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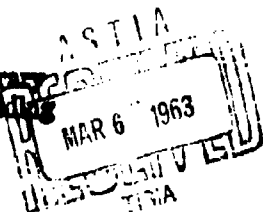
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PROCEDURES AND ANALYTICAL METHODS
FOR DETERMINING TOXIC GASES
PRODUCED BY SYNTHETIC MATERIALS.

PROCEDURES FOR FLASH IGNITION
AND SELF-IGNITION TEMPERATURE
DETERMINATIONS.

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SIGNED *J. J. Crowley*

BY J. J. Crowley

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ABSTRACT

Equipment, procedures and analytical methods for determining the nature and concentration of toxic gases produced when synthetic materials are subjected to flammability tests are described. A method for flash-ignition temperature determination is given. The necessary equipment and a procedure for determining the self-ignition temperature of heat resistant material is described.



INTRODUCTION

The general purpose of these tests is to determine the nature and quantity of toxic gases produced when various types of synthetic materials are subjected to flammability tests under prescribed conditions. The test results are used to evaluate potential hazard from toxic gases produced should such materials be burned or thermally decomposed in enclosed spaces. The data developed include the determination of (1) ignition time, (2) burning time, (3) weight lost from the material as a result of the test, (4) composition of the atmosphere produced, (5) flash-ignition temperature, and (6) self-ignition temperature. In brief, the tests are conducted by placing a stick of the material to be tested in the center of a heating coil which is situated in an airtight chamber. The heating coil is activated and the number of seconds it takes from the time the coil is activated until the stick begins to burn is recorded as the ignition time. After the stick has burned for 30 seconds the heating coil is deactivated, and the number of seconds it takes for the stick to stop burning (from the time of deactivation) is recorded as the burning time. When the stick has stopped burning, the atmosphere of the chamber is mixed by a circulating fan which is located within the chamber. After a specified time, a manifold



INTRODUCTION (Cont'd)

circulating pump is turned on. The gas within the chamber is flowed through a manifold where samples are withdrawn into gas analyzing apparatus so that the composition of the atmosphere produced can be determined. After the gas samples are drawn, the chamber is purged by flushing compressed atmospheric air through it. When the old atmosphere of the chamber has been replaced, the test material can be removed to determine its weight loss.



SAMPLES TO BE SUBMITTED
FOR TESTING

Twelve (12) sample sticks 5 x 1/2 x 1/2" should be submitted for testing. If such samples cannot be submitted, and odd size samples are substituted, this fact should be noted in the Test Report. In the past plastics molded on metal bars have been submitted for test. The total weight of the plastic should be calculated by weighing the metal bar alone after all tests are completed so that the % weight loss of the plastic may be determined. The sample sticks are sometimes held together with adhesive when they are submitted. All the adhesive should be removed from the sticks before proceeding with the tests.

KIND AND NUMBER OF TESTS
TO BE PERFORMED

Four of the sample sticks should be tested according to the flammability test procedure and the nature and quantity of the toxic gases evolved should be determined.

The flash-ignition determinations should be performed in duplicate.

One self-ignition temperature determination should be made.

TEST REPORT FORMS

Test Reports should take the same general form that has been used in the past. Old Test Report forms may be obtained from the Bureau of Ships.



TEST EQUIPMENT

The equipment used to burn or thermally decompose the various materials is similar to equipment formerly employed at the Materials Laboratory of the New York Naval Shipyard, 1/2/3/4/ and by the Bureau of Mines Central Experiment Station at Pittsburgh⁵ for determining the flame resistance of thermosetting plastics. Methods for determining the nature and quantity of gases evolved were adapted to the test procedure by the author.

The equipment consists of a specimen support, heating coil, and spark generators mounted in an essentially gas-tight chamber equipped with facilities for sampling the test atmospheres produced. Pictures of the apparatus are in the appendix.

The specimen support is made of four pieces of metal set at right angles to one another. (See apx. p. 5). Three of the pieces are made of flexible metal while the fourth piece is rigid. The support is secured to a raised platform which is anchored to the base of the chamber. The support is constructed so that pressure will be applied to the specimen when it is inserted within the metal clips, and will hold specimen upright. In tests of thermosetting materials this is the only support used. In tests of thermoplastic materials, the test specimen may be supported additionally at the top by a small rod to prevent it from falling against the heating coil if the portion within the coil should soften or melt.

The heating coil (apx. p. 5) consists of seven turns of No. 10 (0.102 inch diameter) Nichrome resistance wire, space wound to 0.25 inch per turn and 1-3/16 inches diameter. (The coil should be checked periodically to insure it has not contracted or changed its dimensions. The heating coil is of proper dimensions if there is a distance of 1/4" between the centers of successive turns and the total length of the coil is 1-1/2" when measured from the middle of the first coil to the middle of the last. The coil ends are clamped into heavy copper lugs with the axis of the coil coincident with the axis through the opening in the specimen support and with the lower end of the coil 5/8 inch above the top of the support (1-5/16" above the bottom of the plastic). The test specimen should extend about 1-1/2" above the top of the coil. The coil should be inspected after each determination, and if it has contracted it should be restored to its prescribed size. If the coil has become

TEST EQUIPMENT (Cont'd)

distorted and cannot be restored to its original size and shape it must be replaced.

Two spark generators with extended electrodes diametrically opposite are placed with their longitudinal center lines in a horizontal plane about $1/2$ of an inch above the top of the heater coil, to ignite gases emitted from the heated specimen. The spark generators are mounted in such a manner that they may be moved to within $1/8$ inch of the surface of the specimen when in operation or away from the specimen after ignition occurs, to prevent their electrodes from becoming fouled by soot. The spark igniters are set $1/8$ inch away from the specimen stick by using a pincer-like arrangement which has two strips of material $1/8$ of an inch thick set $1/2$ inch apart from each other. This device is placed so that the two $1/8$ inch strips are set outside the sides of the test stick which face the spark generators. The spark generators are moved up until they touch the adjusting pincers, and then the pincers are removed. A suitable electric circuit is provided to maintain continuous sparking at the electrodes. The figure on p. 3 of the appendix is a diagrammatic representation of the electrical system of the apparatus. The spark gap between the electrodes is periodically inspected and maintained by using a spark gap adjust wire at about 0.02 inch.

A 55-ampere current is applied to the heater coil through the heavy copper lugs which are, in turn connected to the secondary of a transformer. Current is controlled by means of a variable auto-transformer in the primary. The equilibrium temperature of the coil is measured when the coil is installed and periodically checked to determine its temperature at equilibrium. The equilibrium temperature of the coil is reached after about 50 seconds of heating. The temperature of the coil is determined by affixing the bead (thermocouple junction) of a 28 gauge chromel-alumel thermocouple to the inner face of the middle (fourth) turn of the heating coil and applying slight but definite pressure to the thermocouple to insure intimate contact of the junction with the coil. The thermocouple for this purpose is constructed by making a junction having potentiometer leads and leads to be held by hand on either side of the junction. The potentiometer reading will fluctuate slightly while a reading is being taken (heat loss to air currents, power supply fluctuation) as the temperature of the coil is subject to fluctuation. The average of the readings obtained will be recorded as the equilibrium temperature of the coil. Oxidation of the heating

TEST EQUIPMENT (Cont'd)

coil with age will cause the equilibrium temperature of the coil to increase at a fixed amperage: $W=I^2R$.

The test chamber is of wood construction, with glass sides and with a small window set into the door at the front of the chamber to permit observation of the specimen during test. Inside dimensions of the chamber are 24-3/4 inches by 21 inches by 32-3/4 inches, and its volume is 270 liters. The door of the chamber closes on a soft rubber gasket and is secured when closed by four refrigerator-door-type clamps. A baffle plate, to facilitate mixing of the chamber atmosphere, is situated 6 inches from the rear wall and extends downward from the top of the chamber to within 5 inches of the base supporting the flammability-test equipment. A 4 inch fan is mounted in a circular opening near the top of the baffle. This fan is operated only after burning of the test specimen has ceased, circulation of the atmosphere of the chamber being obtained during the test by convection set up by the heating coil and by combustion of the specimen. The chamber is ventilated at the conclusion of a test by opening the exhaust duct and blowing pressurized air through the chamber (40 p.s.i. gauge). This duct is closed off from the chamber by a water seal during the test. The seal is made or broken by raising or lowering a water bottle and consequently adjusting the water level within the water seal. (apx. pp. 1 and 2). To prevent undue pressure changes in the chamber during the test, as a result of heating and cooling, the chamber atmosphere is permitted to expand through a suitable connection into a 3-inch diameter metal tube, open at its end to the atmosphere during operations that evolve heat. When burning of the test specimen has ceased and cooling of the chamber atmosphere ensues, the gases discharged by thermal expansion from the chamber into the tube are again drawn into the chamber from the tube by contraction due to cooling. Error from loss due to expansion on heating and dilution of the test chamber atmosphere due to contraction on cooling, is negligible with this arrangement. A centigrade dial thermometer is supported by a bracket inside the test chamber, and faces the window so that the temperature of the gases being analyzed are known.

The toxicity test apparatus should be situated in a room free of reagent bottles or other possible source of contamination.



TEST PROCEDURE

The following procedure should be employed:

1. Evacuate the test chamber and replace the air within with uncontaminated air by blowing the chamber out with pressurized air (40 p.s.i.) for thirty minutes. (If a shorter evacuation time is to be employed, blank determinations must be run to assure that no toxic gases from the previous determination have remained behind).
2. Oil all movable parts including the retractable sparking gear, the fan shaft and fan shaft support junction, the chamber circulating fan motor and the manifold pump motor. Wipe up all excess oil to prevent pre-ignition because of the presence of oil and to prevent erroneous combustibles readings.
3. Make the water seal by adjusting the level of the water bottle so that it is high enough to prevent gas from escaping through the evacuation duct, yet not high enough to cause water to overflow from the trap into the test chamber.
4. Vacuum clean the chamber to remove carbon particles from the previous burning and wash and dry the glass windows so that the specimen may be clearly viewed during the test. The presence of carbon particles in the chamber will result in the adsorption of gas molecules and prevent accurate gas analysis.
5. Replace the filter on the outlet manifold with clean glass wool to remove carbon and other decomposition products from the previous test.
6. Measure the heating coil to insure that it is 1-1/2 inches long. Make sure that its coils are uniform. Place the test strip in the specimen support and see that it sits squarely in the middle of the heating coil. (If the specimen is not exactly in the center of the coil, realign the coil so that it is).



TEST PROCEDURE (Cont'd)

7. Check the spark gaps on both the spark ignitors to insure that the gaps are equal or slightly less than 0.02 inch.
8. Move the sparking apparatus to within 1/8 inch of the plastic and see that the spark gaps are at about the middle of the side of the plastic they face and about 7/8 inch from the top of the plastic. Remove the plastic stick from the chamber.
9. Place a piece of Fluorescein -KBr paper on the end of the thermometer to qualitatively pick up any chlorine (or fluorine) that may be omitted by a burning plastic. (One fluorescein-KBr paper will serve until it has to be replaced because of a positive reaction, or until it appears to be deteriorated).
10. A bellstein Test on some drillings of an unweighed test strip may be performed to determine if the plastic was formulated with chlorine. If the test proves negative HCl, chlorine and phosgene need not be tested for.
12. Measure and record the equilibrium temperature of the coil by the method described previously, when it is heated by 55 amperes of current (supplied by throwing the manual heater switch and adjusting the variable resistor until the ammeter reads 55 amps).
13. Check the pump fill time of the Draeger pump and the MSA Cl₂, HCN and NO₂ pumps and adjust them to fill in the time prescribed. Any determination performed with a pump that fails to fill within the prescribed time limits is invalid.
14. Check the shelf-life expiration dates of all tubes to be used. Check the tubes for discoloration. Any discolored tubes, or tubes whose shelf lives have expired should not be used.
15. Record the atmospheric pressure of the room from a barometer which reads in inches of mercury. Record the amount of water vapor in the chamber by using The Draeger O.1 (Ch 234) Water Vapor Tube.

TEST PROCEDURE (Cont'd)

16. Adjust all switches on the top section of the electric console to the left; throw to the "on" position the "main switch" and the "heater transformer" switch. Turn both timers back to zero by pushing down on the dials to the left of the timing indicators. Make sure the specimen stick has been removed from the chamber and then close the doors of the chamber and push the red button to commence the test. About 15 seconds after the red button has been pressed, the heating coil will begin to draw current. Adjust the amperage flowing through the coil to 55 amps. by manipulating the heater current adjust knob. After approximately 50 seconds of heating, current will automatically cease to flow through the heater. The ignition timer will read 50-55 seconds. A 100 second waiting period will follow. During this time, the following must be done:
17. The door to the test chamber must be opened and the plastic test strip inserted within the coil. Push the strip down as far as it will go to assure a secure fit. Take the plastic measuring device that is attached to the bottom handle of the chamber and place it so that its inner ends just touch the outer ends of the sides of the plastic test strip. Move both handles which control the positioning of the sparking mechanism as far as they will go so that the sparking wires just touch the outer ends of the plastic measuring device. In this manner the spark igniters will have been placed exactly $1/8$ of an inch away from the test specimen. Those plastics which bear molding impressions should be set so that the unmolded sides face the spark igniters. Those plastics which have laminated sides should be set so that the laminated sides face the spark igniters. Close the chamber door and pull down the four locking handles. About 15 seconds before the heater and spark igniters will go on, a red safety signal will go on. (If for any reason it is inadvisable to proceed with the test, the test may be discontinued by throwing the switch marked "Switch Position 30 seconds after Ignition Starts" to the right and the "Spark Interruption Switch" to its "off" position. The red light must go off before it is possible to proceed with the test once the two aforementioned switches have been thrown. This will take about 420 seconds).



TEST PROCEDURE (Cont'd)

18. Turn off the room lights. It is easier to spot smoking, charring or a flame when the room is dark. After the red safety signal has been on for about 15 seconds, the spark ignites and the heating coil will automatically go on. The moment the heater coil goes on, the ignition timer (the timer on the left side of the electric console) will again begin to operate. Note how the plastic behaves when it is heated -- when it begins to char and smoke. Observe the plastic strip from the front window of the chamber and when the plastic ignites throw the first switch on the upper left hand side of the upper portion of the electric console (the switch marked "Switch Position when Ignition Starts"). Ignition is considered to occur when the flame is transferred from the escaping gases to the surface of the specimen and continues there. Those momentary flashes which occur in the gassing space prior to the sustained flame are disregarded. Once the switch has been thrown, (ignition time switch), the ignition timer will stop and the second timer will commence. When ignition occurs, turn off the sparking apparatus by throwing the "Spark Interruption Switch" to the right, and move the sparking gear away from the test specimen. When the plastic begins to burn note how rapidly and violently it burns and the height of the flame that extends from the top of the plastic.
19. The ignition time of the specimen may be determined by reading the ignition time dial and subtracting 50-55 seconds (the time of the pre-heat period). Ignition time is the time of heating after re-energizing the coil (following the 100 second cooling period) until ignition of the specimen occurs.
20. After the second timer has registered 30 seconds, throw the second switch to the right (the switch marked "Switch Position 30 Seconds after Ignition Starts"). Throw this switch deactivates the heating coil. Continue to observe the plastic strip from the front and right side window to determine when the flame has gone out completely. As soon as the flame goes out, switch the third switch to its right hand position (the switch marked "Switch Position when Burning Ends"). Burning time is the time elapsed between de-energizing the coil and the complete extinguishment of the flame.

TEST PROCEDURES (Cont'd)

20. (Continued)

The specimen is considered to be burning as long as any flame - no matter how small - persists. The two timing meters now read, respectively: The "Ignition Time" of the specimen plus 30-55 seconds and the "Burning Time" of the specimen plus 30 seconds. To determine the ignition time, subtract 50-55 seconds from the reading on the first timer; to determine the burning time subtract 30 seconds from the reading on the second timer. Record these values on the data sheet.

21. Stir the test atmosphere immediately after the flame on the plastic is extinguished, with the chamber circulating fan. Immediately test for the presence of HCl with the appropriate detector tube. If HCl is present in concentrations of over 25 p.p.m., it should be determined by the mercuric nitrate titration method. Chlorine is qualitatively tested for with fluorescein-KBr strips. If present, chlorine is determined quantitatively. It is necessary to stir the chamber atmosphere to assure a fairly representative sample and to test for the gases rapidly to minimize losses by reaction with one another, the chamber walls and other accessories. The other gases are tested for after hydrogen chloride, chlorine and phosgene have been tested for, in the order in which they appear on the data sheet.
22. Turn off the circulating fan after it has been on for five minutes, and record the temperature within the chamber at this time.
23. After all the toxic gases are tested for purge the test chamber atmosphere with pressurized air (40 p.s.i.) (Break the water seal before attempting to purge the chamber).
24. Remove and reweigh the burnt test strip after 30 minutes of purging. Calculate the % weight loss. Remove the test strip with care to prevent it from breaking so that a true weight loss because of ignition can be made.

In the event of non-ignition of the test specimen, the heating current is discontinued after 410-420 seconds of heating. The atmosphere is stirred and the gas determinations and weight loss determination are made in the manner described above.

CHEMICAL AND ANALYTICAL METHODS

The Beilstein test⁶ is performed on powdered drillings of the plastics to determine if the plastic strip was formulated with either chlorine, bromine or iodine. Organic compounds containing fluorine do not respond to the Beilstein test because copper fluoride is non-volatile. The test is performed by inserting the end of a copper wire into the oxidizing part of a bunsen flame to produce a CuO coating on it. Get some of the plastic drillings to cling to the end of the wire. Then place the wire into the oxidizing part of the flame for at least 10 seconds and observe the color of the flame. The appearance of a green or blue-green color in the flame indicates chlorine, bromine or iodine may have been used in the formulation of the plastic. Certain organic nitrogen compounds will also impart a green or blue-green color to the flame. The absence of a green or blue-green color in the flame indicates that no chlorine, bromine or iodine was used in the formulation of the plastic.

If the green or blue-green color appears, chlorine, phosgene and hydrogen chloride must be tested for when analyzing the toxic gases emitted by the plastic strip. If no green or blue-green color is seen in the flame as a result of the Beilstein test, these gases need not be tested for.

DETERMINATION OF HYDROGEN CHLORIDE 7/5/
(In Amounts greater than 25 p.p.m.)

by titrating with standard mercuric nitrate using Sodium Nitroprusside as the indicator.

Stir the atmosphere created by the burnt plastic for two minutes and then bubble a known volume of the atmosphere (about 10 liters) into a sampling vial containing 10-12 ml of distilled water. The flow rate should be about 5 l./min. and can be metered by using a suitable rotometer (apx. p. 9). Hydrogen chloride is highly

CHEMICAL AND ANALYTICAL METHODS (Cont'd)

soluble in water and will be absorbed quantitatively. After the sample has been flowed through add two drops of indicator solution to the vial, and titrate with standard mercuric nitrate solution (0.1N) until a faint but permanent turbidity appears. Run a blank with distilled water and make the necessary correction (no more than 2 drops of mercuric nitrate should be needed for the blank).

Calculations for determination of ppm HCl in Atmosphere

$$\text{ppm HCl} = \frac{\text{ml Hg (NO}_3)_2 \times N \left(\frac{\text{meq}}{\text{ml}} \right)}{\text{liters air sample}} \times \frac{36.5 \text{ mg HCl}}{\text{meq}} \times \frac{670 \text{ ppm}}{\text{mg HCl}}$$

$$\text{ppm HCl} = \frac{\text{ml Mercuric Nitrate} \times \text{Normality (Mercuric Nitrate)}}{\text{liters of air sampled}} \times 24.5 \times 10^3$$

REAGENTS

Indicator: Dissolve 10 g of sodium nitroprusside ($\text{Na}_2\text{Fe(CN)}_5$ No. $2\text{H}_2\text{O}$) in 90 ml of water and store in a brown bottle. Discard if a green color develops.

Standard Mercuric Nitrate Solution (0.1N): Dissolve 16.3 g of mercuric nitrate ($\text{Hg(NO}_3)_2 \cdot x \text{H}_2\text{O}$) in 50 ml of 1:1 nitric acid, then dilute with water to one liter. Standardize against pure sodium chloride or against a standard solution of 0.1N HCl.

Total chloride is determined by this method. Chlorine and/or phosgene if present can be determined quantitatively by using appropriate detector tubes. A suitable correction should be made when these gases are present, in calculating the amount of HCl in the atmosphere.

CHEMICAL AND ANALYTICAL METHODS (Cont'd)

Cyanides, if present, will interfere with the total chloride determination giving a positive error. Cyanides, however, are seldom found in atmospheres containing chlorides. If when testing a plastic which is allowed a maximum HCl concentration of 100 p.p.m., cyanide is present, the following should be done: Add formaldehyde to the solution to be titrated. This will cause any hydrocyanic acid that is present to react to form glycolonitrile which will not interfere.

When testing a plastic which is allowed a maximum HCl concentration of 1000 p.p.m., it is in all probability unnecessary to add formaldehyde as the cyanide concentration will probably be considerably less than 100 p.p.m., and cause no appreciable error.

TEST FOR CHLORINE (QUALITATIVE)^{8/}

Fluorescein-potassium bromide paper is used to qualitatively detect the presence of chlorine. Fluorescein (a yellow dye) reacts with free bromine to produce red eosin (tetrabromofluorescein). The presence of chlorines (or fluorine) causes free bromine to be liberated. The free bromine reacts with the fluorescein and turns the paper red.

Reagents: Fluorescein-potassium bromide paper is made by bathing strips of filter paper in a very weakly alkaline solution containing 0.1 g dye and 0.5-0.8 g KBr and dried.

Limits of detection: 0.001 mg Cl₂

Chlorine can be determined quantitatively by using the MSA Cl₂ detector. See the discussion as to how interfering gases affect the results. (Page #22).

