air. It quickly and easily measures the levels of carbon monoxide, carbon dioxide, oil mist, water vapor, and oxygen (see Table 17-I-20). Unlike other methods, there is no need to take a grab sample and analyze it off-line; the 8014BAK is designed to connect directly to the compressed breathing air source (see Instrument 17-28).

Principle of Operation: The Model 8014BAK system is essentially comprised of a pressure regulator, flowmeter, and a variety of detector tubes. In operation, measurements are made by passing the breathing air through each detector tube at a specified flow rate, pressure, and time interval. Each detector tube is formulated with a high purity reagent which adsorbs and reacts with the component being measured. This causes a colorimetric stain whose length is directly proportional to the amount of component in the breathing air. Its concentration can be read directly from the scale printed on each tube.

It is available with a choice of three connections-CGA 346, CGA 347, and 1/4" NPT Female. It is very important that the correct connection type be selected to match the application.

The Model 8014BAK-01 is fitted with a CGA 346 connection, and is rated for inlet pressures of 0-3000 psig. This model should be selected for analyzing compressed air in U.S. D.O.T.-approved cylinders with a Stamped Service Pressure in the range of 0–3000 psig. The Model 8014BAK-03 is fitted with a CGA 347 connection, and is rated for inlet pressures of 3001–5500 psig. This model should be selected for analyzing compressed air in U.S. D.O.T. approved cylinders with a Stamped Service Pressure in the range of 3001–5500 psig. The Model 8014 BAK-02 is fitted with a 1/4" NPT Female connection, and is rated for inlet pressures of 0–400 psig. This model should be selected for analyzing compressed air from non-cylinder sources having pressures no greater than 400 psig. [*Caution:* Adapters must not be used which connect a high pressure source to equipment rated at a lower pressure.] *Some Typical Applications:* The Model 8014BAK is ideal for anyone involved with the filling, generating, or usage of compressed breathing air. It has been proven through use in a variety of industries and applications such as: Emergency air packs/respirators, Fire departments/rescue squads, Scuba/diving, Hazardous waste cleanup.

17-29. Matheson's Indoor Air Quality Test Kit

Matheson-Kitagawa

The Matheson Model 8078 is a complete kit for analyzing many parameters pertaining to indoor air quality. All of the items included are also available as stand-alone products. The heart of the Model 8078 kit is the Matheson-Kitagawa precision air sampling pump. It is used in conjunction with a variety of detector tubes. Included in the kit are tubes for measuring the concentration of formaldehyde, carbon monoxide, carbon dioxide and organic hydrocarbons. And although not included in the kit as standard, tubes are available for ammonia, ozone and a host of other gases and vapors. Qualitative tubes are also included for analysis of unknown materials. An air flow indicator kit (smoke tubes) is provided for determining ventilation patterns and efficiencies. And a 10-meter extension sampling hose is provided for remote sampling in hard-to-reach places. All of these products are packaged with relevant maintenance items in a convenient, extremely durable carrying case (see Instrument 17-29).

INSTRUMENT 17-29. Matheson Indoor Air Quality Test Kit.

