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Annual Meeting of Members

TUESDAY EVENING SESSION

October 27, 1942

The Annual Meeting of Members of the National Safety Council, at the 31st National Safety Congress and Exposition, was called to order in the Grand Ballroom of the Sherman Hotel, Col. John Stilwell, President, presiding.

Following the singing of the Star Spangled Banner by the assembled delegates, Colonel Stilwell announced a quorum present in person or by proxy. He then gave his annual address to members.

Other business being dispensed with by vote of the members, Colonel Stilwell called for a report of the Nominating Committee. This report was made by Mr. H. J. Griffith, who read the slate prepared by the Committee. There being no further nominations from the floor, the slate was elected by directed vote. The names of the newly elected directors of the Council appear elsewhere in the Transactions.

One of the highlights of the Congress was the presentation of an honorary life membership to William H. Cameron, one of the founders of the National Safety Council and its managing director until his retirement last July. The membership certificate, a solid gold card inscribed with a statement of Mr. Cameron's devoted service to the cause of safety, was presented to him by President Stilwell at the Annual Meeting.

Colonel Stilwell then introduced the next two speakers of the evening, Ned H. Dearborn, Executive Vice-President, National Safety Council, Inc., and William A. Irvin, Chairman, War Production Fund to Conserve Manpower. The meeting adjourned at the conclusion of Mr. Irvin's speech.

Annual Address to Members

By COLONEL JOHN STILWELL

President, National Safety Council, Inc.

Ladies and Gentlemen:

The welcome I extend to you today bears a deeper significance for our national welfare than ever before.

You are welcome. You are doubly welcome in this fateful year of 1942, for you have come as the captains and the generals of a great branch of the national service. Never have you been so needed, never have your efforts as safety leaders been so indispensable.

Many of you make a two-fold contribution to the nation in these days of its greatest peril. You come—as you always have—as safety leaders—as conservers of the nation's manpower. Thousands of you come this year also as producers of its fighting equipment. As such you feel even more keenly the sharp edge of our desperate necessities. As such

Dust, Fumes, Gases and Vapors

WEDNESDAY MORNING SESSION

October 28, 1942

Presiding—STUART F. MEEK, M.D., Asst. Medical Dir., Chrysler Corp., Detroit

Maintenance of Exhaust Systems An Important Safety Measure

By JOHN M. KANE

Engineer, American Air Filter Company, Inc., Louisville, Kentucky

In recent years the safety engineer's responsibilities have increased by leaps and bounds. Under his widening control logically comes the checking of exhaust systems for the control of hazardous dusts and fumes.

This discussion will assume that such hazards are evaluated by the industrial hygienist or safety engineer. Where exhaust ventilation is required, the ventilation engineer makes recommendations for exhaust capacities, system and hood design to control the condition. It will be further assumed that this coordination results in an effective exhaust system removing the dust or fumes at the points of generation and preventing their dispersion to the workroom. Consequently, unless the process is changed, the hoods or enclosures altered, or the method of material handling revised, the hazard should remain controlled as long as the exhaust system functions *properly*. The word "properly" can rightly be underscored because in many cases little attention is given to such an installation after the project has been completed. Yet mechanical exhaust equipment and dust collectors require the same attention that machine tool and other plant equipment require and usually receive.

If this precept is correct, a discussion of fundamentals may assist the safety engineer in quickly setting up a routine check on the performance of an exhaust system and catching any reduction in the system's effectiveness. The tools required under most cases are a manometer (U-Gage), and a short piece of rubber tubing. The engineer must also have an understanding of static pressure losses and hood suction.

While hood suction readings have rightfully fallen into a state of ill repute as a means of measuring air flow, they do offer a quick and accurate method of measuring relative air flow. If the hood suction is known while an exhaust system is functioning properly, its continued effectiveness can be assured as long as the hood suction does not reduce from its original value. An expansion of this statement should indicate why this simple measurement can be used as a ready check.

The Exhaust System

Exhaust ventilation is by far the most predominant means of controlling dust hazards. The fundamental elements and the design are not altered, whether the purpose of the exhaust system is to remove toxic or explosive particles, or simply to prevent dispersion for reduction in workman fatigue, improvement of visibility or general betterment of working conditions. In most cases the system wi

of material exhausted, or leakage losses caused by loose cleanout doors, broken joints, holes worn in duct (most frequent in elbows), poor connection to exhauster inlet.

Losses in suction can also be charged to additional exhaust points added to the system (sometimes systems are designed for future connections and more air than required is handled by present branches until future connections are made), change of setting of blast gates in branch lines (blast gates adjust the air distribution between the various branches. Tampering with blast gates can seriously affect such distribution and therefore gates should be locked in place immediately after system has been installed and its effectiveness checked). Increased pressure loss through dust collector due to lack of maintenance, improper operation, wear, etc. vary with the collector design. Refer to operation and maintenance instructions furnished with the collector or consult the equipment manufacturer.