The remaining gases are tested for by using detector tubes.

The detection tubes employed are glass tubes packed with silica gel, alumina gel or glass impregnated with reagent chemicals which give a characteristic color reaction with a specific gas. The detector tubes are hermetically sealed at both ends. When a gas is to be analyzed for, the ends

CHEMICAL AND ANALYTICAL METHODS (Cont'd)

of the detector tube for this gas are broken off and the tube is inserted into the pump it was designed to be used with. A known volume of the gas to be analyzed is drawn through the tube by the pump. The detecting reagent in the tube reacts with the gas it is designed to detect and changes color. The length of color change in the tube is proportional to the concentration of the gas being analyzed. The concentration of a given gas can be determined by making reference to calibration charts supplied for this purpose. For a detailed discussion of this topic see references 9/ and 10/.

The following indicates how each gas is to be tested for:

Chlorine	Qualitatively by a Fluorescein-Potassium Bromide test strip. The strip should be hung from the end of the dial thermometer or other suitable support inside the chamber. If the strip turns from yellow to pink or red chlorine is present. Quantitatively by the MSA Chlorine-in-air Detector, Part No. DT-82400/tubes Cat. #DY-82399.
Hydrogen Chloride	Use Draeger Detector tubes Hydrochloric Acid 2/a Cat. No. Ch 295 and 10 strokes Draeger pump. If reading obtained is in excess of 25 ppm, hydrogen chloride must be determined wet by the method on p. #13. (See apx. pp. 9, 20-22, 31.)
Phosgene	Draeger Phosgene 0.25b Detector Tube Cat. No. CH 283. 5 strokes of the Draeger pump. (apx. pp. 20-22, 32).
Aldehydes as Formaldehyde	Draeger Formaldehyde 0.002 detector tube Cat. No. Ch 264 and Draeger pump. Break the inner vial of the Draeger Formaldehyde detector tube. Take 5 pump strokes. The answer obtained is in $\text{mg/l} \times 10^{-3}$ of formaldehyde. Convert this answer to ppm by multiplying by 815. (apx. pp. 20-22, 33-34).



CHEMICAL AND ANALYTICAL METHODS (Cont'd)

Ammonia	Kitagawa Ammonia detector tube Cat. #105b and Kitagawa Pump. Use 1 stroke of the pump. (apx. pp. 25-27, 35, 36).
Carbon Monoxide	Draeger carbon monoxide detector tube marked 5/a Carbon Monoxide Cat. No. Ch 256. 10 Draeger pump strokes (apx. pp. 20-22, 37). Eacharach Carbon Monoxide Indicator Tubes 22-333 in conjunction with Eacharach Monoxer -- Carbon Monoxide Indicator Model CDE. (apx. pp. 38-42). Report answer as the average of the Draeger and Eacharach readings.
Carbon Dioxide	Kitagawa carbon dioxide detector tube Cat. No. 126b and Kitagawa pump. (apx. pp. 25-27, 43).
Oxides of Nitrogen as NO ₂	MSA Nitrogen Dioxide-In-Air Detector Pump Part No. DV 83100, tubes DV 83099. 1 or 3 squeezes of detector bulb. (apx. p. 44).
Cyanides as HCN	MSA sampling tubes Cat. #DE-73427 and MSA Hydrocyanic acid gas detector Part No. 73492. Three squeezes of the detector bulb. (apx. pp. 18-19, 45).
Combustibles as Natural Gas	10 or more squeezes of the bulb of the Davis Naphtester Model M-6 and use of Curve No. 250 for Model M-6 Naphtester which reads ppm Natural gas in the 10:1 scale. (apx. pp. 12-17, 46).
Oxygen	MSA Portable Oxygen Indicator (Type E). (apx. pp. 25-30).

The manufacturer's instructions regarding the use of these materials should be strictly adhered to.

The additional points which follow should be noted to prevent introducing avoidable errors.

CHEMICAL AND ANALYTICAL METHODS (Cont'd)

The length of discoloration depends to a great extent upon the rate at which gas is flowed through the detector. The rate of flow through the pump differs for the different detector tubes. The pumps must be checked frequently to assure that they are operating with the flow rates that they were calibrated for as specified in the manufacturer's literature.

In using the Draeger Pump be sure that the bellows are depressed completely before beginning an intake stroke. Let the pump expand itself and do not attempt to speed up the process.

Should a tube become completely discolored before the required number of strokes are taken the following procedure should be followed: Take as many strokes as can be taken without discoloring the entire reactive layer. Multiply by the proper factor to determine the concentration of the gas, e.g. if the Draeger Carbon Monoxide tube reads 180 after two strokes of the Draeger pump, additional strokes should not be made. $2/10 \times 180$ so that the concentration of carbon monoxide in ppm is 360. The shelf lives of the detector tubes vary---the expiration dates being stamped on each box of tubes. No tubes should be used after their expiration date, nor should any tube be used which is discolored before it is opened.

Detector tubes may sometimes channel: only one part of a reactive layer becomes discolored - either the front of the layer or the back of the layer, but not the entire circumference of the layer becomes discolored. If the channeling is severe - makes a significant difference in the reading obtained, the determination should be performed again using a new tube in an attempt to avoid channeling. Should channeling persist, the value for the gas determined should be reported as the average of the high and low readings except where the manufacturer's instructions are otherwise.

Substitution of Detector Tubes

In the future other tubes or methods of analysis will be developed which are as accurate or more accurate than those tubes presently used, and may be substituted. These new tubes should not be used if the other gases which may be present in the toxicity atmospheres will interfere with the readings obtained. The suitability of a given tube for these gas determinations may be determined by formal reports, empirical trials, or the manufacturer's data.

<u>Chlorine</u>	<u>Hydrogen Chloride</u>	<u>Phosgene</u>	<u>Aldehydes as H₂C=O</u>	<u>Ammonia</u>	<u>Carbon Monoxide</u>	<u>Carbon Dioxide</u>	<u>Oxides of Nitrogen as NO₂</u>	<u>Cyanides as KCN</u>	<u>Gases</u>	<u>Combustibles as Natural Gas</u>
KBr-fluorescein Test Strips (Qual.) MSA Cl ₂ detector (quant.)	Draeger 10 str-oks If Draeger reading greater than 25 ppm take 10 liter sample in 10 ml water; titrate with standardized Hg(NO ₃) ₂	Draeger 5 strokes	Draeger 5 strokes	Kitagawa #105b	Draeger Kitagawa 5/a 126b	MSA NO ₂ Detector	MSA HCN Acid Gas Detector	Mine Safety Appliances Oxygen Meter	Davis Vapo-tester and Natural Gas Calibrating Chart	By difference

Note: The number of strokes to be taken for a given tube and pump are sometimes revised as tubes are improved and recalibrated. The instructions of the manufacturer should be consulted and followed when these are made.

NECESSARY EQUIPMENT AND SOURCE OF SUPPLY LIST

EQUIPMENT

SUPPLIER

Union Industrial Equipment Corporation
Port Chester, New York

Kiragava Precision Gas Detector
Unico Model Number 400

Tube No. 126 b Carbon Dioxide -- low
range (500 - 12,000 ppm) detectors
20 tubes/box

Same

Tube No. 105 b Ammonia Low Range Tubes
(10-400 ppm)

Same

Draeger Gas Detector Model 19/31
Catalog #CH 235

Draeger Oxygen Apparatus Company
432 Park Avenue South
New York, New York

Draeger Detector Tubes in boxes of 20 tubes

Same

5/a Carbon Monoxide Ch 256/2
2/a Hydrochloric Acid Ch 295/2
Formaldehyde 0.002 Ch 264/2
O ₂/h Phosgene Ch 283/2
Water Vapor 0.1 Ch 234/2

MSA Hydrocyanic Acid Gas Detector
Part. No. 73493

Mine Safety Appliance Co.
1100 Globe Avenue
Mountainside, New Jersey

Tubes for KCN Detector (12 tubes)
Cat. #DH-73497
MSA Nitrogen Dioxide-In-Air Detector
Pump Part No. DY 83100 Tubes for NO₂
Detector (12 tubes) cat # DY 83099

Same

MSA Chlorine in Air-Detector Part No.
DY-82400

Same

MSA Chlorine in Air-Detector Part No.
DY-82400

Same

MSA Chlorine in Air-Detector Tubes (12
tubes) cat #DY-82399

Same

NECESSARY EQUIPMENT AND SOURCE OF SUPPLY LIST
(Cont'd)

EQUIPMENT

SUPPLIER

Bacharach Monoxor -- Carbon Monoxide
Indicator Model CDE

Bacharach Industrial Instrument Co.
200 North Braddock Avenue
Pittsburgh 8, Pa.

Carbon Monoxide Indicator Tubes CC-333

Bacharach Industrial Instrument Co.
200 North Braddock Avenue
Pittsburgh 8, Pa.

Davis Vaportester Model M-6 Code No.
11-320

Davis Emergency Equipment Co., Inc.
45 Halleck Street
Newark 4, New Jersey

Curve No. 380 for Model M-6 Vaportester
*PPM Natural Gas, 10:1 scale
Natural Gas Test Kit Code 11-435

Same

MSA Portable Oxygen Indicator Type E

Mine Safety Appliances Company
201 North Braddock Avenue
Pittsburgh 8, Pa.

DF-49207 Oxalite Refill

or

DF-76652 Carbon Electrodes (2 per carton)

1100 Globe Ave.
Mountainside, New Jersey

Thermocouple Wire
28 Gauge Chromel Alumel

Thermo Electric Co., Inc.
Sedell Brook
New Jersey

NECESSARY EQUIPMENT AND SOURCE OF SUPPLY LIST
(Cont'd)

REAGENTS

SUPPLIER

For HCl Determination

Sodium nitroprusside $\text{Na}_2\text{Fe}(\text{CN})_5 \cdot \text{NO} \cdot 2\text{H}_2\text{O}$ (Reagent Grade)	Any laboratory supply house
Mercuric Nitrate (Reagent Grade)	Any laboratory supply house
Nitric Acid (Reagent Grade)	Any laboratory supply house
Sodium Chloride (Reagent Grade) or standardized 0.1N HCl	Any laboratory supply house
Fused Calcium Carbonate (for drying chamber of M-6 Vapotester)	Any laboratory supply house
Fine Glass Wool	Any laboratory supply house
Drying Tubes (Kimax, Straight) (length to bottom of bulb 150 mm) Fisher Cat. #9-216	Fisher Scientific Company 533 Greenwich Street New York 14, New York
Batteries (for Vapotester and O ₂ meter)	Any laboratory supply house

ACCURACY OF THE ANALYTICAL METHODS

Chlorine (Qualitative Test for)^{8/} - The KBr - fluorescein test strip is specific for chlorine. Only fluorine will interfere.

Chlorine (Quantitative)^{12/} - The M.S.A. Chlorine-in-Air detector is accurate to $\pm 15-20\%$ of the scale reading. Interfering gases - If a concentration of 10 ppm nitrogen dioxide is introduced to these tubes the results will yield an 8-15 ppm reading on the tube. The stain, however, is yellow rather than the blue of normal chlorine indication. If a mixture of 5 ppm nitrogen dioxide and 2 1/2 ppm chlorine is introduced the length of stain reading corresponds to 6 ppm, but the stain is still yellow. Thus it appears that if the nitrogen dioxide concentration is in excess of the chlorine concentration there will be a tendency of the former to bleach the blue stain to a yellow, but since this definite indication occurs, it should cause no problem. Methane, carbon dioxide, carbon monoxide, and aldehydes will have no effect on these tubes. Hydrogen chloride and phosgene, in general, will have no effect up to their threshold limit values.

	<u>Known Test Concentration</u>	<u>Tube reading, ppm</u>
Chlorine ^{13/}	1	Trace
	2	0.5
	5	Less than 2

The MSA tube for chlorine was tested and gave the following results: A trace of 1 ppm, 0.5 ppm at 2 ppm, and 2 ppm at 5 ppm.

Hydrochloric Acid

Hydrochloric Acid ($\text{Hg}(\text{NO}_3)_2$) Titration

The accuracy of this determination is limited by the accuracy of the gas flowmeter employed. The flowmeter employed in this determination is accurate to $\pm 20\%$. (More accurate flowmeters are obtainable should greater accuracy be desired).

Draeger 2/a Hydrochloric Acid Detector Tube (Draeger Information Sheet No. 39 - June 1960)14/

Properties of the 2/a HCl Detector Tube

The (violet) discolorations of the indicating layer caused by hydrochloric acid only last for a limited time; they tend to pale. It is necessary therefore to note the readings directly after the test. The 2/a HCl Detector Tubes have a storage life of at least two years.

Range of Indication - About 2 to 30 p.p.m.

Specificity

The indication of the 2/a HCl Detector Tube is based on a reaction of the hydrochloric acid with an organic metal complex. The reaction is determined therefore not by the acid function but by a complex reaction of the anion. This means that the HCl indication is rather specific.

HCl analysis can be upset by nitrous gases and chlorine if they are present in excess. They produce a discoloration of the indicating layer. Hydrogen sulfide can also offer interference; It discolours the indicating layer blue. Hydrogen fluoride, offers no interference.

Effects of the Ambient Humidity and Temperature on the Measurement

In calibrating this detector tube, we encountered the difficulty of allowing for the effects of the moisture in the test gas. As the relative humidity in the air increased, we had to allow for a part of the hydrochloric acid vapour condensing as a mist. Mists of this type cannot be accurately measured with a detector tube but can be allowed for dur-

Hydrachloric Acid

ing calibration. We first determined, therefore, the calibration curve for a test gas of 50% r.h. at 20°C. The HCl concentration of the test gas was determined by the Vollhardt method in a flow-metering arrangement. This gave us the total of HCl vapour plus HCl mist. The calibrated scale which we have printed on the detector tube allows for these test conditions. Subsequently, at a given HCl concentration, we investigated the divergencies from the scale value at a lower and higher relative humidity of the test gas. We found that in drier air of about 30% r.h. (20°C), the scale reading was 10 to 20% too high. At the bottom end of the scale, the divergence from the scale value is at its maximum (25%). At higher humidity was higher (70% r.h. at 20°C), the scale reading was at the opposite. The divergence from the scale value is at its maximum (25%).

These relative divergencies in the scale reading are not to be taken as a basis for the evaluation of the results. The scale reading is only a guide for the evaluation of the results. The results of the analysis are only valid if the test gas sample are at the same conditions.

Interference Tests

NO₂ and Cl₂ interference with the HCl detection is described in their interference is described in the following.

Influence of NO₂ and Chlorine on the HCl indication

Predetermined HCl concentration p.p.m.	Predetermined NO ₂ concentration p.p.m.	HCl actually found p.p.m.	Remarks
7	3	7	
7	5.5	approx. 4	Zone of discoloration rather pale; evaluation difficult.
15	5	12.5	
15	7	10	
15	10	approx. 8	Evaluation uncertain.

As long as the NO₂ concentrations are substantially smaller than HCl concentrations, the HCl analysis is not affected. On the other hand, if the NO₂ concentrations are of about the same magnitude as the HCl concentrations, then too little HCl is indicated. With an excess of NO₂ there may be even be no indication of HCl whatsoever.

Chlorine upsets the detector tube reading in a similar way.



Phosgene

Draeger 0.25/b Phosgene Detector Tube
(Draeger Information Sheet No. 38 - May 1960)¹⁴

Properties of the 0.25/b Phosgene Detector Tube

General

The calibrated scale (in p.p.m.) printed on the detector tube is valid for an air sample of 1/2 litre, corresponding to 5 strokes of the bellows pump. The 0.25/b Phosgene Detector Tubes may be stored for at least two years. So long as both the tube and the gas sample are within a temperature range of 5 and 35°C, the ambient temperature has no effect on the readings.

Range of Indication

As the illustration shows, the range of measurement under the test conditions indicated (5 strokes = 1/2 litre of air sample) is from about 0.25 to 15 p.p.m. The length of the bluish-green discoloured zone is the measurement of phosgene concentration. The range of measurement may be increased upwards by the factor 5 (to approximately 75 p.p.m.) when the gas sample is drawn through the tube with only one stroke of the pump. Then, logically, the scale values must be multiplied by 5.

Specificity

The indication of the 0.25/b Phosgene Detector Tube is based on the colour reaction of the phosgene with aromatic amino aldehydes. The indication reaction is specific for phosgene. By virtue of the pre-cleansing layer incorporated in the 0.25/b Phosgene Detector Tube, all disturbing factors which might affect the quantitative aspect of the test result are eliminated. The possible adverse effect of water vapour in instances of very high relative humidity is also excluded. The phosgene reading with the 0.25/b Phosgene Detector Tube is not in any way influenced by simultaneously present ammonia.

Phosgene

The Measurement of Phosgene in the Presence of Humid Air

These tests were carried out at room temperature and with a relative humidity between 25 and 95%. The predetermined phosgene concentrations were between 5 and 15 p.p.m. The humidity in the air was measured with the 0.1 Water Vapour Detector Tube (absolute values between 5 and 18 mg H₂O/litre). The phosgene concentrations were determined immediately (i.e. within 5 minutes) after the gas mixture had been prepared.

Result of our investigations: In no case was the divergence from the pre-determined phosgene concentration greater than 10%. It may therefore be concluded that atmospheric humidity (at least up to a relative humidity of 95%) has no effect on the result of the test. Where the relative humidity is even greater, i.e. close to saturation point, small concentrations of gas cannot any longer be clearly provided, so we decided not to continue the tests beyond the stage reported.

The Measurement of Phosgene in the Presence of HCl

Upon repetition of the experiments described in Information Sheet No. 32, in Table 2, we found that the phosgene was indicated by the 0.25/b Tube even where there was a high excess of hydrochloric acid. Under extreme conditions of concentrations (about 1:150), there may always be a slight plus-error. For example, where the concentration of phosgene was 2.5 p.p.m. and that of hydrochloric acid 350 p.p.m., the phosgene reading was 3 p.p.m.

The Measurement of Phosgene in the Presence of Chlorine and Nitrous Gases

Chlorine and nitrous gases alone discolour the indicating layer in orange-tinged zones. There is no possibility of confusion with the bluish-green discolouration produced by phosgene. Furthermore, this discolouration only occurs where there is a relatively high chlorine or nitrous gas concentration.

Phosgene

If phosgene is measured in the presence of chlorine or nitrous gases, the result is not affected by these gases even if they are present to great excess. With a high excess of nitrous gas, the most that may be expected is a paling of the green tinge produced by the phosgene.

The Measurement of Phosgene in the Presence of AmmoniaTable 1

The measurement of Phosgene in the presence of Ammonia. The concentrations were made up in a 50 litre glass bottle. The tests were made at room temperature with 5 mg/litre atmospheric moisture. The values were ascertained in each case 5 minutes after the gas mixture had been prepared.

Pre-determined NH ₃	Pre-determined Phosgene	Phosgene readings 0.25/b Phosgene Detector Tube
100 p.p.m.	12.5 p.p.m.	12 p.p.m.
500 p.p.m.	12.5 p.p.m.	10.5 p.p.m.

Table 2

Showing the gradual decomposition of the Phosgene in the presence of Humidity and Ammonia respectively. The gas concentrations were prepared in a 50 litre glass bottle. The tests were made at room temperature.

Pre-determined

Phosgene:	12.5 p.p.m.	12.5 p.p.m.	12.5 p.p.m.
Ammonia:	-	100 p.p.m.	100 p.p.m.
Water Vapour:	20000 p.p.m.	7000 p.p.m.	20000 p.p.m.

Time (hours)	Phosgene found as a % of the pre-determined concentration		
0	100	100	100
1/2	94	94	90
1	88	88	82

Formaldehyde

Draeger Formaldehyde Detector Tube C.002

(Draeger Information Sheet No. 9 - September 1957)^{14/}

Characteristic Features of the Formaldehyde
Detector Tube C.002

This Detector Tube has a measuring range of about 0.002 mg to 0.05 mg of formaldehyde per litre of air. This corresponds to about 2 to 40 p.p.m. The test is based on the reaction of formaldehyde with an aromatic hydrocarbon in the presence of sulphuric acid. The indication of formaldehyde is practically specific.

By the novel composition of the Detector Tube it has been rendered capable of practically unlimited storage. To take a measurement 5 strokes of the bellows pump of the Gas Detector are made. The concentration of the formaldehyde in the air being tested is read off directly in mg/litre from the scale printed on the tube.

	<u>Known Test Concentration</u>	<u>Draeger Tube</u>	<u>Tube reading p.p.m.</u>
Formaldehyde ^{13/}	2	264	Trace
	5	264	4-5
	20	264	17

The Draeger tube 264 gave readings which are slightly lower than the known concentration, and it was noted that the stain color varied from very light red to red depending on the concentration.

At 5 ppm the tube indicated from 4 to 5 ppm with the color forming a light red. This color was reproducible and always remained the same at 5 ppm concentrations.

At 20 ppm the tube indicated from 15 to 18 ppm and gave a definite red stain.

At 2 ppm a slight change in the reaction layer was observed but not enough to be considered adequate for use at 2 ppm.

Ammonia

	<u>Known Test Concentration</u>	<u>Kitagawa Tube</u>	<u>Tube reading p.p.m.</u>
Ammonia 13/	50	105B	50
	100	105B	100
	200	105B	200
	400	105B	400

Temperature corrections: No temperature corrections are necessary when the gases measured are between 10°C - 32°C.

Interfering gases: The only listed interfering gases are amines and amine derivatives.

(Reference - Kitagawa Instruction Sheet)

Carbon Monoxide

Draeger Carbon Monoxide Detector Tube 5/a
(Draeger Information Sheet No. 45 - November 1960)^{14/}

In addition to the new 10/a CO Detector Tube described in No. 42 in the series "Information on the Draeger Gas Detector", other detector tubes have been developed during the course of time for measuring CO. They differ from one another only in their ranges of measurement, each range being adapted to suit the particular application.

