U.S. Department
of Transportation
**Federal Railroad
Administration**

Monitoring Devices for Railroad Emergency Response Teams

Office of Research and
Development
Washington DC 20590

John R. Hobbs

Transportation Systems Center
Cambridge MA 02142

DOT/FRA/ORD-86/02
DOT-TSC-FRA-85-1

February 1986
Final Report

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FRA/ORD-86/02		

4. Title and Subtitle	5. Report Date
MONITORING DEVICES FOR RAILROAD EMERGENCY RESPONSE TEAMS	February 1986
	6. Performing Organization Code: DTS-73
7. Author(s): John R. Hobbs	8. Performing Organization Report No.: DOT-TSC-FRA-85-1
9. Performing Organization Name and Address: U.S. Department of Transportation, Research and Special Programs Administration, Transportation Systems Center, Cambridge, MA 02142	10. Work Unit No. (TRAIS): RR528/R5315
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address: U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, DC 20590	13. Type of Report and Period Covered: Final Report, October 1984-March 1985
	14. Sponsoring Agency Code: RRD-20

15. Supplementary Notes

16. Abstract

This report examines new devices and technologies either commercially available or being developed which might have application to the railroad hazardous material spill response problem. Procedure and monitoring device information from Southern Railway, U.S. Coast Guard, Environmental Protection Agency, and Department of Defense experts is presented. Monitoring device data include combustible gas detectors, specific single component and multiple component detectors, mobile laboratories, and mobile remote multiple sensing equipment. Comparative analyses of these devices and their manufacturers are summarized. Results indicate that two currently available portable detection systems have potential for railroad emergency response teams. Recommendation is that further tests of the two systems be performed for the evaluation of detection capabilities of hazardous materials carried by the railroads.

17. Key Words	18. Distribution Statement
Hazardous Materials; Spills, Response Team; Monitoring Device; Photo-ionization; Gas Chromatograph Mass-Spectrometer	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	128	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

This report is an examination of new devices and technologies either commercially available or being developed which might have application to the railroad hazardous material spill response problem. Monitoring device data has been compiled, analyzed, and summarized to determine which detection system would be most advantageous for railroad emergency response teams.

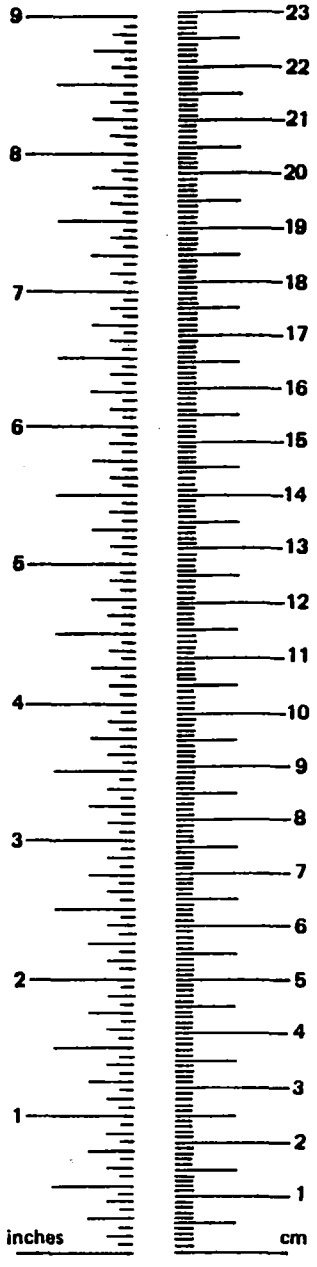
The work was sponsored by the U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Equipment and Operating Practices Safety Research Division, Washington, DC. The report was prepared by the U.S. Department of Transportation, Transportation Systems Center, Cambridge, MA.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see *NBS Misc. Publ. 286, Units of Weight and Measures.* Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

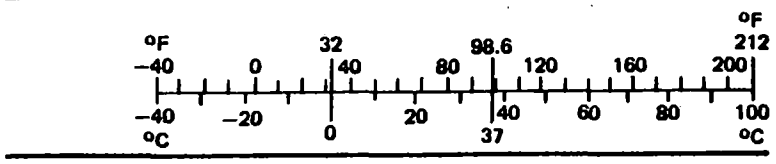


TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

LIST OF ILLUSTRATIONS

LIST OF TABLES

1. INTRODUCTION

Railroads are used regularly to transport hazardous, toxic, flammable, and reactive materials. Occasionally, accidents or derailments occur that cause spills of these materials. In response to such spills, safety and fire officials must know the nature of the spilled material in order to properly evacuate residents of surrounding areas, put out any resulting fires, and render the spill safe for proper clean-up. If the exact nature of the spilled material is not known, and turns out to be highly toxic, flammable, or dangerous only when handled, the risks to the response personnel could be very high. Recently, the Federal Railroad Administration (FRA) conducted a study of monitoring devices for railroad safety in which a survey was conducted of various chemical vapor detectors suitable for railroad use. (1) Because of continuing interest by the FRA in the latest development in chemical vapor detectors, the Transportation System Center (TSC) was asked to update the original study using any new equipment and techniques developed since 1982.

1.1 OBJECTIVE

The objective of this effort is to augment the original work (1) and determine if any new equipment or technologies have been developed since 1982 that could be used by railroad emergency response teams.

1.2 SCOPE

This report will be a compendium of any new devices and technologies either commercially available or being developed which might have application to the railroad spill response problem.

2. LITERATURE SEARCH

The report by Saunders and Kager (1) looked only at those potential monitoring devices that fit the response team detector requirements of the National Strike Force. This report deals with any detection technique with potential to aid response teams regardless of cost, operational problems, or complexity. A literature search of the following data bases was conducted:

1. National Technical Information Service (NTIS)
2. Pollution Abstracts
3. Transportation Research Information System (TRIS)
4. Enviroline
5. Conference Proceedings.

These data bases were searched for the following topics: railroads, railways, hazardous, chemical, and toxic materials, spills, accidents, detection, monitor, sensing, response teams, and emergency response. The first search netted about 20 references most of which were not cited in the original report of Saunders and Kager. (1) A second search of the same topics with the omission of the reference to railroads or railways was carried out to find references to detection equipment used in other environmental situations, such as U.S. Coast Guard or Environmental Protection Agency studies. This search uncovered approximately 60 citations concerned with the remote detection of spills, most of which pertained to oil. Out of these 60 citations, approximately 10 were of some interest to this program. A third search was conducted of the same data bases, but this time omitting railroads, railways, accidents, and spills in order to find any reference to reports dealing with the remote detection of hazardous, chemical, or toxic materials. This search resulted in approximately 454 citations with about 28 directly related to the remote detection of hazardous materials.

In addition to the literature search, trade publications such as Pollution Equipment News, Industrial Hygiene News, Instruments and Apparatus, Laboratory Equipment, Instrumentation and Control News, and numerous other chemical references were searched for any useful detection equipment.

3. INFORMATION OBTAINED FROM EXPERTS

3.1 SOUTHERN RAILROAD GO-TEAM

Mr. J.J. O'Driscoll of the Southern Railway Company and leader of the Southern Railroad's Go-Team outlined their procedure for a hazardous materials spill. Over the course of a year, they have about 100 incidents with not very many being of a toxic nature. Since his concern is with the flammable materials, Mr. O'Driscoll is the only member of the response team who carries any monitoring equipment. This equipment includes a universal sampler length-of-stain detector, a HNU portable photo-ionization detector, a combustible gas indicator, and a Mine Safety Appliances Model 2A explosives meter. Since the use of the HNU photo-ionization detector and the length-of-stain indicator tubes are limited, the most important devices are the explosives meter and the combustible gas detector.

The Southern's emergency response action proceeds as follows. Mr. O'Driscoll and two or three other members of the Go-Team immediately contact the shipper of the material. This has always produced a good response from the shipper in that they usually send their most knowledgeable person, monitoring devices for the material if they exist, and protective clothing. First, the Go-Team tries to identify the material from the way bill. Next, they determine if any railroad personnel or bystanders are injured; if so, they notify the proper emergency people. The team then determines from a safe distance, either by the presence of a cloud, fire, or odor, the condition of the spill. Finally, they notify the dispatcher. The main concern of the emergency response team is whether or not the material has escaped from the container. If the material has escaped, one either does not go in to the spill area or if one does go in, one uses full protective clothing and self-contained breathing apparatus. The most critical incidents are those that involve fire exposure or a mass leak with a fuel-air cloud or a toxic gas cloud.

Mr. O'Driscoll stated that he would be interested in any device that could provide more information to the responsible railroad people. However, such equipment would only be given to experts in the response units who have had real life field experience with hazardous materials. There are not enough

experienced people, even on the Southern Railway, to give each emergency unit equipment because of the problems of calibration, cost, maintainence, and training, and the large number of trains covering a broad geographical area. Mr. O'Driscoll is reluctant to give monitoring equipment to people on the scene who cannot make decisions and does not want to pass off responsibility for control of the incident to someone else who does not have any practical experience with hazardous materials; e.g., someone who does not know what materials are flammable could make fatal mistakes. He feels comfortable with the present response guidelines and does not want his railroad people doing response functions of fire departments, ambulances, and other response personnel.

3.2 U.S. COAST GUARD STRIKE TEAM

Lt. Phil Glen of the U.S. Coast Guard Atlantic Strike Team (AST) indicated that a monitoring device that would identify hazardous materials would be welcome. Currently, the AST uses length-of-stain indicators, oxygen meters, combustible gas detectors for the Lower Explosives Limit (LEL), portable flame ionization detectors, HNU portable photo-ionization detectors, Century Systems OVA-98 portable flame ionization gas chromatographs, and have just recently purchased a Foxboro Miran 1B portable infrared detector. Lt. Glen stated that all of these units are useful if used properly and their limitations noted. The best method of analysis for the unknown hazardous material is the gas chromatography-mass spectrometer analysis of a grab sample. In general, if the situation is not serious, the AST takes a grab sample and sends it out for analysis. If they must go into the spill, they use self-contained breathing apparatus and proper protective clothing. If available and appropriate, the AST will use their monitoring equipment noting the limitations.

A universal hazardous materials identification device is essential but should not be used by everyone because of the cost, training, and calibration required. The equipment now used by the AST requires calibration before going into the field which must be carried out by properly trained personnel in order for proper interpretation of the results and proper decision making. The AST is aware of the mobile monitoring systems such as the U.S. Coast Guard mobile laboratory and would use it if available, but knows that such equipment cannot be available to everyone, at any time, at any location.

3.3 THORNEY ISLAND HEAVIER THAN AIR DISPERSION TESTS

Tests were conducted at Thorney Island, England, to study the physical phenomenum of dense gas dispersion. Mixtures of Freon in nitrogen were pumped into a natural gas tank about 40 feet tall. The tank was allowed to rupture and the effects of the wind, temperature, and terrain on the dispersion of the mixture were measured. The purpose of these experiments was to verify or determine the accuracy of the dense gas dispersion models. To date, no final report has been written on this study, and little information is available as to which dense gas dispersion models performed the best.

3.4 ENVIRONMENTAL PROTECTION AGENCY EMERGENCY RESPONSE TEAM

Dr. Harry Allen of the Environmental Protection Agency (EPA) Eastern Emergency Response Team indicated that his emergency response team uses the HNU portable photo-ionization detector, the Century Systems OVA detectors, and Dragger Tubes. They have just purchased a mobile Sciex tandem mass spectrometer, but have not yet used it in the field. His experience has been that the manifest or way bill has usually been very good and the tank car placards have also been useful. According to Dr. Allen, most railroads have on retainer a company experienced with hazardous materials. These companies provide experts who know what to do with each type of hazardous material. The emergency response team has also received good assistance from CHEMTREC (Chemical Transportation Emergency Center).

Usually at a spill site, air samples are taken in Tedlar bags or trapped on ERT 2-stage adsorption tubes and analyzed at a contract laboratory. Liquid samples are grab sampled and gas chromatography-mass spectrometry analysis are performed. Where necessary, protective clothing and self-contained breathing apparatus are used. The emergency response team is investigating with the Rockwell Corp. the use of a radio-controlled drone to carry a HNU photo-ionization detector through a spill site. Dr. Allen was not aware of the Microsensor Technology Inc., portable gas chromatograph, but was familar with the Foxboro Miran 1B infrared analyzer. He did comment that he was not in favor of giving highly sophisticated equipment to railroad personnel who lacked the practical field experience with hazardous materials to interpret the results properly and safely.

3.5 DEPARTMENT OF DEFENSE MONITORING ACTIVITIES

The Department of Defense sponsors several monitoring activities, but none of them involve the requirement for the identification of unknown materials such as those involved in hazardous materials spills. The U.S. Army conducts a great amount of research towards the detection of chemical and biological agents. The detection methods are very specific to a particular species and no universal survey techniques except the very expensive remote monitoring techniques have been investigated. The U.S. Air Force has been interested in monitoring the combustion products of jet and rocket engines, but has not funded development of any multi-component monitoring devices. They are concerned with monitoring the traditional pollutants such as carbon monoxide, carbon dioxide, oxides of nitrogen, hydrocarbons, and sulfur compounds. The Air Force is also interested in the detection of solid state and liquid rocket fuels such as hydrazine. The U.S. Navy has no program in monitoring except for the measurement and control of stack emissions from Navy vessels and the specific case of monitoring devices for measuring the quality of the air in submarines. In these cases, specific monitoring devices are required for specific compounds and no work has been done on multi-component monitoring devices.

4. HAZARDOUS MATERIALS MOST OFTEN SHIPPED AND SPILLED

A survey of the most often shipped and most often spilled hazardous materials was conducted to aid in the selection of hazardous materials that might be detectable by some of the monitoring devices listed below. Tables 1 through 6 list the top 18 or 20 commodities involved in railroad incidents for the years 1979 through September of 1984. This information was obtained from the U.S. Department of Transportation, Materials Transportation Bureau's Hazardous Materials Information System. Table 7 lists all the hazardous materials spilled in railroad incidents that were reported to the Environmental Protection Agency. This list includes the name of the material, how much was spilled, how much was being shipped on the trains when the spill occurred, and the number of spills that occurred. This information was obtained from the Environmental Protection Agency's Hazardous Materials Information Data Base.

TABLE 1. TOP 20 COMMODITIES INVOLVED IN RAIL INCIDENTS IN 1979

Commodity	Incidents
Liquified Petroleum Gas	124
Sulfuric Acid	123
Ammonia, Anhydrous	76
Phosphoric Acid	74
Hydrochloric Acid	63
Flammable Liquid, N.O.S.	46
Corrosive Liquid, N.O.S.	45
Acetaldehyde (Ethyl Aldehyde)	35
Sodium Hydroxide, Liq or Sol	34
Ethyl Acrylate, Inhibited	31
Styrene Monomer, Inhibited	30
Alcohol, N.O.S.	27
Paint Related Material	21
Fuel Oil	16
Phosphorus White or Yellow, in Water	16
Methyl Alcohol	16
Chlorine	15
Combustible Liquid, N.O.S.	15
Ammonium Nitrate Fertlizer (≤.2% C)	14
Acetone	13
Total (Total Incidents For Year = 1274)	834/1274 = 65%

TABLE 2. TOP 20 COMMODITIES INVOLVED IN RAIL INCIDENTS IN 1980

Commodity	Incidents
Liquified Petroleum Gas	154
Sulfuric Acid	140
Ammonia, Anhydrous	76
Hydrochloric Acid	60
Alcohol, N.O.S.	54
Flammable Liquid, N.O.S.	50
Phosphoric Acid	48
Sodium Hydroxide, Liq or Sol	48
Corrosive Liquid, N.O.S.	40
Styrene Monomer, Inhibited	28
Paint Related Material	25
Petroleum Naphata (Combustible)	22
Methyl Alcohol	22
Combustible Liquid, N.O.S.	21
Fuel Oil	19
Ethyl Acrylate, Inhibited	17
Acetaldehyde (Ethyl Aldehyde)	15
Ammonium Nitrate Fertlizer (<.2% C)	15
Crude Oil, Petroleum	15
Petroleum Naphata (Flammable)	14
Total (Total Incidents For Year = 1372)	883/1372 = 64%

TABLE 3. TOP 20 COMMODITIES INVOLVED IN RAIL INCIDENTS IN 1981

Commodity	Incidents
Sulfuric Acid	121
Flammable Liquid, N.O.S.	82
Phosphoric Acid	81
Hydrochloric Acid	76
Liquified Petroleum Gas	63
Ammonia, Anhydrous	60
Corrosive Liquid, N.O.S.	50
Alcohol, N.O.S.	35
Sodium Hydroxide, Liq or Sol	33
Styrene Monomer, Inhibited	24
Ethyl Acrylate, Inhibited	17
Combustible Liquid, N.O.S.	15
Ammonium Nitrate Fertlizer (<.2% C)	14
Petroleum Naphata (Combustible)	14
Fuel Oil	12
Gasoline	11
Petroleum Naphata (Flammable)	11
Sulfuric Acid (Spent)	11
Toluene	11
Carbon Dioxide, Liquid, Refrigerated	10
Total (Total Incidents For Year = 1183)	751/1183 = 63%

TABLE 4. TOP 19 COMMODITIES INVOLVED IN RAIL INCIDENTS IN 1982

Commodity	Incidents
Sulfuric Acid	94
Hydrochloric Acid	64
Alcohol, N.O.S.	55
Flammable Liquid, N.O.S.	51
Liquified Petroleum Gas	48
Ammonia, Anhydrous	37
Phosphoric Acid	35
Sodium Hydroxide, Liq or Sol	34
Corrosive Liquid, N.O.S.	22
Combustible Liquid, N.O.S.	21
Petroleum Naphata (Flammable)	16
Petroleum Naphata (Combustible)	15
Acetone	13
Ammonium Nitrate Fertlizer (<.2% C)	12
Ethyl Acrylate, Inhibited	11
Carbon Dioxide, Liquid, Refrigerated	10
Styrene Monomer, Inhibited	10
Potassium Hydroxide, Liq or Sol	9
Methyl Alcohol	9
Total (Total Incidents For Year = 893)	566/893 = 63%

TABLE 5. TOP 20 COMMODITIES INVOLVED IN RAIL INCIDENTS IN 1983

Commodity	Incidents
Sulfuric Acid	110
Liquified Petroleum Gas	70
Alcohol, N.O.S.	67
Hydrochloric Acid	54
Flammable Liquid, N.O.S.	52
Phosphoric Acid	48
Ammonia, Anhydrous	46
Sodium Hydroxide, Liq or Sol	28
Corrosive Liquid, N.O.S.	22
Fuel Oil, NO. 1,2,4, or 5	15
Petroleum Naphata (Combustible)	15
Petroleum Naphata (Flammable)	15
Combustible Liquid, N.O.S.	14
Methyl Alcohol	14
Benzene	10
Poison B, Liquid, N.O.S.	10
Vinyl Acetate	9
Acetone	8
Hydrogen Sulfide	8
Styrene Monomer, Inhibited	8
Total (Total Incidents For Year = 917)	623/917 = 68%

TABLE 6. TOP 18 COMMODITIES INVOLVED IN RAIL INCIDENTS IN 1984

Commodity	Incidents
Phosphoric Acid	78
Hydrochloric Acid	48
Sulfuric Acid	46
Liquified Petroleum Gas	35
Ammonia, Anhydrous	25
Denatured Alcohol	16
Flammable Liquid, N.O.S.	14
Methanol	14
Acetone	13
Caustic Soda, Liq or Sol	13
Ethyl Alcohol	13
Petroleum Naphta (Combustible)	11
Sodium Hydroxide, Liq or Sol	11
Vinyl Acetate	11
Corrosive Liquid, N.O.S.	10
Alkaline, Liquid, N.O.S.	7
Combustible Liquid, N.O.S.	7
Cresote, Coal Tar	7
Total (Total Incidents For Year = 652)	379/652 = 58%

TABLE 7. HAZARDOUS MATERIALS SHIPPED/SPILLED IN 1984

Hazardous Material	Shipped In Consists Where Spills Occurred (lbs)	Spilled (lbs)	No. Spilled
Dichloroethylene	499200	333216	1
Isobutyl Amine	182640	182640	1
Silver Cyanide	143462	8	1
Isobutyl Acetate	342102	168563	2
Triethylamine	1753565	50	2
Arsenic Acid	116480	416	3
Isobutyl Amine	424161	182732	3
Sodium Hydrogen Sulfate	1664000	26	3
Diethylamine	1038128	8253	4
Phosgene	440016	26	5
Ethylene Dichloride	1391944	385558	5
Acetonitrile	792463	449771	6
Ethyl Benzene	2313505	86289	6
Benzyl Chloride	2081281	216	6
Potassium Nitrate (Nitrite)	406700	400028	6
Arsenic Trioxide	39600	9147	6
Calcium Carbide	2130600	12161	7
Butyl Acetate	2310123	255857	7
Methyl Chloride	2426645	181234	8
Cresote	2099071	268490	8
Iso-and Butyl Acetate	2652225	424422	9
Sodium Hydrosulfite	334356	6674	9

TABLE 7. HAZARDOUS MATERIALS SHIPPED/SPILLED IN 1984 (CONT.)

Hazardous Material	Shipped In Consists Where Spills Occurred (lbs)	Spilled (lbs)	No. Spilled
Ferric Chloride	770833	191424	10
Sodium Cyanide	580853	1042	10
Acrylic Acid	1655270	250	10
Pyridine	1412395	683	11
Ammonium Sulfide	2635953	6856	11
Monomethylamine	1705909	124843	12
Ammonia (SOLN)	1342939	28847	12
Radioactive	877483	52	12
Cyclohexane	2848818	650907	14
Tetra Ethyl Lead	1153194	76138	14
Ethylene Oxide	2170278	522224	14
Tetrahydrofuran	1973261	845545	14
Potassium Permangnate	23986604	1048	15
Aniline	8920604	34561	16
Carbon Disulfide	1524124	19420	16
Diethylamine (Anhyd)	3080150	99392	17
Phosphorous Oxychloride	903144	2103	18
Hydrogen Fluoride	1350577	148321	20
Propylene Oxide	2659205	235317	20
Benzene	2147550	23221	22
Acetic Anhydride	4136122	892528	24
Phosphorous Trichloride	1441107	76899	25

TABLE 7. HAZARDOUS MATERIALS SHIPPED/SPILLED IN 1984 (CONT.)

Hazardous Material	Shipped In Consists Where Spills Occurred (lbs)	Spilled (lbs)	No. Spilled
Nitrating Acids	2347663	111980	25
Sulfur Chloride	1827271	1283	26
Ethyl Acetate	2464144	144590	26
Benzol Chloride	3759209	1220	26
Hydrofluorsiliac Acid	3295561	307940	29
Toluene Isocyanate	2647898	356648	31
Formaldehyde	3724903	1902332	32
Sodium Nitrate	1687952	215432	35
Vinyl Chloride	4584178	3371739	36
Methyl Ethyl Ketone	3592485	19614	37
Carbolic Acid	5107993	632601	43
Naphtha	4165997	190462	46
Hydrogen Peroxide	3648721	140163	49
Nitric Acid	5213157	106391	49
Methyl Methacrylate	7925793	505418	55
Acrylonitrile	9805677	1141405	56
Xylene	7283967	587187	57
Sulfuric Acid (Spent)	10710777	446381	73
Potassium Hydroxide	5256657	981235	78
Vinyl Acetate	10923720	2921974	78
Toluene	10051621	231209	81
Acetone	11735728	1020129	81

TABLE 7. HAZARDOUS MATERIALS SHIPPED/SPILLED IN 1984 (CONT.)

Hazardous Material	Shipped In Consists Where Spills Occurred (lbs)	Spilled (lbs)	No. Spilled
Acetaldehyde	13609293	1495182	84
Acetic Acid (SOLN+Glacial)	11776471	1293336	85
Chlorine	7278101	242645	86
Phosphorous	10634373	1375462	89
Ethyl Acrylate	18683424	1168437	94
Styrene Monomer	22902792	841470	139
Methyl Alcolhol	30100314	2953391	162
Sodium Hydroxide	42762246	2946205	422
Hydrochloric Acid	75592120	2458607	511
Ammonia (Anhyd)	102772605	4355835	591
Phosphoric Acid	71731198	8048869	623
Sulfuric Acid	334050848	1962382	1128

5. MONITORING DEVICES

5.1 INTRODUCTION

The monitoring devices fall into four categories based upon intended use, complexity, or cost. These categories are:

1. Combustible gas detectors and specific single component detectors requiring close proximity to spilled material.
2. Multiple component detectors requiring close proximity to spilled material.
3. Mobile laboratories requiring sample of spilled material for remote analysis in mobile laboratory.
4. Mobile remote multiple sensing equipment that can be used at distances of up to 1 kilometer from a spill.

These monitoring devices fall into four cost categories with category (1) being the least expensive and category and (4) being the most expensive. All new monitoring techniques in each category will be described in detail and each evaluated for use with the response teams. Where available, descriptive literature from the manufacturers is included in the Appendix.

5.2 SINGLE COMPONENT MONITORING DEVICES

There are numerous varieties of combustible gas detectors which are designed to measure the Lower Explosive Limit (LEL) of combustible/explosive materials. There are other detectors to monitor total hydrocarbons, chlorine, carbon monoxide, carbon dioxide, oxides of nitrogen, sulfur dioxide, phosgene, arsine, and other gases. However, there is not a one to one correspondence of detectors for all the hazardous materials listed in Section 4.0. Table 8 lists various types of these detectors and is only representative of the numerous manufacturers of similar equipment.

In view of the multicomponent monitoring devices discussed in Section 5.3, it would not be cost-effective to spend $30,000 for ten $3,000 single monitoring devices if a single, multicomponent device will do approximately as

TABLE 8. SINGLE COMPONENT MONITORING DEVICES

Manufacturer	Material Detected
MAST Development Co.	Oxidation Products
Airco, Industrial Gases	Arsine/Phosphine
CEA Instruments, Inc.	NH3, C12, HC1,HCN,HF,H2S, NO2, HCHO, N2H2, SO2
M-C Products	Combustible Gases
U.S. Industrial Products, Inc.	Combustible Gases, H2,NH3, LP/Gasoline, CO
Detektor	Combustible Gases
Gas Tech	Combustible Gases, H2S
Bacharach	Combustible Gases
Delphian Corporation	Combustible Gases
Bendix	Combustible Gases, H2S,NH3, HCN,C12
Sierra Monitor Corporation	Combustible Gases
Horiba	Hydrocarbons, CO, CO2

well for less money. Single component monitoring devices only make sense if one is looking for only a single device to monitor the most frequently spilled material, the most hazardous material, or the most frequently shipped hazardous material, and only when cost is the limiting factor. For example, if chlorine gas were frequently shipped and frequently spilled, say 75 percent of the time, it might be cost-effective to have a detector for chlorine gas on those shipments. However, to select 10 or more sensors for various materials thought to be potential problems, but not frequently spilled, would be a waste of time and money for purchase of the sensors, training, and operating supplies.

5.3 MULTICOMPONENT MONITORING DEVICES

Since the Saunders and Kager report was written, (1) a number of portable monitoring devices have been developed that could be taken to the site of a spill and used to determine the presence of up to eight or more different compounds. These devices would require that the response team personnel go to the vicinity of the spill and take a quick sample sniff of the order of 10 to 20 seconds. If the spilled material is dangerous, i.e., flammable, explosive, or highly toxic, special protective clothing or a breathing apparatus will be required. These portable devices are usually precalibrated for the compounds of interest and can measure concentrations in addition to identifying the compounds, if present. One of the main disadvantages to these devices is that the calibration has to be done ahead of time, and if the compound at the spill site is not in the calibration, the unit must be recalibrated for different compounds. These devices almost require the response personnel to have some knowledge of what the spilled material might be. Such devices could be calibrated for the most frequently spilled materials, the most frequently shipped commodities, or the most hazardous materials. For example, from the information provided in Section 4, eight or ten selected components could be programmed into the sensors and the probability of these occuring in spills would be reasonably high.

5.3.1 XonTech GC-810 Hazardous Vapor Detector

XonTech, Inc.'s Model GC-810 Hazardous Vapor Monitor is a portable, automatic gas chromatograph capable of automatically sampling ambient air, and

detecting up to four constitutents and their respective concentrations. System operation consists of four stages; sampling stage, chromatographic separation stage, detection stage, and analysis and data processing stage. With the exception of a carrier gas cylinder, the unit is self-contained. (See Figure 1.) A sample pump pulls an air sample over a specially coated platinium wire concentrator in the sampling position. The sampling cartridge containing the platinium wire concentrator is moved into the analysis position after which the platinium wire is quickly heated to remove any absorbed gases. These desorbed gases are then swept by carrier gas into the gas chromatographic column where they are separated and then identified by the appropriate detector.

Currently, only four different compounds may be detected, but there are plans to greatly increase the number of identified compounds. The limit to the number of compounds detected is determined by the chromatographic column and detector used. Any chromatographic column may be used that separates the desired compounds. Situations may arise in which all the compounds of interest may not be separated. The compounds have to be detectable by either the electron capture or the argon ionization detector. This requirement does limit the number of compounds detected to those that have responses to these detectors, but this number is very large. It includes all halogenated compounds; all nitrated compounds; compounds containing phosphorus; most aromatic compounds; and most organic compounds containing carbonyl groups (-C=O) and/or double bonds. In order to respond in concentration units of specifically identified compounds, the detector must be calibrated with standards for each identified compound. The minimum detectable concentration is as low as 5 parts per billion (5 ppb). A portable sampling pump containing the preconcentrator platinium wire may be taken to the site of the spill, the vapors sampled, and the preconcentrator unit returned and placed in the gas chromatographic unit for analysis at some other convenient location. The gas chromatograph weighs 50 pounds, can be operated manually or controlled automatically by a microprocessor, and can operate continuously or in single cycles on a batch basis. The current cost of this system is approximately $11,000.

5.3.2 Sensing Technology, Inc., Portable Gas Chromatograph

Sensing Technology, Inc. produces a portable gas chromatograph, called the "Scentor," which operates similarly to the XonTech GC-810 described above.

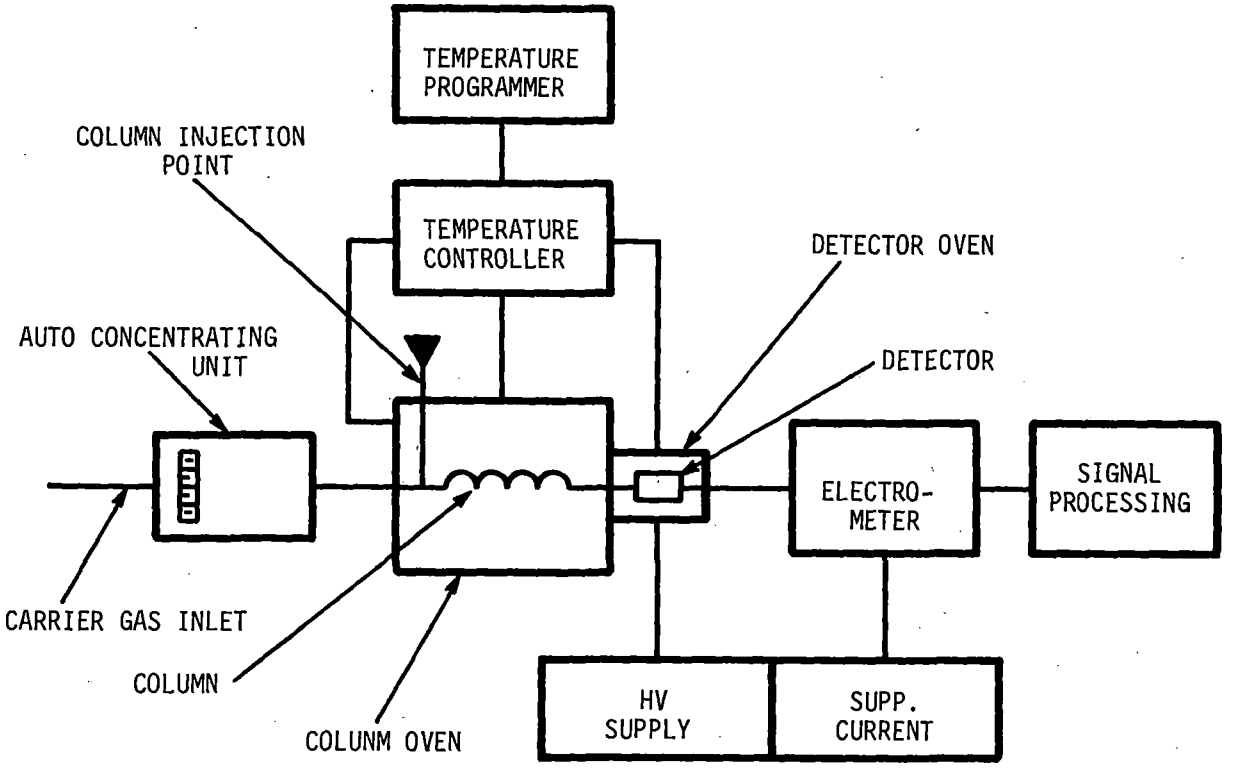


FIGURE 1. SCHEMATIC OF XONTECH GC-810 HAZARDOUS VAPOR MONITOR

This device has been designed to detect only five compounds and comes preprogrammed to detect only these compounds (benzene, toluene, vinyl chloride, ethylene oxide, and ethyl benzene). The manufacturer has indicated that the list of compounds will be expanded. The unit was designed for industrial hygiene monitoring of these specific compounds in the workplace. If the expanded list of compounds is extensive, this device would be competitive with the XonTech GC-810 in its importance to the response team monitoring requirements. The unit is very similar in design and operation to the XonTech GC-810 and costs about the same.

5.3.3 Microsensor Technology, Inc., Micromonitor

Microsensor Technology, Inc. has developed the Micromonitor Universal Gas Monitor that can identify up to 100 different gases, 10 at a time, in 45 seconds. The heart of this instrument is a series of miniature modules which are complete gas chromatographs. Based on development begun over 12 years ago at Stanford University, a new technology called silicon mircomachining allows all carrier gas and sample channels, valve structures, and a tiny thermal conductivity detector to be integrated onto a single 3-inch silicon wafer. A 0.1 mm ID capillary gas chromatography column is interfaced to this wafer. The result is an ultra-high-speed, high-resolution gas chromatography system with outstanding performance.