17-30. MSA Kwik-Draw Deluxe and Toximeter II Detector Tube Pumps

Mine Safety Appliances Company

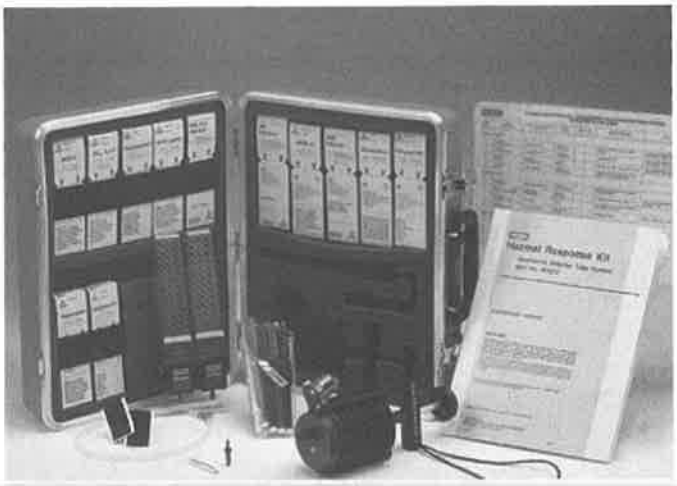
The MSA Kwik-Draw Deluxe and Toximeter II pumps are designed for use with MSA's full selection of nearly 200 different detector tubes. They are partially listed in Table 17-I-21. Nearly all of MSA's detector tubes are printed with calibration scales that illustrate the concentration of the target contaminant. The Kwik-Draw Deluxe is a manual, bellows-type pump that delivers a 100 mL volume. The Kwik-Draw Deluxe features a patented end-of-stroke indicator and stroke counter. The Toximeter II is an automatic detector tube pump that requires no manual squeezing. It can be programmed for up to 250 pump strokes (see Instrument 17-30)

INSTRUMENT 17-30. MSA Kwik-Draw Deluxe and Toximeter II Detector Tube Pumps.

17-31. MSA Haz Mat Kit

Mine Safety Appliances Company

MSA offers a specialized Haz Mat Response Kit for use at Haz Mat spills. This kit features detector tubes for 12 different chemical classes which allows quick identification of hazards at spills (see Table 17-I-22). The MSA Haz Mat Response Kit offers a special manifold for testing four detector tubes at one time (see Instrument 17-31).



INSTRUMENT 17-31. MSA Haz Mat Kit

17-32. MSA Indoor Air Quality Kit

Mine Safety Appliances Company

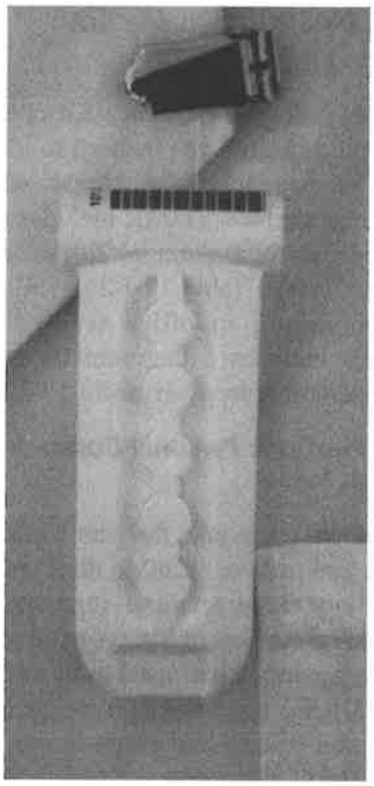
The MSA Indoor Air Quality Kit checks for "sick building" syndrome, and can be used to identify worker complaints of headaches, dizziness, allergies, and nausea in the workplace. The kit includes tubes for carbon monoxide, carbon dioxide, formaldehyde, ozone and water vapor (see Table 17-I-23)—all of which are common components in office settings. The box of detector tubes includes a thermometer on the side to monitor temperature (see Instrument 17-32).

17-33. The PiezOptic Personal Dosimeter System

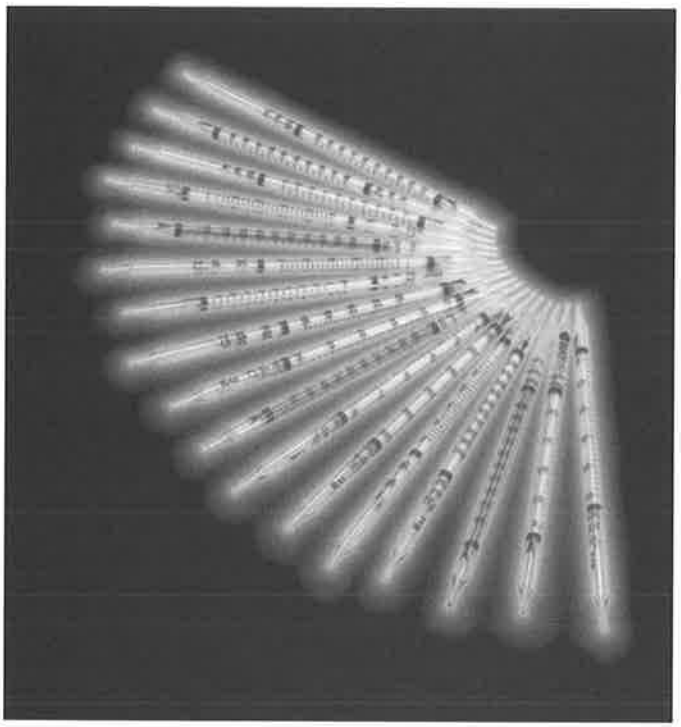
PiezOptic, Ltd.