At the outset, we would mention that the same principle of reaction - the iodine pentoxide reaction - is used for all the detector tubes mentioned in this review. Also, the design of the various types is similar: In front of the white indicating layer on which the calibrated scale is printed is an orange-coloured pre-cleansing layer. The purpose of this is to absorb selectively any disturbing substances which might be contained in the gas being tested - particularly hydrocarbons - so that the carbon monoxide indication will be specific. As it performs its function, the pre-cleansing layer will change from orange to green.

No. 42 in the series "Information on the Draeger Gas Detector" gave full information on all the general properties of the 10/a CO Detector Tube. This information applies appropriately to all the other types) and therefore to the 5/a tube).

Excerpts from the Draeger Information Sheet No. 42
September 1960^{14/}

Effect of the Ambient Conditions upon the Result

Moisture in the test air does not affect the result. It is absorbed quantitatively in the pre-cleansing layer in the tube. This causes the colour of the pre-cleansing layer to change from orange to red. It remains, however, nonetheless effective. The ambient temperature does not affect the result so long as both the gas sample and the tube are within the temperature range of 0 and 30°C.

Carbon MonoxideSpecificity

Virtually the only interfering substances are the saturated and unsaturated hydrocarbons.

This table gives the concentrations of hydrocarbons which, in the 10/a CO Detector Tube, simulate a CO concentration of 10 ppm (=0.001%-Vol.).

Test gas	Concentration		Simulated quantity of CO
	% Vol.	ppm	in the 10/a CO Detector Tube ppm
Propane	0.1	1000	10
Butane	0.1	1000	10
Pentane	0.03	300	10
Hexane	0.04	400	10
Heptane	0.025	250	10
Ethylene	0.05	500	10
Benzol	0.03	300	10

It can be seen from this table that the reading of the 10/a CO Detector Tube is adequately specific for CO. An additional safety factor in evaluation is that the tester's attention is immediately drawn to the possible presence of interference substances by the discoloration of the pre-cleansing layer. As long as the pre-cleansing layer is not completely discoloured (the colour changes from orange to green), the indication is proof of the presence of carbon monoxide. With the type 10/a Tube, the reading is not affected by hydrogen.

Accuracy

The length of the sharply delineated green zones of discoloration produced by CO show the concentration.

With the 10/a CO Detector Tube, with a test concentration of 100 ppm CO (in other words the MAC value), we found a standard deviation of + 7 ppm. This means, therefore, that the error in a single test, in the region of the MAC value, will, with a statistical certainty of 95% be less than about + 15 ppm (twice the standard deviation). Since the pump error (+ 5%)

Carbon Monoxide

might, in the most unfavorable case, be added to this, then with the same statistical certainty, a relative maximum error of $\pm 20\%$ is possible in the isolated cases.

Bacharach Carbon Monoxide Indicator Tubes^{10/}

Length-of-stain tube, color change from yellow to dark brown, very easy to see. Good response at 2.5, 25 and 230 ppm. No interference with 200 ppm CH₄ or 7 ppm NO₂.

A dark brown stain is formed in a yellow indicator gel. Near the interface, the intensity of the brown color is much less than that of the major portion of the stain.

Kushetz^{10/} remarks further that a greater uniformity between observers' interpretation was achieved by rewriting the manufacturer's directions for making the reading by suggesting to the readers that the tubes be read by transmitted light rather than by reflected light. Where the gel and packing were such that light could be transmitted it was found that the end-point became easier to see when the light was placed behind the tube. Reflection and glare from the outer surface of the tube were minimized in this way.

Since this method gives the same end-point as the manufacturer's method with greater ease, it should be employed if difficulty in fixing the end-point is experienced.

The manufacturer indicates temperature corrections are unnecessary for gas measurements performed between -56°C and 51°C .

Carbon Dioxide¹⁵

An evaluation of Kitagawa Detector Tubes Carbon Dioxide - Low Range - 500 to 8,000 ppm follows:

Date of Evaluation:	December 7, 9, 1960
Date of Report:	December 19, 1960
Conducted by:	William A. Burgess

A. Description of Detector Tube

1. Two boxes of twenty tubes each of Kitagawa Carbon Dioxide - Low Range Detector Tubes (Catalog No. 126 b) were submitted for evaluation. An instruction sheet and a calibration curve were submitted with each box of tubes.
2. The detection method for low range CO₂ is apparently the same method in use for the high range CO₂ detector tube. The length of discoloration of a bluish purple reactive chemical is directly proportional to the air concentration of carbon dioxide.

B. Calibration

1. Known concentrations of CO₂ in air for use in evaluating the accuracy of the detector tube were generated by a static technique.
2. The CO₂ gas used in this study was Colonial Carbon Dioxide distributed by New England Gas Products.

C. Results

1. The results of this evaluation study, presented in Table 1, indicate that the detector tubes supplied for this study accurately predict the concentration of CO₂ in air up to a maximum concentration of 3000 ppm.
2. Above 3000 ppm the tubes read low by as much as 25%.
3. The variation in predicted concentration among a number of tubes at one standard test concentration is also substantial above 3000 ppm as shown in Tests 24 through 28.

UNITED STATES TESTING COMPANY, INC.

Carbon Dioxide

Table 1
Test Results
Kitagawa Low-Range CO₂ Detector

Test No.	Standard Test Concentration	Test Concentration ppm	Concentration from Kitagawa, ppm
1	A	300	400
2	B	500	600
3	B	500	550
4	C	1000	1000
5	C	1000	1000
6	D	2000	2000
7	D	2000	2000
8	E	3000	3300
9	E	3000	2900
10	E	3000	2800
18	F	3000	3000
19	F	3000	2800
20	F	3000	3000
21	G	3910	3500
22	G	3910	3500
23	G	3910	3500
24	H	4940	4500
25	H	4940	5000
26	H	4940	4000
27	H	4940	3500
28	H	4940	3800
29	I	5920	5000
30	I	5920	4400
31	I	5920	4300
32	J	6900	6000
33	J	6900	5700
34	K	7880	7000
35	K	7800	6900
4	L	7890	6800
15	L	7890	7700
16	L	7890	6800
17	L	7850	6300

Carbon Dioxide 13	Known Test Concentration	Kitagawa Tube No.	Tube reading ppm
	2,500	126A-B	2,500
	5,000	126A-B	5,000
	10,000	126A-B	10,000
	500	126B	500

The Kitagawa tube read according to the manufacturer's calibration at 2,500 ppm, 5,000 ppm and 10,000 ppm.

Carbon Dioxide

D. Discussion

1. The stain presented by the detector tubes after exposure was quite easy to read. As the test concentrations were increased the pink stain became lighter in color presenting a marked difference between the stain and unreacted purple chemical.

2. The sketch of an exposed tube presented on the instruction does not accurately show the position of cotton plug, end packing, and reactive chemical. This deficiency, coupled with the description of the method for using the concentration chart, could confuse a person using the equipment for the first time. (Note: This failing has since been corrected).

Temperature Corrections: No temperature corrections are necessary when the gasses measured are between 0°C - 49°C.

Interfering gases: Other acid gases can interfere with accurate measurements, but only at air concentrations many times their respective MAC's.

(Reference - Kitagawa Instruction Sheet)



Nitrogen Dioxide

The MSA Nitrogen Dioxide-In-Air detector ¹² is accurate to $\pm 15-20\%$ of the scale reading.

Interfering gases - When 5 ppm of chlorine are introduced into a tube, there is no effect noticeable. A mixture of 5 ppm of NO_2 and 1 ppm of chlorine give an indication of 5 ppm. A mixture of 5 ppm nitrogen dioxide and 2-1/2 ppm chlorine indicates 4 ppm. This indicates that as the chlorine concentration increases above the threshold limit value, there is a tendency to reduce a nitrogen dioxide indication.

Methane, carbon dioxide, carbon monoxide, aldehydes and hydrogen cyanide will have no effect on these tubes. Hydrogen chloride and phosgene, in general, will have no effect up to their threshold limit values.

	<u>Known Test Concentration</u>	<u>MSA Tube Reading</u>
Nitrogen Dioxide ¹³	1	1
	5	4
	10	10

The MSA tube for nitrogen dioxide gave results of from 3 to 5 ppm (avg. 4 ppm. At 10 ppm (2 MAC) the stain read 9 to 12 ppm.

The color change using this tube was blue at the inlet end of the tube and a brown at the end of the stain. The total stain was used in reading the concentration.

This was by far the best tube for NO_2 tested.

Hydrogen Cyanide, Combustibles and Oxygen

Hydrogen Cyanide

The MSA Hydrocyanic gas detector¹² is accurate to $\pm 15-20\%$ of the scale reading.

Interfering gases - When these tubes are subjected to a mixture of from 0-50 ppm ammonia mixed with 10 ppm hydrogen cyanide, there is no effect indicated on the indication of 10 ppm hydrogen cyanide. A varying mixture of from 0-10 ppm chlorine and 0-10 ppm hydrogen cyanide, there is no effect on the accurate indication of hydrogen cyanide.

Methane, carbon dioxide, carbon monoxide, aldehydes and the oxides of nitrogen, will have no effect on these tubes. Hydrogen chloride and phosgene, in general, will have no effect up to their threshold limit values.

Combustibles as Natural Gas

This determination is accurate to ± 10 per cent of the scale reading. (Reference - instruction manual).

Oxygen

This determination is accurate to $\pm 1/2\%$ O₂. (Reference - instruction manual).

It should be noted that if the concentration of a given gas is greater than the upper calibration limit of its detector tube, the accuracy of the determination will be reduced.

PROCEDURE FOR DETERMINATION OF
"FLASH-IGNITION" TEMPERATURES

"Flash-ignition" temperatures are determined by the method of Gale, Stewart, and Alferts². The equilibrium temperature of the heating coil is determined and recorded. The conventional 1/2x1/2 x 5-inch specimen is heated in the coil of the flammability test apparatus (with spark igniters operating) until ignition occurs. During this determination the door of the test chamber is shut tight. A 28 gauge chromel-alumel thermocouple junction is firmly affixed in a notch that has been cut in the plastic so that the junction is flush with the edge of the specimen. The same or similar type thermocouple that is used to measure the equilibrium temperature of the coil may be used for this purpose. The notch should be made on the far edge of the plastic (the edge which is in back of the edge facing the front window of the chamber.) The notch should be made 2-1/2 inches from the upper end of the plastic strip and extend across the entire face of the plastic. A notch slightly larger than 1 mm wide x 1 mm deep and a thermocouple that will fit snugly in a notch of this size has proved satisfactory. When the thermocouple is properly positioned it will remain in the notch one place there, and be located at about the middle of the heating coil. A set of thermocouple leads leave the chamber through a small hole at the top drilled for this purpose.

In the case of those plastics that have 2 laminated sides, the laminated sides should face the spark igniters, and the plastic should be notched on one of its remaining faces. The rise in temperature of the plastic as it is heated is tracked with a suitable (0-30 or greater mv) potentiometer. The last temperature recorded before ignition occurs is reported as the flash-ignition temperature of that plastic. The time of heating with the 55-ampere current until ignition occurs may also be recorded. The usual 50 second preheating and 100 second cooling periods are omitted. The determination is conducted by throwing the main switch, the heater transformer switch, the manual heater switch and the manual spark switch to their "on" positions.

PROCEDURE FOR DETERMINATION OF
"SELF-IGNITION" TEMPERATURES

"Self-ignition" temperatures are determined by a modification of the method of Scott, Jones and Scott¹² in which powdered pieces of the material are dropped into a stainless steel cup surrounded by a stainless steel core which sits in a high temperature furnace. (apx. pp. 10, 11). The stainless steel core prevents sudden changes of temperature within the cup from occurring. The stainless steel core is hollow for 2-1/4 inches to permit the entrance of the cup. At the bottom of the hollow sits a chromel-alumel thermocouple junction.

Small amounts of the powdered plastic to be tested are sprinkled into the orifice of the cup. The proper amount of powdered plastic to be used can be decided upon after the operator has gained some experience with the apparatus. The amount should be sufficient for sparking to be seen should it occur, though not so much as to cover the bottom of the cup with any more than a thin film. A few seconds after the powder is introduced and smoke begins to come through the orifice of the cup, compressed air under 40 p.s.i. pressure is blown straight down into the mouth of the cup while the bottom of the cup is watched to see if sparking will occur. The bottom of the cup will resemble the glowing end of a cigarette when sparking occurs. The compressed air is blown in for at least 30 seconds to determine if sparking occurs at a given temperature. After several such determinations have been performed the cup should be removed with tongs and inverted to remove the charred powder. The cup should be allowed to reach equilibrium before another determination is attempted. 1 minute should be sufficient. The self-ignition temperature is the lowest temperature at which the powdered form of the material will ignite.

It seems that the best plan of attack is to subject the plastics first to high temperatures where they will ignite, and then lower the temperature and see how low you can go before the plastic stops igniting.

The operator would be well advised to wear ear-plugs during this determination, as the pressurized air running into the tiny cup makes quite a racket. Care must be exercised in directing the pressurized air straight down into the cup. If the air is applied at an angle it may cause the cup to jump up and out of the core.

MAINTENANCE AND CARE OF EQUIPMENT

To insure consistent and accurate results all the analytical equipment should be checked before each series of determinations. All the apparatus should be functioning properly before a gas determination is attempted.

The sample volume and its rate of flow through the detector tube should be checked to conform to the manufacturer's specification. To adjust the MSA pumps, the black rubber band (in which the bottom part of the detector tube is usually placed) must be removed to adjust the flow control valve.

The Kitegawa pump needs to be taken apart periodically to be cleaned and relubricated.

The batteries and the calcium carbonate of the vapo- tester frequently need to be replaced. The vapo- tester should be recalibrated when needed using the Natural Gas Test Kit (Code 11-435) provided for this purpose.

The oxygen indicator electrolyte should be replaced after two months of use. It may be necessary to replace the carbon electrode and clean the zinc electrode when the electrolyte is changed. The dry cells need to be replaced periodically.

The highly reactive gases evolved from the burning and decomposing synthetics make frequent lubrication of all moving parts a necessity.

The chamber circulating fan will become fouled by soot if it is not continually cleaned and lubricated.

REGARDING THE MEASUREMENT OF THE
TEMPERATURE OF THE HEATING COIL

The temperature of the coil has been and is presently being measured by placing the thermojunction of a 28 gauge chromel-alumel thermocouple on the inner face of the middle turn of the heating element. This is in effect, placing the thermojunction within an A.C. induction field. Because the thermojunction sits within an induction field, an indeterminate error is incurred when measuring the coil temperature. This error may be as great as 100 Centigrade degrees. However, the error should be constant so that subsequent determinations performed in the same fashion should agree.

The door of the chamber must remain open when the temperature reading is being made. This subjects the coil to any drafts present in the room and causes temperature reading variations of up to 20 or more Centigrade degrees.

The 28 gauge thermocouple wire is not of sufficient diameter to stand the temperature of the coil and the tension placed on it for more than a few coil temperature determinations. After a few determinations the thermocouple wires usually become brittle and snap. For this reason it seems desirable to investigate substitute coil temperature measurement methods.

There is no way at present to accurately measure the temperature within an A.C. induction coil. The use of a bi-file would element has been suggested to reduce the effects of the induction coil. It has also been suggested that the temperature of the outer portion of the coil be determined instead, so that the error caused by induction can be avoided, and so that the chamber door can be closed to prevent the variation in temperature readings due to room drafts. This determination would be performed by using a thermocouple encased in an alumina protection tube of such diameter that the edge of the tube can be placed between two of the coils of the heating wire and will remain there unaided. The door of the chamber can then be closed while the temperature reading is taken. The potentiometer leads can exit from a hole in the top of the chamber.

It has also been suggested that if the coil temperature determinations continue to be performed in the same manner that they are now being performed, it may be best to substitute a 24 gauge platinum-rhodium thermocouple, with compensating lead wires for the chromel-alumel thermocouple.



REGARDING THE MEASUREMENT OF THE
TEMPERATURE OF THE HEATING COIL (Cont'd)

Platinum-Rhodium is less brittle than chromel-alumel, and the slightly wider wires should last longer under the heat they will be subjected to.

It is probably not advisable to substitute lower gauge (20-18) chromel-alumel wires, as they will act as heat sinks, giving inaccurate coil temperature measurements.

It seems desirable to modify the method of coil temperature measurement. The above considerations should be taken into account.

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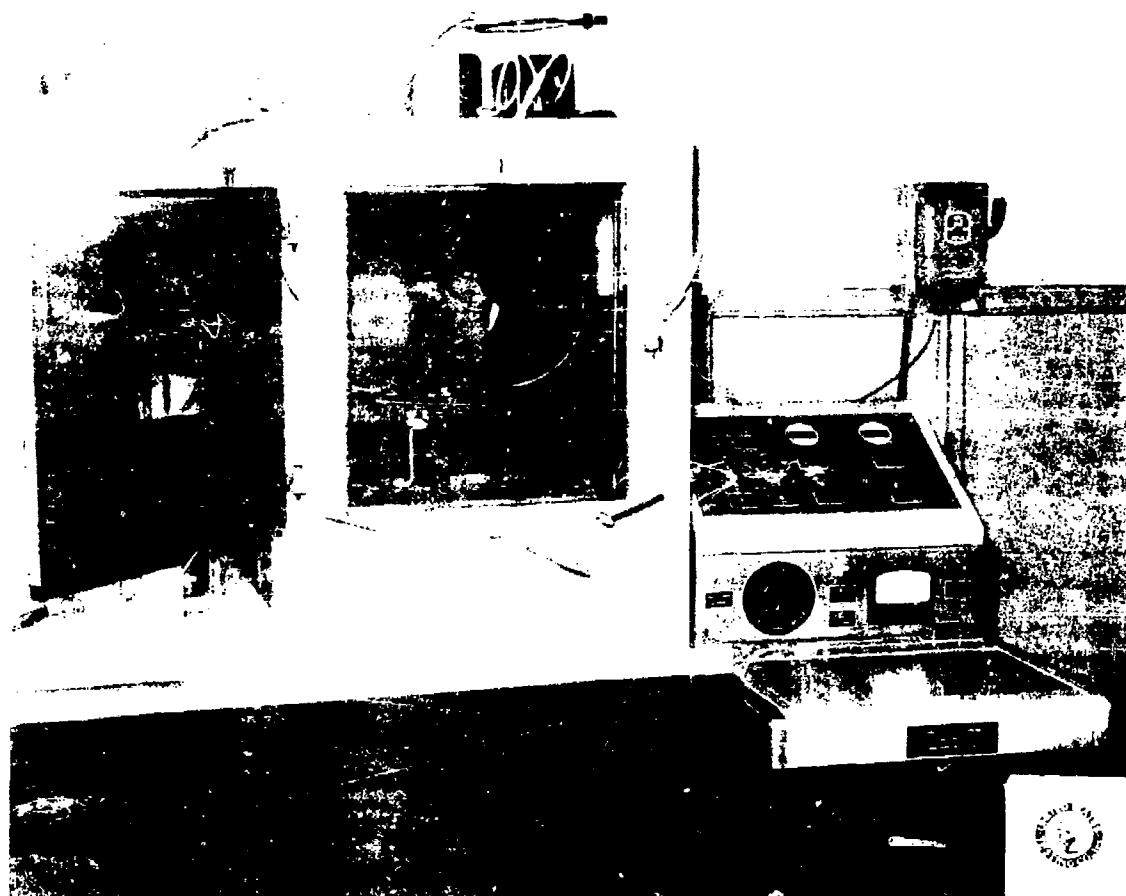
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CREDITS

The American Conference of Governmental Industrial Hygienist should be credited for pp. 12-29 of the appendix. These pages appear in their book "Air Sampling Instruments" (1960). This manual can be obtained for \$7.50 by writing to the American Conference of Governmental Industrial Hygienists, 1014 Broadway, Cincinnati 2, Ohio.



UNITED STATES TESTING COMPANY, INC.

