coffee or degreasing operations, hexane from soybean extraction and other vapors from food, chemical processing, paint spraying or coating can be easily and rapidly measured.

benzene concentrations as low as .1 ppm can be selectively measured using a 9.5 eV lamp. This lamp eliminates most common interferences.

non methane hydrocarbons in the atmosphere can be measured directly since the photoionizer does not respond to methane.

vinyl chloride measurements in monomer plants can be made without interference from major starting materials or by-products such as ethylene and ethylene dichloride (dichloroethane). Low level vinyl chloride measurements in PVC fabrication processes do not have the 1-2 ppm methane background interference seen in other portable instruments.

For additional information on specific applications, please fill out the attached postage-paid reply card or call us at (617)964-6690. To place an order, call us toll-free at (800)527-4598.

represented by

SL 086719

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SENSIDYNE DETECTOR TUBES

VINYL CHLORIDE LOW RANGE TUBE

No.131La

1. Performance:

Calibration Scale	1 – 20 ppm	(n=1)	Color Change	Yellow – Reddish Brown
Measuring Range	0.25 – 1 ppm 1 – 20 ppm 20 – 64 ppm	(n=4) (n=1) (n=½)	Sampling Time	1 minute/pump stroke
Detecting Limit	0.05 ppm	(n=4)	Shelf Life	2 years

2. Detection Principle:
Vinyl chloride is decomposed by oxidizing agent to liberate hydrogen chloride, which discolors Hammett indicator (benzenazodiphenylamine) to reddish brown.

Primer Tube $K_2Cr_2O_7 + H_2SO_4 \longrightarrow (O)$
$(O) + CH_2:CHCl \longrightarrow HCl$

Analyzer Tube $HCl + C_6H_5N:NC_6H_4NHC_6H_5 \Rightarrow$ Redish brown compound

3.

Interferant	Concentration	Result	Comment
Benzene	Up to 400 ppm	No effect	At more than 400 ppm, gives minus error
Toluene & Xylene	Up to 500 ppm	"	At more than 500 ppm, gives minus error
Ethylene	More than 300 ppm	Plus error	
Chlorine & Hydrogen chloride	Up to 600 ppm	No effect	Produces similar stain at more than 600 ppm as cannot be removed in primer tube
Trichloroethylene	More than 1/2 of VCM conc.	"	
Perchloroethylene	More than 3 times of VCM conc.	"	

4. 4.1 Standard Gas Generation Method: Dynamic permeation tube method
4.2 Method of Analysis: Gas chromatography (FID)

5. Dangerous & Hazardous Properties
T.L.V. = 5 ppm
S.T.E.L. = –
F.L. = 4 – 22%

Concentration	Physical Effects
–	Suspected carcinogen
1,000 ppm	Slowly produces mild disturbances such as drowsiness, blurred vision
25 000 ppm	Causes dizziness disorientation and burning sensation
120,000 ppm (12%)	Dangerous to life

6. Physical Constants
C.F.: CH_2CHCl M.W.: 62.50 S.G.: 0.97 (–13°C) M.P.: –160°C
B.P.: –13.8°C AIT: 472°C V.P.: 1700 mmHg

7. Application for other gases:

Gas	Formula	TLV	STEL	Measurable Range	
Allyl Chloride	C_3H_5Cl	1	2	25 – 270 ppm	(n=1)
Vinylidene Chloride	$CH_2:CCl_2$	10	20	0.3 – 6 ppm	(n=2)
				0.7 – 14 ppm	(n=1)
				10 – 30 ppm	(n=½)
Ethyl Chloroformate	$ClCOOC_2H_5$	–	–	15 – 140 ppm	(n=2)
Methyl Chloroformate	$ClCOOCH_3$	–	–	70 – 1,050 ppm	(n=5)
1,1,2,2-Tetrachloroethane	$Cl_2CHCHCl_2$	5	10	3 – 75 ppm	(n=4)
1,2-Dichloropropane	$CH_3CHClCH_2Cl$	75	110	40 – 600 ppm	(n=2)
Ethyl Benzyl Chloride				6 – 42.5 ppm	(n=1)

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