Designed to overcome the shortcomings of most detector tube and passive diffusion direct-reading devices (poor sensitivity, accuracy and reproducibility), the PiezOptic system consists of a range of single-use passive badges and a generic reader used to quantify the results. The small (4.0 × 1.5 × 0.5 in), light-weight (<25g) badges are supplied foil-packed and ready-to-use. They can be clipped onto the clothing near the mouth to conveniently monitor the breathing zone. After the exposure period, which can be either short-term (15-30 min) or long-term (4-12h), the badge is placed into the reader and an accurate, quantitative value for exposure is obtained in a few seconds. The patented piezofilm sensing technology is extremely sensitive and precise allowing the detection of, for example, gluteraldehyde to ppb levels with a precision of around 5%. Bulky pumps and time-consuming pre-calibrations are not required and the result does not depend on the subjective evaluation of stain length or comparative color. Badges (long-term and short-term) are currently available for styrene, ozone, gluteraldehyde, formalde-

INSTRUMENT 17-32. MSA Indoor Air Quality Kit.



INSTRUMENT 17-33a. PiezOptic Personal Dosimeter Badge.



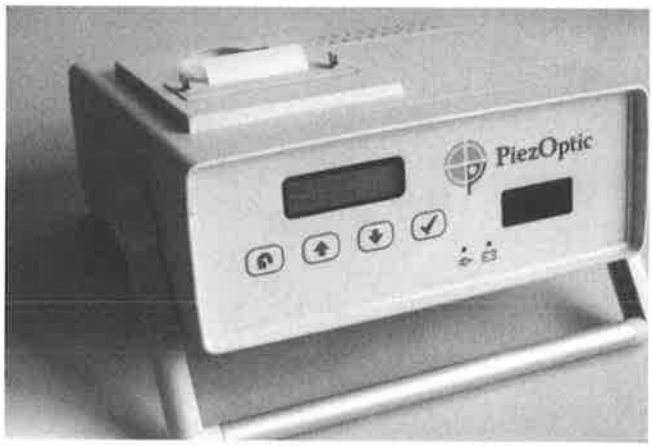
INSTRUMENT 17-34a. RAE Systems Detector Tubes.

hyde, hydrazine, NO_2 and CO. Many others are becoming available (see Instruments 17-33a and 17-33b).

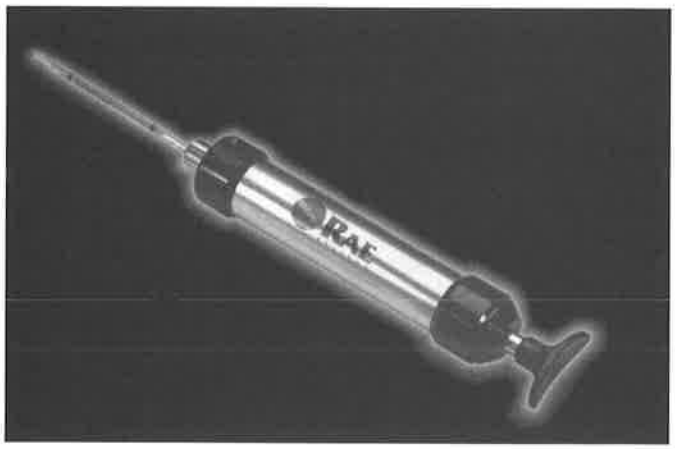
17-34. LP-1200, SampleRAE, RAE Tubes

RAE Systems, Inc.

