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THE USE OF DETECTORS AND TEST KITS

IN

INDUSTRIAL HYGIENE INVESTIGATIONS

Aeronautical Systems Div.
Air Force Systems Command
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- BY -

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by

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When one reviews the continuous progress being made in the field of industrial hygiene it soon becomes apparent that a contributing factor to this progress has been the acquisition of much needed data through the improvements made in air sampling instruments.

Those who recall the arduous tasks of calibrating, transporting, setting up and dismantling heavy pumps, motors and sampling devices that preceded current developments in this field certainly must admit that we have come a long way. Today, to add to our collection of midget impingers and scrubbers, we can have our selection of lightweight pocket size vacuum pumps, A.C. or D.C., miniature plastic rotameters for measuring rates of air flow, and small filters that collect particles down to fractions of a micron.

This streamlining of conventional air sampling equipment to facilitate sample collection and thereby aid industrial hygiene investigations has been accompanied by a noted increase in the output of detectors and test kits.

These inexpensive, compact, portable, simple to operate, quick detecting, rapid performance, on the spot, grab samplers can apparently determine everything from arsine to unsymmetrical-dimethyl hydrazine. I have been informed that even at this writing three new ones are currently under development and soon will be commercially available.

Although detectors and test kits embrace a broad category of sampling devices, the basic instrument to be discussed here consists of two parts (a) the sampler, or mechanical device for drawing the air to be tested through the detecting or collecting medium and (b) the detecting or collecting medium.

The principal types of samplers are (1) electrical pumps, (2) metal hand pumps, (3) gas aspirating devices (4) rubber bulbs or bellows and (5) glass syringes. All of these devices are usually calibrated in advance and are intended to be used in a manner that will cause a known volume of air to pass through the detecting medium.

The most widely used types of detecting or collecting mediums consist of (1) prepared solutions (2) special papers or filters impregnated with selected reagents in advance or at the sampling site and (3) solid granules such as silica gel, diatomaceous earth or alumina impregnated with selected reagents.

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**The opinions expressed in this report are those of the author and are not to be construed as reflecting the views of the U. S. Air Force.

These detecting mediums usually function by developing a color the intensity of which is proportional to the atmospheric concentration of the air-borne material. In some instruments, depending upon the volume of air sampled, the concentration is indicated by the length of the stain formed in the detecting tube.

In one type, the sampling device is used to scrub a known volume of air through a selected absorbing solution which changes color and the volume of air required to cause the color change is noted. Reference to a prepared chart, or a knowledge of the stoichiometric requirements indicates the PPM of gas or vapor present in the air being tested. For some tests the collecting solution is immediately treated with reagents to produce a color.

With nearly all detectors that depend upon color formation, the color developed on the detecting medium is visually observed as to length of stain or its intensity is compared with standards. Standards usually consist of selected liquid reagents already treated with known amounts of the substance being determined, or permanent colored glass, papers or plastics. Examples of such instruments are shown in Figures 1, 2, 3 and 4. Permanent glass standards are excellent for field use as employed in the type of test kit shown in Figure 5. This kit was developed by the writer for the determination of HCN and other gases and vapors. Its basic principle involves development of colors in solution and subsequent comparison with a special disc and a Hellige comparator.

Depending upon the remoteness of laboratory facilities and the urgency required for the data, somewhat larger test kits can be assembled completely furnished with a small photoelectric colorimeter as shown in Figure 6. Recently, West and Gaeke[1] developed an all purpose semi-quantitative gas analysis test kit for detecting and identifying air pollutants as shown in Figure 7. This kit contains a number of solid and liquid reagents in addition to the electrically driven sampling assembly. Its developers claim that it is capable of detecting 18 common air contaminants. Although designed for air pollution investigations, it may find some usefulness in the field of industrial hygiene especially in the heavy metal refining and chemical industries.

A newly developed lead-in-air detector utilizes the principle of aspiration provided by a constant flow of freon gas to induce suction that causes contaminated air to pass through a filter. The filter traps inorganic lead fume or dust and is then treated with special reagents to form a colored stain whose intensity is a measure of the amount of air-borne lead present. The device is shown in Figure 8.