The instrument will measure the concentrations of any of the 100 gases stored in its internal library. Gases can be selected and measured in any combination of up to 10 gases at a time. Nine groups of up to 10 gases may be defined and stored in the microprocessor memory for recall. Concentrations from 1 ppm to 100 percent can be measured with a cycle time of 45 seconds for up to 10 gases per cycle. The instrument can be programmed to take automatic samples at any interval up to one sample per minute. The results of at least 1000 analyses can be retained in the instrument's microprocessor. Calibration is executed by the internal computer using a standard calibration gas mixture or user-supplied standards. The instrument weighs 35 pounds, uses a small internal helium carrier gas cylinder good for 16 to 48 hours of continuous sampling at a rate of one sample per minute, and operates either on internal rechargable batteries with built-in charger or directly on 110 VAC power. The instrument

costs $8,800 and each detection module is $2,500. With a maximum of five detection modules, approximately 50 to 60 different gases could be detected for a cost of $21,500. The number of gases detected would depend upon the choice of the chromatography columns used.

5.3.4 Foxboro Miran 1B Portable Ambient Air Analyzer

The Miran 1B Infrared Analyzer is a portable microprocessor-controlled instrument that can detect and quantitatively measure any gas having absorption bands in the infrared region from 2.5 to 14.5 micrometers. This range clearly covers over 300 OSHA cited vapors and gases, plus numerous others (see the manufactures literature in the Appendix for the compound library). The microprocessor of the Miran 1B analyzer simplifies the operation and calibration of the instrument with automated wavelength and pathlength settings. An operator-interactive keyboard with extensive alphanumeric display prompting leads the user through the modes of operation. All calibration and analysis parameters are stored in a nonvolatile memory. The instrument comes precalibrated to analyze for 116 OSHA-cited and frequently encountered gases. The compound library has room for up to 10 additional user-selected gases that are entered through the keyboard.

The Miran 1B provides fast on-the-spot, real-time analysis in just 10 seconds. Because of the microprocessor control, all operations are simplified; the software program prompts the operator through all steps of the analysis, thus eliminating the chance of errors in monitoring hazardous gases. The operator simply enters the gas code name and the analyzer automatically sets the wavelength and the pathlength for that particular compound. A complete analysis takes only a few minutes. The results are clearly shown in concentration units on the liquid crystal display. Alarms can be set for concentration limits, operator error, and exceeded concentration limits.

The Miran 1B is lightweight, weighing just 28 pounds, and can be powered by an internal rechargeable battery pack for up to four hours. The unit is easy to use, is error free, and requires little operator training. Concentrations from a few ppm's to percent concentration levels can easily be made. The detector costs $12,500 and a complete system with calibration modules is $20,000.

5.3.5 Argonne National Laboratory CPS-100 Chemical Parameter Spectrometer

Under contract to the U.S. Coast Guard, Argonne National Laboratory is developing a prototype portable monitor for use by U.S. Coast Guard emergency response teams. The FRA is participating in the contract and will receive a prototype monitor for evaluation. The prototype is a portable instrument for detecting, identifying, and monitoring all or most of the approximately 30 compounds frequently encountered in JANNAF (Joint-Army-Navy-NASA-Air Force Interagency Propulsion Committee) missions. (2, 3) A battery-powered prototype is about 12 in. by 7 in. by 4 in. in size and weighs about 8 pounds. It utilizes an array of four different amperometric gas sensors operating with or without one of two heated noble metal filaments. The latter generates electrochemically detectable products, and thereby extends the applicability of amperometric sensors to those compounds which are not normally electrochemically active. Moreover, by operating the array with or without a heated filament, and by switching to a different filament temperature or composition, it is possible to obtain several differently selective sensing modes with the same array. This yields easily 16 to 36 independently measured parameters using only 4 to 6 sensors. With a suitable choice of sensors and operating modes, it is estimated that a microprocessor algorithm utilizing a set of 24 independent parameters may be able to identify any one of up to about 100 different hazardous compounds in the air either singly or in uncorrelated mixtures of up to four such compounds. (4)

The prototype detector has been under development since 1983 and the first prototypes are now being tested. To date, histogram and response vs concentration plots presented for 17 compounds of interest to JANNAF members show that each compound is distinguishable from the others through its response pattern, and that the sensor responses are proportional to the concentration of each compound in the usually encountered ranges (0 to 50 ppm). For the subject array, the estimated lower limit of detection ranges from 0.1 ppm to 12 ppm depending upon the compound. (5) The U.S. Coast Guard R&D Center estimates that a commercialized first generation monitor that could detect up to 25 hazardous compounds should be available sometime in 1987. Expanding the capability to monitor up to 100 compounds will be investigated later. No estimated cost information is available.

5.3.6 Photovac, Inc., Portable Photo-Ionization Gas Chromatograph

Photovac's Model 10A10 portable photo-ionization gas chromatograph was designed to analyze directly injected air samples for contaminants in the 0.1 ppb to 100 ppm concentration under laboratory or field conditions. The unit operates in conjunction with a portable chart recorder, has a built-in supply of air carrier gas and is provided with rechargeable batteries. The unit is normally configured for a sample introduction by a gas syringe; both manual and automated valve versions are available. The gas chromatography columns are mounted inside the unit and operate at room temperature. There are flow controllers to regulate the carrier gas flow. The unit weighs about 25 pounds and with the chart recorder sells for about $10,500.

This unit is the most sensitive of the portable gas chromatographs. Its sensitivity derives from the design of the special photo-ionization detector. However, the unit cannot be operated automatically and interpretation and calibration by the user are required. This is somewhat of a drawback when the spilled material is not known. In addition, this detector is only sensitive to those compounds that can easily be photoionized. Such compounds include:

Volatile Hydrocarbons: alkanes above ethane, ethylene, isoprene and other alkenes, cyclic compounds, benzene, toluene, xylene and other aromatics.

Chlorinated Hydrocarbons: vinyl chloride, chloroform, methyl chlorides, haloethane, trichloroethylene, and other alkyl and aryl chlorides and fluorochlorocarbons.

Sulfur Compounds: hydrogen sulfide, carbon disulfide, mercaptans, and other alkyl and aryl sulfides.

Nitrogen Compounds: acrylonitrile and other cyanides, methylamine, ethylamine, and other amines, nitrobenzene and other nitrocompounds, and isocyanates.

Alcohols, Aldehydes, Ketones, Esters: ethanol, isopropanol, formaldehyde, acetaldehyde, acetone, methylethylketone, cyclohexanone, ethyl acetate, and others.

Inorganic Compounds: phosphine, arsine, ammonia, hydrazine, nitric oxide, and others.

Photovac has produced an automated multichannel air monitor that can monitor from one to four locations automatically at predetermined times and with automatic calibration and direct readout of concentration. However, the cost of a unit that could detect up to four compounds is approximately $35,000, which would make such a unit impractical for response team monitoring. In addition, this automated unit is not a portable device and would have to be placed in a van for power and mobility, making it somewhat of a marginal technique for the use of response teams.

5.3.7 MDA Scientific, Inc., Model 7100 Continuous Toxic Gas Monitor

The Model 7100 Continuous Toxic Gas Monitor is not a portable device and therefore must be used in a van or at a location with 110 VAC power. The system is specific and highly sensitive to a particular substance or a group of substances. This selectivity is achieved through the use of a proprietary Chemcassette Detection System which can provide up to 4 weeks of unattended operation. During operation, the Chemcassette is indexed through a sampling window where it is exposed to a metered sample stream. If the target gas is present, a stain proportional to the concentration develops. Simultaneously, a beam of light is reflected off the exposed portion of the tape and the intensity continuously measured. As the amount of reflected light decreases due to stain development, the reduction is sensed by a photocell detector analog signal. This signal is converted to a digital format, matched to the gas response curve stored in the 7100's permanent memory, and displayed/documented as the actual concentration value.

The 7100 may be programmed to detect and measure up to 8 different gases through user friendly software. The unit is fast responding and can detect the selected gases at the low ppb level. The main disadvantage of this system is that only 19 different gases can be detected, with most of these being inorganic gases such as ammonia, chlorine, phosgene, hydrides, hydrogen halides, and others. No organic hydrocarbons are detectable. It would appear that this detector would have limited use for a response team.

5.3.8 Other Portable Gas Chromatographs

There are other portable gas chromatographs of comparable quality such as the Baseline Industries, Inc., Model 1030, the Analytical Instrument Development, Inc., Model 910, and the Foxboro Corp. Models 108 and 128 Century Organic Vapor Analyzers. Each of these is portable, battery operated, and easy to use. However, the limiting sensitivity is about 1 ppm and there is no means of automatic calibration and identification. This requires the user to take a sample and then run standards until the correct compound retention time is found. The correct retention time identifies the compound and now a calibration must be performed. This would be too time-consuming for a response team and thus such devices are not recommended for serious consideration.

5.4 MOBILE LABORATORIES FOR ON-SITE ANALYSIS

5.4.1 Background

There have been several mobile analytical facilities developed in the past few years to provide analysis of spilled materials, measurement of airborne contaminant concentrations, and mapping of hazardous vapor clouds to determine if evacuation of the populace is advisable. These mobile vans are usually equipped with state-of-the-art analytical equipment and are very expensive. It would not be cost-effective for each response team to have such a van, but if a mobile analytical facility were in the vicinity of the spill, use of the facility would be ideal for the response team to evaluate the spilled material. Again, the requirement would be that a grab sample or a sniff of the spilled material be taken to the mobile lab for analysis.

5.4.2 U.S. Coast Guard Mobile Response Laboratory

The U.S. Coast Guard has constructed a mobile analytical laboratory to avoid the forwarding of a spilled sample to an analysis facility. (6) This mobile facility can be outfitted with specific instrumentation for known spilled materials such as oils and fuels, or it can be instrumented with equipment for the identification of unknown spilled material. The analytical instrumentation

that can be included in the van are gas chromatographs, high-performance liquid chromatographs, fluorescence/absorption spectrometers, Fourier transform infrared spectrometer, Vreeland spectroscope, and more recently, gas chromatograph-mass spectrometers. There is also a host of support equipment such as fume hoods, pH meters, ovens, centrifuge, balances, remote air sampling systems, wet chemistry kits for specific materials, and a computer for analysis of data.

The mobile van can be deployed by a flatbed trailer or carried on an air transport plane. The U.S. Coast Guard has deployed the mobile laboratory six times during the past three years and, in all cases where used, has been a vital aid to the response teams. In Kodiak, Alaska, the repsonse van was airlifted to a spill site and within two hours was making analytical analysis of spilled PCB's in order to assess the effectiveness of the clean-up procedures. Because the van must be moved by flatbed to the response site, the response time to most spills is estimated to be 24 hours. This would not be adequate in the event of a toxic or very dangerous spill; but if a mobile van were in the vicinity of a spill, it would be a valuable tool.

5.4.3 Mobile Mass Spectrometers

There are three companies that offer mass spectrometers in mobile vans for on-site analysis of hazardous materials. Sciex, Inc. pioneered in the development of mobile mass spectrometers with the introduction of first the TAGGA 3000 mass spectrometer and more recently, the TAGGA 6000E tandem mass spectrometer/mass spectrometer. The TAGGA 6000E is a $500,000 triple quadrupole mass spectrometer and data system that has very high sensitivity and resolution. The system can perform ppt detections with very high specificity obtained by using the triple quadrupole mass spectrometers.

One of the most famous uses of the mobile mass spectrometers was the Sciex Mobile TAGGA 3000 monitoring of the Chlorine gas spill in Mississauga, Ontario, Canada, November 10, 1979. (7) The manifest of the derailed cars indicated that there were 90 tons of chlorine, 225 tons of styrene, 67 tons of toluol, 742 tons of propane, 366 tons of caustic soda, 135 tons of toluene, and 52 tons of fiberglass insulation. After the initial explosions, fire broke out and continued for several days. In the middle of the derailment was the chlorine

tank car which begain leaking. By the evening of November 11, 200,000 residents had been evacuated because of the leaking cloud of chlorine gas. The Sciex mobile van was called in to measure the extent of the chlorine gas cloud and was able to map the concentration of the chlorine gas downwind of the derailment and determine the extent of the required evacuation. The chlorine levels measured were used by the Canadian MOE (Ministry of the Environment) to determine the potential effect on human health. The mobile nature of the monitoring system, and the ability to provide real-time measurements of chlorine concentrations or the detection of other compounds, allowed the officals at the command center, who were directing the operations of the containment of the fire, evacuation of the citizens, and removal of the chlorine, to be continually aware of the chemical hazard level in the area around the site. Although the chlorine concentrations in the areas where the TAGGA system monitored did not rise to a level which presented a severe hazard to the emergency response personnel working in the area, the continuous monitoring provided assurance that they would be warned if the levels did become hazardous. The cost of doing such monitoring is not known, but it was very expensive. Again, this is not the type of system that each emergency response team should use, but if such a system is in the vicinity of a derailment its use should be considered.

York Research Consultants, Inc., and TMS Analytical Services, Inc., offer a Sciex 6000E tandem mass spectrometer/mass spectrometer with chemical ionization and atmospheric-pressure chemical ionization sources for the rapid on-site analysis of trace organics in water, air, and soil samples at the ppt level. This analyzer can be interfaced with a gas chromatograph, a liquid chromatograph, or a direct air inlet system. The charge for a MS/MS scan of a single gas chromatograph peak is $200, and the cost for a MS/MS scan on a single liquid chromatograph peak is $500, and $50 for each additional peak in the sample. An air scan with background subtraction or a scan for a series of targeted compounds is $500 per sample. Again, this is a very expensive service, but would be the best and most versatile in identifying any unknown material and should be used if available.

5.5 REMOTE DETECTION MONITORING TECHNIQUES

5.5.1 Optical Remote Monitoring Techniques

One general class of methods for measuring pollutant concentrations makes use of lasers and other optical sources to probe the atmosphere remotely and obtain spectoscopic information about the molecules present in the segment of the atmosphere under consideration. These methods are listed below:

- o Raman Lidar
- o Remote sensing laser fluorometer
- o Tuneable semiconductor lasers
- o Tuneable infrared lasers
- o Coherent laser radar
- o Laser Raman spectroscopy
- o Laser near-resonance Raman spectroscopy
- o Resonance absorption of semiconductor and gas laser radiation
- o Dispersive mechanical correlation spectroscopy
- o Nondispersive optical correlation spectroscopy
- o Interferometry
- o Infrared fluorescence emission measurement.

All of the above methods are based on optical concepts. The Raman measurements entail the use of lasers that emit in the ultraviolet spectral range. The other measurement techniques involve the use of radiant energy sources that emit in the infrared spectral range.

All of the above remote sensing techniques were developed to detect and measure the concentration of individual atmospheric pollutants such as SO2, NO, CO2, NO2, etc., and were not designed to scan over a variety of wavelengths for other unknown compounds. What is needed is a high powered, tuneable laser system, that operates over the wavelength range of interest, is not affected by the absorption of the atmosphere, and has the correct laser line in the windows required for the various compounds. Such systems are only available for special cases and should not be considered for use by emergency response teams.

One special case is the LNG monitor developed by the Jet Propulsion Laboratory. (8) Two systems were developed for the U.S. Coast Guard for monitoring leaks in LNG tanks. One of these systems utilizes a helium-neon laser operating at 3.39 μm, a wavelength which overlaps a very strong methane spectral line. The other system, a two-band differential radiometer (TBDR), utilizes the differential absorption of methane at two narrow wavelength regions in the near infrared. The successful testing of the TBDR sensor led to the development of an instrument to be used to detect, simultaneously, concentrations of methane, ethane, and propane within a dispersing vapor cloud from an LNG spill test. This instrument is the Four-Band Differential Radiometer (FBDR), which operates similary to the TBDR with the exception that four filters make up the species-specifying component of the system. These systems demonstrated the detection of LNG spills and the response time of the FBDR allowed measurements of concentration vs. time rapidly enough to be useful in obtaining data for use in modeling the overall dispersion behavior of the LNG test cloud.

Another special case is the Backscatter/Absorption Gas Imaging (BAGI) technique developed by Lawrence Livermore National Laboratory for detecting spills of liquified gaseous fuels. (9, 10) The principle of operation of the BAGI technique is based on the irradiation of the field of view of an imaging device by laser radiation corresponding to an absorption line of the gas species to be detected. The technique requires that a reflective or scattering background be in the field of view, and also that the laser wavelength corresponds to an atmospheric transmission window. The selected laser output beam is made to coincide with the field of view of the IR imaging system detector. The laser power must be of sufficient magnitude that the backscattered component is equivalent to the thermal emission of the background integrated over the spectral bandwidth of the imaging system. To avoid the possibility that the laser component could cancel out the thermal component rather than augment it, the spectral bandwidth of the imaging system must be reduced until the back-scattered laser component dominates the signal. In the absence of the hazardous gas, the backscattered laser component produces an image of the terrain on the TV monitor. However, when the hazardous gas is present, both the incoming and backscattered laser radiation are reduced due to

the strong molecular absorption of the gas at the laser wavelength. The difference in contrast between the area where the gas is present and where it is absent produces an image or shadow of the gas cloud on the TV monitor. The higher the gas concentration, the greater is the absorption, and the more apparent the image of the cloud. A fundamental requirement for the success of the BAGI technique is the existence of a laser whose radiation is reasonably well absorbed by the hazardous gas of interest. With the existence of tuneable lasers, this requirement is theoretically obtainable for all gases. These tuneable laser systems are expensive, complicated, and not designed for use in the field. Until tuneable laser systems are developed, the BAGI system is limited to the use of continuous wave gas lasers which have the necessary wavelength stability, output power, beam divergence, and are reasonably compact and rugged. These requirements limit the gases that can presently be detected by this method.

5.5.2 Fourier Transform Infrared

The Environmental Protection Agency sponsored research to develop a remote Fourier Transform Infrared system to measure the concentrations of gaseous pollutants. (11, 12, 13) This system, called the ROSE (Remote Optical Sensing of Emissions) System, is used in two modes: (1) with a remotely located light source to make longpath (up to 1.5 kilometers) absorption measurements, and (2) with an adjustable tracking mirror to make single ended emissions measurements of stack effluents. The light-source telescope used for the long-path absorption measurements is an f/5 Dall-Kirkham configuration with a 30 cm diameter primary mirror. The light source is a 1000 watt quartz-halogen lamp. The receiver telescope (identical to the source telescope described above) collects energy from the remote light source directly and focuses the energy (in either mode of operation) at the interferometer aperature. The interferometer and peripheral equipment comprise a standard Nicolet Instrument Corporation Model 7199 FT-IR System. The detector is a dual-element, sandwich-type configuration mounted in a liquid nitrogen dewar. For the 1800 to 6000 cm-1 region, Indium Antimonide is used, and Mercury Cadmium Telluride is used from 600 to 1800 cm-1; the regions are scanned separately. The system has been used to monitor a jet engine, brick kiln, gypsum pond, and industrial stack emissions.

As with the other remote detection devices, this device is very expensive and not cost-effective to use as a standard response team sensing device. However, if such an instrument were available in the vicinity of a major spill, it would provide the needed information for the response teams' safety. To attempt to provide each response team with such a system would be impractical.

6. CONCLUSIONS

As a result of this review of commercially available monitoring devices, two candidate detection systems stand out as having potential for use by railroad emergency response teams. These devices are the Foxboro Miran 1B Infrared Analyzer and the Microsensor Technology, Inc., multichannel minature gas chromatograph. Both devices cost in the neighborhood of $20,000, but the Miran IB Infrared Analyzer offers the potential to survey for more compounds than the Microsensor Technology gas chromatograph. It is suggested that the potential of these systems be evaluated for their detection capabilities of the most often spilled, most toxic or flammable materials transported by tank cars.

In keeping with the comments of some of the various emergency response people contacted, the detection device should be assigned to individual members of a response team or selected railroad person so that the training and use of the instrument is restricted. These people should be the senior response personnel or should report directly to the senior response offical. In this way, proper interpretation of the results is assured, training is minimized, and correct operation of the equipment is guaranteed.

It should also be kept in mind that the surest way to identify compounds at a spill is the analysis of a grab sample by gas chromatography-mass spectrometry. This type of analytical equipment is becoming more and more routine; cheaper, with full systems and data analysis costing only $60,000; and user-friendly software that requires trained technicians instead of highly trained professionals. Although this equipment is expensive, the railroads could establish some central locations where grab samples could quickly be analyzed. As an alternative, some other agency could establish 10 or 12 regional laboratories where samples could be taken for analysis.

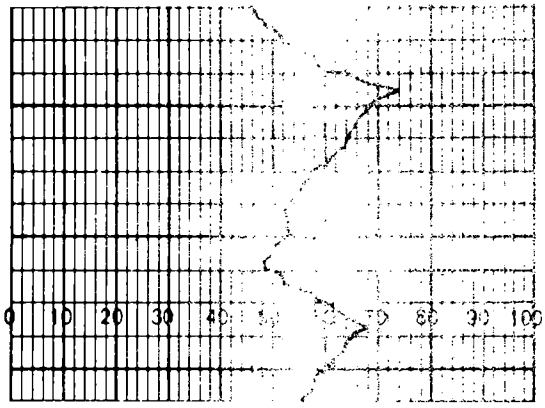
There are several remote detection devices and mobile laboratories around the country and these could be used whenever one is within practical distance to a hazardous materials spill.

APPENDIX

MANUFACTURERS' LITERATURE

TABLE OF CONTENTS

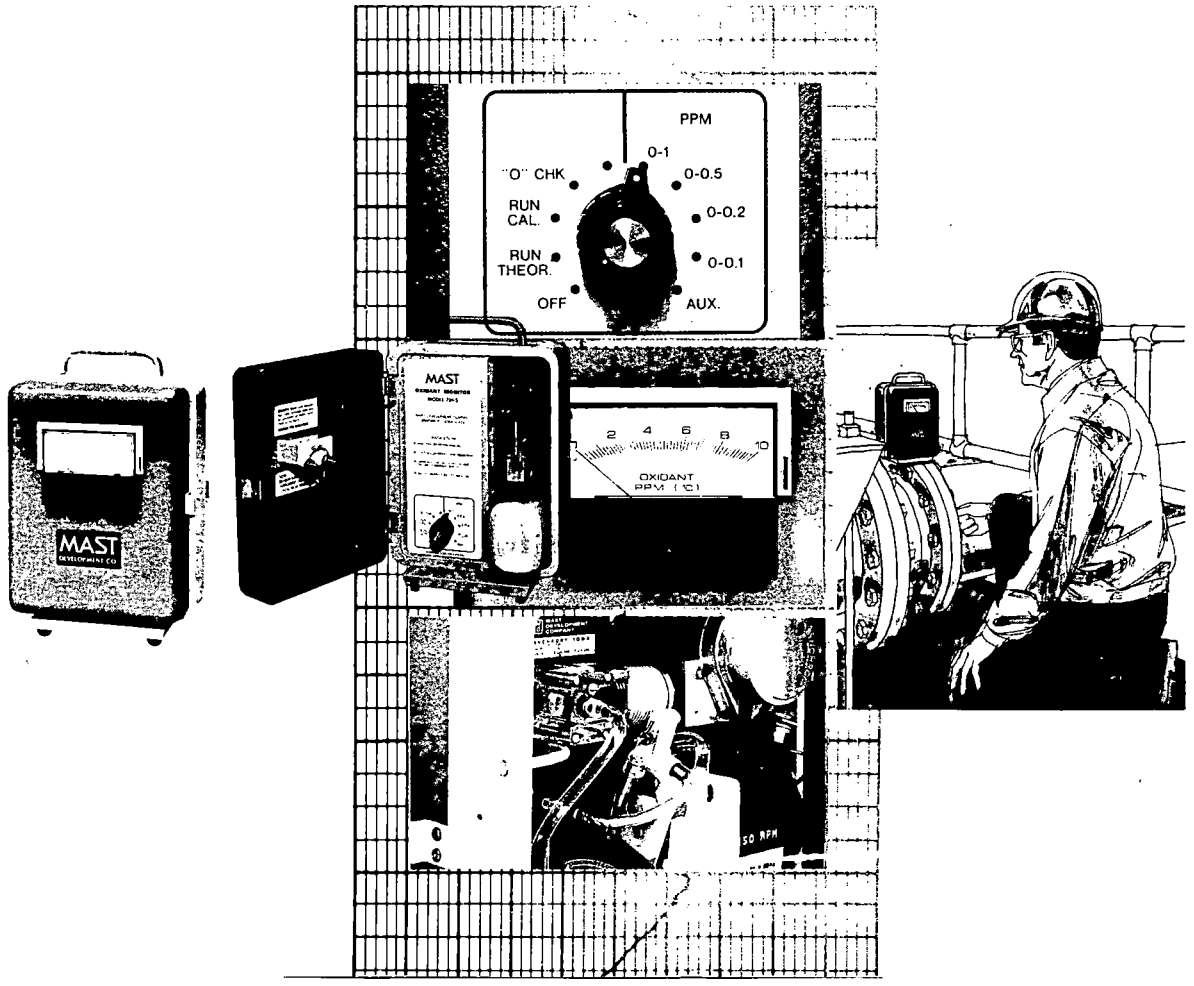
TABLE OF CONTENTS (CONT.)



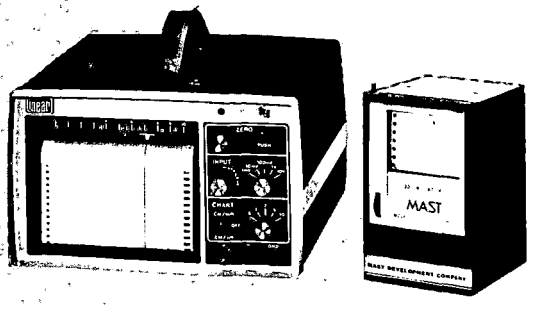
MAST

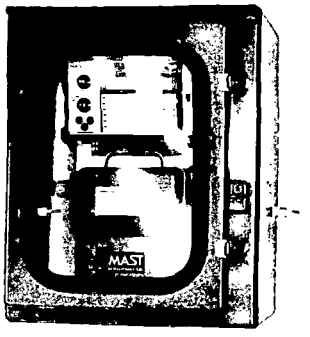
AIR MONITORING DIVISION

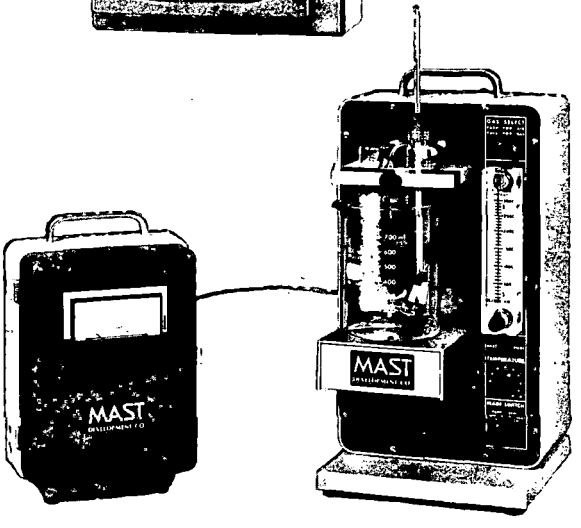
Series 724 Oxidant Monitors



Accessories







RECORDERS:
Several recorder models are available for use with Series 724 Monitors.

FILTERS:
Model 725-30 SO_2 filter kit is used when oxidant sample may contain interfering sulfur dioxide. Filter removes SO_2 but does not destroy 0_3 or other oxidants. Twelve individual filters supplied with each kit.

WEATHER-PROOF AND CORROSION RESISTANT CASES:
Special housings to protect monitors from harsh atmospheres are available. Consult factory.

CALIBRATION SYSTEM:
Model 822-1 Calibration System is used with permeation tubes to provide calibration standards. Request Bulletin C-70 for full details.

Represented by:

MAST
DEVELOPMENT CO.
AIR MONITORING DIVISION
2212 East 12th Street, Davenport, IA 52803
Phone: 319-326-0141 Telex: 468444

73-6916

HCl HCHO HF

NO_2 CL_2

HCN NH_3

NOx H_2S

N_2H_4 SO_2 TOx

AND CAN BE ADAPTED TO OTHER ANALYSES

FEATURES

- TRULY PORTABLE
- CONTINUOUS ON-SITE READOUT
- HIGH SENSITIVITY
- USES STANDARD CHEMICAL PROCEDURES
- PORTABLE AC/DC OR PERMANENT RACK MOUNTING
- LIGHTWEIGHT
- RUGGED FOR USE ANYWHERE
- COMPLETELY SELF CONTAINED
- RECORDER OUTPUT
- EASILY CONVERTED TO OTHER ANALYSIS

ENGINEERED FOR PORTABLE USE

The interchangeable TGM 555 air monitor weighs only 30 pounds and measures 20" x 16" x 7". That's ultra portability. It is a rechargeable battery operated unit that can provide over 12 hours of independent DC operation. It can also run on AC for laboratory operations for indefinite periods.

The TGM 555 can be taken into places completely inaccessible to other analyzers. It was designed to be hand carried into the field, into the plant, as well as used in stationary installations, even in moving vehicles.

The TGM 555 is truly flexible and easily interchanged. All that is required is to change reagent(s), and in some cases, to change the analytical module tray which contains the necessary glassware. The unit is extremely sensitive and for many of the analyses can operate over a range of maximum sensitivity of 0-0.2 ppm full scale, detecting as minute a quantity as 0.002 ppm or 2 ppb of the gas to be measured, adjustable to a full scale range of more than 10 ppm.

Yet it is significantly lower in cost than other air pollution data acquisition systems you can buy.

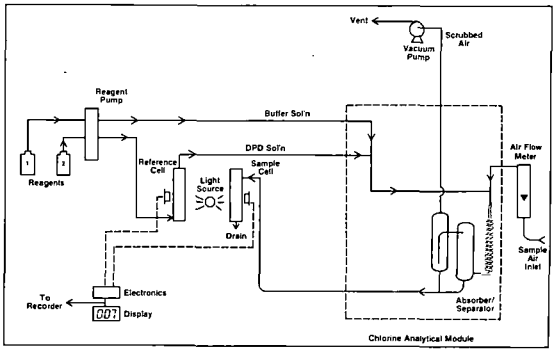
The TGM 555 is extremely precise and quick to respond, but is so simple to operate, even an unskilled assistant quickly learns its operation.

TGM 555 TOXIC GAS MONITOR

PRINCIPLE OF OPERATION

The TGM 555 contains a rechargeable DC power source and a constant-volume, adjustable air pump. An air sample is continuously drawn into the unit and scrubbed with an absorbing reagent which removes a trace pollutant from the air stream and transfers it into the liquid reagent system.

The subsequent color formation is read by a colorimeter and displayed on a digital readout. A recorder output is also provided.



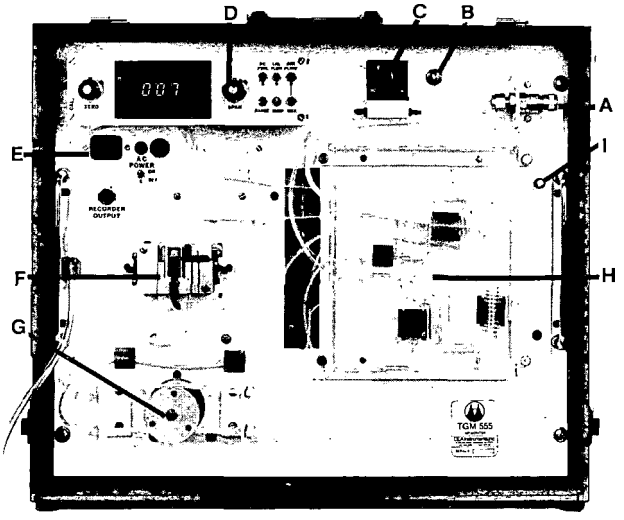
SIMPLER DESIGN, LOWER COST

The TGM 555 has fewer parts, less circuitry. Through the use of a patented optical system, there are no mirrors, prisms, or light choppers to go out of critical alignment. Because it has fewer mechanical parts, maintenance costs are minimal. You will save many man-hours with the 555 too, because it will operate unattended for extended periods. The 555 is precise, quick to respond and simple to operate, even an unskilled assistant can learn its operation. Changing analysis is as easy as changing a tray.

TYPICAL PERFORMANCE SPECIFICATIONS

CHLORINE

Standard Range:	0-2 ppm (adjustable 0-0.2 ppm up to 0-5 *ppm full scale*)
Reproducibility:	1%
Minimum Detection:	0.002 ppm at 0-0.2 ppm full scale or 1% of full scale
Nonlinearity:	Less than 2% up to 3 ppm
Zero Drift:	Less than 2% per 24 hours
Span Drift:	Less than 2% per 24 hours
Airflow Drift:	Less than 1% per 24 hours
Zero Noise:	± 0.2%
Lag Time:	Less than 3 minutes
Rise Time:	(90%) 3 minutes
Fall Time:	(90%) 5 minutes
Air Sample Flow Rate:	0.5 liters per minute
Optimum Temperature Range:	60° to 80°F.
Relative Humidity Range:	5 to 95%
Dimensions:	20"L x 16"H x 7"D
Weight:	30 lbs.
Power:	12V DC unregulated, 4 watts, 115/230V AC, 50/60 Hz (specify)
Operating Period:	12 hours on fully charged internal batteries
Recorder Output:	0-1V 2K impedence



The TGM 555 consists of the following components:

A. Air sample inlet
B. Air sample flow control
C. Air sample vacuum pump
D. Readout and control panel
E. AC power input
F. Continuous dual beam *colorimeter*
G. Peristaltic pump for the transfer of liquid to the scrubber and to the reaction and detection systems.
H. Analytical module tray consisting of vertical gas absorption coil, liquid-air separator and time delay coil.
I. Hinged door behind which reagent containers are stored.

OTHER AVAILABLE ANALYSIS

The 555 is truly flexible and easily interchanged. Changing chemistries is as easy as changing a tray. All that is then required is to change reagent(s). The techniques utilized, where possible, are in accordance with the latest *EPA reference methods and NIOSH publications.*

Acrylonitrile	AN	Chromic Oxidation	0-0.25 ppm adj up to 1.5 ppm
Ammonia	NH_3	Modified Berthelot	0-1.0 ppm adj up to 0-50 ppm
Bromine	Br_2	DPD Procedure	0-0.25 ppm adj up to 0-5 ppm
Chlorine	Cl_2	DPD Procedure	0-0.25 ppm adj up to 0-5 ppm
Fluorine	F_2	DPD Procedure	0-0.25 ppm adj up to 0-5 ppm
Formaldehyde	HCHO	Pararosaniline	0-0.2 ppm adj up to 0-10 ppm
Hydrazine	N_2H_4	p-DMAB	0-0.5 ppm adj up to 0-20 ppm
Hydrogen Chloride	HCl	Thiocyanate Method	0-2.5 ppm adj up to 0-100 ppm
Hydrogen Cyanide	HCN	Chloramine T	0-0.25 ppm adj up to 0-1 ppm
Hydrogen Fluoride	HF	Zirconium-SPADNS	0-1.0 ppm adj up to 0-10 ppm
Hydrogen Sulfide	H_2S	Methylene Blue	0-0.25 ppm adj up to 0-10 ppm
Nitrogen Dioxide	NO_2	Griess-Saltzman	0-0.25 ppm adj up to 0-10 ppm
Oxides of Nitrogen	NOx	CrO_3 Oxidation	0-0.25 ppm adj up to 0-10 ppm
Sulfur Dioxide	SO_2	West-Gaeke	0-0.25 ppm adj up to 0-10 ppm
Total Oxidants	TOx	DPD Procedure	0-0.25 ppm adj up to 0-5 ppm

*with optional stream splitter all ranges can be multiplied by a factor of 10 or 100.