RAE Systems is a manufacturer who started producing their own colorimetric detector tubes and pumps since 1997. As of 2000, they manufactured 46 different types of tubes for a total of 19 organic and inorganic gases and vapors (see Table 17-I-24). Their tubes were designed with a two-year shelf life (see Instrument 17-34a). Most of the tubes work with a one-pump stroke. RAE Systems offers a hand-held piston pump (see Instrument 17-34b) and an automatic sampling pump. The hand pump (model LP-1200) samples either 50 or 100 cc volumes. The automatic pump (model SampleRAE) (see Instrument 17-34c) can be used with detector tubes to sample fixed volume samples; or it can be used to sample high-volume samples (multiple pump strokes) from 50-950 cc in 50 cc increments. The 12 ounce intrinsically-safe unit is battery-powered (16-hours with 4 AA alkaline batteries), has a microprocessor, an LCD direct readout for the volume or flowrate, and comes with a calibration tube. SampleRAE can also be used with sorbent tubes and can collect a



INSTRUMENT 17-33b. PiezOptic Personal Dosimeter Reader.



INSTRUMENT 17-34b. RAE Systems LP-1200 Pump.

INSTRUMENT 17-34c. RAE Systems SampleRAE Automatic Pump.

fixed-volume of sample in a gas bag. RAE Systems funded an independent university lab study which resulted to a conclusion that the RAE tubes are interchangeable with Sensidyne and Kitigawa tubes; also, that their LP-1200 hand pump is interchangeable with the Gastek/Sensidyne GV/100 and Kitagawa 8014-400A hand pumps.

17-35. Sensidyne/Kitagawa Haz Mat Kits

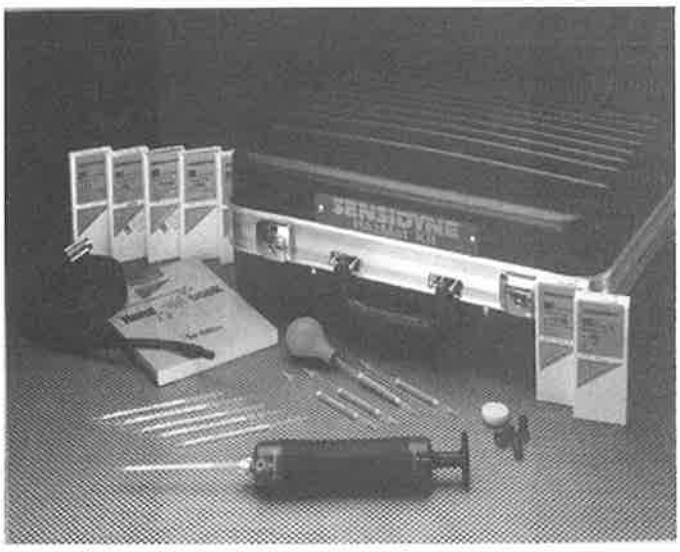
Sensidyne, Inc.

The Sensidyne/Kitagawa Haz Mat Kit is a portable hazardous material detection kit requiring no electrical power or user calibration. The kit uses the Model AP-IS hand-held piston pump and extension cable and incorporates 15 different types of detector tubes for commonly encountered substances, as shown in Table 17-I-25. The kit includes two laminated sampling logic charts which allow the user to identify unknown compounds using the 15 tubes and incorporates all of these elements plus an air flow indicator, smoke tube kit, and 15 boxes of detector tubes in a hard-sided carrying case. This system is expandable and is ultimately capable of measuring over 200 gases (see Instrument 17-35).