The toxic gas detector is a new instrument that depends upon pyrolysis of the vapor being determined to produce a color stain in a specially constructed detector tube. The length of the stain indicates, for the particular gas or vapor encountered, whether or not it is present in concentrations below or above the currently acceptable maximum allowable

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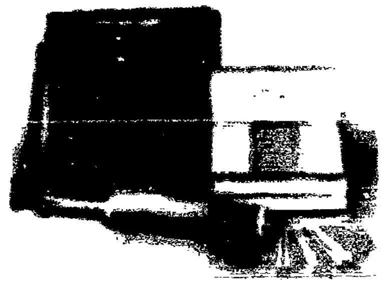

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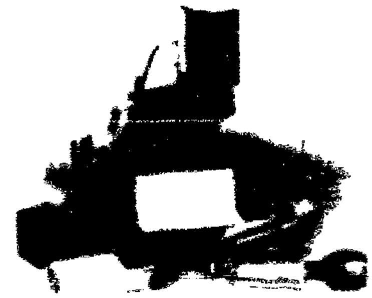

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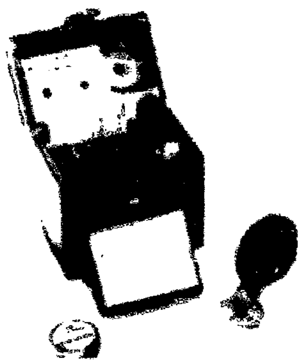

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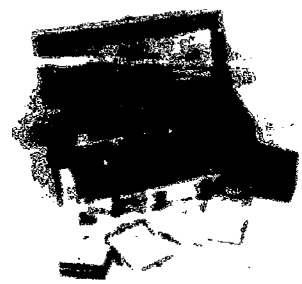

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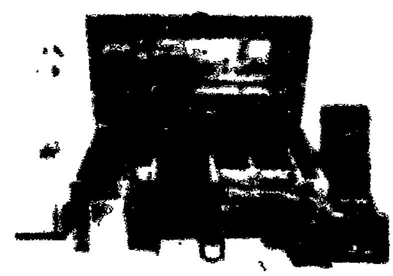

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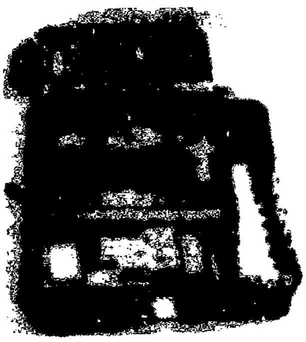

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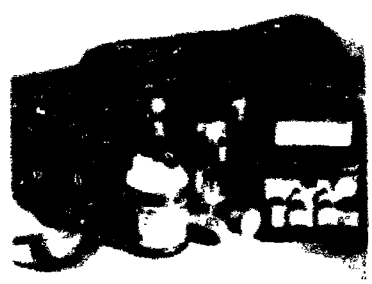

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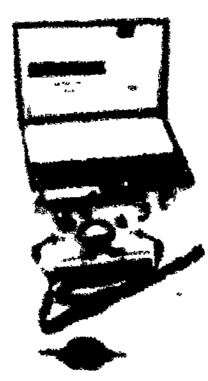

9.

1. Drager Gas Detector. Courtesy Safety Supply Company.
2. Kitagawa detector. Courtesy Union Industrial Equipment Corp.
3. Sulfur dioxide detector. Courtesy Mine Safety Appliances Co.
4. Uns-Dimethyl Hydrazine detector. Courtesy Mine Safety Appliances Co.
5. HCN test kit. Courtesy Compact Air Samplers.
6. Field test kit with colorimeter. Courtesy Compact Air Samplers.
7. Gas Analysis test kit. Courtesy Kem-Tech Laboratories, Inc.
8. Uni-jet lead in air detector. Courtesy Union Industrial Equip. Corp.
9. Davis toxic gas detector. Courtesy Davis Emergency Equipment Co.

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concentration. After this estimation has been made, [illegible] can be applied, if necessary, to determine the concentration [illegible]. The device is shown in Figure 9.

It would seem therefore that the industrial hygienist and safety engineer have a multiplicity of instruments from which to choose the most appropriate in their constant efforts to seek out and control health hazards in the working environment. Furthermore there must be good reasons for the continued selection and application of this type of instrument. Let us explore a few:

1. Industrial expansion and increased production engender more health hazards:

For economical and geographical reasons industrial expansion frequently necessitates plant locations in areas quite distant from established industrial hygiene services. This makes the problems of industrial hygiene more acute with the added problem of an increasing number of new workers being exposed to industrial health hazards.