TEST APPARATUS

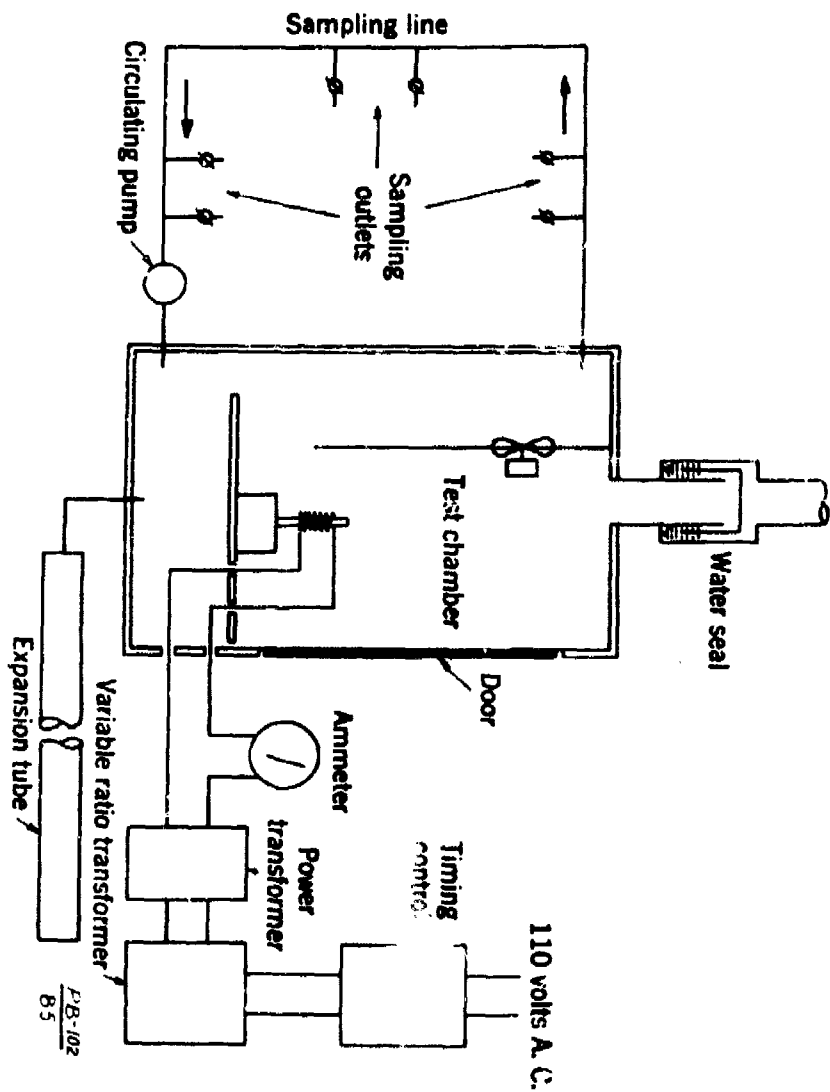
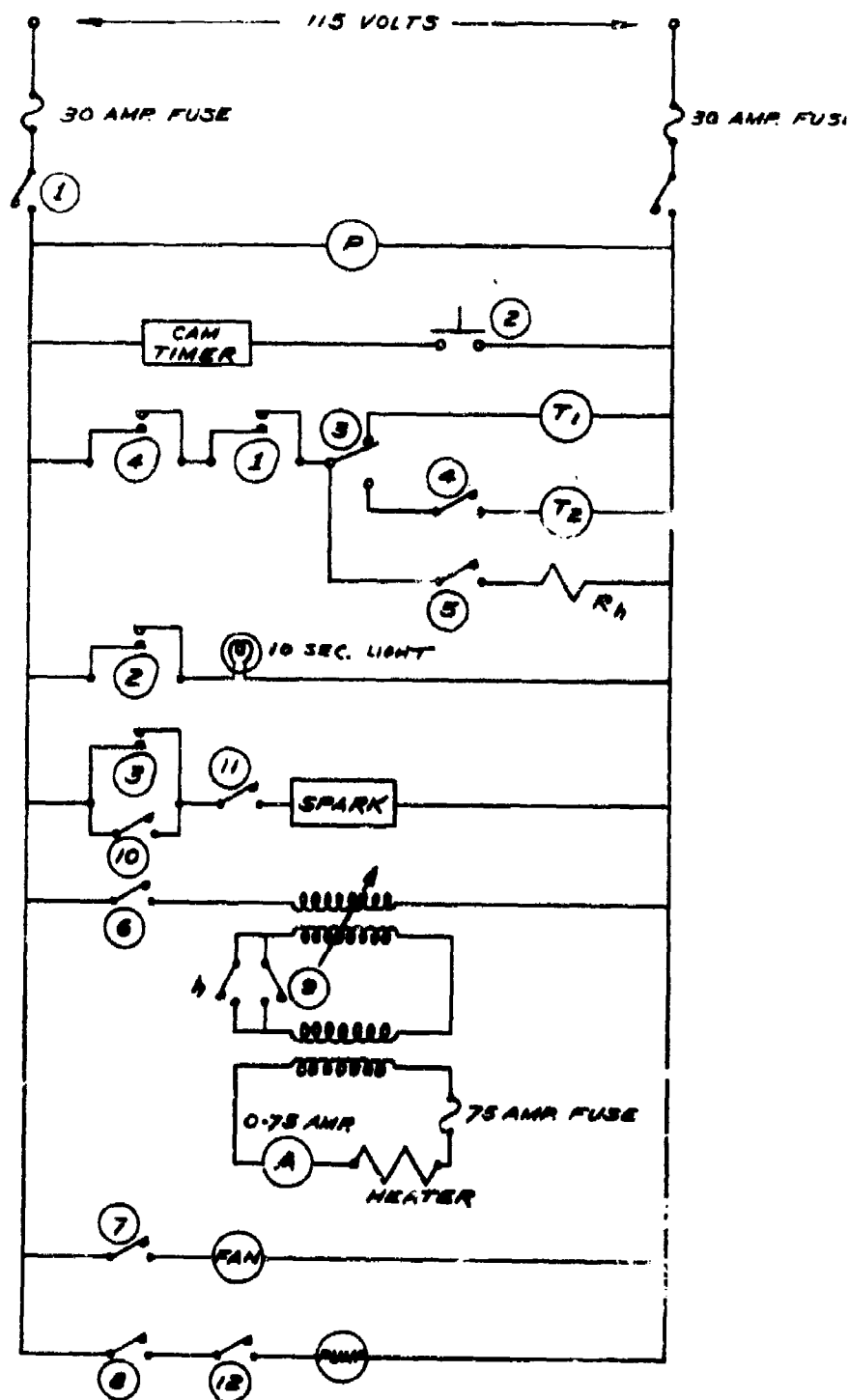


Figure 2. - Test apparatus; diagrammatic sketch showing accessory apparatus and gas-sampling arrangement.



TOXICITY TEST APPARATUS
DEC. 1960

FIGURE 1

SWITCH IDENTIFICATION

NO.

- ① MAIN ON-OFF DPST
- ② TIMER START - MOMENTARY SWITCH
- ③ IGNITION TIME DPDT (USING ONLY 1 POLE)
- ④ BURNING TIME OFF SPST
- ⑤ HEATER SPST
- ⑥ HEATER TRANSFORMER SPST
- ⑦ CIRCULATION FAN SPST
- ⑧ PUMP (AT CONSOLE) SPST
- ⑨ MANUAL HEATER SPST
- ⑩ MANUAL SPARK SPST
- ⑪ SPARK INTERRUPTION SPST
- ⑫ PUMP (AT TEST BOX) SPST

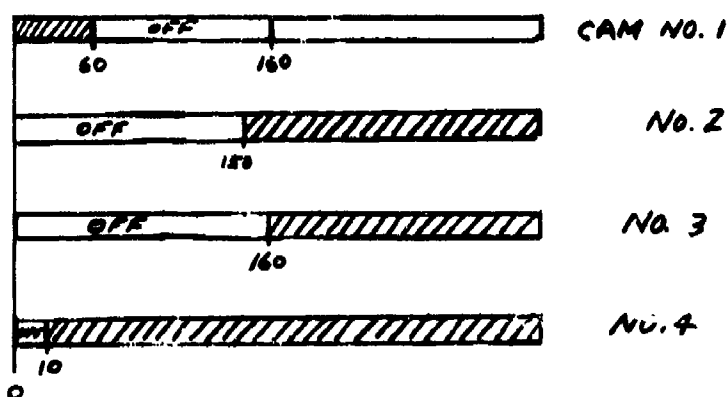


FIGURE 1 (CON'D) -- Electrical and Timing System

TOXICITY TEST APPARATUS
DEC. 1960



INTERIOR VIEW OF TEST CHAMBER

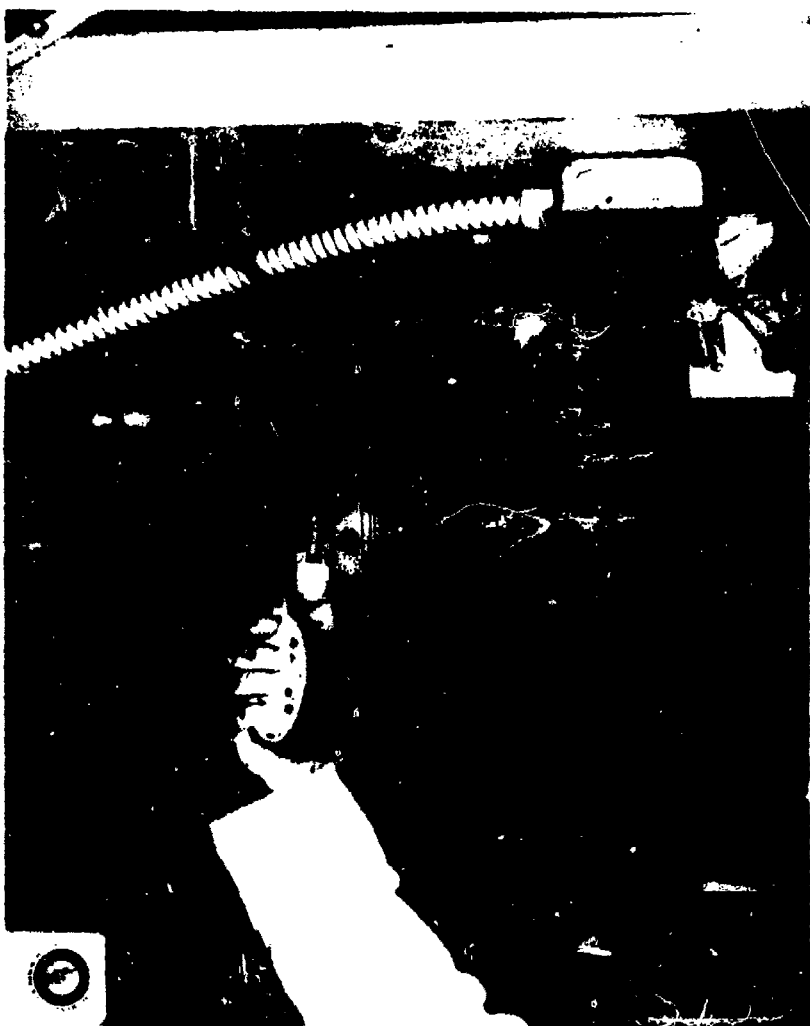
Main drying tube packed with fine glass wool, to prevent the entrance of soot particles into the circulating manifold. Fluorescein test strip is attached to thermometer at middle-right of photo. Also pictured is chamber circulating fan, wooden baffle, retractable sparking apparatus, heating coil set in copper legs, and specimen support set on raised platform.



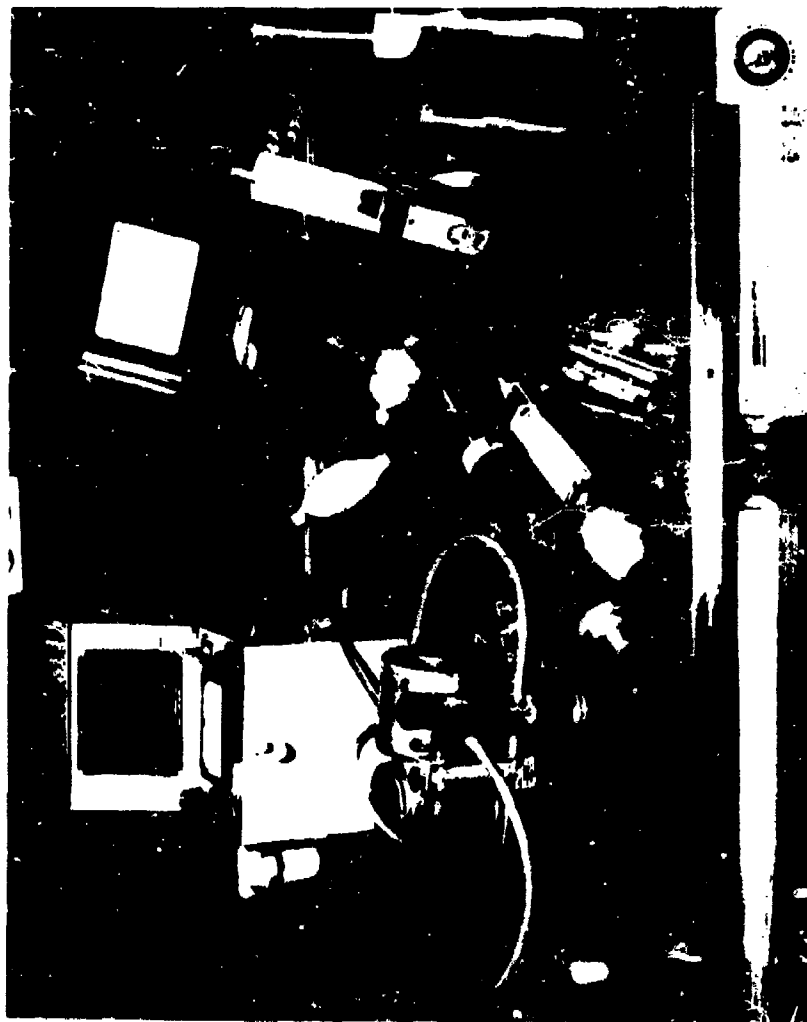
PLASTIC HAS IGNITED



PLASTIC BURNING IN TEST CHAMBER



Samples of the atmosphere produced being drawn off through a returning manifold into gas analyzing equipment. A manifold pump (not shown) sits on top of the test chamber and flows the gas in the chamber through the sample manifold. The gas can be sampled through orlers in the manifold. The unsampled gas is returned to the chamber by the manifold which continues past the orlers and re-enters the chamber (lower left).



GAS ANALYZING EQUIPMENT

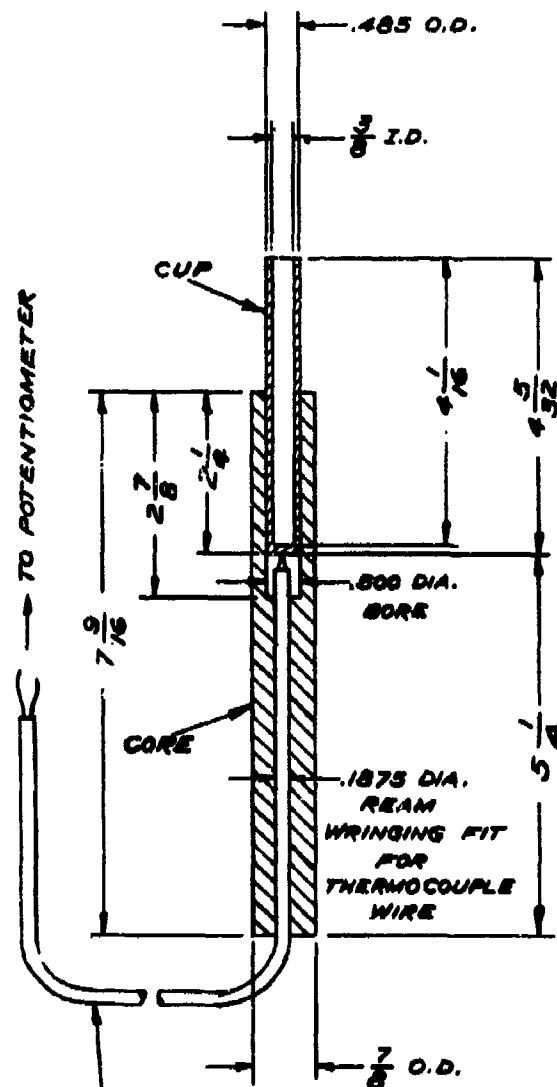
Rear, left to right - DAVIS VAPOTESTER (for Natural Gas), MSA O₂ Meter, Front Row, Left to Right - Pump, Retestor, Vial and Impinger for HCl determination; Kitigawa Pump; MSA HCN Pump; acid detector tubes; Bacharach CO apparatus; Draeger Pump.



SELF-IGNITION TEMPERATURE DETERMINATION APPARATUS

At the left of the photo is a Fisher Model 20-2P4 Combustion Furnace. In its refractory is a stainless steel cone with a removable stainless steel cup. Self-ignition temperature determinations are made with both reflectors closed about the cone. Pressurized air is blown directly into the cup - the tip of the nozzle is about an 1/8 inch from the top of the cup and the air is blown straight down, perpendicular to the base of the cup. At the right of the photo is a Leeds and Northrup air thermometer with a reference function correction slide wire that will correct for room ambient temperature. No ice bath reference junction need be used with this instrument.

DIMENSIONS OF CORE AND CUP OF SELF-IGNITION
TEMPERATURE DETERMINATION APPARATUS



The core and cup are both made of a stainless steel with a melting point in excess of 1000°C. The base of the cup sits on the thermocouple junction as depicted in the diagram.

The core and cup are placed within a Fisher Micro-Combustion Furnace (110 V, 50-60 cycles A.C.) (Model 20-286 or equivalent). (See appendix p 10).

The rate of temperature rise of the cup is controlled by a variable powerstat in the furnace. Nichrome heating coils (Fisher Replacement Part #20-287) are the heating elements.

The thermocouple wires that are used are insulated by an inorganic salt and are sheathed in stainless steel. The thermocouple wires shown in the picture on appendix p 10 were formerly used and found to be unsuitable. The insulation on these wires frequently became abraded causing the wires to come in contact with the core. This was remedied by substituting thermocouple wire insulated and sheathed in stainless steel.

THERMOCOUPLE WIRE TYPE C6304
3/16 O.D. - CT "CERAMO" CHROMEL-ALUMEL ISA-K
THERMO ELECTRIC CO.
SADDLE BROOK, N.J.

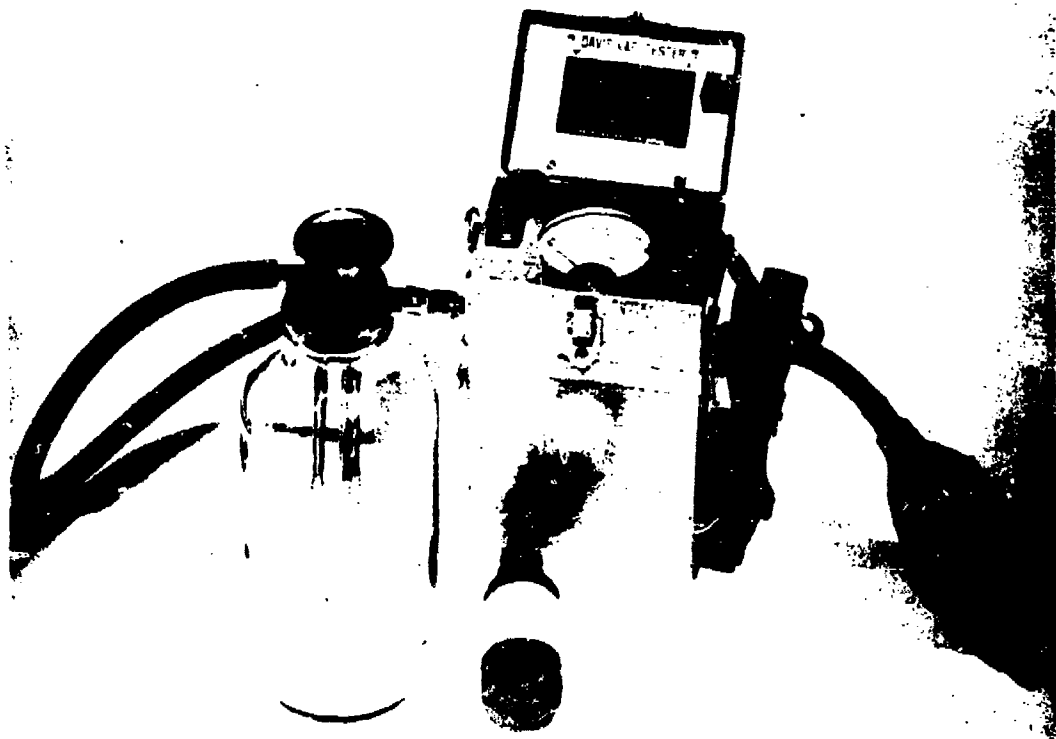


Figure 1 - Davis Vaportester, Model M-1, Type A, with Styrene Test Bottle Attached for Calibration Check.

Uses

Two types of this instrument are available. Type A is designed to read zero gas or vapor to the lower explosive limit (L.E.L.) It can be used for miscellaneous combustible gases and vapors as well as for detecting hazardous gas or vapor-air atmospheres. Type A is not for use where vapors of leaded gasoline may be encountered. Type L is similar to Type A except that the former can be used in the presence of leaded gasoline vapors.

These instruments are used in general industrial hygiene surveys and safety inspections to determine the presence or absence of combustible gas or vapor in confined spaces, storage areas, work spaces, etc.

The Model M-6 Vaportester is similar to Model M-1 described on this page except that in addition to the 1:1 range, a 10:1 range switch is provided which increases the sensitivity. The meter scale readings, when interpolated with conversion curves of a particular gas or vapor, will give results in parts per million.

In addition to portable instruments such as the M-1 and M-6 Vaportesters, the Davis Emergency Equipment Company, Inc. also manufactures combustible gas alarm systems which operate on a continuous basis, utilizing a basic circuit similar to the portable units, with relay systems for the sounding of signals and alarms. As a few examples, such alarm systems may be used in conjunction with: solvent recovery systems, solvent evaporating ovens, combustible gas storage areas, storage vaults, rooms and tunnels, gas generating plants, refineries, and engine test cells.

The cost of such installations varies with size. Specific prices are available on request.

Operating Principle

The measurement of combustible gases and vapors by the use of portable and continuous indicators is based on the principle of catalytic combustion of these vapors.