Testing Toxic Atmospheres

By N. R. BERNZ

Chief Industrial Hygienist, The Fidelity & Casualty Co. of N. Y., New York, New York

In manufacturing, many operations and processes of one industry are common to those of another, although the two industries may be engaged in the production of entirely different types of goods. For example, welding is used very extensively throughout the aviation, shipbuilding, automobile and steel industries; this applies also to spray painting, electroplating, buffing, grinding, and many other operations. Similarly with raw materials, various kinds of acids, organic solvents, etc., are found in almost any type of plant. For this reason there are certain industrial poisons which appear much more frequently than others and which may be found throughout the entire defense industry. Some of these are:

Dusts	Toluene
Carbon Monoxide	Xylene
Hydrogen Sulfide	Trichloroethylene
Hydrogen Cyanide	Carbontetrachloride
Sulfur Dioxide	Carbon Disulfide
Oxides of Nitrogen	Nitric Acid
Ammonia	Chromic Acid
Phosgene	Hydrofluoric Acid
Lead	Hydrochloric Acid
Cadmium	Sulfuric Acid
[illegible]	

[illegible] directly associated [illegible]

Trinitrotoluene (dust and vapors)
Ammonium Picrate (dust)
Mercury (vapors)
Aniline
Radon
Thoron

As will be seen by examination of the above list, some of these substances are present as raw materials, others are final products, while a third group occurs as by-products generated in the various operations. Typical of the first group are the various acids, organic solvents, chlorinated hydrocarbons, ammonia, and carbon disulfide. In the second class we have TNT and ammonium picrate, while the remainder are commonly occurring dusts, fumes, gases and vapors of a toxic nature generated in various industrial processes. While the theoretical possibilities for exposure to toxic substances in the above industries are far too numerous for tabulation, this list represents those most commonly encountered.

Dusts

Silica-bearing inorganic dusts are probably found in all of the above industries. For example, mining of the iron ore in the steel industry presents exposures to free silica dust in considerable quantities. Buffing, polishing, and grinding operations done very

extensively in a great many industries, generate inorganic dusts, which for the most part consist of aluminum oxide and silicon carbide, but also include free silica in amorphous and crystaline forms.

For the purpose of quantitative determination, dusts may be divided roughly into three classes, as follows:

1. The inorganic type such as free silica and asbestos, which is collected and the number of particles per unit volume of air determined microscopically.

2. Organic dusts of natural origin, the amount of which is usually determined by weight. Typical of these are tobacco and flour dusts.

3. Synthetically manufactured organic compounds which may occur in the form of dusts, such as TNT and ammonium picrate. These substances when present as air contaminants in low concentrations are generally evaluated quantitatively by chemical means.

Besides above types, there are also metallic dusts such as lead, zinc, cadmium, manganese, etc., some of which will be discussed under another heading.

Inorganic Dusts

The most common method for evaluation of this type of dust is to collect air samples in liquid solutions by means of an impinger (1) and to make the quantitative determination microscopically. When calculating the dust concentration, usually expressed in number of particles per cubic foot of air, the microscopic calibration factor, the volume of the sampling liquid, and the size of the air sample are taken into consideration.

The sampling procedure, microscopic arrangement, and calculations are extremely simple, but the actual counting is a tedious job associated with severe eye strain and requires considerable experience before dust counts can be relied upon. In recent years the microprojection method (2) has been used for counting of impinger samples. With this method in which the microscopic field is projected on a translucent screen, the eye strain determined in direct microscopic work, is eliminated.

Other methods for evaluation of this type of dust are by means of electrostatic precipitators (3) and various types of "grab" samplers. With the electrostatic precipitator, the dust is collected in a dry state and either weighed as is, or suspended in water and counted in a manner similar to that employed with the impinger method. Several of the grab samplers have microscopes incorporated with the sampling device and these are calibrated in such a manner that the number of particles per cubic foot of air can readily be obtained by almost instantaneous readings (4).

Organic Dusts (Natural)

This group as a rule is not classified by medical authorities as fibrosis producing dusts, and hardly warrants any discussion in this paper. While claims do exist to the effect that some dusts in this class have produced respiratory irritation, bronchitis, asthma, etc., these dusts are generally looked upon as nuisances rather than occupational disease producers. No official physiological threshold limits have been established and sampling of this type of dust for the purpose of evaluating an occupational disease hazard has little or no meaning.

Most of these dusts, however, are explosive when dispersed in certain proportions in the air and require control from this point of view. Considerable work to establish explosive limits for this type of dust has been done by the United States Department of Agriculture.

Synthetic Dusts

In the manufacture of TNT and ammonium picrate, both of which represent basic war industries, we are confronted with toxic raw materials as well as hygienically injurious final products. In this industry great quantities of toluene, anhydrous ammonia, sulfuric and nitric acids are used, all of which are classified as industrial poisons. TNT and ammonium picrate are themselves systemic poisons as well as skin irritants known to have produced fatalities and severe cases of dermatitis.

A method for sampling and determination of TNT was described recently by Pinto and Fahy (5). This procedure calls for the use of 10 cc. of isopropyl alcohol in the midget

impinger. The chemical determination is based on the reduction of TNT to triaminotoluene, and finally, a colorimetric comparison with known standards.

Ammonium picrate is highly soluble in water which therefore can be used as the collection medium in an impinger when sampling for this material in industrial atmospheres. The deep color which results upon solution of ammonium picrate in water is also evident in extremely low concentrations and for this reason a direct colorimetric comparison of the sample with known standards can be made. With this method there is a possibility of interference from dinitrophenol, the extent of which has not been determined (6).

Carbon Monoxide

This is a very toxic gas encountered in various industrial activities. The toxic limit for this gas is generally accepted as 100 ppm for prolonged exposure. To the public in general its presence is most commonly associated with automobile exhaust and gas burning appliances utilizing manufactured gas with a high percentage of carbon monoxide. As a result of incomplete combustion it may also be present when burning natural gas or other fuels. In industrial operations involving baking ovens, drying kilns, coke ovens, blast furnaces, etc. carbon monoxide is frequently encountered. In industrial processes in general, and particularly where chemical reactions are involved, carbon monoxide may be generated as a dangerous by-product. In prism grinding, which is closely allied with the defense industry, a high quality iron oxide rouge is required. Occasionally this material is manufactured on the premises as an adjunct to the prism grinding work. This involves the use of oxalic acid for production of iron oxalate which is later decomposed by heat to yield iron oxide rouge. In this process carbon monoxide as well as other gases are generated.