While desiring to be helpful, official government health agencies find it difficult to service all plants as often as they would like. Plant management and those assigned to health and safety programs recognize this. The plants cannot afford to hire full time industrial hygienists and some plants even consider safety a part time job. Nevertheless, problems of an industrial hygiene nature often arise. It is the safety man's job to investigate, gather facts and find a solution. If he is not well trained, he has limited knowledge on the hazards of certain dusts, gases and vapors and the means of checking atmospheric concentrations. He wants to obtain maximum information with a minimum of financial investment because his budget is limited. He therefore turns to detectors and test kits in the hope they will help him find answers to his problems. This basic situation is probably the principal reason why detectors and test kits are finding more widespread use in industry. I do not mean to imply, however, that safety men are the only users of detectors and test kits in industry. Miller[2] at Eastman Kodak reports that new types of instruments of this kind are being tried out routinely in their extensive environmental health program.

Management indirectly promotes this use of detectors and test kits by its own increasing knowledge of industrial health problems. It has learned to rely more and more on scientific methods that can be brought to bear upon the solution of problems in production and expects the same diligent application to industrial hygiene problems. An enlightened management now asks and wants to know, "What is the exposure?" "Is it continuous?" "How harmful is it?" "Can it be measured? The last question poses the challenge to obtain data for data means a point from which to proceed.

At the same time management is much more alert to and aware of the rising costs of installations including extensive exhaust ventilating systems. In this area especially, it is not apt to be swayed by opinion as much as convinced by facts. This places an added burden upon the hygienist or safety man to utilize equipment that can obtain factual data for presentation in the shortest possible time.

Spurred by this acceptance, manufacturers of detectors and test kits have been willing to take on new problems. The formidable foe of industrial hygienists for many years, air-borne lead, has finally succumbed to field determinations. Every industrial hygienist who has ever carried an electrostatic precipitator has had the occasion to collect atmospheric samples for lead in one of its physical states or for lead compounds. The procedure has always been to submit samples to laboratory analysis because the dissolution of lead, its separation and final determination have always been sufficiently laborious and complex to require laboratory procedures.

The initial work undertaken by Amdur and Silverman[3], followed by McConnaughey[4], Quino[5] and others, has lead to the development of test kits for the quantitative estimation of lead in air. The kits leave something to be desired but they do represent a break-through in the evaluation and control of a respected and ubiquitous health hazard. No doubt refinements will be forthcoming and the kits will be of considerable value in the protection of workers against the insidious toxic effects of this element.

The rapid development of boron hydrides as a source for more powerful fuels and propellants presented a new health hazard to those employed in manufacturing and handling this compound. The rapid absorption by inhalation, the marked susceptibility of the nervous system and the lack of immediate warning symtomatology are major factors in borane toxicology. This is a typical example of a challenging new industry with its attendant health hazards that must be recognized and evaluated immediately. There is no better way of doing so than ample testing of the atmosphere with a detector that will supply information at once as to the degree of severity of an exposure. The challenging industrial hygiene problem has been met with the development of a test kit that is currently available for this purpose.

The development of unsymmetrical-dimethyl hydrazine as an improved fuel for rocket engines also poses another potential health hazard. Extremely low concentrations are irritating to mucous membranes, setting up a physiological response wherein the nose cannot be relied upon to detect increasing concentrations. Complete clinical studies not being available, good industrial hygiene practice dictates that immediate warning of potentially dangerous concentrations should be made available. Conventional air sampling methods and analysis involve too much of a delay when data is required for immediate evaluation and the best recourse is to use available test kits for this purpose.

2. Detectors and test kits furnish immediate information on hazardous conditions:

In the course of any industrial hygiene investigation there is a certain amount of impatience frequently expressed in waiting for laboratory findings on air samples collected in the field. As a result many field investigators prefer to use detectors and test kits instead of conventional air sampling and analysis procedures. It must be admitted there are a number of advantages to "on the spot" data, especially when applied to very toxic substances that are odorless or possess odors that are not unpleasant when inhaled. For example, workers may be exposed to hazardous concentrations of arsine, carbon monoxide, hydrogen cyanide, nickel carbonyl, aniline, nitrobenzene, inorganic compounds of toxic heavy metals, certain halogenated hydrocarbons, etc., without experiencing immediate discomfort. Other gases and vapors may cause varying degrees of annoyance but are not necessarily disabling until a sufficient quantity has been inhaled. In this category are oxides of nitrogen, certain nitriles, hydrogen sulfide, phosgene and others.

It is through the use of detectors and test kits that dangerously high concentrations of air-borne substances can be found immediately and appropriate corrective measures taken. It is encouraging to find such progress being made and it would be even more assuring to have "on the spot" methods available for all highly toxic air-borne dusts, gases, vapors and mists.