CEA Instruments, Inc.
15 CHARLES ST. • WESTWOOD, NJ 07675 • (201) 664-2300 • TELEX 642128
PLEASE NOTE OUR NEW ADDRESS:
CEA Instruments, Inc.
16 Chestnut Street
Emerson, NJ 07630

Instrumentation

Instant Alert to Hazardous ARSINE and PHOSPHINE

A new generation in Arsine/Phosphine monitors

AIRCO Industrial Gases

Multipoint Sequencer - Model 106S

The Multipoint Sequencer allows rapid analysis of gas samples from multiple sources (10 points) by sequentially switching sample sources into a single analyzer.

The new state-of-the-art digital electronics guarantees reliability unmatched in old style mechanical switching systems.

The Multipoint Sequencer consists of two subsections: the fluidics draws each sample from its source through a filter and flowmeter, and then into a three-way valve. The electronics automatically switches the three-way valve allowing that sample to flow into the analyzer. The signal from the analyzer and channel number of the sample stream being analyzed are digitally displayed on the front panel of the sequencer. The electronics then sequentially repeats this process with the remaining sample streams.

Multipoint fluidics are accessible from front and top - the fluidics input is 10 lines in, 1 line out.

Physical Size

33" w x 5" x 18" d (deep), for attachment and coupling to top of main analyzer.

Printer - Model 106P

Manual Printout: push buttons on the front panel are operated to printout all information in memory on the current shift for all ten channels (ten sheets of information are printed on one sheet for each channel).

Programmed Printout: following an eight hour shift, each of the ten channels will printout the statistics from that shift.

Emergency Printout: any internal problem causing inoperability automatically triggers a full memory printout (one page per shift per channel).

Real Time Printing: results of the analysis are stored on memory and then printed out with: number, time, date, and alarm status.

Peak height, column retention time, and calibration time are also printed.

Specifications	
Max. Inlet Pressure:	1 Atmosphere (100 kPa)
Operating Temperature Range:	32°F to 104°F (0°C to 40°C)
Power Requirements:	115/220 VAC, 50/60 cycles; Monitor 5-10 amps, Sequencer 1.5 amps.
Outputs:	RS 232C terminal (ASCII). 0-1 volt Analog and Alphanumeric. Data reported as average concentration, as time weighted average per/shift (TWA), the number of times the TLV has been exceeded during shift, and the maximum reading per shift. Relays for Alarm Closures; contact rating 2 amps.
Inlet/Outlet Fittings:	¼" Compression Tube
Dimensions:	Basic Monitor, Width: 33" (84cm.) Height: 18" (46cm.) Depth: 18" (46cm.) Sequencer adds 5" (12.7cm.) to Height.
Shipping Weight:	Monitor: 119 pounds (54 kilos) Sequencer: 25 pounds (11.4 kilos).
Flow Rates:	
Monitor:	30-40 ccm. carrier gas
Sequencer:	Primary, 10 lit./min. on 9 sampling lines; Secondary, 3 lit./min. on active sampling line.
Sensitivity:	Arsine or Phosphine, less than 0.02 ppm (20 ppb).
Alarm Settings (internal):	Arsine 50 ppb; Phosphine 300 ppb.
Sensitivity Range:	0-750
Specificity:	Measures arsine and/or phosphine concentrations only.

Materials of Construction	
Body:	Steel
Tubing or Pipe:	Stainless Steel, PFA or Virgin Teflon®
Fittings:	Stainless Steel or PFA, ¼"
Internal Trim:	Stainless Steel, PFA and Virgin Teflon
Seat Material:	Virgin Teflon
Filters:	Glass/Acrylic
Gauges:	Stainless Steel, 0-100 PSIG (0-700 kPa)

Recommended Supplies and Equipment	
SUPPLY GASES	
Calibration:	AIRCO Combination Arsine/Phosphine TLV Standard Electronic Grade, 2200 PSIG, Size 150 Aluminum Spectra Seal® cylinder, CGA Fitting No. 350.
Carrier/Purge:	AIRCO Grade 4.5 Nitrogen, 2200 PSIG, Size 200 cylinder, CGA Fitting No. 580.
Cal. Gas Purge:	AIRCO Grade 4.5 Nitrogen, 2200 PSIG, Size 200 cylinder, CGA Fitting No. 580.
Pneumatic Valve:	AIRCO Zero 2.0 Air, CGA Fitting No. 590.
SUPPLY GAS PRESSURES & RECOMMENDED REGULATORS	
Calibration:	10 PSIG, AIRCO Model 52-15 (350) Regulator, with Deep Purge Valve®.
Carrier/Purge:	60 PSIG, AIRCO Model 18-75 (580) Regulator.
Pneumatic:	80 PSIG, AIRCO Model 18-150 (590) Regulator.
PURGING DEVICES	®AIRCO Model S31DD "Deep Purge" Valve.
CHECK VALVES	AIRCO Model S38K with KALREZ® seat.

OPTIONS	
Option Number	**Item and Description**
106S	**Multipoint Sequencer** — to convert from single point to ten points.
106P	**Printer** — for hard copy and record of Monitor output.
106SB	**Slide Base** — for access to rear of wall-mounted Monitor.
106F	**Sample Line Particulate Filters**
106L	**PID Lamp Replacement**
105CP	**Lamp Cleaner** — for PID lamp

AIRCO Industrial Gases
575 Mountain Avenue
Murray Hill, New Jersey 07974
(201) 464-8100

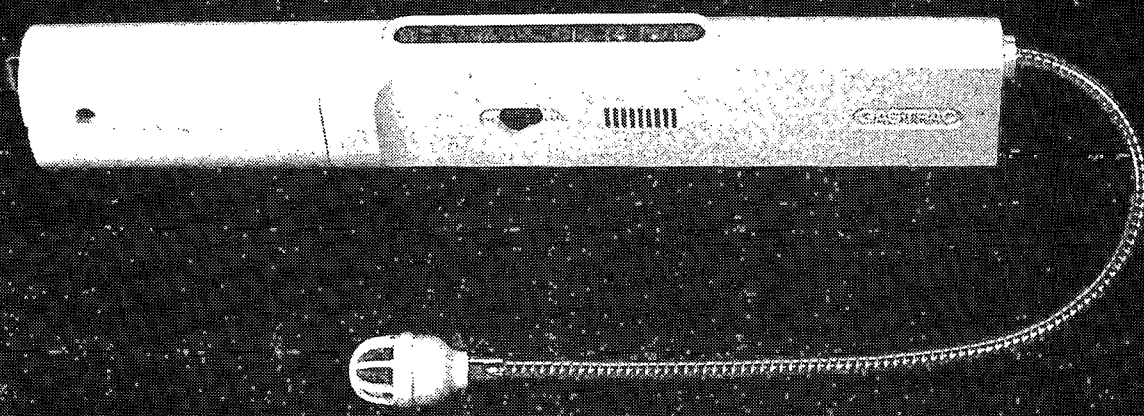
PRINTED IN U.S.A.

5M 1119RR 11-83

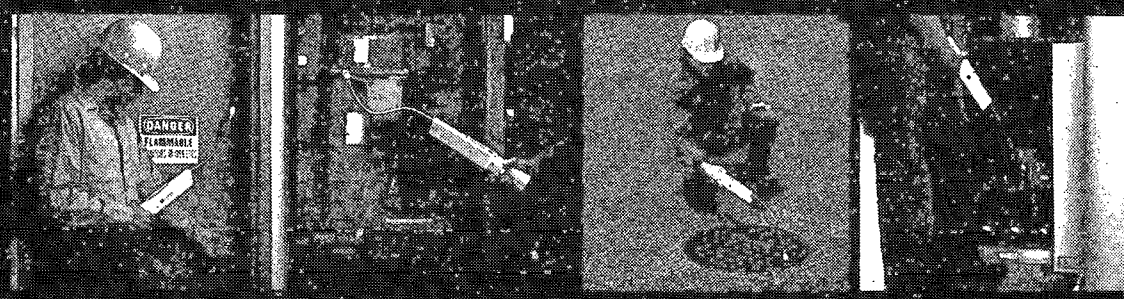
BULLETIN NO. GT-523

*GAS·TRAC®

NEW from M-C PRODUCTS



Computer technology adds a new dimension to the Detection of Combustible Gases



M-C Products *Gas·Trac® is capable of sensing and warning the operator of the presence of most types of combustible gases. High instrument sensitivity can quickly locate very small leaks. It easily finds leaks that even soap bubbles cannot find.

Features:

- Solid state
- Automatic shutoff
- No pump
- Ultrasensitive
- Hazardous alarm
- Audio detection

New technical achievements:

This unique design eliminates pumps, tubes, or squeeze bulbs. There is no need for purging after sampling. The solid-state sensor continuously samples the atmosphere by diffusion. The advanced, solid-state electronics eliminates adjustment prior to use. This device can detect as little as 100 ppm methane-in-air. It can be used in place of the much more expensive "FI"-type detectors.

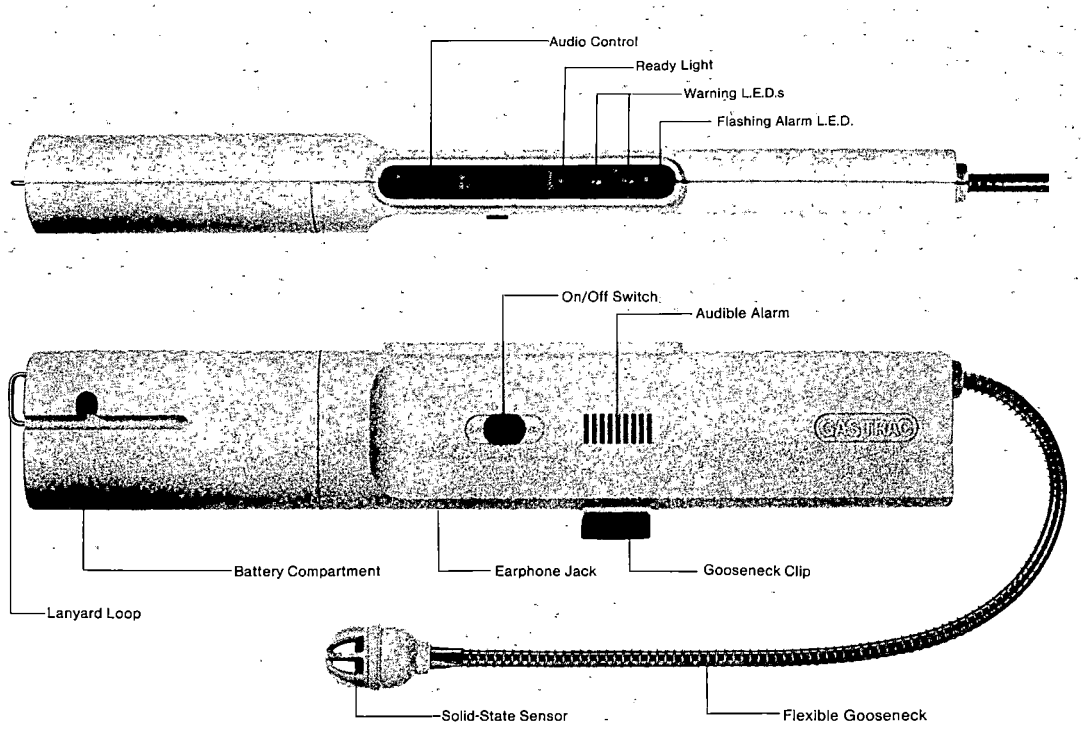
M·C PRODUCTS

Division of Material Control, Inc.

7720 E. Redfield Road ◆ Suite 2, Scottsdale Arizona 85260

Telephone: (602)998-9577

Check These Important Features:



Technical Data

Specifications:
Sensor: Solid state, no contamination worry
Power: 2 D cells; 2 AA cells
Size: 1⅝" x 2½" x 14⅝"–Probe length 16"
Weight: 2 pounds
Alarm: Approximately 50% L.E.L. methane; capability for calibration in other gases
Battery life: 8 hours
Temperature range: 0°-100°F

Standard Features:
Battery-saver circuitry-auto shutoff after 15 minutes use. Sensitivity of 0.01% methane gas. 100% solid state. No maintenance. Extremely durable plastic case. Reinforced at stress points. Simple to use.
L.E.D. warning lights. Loud, audible, variable rate, tick warming system. Adapter available for high or inaccessible places. Accessories include case, earphone, batteries, extension adapter, storage pouch, and wrist strap.

Senses the following gases—partial list:

Xylene	Methane
Hydrogen	Acetylene
Butane	Industrial solvents
Gasolines	Lacquer thinners
Propane	Refrigerants
Toluene	Benzene
Ammonia	Carbon monoxide
Acetone	Naphtha

***Gas•Trac* can be of service to many industries:**

Gas/Electric Utilities	Street Departments
Chemical Plant Workers	Appliance Repairmen
Fire and Police Services	Marine Operators
Emergency Vehicle Teams	Plant Maintenance Personnel
Safety Engineers	Heating/Plumbing Contractors

Warranty: One year from date of purchase against defects in manufacturing, workmanship and materials. Accessories are limited to manufacturer's warranty limitations.

PRICE LIST

(Subject to change without notice.)

Terms: Net 30 days — Phone Orders Collect-(602) 998-9577
F.O.B. Factory — Effective 3/1/82

Description	Price	Weight
Complete *Gas•Trac* (Price includes *Gas•Trac* Instrument, Alkaline Batteries, Storage Pouch, Wrist Strap, Extension Adapter, and Earphone)	$575.00	3 lbs.
Model RSU-01 (Non-portable unit, not shown) Remote atmosphere monitor for continuous 12 VDC operation. Features adjustable sensitivity level, optically isolated output, and piezoelectric 80 db audio alarm. Includes power supply to convert 110 VAC to 12 VDC.	495.00	1 lb.

ACCESSORIES

Description	Price
Nickel Cadmium Battery Kit	$230.00
Extra Nickel Cadmium Batteries	Upon Request
Holster	35.00
Calibration Test Kit (Includes charged cylinder containing 2.5% methane in air, valve and test chamber)	75.00
Charged Cylinder (Replacement Cylinder for Calibration Test Kit)	35.00
Instrument and Accessory Carrying Case (Briefcase size)	95.00
30'' Non-Conductive Probe Kit	75.00
Earmuff Type Earphones	75.00
Survey Probe (Find outside leaks in wind conditions, arson investigation, etc.)	240.00
Filter Kit (Indicates if operator is sensing hydrocarbons or methane gas)	65.00
Filter Refill Kit (Contains 6 refills)	35.00

M-C PRODUCTS
Division of Material Control, Inc.
7720 E. Redfield Road • Suite 2 • Scottsdale, Arizona 85260
Telephone (602) 998-9577

Printed in U.S.A.

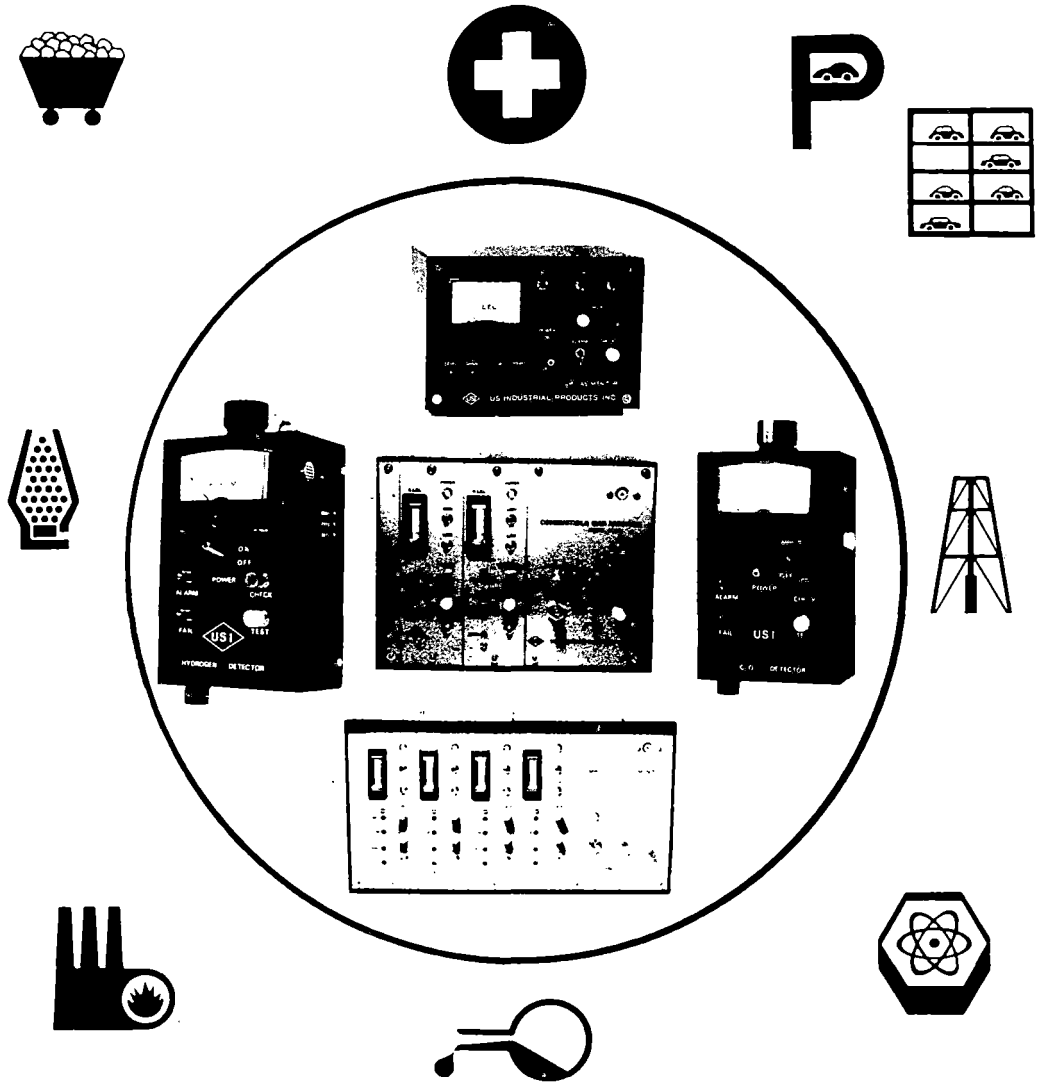
*Gas•Trac is a registered trademark of Northern Illinois Gas Company

USI

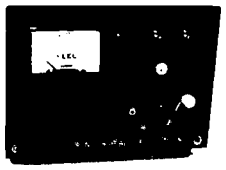
CONSUMER SAFETY PRODUCTS

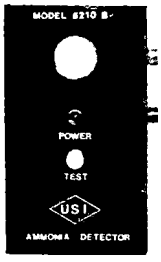
A Complete Line of Toxic Gas Detectors
and Flammable Gas Monitors

. . . with advanced gas sensor technology



US INDUSTRIAL PRODUCTS CO.,INC.





SPECIFICATIONS:

CONTROLLER MODULE

Dimensions:	7"W x 5"H x 6.5"D
Storage Temperature:	-15° to +55°C
AC Power:	115±10VAC or 220VAC, 50-60Hz
Power Usage;	8.5 watts
Readout Range:	0-100% LEL (low explosive limit)
Repeatability:	± 2%
Alarms:	Circuits - fail, low (caution), high (danger) Audio - low (pulsed tone), high (steady tone)
LED Indicators:	Power (green), fail (yellow, steady), low (yellow, flashing), high (red, steady)
Panel Controls:	Zero, span, low & high alarm settings,alarm and bypass (audio select), reset (latching or non-latching), low & high alarm checks
Analog Output:	0-1 VDC full scale (maximum 5mA)
Relay Output:	NO,COM,NC: 1A-125VAC or 2A-30VDC
Weight:	5 lbs.

SENSOR

Type:	Diffusion type, catalytic
Temperature Range:	-30° to +65° C
Humidity Range:	5-95% R.H.
Warm Up Time:	3 minutes
Sensor Life:	Up to 2 years, normal operations
Sensitivity:	0.5% LEL
Zero Drift:	⩽3% per year
Response Time:	⩽ 10 seconds to 90% full scale
Recovery Time:	⩽ 20 seconds for return to 90% full scale
Accuracy:	± 3% of measured value
Electrical Classification:	General purpose area or NEC requirements of explosion-proof Class I, Div. I, Group B, C and D hazardous areas
Warranty:	2 years, normal operations
Cable Length:	Up to 4000 feet using #16 (AWG) wire size

SENSOR HOUSING

Custom Crouse-Hinds explosion-proof junction-box, and NEMA -type weather-proof enclosure.

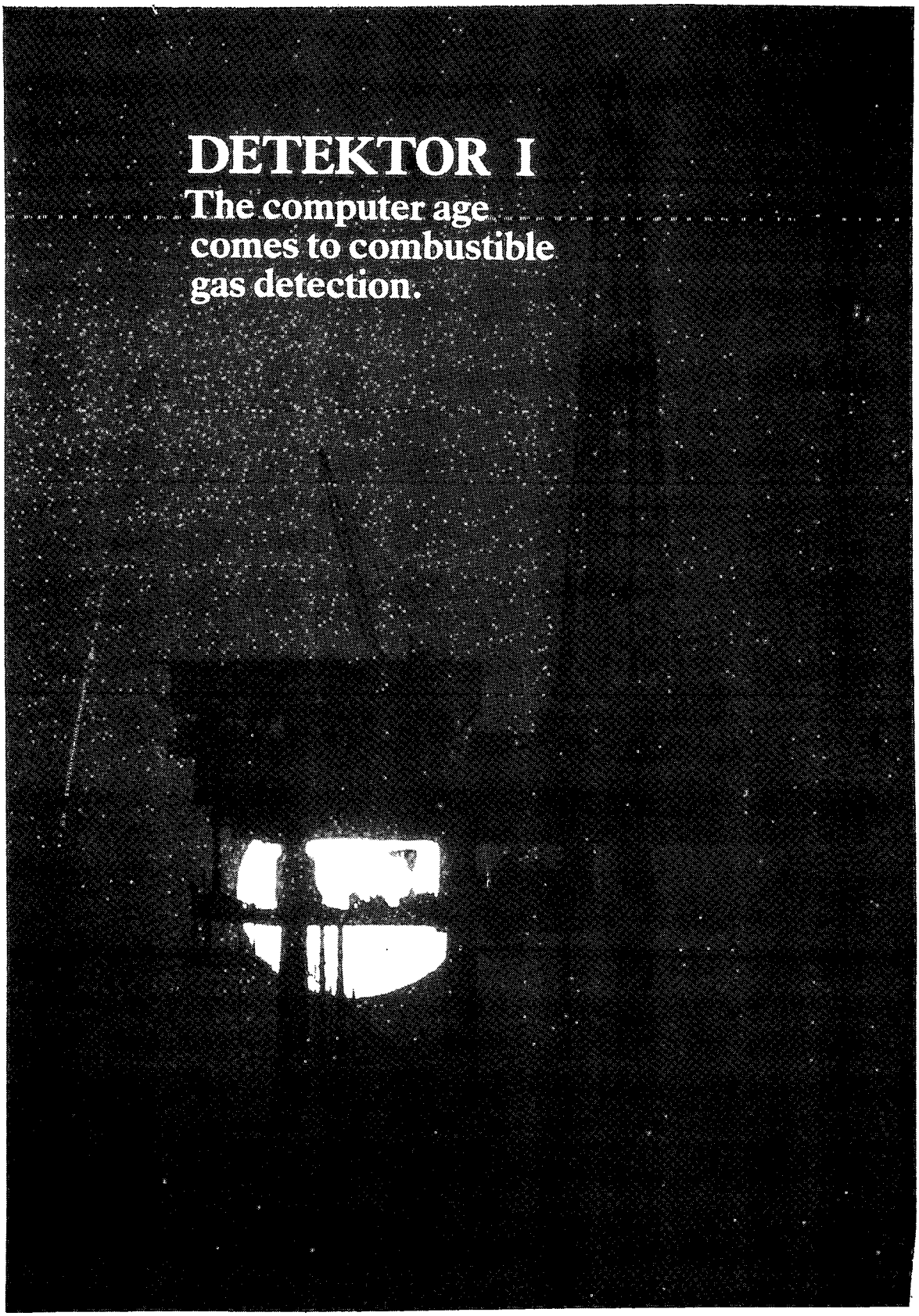
Represented By:

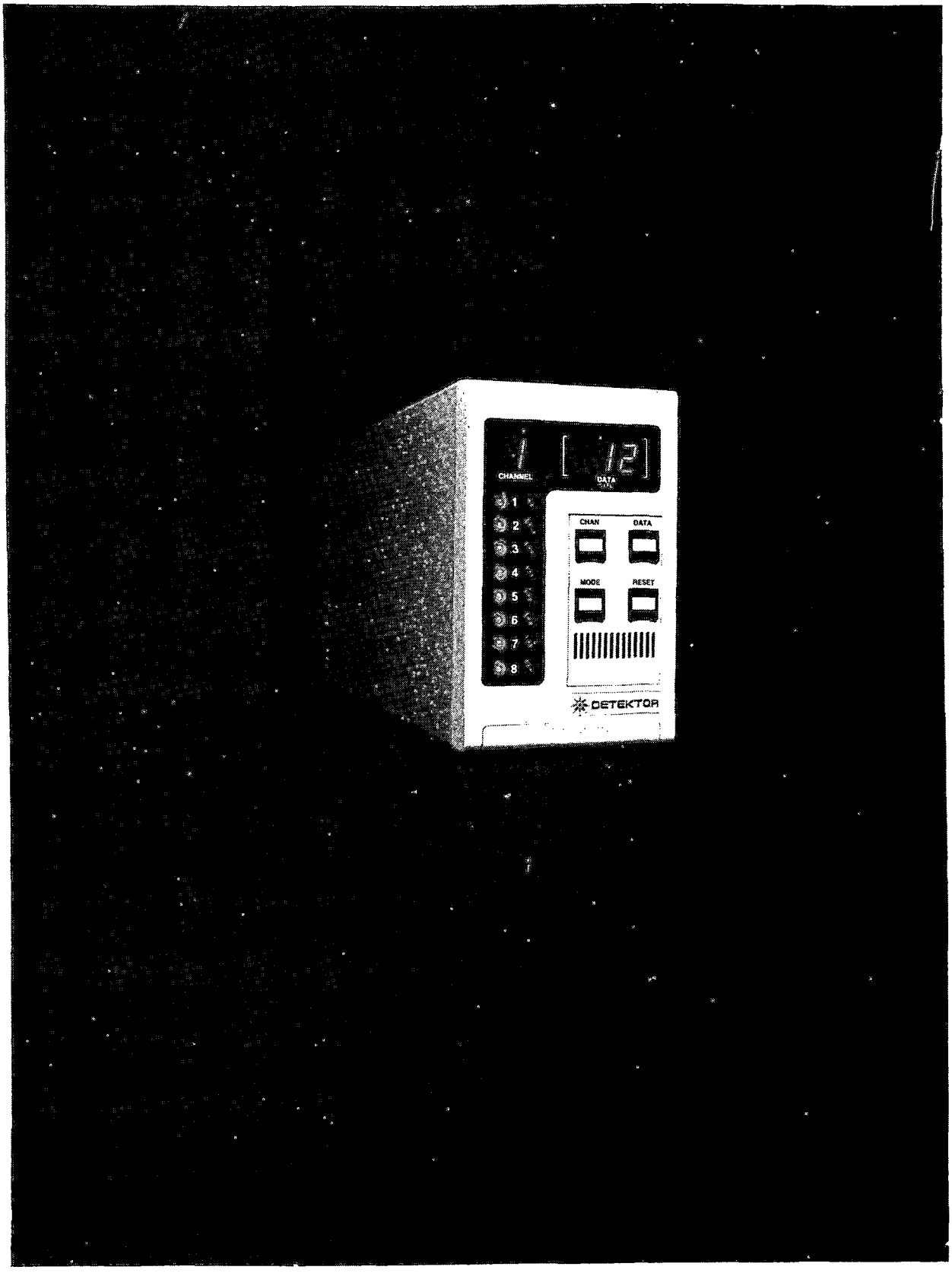
US Industrial Products Co., Inc.

13564 Pumice Street
Norwalk, California 90650

Phone: 213/921-4342
213/921-0686

2/1984


DETEKTOR I
The computer age
comes to combustible
gas detection.


CHANNEL
DATA
CHAN
DATA
MODE
RESET
DETEKTOR

Specifications: DETEKTOR I Combustible Gas Detection System

CONTROLLER MODULE

Channel Capacity
Up to 8 channels per module
32 channels per 19" rack

Dimensions
Stand Alone Controller, 8 channels
Width: 11.1 cm (4⅜")
Height: 17.8 cm (7")
Depth: 44.5 cm (17½")
Rack Mount Unit, four controllers, 32 channels
Width: 48.3 cm (19")
Height: 17.8 cm (7")

Power Consumption
115/230 VAC ± 15% 50/60 Hz
Approximately 75 watts maximum

Outputs
Low Alarm Relay
High Alarm Relay
Error Alarm Relay
All relays are SPDT and are rated at ⅛ HP 120 VAC.
8 channel chart recorder output 0–5 VDC
Parallel (Centronics) printer interface
Audible alarm on front panel
Optional alarm relay expansion fits inside controller and provides SPDT ⅛ HP contacts for Low Alarm and High Alarm for each channel (total of 16 relays)

Operating Temperature Range
0° C to 40° C (32° F to 104° F)

Storage Temperature Range
−35° C to +55° C (−95° F to +131° F)

Front Panel Indicators
4 digit display
7 segment 0.56" LEDs provide alphanumeric data about system operation and status
8 pairs of channel status indicator LEDs provide continuous status information on each channel, such as: sensor present, low alarm, high alarm, error condition, etc.

Front Panel Switches
CHANNEL switch—Allows operator to lock display onto a desired channel
DATA switch—Permits entry of setpoint data
MODE switch—Moves system from normal scanned mode to Cal and setpoint routines
RESET switch—Acknowledges alarm, returns system to scanned mode from Cal/setpoint routines

Self-test/Diagnostic Capabilities
Before Calibration procedure and at system turn-on, a complete self-test is performed. System will report on errors such as: PROM checksum error, RAM error, Cal data checksum error, etc.

Battery Backup for Cal Data
3 months of unpowered storage with full retention of Cal data

Range
0 to 99% LFL (Automatic sensor shutdown at 60% LFL)

Accuracy
± 5% of full scale (99% LFL)

RFI/EMI
Provides protection against all RFI/EMI sources

Wall Mounting Enclosures (optional)
Enclosures meet NEMA 3 (dust and rain proof, sleet resistant—outdoor) and NEMA 7 (explosion proof Class I, Group C and D) requirements. Available in single and multiple unit versions.

SENSOR/TRANSMITTER

Type
Constant Resistance (Pat. Pend.) holds sensor beads at optimal operating temperature to prolong sensor life and to improve system accuracy.

Dimensions
Explosion-proof housing approximately 4" diameter with 3" extension for sensor

Maximum Loop Resistance
40 ohms

Operating and Storage Temperature Range
−40° C to +75° C (−104° F to +167° F)

Electrical Classification
NEC Class I, Division 1, Groups A, B, C and D

SENSOR ASSEMBLY

Housing
All stainless steel for maximum ruggedness and resistance to corrosion

Type
Diffusion catalytic bead
Poison-resistant type is available as an option

Life
Up to 3 years in normal environments

Calibration Cycle
60 to 90 days in normal environments

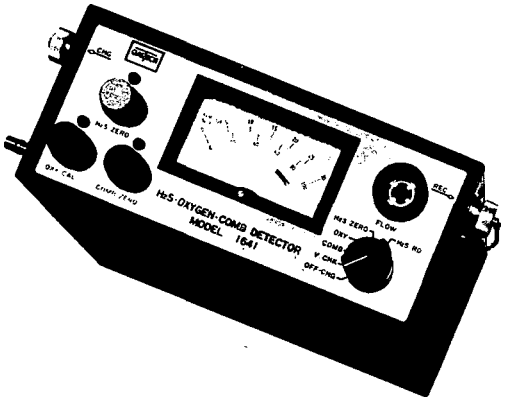
Specifications are subject to change without notice.

DETEKTOR
A Division of Semetex Corp.
3450 Fujita Street
Torrance, California 90505
Tel: (213) 539-0407
TWX: 910-347-6242

Printed in U.S.A. Form Det 1-7/82

TRIPLE COMBINATION DETECTOR
Combustible Gas/Oxygen Deficiency/ Hydrogen Sulfide
MODEL 1641

GASTECH



FEATURES

- Fully Portable
- Triple Range—Hydrogen Sulfide, Oxygen, Combustible Gas
- Fast Warmup and High Stability
- Visual and Audible Alarms Characteristically Coded
- Field Serviceable
- Simultaneous Monitoring

A TRIPLE PURPOSE GAS DETECTOR

The three commonly-encountered hazards of confined space entry—combustible gas, oxygen deficiency and hydrogen sulfide—all are tested and detected simultaneously by the GasTech Model 1641. Audible and visual warnings are given automatically if any of these gases go beyond preset limits. Characteristic signals identify the hazard, and the operator can select any one of the three ranges for precise readout of concentration.

DESCRIPTION

The GasTech Model 1641 is a rugged metal-cased field instrument, readily portable in a protective synthetic leather carrying case with shoulder strap and accessory pouch.

A sample of gas to be tested is drawn into the instrument continuously by a built-in diaphragm pump with brushless DC motor. Sample flow is verified by a visual rotary flow indicator on the top panel. Teflon-lined hoses and a probe with dust filter element are provided to reach into otherwise inaccessible areas.