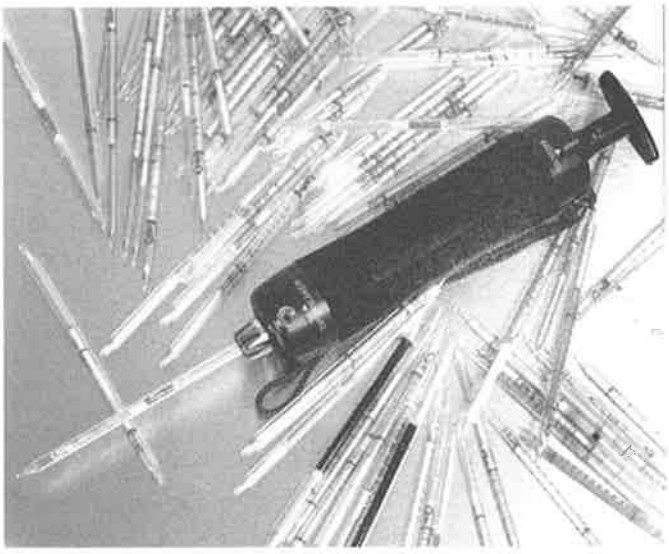
17-36. Sensidyne/Kitagawa Precision Gas Detector System

Sensidyne, Inc.

Over 200 gases and vapors can be measured with the High-precision Gas Sampling System using the detector tubes which are partially listed in Table 17-I-26. The two major components are: 1) direct-reading detector tubes



INSTRUMENT 17-35. Sensidyne/Kitagawa Haz Mat Kit.



INSTRUMENT 17-36. Sensidyne/Kitagawa Precision Gas Detector System

and 2) the high-precision, piston-type volumetric pump (see Instrument 17-36). Each detector tube contains a reagent that is specifically sensitive to a particular vapor or gas. These reagents are contained on fine-grain silica gel, activated alumina, or other adsorbing media (depending upon application requirements), inside a constant-inner-diameter, hermetically sealed glass tube. To sample, the operator snaps off both breakaway ends of a tube, inserts the tube into the hand-held pump, and pulls the pump handle out. A measured volume of ambient air is drawn inside the tube. The reagent changes color instantly and reacts quantitatively to provide a length-of-stain indication. The farther the color stain travels along the tube, the higher the concentration of gas. The calibration mark on the tube, at the point where the color stain stops, gives the concentration. Calibration scales for the detector tubes are printed on the basis of individual production lots. Calibration scales are in ppm, mg/L, or %, depending on the substance to be measured and the desired measuring range. Every tube and tube box carries the quality control number, chemical symbol, and the expiration date. The expandable measuring range permits measurement of concentrations above or below the printed scale simply by increasing or decreasing pump strokes.

17-37. Sensidyne/Kitagawa Qualitative Multistage Tubes

Sensidyne, Inc.

Provides qualitative detection of 12 inorganic gases simultaneously with simple single pump stroke operation and results in 20 seconds. Ideal for haz mat, confined space entry, and fire site re-entry testing. The Inorganic Qualitative Tube detector tube (Catalog No. 131) incorporates a unique multi-layer design to qualitatively test for 12 common toxic gases simultaneously. These gases are ammonia, hydrogen chloride, hydrogen sulfide, chlorine, sulfur dioxide, nitrogen dioxide, carbon monoxide, amines, acetic acid, phosphine, acetylene, and methyl mercaptan. An operator simply breaks off the ends of the sealed glass tube and places it into the Model AP-IS piston pump, observing the directional arrow. After taking one pump stroke, the operator waits 20 seconds and then compares the tube to a color chart (see Instrument 17-37). A second tube (Catalog # 186B) for organic qualitative analysis of 41 compounds works in 30 seconds and utilizes the reverse side of the same color chart. The system is expandable with direct-reading quantitative detector tubes for over 200 substances.

INSTRUMENT 17-37. Sensidyne/Kitagawa Qualitative Multistage Tubes.