Several methods have been developed for the quantitative determination of carbon monoxide, but only the two most expedient procedures employed in industrial hygiene work will be discussed here. One of these is (1) carbon monoxide indicator [Fig. 1] the catalytic reaction of iodine pentoxide with carbon monoxide to oxidize iodine. The small electric current produced by the heat of the reaction through a thermocouple is calibrated in terms of carbon monoxide concentration which is read directly on the dial of a milliammeter. The source of suction in this instrument is a small centrifugal blower, the motor of which is operated either from a built-in 6 volt battery or from a 110 volt lighting circuit through a transformer.

Another convenient method for estimation of carbon monoxide through less sensitive and not so accurate is the use of palladium chloride ampoules. In this reaction the palladium chloride is reduced to metallic palladium thereby producing a stain, the intensity of which is in direct proportion to the amount of carbon monoxide in the atmosphere under observation. The stain produced is compared to known color standards for evaluation of the carbon monoxide present. This method is not specific for carbon monoxide, however; there are other reducing gases which also will produce a stain in the presence of palladium chloride. Incidentally, the standard method for carbon monoxide evaluation, adopted by the British Department of Industrial Research (7) consists of a palladium chloride test paper through which the air to be sampled is drawn by means of a handpump. The stain thus produced is compared with a standard color chart.

Hydrogen Sulfide

Hydrogen sulfide is a very toxic gas with a disagreeable odor. It is found in many industrial operations where sulfur or sulfur compounds are used, but primarily it is encountered in the artificial silk, chemical and petroleum industries. Safe limits varying between 20 and 50 ppm by volume have been suggested by various State authorities in this country.

The most rapid method for determination of hydrogen sulfide is undoubtedly the use of a hand operated instrument consisting essentially of an aspirator bulb and a detector tube through which the air sample is drawn. The detector tube contains a chemical substance which when in contact with hydrogen sulfide produces a discoloration the length of which is in proportion to the amount of hydrogen sulfide present, and can be measured on the attached scale. It can also be determined colorimetrically either by bubbling

through a sodium hydroxide solution and titrating with iodine, or by bubbling through potassium iodide starch solution and a measured amount of standard iodine in which reaction the disappearance of the color indicates the end point (8).

Hydrogen Cyanide

This gas for which the industrial hygiene bureaus of California, Connecticut and Massachusetts have established a safe limit of 20 p.p.m. by volume, is found in electroplating operations, heat treating, etc.

A portable instrument of the type discussed in connection with hydrogen sulfide, has been developed for hydrogen cyanide also. I have been informed, however, that the hydrogen cyanide detector in its original form proved less satisfactory and that it has been withdrawn from the market temporarily, pending further research.

Chemical tests are available for detection of hydrogen cyanide, such as the prussian blue and thiocyanate reactions, both of which are specific for this gas but allegedly not sensitive enough for concentrations encountered in industrial hygiene work. Other methods suitable for determination of this gas in small concentrations are the Congo red-silver nitrate and the benzidine—copper acetate test papers. These methods, which have been adopted as standard tests by the British Department of Industrial Research, are non-specific, however, so that the possible interference of other gases such as HCl, H_2N, SO_2 and H_2S should be taken into consideration.

In a method suggested by the Air Hygiene Foundation (AHF) the air sample is bubbled through 0.5 per cent potassium hydroxide after which the determination is made by titrating with silver nitrate (9).

Sulfur Dioxide

Exposures to sulfur dioxide gas are common in the petroleum industry, rubber works, and sulfuric acid manufacturing. Sulfur dioxide is also encountered in bone and glue works, magnesium foundries, and other industries where sulfur compounds are used. It is an extremely irritating gas for which the threshold limit of 10 p.p.m. has been established.

For the testing of sulfur dioxide, the American Public Health Association (A.P.H.A.) (10) refers to the iodimetric method (11), by means of which the air sample is passed through a gas wash bottle containing a measured amount of standard iodine in potassium iodide-starch solutions. The disappearance of the color indicates the end of the test, after which the amount of sulfur dioxide present can be calculated.

The British Department of Industrial Research employs a starch-potassium iodate test paper through which the air sample is drawn by means of a hand pump. The sulfur dioxide reduces the iodate to iodine with the production of a stain the degree of which is compared to known color standards.

Oxides of Nitrogen

This is a group of gases, some of which are extremely toxic. They are produced when nitric acid comes in contact with organic materials and certain metals, during chemical nitration processes and burning of nitrated materials; they are also present in small quantities during electrical discharges in the air. Above gases may, therefore, be found in such industries and operations as ammunition works, photographic film manufacturing, nitric acid plants, electroplating (bright dipping), detonation of explosives, electric welding, etc.

During the chemical reactions that accompany above operations, a mixture of oxides are formed. The hazardous nature of this group, also called "nitrous fumes" is due primarily to the nitrogen dioxide, a reddish brown gas which reacts with water and upon respiration forms nitric acid in the lungs. The result is often pulmonary edema which frequently proves fatal. The fact that the respiration of these gases does not produce any immediate discomfort in spit of their toxicity, makes them doubly dangerous. A person may be exposed to these fumes and experience only a slight respiratory irritation immediately following the exposure, while the case may develop into a fatal condition by next day.