The operating controls on the top panel are color-coded for ready identification. They include power on, battery check and selective indication of range on the large-scale built-in meter. Response is quick: under 5 seconds for combustible gas and oxygen; 30 seconds for hydrogen sulfide. Ready to go as soon as it is turned on, the Model 1641 can be used to test intermittently or continuously over a 6-hour period before recharging. A chart recorder can be plugged into outlet socket for recording concentration of one, two or three constituents.

The Model 1641 is fail-safe against most sensor or electrical defects and is designed for easy field maintenance. The combustible gas sensors and flame arrestor, as well as the plug-in oxygen cell, are interchangeable with those in the GasTech Model GX-3. Electronic circuitry is arranged on three plug-in circuit boards. The nickel-cadmium battery pack can be recharged hundreds of times, and is equipped with a plug connector for easy replacement. Battery charger (115 or 230 volts AC) is included for overnight recharge. Extension hoses and calibration kit are available accessories.

DETECTION METHODS

HYDROGEN SULFIDE (H_2S)

Sample drawn into the instrument first flows through the electrochemical H_2S cell, where any H_2S present reacts and produces a proportional signal that can be read on the meter in ppm H_2S, range 0–30 ppm, and will trip the alarm at a preset point, usually 10 ppm. Detection is by a two-electrode electrochemical cell which discriminates against most other gases. However it does respond to carbon monoxide in the ratio of about 5:1, so that the instrument also serves as an alarm for toxic concentrations of CO. Other interferences that may be significant include:

Sulfur dioxide (SO_2)	6:1
Ethylene (C_2H_4)	20:1
Ethanol (C_2H_5OH)	8:1

OXYGEN
The second detection element is an electrochemical self-generating oxygen cell, which produces an output directly proportional to the oxygen concentration, range 0–30%. The meter can be used to read concentration, and the oxygen deficiency alarm trips when oxygen decreases to 19.5%. Increasing oxygen, or rise in output due to cell malfunction, actuates a second alarm at 25%. There are no significant interferences in the oxygen measurement. Cell is guaranteed for 6 months and then can be reactivated at low cost.

COMBUSTIBLE GAS
From the oxygen cell the sample flows to the combustibles detector, a catalytic element which forms one leg of a Wheatstone bridge measuring circuit. A reference element, shielded from the sample, gives compensation for changes in ambient temperature or pressure. Bridge voltage is precisely regulated, and bridge output is amplified to drive the meter (range 0–100% LEL), and trip an alarm at 20% LEL. Output is calibrated on methane but detection principle used gives approximately correct readings on a wide range of flammable gases and vapors. Principal interferences are argon and helium.

ALARM FUNCTIONS

HYDROGEN SULFIDE—The toxic gas alarm is a slow intermittent audible pulsing tone that is accompanied by a flashing AMBER (LED type) alarm light. The alarm is self-resetting and initially set at 10 ppm (setting adjustable).

OXYGEN—The oxygen alarm is a long-short audible pulse pattern. The audible signal is accompanied by a YELLOW (LED type) alarm light flashing in synchronism. The oxygen alarm is self-resetting and initially set at 19.5% (setting adjustable).

COMBUSTIBLE GAS—The gas alarm is a rapid intermittent audible pulse pattern of one second each pulse. The audible signal is accompanied by a RED (LED type) alarm light. The gas alarm is self-resetting and initially set at 20% LEL (setting adjustable).

MALFUNCTION/TROUBLE ALARM—This alarm is an automatic non-adjustable, steady audible tone with no alarm lights showing. The malfunction alarm will sound if the following conditions exist:

1) Low battery condition
2) Open combustible gas detector
3) Downscale drift combustible gas detector (actuates at –10% scale)
4) Upscale oxygen detector drift (actuates at 25% oxygen)

Output is available for connection of an optional remote alarm device which repeats simultaneously the audible alarm signal at a remote location.

SPECIFICATIONS

Sampling method: Sample-drawing with a built-in diaphragm pump

Power Supply: Batteries, rechargeable Nickel-Cadmium type, give 6 operating hours per charge.

Range: Hydrogen Sulfide: 0–30 ppm
Oxygen: 0–30%
Combustible gas: 0–100% LEL

Accuracy: Hydrogen sulfide: ±5% of full scale
Oxygen: ±.5% oxygen
Combustible gas: ±5% of full scale

Repeatability: Hydrogen sulfide: ±2% of full scale
Oxygen: ±.25% oxygen
Combustible gas: ±2% of full scale

Warmup Time: 90 seconds, all circuits stabilized and ready for operation

Response Time: Hydrogen sulfide: 90% in 30 seconds
Oxygen: 21% to 0 in 4 seconds
Combustible gas: 90% in 4 seconds

Sample Flow Rate: 1 liter per minute

Flow Indication: Rotary indicator on top panel

Ambient Temp. Range: 0–40°C; 30–110°F

Recorder Output: 0–1 volt (0–1 ma into 1,000 ohms)

Dimensions: 10" wide X 4.3" deep X 8" high

Weight: 8 lbs.

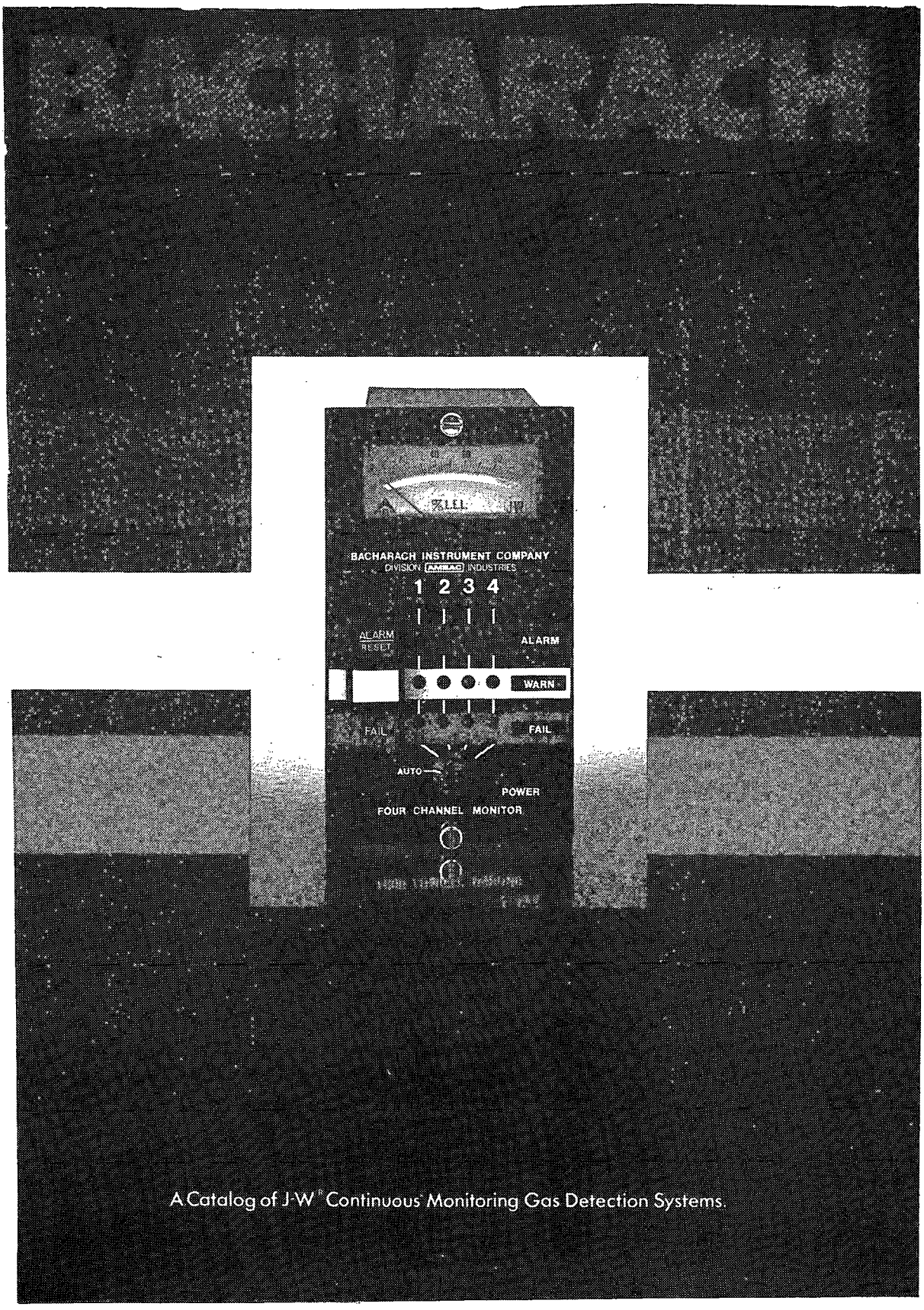
Accessories: All accessories for normal operation and maintenance are included: leather carrying case with shoulder strap, 6' hose, probe with filter, 115 VAC charger and filter replacements. (230 volt charger optional)

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

Distributed by:

GasTech Inc./Johnson Instrument Division/331 Fairchild Drive/Mountain View/California 94043/(415) 967-6794/Telex: 334-462

GasTech. THE TRUSTED NAME IN GAS DETECTION. 479



A Catalog of J-W® Continuous Monitoring Gas Detection Systems.

HOW TO ORDER CONTINUED.

DETECTOR HOUSINGS

			Part No.	For	Description
23-4017	Combustibles-all models	Explosion-proof, sample-draw detector housing w/o sensor. Rated Class I, Group B, C, D hazardous areas.	Custom	H_2S all models	Explosion-proof detector assembly with sensor, special nickel corrosion-resistant construction.
23-7317	Combustibles-all models	Special corrosion-resistant stainless steel housing w o sensor. Rated Class I, Group B, C, D hazardous areas.	23-7206	O_2 all models	Detector housing, diffusion-type w/o detector (not suitable for classified areas).
23-7363	Combustibles-all models	High temperature probe housing w o sensor (12")	23-7207	O_2 all models	Detector housing with (not suitable for classified areas).
23-7308	H. S all models	Explosion proof detector assembly with sensor. Rated Class I, Div-I Group C, D hazardous areas.	23-7221	O. S. all models	Explosion-proof sample-draw detector housing with detector.

B. DETECTORS/SENSORS

23-7338	Combustibles-all models	High-temp detector probe used with 23-7363
23-4539	H. S all models	Detector element assembly.
514-010-00	O. all models	Detector for sample-draw housings.
514-010-10	O. all models	Detector for diffusion housings.

C. AMPLIFIERS

23-7392	4 channel only all versions	Explosion-proof amplifier (1 for each detector housing)
23-7232	1 or 2 channel all versions	Explosion-proof long distance
23-7233	H. S Combustible all versions	Explosion-proof, long distance power supply used with 23-7392, 23-7332

REQUIRED WITH ORDER:

1. Voltage & cycle (120 VAC, 230 VAC, 12 VDC, 24 VDC).
2. Gas on which system is to be calibrated.
3. Warning and alarm set points (for O_2 systems also specify rising or falling alarms).

NOTES:

1. Modular control units require an appropriate enclosure listed in section 2.
2. All four-channel units require one detector amplifier (23-7392) per detector used.
3. Explosion-proof housings rated for Class I, Div I; group C, D by the manufacturer.
4. Weather proof wall mountings are acceptable for Class I, Div II, group C & D if properly purged.
5. Model number preceded by "CD" represents "Catalytic Diffusion," "XD" represents " Toxic Diffusion," "KD" represents "Oxygen Diffusion."
6. All control units have lock-out circuits to prevent alarm actuation on initial warm-up following power start-up.
7. Single and dual channel units have a brief time delay on Warn and Alarm relay closures to prevent false alarms due to power line transients or electrical noise.
8. All control units are available on request with all relay circuits normally energized—consult your representative.
9. All control units operate with manual reset Warn and Alarm relays (latching type). Automatic reset (non-latching) relay functions are available on request.

Gas Detection Sales Group
Bacharach Instrument Company
301 Alpha Drive
Pittsburgh, PA 15238 (412) 782-3500

Form 5005R-8/81

Printed in U.S.A.

DELPHIAN

MICRO 550 COMBUSTIBLE GAS MONITOR

Bulletin 900040A

SIMPLE, RELIABLE, EASY TO MAINTAIN

A combustible gas monitor has a simple job – to continuously monitor a single point in space for combustible gases and give an alarm when an alarm condition exists. No more... No less...

The essence of Delphian's MICRO 550 Combustible Gas Monitor is its simplicity. It is no more complicated than necessary to do the job right yet it gives you everything you need. It has every feature necessary to reliably and safely detect combustible gases and give an alarm. Because it's simple, it is more dependable and maintenance is easier. Delphian's MICRO 550 is simple, reliable and easy to maintain. No more... No less...

APPLICATIONS

- **Petrochemical & chemical plants**
- **Natural gas plants & refineries**
- **Offshore platforms & drilling rigs**
- **Gas storage and loading facilities**
- **Pipelines/compressor stations**
- **Solvent monitoring**
- **Sewage treatment plants**
- **Semiconductor processing**
- **Battery rooms**
- **Cable vaults**
- **Drying ovens**
- **Boiler rooms**

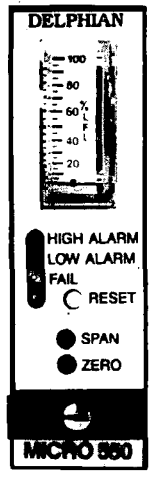
SYSTEM DESCRIPTION

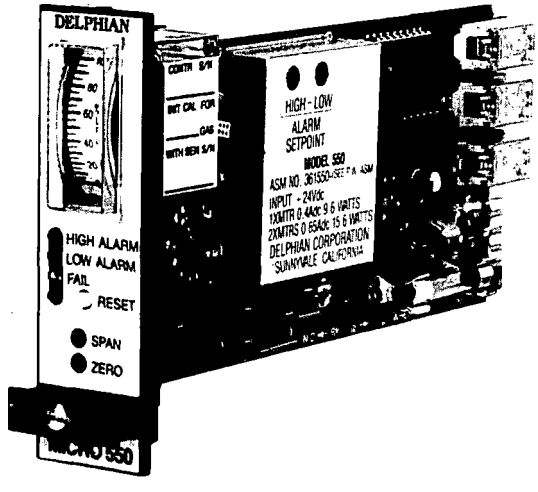
The MICRO 550 is a fixed installation single channel combustible gas monitor with a compact controller that requires just one inch of panel space three and one-half inches high. It's the smallest single channel system available. It is a simple design with few parts so there is less that can go wrong making it easy to repair and maintain.

The controller uses a rugged analog meter and has LED indicators for power, fail, high and low alarms. Full 100% RFI shielding and sealed relays are standard. Relays can be normally energized or de-energized with manual or auto reset. The system operates from a nominal 24 Vdc power supply or 115 Vac. A 4 to 20 ma current output is standard with other outputs available.

An encapsulated transmitter module powers the sensor so that it is held at a constant temperature under all operating conditions, maximizing sensor life. The transmitter module is mounted in an explosion-proof junction box into which the sensor is also installed. One man remote calibration is available.

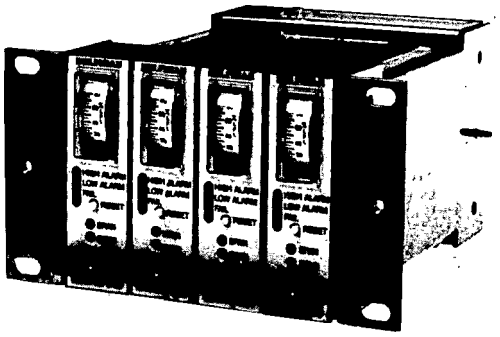
The system uses a platinum bead type sensor. A sponge-like catalytic coating assures maximum resistance to loss of sensitivity caused by poisons and contaminants.



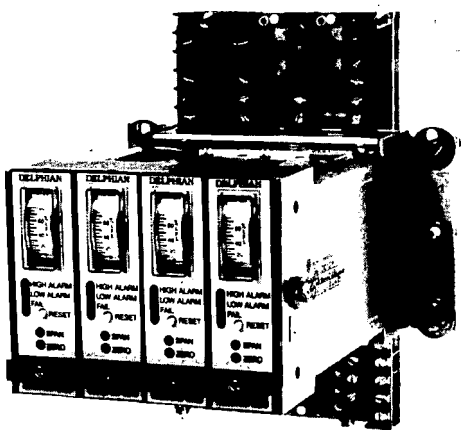


USER BENEFITS

- **Long Sensor Life** – The longer a sensor lasts the lower are the maintenance costs. A sensor's life is governed by its operating temperature. Operation above or below a sensor's optimum operating temperature shortens its life. Delphian's unique SENSOR SAVER™ transmitter guarantees constant temperature sensor operation assuring long and stable sensor life even in continuous high ambient temperatures or gas concentrations. Sensor burn-out is eliminated, zero and span drift are negligible. SENSOR SAVER delivers maintenance and calibration cost savings. For more information ask for our SENSOR SAVER Technical Note.
- **Field Installation Tough** – Delphian's transmitter, which is epoxy encapsulated for complete environmental protection, puts sensor power regulation and support electronics where it counts – at the sensor location. In gas monitors with no remote transmitter, sensor performance is degraded by changes in electrical resistance caused by moisture, corroded terminals, splices or loose contacts in the wires between the sensor and controller. To insure that power to and signal from the sensor are not degraded, support electronics must be used at the sensor. Delphian's remote transmitter module assures optimum sensor performance and reliable sensor signals.
- **No False Alarms** – False alarms destroy confidence in gas monitors and cost money. Most gas monitors are RFI resistant or use filter networks. This isn't enough. Delphian eliminates false alarms from any electrical source by using 100% electromagnetic shielding around all sensitive parts. False alarms typically caused by walkie-talkies, SCR control circuits, DC motor brushes, nearby lightning strikes or microwave transmitters are eliminated.
- **No Shielded Wire** – The MICRO 550 controller uses true electromagnetic shielding so shielded field wires between the controller and transmitter are unnecessary. Installation is simpler and less expensive.
- **Built-In Surge Protection** – Delphian's transmitter and controller have built-in power surge protection. They can withstand up to 500 watts of electrical energy for a millisecond with no damage. Most lightning strikes or power supply spikes can't harm the system.
- **Easy, Versatile Installation** – From one to any number of channels in either wall or panel mount configuration are standard and off-the-shelf with our FLEXIRACK™ mounting system. FLEXIRACK lets you wire directly to sensors and alarm circuits with no extra terminal strips. FLEXIRACK makes custom installations standard. Get the exact number of channels you need in the configuration you want. Ask for our FLEXIRACK Data Sheet.
- **Low Rack Space** – Up to thirty-two individual controllers can be mounted in a standard 19″ rack space 7″ high. Since sensor power is regulated in the transmitter module little power is dissipated in the controller. No cooling fans are needed, even with dozens of controllers in a totally sealed box. Don't waste valuable control room space.
- **Interchangeability** – MICRO 550 and MICRO 750 H_2S monitors are interchangable in the FLEXIRACK. In fact, they are identical except for front panel markings. The same transmitter module is used for the H_2S sensor and the combustible gas sensor. Lower spares inventory is required. Service and maintenance people have less to learn.
- **Reliability** – If an operator lacks confidence in a gas monitor because of reliability, the monitor is of little value. Delphian designed its own CAT (Computer Aided Tester) to help us achieve the highest product reliability possible. Every MICRO 550 gas monitoring assembly and system is thoroughly analyzed by the CAT. By using the CAT hundreds of tests are made with speed, precision and accuracy impossible by manual methods. The CAT never naps. All systems pass every test or they don't leave Delphian.



Panel mount FLEXIRACK™ (bezel not shown)



Wall/enclosure mount FLEXIRACK™

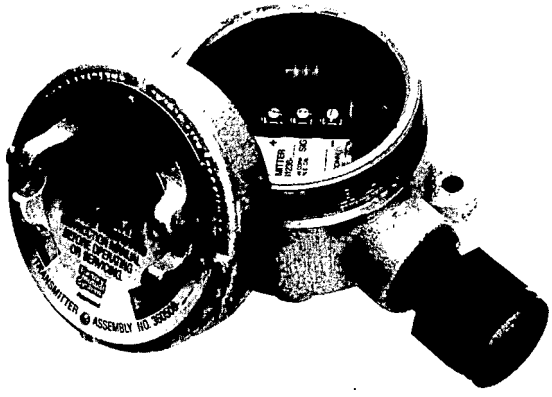
DELPHIAN'S PHILOSOPHY

Today's MICRO 550 is Delphian's fourth generation of combustible gas monitor and yet it looks little different from our first MICRO 550. Our approach to gas monitor design is disciplined. We have resisted the temptation to add digital displays, make our alarm lights flash, offer sophisticated built-in diagnostics, go multichannel or use membrane pushbutton switches. None of these features make a gas monitor more simple, reliable or easy to maintain.

Over the past 4 generations of gas monitor designs Delphian's engineers have reduced the MICRO 550 parts count by over 30%. That increases the reliability by nearly the same amount and makes the unit easier to repair. They have developed an encapsulated remote transmitter that provides complete environmental protection for the remote transmitter electronics. The same transmitter works for both combustible and H_2S sensors. They designed, developed and built the CAT which gives Delphian the most advanced product reliability control possible.

Delphian makes the best gas monitor available. It's that simple!

Encapsulated transmitter module



Sensor/transmitter assembly

OPTIONS & ACCESSORIES

- **One man remote calibration**
- **Hydrogen specific sensor**
- **Sensor with calibration gas port**
- **Duct mounting system**
- **Sensor extension kit to separate sensor and transmitter by up to 100 feet**
- **Calibration kit with carrying case**
- **Enclosures: one/two channel explosion proof controller housing, a variety of NEMA 4X fiberglass enclosures**
- **Sensor dust covers**
- **Extender cards**
- **Stand-Alone Sensor/Transmitter**

SPECIFICATIONS

Controller

Range
0-100% lower flammable limit

Display
Meter. Vertical linear scale. Moving magnet type. Adjustable span and zero.Green LED power on indicator.

Alarms

Low	High	Fail
Orange	Red	Yellow
LED	LED	LED
Adjustable	Adjustable	
0-60%	0-60%	
LFL range	LFL range	

One isolated relay contact for each alarm rated at 3A at 117Vac. Field adjustable for N.O./N.C. and normally energized/normally de-energized.

Power
24 Vdc (20V min, 28V max)

Power consumption
10 watts per channel

Recorder output
4-20 mA standard for 0 to 100% LFL. 0-5 Vdc optional.

RFI Shielding
Protection against all citizen/industrial radio bands and spurious electrical noise

System reponse time
90% of final response within 20 seconds following a step change in methane concentration from 0 to 50% LFL.

System linearity
Meets or exceeds C.S.A. and F.M. requirements.

System zero drift
±5% per year

Electrical classification
Standard configuration mounts in any general purpose area. Class I, Division 1, Group D housings available.

Ambient temperature range
– 0 to 70°C (32 to 158°F)

Dimensions
Width: 2.5 cm (1.05″)
Height: 8.75 cm (3.47″)
Depth: 16.25 cm (6.75″)

Weight
175 grams (6.1 oz.)

Mounting
19 inch rack mount, panel mount, wall mount or enclosure mount.

Warranty
One year

Sensor/Transmitter

Sensor Type
Diffusion, catalytic bead designed for use with combustible gases and vapors.

Sensor ambient temperature range
– 55 to 100°C (– 67 to 212°F)

Transmitter ambient temperature range
– 40 to 85°C (– 40 to 185°F)

Electrical classification
NEC class I, division 1, Groups A, B, C & D

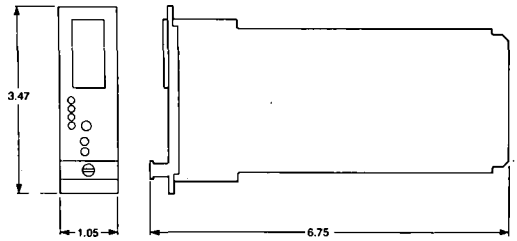
Cable length*
To 10,000 feet.
Maximum loop resistance between controller and sensor is 36 ohms. Three conductors are required.

AWG	Meters	Feet
20	460	1500
18	760	2500
16	1220	4000
14	1830	6000
12	3050	10,000

Consult factory on specific application

Warranty
Sensor – Two years
Transmitter – One year

*At 24 Vdc ±5%



Factory Mutual System Approved

Delphian Corporation has a policy of uninterrupted research and development. Therefore specifications are subject to change without notice.

DELPHIAN CORPORATION 473 Macara Avenue, Suite 704, Sunnyvale, California 94086 (408) 732-7730
900040A
Printed in U.S.A. 124

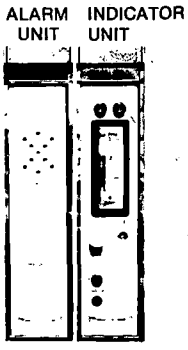
BENDIX HYDROGEN CYANIDE TOXIC GAS DETECTION SYSTEM

Each industrial environment has its own specific toxic gas problems. These gases can produce disease, acute discomfort, bodily injury or death. Any facility with toxic gas problems needs continuous and reliable toxic gas detection instrumentation.

Bendix provides reliable toxic gas detection. The Bendix Hydrogen Cyanide Toxic Gas Detection System continuously monitors the atmospheric hydrogen cyanide concentration and gives an alarm when a preset upper limit of the gas is exceeded in the working area.

Bendix also offers gas detection systems for combustibles, hydrogen sulfide, chlorine and ammonia.

The Bendix Hydrogen Cyanide Detection System is available in single channel units. A single channel unit consists of a diffusion type detector, an alarm unit and an indicator unit. The detector is usually remotely located in the area to be monitored. The alarm and indicator units are designed for rack or panel mounting in a control room. One alarm unit will serve up to 12 indicator units and these will all fit in a standard 19" rack. Blank panels for vacant space are also available.



6 CHANNEL

12 CHANNEL

The sensor used in the Bendix Hydrogen Cyanide Gas Detection System is a diffusion type electrochemical gas detector. The detector consists of a sensing electrode, a counter electrode and liquidous electrolyte enclosed together behind a membrane. The hydrogen cyanide gas molecules permeate this membrane and react with the electrolyte causing a potential change of the sensing electrode. The potential change is applied to provide meter indication and alarm performance.

DETECTOR UNIT

Bendix

Environmental & Process Instruments Division

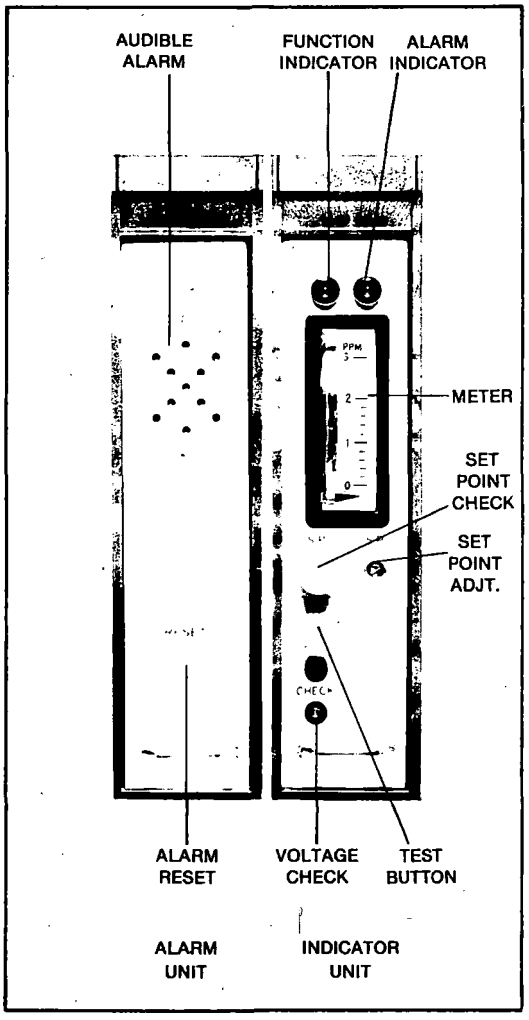
FEATURES

Simple Calibration
The calibration bottle method is recommended. The use of calibration gas ampules, breaker balls and the calibration bottle provide an economical and reliable method for calibrating the system.

Intrinsically safe - Designed with a FM approved Zener barrier, the system can be safely installed in hazardous areas.

Low interference - Due to the excellent specificity of the electrochemical hydrogen cyanide sensor, the detector has selectivity with little interference from co-existing gases (See Interference Chart Below).

Easy maintenance - Corrosion-resistant, drip-proof construction allows almost maintenance free operation.



SPECIFICATIONS

Alarm and Indicator Units
Dimensions: The alarm and indicator, each unit measures 7" high x 12" deep x 1.18" wide

Mounting options: rack or panel
Operating temperature range: 20°F to 122°F.

Power requirements: 24 vdc
Power consumption: 2.5W/channel
Alarm point: variable setting
Alarm light: blinking red light
Output for recorder: non-isolated output 1-5 vdc
Sensor
Type: diffusion type, electrochemical
Gas detected: hydrogen cyanide
Range: 0-30 ppm, (Logarithmic scale)
Alarm setting: 10 ppm adjustable
Accuracy: ±5% full scale
Output level: 4 to 20 ma to the indicator unit.

INTERFERENCE CHART

Interfering Gas	Concentration	Meter Indication
SO_2	200 ppm	Zero
NO	200 ppm	Zero
NO_2	200 ppm	Zero
CO	200 ppm	Zero
CO_2	1,000 ppm	Zero
Water Vapor	3%	Zero
Natural Gas	100%	Zero

ORDERING INFORMATION

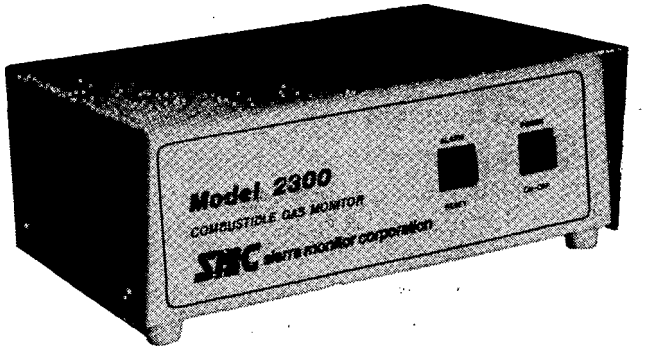
Single point alarm module and housing
Single point indicator
6 point alarm module and housing
Multi-point indicator
12 point alarm module and housing
HCN Sensor and sensor electronics
Zener barrier

The Bendix Corporation
Environmental and Process Instruments Division
12345 Starkey Road, Largo, Fla. 33543 • Telephone: (813) 536-6523 • TWX: 810-866-0880

SMC sierra monitor corporation

MODEL 2300

Combustible Gas Monitor



Now use hydrogen safely as the carrier gas in chromatographic analyses by protecting your equipment and personnel with the Model 2300 from SMC, the Gas Detection Company.

The superior performance characteristics of capillary columns for gas chromatographic analyses have become widely recognized and applied. Although it has been demonstrated that hydrogen is the carrier gas of choice for these procedures,[1] there exists, nonetheless, an inherent risk of explosion due to the accumulation of hydrogen leaking into the gas chromatograph (G.C.) column oven.

The Model 2300 Combustible Gas Monitor is a fail-safe combustible gas sensing instrument which samples continuously the air in the gas chromatograph (G.C.) column oven and sounds an alarm when the hydrogen level reaches 1%, or 25% of the LEL (lower explosive limit) of hydrogen. The alarm is accompanied by a relay-activated shut-down of AC power to two receptacles on the rear of the instrument. This feature permits the gas chromatograph and a solenoid-operated valve for the hydrogen source line to be powered through the Model 2300. Early warning and automatic fail-safe response to gas build-up by the Model 2300 combine the benefits of using hydrogen with considerably reduced risk to equipment and personnel.

Features

☐ *Audible alarm* sounds when the level of hydrogen exceeds preset alarm threshold.
☐ Two alarm-deactivated *AC receptacles* provide power to G.C. and a solenoid-operated valve for the hydrogen source.
☐ Power is restored to output AC receptacles by manual *reset switch.*
☐ Alarm threshold point is user-adjustable.
☐ *Solid-state* semiconductor-type sensor requires no maintenance.
☐ Gas outlet tube connection is provided for directing air flow through water to verify sampling pump operation.
☐ Compact console may be placed up to one meter away from G.C. for optimum space utilization. Connects to G.C. column oven with 3.2 mm (1/8-inch) OD copper tubing.
☐ Sensor-failure alarm.
☐ Quiet, long-life sampling pump ensures steady sampling of G.C. oven environment.
☐ Automatic shut-down if sample intake tube becomes blocked.
☐ System may be installed and ready for use in a matter of minutes.

Reference: [1]Jennings, W.G., "Gas Chromatography with Glass Capillary Columns," 2nd edition, Academic Press, New York, 1980.

Principle of Operation and Function

The Gas Sensor

Sierra's unique capabilities in gas sensor technology have been applied to a laboratory instrument to ensure safe operation of your gas chromatograph when using hydrogen as a carrier. The electrical conductivity of an n-type metal oxide semiconductor sensor is changed by the presence of a combustible gas. The mechanisms by which such semiconducting sensors operate have been studied with general agreement that chemisorbed oxygen ions influence the electrical resistance of the sensor.

In clean air, the resistance of the sensor provides a nominal reference value which changes considerably upon oxidation of hydrogen. The interaction of surface-absorbed oxygen ions with the hydrogen releases electrons into the conduction levels of the semiconductor, thus producing a decrease in resistance. This decrease is translated by the logic circuits of the Model 2300 into an analog signal representation of the change in gas concentration.

An integral filament maintains the sensor temperature at 450°C for optimum performance.

Gas Sampling

A vacuum pump within the Model 2300 console draws G.C. oven air over the gas sensor at about 0.38 liter per minute. A one-meter length of copper tubing connects the G.C. oven to the Model 2300 and serves to cool the sampled oven air to room temperature. (This is necessary to maintain the calibration threshold of the gas sensor.) The sampled air is exhausted out of a tubing fitting on the rear panel. To this may be connected a plastic tube so that pump operation may be verified by bubbling the air flow through water.

Alarm Threshold and Indicators

The sensor and its associated measurement and comparison circuits are DC-powered (9 V source), and factory-calibrated to trigger the alarm when the sensor encounters a concentration of 10,000 ppm (1%) hydrogen, ± 1000 ppm.