TABLE 17-I-1. Index of Direct-Reading Instrument Types and Manufacturers

	Manufacturer	Detector Tubes		Passive Dosimeter Tubes	Passive Badges
		Short-Term	Long-Term		
1.	Acculab Technologies, Inc.				✓
2.	American Gas & Chemical Co., Ltd.				✓
3.	Assay Technology, Inc.				✓
4.	Bacharach, Inc.	✓			✓
5.	Draeger Safety, Inc.	✓	✓	✓	✓
6.	K & M Environmental				✓
7.	Matheson-Kitagawa	✓			✓
8.	Mine Safety Appliances Co.	✓	✓		
9.	PiezOptic, Ltd.				✓
10.	RAE Systems	✓			
11.	Sensidyne, Inc.	✓	✓		

TABLE 17-I-2. LEAK-TEC Personal Protection Indicators (Instrument 17-2)

Gas	Part #	Sensitivity	Color Change*
Ammonia	A-15	25 ppm/5 min	Yellow to blue
Carbon monoxide	CO-50	50 ppm	Tan to black
Chlorine	C-2	1 ppm/15 min	White to yellow
Hydrazine	H-5	0.1 ppm/15 min	White to yellow
Hydrogen sulfide	HS-5	10 ppm/10 min	White to brown
Nitrogen dioxide	N-1	5 ppm/15 min	White to yellow
Ozone	O-1	0.1 ppm/15 min	White to brown

* A color chart is available for all badges except carbon monoxide and ozone

TABLE 17-I-3. Assay Technology *ChemChip*™ Personal Monitoring Badges (Instrument 17-3)

Analyte	for Sampling	Range (ppm)	Item No.
Ethylene Oxide	8-hr TWA	0.1–6.0	502
Ethylene Oxide	15-min STEL	1–60	506

TABLE 17-I-4. Bacharach/GMD System (Instrument 17-4)

Part Number	Description
2755-0610	TDI Starter Kit
2756-0610	Hydrides Starter Kit
2750-1010	Phosgene Dosimeter Badge (std. model) – 1 day
1753-0610	Hydrazine Starter Kit
2780-0700	MDI Test Kit
2780-0500	TDI Test Kit
2780-0800	HDI Test Kit
2780-0900	NDI Test Kit

TABLE 17-I-5. Bacharach Carbon Monoxide Indicator Ranges

Complete Kit	Gas Type	Range
19-0240	CO	0–0.2%
19-0241	CO	0–0.5%
19-0244	CO	0–2,000 ppm
19-0245	CO	0–5,000 ppm

TABLE 17-I-6. Draeger CMS Chips (Instrument 17-11)

Chip	Measuring Range	Catalog No.
Ammonia	2–50 ppm	6406130
Ammonia	10–150 ppm	6406020
Benzene*	0.2–10 ppm	6406030
Benzene*	0.5–10 ppm	6406160
Benzene	10–250 ppm	6406280
Carbon Dioxide	200–3,000 ppm	6406190
Carbon Dioxide	1,000–25,000 ppm	6406070
Carbon Dioxide	1–20% vol	6406210
Carbon Monoxide	5–150 ppm	6406080
Chlorine	0.2–10 ppm	6406010
Hydrochloric Acid	1–25 ppm	6406090
Hydrochloric Acid	20–500 ppm	6406140
Hydrogen Cyanide	2–50 ppm	6406100
Hydrogen Sulfide	2–50 ppm	6406050
Hydrogen Sulfide	20–500 ppm	6406150
Hydrogen Sulfide	100–2,500 ppm	6406220
Mercaptan	0.25–6 ppm	6406360
Nitrogen Dioxide	0.5–25 ppm	6406120
Nitrous Fumes	0.5–15 ppm	6406060
Nitrous Fumes	10–200 ppm	6406240
Perchloroethylene	5–150 ppm	6406040
Petroleum Hydrocarb.	20–500 ppm	6406200
Petroleum Hydrocarb.	100–3,000 ppm	6406270
Phosgene	0.05–2 ppm	6406340
Phosphine	1–25 ppm	6406410
Phosphine	20–500 ppm	6406420
Phosphine	200–5,000 ppm	6406500
Propane	100–2,000 ppm	6406310
Sulfur Dioxide	0.4–10 ppm	6406110
Sulfur Dioxide	5–150 ppm	6406180
Toluene	10–300 ppm	6406250
Training Chip	—	6406290
Vinyl Chloride	0.3–10 ppm	6406170
Vinyl Chloride	10–250 ppm	6406230
Xylene	10–300 ppm	6406260

TABLE 17-I-7. Short-Term Draeger Tubes (Instrument 17-12)