For example, I know of a case in a nitric acid plant where a man was engaged in filling nitric acid into carboys in a department with a wooden floor. One of the carboys accidentally broke causing the acid to

flow over the wooden floor, producing the product nitrogen dioxide gas in great volumes. The operator not being familiar with the toxicity of this gas and experiencing no immediate physiological warning, remained on the job attempting to clean the floor by mopping up the acid, instead of leaving the work place for fresh air. As a result a considerable portion of this gas was probably inhaled. He became seriously ill a few hours later and died within 48 hours. Cases of men becoming sick while doing electric welding inside tanks or in other confined spaces are often referred to in the literature. Many of these cases are undoubtedly due to oxides of nitrogen generated in the electric arc.

While there are several methods known for the quantitative determination of oxides of nitrogen, testing for these air contaminants is not so simple as that for some of the others discussed in this paper. Incidentally, in view of the cumbersome procedures involved in testing for these gases, the amount of ventilation required for their control after blasting in mining and tunnel work is sometimes based on the amount of carbon monoxide present, which can readily be determined. With explosives designed for a low oxygen balance resulting in a relatively high carbon monoxide concentration and correspondingly low volumes of oxides of nitrogen, this is a safe and expedient procedure.

For actual detection of nitrogen dioxide, the method employing starch-potassium iodide test paper is probably the best known. This paper when damp is colored blue in the presence of nitrogen dioxide. This method is non-specific, however. Other, specific methods for evaluation of nitrogen dioxide, and sensitive at low concentrations are the Griess-Ilosvay and the Bismarck Brown tests. With both methods, the air sample is bubbled through chemical solutions after which the quantitative determinations are made in the laboratory by colorimetric analysis. Although physiological safe limits up to 40 ppm have been proposed for these gases, atmospheres which by odor or color indicate the presence of nitrous fumes should always be treated with caution.

Ammonia

[illegible]

[illegible] industry. It is a[n] [illegible] respiratory irritant for which safe limits ranging between 50 and 85 ppm have been recommended (Russian investigators 10-30 ppm; State of Massachusetts 50 ppm; Flury and Zernik 85 ppm).

Ammonia vapors can be evaluated directly in the field by bubbling the air sample through a measured volume of 0.1 N hydrochloric acid in water to which using phenolphthalein as an indicator, the appearance of a pink color indicates the end point. From the amount of acid used and the size of the air sample, the concentration of ammonia vapors can be calculated (3).

Sulfuric acid can also be used with above method. In another method, recommended by the A.P.H.A., the air sample is collected in sulfuric acid, but the final evaluation is made in the laboratory by standard analytical means.

Lead

Exposure to this metal occurs very extensively in nearly all types of manufacturing. The most frequently encountered forms of lead are fumes, dust and dispersed pigments. These occur around lead melting operations, soldering, welding of metals covered with lead-bearing paints, and in spray painting work.

Sampling of lead-contaminated atmospheres is usually done either by means of the impinger or by the electrostatic precipitator. When the impinger is used, as is frequently the case when investigating spray painting and many other types of work involving lead dispersion, the sampling liquid may be either distilled water or dilute nitric acid.

Regardless of the collection method used, the final evaluation of the amount of lead present is done in the laboratory by various analytical methods, the description of which is beyond the scope of this paper. It probably should be emphasized, however, that although some of these methods are highly sensitive and the experienced analyst usually well-trained to handle minute quantities of lead in dust work, it is possible to obtain [illegible] when one proceeds to read the [illegible] With the [illegible] and the [illegible]

with sampling rates of 1 and 3 cubic feet of air per minute respectively, this is not a problem. With the midget impinger, on the other hand, with a sampling rate of only 0.1 cubic foot per minute, this becomes a tiresome task, especially if the hand-cranked instrument is used. Let us take, for example, a case in which the atmospheric lead dispersion is just about on the border line of the safe limit, i. e. 1.5 mg. per 10 cubic meters of air. For a 30 minute sample with the midget impinger, only 3 cubic feet of air have been handled. This represents only 0.015 mg. of lead in the air sample, which evidently requires a fairly sensitive analytical method and careful handling for a successful completion of the test.

Cadmium

The United States Public Health Service (U.S.P.H.S.) (16) suggests as a safe limit with respect to toxicity of cadmium fumes a concentration of 1 mg. per 10 cubic meters of air.

The metal is used extensively as a coating of iron and steel for rust prevention as well as in structural steel to impart certain properties. Exposures to cadmium and cadmium fumes may, therefore, be encountered in such operations as electroplating, welding of cadmium-bearing iron and steel as well as many other processes where work involves cadmium-plated articles. Some of you are probably familiar with the case of cadmium intoxication in a plant in Ontario, Canada, a few years ago, when 14 persons were poisoned—two fatally—during annealing of cadmium plated rivets (17).

As in the case of lead, sampling for cadmium fumes or dust may be done either with the impinger (with water as collection medium—A.P.H.A.) or by the electrostatic precipitator and the samples evaluated in the laboratory by gravimetric or colorimetric analytical methods.

At this point it probably should be brought out that for sampling of metal fumes, the midget has a lower efficiency than the electrostatic precipitator, which should be taken into consideration when comparing results obtained on samples collected with the two instruments (18).

Mercury

The present emergency has greatly accelerated the use of mercury, not only in our ammunition works, but also in many other plants directly or indirectly connected with the defense industry. In some cases entirely new uses have been introduced for this metal. For example, a recent development is an anti-fouling paint containing mercury, now used in our shipyards. Application of this mercury-bearing paint by means of spraying naturally introduces a serious exposure to mercury poisoning and calls for careful control; this applies also to the manufacture of the paint. Due to the great demand for mercury and the shutting off of foreign supplies, many old mercury mines are now being reopened so that mining of this metal with accompanying occupational disease hazards has expanded considerably during the past year.