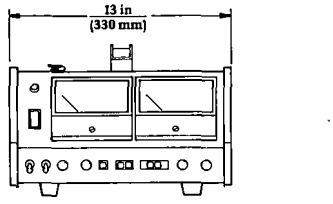
When this happens:

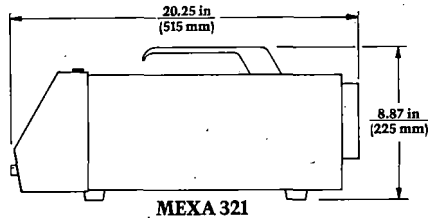
- **The red ALARM light comes on and remains illuminated,**
- **high-pitched, continuous tone sounds during the time the high gas concentration is present, and**
- ***both AC output (through-power) receptacles* on the rear panel are turned off.**

SPECIFICATIONS

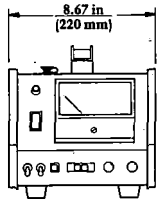
Model	MEXA-201-E	MEXA 211E	MEXA 221E	MEXA 321E
Measured Gas	CO	CO_2	HC	CO HC CO CO_2
Standard Measuring Ranges	0–2% 0–8% or 0–1000 ppm 0-5000 ppm	0–5% 0–15%	0–500 ppm 0–2000 ppm	CO-O-2/8% HC: 0–500/2000 ppm or CO: 0–1000/5000 ppm CO_2: 0–5/25%
	Non standard ranges available. Consult your Horiba representative.			
Repeatability	± 2% full scale ± 5% full scale *	± 5% full scale	± 2% full scale	± 2% full scale ± 5% full scale *
Meter Scale Length	3.8 inches (98mm)			
Response Time	90% Response within 10 seconds			
Warm up Time	30 Minutes			
Signal Output	0–100 Millivolts D.C.			
Power Requirement	110 VAC	± 10% 50 Watts	60Hz	110VAC 60Hz 80 Watts
Ambient Temperature	0–40°C 32–104°F		Less than 90% R.H.	
Dimensions	8.7 inches x 8.9 inches x 20.5 inches 220mm x 225mm x 520mm			13 inches x 8.9 inches x 20.5 inches 330mm x 225mm x 520mm
Weight	21 pounds 9.5 KGS			28.6 pounds 13 KGS

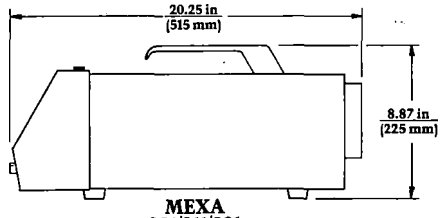
*Applies to most sensitive ranges



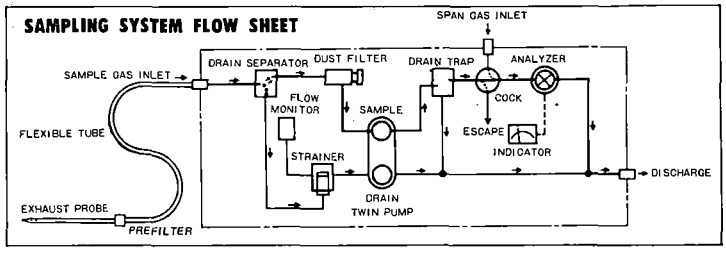


MEXA 321





MEXA 201/211/221



HORIBA

U.S. REGIONAL SALES AND SERVICE OFFICES:

Horiba Instruments, Inc.
1021 Duryea Avenue
Irvine, California 92714
Phone: (714) 540-7874
Telex: 65-5463

3901 Varsity Drive
Ann Arbor, Michigan 48104
Phone: (313) 973-2171

5200 Mitchelldale
Suite D-8, Room 16
Houston, Texas 77092
Phone: (713) 683-7143

3001 Hadley Road/Section 5A
South Plainfield, New Jersey 07080
Phone: (201) 755-0104

INTERNATIONAL OFFICES:

Japan
Horiba, Ltd.
Miyanohigashi, Kisshoin
Minami-ku
Kyoto, Japan
Phone: (075) 313-8121
Telex: 5422130

Switzerland
Horiba Instruments,
Société Anonyme
41 Rue Marziano
Ch-1227 Acacias
Geneva, Switzerland
Phone: 022-43-85-20
Telex: 28-93-13

England
Horiba Instruments, Ltd.
5 Harrowden Road
Blackmills
Northampton NN4 OEB
England
Phone: 0604-65171
Telex: 311869

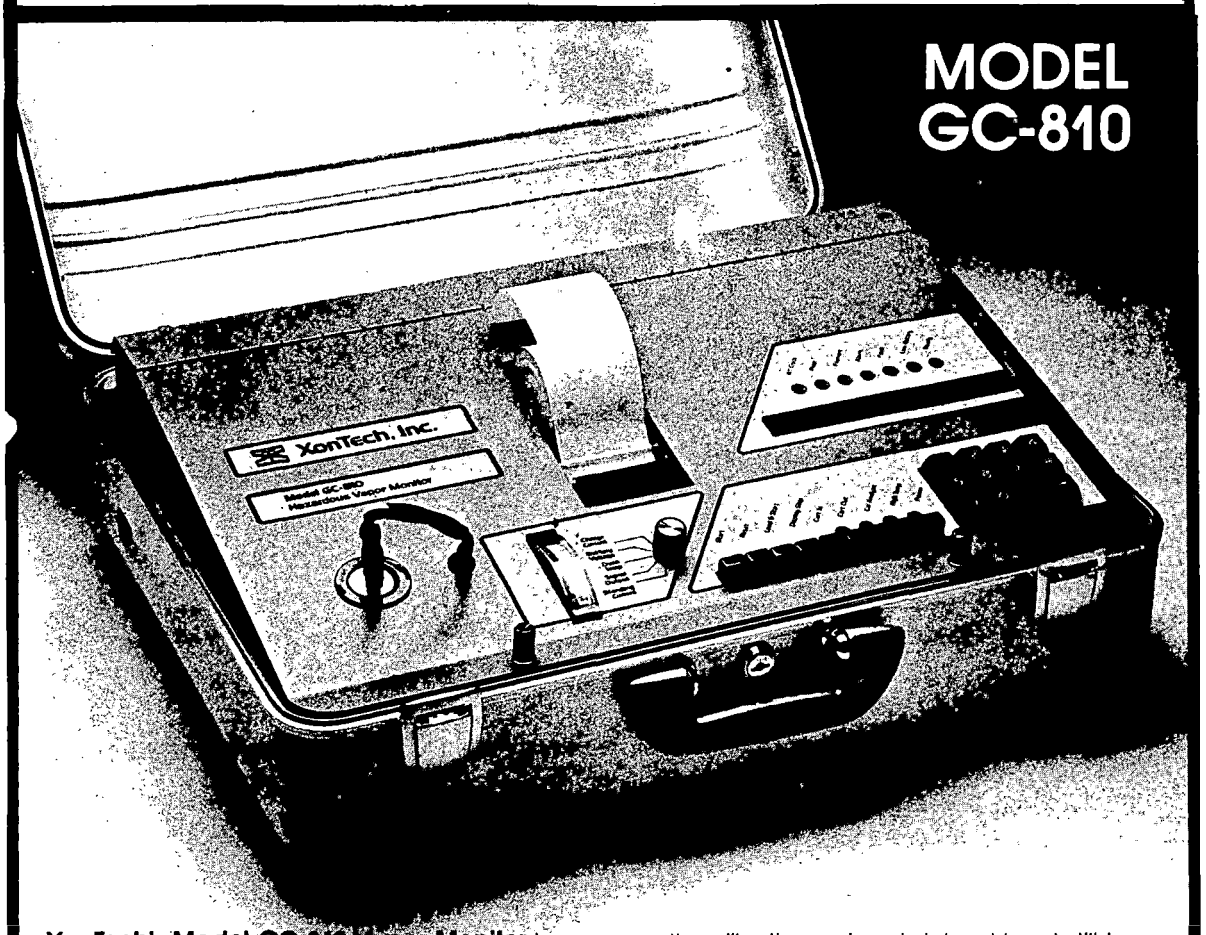
West Germany
Horiba Europe GmbH
Industriestrasse 8
6374 Steinbach
West Germany
Phone: 06171-7755
Telex: 410829

France
Horiba France
13 chemin du Levant
F01210 Ferney Voltaire
France
Phone: (50) 40-85-38
Telex: 842-385054

Printed in U.S.A.

XonTech, Inc.

Hazardous Vapor Monitor



XonTech's Model GC 810 Vapor Monitor is a sensitive instrument consisting of a patented preconcentrator, automatic gas chromatograph and a detector programmable to seek out and measure hazardous vapors in industrial environments. The combination of these three subsystems results in a unique instrument both sensitive and versatile. Automatic calibration and analysis is achieved utilizing a microcomputer; resulting data is automatically displayed and printed in engineering units. The portable, battery-operated unit simultaneously measures up to four constituents in the atmosphere. Any four vapors, selected by the user, may be programmed into the memory of the GC 810 for future surveillance.

APPLICATIONS

- HAZARDOUS VAPOR IDENTIFICATION AND MEASUREMENT FOR FUGITIVE EMISSIONS
- WORK AREA SURVEILLANCE
- ENVIRONMENTAL SURVEYS FOLLOWING ACCIDENTAL SPILLS
- CONFINED AREAS SURVEYS
- CONTINUOUS AIR VENTILATION DUCT MONITORING FOR HAZARDOUS VAPORS
- CONTINUOUS DIRECT READOUT OF TOTAL VAPOR CONCENTRATION
- PROCESS CONTROL MONITORING

SPECIFICATIONS

• Range:	10 ppb to 100 ppm
• Sensitivity (minimum detectable concentration):	As low as 5 parts in 10^9 (5 ppb)
• Time Response:	Approximately 20 seconds to 30 minutes
• Selectivity:	1.0% false alarms
• Warm-up Time:	20-30 minutes
• Alarm Indication:	Audible and visual alarm
• Power Requirements:	12 VDC or 120/220 VAC (rechargeable battery)
• Chromatographic Column:	Variety of columns available
• Column and Detector Temperature:	60 to 200°C
• Column Conditioning:	High temperature (manually selectable)
• Column Temperature Stability:	±0.25°C
• Column Temperature Adjustment:	Manually adjustable
• Recorder Output:	0-1 volt dc
• Detector:	Electron capture or Argon ionization, H^3 source 150 mCi
• Detector Voltage:	10 VDC (ECD), 300 VDC (Argon)
• Flowrate of Sampled Air:	Adjustable to 1000 cc/min
• Sampling Time:	2 seconds to 5 minutes
• Injection Time:	3 seconds or less
• Filament Temperature of Vapor Concentrator:	Adjustable between 80°C to 150°C
• Analysis Time:	Adjustable between 20 sec. to 30 min.
• Automatic Calibration:	2 to 120 per calibration (operator selectable)
• Alarm Limits:	1% to 999% of calibration

XonTech, Inc.

6862 Hayvenhurst Ave., Van Nuys, CA. 91406
(213) 787-7380 TWX (910) 495-1725

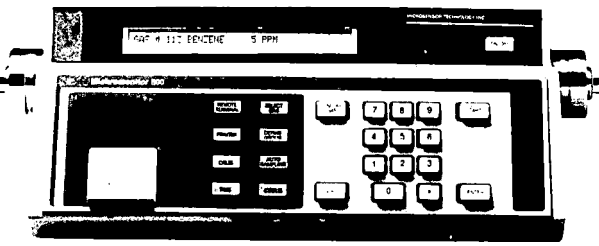
AUTOMATED ON SITE G.C.MEASUREMENTS OF VAPORS IN THE ATMOSPHERE

A. LINENBERG

MAY 1983

Sentex SENSING TECHNOLOGY, INC
339 Broad Avenue • Ridgefield • New Jersey 07657
201-945-3894

Michromon

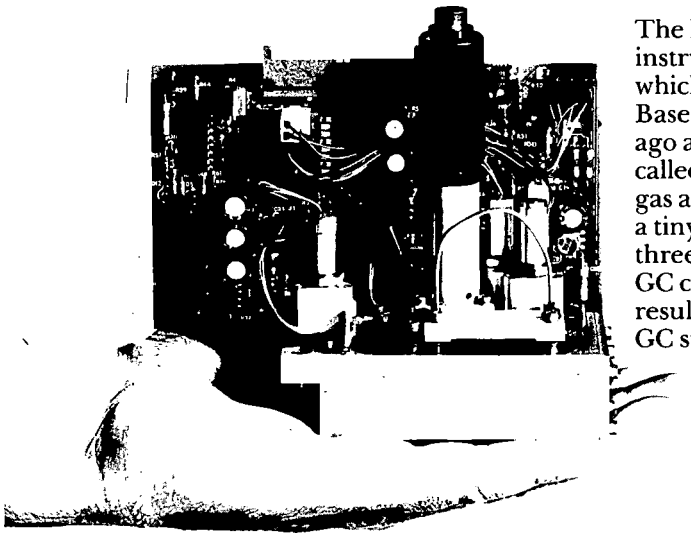


You can make rapid analyses – to the PPM level – without waiting. Take this rugged high-performance gas chromatograph anywhere to identify up to 100 different gases – any ten gases in 45 seconds.

Use the Michromonitor for

- Industrial safety and hygiene
- Process control
- Natural gas analysis
- Stack gas monitoring
- Combustion control
- Environmental analysis
- QC and analytical laboratories
- Energy exploration and research
- Bioengineering
- Aerospace and military
- Medical and forensic
- Food processing

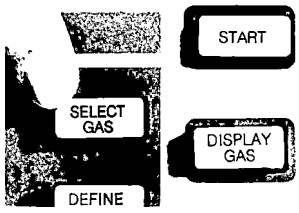
Revolutionary GC Design



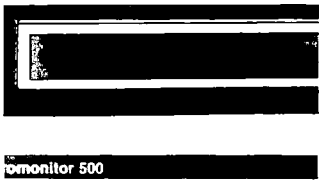
The heart of this remarkable compact instrument is a series of miniature modules which are complete gas chromatographs. Based on development begun over twelve years ago at Stanford University, a new technology called silicon micromachining allows all carrier gas and sample channels, valve structures, and a tiny TC detector to be integrated onto a single three-inch silicon wafer. A 0.1mm ID capillary GC column is interfaced to this wafer. The result is an ultra-high-speed, high-resolution GC system with outstanding performance.

itor™ Universal Gas Analyzer

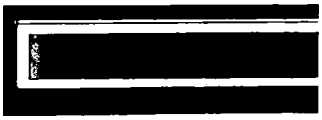
Easy To Use. Anyone can use the Michromonitor with a few minutes of instruction. It's as easy as 1 - 2 - 3! First, SELECT the gases for analysis. Second, press the START button. Third, DISPLAY the results. The powerful microcomputer automates the entire analysis cycle, and calculates and displays the gas concentrations.



Fast Results. In less than one minute, the Michromonitor will display the identity of each gas analyzed *and* its concentration in PPM or %. If you desire permanent records simply connect the Michromonitor to other devices. Its memory will store the results of at least 1000 analyses, including date and time, for subsequent transfer to a printer, computer, or other storage device.

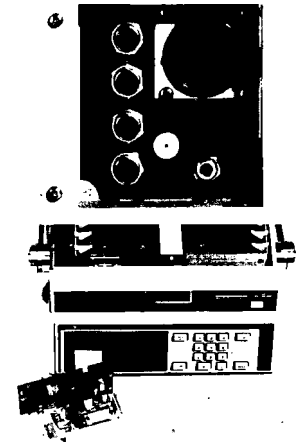


Reliable Operation. For many gases, the on-board microcomputer uses correlation chromatography, a well-proven technique which compares the analytical results of two GC modules to eliminate—or warn you—of potential interferences. The computer continuously performs diagnostic checks of mechanical and electrical functions, and the display alerts you to possible problems.



Take It Anywhere. Use the Michromonitor anywhere: indoors or out, under or above ground, over a broad temperature range. Fully self-contained, it has rechargeable batteries and uses disposable carrier gas cartridges. In a fixed location, plugged into a standard 110 volt outlet and connected to a large carrier gas tank, the Michromonitor will operate as an automatic and continuous monitor.

Completely Automatic. You can easily select manual, automatic, or remote control operation. You can use the Michromonitor with external sampling devices and controllers. It can send results to, or be controlled by, an external computer. Built-in statistical programs continuously calculate and update concentration minimums, maximums, means, time-weighted averages, and standard deviations for each gas analyzed.



Flexible. From one to five GC modules may be incorporated into the Michromonitor mainframe. This modular design meets your individual gas analysis needs with a custom but cost-effective system. Modules can easily be added to existing instruments as new applications arise.

This is a preliminary specifications sheet and is subject to change.

Michromonitor Universal Gas Analyzer Specifications

Gases measured The instrument will measure the concentrations of any of the 100 gases in its internal library. Gases can be selected and measured in any combination of up to ten gases at a time. Nine groups of up to 10 gases may be defined and stored in memory for recall at the touch of a button. Additional gases can be added to the instrument's library.

Sample conditioning Samples must be near ambient temperature and less than 5 psi at the inlet of the instrument.

Diagnostics Internal computer reports carrier gas status and battery charge. Complete automatic instrument diagnostic check is performed when instrument is turned on. Mechanical or electrical problems which could affect the reliability of results are immediately flagged.

***Range and sensitivity** Measures concentrations from 1 PPM to 100% (for a few gases in the library, minimum concentration level is 20 PPM).

***Accuracy** (for Pentane) Plus or minus 20% at 1 PPM; Plus or minus 1% at 10 PPM; Plus or minus 0.2% at 100 PPM and above.

Calibration Calibration executed by internal computer using a standard calibration gas mixture or user supplied standards.

Programmable automatic sampling The instrument can be programmed to take automatic samples at any interval up to one sample per minute. The results of at least 1000 analyses are retained in the instrument's memory. These can be accessed for hard copy printout. Built-in statistical routines continuously update minimums, maximums, means and standard deviations for each of the selected gases. The internal real-time clock also provides time of day and date of each analysis and when minimums and maximums occur. Alternatively, the results can be dumped to an external computer for storage or later manipulation.

Internal display Gas concentrations in percent or part per million are indicated on a 40 character alphanumeric display. Typical information displayed: a) gas number, b) name of gas, c) concentration.

The alphanumeric display is also used to indicate: date and time of day; statistics from programmed automatic sampling; gases selected; and instrument diagnostics.

***Response time** Complete measurement cycle time is 45 seconds for up to 10 gases per cycle. The number of gases selected does not affect cycle time.

External outputs Output connections include external chart recorder, storage oscilloscope, CRT terminal, printer, external computer.

Alarm levels Upper and lower alarm levels are individually presettable for each of the ten gases selected for a given measurement.

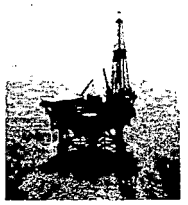
Physical Dimensions: Height-7" (18cm); Width-14" (36cm); Depth-23" (58cm); Weight-35 lbs. (16kg).

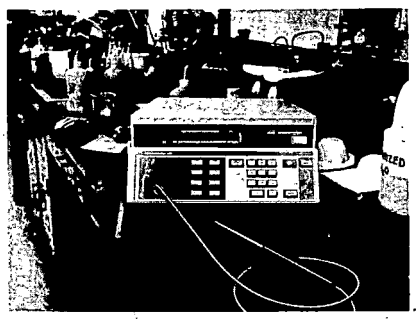
Environmental Moisture and dust resistant, rugged packaging, intended for field or laboratory use. Operating temperature range: 0-45 degrees centigrade.

Power Internal rechargeable batteries with built-in charger. Also operates directly from 110 VAC power line.

Consumables Instrument utilizes a small internal helium carrier gas cylinder. Sixteen to forty-eight hours of continuous sampling (one sample per minute) can be obtained from a single, disposable carrier gas cylinder.

*These specifications are all at 25°C.





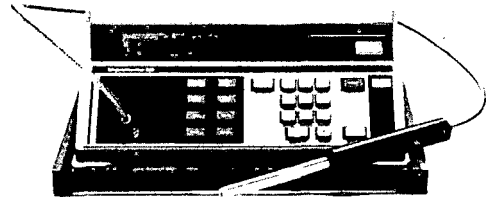
Microsensor Technology, Inc.
47747 Warm Springs Blvd., Fremont, CA 94539 (415) 490-0900 • Telex 171627

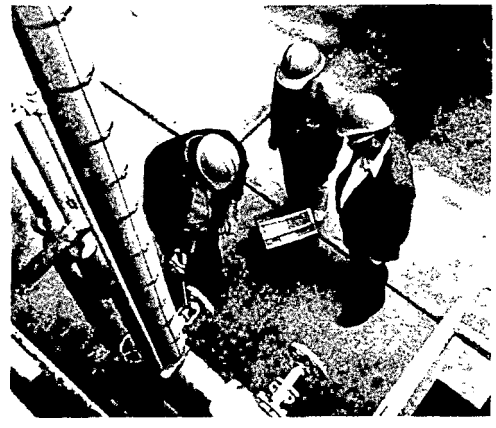
microsensor technology inc.

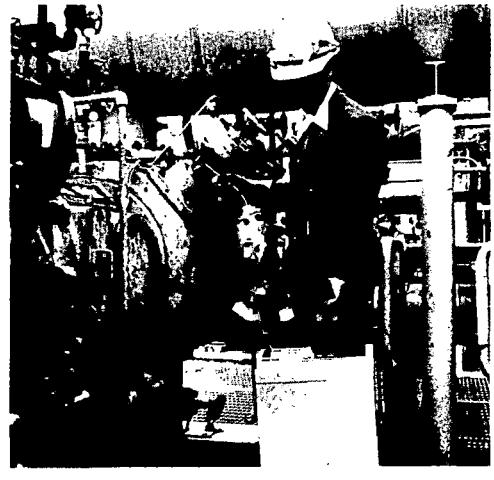
Product Profile

Michromonitor 500 Price List

Part Number	Description	Price
M500-0000	Mainframe - includes Master computer, one slave computer keyboard, memory board, display, rechargeable battery & power supply, carrier gas system, etc.	$ 7500.00
M500-0001	Slave #2 - must be added when more than 3 G.C. modules are installed.	750.00
M500-0002	Sample Probe - a hand held probe with cable ideal for portable use.	450.00
M500-0003	Sample Cable - a 3 ft. cable with fitting for direct hookup to a sample stream.	250.00
M500-1001	G.C. Module #1 - for O_2,N_2,CO,and Methane (20ppm detection limit).	2250.00
M500-1002	G.C. Module #2 - For Air, CO_2, Methane, Ethane, Ethylene, Acetylene (20ppm detection limit).	2250.00
M500-1003	G.C. Module #3 - for C_2-C_7 nonpolar hydrocarbons, (Propane, Butene,etc.) Chlorinated hydrocarbons (Chloroform, Methybromide, etc.) and Freons.	2750.00
M500-1004	G.C. Module #4 - for C_2-C_7 polar hydrocarbons (Methanol, MEK, Ethyl Ether, etc.).	2750.00
M500-1005	G.C. Module #5 - for C_7 + Hydrocarbons (heptane, isooctane, etc.) Aromatics (Benzene, Toluene, etc.).	2500.00
M500-1006	G.C. Module #6 - for Amines (Methylamine etc.) and other basic compounds.	$ 2500.00
M500-1007	G.C. Module #7 - for Sulfur Compounds (H_2S, Mercaptans, etc.) and other acidic compounds.	2500.00
	CONSUMABLES	
9510-0115	Disposable Carrier Gas Cartridge	14.00
9510-0125	Calibration Gas Mixture, 14 liter cylinder	49.00
9510-0135	Pressure Regulator for calibration gas mixture cylinder	49.00







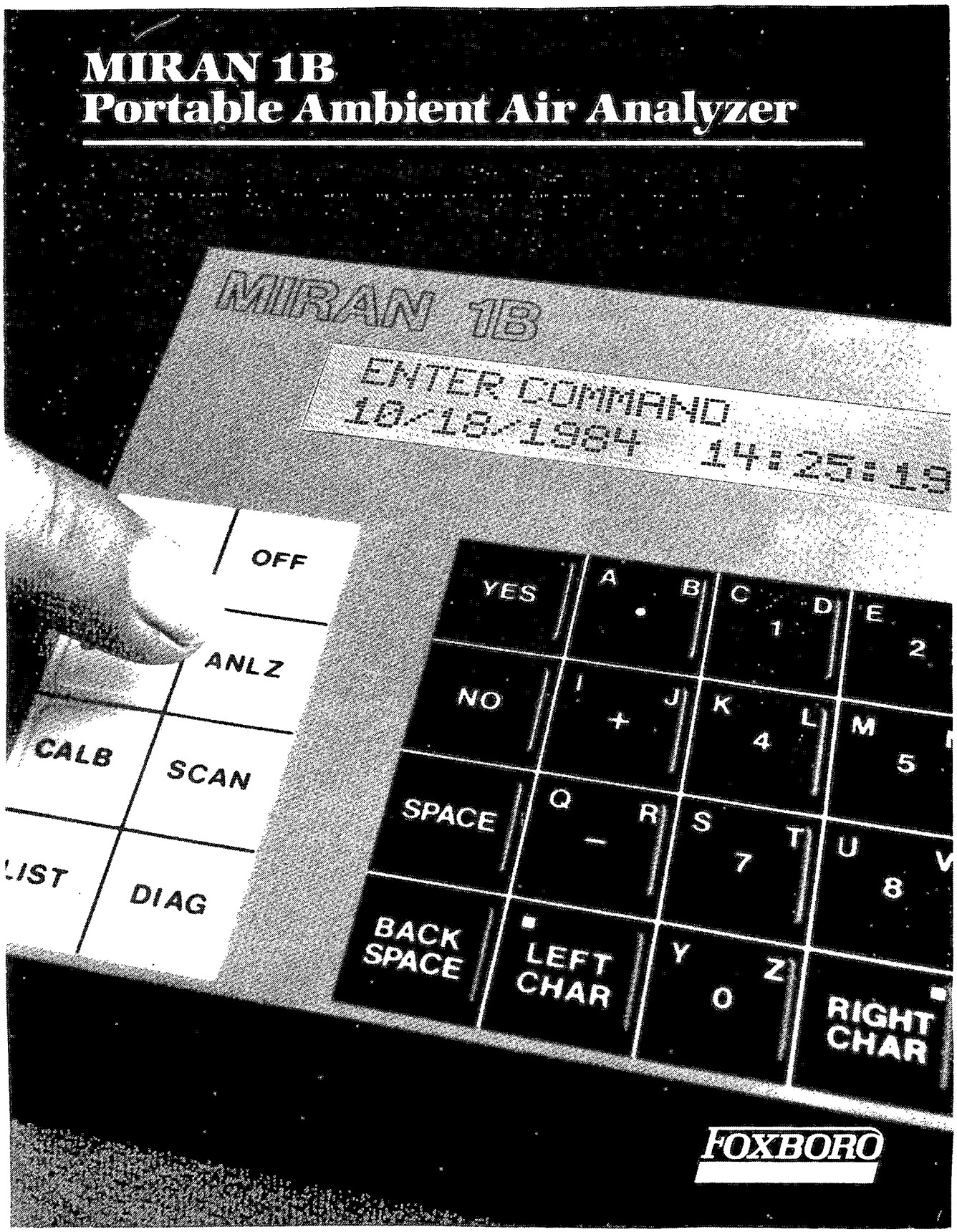
ORDERING INFORMATION

Prices are F.O.B. Fremont, California and are subject to change without notice.

Orders may be placed by calling Toll Free (800) 421-7372. Inside California (415) 490-0900.

Mail and Confirming orders may be sent to:

Microsensor Technology, Inc.
47747 Warm Springs Blvd.
Fremont, CA 94539
ATTN: Order Processing


MIRAN 1B
Portable Ambient Air Analyzer
MIRAN 1B
ENTER COMMAND
10/18/1984 14:25:19
OFF
ANLZ
CALB
SCAN
LIST
DIAG
YES
NO
SPACE
BACK SPACE
LEFT CHAR
RIGHT CHAR
FOXBORO

A. *Semiconductor Manufacturing*
B. *Hospitals*
C. *Chemical Plants*
D. *Petrochemical Facilities*
E. *Textile Manufacturing*
F. *Pharmaceutical/ Cosmetic Industries*

Features of the MIRAN 1B Portable Ambient Air Analyzer

- ☐ Automatic wavelength and path-length selection
- ☐ Table of over 100 compounds for which the analyzer has been precalibrated
- ☐ Storage of calibration and analysis parameters
- ☐ Audible alarms for operator error, when preset concentration level has been reached, and variable frequency to help locate source of leaks
- ☐ Peak picker scan to locate absorption bands
- ☐ Prompting of the user through the keyboard to simplify operation
- ☐ Covers infrared region from 2.5 to 14.5 micrometres
- ☐ Variable pathlength gas cell to measure from low ppm to percent level concentrations
- ☐ Lightweight—weighs 12.7 kg (28 lbs.)
- ☐ Internal sampling pump and 0.9 m (3 ft.) of sampling hose to provide real-time data continuously
- ☐ Internal rechargeable battery for up to 4 hours of portable operation
- ☐ LCD display with concentration or absorbance readout
- ☐ Scanning capability for qualitative analyses

Adjustable, Padded Shoulder Strap

Made of tough, durable material. Easily adjusts for operator comfort, balance, and height.

Rugged Housing

Made of tough, heavy-duty Noryl structural foam, the housing protects the internal electronics and infrared gas cell from shock damage.

Flexible Sample Probe Assembly

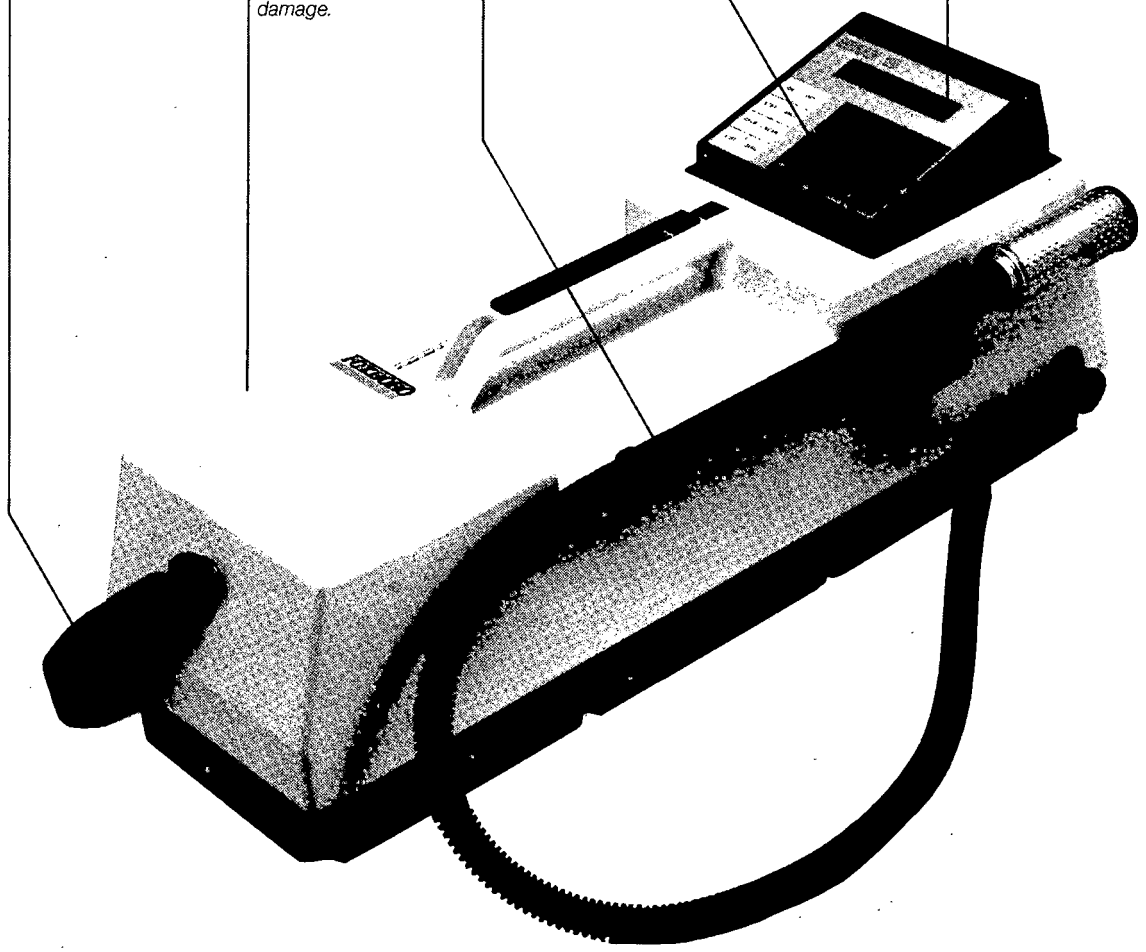
The flexible hose and sensitive sniffer allow the operator to reach difficult areas.

Tough Sensitive Keyboard

Instantly responds to finger pressure. Large size keys help assure error-free entries.

Easy-To-Read Display

Two line, 20 characters per line, liquid crystal display which is back lit to be seen in low-light areas.