***Note*: The list below is only a partial list of products. The full list can be found at *www.draeger-usa.com*.**

Gases and Vapors	Draeger Tube	Measuring Range	Part No.
Acetaldehyde	Acetaldehyde 100/a	100–1,000 ppm	6726665
Acetic Acid	Acetic Acid 5/a	5–80 ppm	6722101
Acetic Anhydride	Formic Acid 1/a	Qualitative	6722701
Acetone	Acetone 100/b	100–12,000 ppm	CH22901
Acetylene	Petroleum Hydrocarbons100/a	100–2,500 ppm	6730201
Acid Compounds in air	Acid Test	Qualitative	8101121
Acrolein	Dimethyl Sulfide 1/a	0.1–10 ppm	6728451
Acrylonitrile	Acrylonitrile 0.5/a	0.5–20 ppm	6728591
Air Current	Smoke Tube	—	CH25301
Aliphatic Hydrocarbons (Boiling Range 50–200°C)	Hydrocarbon 2	2–23 mg/L	CH25401
2-Aminoethanol	Ammonia 0.25/a	0.5–6 ppm	8101711
2-Aminopropane	Cyclohexylamine 2/a	2–30 ppm	6728931
Ammonia 0.25/a	Ammonia	0.25–3 ppm	8101711
	Ammonia 2/a	2–30 ppm	6733231
	Ammonia 5/a	5–700 ppm	CH20501
	Ammonia 5/b	2.5–100 ppm	81019,41
	Ammonia 0.5%/a	0.05–10 Vol. %	CH31901
n-Amyl acetate	Ethyl Acetate 200/a	200–3,000 ppm	CH20201
Aniline	Aniline 0.5/a	0.5–10 ppm	6733171
	Aniline 5/a	1–20 ppm	CH20401
Antimony Hydride (Stibine)	Arsine 0.05/a	0.05–3 ppm	CH 25001
Arsenic Trioxide	Arsenic Trioxide 0.2/a	0.2 mg/m3	6728951
Arsine	Arsine 0.05/a	0.05–60 ppm	CH25001
Aziridine	Ammonia 0.25/a	0.25–3 ppm	8101711
Basic Cmpds. in air Amine Test	Qualitative	—	8101061

TABLE 17-I-8. Long-Term Draeger Tubes (Instrument 17-13)

Draeger Tube	Measuring Range	Maximum Sampling Time (hrs)	Part No.
Acetic Acid 5/a-L	1.25–40 ppm	4	6733041
Acetone 500/a-L	62.5–10,000 ppm	8	6728731
Ammonia 10/a-L	2.5–100 ppm	4	6728231
Benzene 20/a-L	10–200 ppm	2	6728221
Carbon Dioxide 1000/a-L	250–6,000 ppm	4	6728611
Carbon Disulfide 10/a-L	1.25–100 ppm	8	6728621
Carbon Monoxide 10/a-L	2.5–100 ppm	4	6728741
Carbon Monoxide 50/a-L	6.25–500 ppm	8	6728121
Chlorine 1/a-L	0.13–20 ppm	8	6728421
Ethanol 500/a-L	62.5–8,000 ppm	8	6728691
Hydrocarbons 100/a-L	25–3,000 ppm	4	6728571
Hydrochloric Acid 10/a-L	1.25–50 ppm	8	6728581
Hydrocyanic Acid 10/a-L	1.25–120 ppm	8	6728441
Hydrogen Sulfide 5/a-L	0.63–60 ppm	8	6728141
Methylene Chloride 50/a-L	12.5–800 ppm	4	6728881
Nitrogen Dioxide 10/a-L	1.25–100 ppm	8	6728281
Nitrous Fumes 5/a-L (NO + NO2)	1.25–50 ppm	4	6728911
Nitrous Fumes 50/a-L (NO + NO2)	12.5–350 ppm	4	6728191
Perchloroethylene 50/a-L	12.5–300 ppm	4	6728671
Sulfur Dioxide 2/a-L	0.5–20 ppm	4	6728921
Sulfur Dioxide 5/a-L	1.25–50 ppm	4	6728151
Toluene 200/a-L	25–4,000 ppm	8	6728271
Trichloroethylene 10/a-L	2.5–200 ppm	4	6728291
Vinyl Chloride 10/a-L	1–50 ppm	10	6728131