The toxic properties of mercury as a respiratory hazard when present in the form of vapors or in a finely divided metallic state are probably fairly well-known to most men concerned with industrial health. A safe limit toxicologically, of about 2 mg. per 10 cubic meters of air appears to be generally accepted for inhalation exposures. Although the metal has a relatively low vapor pressure at ordinary temperatures, investigations have shown that sufficient vapors are emitted to produce a mercury hazard in rooms where this material is used in metallic form.

A number of methods are available for the evaluation of mercury vapors in air. One of the most expedient procedures is probably by means of the Nordlander apparatus utilizing a cadmium sulfide test paper, the color of which darkens in the presence of mercury. The amount of mercury present is estimated by comparing the degree of darkening with a standard color chart.

Another more recently developed method involves an optical instrument based on the opacity of mercury vapors to ultra violet light of a certain wave length. In this instrument, therefore, when ultra violet light of a specific wave length is directed towards a photocell, mercury vapors will reduce the light received by the photocell and consequently also its current flow, which in turn is calibrated in terms of mercury concentration. This instrument is not specific for

subject to other light intercepting media such as smoke and fog.

There are also other methods for determinations of mercury, entailing condensation of the vapors and subsequent electrolytic deposition of the metal, chemical reaction methods, etc. The first two mentioned above, however, are the most expedient and yield immediate results during the field investigations.

Benzene (Benzol), Toluene and Xylene

These three aromatic hydrocarbons are widely used as industrial solvents and ingredients in a number of chemical reactions. Toluene, for example, is an important raw material in our ammunition manufacturing, especially in the production of trinitrotoluene. With the increased demand for toluene and the corresponding scarcity of this material, benzene is rapidly taking its place as a solvent in many industries. Xylene, which besides being an important solvent, also does enter as a raw material in certain chemical processes, at present associated with the defense industry, and therefore used in great quantities. For instance, in a plant I visited recently xylene is used in the production of a certain type of resin, which in turn is employed in an article manufactured for the United States Army.

All these three materials are classified as industrial poisons, although there appears to be some confusion as to the relative toxicity of each. Benzene is generally considered as the worst offender, although this may not be due to a greater toxicity of the material per se but to the fact that it has a higher vapor pressure than the other two so that for a given temperature more of it will be found in the air. However that may be, the toxic effect of all of them, once dispersed in the air, is generally recognized and therefore indicates the need for strict control wherever they are used.

For the evaluation of these materials some chemical as well as physical methods are available. Most of these, however, are complicated and cumbersome, involving such operations as stirring by bubbling the air through nitric acid with subsequent colorimetric determination, or condensation of the vapors followed up by laboratory analytical procedures for the final evaluation. While [illegible] may be satisfactorily [illegible] in [illegible] plants or [illegible] [illegible] work in industrial plants or [illegible] [illegible] [illegible]

relatively low safe limits have been suggested by various authorities. Russian investigators have recommended a threshold limit of only 3 p.p.m. for prolonged exposures, while the British Department of Scientific and Industrial Research has suggested a value of 10 p.p.m. and our own State of Massachusetts, 20 p.p.m. While there is a wide divergence between these values, they all tend to indicate the potential dangers connected with exposures to vapors of carbon disulfide.

Although this solvent may be encountered in a great many industrial operations, it is found primarily in the viscose—and rubber industries where it constitutes an important raw material.

For evaluation of these vapors, the Air Hygiene Foundation recommends drawing the air through an alcoholic potassium hydroxide solution to form potassium ethyl xanthate which is determined iodometrically. The British Department of Scientific and Industrial Research uses a colorimetric method consisting of bubbling the air through diethylamine and copper acetate forming a colored compound the intensity of which is compared with standards. In view of the inflammability of these vapors, a rapid method of their evaluation in high concentrations would be by means of a combustible gas indicator. Unfortunately, however, the sensitivities of these instruments as built at present, are not low enough to get within the physiological safety range of this material.

Acids

In this group probably nitric, chromic, hydrofluoric, hydrochloric and sulfuric acids are those most commonly encountered. Of these, nitric acid has been discussed under another heading. Exposures to chromic acid resulting in chrome ulcers and the perforated nasal septum are frequently found around chromium plating tanks. A safe limit of 1 mg. per 10 cubic meters of air has been established for chromic acid which in electroplating work occurs as a mist over the plating baths. Hydrofluoric and hydrochloric acids also exist in gaseous form as hydrogen fluoride and hydrogen chloride respectively. A safe limit of 3 p.p.m. has been suggested for the former, while it has been set at 10 p.p.m. for the latter.

Sampling for nitric, chromic, and sulfuric acids is usually done by bubbling through a sodium hydroxide solution; hydrofluoric acid through potassium hydroxide; and hydrochloric acid through glycerol-potassium carbonate-water solution. For the final laboratory evaluation I refer to standard methods of the A.P.H.A.

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   - Leaflet No. 4—Benzene
   - Leaflet No. 5—Nitrous Fumes
   - Leaflet No. 6—Carbon Disulfide
   - Leaflet No. 7—Carbon Monoxide
   - Leaflet No. 8—Phosgen
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Selection, Use and Maintenance of Respiratory Protective Devices*

By H. H. SCHRENK
Chief Chemist, Health Division, Bureau of Mines
and
S. J. PEARCE
Associate Chemist, Gas and Dust Section, Central Experiment Station, Bureau of Mines, Pittsburgh, Pa.

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H. H. Schrenk, chief chemist, Health Division, Bureau of Mines and

S. J. Pearce, associate chemist, Gas and Dust Section, Central Experiment Station, Bureau of Mines, Pittsburgh, Pa.

There are several well-recognized procedures for controlling exposure to hazardous atmospheres in industry. They include (a) substitution of less toxic material, (b) change of processes, (c) wet methods, (d) [illegible], (e) general ventilation, and (f) respiratory protective devices, either to be employed as a temporary measure, where [illegible] are being made, or [illegible] where other methods are not practicable. [illegible] use or improper use of other control equipment.