A mixture of gases, such as propane and air may be either flammable or not, according to the concentration of propane in air. The explosive range includes all concentrations of a mixture of flammable vapor or gas in air (usually expressed in percent by volume) in which a flash will occur

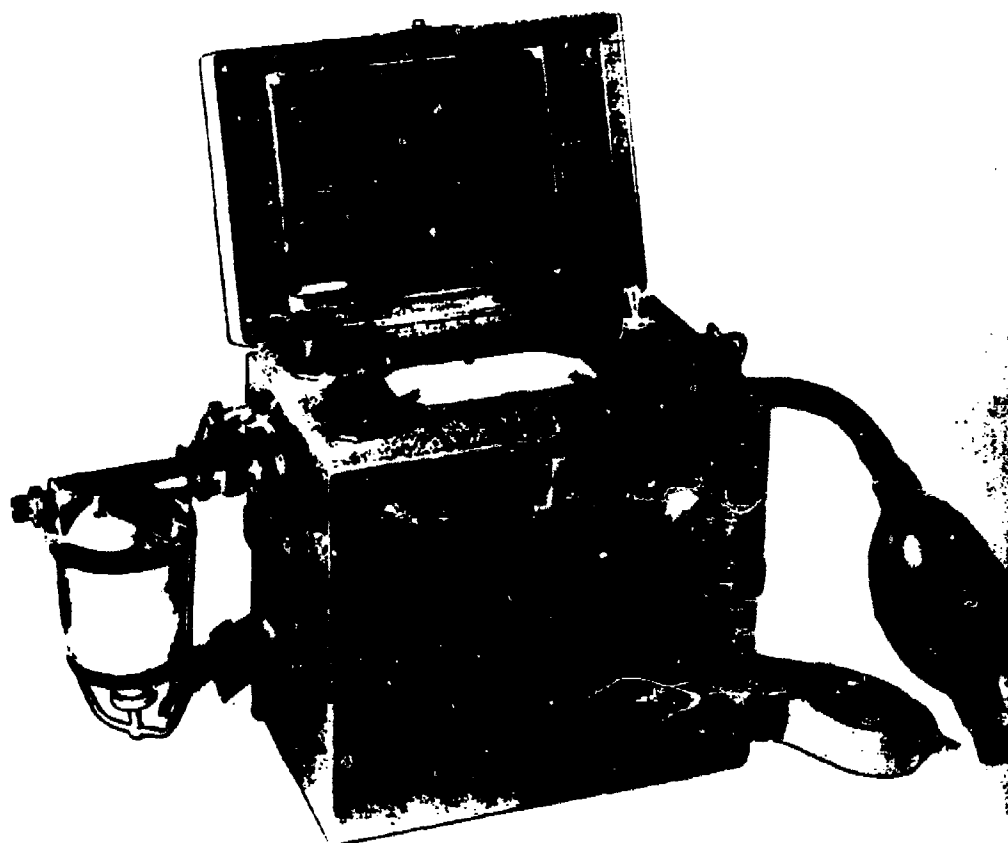


Figure 2 - Davis Vaportester, Model M-6.

or a flame will travel if the mixture is ignited. The lowest percentage at which this occurs is the L.E.L., and the highest percentage is the upper explosive limit (U.E.L.) If such a mixture is confined and ignited, an explosion results. The L.E.L. of propane in air is 2.3 percent and the U.E.L. is 7.3 percent. Mixtures above 7.3 percent are too rich to support combustion, and those less than 2.3 percent are too lean. Since air is the diluent and is readily obtainable, all concentrations above 2.3 percent are dangerous; therefore, the portable indicator is usually calibrated from 0 to the lower explosive limit of some specific gas or vapor. The L.E.L. is considered 100 percent and points below this level are considered as percent of the L.E.L.

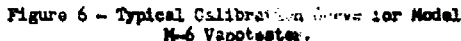
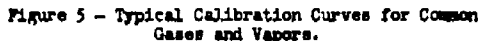
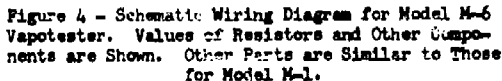
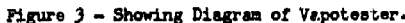
Many common flammable liquids and gases have very wide explosive range. That of carbon disulfide is 1 percent to 50 percent, and hydrogen 4.1 percent to 74.2 percent, which shows that only very lean or unusually rich mixtures of these materials in air are free from an explosion hazard.

When a combustible gas or vapor is passed over a catalytic filament, it burns. The filament is usually a platinum wire, 0.003 to 0.010 inch in diameter, heated to a red glow.

The temperature of the filament is extremely important in the correct analysis of the gas or vapor. It is absolutely necessary that the filament be catalytic to cause this combustion of gases or vapors.

Since the concentration of combustibles may be above the L.E.L., it is necessary that the filament chamber be protected by adequate flashback arresters that will prevent the propagation of flame to the point of origin of the sample. These flame arresters operate on the principle of the flame safety lamp.

Two identical filaments are used in the bridge circuit. One of these filaments, known as the "reference filament," is sealed in air in a separate well of the same chamber as the "active" or exposed filament. Two fixed resistors are used as the other legs of the bridge, connected to-



The basic circuit for Model M-1 is shown in Figure 3 and for Model M-6 in Figure 4.

Weight - 6 1/2 pounds; length - 3 1/4 inches; width - 4 1/2 inches; height - 7 1/2 inches. The components are housed in a welded steel case finished in gray hammerstone. Power is supplied by 6 flashlight type 'D' cells contained in the instrument. Battery life is approximately 4 hours, continuous duty. An aspirator bulb furnishes the suction necessary for

sampling.

Performance Data

Model M-1: Figure 5 shows the range, in proportion of L.E.L., for various gases and vapors for which the instrument is used (1:1 range). Calibration curves are available for a number of other gases and solvents not shown. The user can calibrate the instrument for any combustible gas or vapor. The Davis Vapotesters have an accuracy of ± 10 percent of the scale reading.

Model M-6: Figure 6 shows a typical calibration curve of meter readings of the M-6 Vapotester versus concentration of some of the more common solvents.

This instrument can be used to determine the concentration of any combustible gas or vapor if a calibration curve is prepared for the particular substance under test. However, this instrument is not to be used as a precise measuring instrument but rather as a guide and helpful tool in approximating certain vapor-air readings in the parts per million range.

Source

Davis Instruments, Division of Davis Emergency Equipment Company, Inc., 47 Hallett Street, Newark 4, N. J. Prices available from manufacturer upon request.

Operating Instructions

Model M-1: In Gas Free Air

1. Throw right hand (On and Off) switch to "ON."
2. Throw left hand (Read and Volt) switch to "VOLT."
3. Adjust needle to green arrow with "VOLT ADJ" knob.
4. Throw left hand (Read and Volt) switch to "Read."
5. Squeeze bulb several times.
6. Lift "ZERO ADJ" knob and adjust needle to zero.
7. Proceed with tests.

Model M-6: In Gas Free Air

1. Throw Range Switch to "VOLT" position. (With the switch in this position, the meter is transformed into a voltmeter.)
2. Throw "OFF-ON" Switch to "ON." (This closes the switch and allows current to flow from the batteries through the bridge circuit.)
3. Set meter pointer to green arrow with "VOLT ADJ" knob. (This insures that the correct voltage is being supplied to the bridge circuit, to make certain of correct filament temperature. If the meter pointer cannot be brought to the green arrow, the batteries should be replaced.)
4. Throw range switch to 1 - 1 position. (In this position the indicating meter is across the bridge in the measuring position.)
5. Squeeze bulb several times (to insure complete purging of the analyzing cell from any residue of gas or vapors which might be present.)
6. Lift "ZERO ADJ" knob and adjust pointer to zero. (This balances the bridge circuit to zero in preparation to taking actual gas or vapor concentration readings.) This adjustment is most easily made by moving the knobs so that the needle goes beyond zero and then back to zero on the scale. The knob controls dual resistors—a coarse and a fine adjustment.
7. Proceed with tests. Insert sampling line or probe into area to be tested, and by means of aspirator bulb, draw sample into analyzer. Several depressions of the aspirator bulb will be necessary to insure correct reading, the exact number depending upon the length of sampling lines used. In general, two to three depressions of the bulb are necessary for each foot of sampling hose. If meter pointer does not rise above 0.1 on scale, check voltage and adjust if necessary, then throw range switch to 10 - 1 position and repeat instructions 5, 6, and 7. CAUTION: Always take first gas reading with range switch in 1 - 1 position. Always use drying chamber when purging and sampling on 10 - 1 scale. Periodically check voltage and adjust when necessary to compensate for the voltage drop of the batteries.

For accurate interpretation of readings on specific gases or vapors consult conversion curves for that gas or vapor.

Sample should always be drawn through indicator—never forced through under pressure.

It is desirable to purge the instrument after a test if a sample from another location is to be taken immediately. This will also check zero adjustment.

It is always well to purge the indicator even if another sample is not to be taken right away, as this removes any possible corrosive gases from the combustion chamber.

For additional operating instructions, interpretations of readings, and precautions to be observed, see the operation instruction manual supplied with each instrument.

Calibration Instructions

The Model M-1, Type A Vapotester is calibrated on methane because with this calibration most of the common gases and vapors fall to the left or safe side of the methane curve, that is, mixtures of other gases will read higher than their actual concentration. For calibration of the Vapotesters

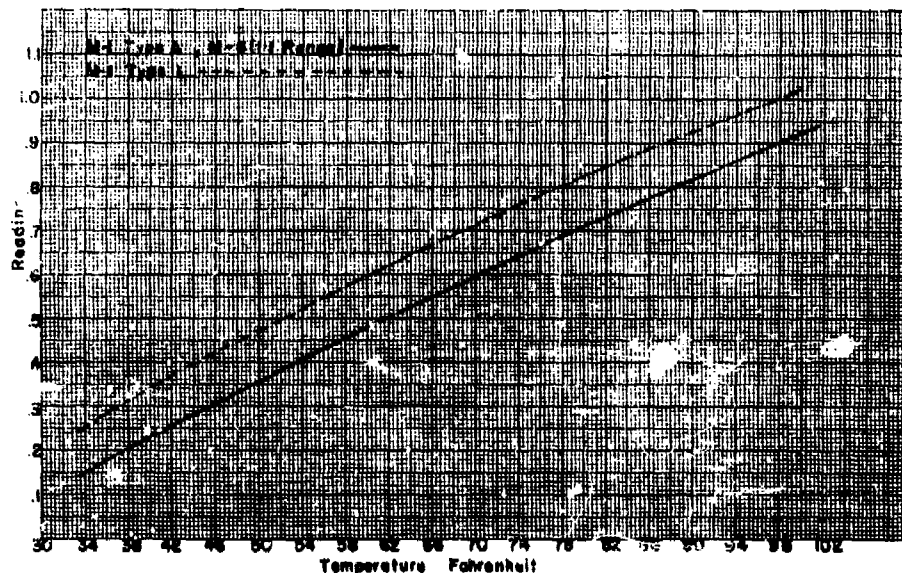


Figure 7 -- Typical Styrene Test Curve for Model M-1, Types A & L and Model M-6 Vapometer. (See Calibration Instructions.)

For other gases or vapors the procedures used can be found in the instrument manual.

A styrene test bottle was developed to permit field checks on calibration and operation of Models M-1 and M-6. The apparatus used is shown in Figure 1 and the procedure is as follows.

1. Pour enough of the styrene from the 2 ounce stock bottle so that by revolving the test bottle the sides are completely wet with the liquid, and a slight amount of excess styrene is present at the bottom of the bottle.
2. Adjust Vapometers as per instructions on cover of the instrument.
3. Make sure that the instrument is at the same temperature or higher than the temperature of the test bottle, to insure that the vapors do not condense in the tube line.
4. Attach hose fitting of test bottle to Vapometers, and make sure that connection is tight (See Figure 1).
5. Aspirate bulb on instrument until maximum deflection is obtained--(at least 15 squeezes of bulb are required to establish equilibrium).
6. Note temperature on test bottle thermometer, and by means of proper curve, determine correct reading of instrument for that temperature. Check expected reading with actual reading. An accuracy of within ± 10 percent is to be expected (See Figure 1).

Calibration on Davis Vapometers is determined by the filament. If the instrument does not track the curve by ± 10 percent, the filament should be replaced, and if this fails to correct the condition refer to instruction book, or return instrument to the Newark office for repair.

It is advisable to store test bottle and styrene stock bottle in a dark location, out of the light. This will prevent decomposition of the styrene, which can be detected when the color of the styrene changes from light straw yellow to brown. In this case the bottle should be cleared out and recharged with fresh styrene. It is recommended that the styrene be kept in a brown bottle.

As long as liquid styrene is present in the bottle, it can be used for a test. Thus, one charge of styrene will last indefinitely, if not exposed to light.

Maintenance Instructions

Model M-1:

1. If needle cannot be adjusted to green arrow with "ON-OFF" switch in "ON" position and "VOLT-READ" switch in volt position—a) Bad batteries; b) On-Off switch open; c) Volt-read switch open; d) Variable resistor mounted under center panel may be open; e) Open wire or connection; f) Volt Adj. Potentiometer may be open.
2. If instrument works on volt position of "Volt-Read" switch, but needle cannot be adjusted to zero with "Volt-Read" switch in "Read" position—a) Filaments bad; b) Zero adj. rheostat open; c) Filament jack not making proper contact; d) Open 20 ohm resistors (tubular 1/2 watt resistors); e) Open wire connection.
3. If meter needle goes to right end of scale and remains there—a) Active filament is burned out.
4. If meter needle goes below zero and remains there—a) The reference filament is burned out.
5. Instrument working but on aspirating gas, no change noted—a) Tubing to and from chamber clogged; b) Inlet cotton filter clogged and should be changed; c) Flashback arresters clogged; d) Aspirator bulb defective; e) Filament (analyzing) inoperative.
6. Instrument fluctuates and works poorly on aspirating in gas—a) Leak in hose or connections; b) Leak in instrument; c) Filaments bad; d) Loose connection.

Model M-6:

1. Instrument fails to work—a) Batteries low; b) "ON-OFF" Switch open; c) Range Switch open; d) Open wire or connection; e) "VOLT ADJ" Potentiometer may be open.
2. Instrument works on "VOLT" but not in 10 - 1 or 1 - 1 position. (No zero adjustment, or needle goes to extreme left or right of meter.)—a) Filaments open or contaminated; b) Zero Adjust Rheostat open; c) Filament jack not making proper contact; d) Open wire or connection.
3. Instrument on "VOLT" cannot reach green arrow when "VOLT ADJ" knob is turned to the extreme right—a) Batteries low; b) Loose battery connection.
4. Instrument working but on aspirating gas, no change noted—a) Lines or chamber clogged; b) Inlet or arrester clogged; c) Aspirator bulb defective.
5. Instrument fluctuates and works poorly on aspirating in gas—a) Leak in hose or connections; b) Leak in instrument; c) Filaments contaminated; d) Calibration changed.
6. On aspirating with bulb, instrument reading goes up and stays up—a) Poisoned chamber or lines.

Detailed maintenance instructions appear in the operation instruction manual furnished with each instrument.

HYDROCYANIC ACID GAS DETECTOR

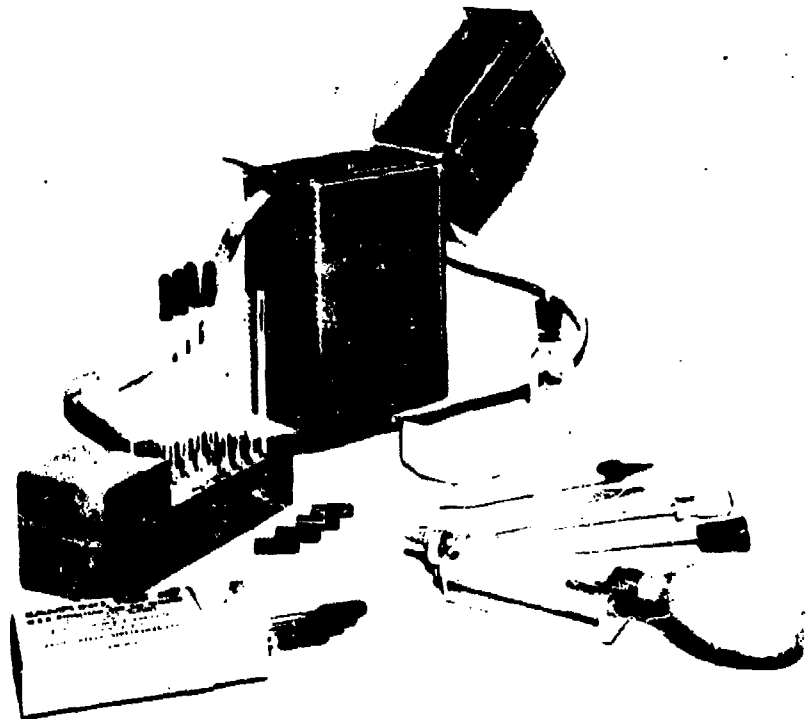


Figure 1 - M.S.A. Hydrocyanic Acid Gas Detector, Complete with Case, 12 Sample Tubes and Refill Supplies.

Uses

The M.S.A. Hydrocyanic Acid Gas Detector, shown in Figure 1, is a self-contained, pocket laboratory for the rapid detection of HCN in working areas, such as plastics manufacture, and where HCN fumigants are used.

Operating Principle

The M.S.A. Hydrocyanic Acid Gas Detector consists of an aspirator bulb, moveable scale and detector tubes which are filled before sampling with a mixture of copper sulphate water, glycerine gel and o-tolidine sand. The sample is aspirated through the tube by means of the aspirator bulb and the rate of flow is controlled by a specially designed metering orifice. The HCN reacts with the chemicals in the detector tube, producing a stain which is directly proportional to the concentration of HCN present in the sample. The length of stain is measured by the moveable scale which is calibrated in ppm by volume.

Physical Description

The detector kit is contained in a brown leather case equipped with a shoulder strap. Dimensions are 3 by 5 by 9 inches high and it weighs 2 3/4 pounds.

In addition to the detector, the kit contains a tube rack, mixing bottle, mandrel, color scale, 12 empty glass tubes with rubber caps, two vials of the chemical reagent and glass cloth swatches.

Performance Data

This instrument has a range of 0 to 50 ppm HCN.

Twelve tubes can be filled at one time and stored one week at temperatures of 90°F, two to three weeks at 70°F, and two months at 40°F without loss of sensitivity.

A three inch probe needle is available for testing the interior of mattresses and furniture upholstery. Various lengths of sampling hose are also available.

Source

Mine Safety Appliances Company, 201 N. Praddock Ave., Pittsburgh 8, Penn. Price available

from the manufacturer upon request.

Operating Instructions

1. After removal of accessories, the partition block may be removed to provide a convenient working block.
2. Remove rubber caps from detector tubes; place tubes in rack provided.
3. Break scored end of each tube of chemical provided by inserting in tube breaker hole at end of chart barrel. Broken tips fall into barrel and may be removed periodically by unscrewing cap. Place contents of both tubes in mixing bottle, closing with stopper provided. Mix thoroughly for at least five minutes. (Caution: Avoid spilling chemical.)
4. To fill detector tubes with chemical mixture, remove glass plug from stopper, insert open end of tube snugly into hole in stopper, tilt bottle and pour chemical to within 1 1/4 to 2 inches of top of tube.
5. Insert a glass tape switch as follows: Place switch on end grain section of working block; pick up with ramrod provided and insert (or hold tube in horizontal position and slide switch into tube), tamping tightly against chemical. Do not touch switches with hands. Close tube with rubber cap until ready for use. (Mixing bottle should always be kept closed by means of glass plug, except when actually filling the detector tube.) After detector tubes are filled, dispose of any excess chemical. Replace prepared tubes in original package until ready for sampling. Do not store prepared tubes in temperatures above 100°F.
6. When ready for use, break tip from detector tube and insert through guide hole at top of frame and then into rubber inlet bushing at head of aspirator bulb. Place spring actuated retaining head over large end of tube and press lightly to make sure a snug fit is obtained.
7. Eject all air from aspirator bulb by squeezing bulb suddenly and forcibly. Release, fluid loosely and allow bulb to fill completely by itself. Squeeze aspirator bulb three times to obtain complete chemical reaction in detector tube.
8. Slide the chart up or down barrel so that zero (0) marker of scale is in line with beginning of stain. Hold scale in position and check reading at other end of stain.
9. To sample from remote location use extension tube on detector, screw coupling line connecting insert provided into retaining head and attach rubber tubing (1/8-inch I.D.) of proper length. Coupling lines are available as an auxiliary accessory. Order Cat. No. DM-73067 for 10 feet, DM-73068 for 25 feet and DM-73069 for 50 feet. Break tip from an empty detector tube and place tube in detector. Break tip from filled detector tube and insert tip end of rubber tubing to take sample.
10. Needles for sampling interior atmospheres of mattresses, pillows, closed cartons, upholstery, etc., are available as an auxiliary accessory. Order Cat. No. DM-10492. To use sampling needle on detector, screw sampling line connecting insert provided into retaining head and attached rubber tubing supplied with sampling needle.

Calibration Instructions

The detector can be checked against known concentration of HCN in air.

Maintenance Instructions

1. It is important that both the flow control valve and check valve of aspirator bulb be protected from dust and liquids.
2. Thirty seconds (± 3 seconds) are required to inflate aspirator bulb when all air is exhausted from it with no tube in place. Adjust flow control valve screw with screwdriver to obtain this flow rate. If proper flow cannot be obtained by adjustment, remove the control valve screw and clean orifice with a fine wire (0.042 inch). Replace screw and adjust to obtain correct flow.
3. If cleaning flow control valve fails to allow for the proper adjustment, check for leakage at the check valve orifice under rubber band by inserting a used tube. Holding finger over open end of tube, deflate aspirator bulb. If bulb fills in less than ten minutes remove rubber band and clean outer surface of check valve orifice. Replace with new rubber band if cleaning fails to make valve function properly.

DRAGER GAS DETECTOR

Uses

The Drager Gas Detector is a portable gas analyzer for measuring trace concentrations of various gases and vapors (See Table I). A number of detector tubes are available for different contaminants; some of these are intended also for technical gas analysis. The apparatus can be supplemented by additional parts making it suitable for the analysis of respiratory gases.

Operating Principles

The Drager Gas Detector consists of a bellows type pump and the detector tubes suitable for the gas or vapor to be measured. The Gas Detector Pump is a single acting bellows which is operated by one hand only (See Figure 1). Figure 2 is a drawing of the bellows type pump.