Compound Library[a]

Compound	Range of Calibration (ppm)	Alpha-numeric Name
Acetaldehyde	0 to 400	ACTALD
Acetic Acid	0 to 50	ACETA
Acetone	0 to 2000	ACETON
Acetonitrile	0 to 200	ACETCN
Acetophenone	0 to 100	ACTOPN
Acetylene	0 to 200	C2H2
Acetylene Tetrabromide	0 to 200	ACNBR4
Acrylonitrile	0 to 20 and 0 to 100	ACRCN
Ammonia	0 to 100 and 0 to 500	NH3
Aniline	0 to 20	ANILIN
Benzaldehyde	0 to 500	BZALDH
Benzene	0 to 50 and 0 to 200	BNZENE
Benzyl Chloride	0 to 100	BZCL
Bromoform	0 to 10	CHBR3
Butadiene	0 to 2000	BUTDEN
Butane	0 to 200 and 0 to 2000	BUTANE
2-Butanone (MEK)	0 to 250 and 0 to 1000	MEK
Butyl Acetate	0 to 300 and 0 to 600	BUTAC
n-Butyl Alcohol	0 to 200 and 0 to 1000	BUOH
Carbon Dioxide	0 to 2000	CO2
Carbon Disulfide	0 to 50	CS2
Carbon Monoxide	0 to 100 and 0 to 250	CO
Carbon Tetrachloride	0 to 20 and 0 to 200	CCL4
Chlorobenzene	0 to 150	CLBZ
Chlorobromomethane	0 to 500	CLBRME
Chlorodifluoromethane	0 to 1000	F22
Chloroform	0 to 100 and 0 to 500	CHCL3
m-Cresol	0 to 20	CRESOL
Cumene	0 to 100	CUMENE
Cyclohexane	0 to 500	CYHXN
Cyclopentane	0 to 500	CYPNTN
Diborane	0 to 10	B2H6
m-Dichlorobenzene	0 to 150	MCL2BZ
o-Dichlorobenzene	0 to 100	OCL2BZ
p-Dichlorobenzene	0 to 150	PCL2BZ
Dichlorodifluoro-methane (Freon 12)	0 to 5 and 0 to 800	F12
1,1-Dichloroethane	0 to 200	11DCE
1,2-Dichloroethylene	0 to 500	CL2ETE
Dichloroethyl Ether	0 to 50	CL2ETH
Dichloromonofluoro-methane (Freon 21)	0 to 1000	F21
Dichlorotetrafluoroethane (Freon 114)	0 to 1000	F114
Diethylamine	0 to 50	ET2NH2
Dimethylacetamide	0 to 50	DMAC
Dimethylamine	0 to 50	ME2NH2
Dimethylformamide	0 to 50	DMF
Dioxane	0 to 100 and 0 to 500	DIOXAN
Enflurane	0 to 10 and 0 to 100	ENFLRN
Ethane	0 to 1000	ETHANE
Ethanolamine	0 to 100	ETOHNH
2-Ethoxyethyl Acetate	0 to 200	CELAC
Ethyl Acetate	0 to 400 and 0 to 1000	ETAC
Ethyl Alcohol	0 to 1000 and 0 to 2000	ETOH
Ethylbenzene	0 to 200	ETBZN
Ethyl Chloride	0 to 1500	ETCL
Ethylene	0 to 100	ETHYLN
Ethylene Dibromide	0 to 10 and 0 to 50	ETBR2
Ethylene Dichloride	0 to 100	ETCL2
Ethylene Oxide	0 to 10 and 0 to 100	ETO
Ethyl Ether	0 to 1000 and 0 to 2000	ETHER
Fluorotrichloromethane (Freon 11)	0 to 2000	F11
Formaldehyde	0 to 20	HCHO
Formic Acid	0 to 20	FORMIC
Halothane	0 to 10 and 0 to 100	HALTHN
Heptane	0 to 1000	HEPTAN
Hexane	0 to 1000	HEXANE
Hydrazine	0 to 100	HYDZ
Hydrogen Cyanide	0 to 20	HCN
Hydrogen Fluoride	0 to 50	HF
Isoflurane	0 to 10 and 0 to 100	ISOFLN
Isopropyl Alcohol	0 to 1000 and 0 to 2000	IPA
Isopropyl Ether	0 to 1000	IPETH
Methane	0 to 100 and 0 to 1000	METHAN
Methoxyflurane	0 to 10 and 0 to 100	MXYFLN
Methyl Acetate	0 to 500	MEAC
Methyl Acetylene	0 to 1000 and 0 to 5000	MEACEN
Methyl Acrylate	0 to 50	MEACRY
Methyl Alcohol	0 to 500 and 0 to 1000	MEOH
Methylamine	0 to 50	MENH2
Methyl Bromide	0 to 50	MEBR
Methyl Cellosolve	0 to 50	MECEL
Methyl Chloride	0 to 200 and 0 to 1000	MECL
Methyl Chloroform	0 to 500	111TCE
Methylene Chloride	0 to 1000	MECL2
Methyl Iodide	0 to 40	MEI
Methyl Mercaptan	0 to 100	MESH
Methyl Methacrylate	0 to 250	MEMAC
Morpholine	0 to 50	MORPH
Nitric Oxide	0 to 100	NTRCOX
Nitrobenzene	0 to 20	NO2BZ
Nitrogen Dioxide	0 to 10	NO2
Nitromethane	0 to 200	NO2ME
Nitrous Oxide	0 to 100 and 0 to 2000	N2O
Octane	0 to 100 and 0 to 1000	OCTANE
Pentane	0 to 1500	PENTAN
Perchloroethylene	0 to 200 and 0 to 500	PERC
Phosgene	0 to 5	PHOSGN
Propane	0 to 2000	PROPAN
n-Propyl Alcohol	0 to 500	PROPOH
Propylene Oxide	0 to 200	PRENOX
Pyridine	0 to 100	PYR
Styrene	0 to 200 and 0 to 500	STYRN
Sulfur Dioxide	0 to 100 and 0 to 250	SO2
Sulfur Hexafluoride	0 to 5 and 0 to 500	SF6
1,1,2,2-Tetrachloro 1,2-Difluoroethane (Freon 112)	0 to 2000	F112
1,1,2,2-Tetrachloro-ethane	0 to 50	CL4ETA
Tetrahydrofuran	0 to 500	THF
Toluene	0 to 1000	TLUENE
Total Hydrocarbons	0 to 1000	TOTHYD
1,1,2-Trichloroethane	0 to 50	CL3ETA
Trichloroethylene	0 to 200 and 0 to 2000	TRI
1,1,2-Trichloro 1,2,2-Trifluoroethane (Freon 113)	0 to 2000	F113
Trifluoromonobromo-methane (Freon 13B1)	0 to 1000	F13B1
Vinyl Acetate	0 to 10	VAC
Vinyl Chloride	0 to 20	VCL
Vinylidene Chloride	0 to 20	VDC
Xylene (Xylol)	0 to 200 and 0 to 2000	XYLOL

[a]The Foxboro Company reserves the right to add (or delete) compounds to (from) the compound library.

Freon is a trademark of E.I. duPont de Nemours and Company.
Noryl is a trademark of General Electric Company.

MIRAN 1B PORTABLE AMBIENT AIR ANALYZER

The MIRAN 1B Analyzer, a microprocessor-controlled instrument, can detect and quantitatively measure any gas having the absorption bands in the infrared region from 2.5 to 14.5 micrometres.

The built-in microprocessor of the MIRAN 1B Analyzer simplifies the operation and calibration of the instrument by automated wavelength and pathlength adjustments. An operator interactive keyboard with extensive alphanumeric display prompting leads the user through the modes of operation. All calibration and analysis parameters are stored in a nonvolatile memory. Also contained in the instrument's memory is a table of over 100 compounds and memory space for up to 10 user-selected and calibrated compounds.

Portability, versatility, and ease of operation are the key features of the MIRAN 1B Analyzer. The instrument incorporates an improved design consisting of the analyzer head and patented 20 metre variable pathlength gas cell in one molded enclosure which contributes to the overall ruggedness and portability of the unit. The gas cell gives the analyzer the versatility of measuring concentration levels from low parts per billion (ppb) to percent levels. Also incorporated into the analyzer is an LCD display concentration or absorbance readout, an internal rechargeable battery, sampling pump, and circular variable filter. The unit is lightweight, 12.7 kg (28 lb), and has a handle and shoulder strap that makes it easy to carry.

The user has the option of calibrating the instrument with user gases or utilizing the calibration information which has been determined by Foxboro. In addition, the user has the capability of editing the parameters in the library to change wavelength, concentration range, alarm level, etc. When a compound name is entered, the instrument automatically selects pathlength and wavelength to the specifications in memory.

Features of the MIRAN 1B Analyzer:

- Automatic wavelength and pathlength selection
- Table of over 100 compounds for which the analyzer has been precalibrated
- Storage of calibration and analysis parameters
- Audible alarms for operator error, when preset concentration level has been reached, and variable intensity to help locate source of leaks
- Peak picker scan to locate absorption bands
- Prompting of the user through the keyboard to simplify operation
- Covers infrared region from 2.5 to 14.5 micrometres
- Variable pathlength gas cell to measure from low ppm to percent level concentrations
- Lightweight — weighs 12.7 kg (28 lb)
- Internal sampling pump and 0.9 m (3 ft) of sampling hose to provide real-time data continuously
- Internal rechargeable battery for 4 hours of portable operation
- LCD display with concentration or absorbance readout
- Scanning capability for qualitative analyses

New Monitor to Detect and Analyze Hazardous Chemical Vapors

Many types of workers risk occupational exposure to unpredictable levels of hazardous gases; such workers include U.S. Coast Guard personnel who clean up spills and inspect the interiors of vessels used to transport industrial chemicals. To help protect the health of such personnel, Argonne National Laboratory, Energy and Environmental Systems Division, is developing an advanced, portable gas monitor.

The Argonne device will quickly detect and identify hazardous chemical vapors, measure even trace concentrations of the vapors, and sound an alarm if the concentrations present a health risk. There are no portable, field-worthy monitors now available that can offer these features.

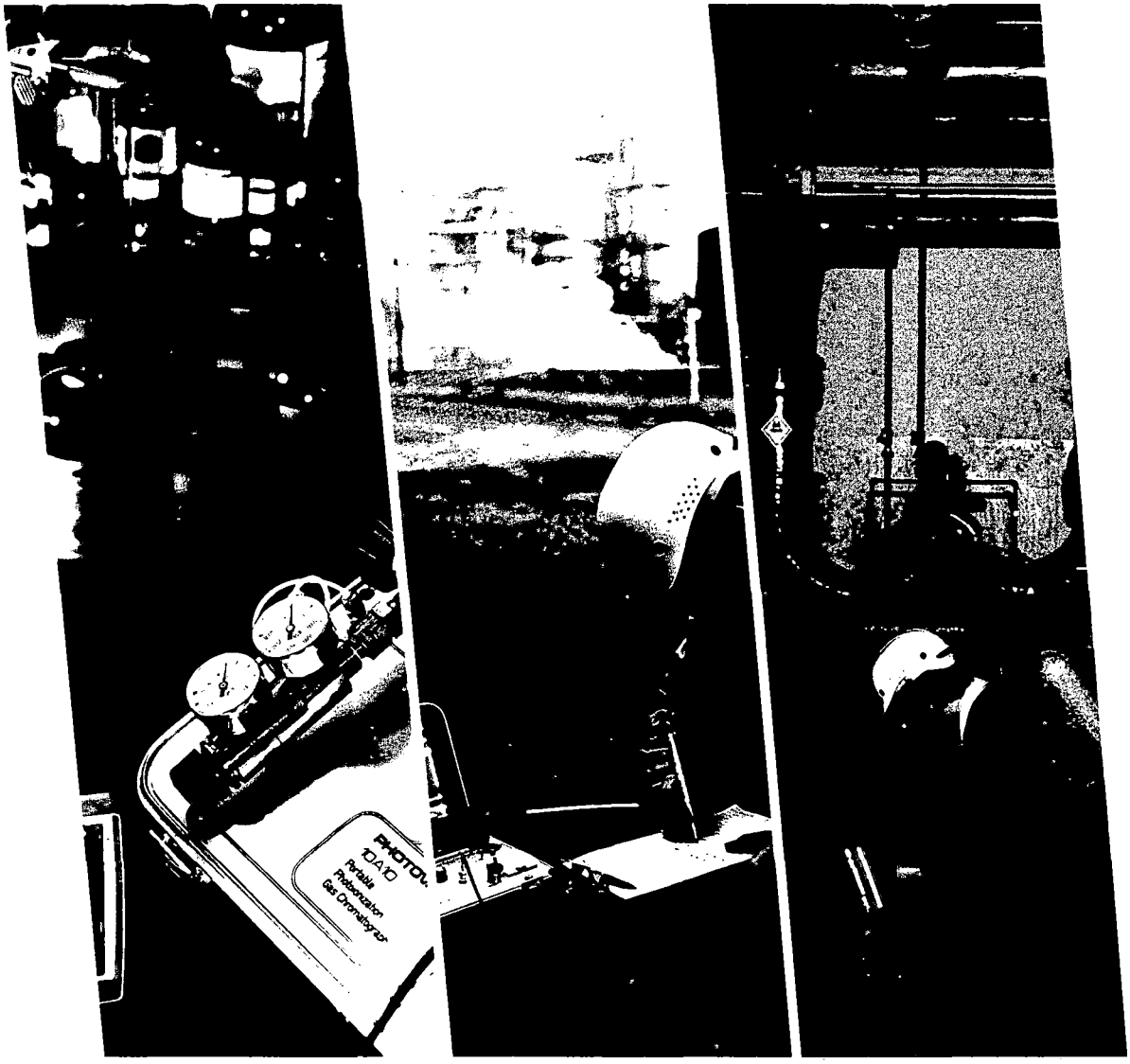
A benchtop laboratory prototype of the monitor has been constructed (patents pending). The Chemical Parameter Spectrometer (CPS-100) can identify and measure the levels of about 20 toxic gases, weighs about 15 pounds, and is battery-operated.

After further research, the completed monitor will be expanded to detect about 100 chemicals. It is being developed for the Coast Guard, but will be useful in any setting where chemicals must be detected and analyzed rapidly and simply.

For more information, contact Lynda Narug, Energy and Environmental Systems Division, Argonne National Laboratory, Argonne, Illinois 60439. Phone (312) 972-8794.

PHOTOVAC introduces the 10A10

a dramatic advance in portable photoionization gas chromatography



•Environmental Protection •Industrial Hygiene •Emergency Response •Routine Analysis

ACHIEVE IMMEDIATE AIR SAMPLING RESULTS

from 0.1ppb to 100ppm

PHOTOVAC
incorporated

Now, air sampling will never be the same

Introducing the Photovac 10A10 Portable Gas Chromatograph

PHOTOVAC
incorporated

Today, as never before, there is an urgent need for an air sampling system which can combine speed, accuracy and reliability with simplicity of operation. The ideal system would have sufficient sensitivity reserve to meet the needs of both Occupational Hygienists and Environmental workers in a single instrument, implying an ability to measure air pollutants over a range from 100 parts per million down to below 1 part per billion, yet still retaining excellent stability.

The Photovac 10A10 does all this and more! As a result of specialized research and development at Photovac, an advanced technology photoionization detector (PID) has been perfected which has permitted the realization of a **portable gas chromatograph with performance beyond the capability of even present-day laboratory systems!**

The 10A10 system combines sampling and direct analysis in one simple, speedy step; even when sub-part per billion measurements are to be made, there is no longer the need for any type of preconcentration procedure.

An air sample, whose volume can be between 1 mL and 1 µL, is injected into the 10A10 and a multicomponent analysis will be in your hands within a few minutes — sometimes even seconds!

Sensitivity and Stability
Traditionally, air sampling of the type described is performed by metering a multilitre air sample into an absorption tube and sending this to the laboratory for analysis. The total time for this two-step procedure can be inconveniently long **and** the degree of confidence in the results (when you finally get them) is extremely low.

Take vinyl chloride and benzene as two topical examples. With the 10A10, both can be directly measured to sub-part per billion levels with an accuracy of 5%; vinyl chloride can be analyzed within 40 seconds, benzene in three minutes. With the results available this quickly, you are free to monitor the effects of time and geography on the situation and to take corrective action immediately.

For the many people who don't need such exotic sensitivity?
Look at the trade-off in terms of stability — now you have an instrument with the sensitivity reserve to measure parts per million with ease...contrast this with most existing instruments which stretch older technologies to the limit and where you have to search to find a ppm amongst the background noise! With readings of this type, the 10A10 is ready to go within 5 minutes of a 'cold' start — and, no noise!

Introduction of the air sample directly into the analyzer, coupled with the ability to take the analyzer to the sampling site avoids so many problems ... and provides the key to a new era of air sampling excellence. Photovac's instrument utilizes a wide range of ambient temperature gas chromatograph columns which are easily changed to meet differing requirements. The unit operates with **air** as the carrier gas — an important feature because the majority of samples to be analyzed are dispersed in an air matrix and the disruption caused by the sample injection is minimized. The Photovac 10A10 is a safe piece of equipment to use; there are no hydrogen cylinders or flames to worry about.

Portability and Ease of Operation
For all air analyses the procedure is the same: the instrument is set up, and a volume of air is injected with a conventional gas-tight syringe. The 10A10 can be easily moved to any sampling site (it weighs only 11 kg.) or kept in a central location, like a lab, with the samples brought to it. The unit will operate directly from an AC outlet and offers the added benefit of built-in rechargeable batteries and up to 10-day air carrier gas supply for extended field use. The Photovac 10A10 is unmatched in its capabilities in field analyses, and offers an unsurpassed capability as a laboratory instrument in its own right.

Because the 10A10 has so few controls and is easy to calibrate, a semi-skilled operator can be trained to use the instrument in a very short time ... with consistent and accurate results. **Thus the 10A10 provides an opportunity for the Professional to extend his expertise through others and greatly increase his own personal effectiveness.**

Applications
The Photovac 10A10 can be applied to almost any situation in which air must be analyzed for gaseous or vaporous pollutants, even at trace levels. In the industrial context this includes both indoor and outdoor Industrial Hygiene operations and Property Line monitoring; for Environmental workers, air monitoring functions of all categories can be readily accomplished, especially Emergency Response situations where a Field Monitoring capability must be deployed as fast as possible and data taken which may later have to be examined in court.

Other significant areas of application include Headspace monitoring for Food and Drug work, Breath monitoring for Biochemical investigations and specialized situations in Military and Forensic work.

A Better Way
With the advent of the Photovac 10A10, air sampling and analysis will never be the same. The benefits of the system, as described above, are numerous when compared to alternative methods such as charcoal or colourimetric tubes. **And** these unsurpassed benefits are available to you at minimal cost. **The very low total unit cost per sample and analysis allows the instrument investment to be written off over a few hundred measurements.** These cost benefits are amplified by the need for only a semi-skilled operator and by the fact that with a single machine you can do both in-field and laboratory analyses — **combining sampling and direct analysis in one simple step.**

Many air analyses previously requiring sample volumes of many litres and tedious sample preconcentration may now be performed in minutes using a direct air injection of no more than 1 mL of sample. The direct air analysis method in conjunction with Photovac's unique 10A10 portable photoionization gas chromatograph offers you the opportunity to increase the speed and quality of your sampling results while reducing your air sampling costs.

APPLICATIONS

While a list of detectable compounds is included under the heading Specifications, we present here some analyses relating to several compounds of topical interest.

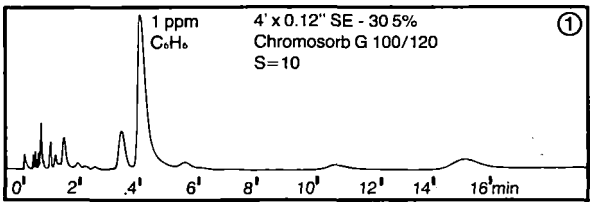
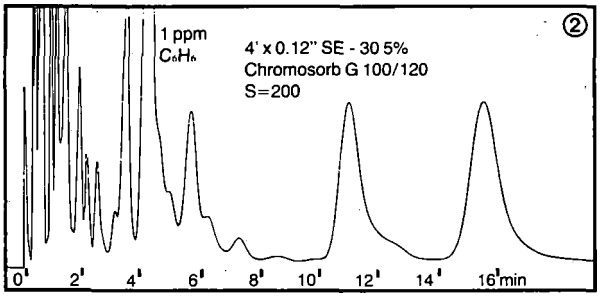
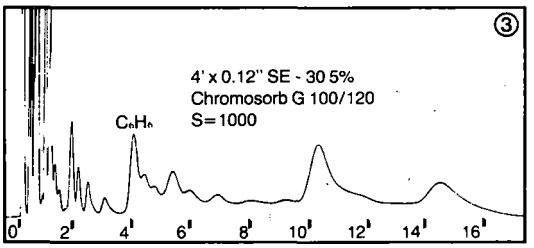
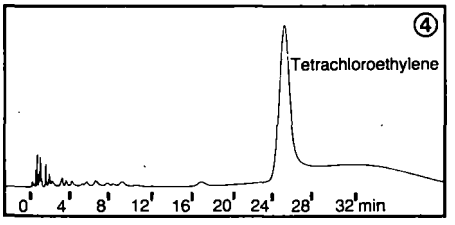


Figure 1 shows an analysis for benzene at a level of 1 ppm in air; this was completed in just under 5 minutes. In Figure 2, the same sample is analyzed again with a 20-fold increase in sensitivity. Figure 2 brings out much of the underlying structure of Figure 1 and compounds of C_2 through C_8 are present at levels down to 10s ppb.



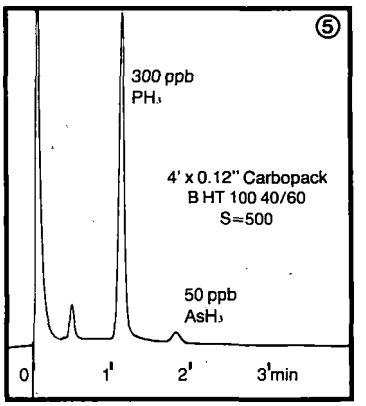


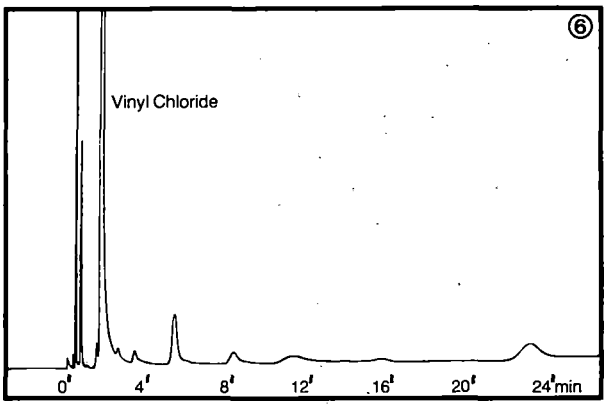
In Figure 3, a sample of typical suburban air is analyzed for the presence of benzene and the response obtained is equivalent to approximately 4 pbb; the majority of the peaks present undoubtedly originate from gasoline.



In Figure 4, the air quality within a large hotel is examined. In general the quality is found to be good but a very large peak is evident which is due to the presence of tetrachloroethylene at approximately the 0.8 ppm level and this originated from the hotel's dry cleaning plant, located in a remote part of the building.

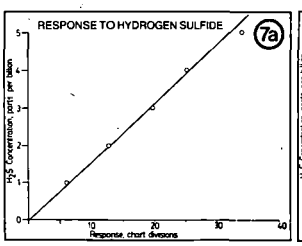
Because of the recent upsurge of interest in the detection of the gases arsine and phosphine at low levels in air, we include results taken for these two compounds at the 50 ppb and 300 ppb levels respectively, these being the currently established Threshold Limit Values (TLVs) for occupational exposure. Figure 5 illustrates this and the ultimate detection thresholds for both gases are close to 1 ppb.

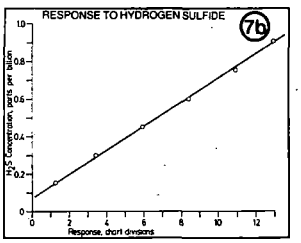




In Figure 6 a headspace analysis is shown for a commercially available food wrap material which is composed of a PVC co-polymer. When warmed to 40°C, the presence of vinyl chloride monomer is readily demonstrated and the 10A10 probably represents the best available technique for such measurements. At room temperature, equilibrium headspace concentrations of vinyl chloride in food wrap are generally in the vicinity of 10 ppb.

Figures 7(a) and (b) show results obtained by Canadian Government Workers[1] for low levels of hydrogen sulfide in air. A sophisticated dynamic generation apparatus was employed and linearity data taken using directly injected air samples of 0.5mL over the range 5 ppb to 0.1 ppb. Other reduced sulfur compounds such as methyl mercaptan and carbon disulfide can be similarly treated.





[1]Lao and Thomas, Air Pollution Control Directorate, Environment Canada, 1980.

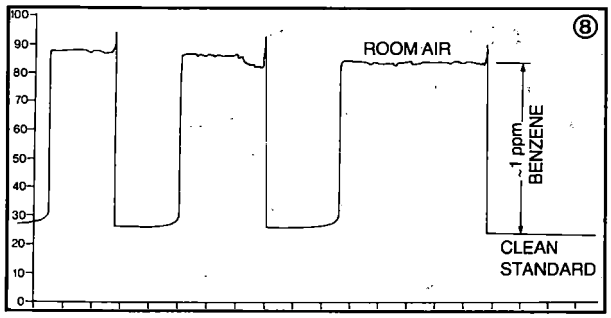


Figure 8 shows operation of the 10A10 in a continuous monitoring mode; the column has been removed and a pump is being used to draw air sample into the detector. Air is ultimately drawn from a clean standard source and then from a work room in which approximately 1 ppm (benzene equivalent) of ionizable contaminant is present. Apparent noise on the signal corresponding to work room air is in fact due to real fluctuations in impurity levels as the probe was moved around. The implied resolution of this technique is comfortably 20 ppb.

SPECIFICATIONS:

Compounds detectable by the 10A10 at levels down to parts-per-billion and below are too numerous to list completely. The following are representative. Please contact our applications lab with your specific interests.

Volatile Hydrocarbons: Alkanes above Ethane, Ethylene, Isoprene and other Alkenes, Cyclic compounds, Benzene, Toluene, Xylene and other Aromatics.

Chlorinated Hydrocarbons: Vinyl Chloride, Chloroform, Methyl Chlorides, Halothane, Trichloroethylene and other Alkyl and Aryl Chlorides and Fluorochlorocarbons.

Sulfur Compounds: Hydrogen Sulfide, Carbon Disulfide, Mercaptans, and other Alkyl and Aryl Sulfides.

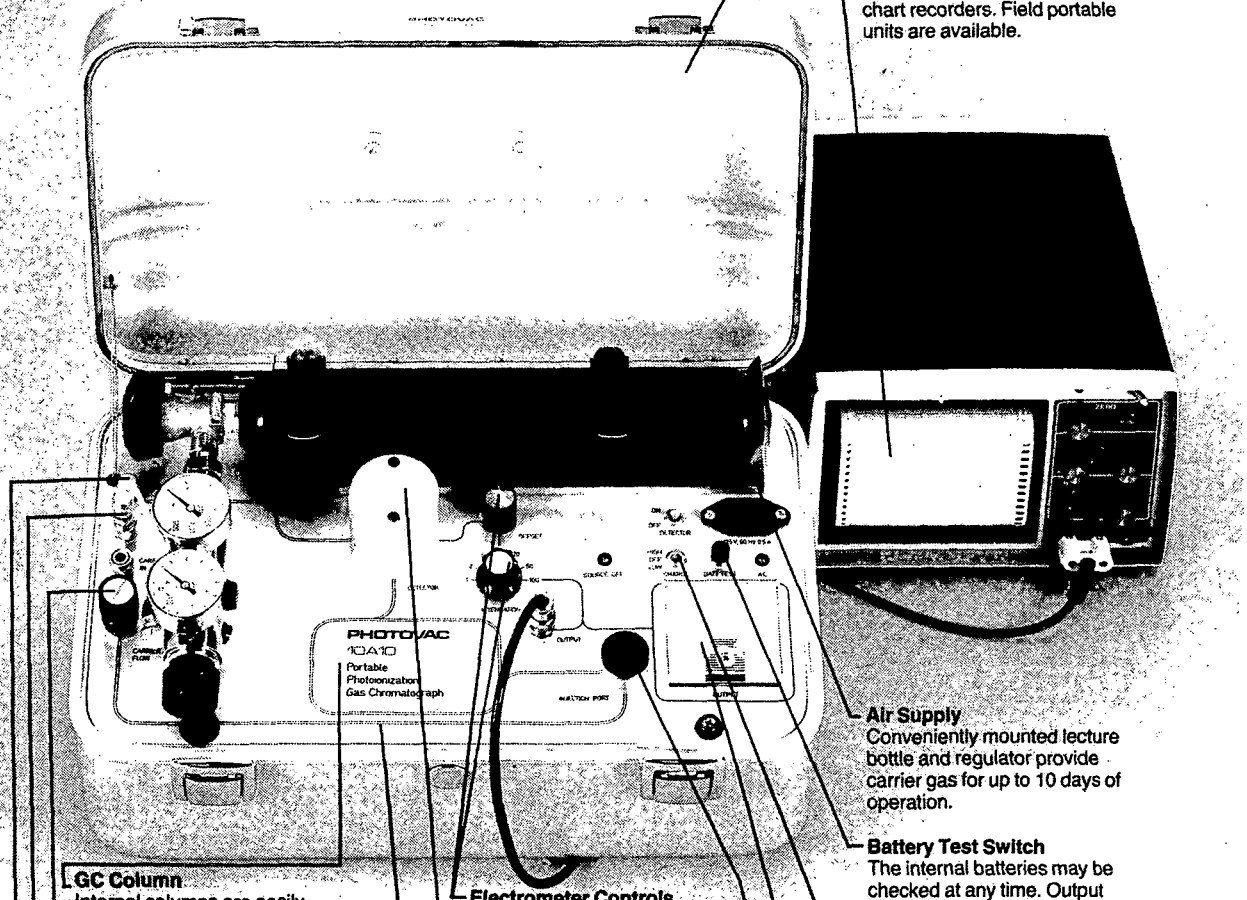
Nitrogen Compounds: Acrylonitrile and other Cyanides, Methylamine, Ethylamine and other amines, Nitrobenzene and other Nitro-compounds, Isocyanates.

Alcohols, Aldehydes, Ketones, Esters: Ethanol, Isopropanol, Formaldehyde, Acetaldehyde, Acetone, MEK, Cyclohexanone, Ethyl Acrylate, and others.

Inorganic Compounds: Phosphine, Arsine, Ammonia, Hydrazine, Nitric Oxide and others.

Detector:	Photovac advanced technology vacuum ultraviolet photoionization system. Inert TFE construction minimizes contamination.
Column:	Lengths from 15cm (6") to 6m (20') of 3.2mm (1/8") can be accommodated. Easily changed in 10 minutes. Flexible capillary columns may be installed using available adapters.
Injection Port:	On-column type standard; accepts syringe injections from 1 millilitre to 1 microlitre. Sample loop optional. Inert surfaces of injection port, column and detector permit analysis of reactive compounds such as H_2S.
Carrier Gas:	Air Extra Dry grade recommended. Two inlet (quick-connect) fittings allow operation from built-in lecture bottle or external gas supply.
Flow Control:	Two stage lecture bottle regulator (dual gauge). Dual fine metering valves with micrometer knob for precise flow control and reproducibility. One lecture bottle provides up to 10 days operation between fillings.
Warm Up Time:	5 minutes for ppm range analyses.
Analysis Time:	Solely dependent upon desired compound and column chosen; typical value for vinyl chloride 40 seconds.
Display Mode:	Chart recorder (not included in price); portable unit available as option. Built-in output meter (100 mV full scale) for set-up and guidance purposes.
Power:	Internal rechargeable batteries provide 8 hours of operation, or 115 V, 60 Hz AC. Batteries automatically re-charged during ac operation.
Dimensions:	Approximately 41 cm (16") × 25 cm (10") × 22 cm (9") height.
Weight:	Approximately 11 Kg (24 lbs)
Options:	Manual and automatic sample injection valves, column backflush valve, a wide variety of packed columns, capillary column adapters.

Photovac invented a better way!



Case
The Photovac 10A10 is packaged in a sleek, rugged, anodized aluminum case. It is constructed to withstand the wear and tear of field trips under the most difficult conditions.

Recorder
Compatible with most types of chart recorders. Field portable units are available.

Air Supply
Conveniently mounted lecture bottle and regulator provide carrier gas for up to 10 days of operation.

Battery Test Switch
The internal batteries may be checked at any time. Output meter indicates charge when button is pressed.

Built-in Rechargeable Batteries
The 10A10 operates from internal batteries for up to 8 hours, or from AC line voltage. Batteries may be recharged during AC operation.

Output Meter
Front panel meter indicates electrometer output.

Sample Injection Port
Simple, versatile syringe injection with on-column injection port. All internal surfaces are made from TFE for chemical inertness. Manual or automated valve versions available.

GC Column
Internal columns are easily changed within 10 minutes. Lengths to 6m (25m for capillary columns) are accommodated.

Carrier Flow Valve
Fine metering valve is equipped with a micrometer handle for visually resetting carrier flow rate.

Quick-connect Gas Fittings
Push-on connectors simplify switching from front panel mounted air bottle to external source, and permit several 10A10's to operate from one air supply.

Detector Outlet Fitting
Monitor carrier flow rate or vent hazardous samples to a fume hood.

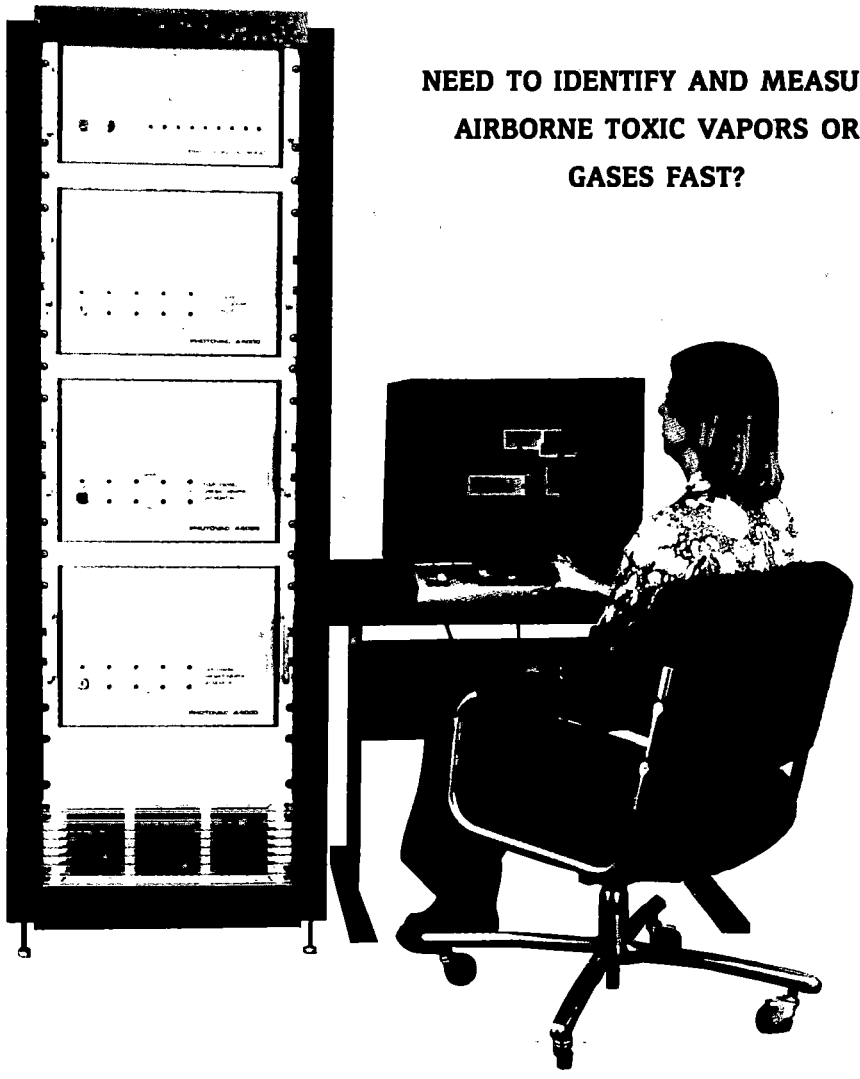
Electrometer Controls
Simple, sensitive electrometer requires only 2 external controls, offset and attenuation.