Respiratory protective devices usually are employed to supplement other methods of control, as a temporary expedient, or when other methods are not readily applicable or practicable. It seems reasonable to assume, however, that where respirators are used, consideration has been given to the factors involved, and that the devices can provide satisfactory protection if used properly. Their use should not be arrived at simply by a process of elimination of other methods that are more difficult to apply.

Atmospheric contaminants include gases, vapors, dusts, fumes, mists, and fogs. Respiratory protective devices that clean contaminants may be required for operations that are momentarily dangerous to life

ness will eliminate these hazards. Passageways, ladders, openings, ditches, etc., should all be kept clear and free as possible of these items. Cables installed in ducts or suspended overhead will eliminate this hazard.

A welder or a worker, on whatever job he may be doing, must be conscious not only of his own safety but of the safety of others working near at hand. By his own safety efforts, his own work not only is made easier and safer, but his fellow workers' opportunity for doing their jobs faster and safer is furthered.

These many factors—proper clothing, protective equipment, ventilation, goggles, fire prevention, elimination of tripping hazards, and the regard for others helps all of us individually and collectively to conserve our efforts so that each of our jobs can be done faster and better.

Health Aspects of Welding

By A. G. CRANCH, M. D.
Union Carbide Company, New York City
and
B. L. VOSBURGH, M. D.
General Electric Co., Schenectady, N. Y.

The purpose of this paper is to offer some practical points for the better protection of the health of welding operators. It is not intended as an exhaustive research document. The health hazards of welding may be classed as "real and unreal". The former should not be ignored, nor should the latter be allowed to cause undue alarm. The real hazards are not mysterious; they should be easily understood by any reasonably well trained operator and means for protection are available and effective when used.

A welding operator is usually exposed to all the general accident hazards common to the industrial field in which he is working. Structural iron workers, ship builders and the like are exposed to increased accident hazards. As a large proportion of welding operations are in connection with such work, this may be one reason for the common assertion that welding is a dangerous and unhealthy occupation.

Another possible source for the charge that welding is a health hazard is the circumstance that the formulas of most rod coatings are "trade secrets" so that there is an opportunity to indulge in all sorts of speculation as to the danger to health from the "secret" ingredients in these coatings. Actually very few coatings would appear to have introduced any important health hazards. As for the "mystery," most of these coatings have been patented. Not long ago the Bureau of Mines issued an Information Circular (I) giving much detailed information on the composition of welding rod coatings and fluxes. This was based on patent information, purposes served by the various ingredients and analyses of many typical coatings. This and other reports remove the "mystery."

A third and perhaps the most important reason for the assumption that welding is a health hazard, are the dramatic deaths which have been reported in a relatively few instances following massive exposures to welding fumes in strictly confined spaces without suitable protection for the operators. That such incidents do not reflect a general hazard is well shown by the fact that in the past three years the number of welding operators has increased some 400% and in the past ten years consumption of welding rods has increased some 2800% with scarcely any increase in such fatalities.

Until quite recently the health problems of welding have been approached from a speculative rather than scientific view point. Unfortunately in a number of instances even medical men, apparently with little attempt to

trade exposures of weigh evidence available, have attributed an amazing variety of ills to welding exposures. These include digestive disorders and malnutrition, liver diseases, respiratory affections even including cancer of the lung, circulatory, blood and glandular changes including thyroid disease and Hodgkin's disease, various skin diseases, neurological changes, sterility, and various other complaints. A careful analysis of these reports generally shows little or no evidence of any connection with welding exposures. The agents usually blamed for these various ailments would ordinarily be present in entirely negligible concentrations, if at all.

Such substances as silica, asbestos, manganese, chromium, nickel, cobalt, various other metals and even lead have been given as "potential hazards" in welding fumes. These have been charged with directly causing ill health or serving to activate other conditions such as pneumonia, tuberculosis, etc. With the exceptions shortly to be mentioned, there seems to be no evidence to indicate that they are present in a form or an amount which would constitute a health hazard. Some have stated that welding operators "are dying every day, and others suffering permanent health impairment as the result of their work," and charge that no studies have been made to identify or control the hazards. Anyone at all familiar with the research which has been done and is still going on in this field will realize that such charges must be due to ignorance or prejudice. The only thorough study conducted by Britton and Walsh (2) and the experimental work and observations by this field by many other investigators (3) (4) (5) (6) fail to show any cases of ill health among welders, helpers, or any incidental [illegible] among them.

The Real Welding Hazards

The real hazards peculiar to welding are essentially from (1) radiation and (2) atmospheric contamination by gases and fumes.

Radiation presents the hazard of intense light, glare and of ultraviolet exposures. Probably all welders soon easily acquire the need to use protection to their eyes, but only those from the [illegible] light. The eyes must be protected by suitable colored lenses. In electric arc welding there is not only the glare but enough ultraviolet radiation to call for a deeper shade of protective lens for the eyes, and also a face shield and protective clothing to cover all skin areas which might be exposed. At present no attempt will be made to go into details as to this form of protection, as these are easily available from a number of sources, especially the American Standard Safety Code for the Protection of Heads, Eyes, and Respiratory Organs (7) (8).