Although our current MAC values are associated with 8 hour exposures, there is a fallacy in assuming that all exposures are continuous over an eight hour period. Intermittent exposures to air-borne dusts, gases, vapors and mists probably occur more often in industry than do continuous exposures. Some years ago the writer noted the importance of this variance in the chemical industry and began to develop test kits and simpler analytical procedures to evaluate intermittent exposures.[6,7] King[8] related the importance of this concept and emphasized the need for more attention along this line in the aircraft industry. In reports on toxicity studies of organic solvent vapors toxicologists are attempting to point out concentrations that should never be exceeded. Gerarde[9] of Standard Oil has undertaken further toxicological studies along this line. Should any findings ultimately disclose that information on high intermittent concentrations is very valuable and denotes good industrial hygiene practice, greater reliance will have to be placed upon detectors and test kits. The implication here should be emphasized. It means we may have to revise our air sampling techniques. This does not mean eliminating all concepts of conventional air sampling but it does mean we may have to include methods that will satisfy these new requirements through the use of rapid testing field instruments.

In an excellent report on exposures to toluene diisocyanate in the production of polyurethane foam, Walworth[10] reported at least 1000 air samples were taken for TDI by conventional air sampling techniques within a 17 month period. An analysis of the medical records, however, revealed a lack of correlation between the magnitude of TDI vapor exposure and the appearance of respiratory cases. One of the possible reasons cited for this lack of correlation was brief exposures to relatively high TDI concentrations during periods of generally low average concentrations. It was further stated that the integrating sampling method used would not indicate short peak concentrations. This statement further supports the belief that more attention should be given to evaluating the extent of short term exposures to higher concentrations of solvent vapors. Other than an expensive recording device, the approach is frequent sampling with a manually operated test kit to determine the peak concentrations.

To extend this line of thinking, detectors and test kits are useful devices for investigating complaints which in the light of past history appear to be groundless. The writer can recall an episode in which operators were complaining about the concentration of an irritating gas in a workroom atmosphere. Prior to the complaint, many samples had been taken and analyzed by conventional means and the concentrations found were below the maximum allowable concentration. However, repeated and more painstaking sampling during the operation with a test kit sampling procedure disclosed intermittent high concentrations resulting from the sporadic release of gas from an unexpected source. These peak concentrations were causing the complaints and were not detected when integrated into an average finding by the conventional air sampling method that was previously employed.

The picture that has been presented on the use of detectors and test kits for industrial hygiene investigations, thus far, has been favorable. However, we would be remiss in our responsibilities as hygienists if we ignored certain conditions under which the use of detectors and test kits for field determinations might have certain drawbacks.

For example, if an investigator does not approach a problem in an experienced manner and uses a kit that has no professional appearance his efforts may only succeed in causing loss of respect for his own ability and the kit's capability of performing an important function. Indeed a casual use of a detector or test kit could convey the impression that a few squeezes of a rubber bulb and a quick glance at a color chart are all that is required to solve what may really be a complex problem in environmental health. Simplification in the performance of a difficult test is really appreciated only by those who are aware of the complexities. Moreover, the indiscriminate recommendation of detectors and test kits may result in too many kits getting into the hands of inexperienced personnel who in turn may put them to ridiculous uses. Following the acquisition of data, the resulting course of action may cause more consternation than if the kit had not been used at all. Suppliers of detectors and test kits are continually making claims that non-trained and inexperienced personnel will have no difficulty in using the kits. However, experience indicates that it would certainly be better to at least have a trained person monitor their use in any extensive program.

Even assuming that test kits find their way into the hands of inexperienced, yet responsible and conscientious personnel, the sampling location, the proper time to sample and the number of samples to be taken are details that have considerable bearing upon the outcome of the investigation. The vagaries of human behavior during an industrial operation are sometimes thought provoking as well as dust provoking and very often, more tact, understanding and diplomacy go into air sampling than can be found in the instructions on the label of a gas detector.

In addition, the chemical and mechanical aspects of test kit usage should be thoroughly understood. Campbell[11] of Los Alamos has made a study of certain factors affecting the validity of detectors and test kits and is preparing this information for publication. He makes particular reference to such factors as air volume, rate of air flow, humidity and size of surface area exposed as markedly influencing the reaction between the contaminant and the reagents. It should be noted that color development on filter papers may be adversely affected in dusty atmospheres, and of course, a combination of gases and vapors may give erroneous results when the test is being made for only one. It is certainly the responsibility of manufacturers to point out all possible interferences with a test at least to the best of their knowledge. Even the NBS carbon monxide indicator, one of the best detectors ever developed, is subject to interferences from oxides of nitrogen under certain conditions of use.[12]