The detector tubes are filled with carefully balanced quantities of color reagents the indication of which is practically specific for the gas to be measured. The color reagents are impregnated on carrying agents. Figure 3 is an enlarged view of the carbon monoxide detector tube.

To perform the test, the air to be examined is passed through the detector tube by means of the bellows. While this is being done, the number of strokes is counted and the discoloration of the detector tube is observed. The discoloration and the number of strokes gives a direct measure of the gas or vapor concentration.

Physical Description

The complete apparatus, shown in Figure 4, consists of: the Gas Detector Pump, Type 31, with leather carrying bag; a supply of detector tubes in a leather storage case; the transit case with an additional supply of detector tubes; special spanner wrench; and spare parts.

The complete kit is contained in a metal case 5 by 6 by 6 3/4 inches and weighs 4 pounds. Weight of the bellows type pump is 12 ounces.

Performance Data

The measuring range of the detector tubes includes the range of toxic gas concentrations important in the field of industrial hygiene. The toxicity data are based on published standards in this field, particularly threshold limit values issued by the ACGIH. In detector tubes used for technical gas analyses, the measuring range is adjusted according to the requirements of the analyses.

Specificity: The detector tube for a particular gas or vapor is essentially specific for that gas or vapor. This is achieved not only by the use of specific and stable reagents, but also by the use of a pre-cleaning layer in most types of tubes, which is placed in front of the actual reactive layer. This pre-cleaning layer selectively absorbs any interfering components that may be contained in the gas or vapor sample, and thus increases the specificity.

Effects of Temperature: The calibration data of the various detector tubes in general are valid for temperatures between 32.0° and 104.0°F (0 - 40°C). Changes in the humidity of the air do not affect the result of the measurement.

Error: The tube reading deviates from the true value by ± 25% at the most. In many detector tubes this error is considerably smaller.

The discoloration of the detector tubes will last for some time. When detector tubes are to be kept as evidence, it is recommended that the open ends be sealed with wax.

Source

Manufactured by Dragerwerk, Heinrich & Berth. Drager, Lubeck, West Germany; distributed by: Safety Supply Company, Toronto, Ontario, Canada. Prices and literature are available from the manufacturer and distributor upon request.



Figure 1 - Drager Gas Detector, Type 19/31.

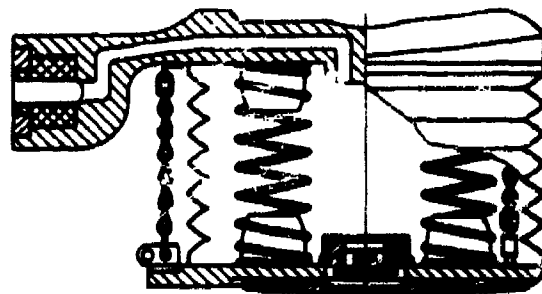


Figure 2 - Drawing of the Bellows Type Pump.

Table I

Gas Detector Tubes		Measuring Range			
for	Index*	mg/liter	mg/cu. meter	P.P.M.	% by vol.
Alcohol	0.2	0.2-40		150-30000	
Ammonia	0.01	0.01-2		13-2600	
Arsine	0.05/a		0.05-3	0.02-1	
Benzene	0.05	0.05-1.4		15-420	.04
Carbon dioxide	0.1/a				1-5
Carbon dioxide	1%				1-20
Carbon disulphide	0.04	0.04-1		13-330	
Carbon disulphide	1	1-10		320-3200	
Carbon monoxide	0.001%				0.001-0.3
Carbon monoxide	0.3%				0.3-4
Chlorine	1/a		1-200	0.33-70	
Formaldehyde	0.002		2-50	2-40	
Hydrocarbons	0.1%				0.1-1
Hydrocarbons	2	2-25		540-6750	
Hydrocyanic acid	0.002		2-150	2-145	
Hydrogen sulphide	0.01	0.01-1.2		7-840	
Mercury Vapor	0.0001		0.1-20		
Nitrous gases	0.005		5-500	2.5-250	
Phosgene	1/a		1-70	0.15-17.5	
Sulphur dioxide	0.01	0.01-0.1		0.15%	
Toluol	0.25	0.25-10		70-2700	
Trichlorethylene	0.1	0.1-2.0		18-370	
Water vapor	0.1	0.1-80			

* This index denotes the type of detector tube.

Operating Instructions

1. The tips of the detector tube are broken off by inserting them in the (red) eye of the chain on the pump.
2. Insert the detector tube into the head of the pump to fit gas-tight, so that the arrow imprinted on the tube points toward the pump.
3. Squeeze the bellows as far as it will go and release. The intake action takes place automatically and is completed when the stroke limiter chain is fully expanded.
4. Perform this operation as often as stated in the instructions for the particular detector tube in use.
5. Evaluate the measurement according to the data contained in the operating instructions.

Readings: The concentration is read either directly from the scale imprinted on the tube, or obtained from a table using the number of strokes required to obtain the discoloration.

A light-colored writing surface is imprinted on that end of the tube pointing toward the air inlet.

Calibration Instructions

The calibration values of the detector tubes can be checked by known gas or vapor concentrations. The desired concentration of the calibration gas or vapor mixture can be obtained by injecting the pure gas or vapor in measured quantities into a metered air flow.

Maintenance Instructions

The gas detector pump is of simple design and comprises a single valve only. By virtue of this, it should not require any maintenance. It is, however, practicable to test the pump for leakage before commencing serial measurements. The leak test is performed by inserting a closed detector tube into the intake at the head of the pump and compressing the bellows as far as it will go. The pump is sufficiently tight if the bellows is not completely expanded after 10 minutes, i.e., the stroke limiter chain is not yet fully expanded. When the pump is sufficiently tight, it also produces the required air flow. A perfectly functioning pump displaces an air volume of 100 ± 5 cubic centimeters per stroke.

If this test shows any leakage, in most cases this can be remedied by cleaning or replacing the valve.

A simple check on the proper performance of the test can be made by timing the intake stroke. The period of time required by the bellows to move from complete compression to complete expansion of the stroke limiter chain is dependent solely on the flow resistance of the detector tube employed. The value of this flow resistance is stated for each type of detector tube in the instruction manual as the "opening time" in seconds. If the time deviates appreciably from the "opening time" the operator should be aware that either the pump does not function correctly or the tips of the detector tube are not properly opened.

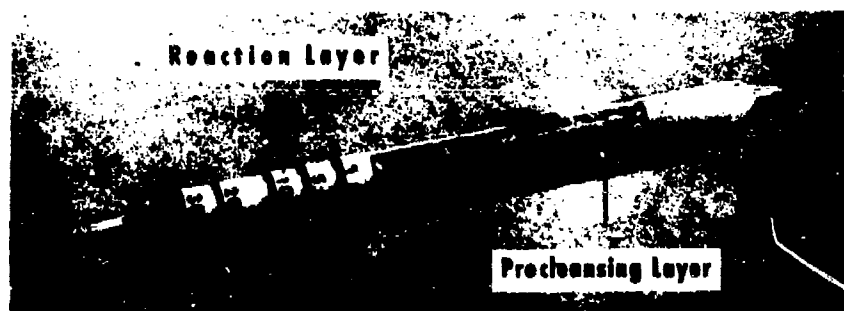


Figure 3 - Enlarged View of Drager Detector Tube for Carbon Monoxide (0.001%) Showing Pre-cleaning and Reaction Layers.

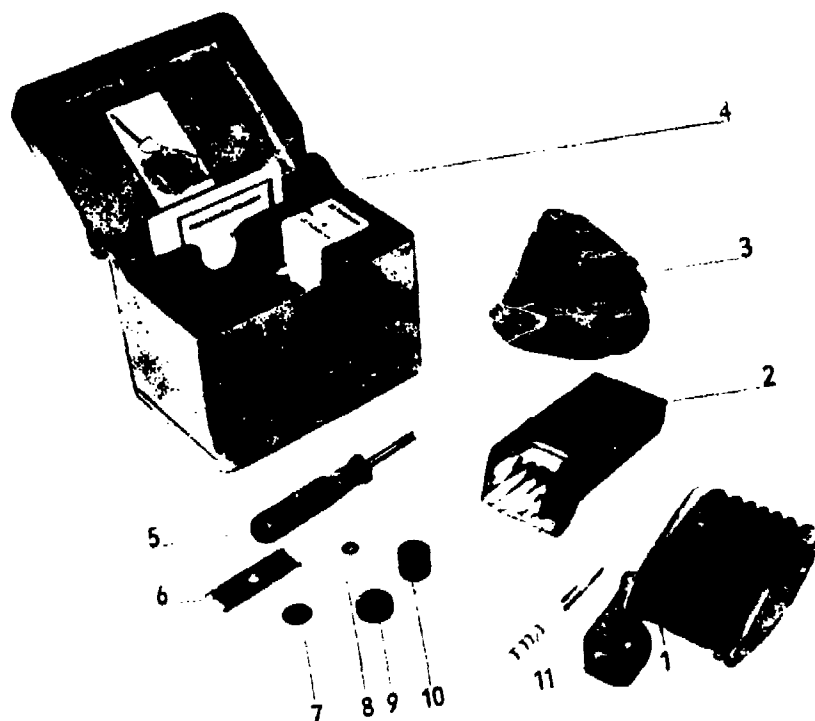


Figure 4 - Components of the Drager Gas Detector Kit. Numerals Refer to Parts Listed Below.

- | | |
|----------------------------|------------------------|
| 1 - Bellows pump, model 31 | 7 - Valve disc |
| 2 - Detector tube case | 8 - Screen |
| 3 - Case for pump | 9 - Valve seat |
| 4 - Carrying Case | 10 - Rubber bung |
| 5 - Special screwdriver | 11 - Gas detector tube |
| 6 - Special spanner wrench | |

MONOXOR CARBON MONOXIDE INDICATOR

Uses

The Monoxor Indicator can be used to determine the concentration of carbon monoxide in industrial working areas. This instrument can be used also for checking CO concentrations in connection with gas operated home appliances.

Operating Principle

The presence of carbon monoxide is shown by the development of a brownish stain on the yellow colored gel contained in the indicating tube. Stain length is proportional to the concentration of carbon monoxide in the air being sampled. Parts per million and percent carbon monoxide by volume are read directly from the scale.

Physical Description

The complete unit consists of the sampler, which is a spring operated bellows contained in a metal housing, and the indicating tube. Attached to the metal case is a double sided, stainless steel, sliding scale consisting of four ranges, two on each face with engraved graduations (see Figure 1). The scale and indicator tube holder fold back onto the bellows case when not in use.

Sampler and spare indicator tubes are packed in a metal carrying case which weighs 2 1/2 pounds and measures 7 by 6 1/2 by 2 3/4 inches.

Performance Data

Four ranges as follows: 0.01% (100 ppm) to 0.2% (2000 ppm) CO, 0.06% (600 ppm) to 0.1% (1000 ppm) CO, 0.006% (60 ppm) to 0.07% (700 ppm) CO, and 0.001% (10 ppm) to 0.03% (300 ppm) CO for one, two, three, and four pump strokes respectively.

Sensitivity is 0.001% CO (10 ppm) with a maximum reading of 0.2% (2000 ppm). Concentrations as low as 5 ppm can be detected.

The white guard gel removes smoke, fumes, and gases other than carbon monoxide. Nitrous oxide, sulfur dioxide, methane and some other gases do not interfere with the CO test.

Since this method is based on a length of stain rather than a color change, color comparisons are eliminated and reliable readings can be made under a wide range of lighting conditions. These tubes are suitable for use between -70° F and +125° F. Each indicator tube can be used for two separate tests where normal CO concentrations are encountered.

Source

Bacharach Industrial Instrument Company,
200 N. Braddock Ave., Pittsburgh 8, Penna.
and 50 f.o.b., Pittsburgh, Penna.

Operating Instructions

1. Unfold scale frame and scale from bottom of indicator sampler and swivel forward until it locks in place.
2. Slide metal tip breaker, on the bottom of the indicator sampler, back to open the tube breaker hole.

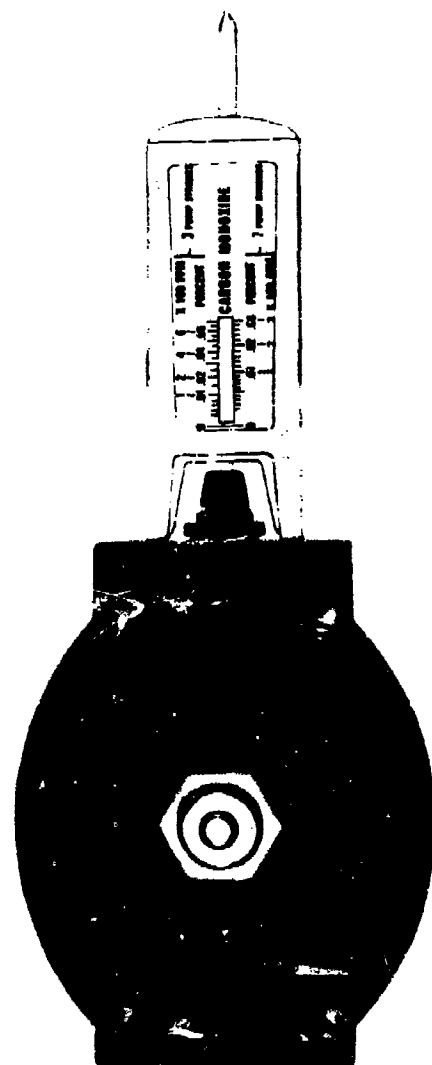


Figure 1 - Monoxor Carbon Monoxide Indicator.

3. Insert indicator tube tip in exposed hole and break off tips to open both ends of tube. Push slide forward to close tip breaker hole.
4. Slide either open end of indicator tube through wire loop under scale and insert the tube snugly into rubber tube connector or indicator sampler.
5. Depress push-button to bottom of travel and hold down for several seconds. Release push-button quickly and allow push-button to return to its original position. This will be shown by appearance of red line on push-button.
6. When red line on push-button is visible wait 15 seconds before examining the indicator tube for brownish stains in yellow colored gel. If stain appears, carbon monoxide is present in test area. Move scale until unstained yellow colored gel appears on one side of scale's zero bar and the stained gel appears on the other side.
7. Read scale at junction of stained gel and white guard gel. If no stain is visible after one pump stroke repeat steps 5 through 7 for a total of 2, 3, or 7 pump strokes for greater sensitivity. When making additional pump strokes, be sure to use correct scale for measuring length of stained gel.

Additional detailed supplementary operating instructions for special applications are included with the instrument.

Maintenance Instructions

Detailed instructions are included in the kit.

KITAJAMA PRECISION GAS DETECTOR



Figure 1 - Kitajama Precision Gas Detector

The Kitajama Precision Gas Detector provides rapid determinations of atmospheric concentration of the following gases:

Operating Principle

The pump, which is a hand-operated device, is designed to draw air sample into a glass tube, fixed with the detector tubes. An expandable plastic sleeve around the pump protects the piston and cylinder from damage.

Air being sampled is drawn through the detector tube containing chemical reagents which adsorb and reacts with the gas or vapor being measured. A color stain is produced which varies in length or intensity with the concentration of the gas or vapor. Each reagent provides a color contrast between the original color and the stained color. The detecting reagents are adsorbed on fine grain silica gel which is hermetically sealed in the glass detector tubes. The very fine grain size of the silica gel insures uniform distribution of airflow through the tubes, and provides sharp demarcation lines on all length-of-stain tubes, and uniform color changes on color-intensity tubes.

Physical Description

The gas and vapor detector kit consists of a hand-operated piston pump, one box of 20 detector tubes (to be specified by purchaser), spare parts, and a leather carrying case with shoulder strap.

Weight of the pump is 1 1/4 pounds and it is 1 1/2 inches in diameter and 7 3/4 inches long. The 10 by 9 by 3-inch carrying case has room for eight boxes of detector tubes. Weight of the complete kit is about four pounds.

Performance Data

At 68° F the average error of the tubes is less than 5%. Accurate temperature correction tables are available for each type of tube.

The following table lists the types of gas and vapor detector tubes available, range of concentrations detectable, color changes produced, and other pertinent information.

TUBES FOR MEASURING ATMOSPHERIC CONCENTRATIONS

Tube No.	Detector Tube	Measurable Concentration	MA. C.	Shelf Life	Discoloring of Reagent	
					Original	Change
101	Acetylene	100-1800 PPM	-	3 years	pale yellow	brownish blue
105B	Ammonia, low range	10-400 PPM	100 PPM	3 years	pink	yellow
110	Benzene	5-250 PPM	25 PPM	3 months*	white	reddish orange
114	Bromine	1-1800 PPM	1 PPM	1 year	grayish white	orange
126B	Carbon Dioxide, low	500-12,000 PPM	5000 PPM	2 years	blue purple	pale pink
106A	Carbon Monoxide	25-4000 PPM	100 PPM	2 years	pale yellow	green-blue
106C	Carbon Monoxide in presence of hydrocarbons and nitrous gases	25-4000 PPM	100 PPM	1 year	pale yellow	green-blue
109	Chlorine	1-150 PPM	1 PPM	1 year	grayish white	orange
108B	Ethylene	0.10-50 PPM	-	3 years	pale yellow	dark blue
113A	Hydrogen Cyanide	10-30,000 PPM	10 PPM	1 year	yellow	reddish brown
190B	Hydrogen Sulfide, low	1-125 PPM	20 PPM	1 year	white	brown
120C	Hydrogen Sulfide in presence of sulfur dioxide	20-1500 PPM	20 PPM	3 years	pale yellow	pink blue
117	Nickel Carbonyl	5-500 PPM	0.001 PPM	6 months*	pale yellow	blue purple
117	Nitrogen Dioxide	0.1-1000 PPM	5 PPM	1 year	grayish white	orange
121	Phosphine	20-800 PPM	0.05 PPM	3 years	pale blue	reddish purple
103B	Sulfur Dioxide, low	5-1000 PPM	5 PPM	3 years	white	orange
124	Toluene	5-1000 PPM	200 PPM	3 months*	white	reddish brown
123	Trichloroethylene	10-500 PPM	200 PPM	1 year	reddish orange	white

HIGHER RANGE TUBES FOR PROCESS CONTROL AND DETERMINING PRESENCE OF EXPLOSIVE CONCENTRATIONS

Tube No.	Detector Tube	Measurable Concentration	Lower Explosive Limit	Shelf Life	Discoloring of Reagent	
					Original	Change
102	Acetone	0.10-7.0%	2.15%	3 years	yellowish-orange	blue
122	Acrylonitrile	.0020-5.0%	3.05%	3 years	orange	blackish green
105A	Ammonia, high	0.10-60%	16% - lower 25% - upper	3 years	pink	purplish blue
126A	Carbon Dioxide, high	0.10-5.0%	-	2 years	blue purple	pale pink
107	Diethyl Ether	0.010-4.0%	1.7%	3 years	orange	blackish green
123	Dimethyl Ether	0.010-1.5%	3.4%	3 years	orange	blackish green
104	Ethanol (Alcohol)	0.050-20.0%	3.30%	3 years	yellow orange	blue green
111	Ethyl Acetate	0.040-7.0%	2.10%	3 years	orange	blackish green
122	Ethylene Oxide	0.010-8.0%	3.0%	3 years	yellow-orange	dark yellow-green
119	Methanol	0.030-8.0%	6.0%	3 years	yellow-orange	blue
103A	Sulfur Dioxide, high	0.050-10.0%	-	3 years	yellow	blue

* All short shelf life tubes will be shipped by air freight against special order.

Please note that new detector tubes are continuously being developed. Addition- to the above list will be sent as these new tubes are made available.

SOURCE

Kogyo Chemical Company, Tokyo, Japan. U. S. distributor - Union Industrial Equipment Corp., 40 Beech Street, Port Chester, New York.

Operating Instructions

The sealed ends of the appropriate detector tube are broken off, and the tube is inserted into the gasket at the pump inlet. The handle of the pump is then withdrawn the length of the cylinder and given a half turn either left or right to lock it in position. After two to three minutes,

depending upon the specific tube, the detector tube is removed and the gas concentration read from the calibration-curve or color standards on the detector tube box. If no stain develops after one pump stroke, repeat the procedure until a stain develops, and divide the reading obtained by the number of strokes.

Calibration Instructions

*Capacity of the hand pump is 100 ml $\pm$ 5%. A simple "soap bubble" technique can be used to check the air flow through the detector tubes. One method is as follows: Construct a buret with a capacity of 125 ml from 3/4-inch I.D., thin-wall (1/16-inch) plastic tubing. Mark off the capacity between 90 and 110 ml in 1 ml divisions by using a volumetric pipette and filling the buret with successive known quantities of water. Seal a nipple to the top of the plastic tube to facilitate attachment of rubber tubing which will slip over the detector tube and form a tight seal. Prepare a solution of detergent and water allowing the resultant foam to subside. Carefully pour this solution into the buret to avoid raising additional foam and pour out the solution in such manner that the inside walls of the buret are coated with a thin film of soapy water. Place the open end of the buret in contact with the surface of the soapy water contained in a beaker. Withdraw the buret and a soap film should cover the mouth of the buret. Insert a detector tube (ends of glass broken off) into the pump and attach the other end of the tube to the top of the buret. Pull out pump handle and lock in extended position. The soap bubble will rise in the buret (from the zero point) and come to equilibrium. Note the total volume and time required to reach equilibrium.

Detector tubes can be calibrated against known concentrations of various gases and vapors. One method for setting up known concentrations is described on page F-7-4. Other techniques are described in the literature.

Maintenance Instructions

- 1) If it becomes necessary to lubricate the piston, use a good grade of silicone grease.
- 2) Check, by using a microscope, or by noting the time rate of flow, to be sure that the constant flow orifice is unplugged. Dirt may be removed by cleaning the hole with an 0.05 mil platinum wire.