Hazards from radiation are not confined to the welding operator alone, but also involve his helpers and others working in the immediate neighborhood, usually considered to be within a forty-five to one hundred feet in the case of arc welding. Any workman within this area should be protected either with suitable goggles or by the use of screens. If screens are used they should be so designed as to ventilate as little as possible with ventilation. Some types of operation can be done in ventilated booths, which may serve to reduce the hazard to others. Not only must direct rays be kept from the unprotected eye, but reflected rays must be considered. This invariably calls for the use of dull non-reflective paint on areas which may otherwise serve as reflectors.

Excessive exposure of the eye to ultraviolet radiation damages chiefly the outer structures of the eye, causing an conjunctivitis of varying degrees. The damage is analogous to a blistering sun burn of the skin and if the exposure is severe very painful reactions will occur, with some temporary visual disturbances. Ultraviolet rays do not penetrate the lens or injure the deeper structures of the eye. Experimental cataracts have been produced in rabbits by prolonged exposure to ultraviolet rays, but in actual welding experience lens changes do not occur and optic nerve injury is improbable from a physical standpoint.

Before leaving the subject of radiation it should be mentioned that in welding there is no exposure to short waves like the x-ray. This has been demonstrated repeatedly by having welding operators carry dental x-ray [illegible] in their pockets. No patients' films have been [illegible]

tion in welding, least of all sterility. This is mentioned because this charge has recently been revived in some quarters. It was originally made during the last World War and several investigations proved it to be unfounded. There is no valid evidence to support such a theory.

Gas Hazards

Among the much discussed hazards of welding are those due to gases. These gases may be essential to the type of welding as the oxygen and acetylene in oxyacetylene welding or they may be produced through the reactions occurring in the welding process as oxides of nitrogen, ozone, or in some cases of imperfect combustion carbon monoxide. It is hardly necessary to state that oxygen as used in welding does not produce a health hazard. Misused, for instance, as a substitute for compressed air in ventilating small spaces, it may increase the hazard from burns, as any material will burn more actively in the presence of an excess of oxygen. Ozone, a "peroxygen," may be formed in the welding arc and in concentrations of over 1 p.p.m. may act as a pulmonary irritant. On leaving the arc, ozone rapidly ceases to exist as such and many investigators have demonstrated that even in confined spaces a dangerous concentration is not found in the air breathed by an operator. It is extremely doubtful that ozone is anything but a theoretical hazard in welding.

While speaking of oxygen, mention may be made of the hazard said to be due to "oxygen deficiency" from welding. This could occur only in very confined spaces, as in tanks or some of the small compartments in ship's holds, and the like. There may have been some accidents due to oxygen deficiency in such locations but in all probability investigation would show that this condition already was present in the area before welding operations were attempted. In the case of oxyacetylene welding where a certain proportion of oxygen is drawn from the atmosphere the welding flame will usually become entirely unsatisfactory for its purpose and the deficiency recognized before the oxygen reaches a [illegible] enough to be dangerous to the operator. Also the heat generated by the [illegible] under normal atmospheric [illegible] would usually be unbearable in a [illegible] before dangerous oxygen depletion occurred. "Oxygen deficiency," then can be put into the category of unreal hazard.

One not infrequently sees references to the toxic effects of unburned acetylene or the "impurities" present in acetylene gas. Acetylene is a simple asphyxiant gas not in itself a poison. It has had fairly wide use as an anesthetic. A hazard would exist only when the gas is present in such concentration as to reduce the oxygen in the air breathed so that not enough remained properly to supply the body. As the lower explosive limit of acetylene in air is about 2½ - 3% it is evident that in the presence of a flame an explosion would result long before the concentration would appreciably reduce the available oxygen in the air. As for the alleged hazard from impurities—arsine, phosphine, hydrogen sulphide or ammonia—this purely theoretical hazard is based chiefly on early analyses of acetylene made from materials of foreign origin. No significant amounts are present in acetylene produced today from raw materials from North American sources. Recently tests were made for arsine in dissolved acetylene from four commercial producers and not even a trace was detected. The minute amounts of impurities sometimes found in acetylene are, of course, destroyed in the flame. The health hazards from acetylene and its "impurities" belong in the "unreal" class.

Gases formed in the flame or arc are the oxides of nitrogen, sometimes called "nitrous fumes." They are not nitrous oxide, but are nitric oxide and other higher oxides of nitrogen. In the concentration present in connection with welding they are so diluted as to be colorless. Under other conditions of exposure these fumes may present other hazards but in welding the real hazard is as a pulmonary irritant. Except in small rooms or in very confined spaces as in tanks, etc., no dangerous concentration would be likely to occur. Just what is a dangerous concentration has been undergoing considerable discussion in the last two or three years. The classic figure of 39 p.p.m. by volume in air admittedly was based on very limited observations but has proved a fairly satisfactory working standard. Just as much more extensive experiments were beginning to indicate that 20 p.p.m. or even up to 100 p.p.m. might be a safe limit for a day's work

others on what basis is not clear, are advocating a "safe concentration" of only 10 ppm. Certainly a study of available evidence indicates that in welding operations concentrations of 50 ppm or less have not produced symptoms, and that probably under many conditions this amount may be exceeded without harm. Protection will be discussed under fume protection.

Carbon Dioxide and Carbon Monoxide

Carbon dioxide is produced by the oxy-acetylene flame and by the electric arc but never in concentrations of physiological importance. Carbon monoxide may be produced through imperfect combustion as when starting welding or cutting of cold material or through the combustion of organic matter which may be present on the surface to be welded, or in the coatings of rods used. There is considerable divergence of opinion on the degree of hazard from carbon monoxide in welding. A careful comparison of the various reports seems to indicate that the danger of a significant concentration is very slight under all ordinary conditions of welding. If standards of ventilation indicated by other features of the work are followed the hazard from carbon monoxide should be non-existent.