Photoionization Detector
The key to the 10A10. A new approach to PID technology developed by Photovac has produced a detector with increased sensitivity and stability. The photoionization source is an electrodeless discharge tube excited by a highly stable, ultra-high frequency oscillator to emit vacuum ultraviolet light. Careful design of ionization chamber can provide detection at levels of .1ppb.

Flow Diagram
Air and signal paths are shown on the front panel to aid the operator.

PHOTOVAC
incorporated

AUTOMATED MULTICHANNEL AIR MONITOR



NEED TO IDENTIFY AND MEASURE AIRBORNE TOXIC VAPORS OR GASES FAST?

PHOTOVAC BRINGS YOU A SIMPLE SOLUTION TO A HIGH TECHNOLOGY PROBLEM!

SUMMARY OF SPECIFICATIONS:

Sensitivity:	*Depending upon compound, down to less than 10 ppb.*
Sampling Frequency:	Depends upon compound, vinyl chloride, arsine, phosphine, methyl bromide can all be done in 1 minute; Ethylene oxide and EDB will require less than 2 minutes; Propylene Oxide and Benzine will take about 3 minutes.
Response Time:	Chromatography time plus sample line transit time (15 seconds/100 feet)
Data Outputs:	"Warning" and "Danger" levels indicated through relay contact closures. Levels set to Customer requirement. RS-232 interface for printer/CRT terminal to provide date, time of day, level of alert, gas detected, concentration detected. Also indicates systems status and verification of calibration. Exclusive Photovac color video graphics package also available.
Sample Line Material:	Teflon™ (copper clad).
Pump:	15 CFM vane type.
Sample Transit Speed:	15 seconds/100 feet.
Maximum Line Length:	1,000 feet (Arsine/Phosphine).
Detector Type:	Photoionization
Carrier gas:	Ultra Zero Air or suitably filtered House air.
Power Required (instrument):	115 vac, 60 Hz, 20 A (Other voltages and frequencies available).
Power Required (pump):	115 vac, 60 Hz, 20 A (Other voltages and frequencies available).
Calibrant:	Non toxic, non flammable Photovac proprietary.
Calibrant Consumption:	1 bottle per year
Power Loss Protection:	Memory protection for 8 hours. Automatic power-up after power resumed.

PHOTOVAC
incorporated

Unit 2 134 Doncaster Avenue
Thornhill, Ontario Canada L3T 1L3

Phone: (416) 881-8225 **Telex: 06-964634**

MDA The Monitoring People

Series 7100 Continuous Toxic Gas Monitor for

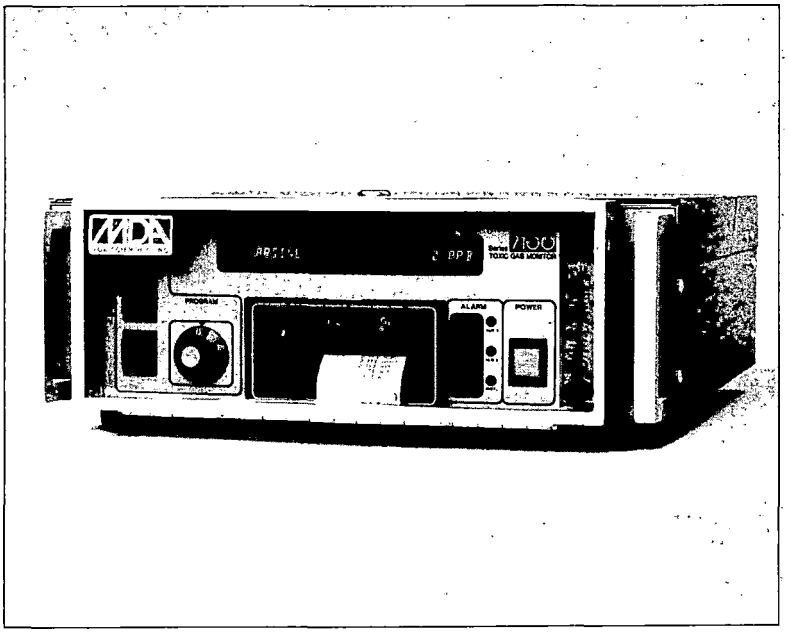
Ammonia
Chlorine
Diisocyanates
Hydrazines
Hydrides
Hydrogen Chloride
Hydrogen Cyanide
Hydrogen Fluoride
Hydrogen Sulfide
Nitrogen Dioxide
p-Phenylene Diamine
Phosgene
Sulfur Dioxide

- **Responds instantly to hazardous gas leaks**
- **Detects concentrations as low as 1 ppb**
- **Substance specific...no "false alarms" caused by other commonly used chemicals**
- **Field-proven Chemcassette® Detection System**
- **User-programmable dual-level concentration alarms**
- **Simple in-field calibration and maintenance**
- **Built-in documentation and data manipulation**
- **Operates continuously from 1 to 4 weeks...completely unattended**

Series 7100 Continuous Monitors are designed for the accurate detection and measurement of toxic, reactive, and/or pyrophoric gases. They respond instantly to hazardous gas leaks, yet detect and document concentrations as low as 1 ppb in as little as one minute.

Combining the well-proven Chemcassette Detection System with sophisticated software control, the Series 7100 provides reliable, around-the-clock monitoring in a wide variety of applications. It detects sub-TLV concentrations quickly, yet ignores other commonly used chemicals; as a result, production "up time" is optimized while false alarms are virtually eliminated.

In addition to this excellent sensitivity and specificity, the user-friendly 7100 also features field-programmable dual-level concentration alarms, a choice of alarm and documentation formats, and simple in-field calibration and maintenance. It will operate for up to 4 weeks completely unattended.



The Monitoring People

MDA Scientific, Inc.
1815 Elmdale • Glenview, Illinois 60025-1394
Phone: 800-323-2000 (in Illinois 312/998-1600) • Telex: 72-6399 MDA-GLVW

MDA Scientific (UK) Ltd.
No. 1 Haviland Road (Unit 6) • Ferndown Industrial Estate • Wimborne, Dorset
BH21 7PQ, England • Phone: (0202) 874318 • Telex: 418267 MDA-UK

Authorized sales agents throughout the world.

Routine Maintenance

Other than periodically replacing the sample line filter and cleaning the optics block, the only regular maintenance required by the Series 7100 is Chemcassette replacement. This should be performed at either one or four week intervals, depending on the type of Chemcassette being used.

Standard type Chemcassettes provide 168 hours of uninterrupted monitoring. Type LP Chemcassettes provide 672 hours of continuous exposure protection. With either type, a "low Chemcassette" warning appears when approximately 24 hours of monitoring time remains on the Chemcassette.

Diagnostics

The Series 7100 features an internal diagnostics system which continually monitors and verifies proper operation of the optics and tape transport systems.

In the event of a malfunction which would disrupt monitoring, the condition is indicated on the built-in thermal printer and audio/visual alarms activated. These alarms may also be remoted to external printers, annunciators and control panels via alarm relays. Events that will not disrupt monitoring, such as low Chemcassette and printer paper warnings, are indicated visually. The low Chemcassette warning is also indicated in hardcopy format when 24 hours of monitoring time remain.

```
**********

DIAGNOSTIC DATA
04/16/84  13:54:24

**********

LAMP OUT     -  NO
LAMP VOLTS   -  5.69
NEG. SAMPLE  -  312
GATE         -  GOOD
TAPE OUT     -  YES
HIGH ZERO    -  312
K FACTOR     -  5.845
Q FACTOR     -  0.948
```

[illegible] verify proper operation of the optics [illegible] systems status [illegible] and correct malfunc

Performance Specifications

Substance	Standard Range*	Lower Detectable Limit
Ammonia	0-250 ppm	1 ppm
Chlorine	0-10 ppm	0.2 ppm
Diisocyanates (1)	0-200 ppb	1 ppb
Hydrazines (2)	0-1000 ppb	10 ppb
Hydrides		
Arsine	0-1000 ppb	3 ppb
Diborane	0-1000 ppb	2 ppb
Germane	0-2000 ppb	50 ppb
Hydrogen Selenide	0-1000 ppb	15 ppb
Phosphine	0-3000 ppb	5 ppb
Silane	0-50 ppm	2 ppm
Hydrogen Chloride	0-100 ppm	0.2 ppm
Hydrogen Cyanide	0-100 ppm	0.8 ppm
Hydrogen Fluoride	0-30 ppm	0.5 ppm
Hydrogen Sulfide	0-50 ppm	0.5 ppm
Nitrogen Dioxide	0-50 ppm	0.5 ppm
Phosgene	0-1000 ppb	12 ppb
p-Phenylene Diamine	0-200 ppb	2 ppb
Sulfur Dioxide	0-20 ppm	0.1 ppm

(1) Lower Detectable Limit for TDI; consult MDA for other diisocyanates.
(2) Lower Detectable Limit for N_2H_4; consult MDA for other hydrazines.
*Special ranges available; consult MDA.

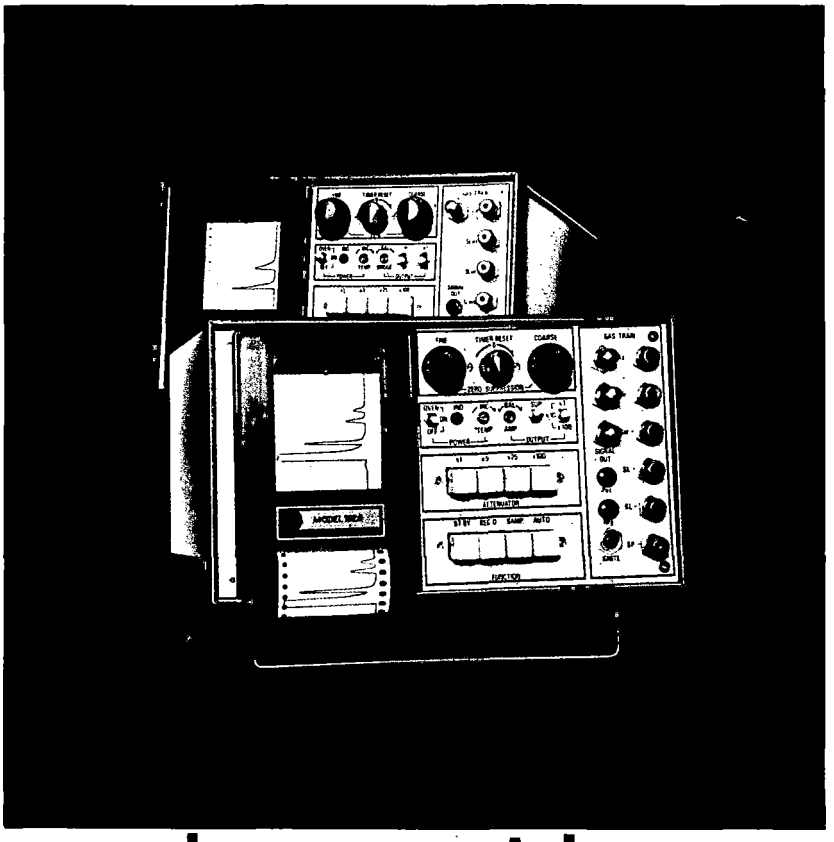
General Specifications

Alarm Points:	User-programmable dual-level
Alarm Relays:	Solid state AC relays; solid state DC relays optional
Output:	4-20 mA; RS232 optional
Sampling Distance:	Up to 100 feet except for diisocyanates and hydrazines.
Repeatability:	Better than ±5% at TLV
Documentation:	Built-in thermal printer. Documents alarm conditions, minute-by-minute concentration, 8-hour TWA.
Operating Temperature Range:	0° to 40°C.
Enclosure:	Designed for use in non-hazardous atmospheres; special enclosures available for use in hazardous or combustible environments. 19" rack mounting optional.
Dimensions:	6½ × 17 × 18 inches (Approx.)
Weight:	45 pounds (Approx.)
Power:	115 V/60 Hz or 220 V/50 Hz

Specifications are for typical applications and are subject to change without notice. Consult MDA for full applications assistance.

Catalog No. 970372 5/84 5M

PORTABLE GAS CHROMATOGRAPHS



Baseline Industries, Inc.

The Baseline Series 1000 Gas Chromatographs offer true portability with laboratory instrument performance. Weighing only 16 lbs. including built in recorder and fully automatic gas sampling for unattended operation, they provide a complete integrated system. Many applications for GC's previously ignored or allocated to complex lab equipment, can now be accomplished easily and inexpensively.

Front panel access to essential controls and gas train connection provide operational simplicity whether transported to field locations, dedicated for routine lab analysis, establishment of in-plant process parameters, or monitoring hazardous atmospheres.

Additional Features and Specifications

Front Panel Controls (Refer to Photographs)

- Fine and coarse zero with tamper proof locks
- Timer reset for automatic sampling
- Power switch for ambient or isothermal operation
- Proportional temperature controller adjust and indicator lamp.
- Bridge balance adjust (TCD 1010)
- Amplifier balance adjust (FID 1020)
- Polarity reversal switch (TCD 1010)
- Suppression "on/off" switch (FID 1020)
- Attenuator multiplier X1, X10 (TCD 1010)
  X1, X10, and X100 (FID 1020)
- Lighted push button attenuator X1, X5, X25, and X100
- Lighted push button function switch, Standby, Record, Sample and Automatic positions. Lights sequence in "auto" mode.
- Signal output terminals for external recorder or digital integrator readout
- Ignitor push button (FID 1020)

Gas Train Connections (Refer to gas train diagram)

- All gas train ports and associated metering valves available on front panel

Heated Injection Port

- Provides "on column" injection
- Conveniently located on instrument cover
- Permits flash vaporization of liquid samples

Recorder

- Continuous rectilinear trace
- Inkless thermal recording with stylus temperature adjust
- 2" X 100' high resolution chart, convenient front loading
- Chart speed 1/2" min. (standard) *
- Sensitivity adjustable 50 to 200 mv full scale, pre-amplifier provides 100 mv out/200 micro volts in, (TCD 1010), and 100 mv out/1 X 10^{-12} amps in, (FID 1020)
- Accuracy including linearity and deadband ±2% of full scale
- Response < 1/2 second full scale
- Zero position continuously adjustable over entire scale

Oven

- Volume 100 cubic inches, accomodates 24' of 1/8" column
- Detector (FID or TCD) mounted internally to oven base
- Heated injection port mounted on column
- Temperature limits, ambient to 200°C
- Ceramic heater element and platinum resistance probe

Temperature Controller

- Fully proportional, and continuously adjustable ambient to 200°C
- Proportional band adjust provides regulation of < ±0.1°C
- "Power limit" adjust prevents thermal runaway

Sample Valve

- 6 port pneumatically operated "O" ring type (standard)
- Sample loop easily changed 1/2 ml minimum, 1 ml (standard)

Automatic Sampling Cycle Timer

- Cycle timer motor 15 minute/revolution (standard)
- Timing cams, 4 each, adjustable ±2°, repeat accuracy ±1°
- 4 each micro switch actuated circuits for programming sample injection, peak selection, (recorder on/off), or accessory controls.

Power Requirements

- 115 vac 60 Hz (standard)
- 30 watts average power including heater

Physical

- Width 11 inches, height 6-1/2 inches, depth 12"
- Weight 16 lbs. complete
- Convenient carrying handle

e t a

ETA Associates
P. O. BOX 13
NONANTUM, MASSACHUSETTS 02195
PHONE (617) 527-4544

nc.
-6661

Options

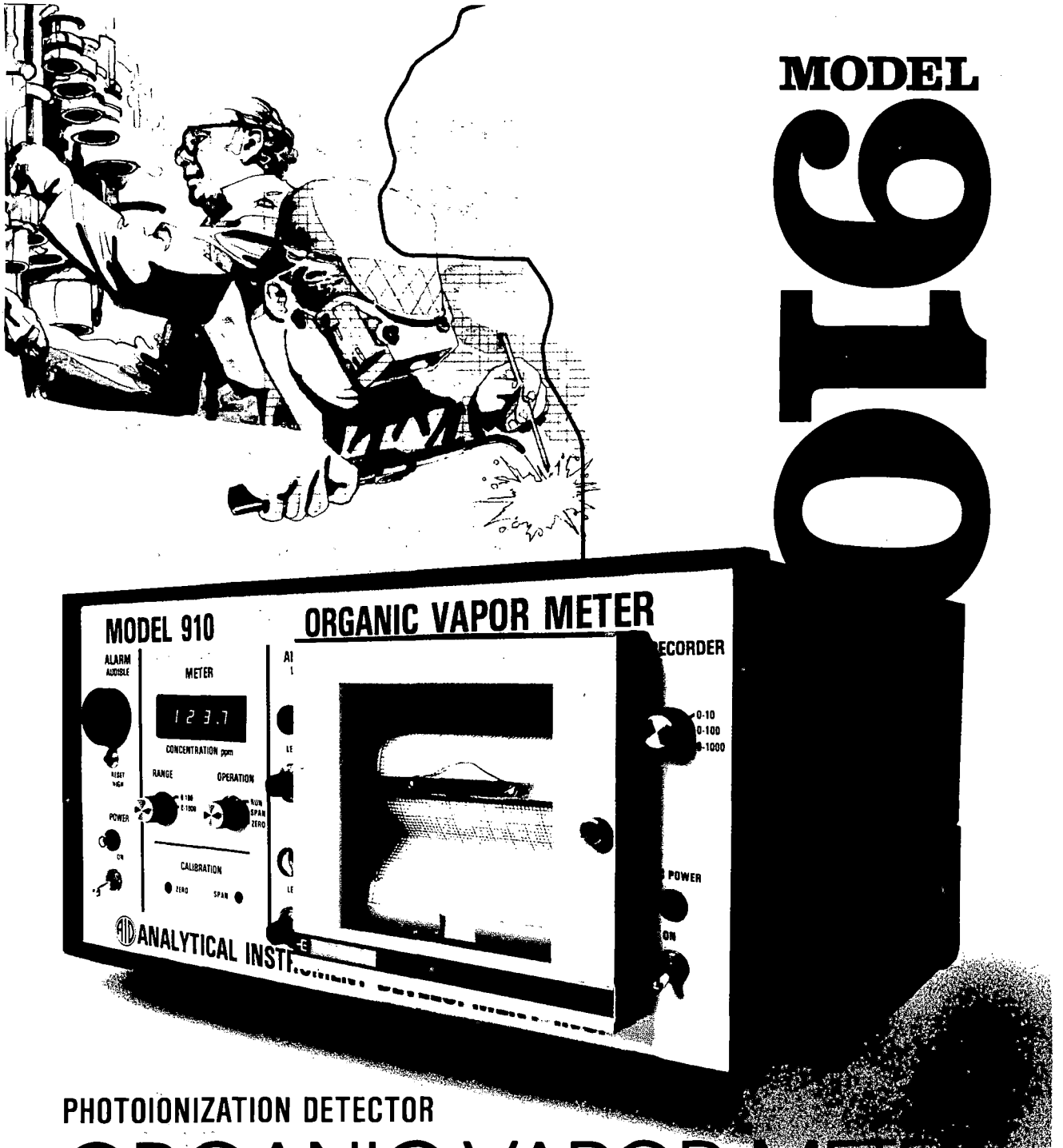
- Special recorder chart speeds*
- Special cycle timer motors
- 24 vdc operation
- 220 vac., 50 Hz operation
- All stainless steel gas train components
- All stainless steel pneumatically operated 6 port rotary sample valve

Accessories

- Lecture bottle gas cylinders 50 liter capacity 15" long x 2"dia.
- Lecture bottle regulators tank and outlet pressure gauges
- "E" size gas cylinders 500 liter capacity, 30" long x 4" dia.
- "E" type cylinder regulators tank and outlet pressure gauges
- "E" type cylinder cart-two wheel medical type
- Chart paper
- Septa, silicon rubber teflon coated
- Packed columns 1/8" or 3/16" stainless steel or copper
- Inverter for 12 vdc operation (only available for ambient operation or with on/off temperature controller)
- On/Off temperature controller

baseline portable chromatographs are "really portable"

Ordering Information — Consult current price list or factory



MODEL 910

PHOTOIONIZATION DETECTOR

ORGANIC VAPOR METER

ANALYTICAL INSTRUMENT DEVELOPMENT, INC.

principles of operation

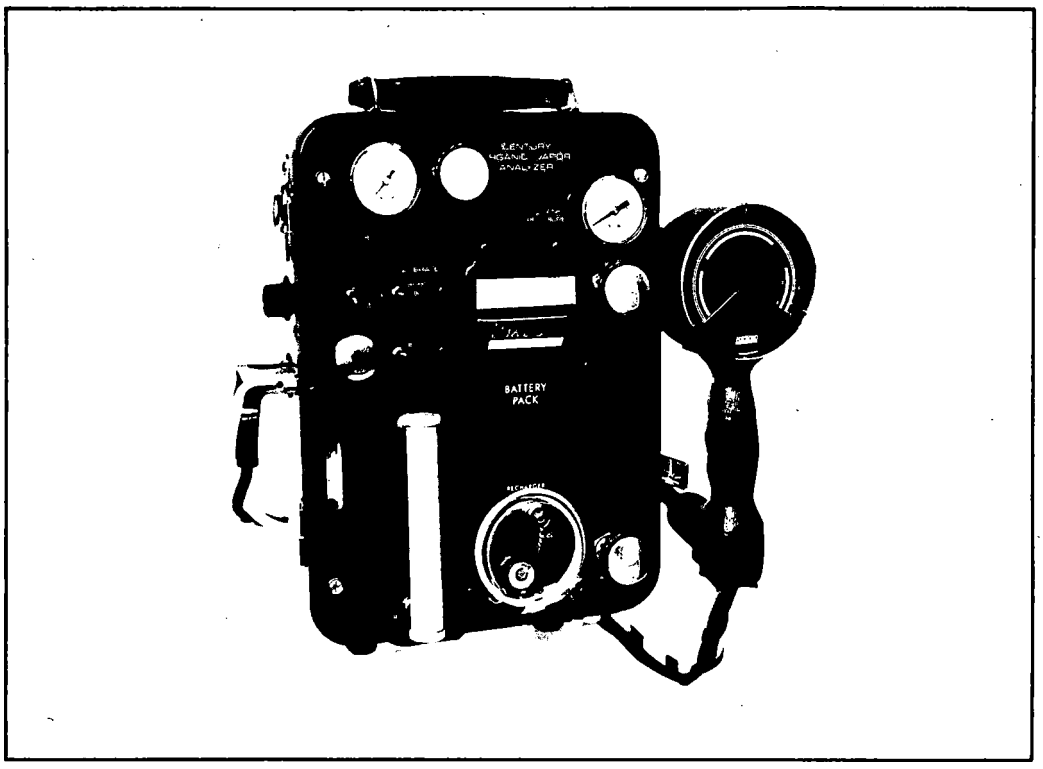
The Photoionization Detector utilizes a high energy ultra violet lamp to ionize the sample which is drawn into the instrument. The ionized sample produces an ion current which is proportional to concentration and is measured with a pico ammeter.

The ionization is a fundamental process. A photon of light from the UV source energizes an electron of the sample molecule producing an ionized species and a free electron:

$$R + h\nu \rightarrow R^+ + e^-$$

For this reaction to occur, the photon energy ($h\nu$) must be equal to or greater than the ionization potential of the sample molecule. In general, the PID will respond to most organic compounds. It is insensitive to methane, ethane, and most of the permanent gases. This insensitivity to materials normally found in ambient air makes the PID a selective device and an invaluable instrumental tool.

ANALYTICAL INSTRUMENT DEVELOPMENT, INC.
Rt. 41 & Newark Road, Avondale, PA 19311 215/268-3181 TELEX: 835441



OVA 108 ORGANIC VAPOR ANALYZER

For Fugitive Emissions Monitoring

INTRODUCTION

On October 18, 1983 the Environmental Protection Agency promulgated the standard of performance for equipment regarding leaks of volatile organic compounds (VOC) in the synthetic organic chemical manufacturing industry (SOCMI). This standard covers what is commonly referred to as fugitive emissions monitoring. These fugitive emissions are generally defined as leaks from process components such as valves, pumps, compressors, pressure relief devices, sampling systems and open-ended lines in VOC service. Fugitive emissions, as defined by the EPA, are limited to emissions which do not occur as part of the normal operation of plants, but are the result of the effects of age, lack of maintenance, improper equipment specifications or externally caused damage. Further information can be obtained from the U.S. EPA Library (MD-25), Research Triangle Park, N. C. 27711. Refer to EPA document number EPA-450/3-80-032a for Benzene Fugitive Emissions; EPA-450/3-80-032a for Benzene Fugitive Emissions; and EPA-450/3-80-33b for VOC Fugitive Emissions in the SOCMI. Also, consult the Federal Register Vol. 48, No. 202 Tuesday, October 18, 1983 Rules and Regulations.

FOXBORO®

Use Of PTD To Analyze Vinyl Acetate And Styrene

The PTD principle of thermal desorption is applicable to a wide variety of industrial hygiene applications. One application which was studied by NIOSH using the CENTURY Programmed Thermal Desorber was the monitoring of vinyl acetate in the industrial environment. For the study, CENTURY stainless steel tubes containing Chromasorb 107 were utilized. Samples were thermally desorbed at 150°C and desorption efficiency was found to be over 90%.

SAMPLE	SAMPLE AFTER DESORPTION
Compound	Vinyl Acetate
Column	T-8 (10% trispropane on chromosorb P)
Temperature	0° C
Retention Time	105 seconds
Sample Concentration	100ppm
Desorption Temperature	150° C
Desorption Rate	1 ml/second
Desorption Tube	Chromosorb 107
Desorption Efficiency	100%

A second application for which the PTD was found suitable is desorption of styrene. For this application, Tenax GC sorbent tubes were utilized. Desorption temperature was 150°C and the desorption efficiency was 100% at a concentration of 1000 ppm in air.

SAMPLE	SAMPLE AFTER DESORPTION
Compound	Styrene
Column	B-10 (3% diisodecyl phthalate on chromosorb W)
Temperature	23° C
Retention Time	372 seconds
Sample Concentration	1000ppm
Desorption Temperature	150° C
Desorption Rate	1 ml/second
Desorption Tube	Tenax GC
Desorption Efficiency	100%

To assist users in selecting the optimum chromatographic columns and conditions for a wide variety of monitoring applications, Foxboro has published a data table called the "OVA Chart." This chart provides retention time information for over 100 different compounds at two different temperatures and for several different column packing materials. The user can thus choose the optimum conditions of packing and temperature to yield optimum analytical results using the CENTURY Organic Vapor Analyzer.

For your free copy of the "OVA Chart", call or write:

A Division of The Foxboro Company
140 Water Street, PO Box 5449
S. Norwalk, CT 06856
Telephone: (203) 853-1616
TWX: 710-648-3054

FOXBORO®

Place Postage Here

A Division of The Foxboro Company
140 Water Street, PO Box 5449
South Norwalk, Connecticut 06856

FOXBORO

SCIEX PRODUCT NOTE

TAGA® 6000 MS/MS
A Versatile Systems Approach to Problem Solving by Tandem Mass Spectrometry

The TAGA® 6000 MS/MS System reflects SCIEX®'s Total Systems Approach to Mass Spectrometry. The design philosophy evolved from utilizing a core system coupled with modular ionization sources and inlets. The result: customized problem solving with outstanding analytical performance and cost effectiveness.

Since all TAGA® 6000 configurations are based on SCIEX®'s Total Systems Approach, you retain the flexibility to respond to changing priorities and the potential to expand your system to accommodate future application requirements.

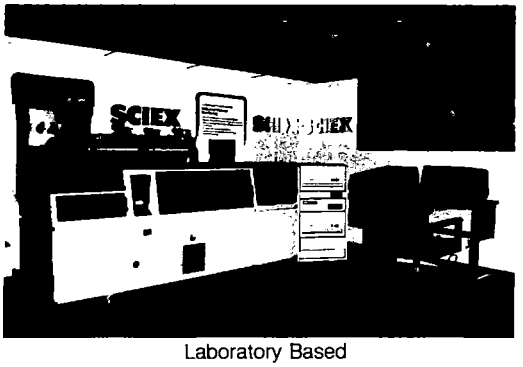
IONIZATION SOURCES

Atmospheric Pressure Chemical **Ionization Source**	Low Pressure Chemical **Ionization Source**	Electron Impact **Ionization Source**	Ion Evaporation **Ionization Source**

INLETS

Direct Atmospheric Sampling **Inlet**	Direct Insertion Probe **Inlet**	Gas Chromatograph **Inlet**	Liquid Chromatograph **Inlet**
Thermal Analysis **Inlet**	Automated Short Term Adsorber **Inlet**	Breath Analysis **Inlet**	Multiple Reagent Gas **Inlet**

PACKAGING

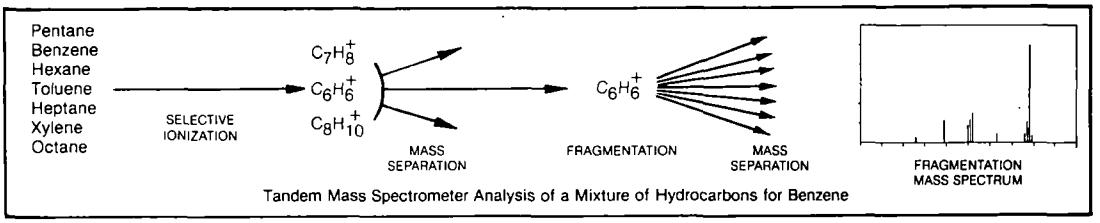


Laboratory Based

Fully Mobile Operation

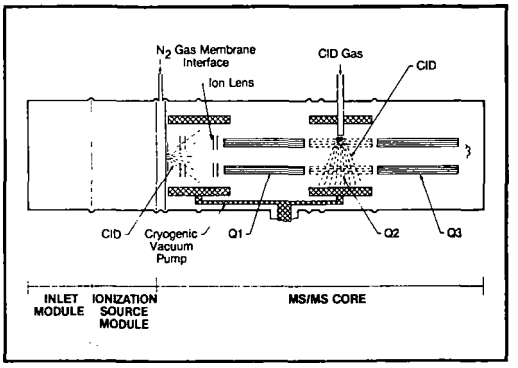
TAGA® 6000 MS/MS Description

Combining the new instrumental concept of Tandem Mass Spectrometry with proven TAGA® technology, the TAGA® 6000 MS/MS provides the analyst with advanced capabilities for complex trace organic mixture analysis, rapid screening for pre-selected traces and molecular structure elucidation. A new dimension of information is generated by the characteristic fragmentation mass spectrum produced through collisionally-induced dissociation (CID) of the molecular ion.



Tandem Mass Spectrometer Analysis of a Mixture of Hydrocarbons for Benzene

Optimized techniques of Triple Quadrupole Mass Spectrometry and the patented ultra-high capacity cryopump comprise the heart of the TAGA® 6000 MS/MS. Two mass filters, quadrupoles Q1 and Q3, form a tandem mass spectrometer while the centre quadrupole, Q2, produces dynamic focussing for the Parent and Fragment ions present in the CID region. The various ionization sources produce an intense beam of molecular ions whose internal energy may be controlled. A schematic representation of the TAGA® 6000 MS/MS is shown here.



For further information contact:

SCIEX®

Division of MDS Health Group Limited

CANADA

Toronto

55 Glencameron Road,
Thornhill, Ontario L3T 1P2
Tel: (416) 881-4646
Telex: 06-964722

U.S.A.

Buffalo

355 Commerce Drive,
Amherst N.Y. 14150
Tel: (716) 691-3556

Boston

Tel (617) 533-4515

9583T

sierra monitor corporation

1050K East Duane Avenue • Sunnyvale,California 94086 • 408/746-0188
TWX 910-338-2290 MSG SNDR SNJ • TELEX 17-1618 MSG SNDR SNJ

DOMESTIC PRICE LIST
Effective 4/1/84

PORTABLE INSTRUMENTS

Order No.	Model No.	Description	List Price
		COMBUSTIBLE GAS LEAK DETECTORS	
2000.....	2000	Combustible Gas Leak Dectector, Portable.	$ 345.00
2000-10...	2000-10	As Model 2000 includes earphone and jack.	$ 350.00
2000-20...	2000-20	As Model 2000 except AC Powered.	$ 300.00
2000-30...	2000-30	As Model 2000-10 with 18 inch flexible sensor extension.	$ 450.00
20XX69037.	901	Leather holster for Model 2000 series.	$ 15.00
		HYDROGEN SULFIDE MONITORS	
10HS-10...	10HS-10	Portable H2S Gas Monitor (0-50 ppm scale) Includes battery charger & earphone.	$1,250.00
10HS-12...	10HS-12	As 10HS-10 except with 15 foot sensor extension substituted for standard sensor.	$1,500.00
10HS-20...	10HS-20	As 10HS-10 except AC powered.	$1,350.00
10HS-22...	10HS-22	As 10HS-12 except AC powered.	$1,600.00
10HS69006.	10HS-SCR	Strip Chart Recorder for 10HS-20, -22.	$ 400.00
10HS69057.	902	Custom leather carrying case for 10HS.	$ 38.00
		OXYGEN DEFICIENCY MONITOR	
55.....	55	Oxygen Deficiency Monitor with internal. sensor. Includes earphone & 9 volt batt.	$ 455.00
55XX11104.	55-XS	External Sensor Assembly on 20' cable.	$ 185.00
55XXXXXXXX	55-OX	Replacement Oxygen Sensor for 55 or 55-XS. Note: Sensor warranty program available.	$ 150.00

FIXED GAS MONITORS

		TOXIC AND COMBUSTIBLE MONITORS - INDOOR	
2200.....	2200	Central Alarm Panel - 10 Channel.	$ 800.00
2101.....	2101	Central Alarm Panel - 1 Channel.	$ 150.00
2001.....	2001	Combustible Gas Monitor.	$ 225.00
2003.....	2003	Hydrogen Sulfide (H2S) Monitor.	$ 345.00
2006.....	2006	Carbon Monoxide (CO) Monitor.	$ 345.00
200XCABLE.	CABLE	Cable Assembly, Monitor to Panel $10.00 plus .20 per foot.	