*Editor's Note: This technique is used by the Occupational Health Field Headquarters, U. S. Public Health Service, Cincinnati, Ohio, to calibrate small air flow rates on several types of field sampling equipment. It is a convenient and accurate method and was submitted for publication in the Amer. Ind. Hyg. Assoc. Jour. by Howard L. Kumetz in October 1959.

PORTABLE OXYGEN INDICATOR

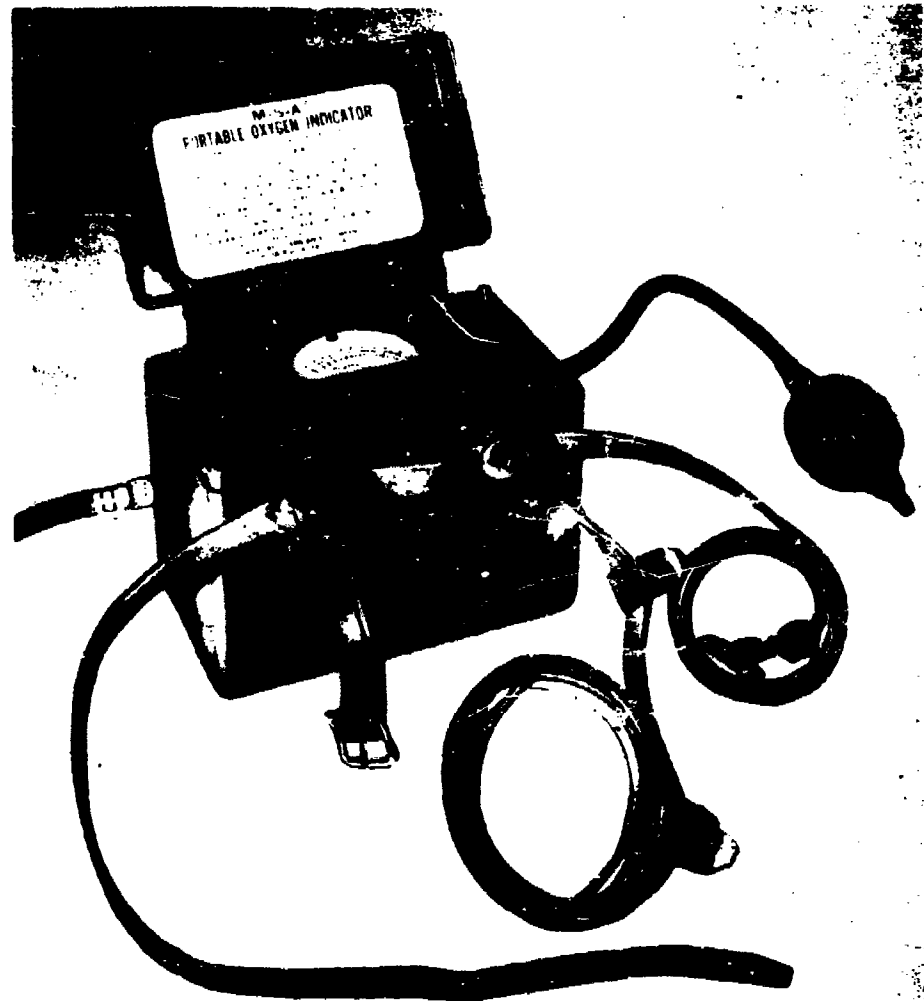


Figure 1 - M-S-A Portable Oxygen Indicator for Measuring Concentrations of Oxygen Within the Range of 0 to 25% by Volume.

Uses

The M-S-A Portable Oxygen Indicator, shown in Figure 1, is a compact instrument which gives a direct, instantaneous reading of the percentage of oxygen in a gaseous mixture. It can be used for oxygen deficiency conditions and for situations where oxygen leakage may increase fire and explosion hazards.

Operating Principle

The M-S-A Portable Oxygen Indicator uses a depolarization cell for oxygen measurement. The cell consists of a Lucite cylinder filled with a special electrolyte, a silver electrode, and a hollow carbon electrode. In this form it becomes a galvanic cell which generates electric current. The flow of this current is retarded by the polarization effect of hydrogen ions attracted to the carbon electrode. When the test sample is circulated inside the hollow electrode, a small portion diffuses through the carbon. Oxygen in the sample combines with the hydrogen ions depolarizing the cell. The amount of depolarization, and thus the amount of current flow through the cell, is in direct proportion to concentration of oxygen present in the sample. This current flow is measured by a

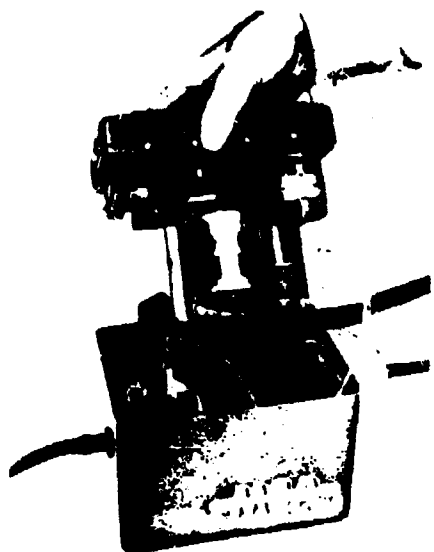


Figure 2 - Interior View of Portable Oxygen Indicator.

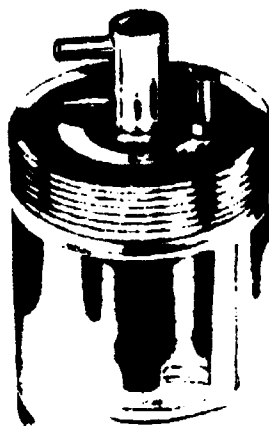


Figure 3 - Detector Cell With Sample Inlet and Exhaust Tubes. Cell consists of Carbon and Zinc Electrodes Immersed in Oxylite Solution.

meter whose scale is graduated in percent oxygen.

Physical Description

Weight - 5 3/4 pounds; width - 6 3/4 inches; depth - 4 1/8 inches; height - 5 3/4 inches. The instrument is housed in a rugged aluminum case with leather neck and waist straps. Power is supplied by one size D flashlight cell.

Performance Data

Scale Range - 0 to 25% oxygen by volume. Accuracy - $\pm 1/2\%$ oxygen throughout the scale range. Scale graduation - square root function places the 5% mark at approximately the mid-point on the scale.

Source

Mine Safety Appliances Company, 201 N. Braddock Ave., Pittsburgh 3, Penn. Price available from manufacturer upon request.

Operating Instructions

1. Move the "OFF-ON" switch, upper right of panel to the "ON" position.
2. Push spring return switch in the "CHECK" position and adjust "CHECK ADJ." until meter pointer is within half of a scale division above the proper setting. Release the switch to the "READ" position.
3. Gently rock or tilt the instrument in several directions a few times. Aspirate air 10 times and adjust meter needle by "AIR ADJ." to 20.8% within a few tenths of a percent.
4. For good stability, allow at least five minutes; then repeat steps 2 and 3 with greater precision. Check setting need not be adjusted closer than to 1/4 of a division; air adjustment should be as close as possible to 20.8%.
5. Aspirate sample and read meter when stable. With a five-foot sampling line, 15 to 20 aspirations are needed.

Calibration Instructions

For greatest accuracy and precision, the M-S-A Portable Oxygen Indicator must be calibrated before taking measurements. For oxygen concentrations above 15%, simply draw a fresh air sample and adjust the meter reading to 20.8%. For measurements at the low end of the scale, adjust the zero setting in addition to the fresh air reading. To do this, draw a sample of oxygen-free gas through the instrument and set the meter to zero by turning the slotted "zero" adjustment screw to the left of the meter.

Maintenance Instructions

Maintenance is confined to replacement of one of the electrodes and the electrolyte after two months or more of use. Dry cells normally last considerably longer. The negative electrode should last approximately a year, but may have to be cleaned when the electrolyte is changed.

DIRECTIONS FOR USE

Detector Tube 2/a Hydrochloric Acid

1. General and Applications

Analysis of hydrochloric acid vapours (HCl) in air and in industrial gases.

Instruction booklet G2341e explains how to use the Detector Tube and the Gas Detector.

For the properties of the tube, see also No. 39 in our series "Information on the Dräger Gas Detector"

2. Description

See illustration.

Opening time (duration of one stroke of the pump to full expansion of the stroke limiter chain): at least 4 secs., but not more than twice that.

3. Measuring Range

With 10 strokes: 2-30 ppm

1 mg HCl/cu. m = 0.67 ppm

1 ppm HCl = 1.5 mg/cu. m } 25° C, 760 Torr.

4. Toxicity Data

MAC value (8 hours): 5 ppm (USA 1959, Ger. Fed. Rep. 1958).

For further toxicity data, see Information Sheet No. 39

5. Storage Life

At least two years. Keep the Tubes out of the light.

6. Remarks

After a negative reaction, the Tube can be used again repeatedly on the same day. Under certain conditions, it may even be used again after a positive reaction. Discolorations last for only a short time and tend to pale if the Tube is left aside. See Information Sheet No. 39.

7. Specificity

Colour change orange → blue violet is based on reaction of the HCl with organic metal complex. The indicating layer is discolored in excessive concentrations of nitrous gases and chlorine. Hydrogen sulfide produces a blue discoloration of reagent. No interference is offered by hydrogen fluoride, sulphur dioxide or SO₂.

Acid chlorides and other substances (e. g. sulphur dichloride) which easily crack HCl can also be measured. See also Information Sheet No. 39.

8. Effects of the Ambient Temperature on the Measurement

The calibrated scale printed on the Detector Tube is valid for 10 strokes of the pump so long as both the Tube and the sample are within 5 and 40° C. The Detector Tubes are calibrated to allow for 40 to 80% rel. humidity in the test gas (20° C).

9. Test and Evaluation of the Result

With 10 strokes of the pump, suck the air to be tested through the Tube. Length of the violet-discoloured zone = HCl concentration in ppm. The discoloration is similar to the covering film on the end of the Tube.

- 1 and 2 Fused tips
- 3 Writing surface
- 4 Pre-cleansing layer (white)
- 5 Indicating layer (orange) with calibrated scale in p.p.m., valid for 10 strokes of the pump (n = 10)
- 6 Arrow (should point towards pump during test)
- 7 covering film (violet)



200-7

DRÄGERWERK Heide & Bernh. Dräger LÜBECK

Tel. 23631

Telex 026807

1st Edition

G 234-295e

May 1960

DIRECTIONS FOR USE

Detector Tube 0.25/b Phosgene

1. General and Application

Analysis of Phosgene (COCl_2) in air and technical gases.

Instructions for using the Detector Tubes and Gas Detector are contained in Instruction Booklet G 2341e.

With regard to the qualities of the Detector Tubes and the formation of Phosgene from hydrocarbon halides, please see Information Sheet No. 13 and No. 28.

2. Description

See illustration.

Opening time (duration of one stroke of the pump to full expansion of the stroke limiter chain): at least 6 seconds, the maximum being twice that.

3. Measuring Range

5 strokes: approx 0.25 — 15 p.p.m.

1 stroke: up to approx 75 p.p.m.

1 mg. Phosgene per cubic metre

= 0.25 p.p.m.

1 p.p.m. Phosgene = 4 mg./cu. metre

25° C.
760 Torr

4. Toxicity Data

MAC value (8 hours): 1 p.p.m. (USA 1959) or 0.1 p.p.m. (German Federal Republic 1958). For further toxicity data, please see Information Sheet No. 13.

5. Storage Life

At least 2 years.

6. Remarks

After a negative reaction, the Detector Tube may be used again on the same day. After a positive reaction however, it cannot be used again. Discolourations last only for a limited period whilst the discoloured zones become somewhat shorter in length.

7. Specificity

The indication is based on coupling reaction of Phosgene with aromatic amino-aldehydes. Colouration: blue-green. Reaction specific for Phosgene. The indication of Phosgene is not affected by other gases; please see Information Sheet No. 38.

8. Influence of Temperature on the Test Result

The printed scale applies for 5 strokes, so long as the temperature of the Detector Tube and gas sample are between 5 and 35° C.

9. Test and Evaluation of the Result

Draw the air to be tested through the Tube with 5 strokes of the pump. The length of the blue-green discoloured zone gives the concentration of Phosgene (p.p.m.). Colouration is similar to the colour of the covering film on the end of the Tube.

Testing with one stroke: Multiply the reading by 5 = p.p.m. Phosgene. Take account the volume of inlet pipette as the volume of the Air Sample is only 100 cc.

10. Measuring concentrations of less than 1 p.p.m.

Draw the air to be tested through the Detector Tube until such time as the discolouration reaches first graduation ("1"), at the same time counting the number of strokes needed (n). The Phosgene concentration in p.p.m. then is

$$\text{p.p.m.} = \frac{5}{n}$$

1 and 2 Fused tips

3 Writing surface

4 Pre-cleaning layer (white)

5 Reactive layer (yellow) with calibrated scale; reading scale in p.p.m. valid for 5 strokes (n = 5)

6 Arrow, should point towards the pump during the test

7 covering film (blue-green)



20519

DRINGBACH Meter & Bosch-Bücher LUBCKE

Tel. 25831

Telex 026807

1st Edition

© 234-253e

April 1960



Formaldehyde 0,002

Description and Instructions for Use

The Formaldehyde Detector Tube 0,002

1. General

The Dräger Formaldehyde Detector Tube 0.002 serves to identify the presence and determine the concentration of formaldehyde (H-CHO) vapours in work-rooms, industrial plant, containers, etc., during industrial hygienic control of such localities. It merits drawing special attention to uses in disinfection work and in plastics' manufacturing and processing plant.

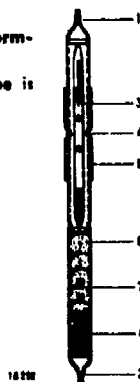
The Formaldehyde Detector Tube 0.002 is used in combination with the bellows pump of the gas detector unit. The technical manipulation of the gas detector is described in Booklet G 2341e.

Distinguishing the Dräger detector tubes by the numbered index gives the lower measuring limit in mg per l. This is based on the volume of test air called for in this instruction booklet.

2. Description of the Dräger Formaldehyde detector tube 0,002

The construction of the detector tube is shown by the adjacent sketch.

- 1 and 2 = melting type tips
- 3 = reagent ampoule
- 4 = breaking point (double-dotted)
- 5 = shrunk-on tube
- 6 = reaction layer
- 7 = measuring scale
- 8 = mask



The Formaldehyde detector tube 0.002 should be inserted into the mouthpiece of the pump so that the arrow printed on the detector tube points towards the pump. The use of the detector tube is described in para. 9.

The resistance of the Formaldehyde detector tube 0.002 is so calculated, that one stroke of the pump (until the locking chain is completely taut) takes at least 3 seconds and at the most twice that time. This guiding principle permits easy checking that the test is being properly conducted. In the event of considerable divergence, check the pump in accordance with the Instruction Booklet for the gas detector apparatus. See also that the tips of the tube, after being broken off, are really open and that the detector tube is properly seated in the mouthpiece of the pump.

3. Measuring Range of the Dräger Formaldehyde detector tube 0,002

The measuring range of the Dräger Formaldehyde detector tube 0.002 is so adjusted that toxically important concentrations can be determined. The range lies roughly between 0.002 mg and 0.05 mg per litre of air. This corresponds in round figures to 2 ppm — 40 ppm*).

4. Toxic Data

The MAC value for formaldehyde is indicated as being a concentration of 5 ppm, corresponding to about 0.006 mg per litre of air.

*) 1 mg formaldehyde per litre air = 800 ppm
100 ppm = approx. 0.12 mg H-CHO per litre of air

5. Remarks

A Dräger Formaldehyde detector tube 0.002, once used, cannot be used again, even if the result of the test was negative.

The colourations after a positive test last for a fairly long time. The tubes can serve as evidence at a later date.

6. Storage

The Dräger Formaldehyde detector tube 0.002 can be stored for at least 2 years. No particular precautions are required when storing.

Every original wrapping is printed with the date by which the detector tube concerned must be used.

7. Specificity

The reading given by the Dräger Formaldehyde detector tube 0.002 is based on the condensation of the formaldehyde with aromatic hydrocarbons in the presence of sulphuric acid.

The reaction is practically specific for formaldehyde. Even the higher homologs of formaldehyde (aromatic aldehyde, etc.) are not indicated. The only exception to this is acrolein. This reaction, however, is considerably less sensitive than the formaldehyde reaction.

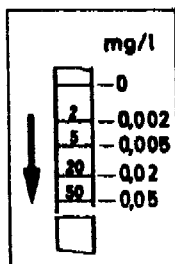
From available experience, interference with the formaldehyde indication from other impurities in the air is not to be expected.

8. Effect of the ambient temperature on the test result

The calibration data for the Formaldehyde detector tube 0.002 are applicable for ambient temperatures ranging from 0 to 40° C. (32—104° F.). The test result is therefore practically unaffected by the temperature.

9. Testing and Assessing the Test Results

After opening up the ends of the detector tube bend the tube at the double-dotted spot shown in the illustration on Page 2, so that the ampoule located inside the tube breaks. The hose shrunk on to the tube holds the two parts of the latter together. The apparatus is now ready for the test. Place the detector tube on the mouthpiece of the pump in the normal way, so that the arrow points towards the pump. Suck the air to be tested through the tube by lifting the pump 5 times. In the presence of formaldehyde, one will see the reaction layer change colour (reddish) to a degree extending lengthwise according to the amount of formaldehyde present. Once the 5 strokes have been terminated, the test is over. For



purposes of evaluation, read off on the measurement scale the length of reagent layer which is discoloured (see illustration).

Note 1

After the test, the reagent layer is discoloured at the outset to the greatest degree, the discolouration becoming gradually less along the length of the layer. The value of discolouration to be taken will be at the point where pale-red grains can still be seen clinging together.

Note 2

If the measuring point is difficult of access, we recommend that the extension hose provided as an additional item for the gas detector apparatus be used with a tube holder; compare the description of the gas detector (Page 9 of corresponding booklet). As the detector tube will be at the free end of the hose, the volume of intake hose need not be taken into consideration. Testing and evaluation are carried out exactly as described in the foregoing.

DRÄGERWERK LUBECK

HEINR. & BERNH. DRÄGER

Tel. 25831

Telepr. 026 807

GERMANY



KITAGAWA

Ammonia-Low Range DETECTOR TUBES

INSTRUCTIONS AND INFORMATION

FUNCTION:

Ammonia low range Detector Tubes provide rapid accurate measurements of air concentrations in the range 10-400 PPM (parts per million) by volume. Sampling and measurement take less than five minutes.

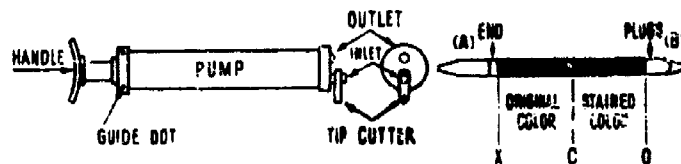
PROPERTIES AND HAZARDS OF AMMONIA:

Ammonia (NH₃) is a pungent, irritating, colorless gas. The M.A.C.* is 100 PPM, which is equivalent to 0.010% by volume, or 0.70 mg/liter. The odor threshold is approximately 50 PPM. Exposures of greater than 200 PPM are likely to cause irritation of mucous membranes and skin. Ammonia forms explosive mixture with air in concentrations between 16 and 25%. To measure concentrations between 1.0% and 25%, use Kitagawa No. 10EA Ammonia (High Range) Detector Tubes.

DESCRIPTION OF DETECTOR TUBES:

Each tube contains a carefully measured amount of fine grain resin impregnated with a pink colored reactive chemical which is sensitive to ammonia gas. When air containing ammonia is drawn through the detector tube, the resin at the inlet turns a yellowish-white color with the total length of the discoloration being proportional to the air concentration.

Instructions for Use:



1. Cut off the tips (A) and (B) of a fresh tube by turning each tube end in the tip cutter.
2. Insert tip (A) securely into the pump inlet. If the handle is not in all the way, push it in.
3. Line up the pump handle with the red dots on the end of the pump. Pull the handle all the way out, locking it with a half turn.
4. Wait 3 minutes. During this time, the air being sampled flows through the detector tube and constant-flow orifice into the evacuated pump. At the end of the sampling period, release the handle with a half turn. The handle should not move back more than 50c. (about 1/4"). Occasionally a small particle becomes lodged in the constant-flow orifice, restricting the flow. If this happens, the handle will be drawn back more than 50c. when released and the measurement should be discarded and repeated with a fresh tube.
5. As soon as the sample is drawn, remove the tube from the pump and place it vertically on the concentration chart. Position the tube with the stained end down so that the boundary between the end plug and the resin at the inlet (point O) is over line O-O and point X is over line X-X. Read the Air concentration corresponding to the length of the stain O-C.

Temperature Corrections:

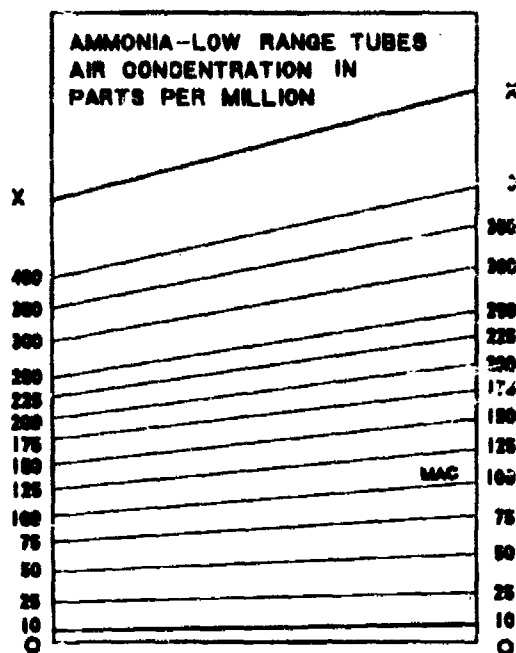
No temperature corrections are necessary between 50°F and 90°F.