Probably the most discussed health hazards of welding are those due to fumes. These are chiefly metallic, from the material being welded or used as a coating on that material or in the welding rod or its coating. The composition of welding fumes is so varied that this furnishes a wonderful field for the discovery of hypothetical and unreal hazards. These fumes also are the source of some very real hazards. If proper precautions are taken to avoid the real and recognizable hazards the same precautions should eliminate the theoretical hazards. Welding is now in such general use and the number of metals and their combinations involved is so great that there are probably but few metals which may not be handled by a welding operator.

The most common complaint due to fume exposure is metal fume fever. This often called zinc chills, brass chills, spelter shakes and the like, is really a [illegible] reaction [illegible] of [illegible] [illegible] [illegible]

Their presence calls for special ventilation.

There is one other source of real hazard which may be present in many operations involving aluminum or some of the "stainless" steels and alloy metals. This is from the presence of fluorides in many of the fluxes or rod coatings used for this work. Hydrofluoric acid may be formed and the fume if inhaled in appreciable concentrations or for long periods may cause considerable irritation to the nose and throat or even pulmonary edema.

Prevention

To sum up: The real hazards of welding are not many, are generally easily identified and protective measures are available and effective when used. These real hazards should not be minimized or passed by. Briefly they are due to:

1. Radiant energy—ultraviolet and visible light.
2. Oxides of nitrogen.
3. Metal fumes—lead, cadmium and zinc.
4. Fumes from organic residues or wastes.
5. Fumes from fluoride-containing fluxes and rod coatings.

Protection from radiant energy has already been outlined. Protection from the rest is almost wholly a question of ventilation. Various means of approach have been tried to establish standards for ventilation. Standards in terms of concentration of contaminant expressed in parts per million by volume for the gases or milligrams per cubic meter for metallic and other fumes have been suggested, as have standards expressed in number of air changes per time unit. Both methods have value and studies made along these lines have done much to solve some of the difficult points in ventilation requirements. Unfortunately, it is very difficult to obtain quickly and easily a determination of fume concentration on a given operation. Local conditions may also change the efficiency of measures based on rate of air change. Notwithstanding some of the practical difficulties in applying such standards in specific cases, several general rules on ventilation have been evolved which have proved to be of considerable help.

Various studies of present day practice have been made which indicate that welding out of doors or in large shops seldom results in any serious air contamination except in the case of lead. In spaces of less than 1000 cu. ft. and especially inside tanks, ship holds, etc., special ventilation is necessary. Usually the exhaust of contaminated air is much more effective than an attempt to force fresh air into the space. In stationary locations this can generally be done with properly located exhaust fans or by the use of hoods and ducts to withdraw fumes as near as possible to their source. Portable exhaust systems have been designed which are adapted to field needs.

In the case of gases such as oxides of nitrogen, or the rare instances of carbon monoxide, if sufficient ventilation is maintained from the beginning of the operation and sufficient to insure good visibility and to insure a comfortable temperature there should be no gas hazard even in confined spaces.

If lead or cadmium fumes are present the only complete protection is by the use of air supplied masks. These are of three types—air supplied by special blower, air supplied from compressed air system, and masks with larger hose without use of forced air supply. If compressed air is used from a general supply, special filters and pressure regulators are required. In the last named type with no forced air supply the length of hose can seldom be over 50 feet. In confined spaces one of the above devices should be used. Out of doors or in large well ventilated shops and for moderately short exposures one of the filter type respirators approved by the Bureau of Mines for lead fumes may be satisfactory. In any confined space at least local exhaust ventilation is required when there is exposure to zinc or fluoride fumes, or to fumes from heavy deposits of organic wastes and sludge. Air supplied respirators offer, of course, the most positive protection.

Briefly, a minimum standard of ventilation is one that will be sufficient to insure good visibility at the point of operaton, and insure a temperature within a reasonably comfortable limit. In confined spaces this would call for exhaust ventilation. In case of lead or cadmium exposures air supplied masks are required. No serious hazard is apt to be present except in confined spaces or when lead is involved. Special standards for venti-

lation in welding of leaded steel have been given by Bailey (8). General requirements for ventilation are given in more detail in the reports of Tebbens and Drinker, (6) and in Special Bulletin No. 3 of the U. S. Department of Labor, "Control of Welding Hazards in Defense Industries, (9) and by Hemeon (10).

Summary and Conclusions

1. Health hazards in welding may be divided into "real" and "unreal."

2. Real hazards should not be feared or minimized. They are usually easy to recognize and effective preventive measures are available.

3. Unreal and imaginary hazards are often alleged if inflated precautions are taken to guard against the real hazards, the unreal will disappear entirely.

4. Hazards from radiation in welding are limited to eyes and skin. No systemic effects have been demonstrated. Means of prevention are well known and available.

5. Hazards from air contamination can usually be controlled by ventilation and in some instances by respiratory protective equipment. Hazard from gas is essentially limited to oxides of nitrogen. Ozone and carbon monoxide hazards are of minor importance. Oxygen deficiency, if present, is usually not due to the welding operation but to other causes. Fume hazards for medical purposes are limited to fumes from lead, cadmium, zinc or fluorine, and rarely from arsenic vapors or sludges. Fumes from other materials when present are usually in insignificant amounts or could be removed by protective measures ordinarily used for the control of hazards just mentioned.

6. No reliable evidence has been presented to show that welding operations have impaired health and accident records of welders working in the same communities or that they show any characteristic type of disease which could be connected with the work.

7. Upon the health basis, welding processes are not to be condemned as such but should be controlled to conform to the custom of practice in welding and be entitled to welding and corresponding insurance rates.

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