TABLE 17-I-9. Draeger Long-Term Diffusion Tubes (Instrument 17-14)

Draeger Tubes	Range in Absolute Units	Range of Measurement for Max. Period of Use (8 hrs)	Part No.
Acetic Acid 10/a-D	10–200 ppm × h	1.3–25 ppm	8101071
Ammonia 20/a-D	20–1,500 ppm × h	2.5–188 ppm	8101301
Butadiene 10/a-D	10–300 ppm × h	1.3–40 ppm	8101161
Carbon Dioxide 500/a-D	500–20,000 ppm × h	65–2,500 ppm	8101381
Carbon Dioxide 1%/a-D	1–30 Vol.% × h	0.13–3.8 Vol.%	8101051
Carbon Monoxide 50/a-D	50–600 ppm × h	6.3–75 ppm	6733191
Ethanol 1000/a-D	1,000–25,000 ppm × h	125–3,100 ppm	8101151
Ethyl Acetate 500/a-D	500–10,000 ppm × h	63–1,250 ppm	8101241
Hydrochloric Acid 10/a-D	10–200 ppm × h	1.3–25 ppm	6733111
Hydrocyanic Acid 20/a-D	20–200 ppm × h	2.5–25 ppm	6733221
Hydrogen Sulfide 10/a-D	10–300 ppm × h	1.3–38 ppm	6733091
Nitrogen Dioxide 10/a-D	10–200 ppm × h	1.3–25 ppm	8101111
Perchloroethylene 200/a-D	200–1,500 ppm × h	25–188 ppm	8101401
Sulfur Dioxide 5/a-D	5–150 ppm × h	0.6–19 ppm	8101091
Toluene 100/a-D	100–3,000 ppm × h	13–380 ppm	8101421
Trichloroethylene 200/a-D	200–1,000 ppm × h	25–125 ppm	8101441
Water Vapor 5/a-D	5–100 mg/liter × h	0.6–12.5 mg/liter	8101391
Diffusion Tube Holder	Package of 3		6733014

TABLE 17-I-10. Draeger Haz Mat Kit (Instrument 17-15)

Detector Tubes	Part Number
Polytest	CH28401
Ethyl acetate 200/a	CH20201
Methyl bromide 5/b	CH27301
Hydrazine 0.25/a	CH31801
Benzene 0.05	CH24801
Hydrocarbons 0.1%b	CH26101
Acetone 100/b	CH22901
Carbon monoxide 10/b	CH20601
Alcohol 100/a	CH29701
Carbon dioxide 0.1%/a	CH23501
Hydrocyanic acid 2/a	CH25701
Hydrogen sulfide 5/b	CH29801
Nitrous fumes 0.5/a	CH29401
Trichloroethylene 10/a	CH24401
Chlorine 0.2/a	CH24301
Oxygen 5%/B	6728081
Formic acid 1/a	6722701

TABLE 17-I-11. Draeger Simultaneous Test Sets (Instrument 17-20)

Description	Catalog No.
Simultaneous Test Set I, Inorganic fumes	8101735
Acid Gases, e.g., Hydrochloric Acid	
Basic Gases, e.g., Ammonia	
Carbon Monoxide	
Hydrocyanic Acid	
Nitrous Gases, e.g., Nitrogen Dioxide	
Simultaneous Test Set II, Inorganic fumes	8101736
Carbon Dioxide	
Chlorine	
Hydrogen Sulfide	
Phosgene	
Sulfur Dioxide	
Simultaneous Test Set III, Organic Vapors	8101770
Alcohols, e.g., Methanol	
Aliphatic Hydrocarbons, e.g., n-Hexane	
Aromatics, e.g., Toluene	
Chlorinated Hydrocarbons, e.g., Perchloroethylene	
Ketone, e.g., Acetone	
Accuro Pump, required	6400000
Adapter	6400090