Last but not least, the interpretation of air sampling results must reflect an experienced approach to the industrial hygiene problems that manifested the need for the investigation. As indicated above much more goes into the picture presented to management than a few tubes of colored granules or strips of stained paper. Management, who pays the bills, deserves the assurance that the proper tests have been selected so that the results are not additive. Those intangible effects such as an over zealous operator who causes more liberation of a gas to occur so the results will be higher are quietly observed and placed in their proper perspective by experienced hygienists. At the same time a knowledge of the operation must be considered in conjunction with air sampling results to determine if the operation has been reduced in magnitude owing to cutbacks in production or reduced demand. Such action could give very low results in the air samples taken but would not represent the conditions of exposure under optimum operation.

If all these considerations are regarded as valid it occurs to me that recourse might be made to some independent agency to evaluate detectors and test kits and issue periodic reports. Various governmental agencies and technical societies are in the process of testing and recommending acceptable methods for sampling and analysis. Perhaps this could be made a part of their program. A reliable agency approving a test kit as being satisfactory for what it is supposed to do would enhance the prestige of the kit and dispel doubts concerning its application and use.

I firmly believe that test kits will continue to play a dominant role in the evaluation of health hazards. The point is to prevent their becoming the hope of the safety man, the despair of the purists and the dilemma of the industrial hygienist. Our profession cannot tolerate such three headed monsters. Cooperative efforts on the part of manufacturers and users will eventually help detectors and test kits achieve the instrumental class distinction to which they rightfully belong. Reasons have been given as to how they could take a decisive part in future investigative work instead of being relegated to an emergency instrument for preliminary investigations.

It must be remembered that when we hold an air sampling device in our hands, we may also hold the life of a fellow human being. They both deserve the best we have to offer.

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REFERENCES

1. Gaeke, G. C. Jr., Kem-Tech Laboratories, Private Communication.

2. Miller, Franklin A., Eastman Kodak Company, Private Communication.

3. Amdur, Mary O. and Silverman, Leslie: Direct Field Determination of Lead in Air, AMA Arch. Ind. Hyg. and Occ. Med. 10:152 (Aug 1954).

4. McConnaughey, Paul W.: Field Type Colorimetric Testers for Gases and Particulate Matter, presented before the annual meeting of the American Industrial Hygiene Association, Atlantic City, New Jersey, April 24, 1958.

5. Quino, Enrique A.: Field Method for the Determination of Inorganic Lead Fumes in Air. Amer. Ind. Hyg. Assoc. J 20:2 (April 1959).

6. Gisclard, J. B., et al: A Simple Device for Air Analysis. Amer. Ind. Hyg. Assoc. Quarterly, 14:1 (March 1953).

7. Gisclard, J. B., et al: A Rapid Empirical Procedure for the Determination of Acrylonitrile and Acrylic Esters in the Atmosphere. Amer. Ind. Hyg. Assoc. J 19:1 (February 1958).

8. King, B. G., High Concentrations - Short Time Exposures and Toxicity J. Ind. Hyg. and Tox. 31:6 (November 1949).

9. Gerarde, Horace, W., M.D. Standard Oil Company, Private Communication.

10. Walworth, H. T. and Virchow, W. E.: Industrial Hygiene Experiences with Toluene Diisocyanate. Amer. Ind. Hyg. Assoc. J 20:3 (June 1959).

11. Campbell, Evan E., Los Alamos Scientific Laboratory, Private Communication.

12. Ayer, Howard E. and Saltzman, B. E., Notes on Interferences by Oxides of Nitrogen with Estimations of Carbon Monoxide in Air by the NBS Indicating Tubes. Amer. Ind. Hyg. Assoc. J 20:4 (August 1959).

SUMMARY

The improvements and versatility found in detectors and test kits are a natural outgrowth of miniaturization of conventional air sampling equipment. Test kits are being used more and more in industrial hygiene investigations because they are relatively inexpensive, they appeal to non-technical personnel and are capable of detecting hazardous concentrations immediately so that corrective measures can be taken. Instances of actual application of test kits have been described and future applications have been indicated. However, all users are admonished that test kits are subject to interferences, the findings are frequently estimates only, and abuse is possible in the hands of non-trained personnel. Hence the selection and use of a detector or test kit should be accomplished with professional appreciation of the entire industrial health problem involved.

ACKNOWLEDGEMENTS

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Grateful acknowledgement is also made to the number of experts in the field of industrial hygiene who submitted results of their experiences with detectors and test kits.

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