Order No.	Model No.	Description	List Price
		TOXIC & COMBUSTIBLE MONITORS - ALL WEATHER	
2102.....	2102	Central Controller - 2 Channel.	$ 300.00
201.....	201	Combustible Gas Monitor.	$ 290.00
203.....	203	Hydrogen Sulfide (H2S) Monitor.	$ 385.00
206.....	206	Carbon Monoxide (CO) Monitor.	$ 385.00
		3000 SERIES H2S SYSTEMS	
3000R-1...	3000R-1	Rack Mounted Controller w/ 1 Sensor Module.	$2,825.00
3000R-2...	3000R-2	Rack Mounted controller w/ 2 Sensor Modules.	$3,350.00
3000R-3...	3000R-3	Rack Mounted Controller w/ 3 Sensor Modules.	$3,850.00
3000R-4...	3000R-4	Rack Mounted Controller w/ 4 Sensor Modules.	$4,350.00
3000N-1...	3000N-1	Nema 4X Enc. Controller w/ 1 Sensor Module.	$3,525.00
3000N-2...	3000N-2	Nema 4X Enc. Controller w/ 2 Sensor Modules.	$4,050.00
3000N-3...	3000N-3	Nema 4X Enc. Controller w/ 3 Sensor Modules.	$4,550.00
3000N-4...	3000N-4	Nema 4X Enc. Controller w/ 4 Sensor Modules.	$5,250.00
3000-JBOX.	3000XMT	Junction Box w/ transmitter for 3000 system.	$ 250.00
3000-SENS.	3000SEN	H2S Sensor for 3000 system.	$ 250.00
		CALIBRATION EQUIPMENT & GASES	
20HS.....	20HS	H2S Gas Sensor Calibrator. Price includes one set of gas cylinders.	$ 450.00
25.....	25	Gas Sensor Calibrator. Price includes two gas cylinders. Note: Specify gas and concentration.	$ 200.00
20HS21014.	GASCYL	Gas Cylinder for Models 20HS & 25. Note: Two cylinders required for 20HS.	$ 35.00
		GAS CHROMATOGRAPH PROTECTOR	
2300.....	2300	Combustible Gas Monitor for protection of Gas Chromatograph.	$ 655.00
		VAULT GAS MONITOR	
2400.....	2400	Combustible Gas and Carbon Monoxide system for permanent confined entry monitoring.	$1,350.00
2401.....	2401	Remote light box for Model 2400 (red/green).	$ 100.00
2402.....	2402	Connector set for 2400.	$ 25.00
2403.....	2403	Connector set with 8' cable installed.	$ 45.00

sierra monitor corporation
1050K East Duane Avenue • Sunnyvale,California 94086 • 408/746-0188
TWX 910-338-2290 MSG SNDR SNJ • TELEX 17-1618 MSG SNDR SNJ

MODEL 5000 SENTRY

DOMESTIC PRICE LIST
EFFECTIVE 4/1/84

Model #	Description	Price	Suffix
5000	Four Channel Controller	$ 1750.00	4
5000	Eight Channel Controller	$ 2995.00	8
5100-1	H2S Sensor Module	$ 625.00	
5100-2	Combustible Sensor Moduel	$ 560.00	
N/A	Zone Relay Option	$ 725.00	Z
N/A	Individual Relay Option	$ 520.00	I
N/A	RS232 Printer Software	$ 375.00	S
N/A	32 Column Dot Matrix Printer	$ 550.00	P
25W	Calibrator - Combustibles	$ 250.00	
20W	Calibrator - H2S	$ 475.00	
N/A	Replacement H2S Sensor	$ 175.00	
N/A	Replacement Comb Sensor	$ 150.00	

Ordering Information:
Construct controller number by writing 5000- applicable suffixes.
[ie 500-8ZSP is an eight channel controller with zone relay option and software and printer option.]

sierra monitor corporation
1050K East Duane Avenue • Sunnyvale,California 94086 • 408/746-0188
TWX 910-338-2290 MSG SNDR SNJ • TELEX 17-1618 MSG SNDR SNJ

TERMS AND CONDITIONS OF SALE

The following Terms and Conditions will apply to all orders:

PRICES

Prices are FOB factory and are subject to change without notice except where quoted prices are guaranteed for specific time periods. Prices prevailing at the time an order is received will apply.

TERMS

U.S. Only: Net 30 days from invoice date.

International: For Payment in Advance all paperwork fees are waived and shipment is made freight collect. For Irrevocable Letter of Credit include paperwork fee of $100.00. Shipment will be made freight collect unless otherwise instructed.

TAXES

Prices do not include any taxes assessed by any governing body upon the manufacture, sales or transportation of the materials, and such levies will be paid by the buyer.

SHIPPING DIRECTIONS

Shipments are routed as specified by purchaser subject to applicable rules and tariffs. If no instructions are provided, shipments will be routed "Best Way" at our discretion. Shipment will be "Prepay and Bill"

DAMAGE CLAIMS

Title to all material becomes vested in the purchaser on delivery by us to the initial carrier. Customer's claims for damage, loss, etc., must be filed against the carrier.

CANCELLATION

Orders which have been received and by us cannot be cancelled except on terms that will compensate us for any loss.

RETURNS

All sales are considered final when shipment passes into the hands of the carrier. Returns will be accepted only as agreed in the warranty. Returns are subject to re-stocking charges.

TMS ANALYTICAL SERVICES INC.
TANDEM MASS SPECTROMETRY

6264 LaPas Trail
Indianapolis, Indiana 46268
317-291-5697

355 Commerce Drive
Amherst, New York 14150

55 Glencameron Road
Thornhill, Ontario
L3T 1P2

May 18, 1984

John R. Hobbs
Dot/Tsc
Code 522
Kendall Square
Cambridge, MA 02142

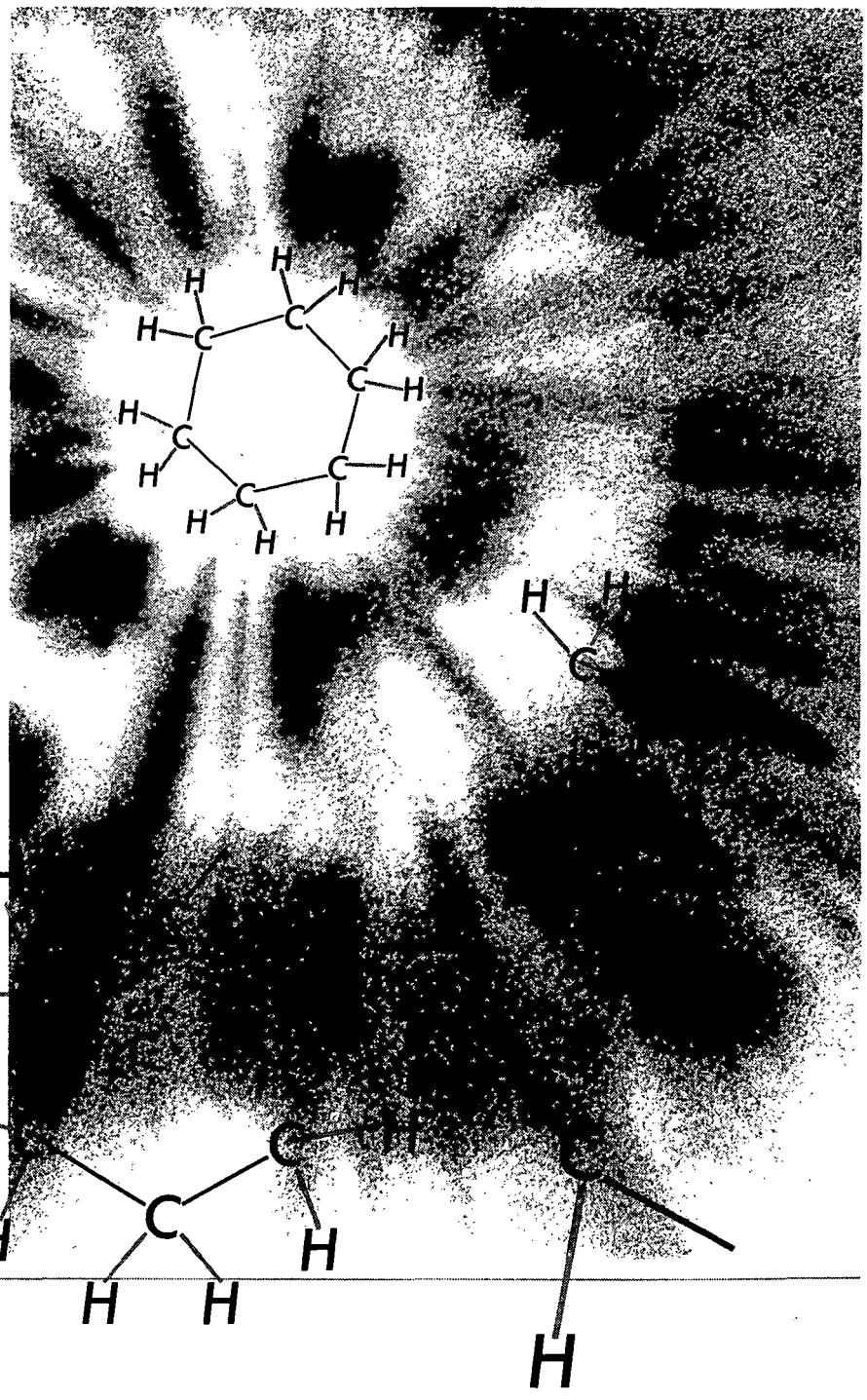
Dear Dr. Hobbs:

Thank you for your response to my recent letter advising you of our MS/MS services. We will be contacting you later to discuss your specific needs in the mass spec area; however, due to the strong response to my letter, it is apparent that it will be some time before we can personally call everyone who has asked for more information. In the interim, I am sending you this letter with some additional information to help you determine how we can best serve as a support service to your own laboratory. In addition, if you are going to the ASMS Meeting in San Antonio, I wanted to personally invite you to visit our hospitality suite and to see our display at the corporate poster session on Tuesday afternoon.

I have enclosed some general information on our equipment and laboratory facility for your review. Note that we have some unique capabilities, including the ability to do LC/MS/MS. Our equipment is particularly good at monitoring selected daughter ions of targeted compounds for either GC or LC input. Sensitivity is generally extremely good, in the picogram range or better. I have enclosed some chromatograms of recent runs that we have made illustrating our capability in this area.

Virtually every MS/MS project that comes along is unique. For that reason, we prefer to review our clients' needs first and the quote a firm price after we have agreed on the work to be done. For some larger open-ended research projects, we sell blocks of time. For smaller projects, we generally work on a fixed-fee basis. We feel that this arrangement provides the client the assurance of knowing in advance exactly what information will be provided and what the total cost will be. To help give you an idea of the average cost of our services, I have enclosed a sheet showing typical prices for some commonly requested items. If you need an estimate of the cost of a project, please call us and we will be happy to give you a quote.

Rapid, On-Site Analysis of Trace Organics in Water, Air or Soil.



MS2™... A Solution to Environmental Monitoring Problems

In 1981, nearly sixty-thousand American companies filed a hazardous waste generator form. To many of these companies, the identification, analysis, monitoring and reporting of environmental contaminants is becoming an increasingly costly and time consuming burden.

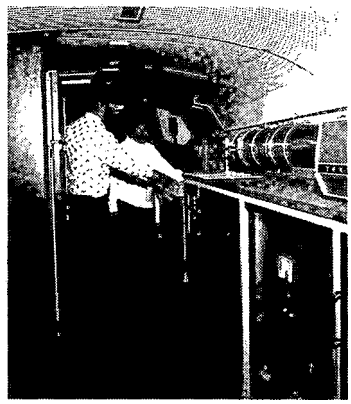
The traditional methods of complying with governmental regulations entail a wide range of difficulties in the areas of sample preparation, packaging, transportation, storage and processing of chemical samples. Both cost and turn-around time can put heavy pressures on companies, especially those that are located far from analytical laboratories.

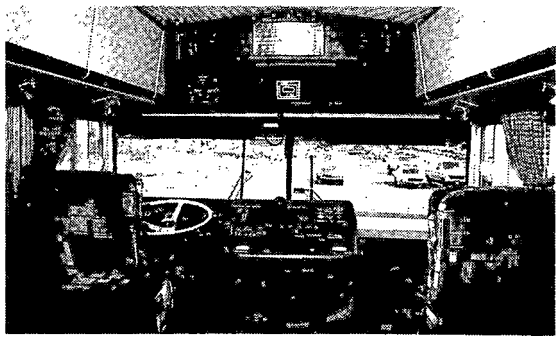
New technology, as exemplified by tandem mass spectrometry and York's MS2 Service, can significantly reduce costs and eliminate problems associated with compliance.

Tandem Mass Spectrometry The State of the Art in Chemical Analysis

The MS2 System is a self-supporting organic chemical analysis laboratory housed in a motor coach. It is designed to provide real time, on-site analysis of water, soil and air samples with reports available in minutes.

Central to the system is the tandem mass spectrometer. Tandem mass spectrometry is an enhancement of the traditional GC/MS procedure offering advanced capabilities for complex trace organic mixture analysis with reduced sample handling and preparation, rapid screening of pre-selected traces and molecular elucidation. It is the only way to measure a broad range of organics in real time at ultra-low levels.





The capabilities of MS2 are unparalleled by less advanced methods. Among its benefits are:

- ☐ Identification of compounds of interest down to the low parts-per-trillion level.
- ☐ Reduction of sample collection and preparation for real time or near real time analysis.
- ☐ Elimination of steps, and associated costs, involved in the "chain of custody" for chemical analysis.
- ☐ Results of analysis available in minutes instead of weeks or months.
- ☐ Provide on-site answers, allowing re-sampling when warranted, or movement to new sites where indicated.
- ☐ Rapid turn around for decisive response to emergency environmental events.
- ☐ A chemical analyst can be included in the sample collection team to assure optimum preparation and interpretation. The analyst can be a doctorate level chemist when an extremely high level of on-site consultation is required.

MS2™... A Service of York Research Backed by Fifteen Years Experience in Environmental Monitoring

MS2 is a service of York Research Consultants, Inc., of Denver, Colorado. York has been involved in finding solutions to environmental problems for over fifteen years. Its clients include a broad range of industrial companies, utilities, research organizations and governmental agencies.

York's staff includes engineers and scientists of many disciplines with wide ranging experience in environmental impact. In addition, the company maintains close ties with many leading researchers in mass spectrometry and environmental scientists.

The development of MS2 is the result of York's continuous efforts to provide state of the art technical services for applications in the environmental community.

We invite your inquiry on MS2 and the environmental services offered by York.

York Research Consultants, Inc.
938 Quail Street
Denver, Colorado 80215
(303) 233-1513
a Helioscience Company

10M484

REFERENCES

1. Saunders, Barbara B., and Thomas L. Kager, "Monitoring Devices for Railroad Safety," U.S. Department of Transportation, Federal Railroad Administration, Washington, DC, DOT/FRA/ORD-82/46.1, August 1982.

2. Stetter, J.R., S. Zaromb, and M.W. Findlay, Jr., "Monitoring of Electrochemically Inactive Compounds by Amperometeric Toxic Gas Sensors," presented at the Pittsburgh Conference and Exposition on Analytical Chemistry and Applied Spectroscopy, Atlantic City, NJ, March 5-9, 1984.

3. Stetter, Joseph R., S. Zaromb, W. R. Penrose, Melvin W. Findlay, T. Otagawa, and A. J. Sincali, "Portable Device for Detecting and Identifying Hazardous Vapors," presented at the 1984 Hazardous Materials Spills Conference, Nashville, TN, April 9-12, 1984.

4. Stetter, J.R., S. Zaromb, W.R. Penrose, T. Otagawa, A.J. Sincali, and J. Stull, "Portable Instrument of the Detection and Identification of Air Pollutants," presented at the Fourth Annual National Symposium on Recent Advances in Pollutant Monitoring of Ambient Air and Stationary Sources, Raleigh, NC, May 8-10, 1984.

5. Stetter, J.R., S. Zaromb, W.R. Penrose, T. Otagawa, A.J. Sincali, and J.O. Stull, "Selective Monitoring of Hazardous Chemicals in Emergency Situations," presented at the 1984 JANNAF Safety and Environmental Subcommittee Meeting, 1984.

6. Jadamee, J. Richard, Alan P. Bentz, Robert R. Hildenbrand, and Gerd A. Kleineberg, "The U.S. Coast Guard Mobile Response Laboratory," presented at the 1984 Hazardous Material Spills Conference, Nashville, TN, April 9-12, 1984.

7. Lane, Douglas A., and Bruce A. Thomson, "Monitoring a Chlorine Spills from a Train Derailment," Journal of the Air Pollution Control Association, 31(2), p. 122, 1981.

8. Colonna, G.R., E.D. Hinkley, and J.M. Conley, "Monitoring of LNG Vapors: Laser and Non-Laser Techniques," presented at the 1980 National Conference on Control of Hazardous Material Spills," Louisville, KY, May 13-15, 1980.

9. McRae, Thomas G., "BAGI: A Technique for the Detection and Tracking of Large Gas Clouds," presented at the 1983 JANNAF Safety and Environmental Subcommittee Meeting, Livermore, CA, March 8-10, 1983.

10. _____, "BAGI: A New Concept for the Detection and Tracking of Hazardous Gases," presented at the International Congress on Applications of Lasers and Electro-Optics, Los Angeles, CA, November 14-17, 1983.

11. Herget, William F., and James D. Brasher, "Remote Measurement of Gaseous Pollutant Concentrations Using a Mobile Fourier Transform Interferometer System," Applied Optics 18(20), p. 3404, 1979.

12. _____, "Remote Fourier Transform Infrared Air Pollution Studies," Optical Engineering 19(4), p. 508, 1980.

13. Herget, William F., "Remote and Cross-Stack Measurement of Stack Gas Concentrations Using a Mobile FT-IR System," Applied Optics 21(4), p. 635, 1982.

BIBLIOGRAPHY

"A Laser Eye in the Sky May Help Spot Polluters," Chemical Week 124(924), p. 29, 1979.

Astleford, William J., et. al., "Investigation of the Hazards Posed by Chemical Vapors Released in Marine Operations--Phase II," U.S. Department of Transportation, U.S. Coast Guard, Office of Research and Development, Washington, DC, CG-D-10-83, April 1983.

Astleford, William J., T.B. Morrow, and J.C. Buckingham, "Hazardous Chemical Vapor Handbook for Marine Tank Vessels," U.S. Department of Transportation, U.S. Coast Guard, Office of Research and Development, Washington, DC, CG-D-12-83, October 1983.

Bannister, William W., et. al., "New Techniques in Chemical Spill Control," presented at the Environment Canada 1st Technical Spills Seminar, Ontario, Canada, October 25-27, 1983.

Barringer, A.R., "Remote Sensing and Airborne Techniques for Pollution and Particulate Monitoring," presented at the 3rd International Congress of Pesticide Chemistry and Symposium on Dispersion Dynamics of Pollutants in the Environment with Special Reference to Pesticides, Helsinki, Finland, July 3-9, 1974.

Barth, D.S., G.B. Morgan, and E.A. Shuck, "Environmental Monitoring," Advances in Environmental Science and Technology: Vol, 7, ed: J.N. Pitts, R.L. Metcalf, and A.C. Lloyd, Wiley-Interscience, New York, pp. 279-314, 1977.

Bauer, W.H., D.W. Borton, and J.J. Bulloff, "Agents, Methods, and Devices for Amelioration of Discharges of Hazardous Chemicals in Water," U.S. Department of Transportation, U.S. Coast Guard, Office of Research and Development, Washington, DC, CG-D-38-76, August 1975.

Bhutani, J.S., J.S. Burton, and P.N. Cheremisinoff, "Remote Sensing Improves Conventional Sampling Procedures, Water and Sewage Works," PR-108 (5), April 30, 1978.

Bills, H. Matthew, and Robert F. Holmes, "Development of Hazardous Waste Site Monitoring Methods and Characterization," Environmental Protection Administration, presented at the 5th International Conference on Air and Water and Noise Protection at Elmia, Sweden, September 21-24, 1981.

Biron, David G., Brian E. Edwards, Stephen Marcus, and Robert J. Hull, "Coherent Laser Radar Remote Sensing," Massachusetts Institute of Technology, Lincoln Laboratory, Lincoln, MA, ESD-TR-82-170, December 1982.

Bonner, William P., and Eric L. Morgan, "On-Line Surveillance of Industrial Effluents Employing Chemical-Physical Methods and Fish as Sensors," University of Tennessee, Water Resources Research Center, Knoxville, TN, OWRT-B-030-TENN(1), August 1976.

Brown, Chris W., "Remote Detection of Water Pollutants by Computerized Laser Raman Spectroscopy," Office of Water Research and Technology, Washington, DC, OWRT-A-054-RI(1), June 1976.

Brownrigg, J.T., D.A. Busch, and L.P. Giering, "A Luminescence Survey of Hazardous Materials," U.S. Department of Transportation, U.S. Coast Guard, Office of Research and Development, Washington, DC, CG-D-53-79, May 1979.

Bukowski, Richard W., "Fire Protection Systems for Rail Transportation of Class A Explosives: Interim Report," National Bureau of Standards, Washington, DC, NBSIR-80-2170, November 1980.

Carlson, G.P., "Haz-Mat Accidents on the Railroad: Know What to do When They Occur," Fire Engineering, 134(8), pp. 29-30, 1979.

_____, "Contingency Planning for First Responders," presented at the National Conference and Exhibition on Control of Hazardous Materials Spills, Louisville, KY, May 13-15, 1980.

Chamberlain, O., P. Robrish, and H. Rosen, "Investigation of the Use of the Resonance Raman Effect as an Environmental Monitor," University of California, Lawrence Berkeley Laboratory, Berkeley, CA, LBL-5288, October 1976.

Cichowicz, N.L., R.W. Pease, P.J. Stoller, and H.J. Yaffe, "Use of Remote Sensing Techniques in a Systematic Investigation of an Uncontrolled Hazardous Waste Site," Mitre Corporation, Bedford, MA, 1981.

Cook, Jerald J., "Proceedings of the International Symposium on Remote Sensing of the Environment (9th)," Symposium held at Environmental Research Institute, University of Michigan, Ann Arbor, MI, sponsored by the Air Force Office of Scientific Research, April 15-19, 1974, AFSOR-TR-75-0515-Vol-3, April 1974.

Davis, A.R., "Use of Fluorescence Spectroscopy for Remote Detection of Pollutants," presented at Symposium on Water Quality Parameters--Selection, Measurement, and Monitoring, Burlington, Canada, November 19-21, 1973.

Delong, Harry P., and V. James Cannaliato, "A Study of CO2 Laser Remote Sensor for Nerve Agent Detection. A Theoretical Survey," Edgewood Arsenal, Aberdeen Proving Ground, MD, ED-TR-76049, August 1976.

Ellis, Gilbert M., Thomas Little, Charlie Frazee, and Bruce Piringer, "Commonwealth of Kentucky Emergency Response to Hazardous Materials Incidents," presented at the National Conference and Exhibition on Control of Hazardous Materials Spills, Louisville, KY, May 13-15, 1980.

Environmental Protection Agency, "Proceeding of Conference on Environmental Quality Sensors (Second)," Office of Monitoring Systems, Environmental Protection Agency, Washington, DC, Proceeding of Conference held at the National Environmental Research Center, Las Vegas, NV, December 1973.

Environmental Science and Technology, "Remote Sensing as a Monitoring Tool," Environmental Science and Technology, 10(10), p. 972, 1976.

Gelbwachs, Jerry A., "Multiple Site Laser Excited Pollution Monitoring System," Department of the Air Force, Washington, DC, PAT-APPL-6-347 391, February 1982.

Gerstle, R.W., "Source Sampling, Analysis, and Monitoring of Gaseous Pollutants," Air Pollution Control: Part III: Measuring and Monitoring Air Pollutants, ed. W. Strauss, Environmental Science and Technology: Wiley Interscience Series of Texts and Monographs, ed. R.L. Metcalf, J.N. Pitts, and W. Stumn, John Wiley and Sons, New York, 1978.

Gill, P.A., "A Railroad's Reaction to Hazardous Materials: Transportation, Spill Control, Mitigation, Clean-up, (Mangement)," Seaboard Coast Lines Industries, Inc., Jacksonville, FL, presented at the National Conference and Exhibition on Control of Hazardous Materials Spills, Louisville, KY, May 13-15, 1980.

_____, "Railroad Management of Hazardous Materials," presented at the National Conference and Exhibition on Control of Hazardous Materials Spills, Louisville, KY, May 13-15, 1980.

Gregory, G.L., D.S. MacDougal, and H.S. Wagner, "An Air Quality Program Designed to Evaluate Remote Sensors," NASA Langley Research Center, presented at the 73rd Annual Air Pollution Control Association Meeting and Exhibition, Montreal, Canada, June 22-27, 1980.

Gross, Geral J., David E. Harris, Gerald Lachs, and Robert M. Dillman, "Instrumentation for Detecting Hazardous Materials," Federal Emergency Management Agency, Washington, DC, 940 4, June 1980.

Guillot, P., "Optical Methods of Remote Sensing of Atmospheric Pollution," Spectrochemica Acta Part B: Atmospheric Spectrocopy 38B (11-12), pp. 1457-1464, 1983.

Halvorsen, F.H., and W.D. Eley, "Development of a Coast Guard Hazardous Material Response Team," presented at the 1984 Hazardous Materials Spills Conference, Nashville, TN, April 9-12, 1984.

Hansen, Warren G., David E. Ross, John G. Kuykendall, and Linda P. Erdberg, "Disposal Systems and Techniques for Oil and Hazardous Chemicals Recovered from Marine Spills," U.S. Department of Transportation, U.S. Coast Guard, Office of Research and Development, Washington, DC, CG-D-35-79, February 1979.

Helnder, P., I. Renhorn, and D. Steinvall, "Detection and Remote Sensing of Chemical Agents," Foersvarets Forskningsnstalt, Stockholm, Sweden, FAO-C-30324-E1, May 1983 (in Swedish).

Instrument Society of America, "First Joint Conference on Sensing of Environmental Pollutants," available from Instrument Society of America, 400 Stanwix Street, Pittsburgh, PA.

_____, "Second Joint Conference on Sensing of Environmental Pollutants," available from Instrument Society of America, 400 Stanwix Street, Pittsburgh, PA.

_____, "Environmental Pollution Instrumentation," available from the Instrument Society of America, 400 Stanwix Street, Pittsburgh, PA.

Isman, Warren E., "A Three-Level Emergency Personnel Response System," presented at the National Conference and Exhibition on Control of Hazardous Materials Spills, Louisville, KY, May 13-15, 1980.

Johns Hopkins University, "Hazardous Materials, 1980 Emergency Response Handbook," U.S. Department of Transportation, Materials Transportation Bureau, Washington, DC, DOT-P-5800.2; HS-030 923, 1980.

Johnson, H.V., "Aerial Reconnaissance of Hazardous Substances Spills and Spill-Threat Conditions," Lockheed Electronics Co., Inc., Remote Sensing Laboratory, Las Vegas, NV, EPA/600/4-79/027, April 1979.

Kloeber, G., M. Cornell, T. McNamra, and A. Moscati, "Risk Assessment of Air Versus Other Transportation Modes for Explosives and Flammable Cryogenic Liquids. Volume I: Risk Assessment Method and Results," U.S. Department of Transportation, Research and Special Programs Administration, Materials Transportation Bureau, Washington, DC, DOT/RSPA/MTB-79/13, December 1979.

Koutsandreas, J., "Extension of Laboratory Measurement Techniques for Field Use," presented at the 2nd Joint Conference on Sensing Environmental Pollutants, Washington, DC, December 10-12, 1973.

Lederman Peter B., and Steven M. Gertz, "Emergency Response Planning and Safety," presented at the 1984 Hazardous Materials Spills Conference, Nashville, TN, April 9-12, 1984.

Malter, John A., Norman Bird, George Patch, and Robert Merchant, "Vermont's Hazardous Materials On-Scene Action Guide," presented at the National Conference and Exhibition on Control of Hazardous Materials Spills, Louisville, KY, May 13-15, 1980.

McRae, T.G., "BAGI: A Technique for the Detection and Tracking of Large Gas Clouds," Lawrence Livermore National Laboratory, Livermore, CA, presented at the JANNAF Safety and Environmental Protection Meeting, Livermore, CA, March 8, 1983, UCRL-88781, February 1983.

_____, "BAGI: A New Concept for the Detection and Tracking of Hazardous Gases," Lawrence Livermore National Laboratory, presented at the International Congress on Applications of Lasers and Electro-optics, Los Angeles, CA, November 14, 1983, URCL-89307, October 1983.

National Transportation Safety Board, "Safety Report on the Progress of Safety Modification of Railroad Tank Cars Carrying Hazardous Materials," National Transportation Safety Board, Washington, DC, NTSB/SR-79/2, September 1979.

_____, "Special Investigation Report. Onscene Coordination Among Agencies at Hazardous Materials Accidents," National Transportation Safety Board, Washington, DC, NTSB/HZM-79/3, September 1979.

_____, "Special Investigation Report - Phosphorus Trichloride Release in Boston and Maine Yard 8 During Switching Operations, Somerville, Massachusetts, April 3, 1980," National Transportation Safety Board, Washington, DC, NTSB-HZM-81-1, February 1981.

_____, "Railroad Accident Report-Derailment of Seaboard Coast Line Railroad Train No. 120, at Colonial Heights, Virginia, May 31, 1982," National Transportation Safety Board, Washington, DC, NTSB/RAR-83-04, May 1983.

_____, "Railroad Accident Report-Illinois Central Gulf Railroad Freight Train Derailment, Fort Knox, Kentucky, March 22, 1983," National Transportation Safety Board, Washington, DC, NTSB/RAR-83/07, August 1983.

Neff, D.E., R.N. Meroney, "Dispersion of Vapor from LNG Spills -- Simulation in a Meterological Wind Tunnel of Spills at China Lake Naval Weapons Center, California," U.S. Coast Cuard, Office of Research and Development, Washington, DC, CG-D-15-80, March 1979.

O'Driscoll, J.J., "Spill Prevention and Control in Railroad Industry," presented at the National Conference on Control of Hazardous Materials Spills, San Francisco, CA, August 25-28, 1974.

_____, "Hazardous Materials in Rail Accidents--Real Cases, Real Solutions," presented at the 25th Canadian Chemical Engineering Conference, Montreal, Canada, November 2-5, 1975.

_____, "Development of a Comprehensive Emergency Reponse System for Railroad Accidents," presented at the National Conference and Exhibition on Control of Hazardous Materials Spills, Louisville, KY, May 13-15, 1980.

Raj, Phani P.K., Albert N. Moussa, and Krishna Aravamundan, "Experiments Involving Pool and Vapor Fires from Spills of Liquified Natural Gas on Water," U.S. Department of Transportation, U.S. Coast Guard, Office of Research and Development, Washington, DC, CG-D-55-79, March 1979.

Rath, Gustave J., et. al., "Study of Hazardous Materials Information Needs and Identification Systems for Transportation Purposes," U.S. Department of Transportation, Office of Hazardous Materials, Washington, DC, DOT-TSA-20-72-4, May 1972.

Renger, W., and G.H. Ruppersberg, "Mission Definition for the First Flight of a Multidisciplinary Lidar System Formulated Following Discussions with Representatives of Various Institutes," Deutsche Forschungs- and Versuchsanstalt fuer Luft- and Raumfahrt, Oberpfaffenhoffen (West Germany). Institut fuer der Atmosphere, August 1976.

Sakai, H., et. al., "Measurement of Atmospheric Emission Using a Ballon-borne Cryogenic Spectrometer," presented at the International Conference on Fourier Transform Infrared Spectroscopy, Columbia, SC, June 8-12, 1981.

Sandness, G.A., J.F. Washburn, and S.B. Ailes, "Study of Detection, Identification, and Quantification Techniques for Spills of Hazardous Materials," U.S. Department of Transportation, U.S. Coast Guard, Office of Research and Development, Washington, DC, CG-D-114-75, October 1976.

Shaver, D.K., R.L. Berkowitz, and P.V. Washburne, "Accident Management Orientation Guide," Air Force Rocket Propulsion Laboratory, Edwards AFB, CA, FRPL-TR-82-075, October 1983.

Showmn, L.R., and D.R. Morgan, "Studies on an Isotopic CO2 Laser LOPAIR System," General Electric Company Electronics Laboratory, Syracuse, NY, ED-CR-74034, November 1974.

Smith, Jr., Al J., H.D. van Cleave, Ronald Y. Wada, Brenner Munger, and Paul Hurt, "Atmospheric Emergencies: Existing Capabilities and Future Needs," Transportation Research Board, Washington, DC, TRB/TRR-092, 1983.

Tejada, Susan, "Chemical Detectives at Work: EPA's Environmental Response Team," EPA Journal 10(8), October 1984.

Thibodeaux, Louis J., "Spill of Soluble, High Density, Immiscible Chemicals in Water," U.S. Department of Transportation, Research and Special Programs Administration, Office of University Research, Washington DC, DOT/RSPA/DPB-50/78/24, December 1978.

Thomas, P.J., "Rotational Raman Spectroscopy for Remote Detection of Atmospheric Pollutants in Smokestack Plumes," presented at the 24th Canadian Spectroscopy Symposium, Ottawa, Canada, October 23-26, 1977.

Tombach, I.H., M.W. Chan, and P.B. MacCready, "Application of Mobile and Remote Monitoring to Modeling of Pollution Dispersion," AeroVironment, Inc., Pasadena, CA, presented at the 71st Air Pollution Control Association Annual Meeting and Exhibition, Houston, TX, June 25-30 1978.

Transportation Research Board, "Transportation of Hazardous Materials; Toward a National Strategy, Volume 1," Transportation Research Board, Washington DC, TRB/SR-197-VOL-1, 1983.

_____, "Applications of Remote Sensing to Hazardous Spill Incidents," Transportation Research Board, Washington, DC, Transportation Research Record N902, 1983.

Vane, G., "Advanced Sensor Technologies for Remote Sensing," presented at the 187th National Meeting of the American Chemical Society, St. Louis, MO, April 8-13, 1984.

Welch, R.I., A.D. Marmelstein, and P.M. Maughan, "A Feasibility Demonstration of an Aerial Surveillance Spill Prevention System," Earth Satellite Corporation, Washington, DC, EPA-15080-HOL-01/72, January 1972.

Wright, M.L., "Studies of DIAL/DISC Remote Sensing Techniques for Chemical Agent Detection," SRI International, Menlo Park, CA, Quarterly Progress Report for Chemical Systems Laboratory, Aberdeen Proving Ground, MD, ARSCL-CR-79032, March 1979.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1986--601-146--20,218