Interference:

Amine chemicals produce a similar discoloration and may interfere with accurate readings.

* Maximum allowable average air concentration for daily 8-hour exposure as established by American Conference of Governmental Industrial Hygienists, 1958.

TYPICAL KITIGAWA CALIBRATION CHART



DIRECTIONS FOR USE

5/a Carbon Monoxide Detector Tube

1. General and range of application

Determining the presence of carbon monoxide in hydrogen (e. g. hydrogen intended for synthesis). If examining CO in the air, follow the somewhat different procedure described in Note 2. Instructions for using the gas detector and detector tube are contained in Instruction Booklet G 2341 e.

2. Description

See illustration.

Opening time (duration of one stroke of the pump to full expansion of the stroke limiter chain):

with hydrogen: 3 seconds, maximum 4 seconds
with air: 7 seconds, maximum 14 seconds.

3. Measuring range

5 p.p.m. — 200 p.p.m. (in hydrogen or air).

4. Storage capacity

At least 2 years.

5. Remarks

After negative reactions, the Tube can be used again up to ten times on the same day; it cannot be used again after a positive reaction.

Discolouration lasts for quite a long time, but the Tube must be protected from moisture (paraffin). Detector Tubes can serve as evidence.

6. Specificity

The indication is based on a colour reaction of the carbon monoxide with a mixture of iodine pentoxide and sulphuric acid. The specificity is ensured by the pre-cleansing layer, which foreign gases discolour from yellow-brown to green. The discolouration must

not extend as far as the reactive layer. If this happens, the test must be repeated with a carbon pre-tube attachment fitted. The measurement technique remains unchanged.

See also Information Sheet No. 17.

7. Effects of the ambient temperature on the measurement

The calibrated scale imprinted on the Detector Tube applies so long as the Detector Tube and the gas sample are within the temperature range of 0 and about 50° C.

9. Test and evaluation of the result

The gas (hydrogen) to be tested is drawn through the Detector Tube with 5 strokes of the bellows. If CO is present, the reactive layer will become pale brown, in zones, the discolouration soon changing to a dirty green. The concentration of CO is read off directly in p.p.m. from the scale on the tube, according to the length of the discoloured zone.

Note 1

After the test, the reactive layer is more intensely discoloured at its beginning than further on. The limit for evaluation purposes is there where green grains can still be seen to agglomerate. If the CO reading is less than 10 p.p.m., it is suggested that the Detector Tube be held against a bright background and re-evaluated.

Note 2

If the 5/a CO Detector Tube is to be used for measuring carbon monoxide in the air, then the air to be tested must be drawn through the Detector Tube with 10 strokes of the bellows. The scale imprinted on the Tube is then also valid for CO in air. The reactive layer becomes, though, discoloured to a more intense brown than it does in the presence of hydrogen.

1 and 2 = fused tips

3 = writing surface

4 = pre-cleansing layer

5 = reactive layer

6 = covering film

7 = arrow. During the test, this should point towards the bellows.



19 206

DEKORWERK Holzer & Bernh. Brügger LÜBCKE

Tel. 23031

Telepr. 026807

2nd Edition

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March 1959

BACHARACH

MONOXOR

CARBON MONOXIDE INDICATOR

MODEL CDE



U.S. PATENT NO. 2,569,895
CANADIAN PATENT NO. 451,675
UNITED KINGDOM PATENT NO. 582,184

- Not affected by presence of other gases normally encountered in safety testing, such as nitrous oxide, sulphur dioxide, methane, etc.
- Reads directly in carbon monoxide percentage—Is independent of operator's color perceptiveness.
- Length of stain measurement is accurate and dependable over wide range of lighting conditions.
- Requires no color matching—no special training.
- Stainless steel scale has engraved graduations and numerals for permanent reading ease.
- Mechanically operated; has no electrical circuit, can be used in presence of flammable gases.
- Suitable for carbon monoxide testing between -70°F and $+125^{\circ}\text{F}$.

The MONOXOR Carbon Monoxide Indicator is based on a method developed to meet requirements of carbon monoxide testing in aircraft, where reliability, accuracy and facility over wide ranges of temperature, humidity and other conditions are of critical importance.

This method establishes percent carbon monoxide by measuring the length of stain developed in the Indicator Tube. It permits accurate reading over a wide range of lighting conditions and reliable measurement of carbon monoxide concentration at ambient temperatures between -70°F and $+125^{\circ}\text{F}$. Color comparison is eliminated; the visual color response of the operator cannot affect the results. Mechanically operated, the MONOXOR has no electrical circuit, and therefore, can be used in the presence of flammable gases.

A test is made by depressing, then releasing the push button on the precision-built Indicator Sampler, thus drawing a controlled sample of air through the glass Indicator Tube. The sealed ends of the glass tube are broken open just prior to use. The tube contains a yellow-colored chemical which reacts with carbon monoxide, together with a white guard gel for removing smoke, fumes and gas other than carbon monoxide.

Presence of carbon monoxide is shown by the development of a brownish stain on the yellow-colored gel. Stain length is proportional to the concentration of carbon monoxide. Parts per million and percent carbon monoxide by volume in air sample tested are read directly from the scale.

The MONOXOR'S double-sided scale has four ranges—each depending on the number of Indicator Sampler strokes. Increasing the number of strokes increases the sensitivity of the instrument. Carbon monoxide concentration from 5 to 2000 parts per million can be measured with this multi-stroke and multi-scale arrangement.



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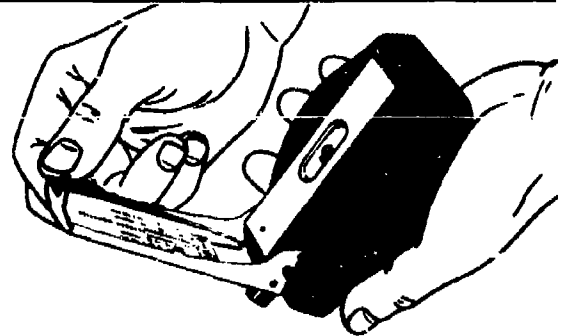
200 N. BRADDOCK AVE. • PITTSBURGH 8, PA.

Telephone: CHURCHILL 2-5400

OPERATING INSTRUCTIONS

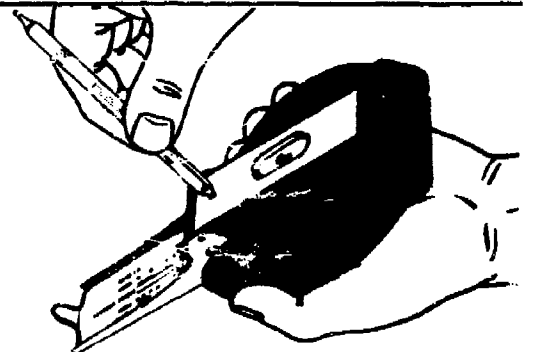
MONOXOR CARBON MONOXIDE INDICATOR—MODEL CDE

- 1** Unfold Scale Frame and Scale from bottom of Indicator Sampler and swivel forward until it locks in place.

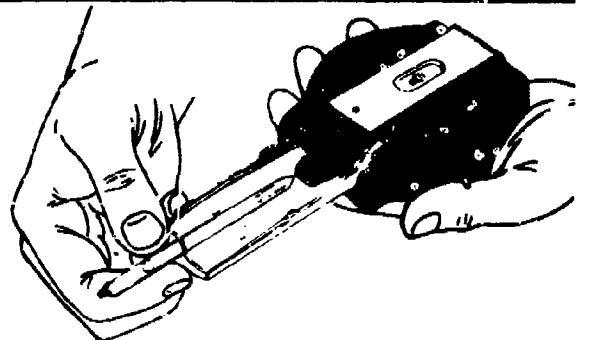


- 2** Slide metal Tip Breaker on the bottom of the Indicator Sampler back to open the tube breaker hole.

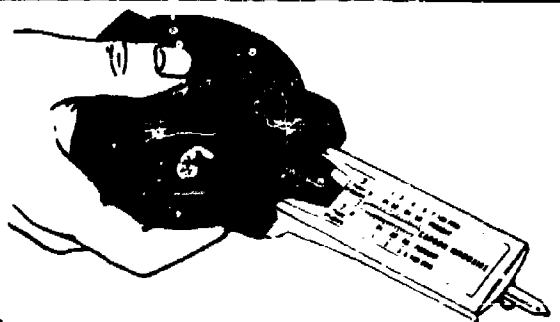
- 3** Insert Indicator Tube tip in exposed hole and break off tips to open both ends of tube. Push slide forward to close tip breaker hole.



- 4** Slide either open end of Indicator Tube through wire loop under Scale and insert tube tip snugly into rubber tube Connector of Indicator Sampler.

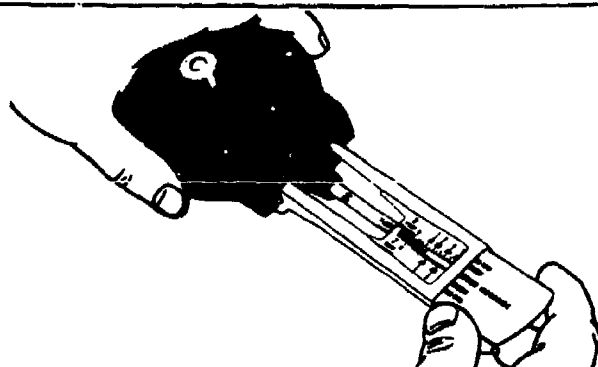


- 5** Depress Push Button to bottom of travel and hold down for several seconds. Release Push Button quickly. Allow Push Button to return to its original position. This will be shown by appearance of red line on Push Button.



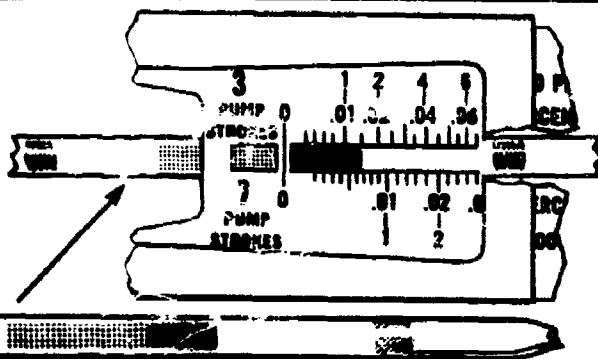
- 6** When red line on Push Button is visible wait 15 seconds before examining the Indicator Tube for brownish stain in yellow-colored gel. If stain appears, carbon monoxide is present in test area.

Move Scale until unstained yellow-colored gel appears on one side of Scale's zero bar and stained gel appears on other side.

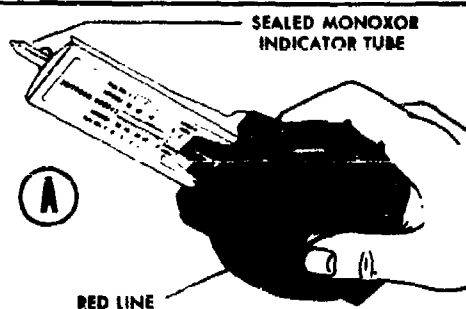


- 7** Read Scale at junction of stained gel and white guard gel.

If no stain is visible after one pump stroke repeat steps 5 through 7 for a total of 2, 3 or 7 pump strokes, for greater sensitivity. When making additional pump strokes be sure to use correct scale for measuring length of stained gel.

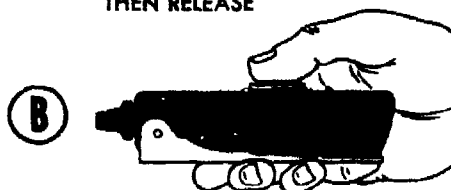


MAINTENANCE INSTRUCTIONS



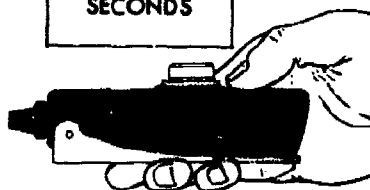
Inspect Indicator Sampler for leakage by inserting sealed Indicator Tube in Tube Connector and depressing Push Button as far as it will go. Hold for several seconds and release quickly. It should take 10 minutes or longer for Push Button to return to original position (red line visible). If time is less than 10 minutes return Indicator Sampler to factory for repair.

DEPRESS PUSH BUTTON;
HOLD DOWN SEVERAL
SECONDS,
THEN RELEASE

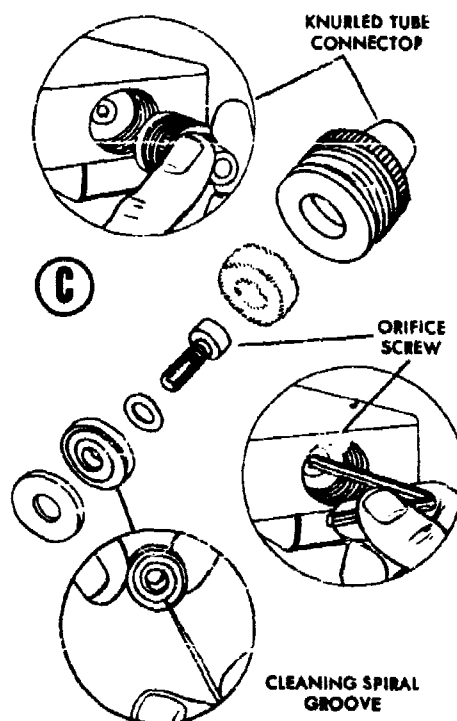


WHEN
CHECKING
TIME
OMIT
INDICATOR
TUBE

RED LINE
ON
PUSH BUTTON
SHOULD
BE VISIBLE
IN
20 TO 25
SECONDS

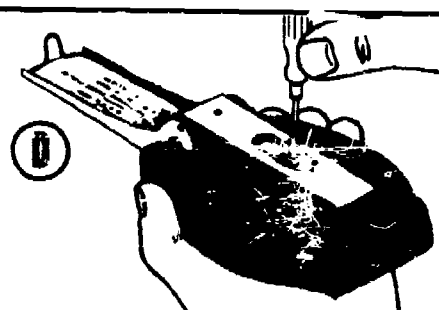


Inspect Indicator Sampler for correct sampling time without Indicator Tube. Depress Push Button as far as it will go. Hold down for several seconds and release quickly. Push Button should return to original position in 20 to 25 seconds. If sampling time is outside the limits adjust the Indicator Sampler as shown.



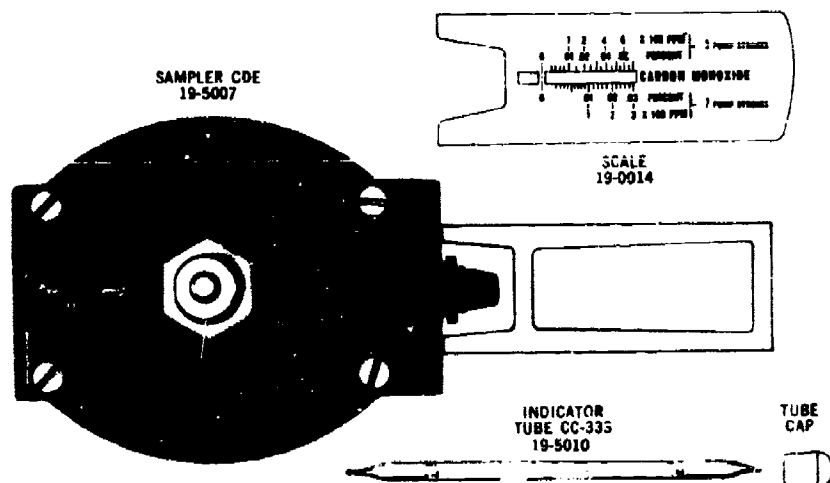
Adjusting Sampling Time

If sampling time is outside limits remove knurled Tube Connector. For sampling time less than 20 seconds use Allen wrench provided with MONOXOR to tighten Orifice Screw visible in Body cavity. If sampling time is more than 25 seconds remove Orifice Screw and Orifice Assembly. Clean spiral orifice groove with toothpick. Assemble as shown above with Felt Washer and adjust Orifice Screw for 20 to 25 second sampling time.



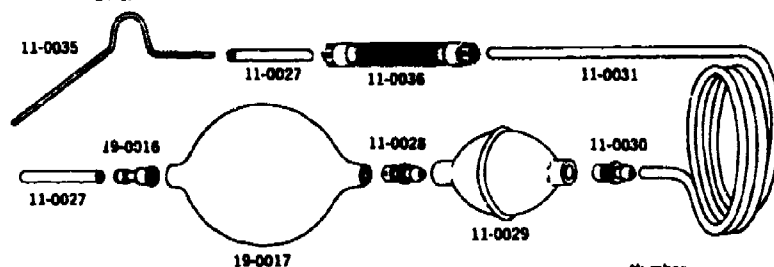
To remove glass fragments from Indicator Sampler Body unfold Scale Frame from Body. Remove Slide Screw from center of Slide and lift off Slide. Discard glass fragments from Sampler and assemble Slide to Body with Slide Screw.

PARTS LIST **MONOXOR CARBON MONOXIDE INDICATOR**



Part	Number Required	List Number
Tube Caps (Package of 6).....	1	19-0001
Carrying Case (not illustrated).....	1	19-4005
MONOXOR Sampler CDE (includes Scale 19-0014).....	1	19-5007
CO Indicating Tubes CC-333 (Carton of 12).....	1	19-5010

SAMPLING ASSEMBLY CEE -- LIST NO. 19-5011



Part	Number Required	List Number
Rubber Tubing (4" length).....	2	11-0027
Outlet Valve.....	1	11-0028
Aspirator Bulb.....	1	11-0029
Inlet Valve.....	1	11-0030
Rubber Tubing (3' length).....	1	11-0031
Sampling Tube.....	1	11-0035
Filter Tube Assembly.....	1	11-0036
Orifice.....	1	19-0016
Bladder.....	1	19-0017

WARRANTY

We guarantee every MONOXOR INDICATOR SAMPLER to be free from defects in material or workmanship for a period of one year. If the instrument develops such defects within one year from date of shipment from our plant, it will be repaired or replaced if it is returned to our

factory, transportation charges prepaid. This warranty, however, does not apply to damage due to misuse or careless handling. Furthermore, we do not assume liability for indirect or consequential damage or loss of any nature in connection with equipment sold by us.

KITAGAWA

CARBON DIOXIDE-LOW RANGE

DETECTOR TUBES

INSTRUCTIONS AND INFORMATION

FUNCTION:

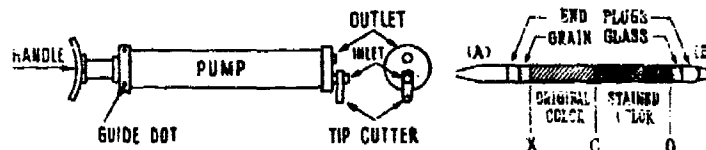
Carbon Dioxide, low range Detector Tubes provide rapid accurate measurements of air concentrations in the range 300~7,000 PPM (parts per million) by volume. Sampling and measurement take less than six minutes.

PROPERTIES AND HAZARDS OF CARBON DIOXIDE:

Carbon Dioxide (CO_2) is a colorless odorless gas. It is a natural constituent of atmosphere air and is usually present in concentrations of the order of 300 PPM by volume, which is equivalent to 0.030% by volume. The M. A. C.* is 5,000 PPM or 0.50%. Exposures of 25,000 PPM or 2.5% for several hours will probably not produce appreciable symptoms. Concentrations of 8% cause noticeable shortness of breath. 4% CO_2 causes irritation of mucous membranes, headache, increased blood pressure, dizziness and vomiting. At 8% breathing becomes difficult and 10% CO_2 causes loss of consciousness. To measure Carbon Dioxide concentrations in the range of 0.10-2.6% by volume use Kitagawa No.126A Carbon Dioxide (high range) Detector Tube. DESCRIPTION OF DETECTOR TUBES:

Each tube contains a carefully measured amount of fine grain activated almina impregnated with a bluish purple reactive chemical which is sensitive to Carbon Dioxide. When air containing Carbon Dioxide is drawn through the detector tube, the activated almina at the inlet turns a pink color, with the total length of the stain being proportional to the air concentration.

Instructions for Use:



1. Cut off the tips (A) and (B) of a fresh tube by turning each tube end in the tip cutter.
2. Insert tip (A) securely into the pump inlet. If the handle is not in all the way, push it in.
3. Line up the pump handle with the red dots on the end of the pump. Pull the handle all the way out locking it with a half turn.
4. Wait 5 minutes. During this time, the air being sampled flows through the detector tube and constant-flow orifice into the evacuated pump. At the end of the sampling period, release the handle with a half turn. The handle should not move back more than 5cc. (about 1/4"). Occasionally a small particle becomes lodged in the constant flow orifice, restricting the flow. If this happens, the handle will be drawn back more than 5cc. when released and the measurement should be discarded and repeated with a fresh tube.
5. As soon as the sample is drawn, remove the tube from the pump and place it vertically on the concentration chart. Position the tube with the stained end down so that the boundary between the end plug and the activated almina at the inlet (point O) is over line O-O and point X is over line X-X. Read the air concentration corresponding to the length of the stain O-C.

Temperature Corrections:

No temperature corrections are necessary between 32°F and 120°F.

Interferences:

Other acid gases can interfere with accurate measurements but only at air concentrations many times their respective M. A. C.'s. For practical purposes, there are no interfering gases.

- * Maximum allowable average air concentration for daily 8-hour exposures as established by the American Conference of Governmental Industrial Hygienists, 1959.

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