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Recognition and Control of

Fume and Dust Exposure

By V. J. CASTROP

RESPONSIBILITY for employee health is delegated by management to the medical director, while the safety director is charged with accident prevention activities. For the smooth functioning of either department, it is necessary that these individuals work in harmony.

The safety engineer spends much of his time in the plant and usually is well informed about working conditions. The doctor, on the other hand, must spend most of his time tending to the medical needs of the employee

and to the administrative work of his department. As a result, he has insufficient time for plant surveys. This is particularly true in plants where the doctor is employed on a part-time basis.

A safety engineer who is capable of recognizing conditions which may be detrimental to health is an excellent team mate for the doctor in a health maintenance program. The safety engineer need not be capable of actually sampling air in the environment or designing a ventilation system for the control of toxic materials. He should, however, have knowledge of the materials which have been proved harmful, and should have some understanding of basic control measures.

The safety engineer, as well as the

doctor, should be informed as to where he can obtain the technical personnel to do the sampling and detailed study of the environment and engineering personnel to render assistance in the control of exposure. Such assistance may be obtained from the industrial hygiene divisions of either the health or labor departments of many states. Some city governments likewise have industrial hygiene bureaus.

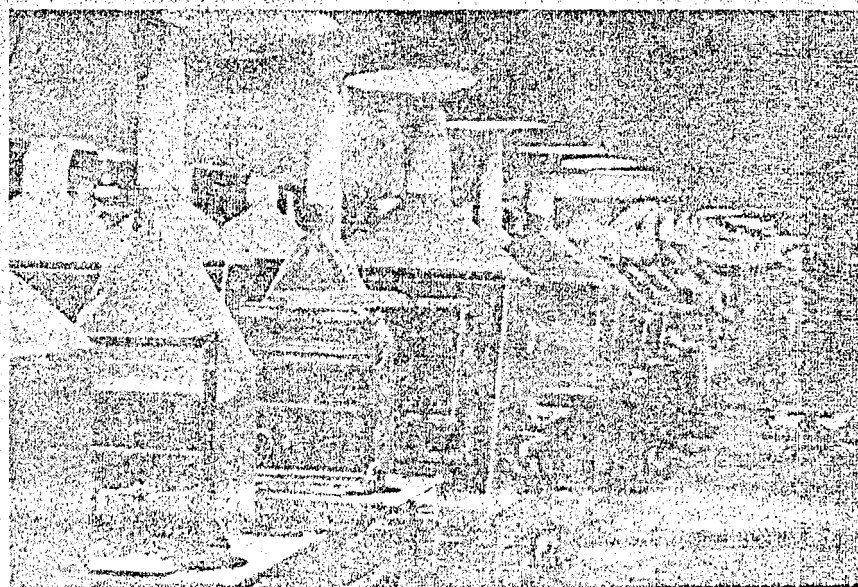
In addition to these governmental agencies, many insurance carriers have on their staffs men who are capable of sampling and rendering engineering assistance. Private consultants are also available, or you may find that an industrial hygienist is employed by your own organization.

V. J. Castrop is Assistant Head, Industrial Hygiene Department, Research Laboratories Division, General Motors Corp., Detroit, Mich. This article has been condensed from a paper presented at the Automotive and Machine Shop Section, 35th National Safety Congress.

and outside views of vapor blasting
 must. Fine silica and water under pres-
 sure used. Cabinets must be maintained
 so leakage of mist does not occur.



and exhaust ventilation of soldering
 operations.



This discussion will be limited to
 the principles of industrial hygiene
 they relate to fume and dust ex-
 posures, to indicate what control
 measures are available or used to
 protect the employee's health, and to
 call attention to operations and ma-
 chinery which are commonly used in
 industry, at the same time indicating
 the generally accepted opinion as to their
 effect on health.

Many conditions are improved for
 reasons other than their effect upon
 health. Better products, better em-
 ployee relationship, reduction in
 maintenance of equipment may be
 used as justification for manage-
 ment decisions for such correction.

Definitions

Men frequently designate as
 dust any vapor, fog, gas, etc., they
 encounter. In industry, the plat-
 form over a chrome tank, the va-
 por of gases, at a metal-cleaning
 station, or the exhaust gases from
 a furnace are frequently referred to as
 "fog." To the industrial hygienist,
 "fog" has a more definite mean-

ing. For this discussion, fume may
 be considered to be particulate matter
 formed by the condensation of a va-
 por. A molten bath of lead at a high
 temperature causes the metal to vola-
 tilize and form a vapor. Upon contact
 with the cooler surrounding atmos-
 phere condensation occurs and the
 physical state changes from vapor to
 a solid metallic particle.

While dust is also a solid particle,
 it is formed by the disintegration of
 solid materials by grinding, crushing,
 abrasion, or similar action.

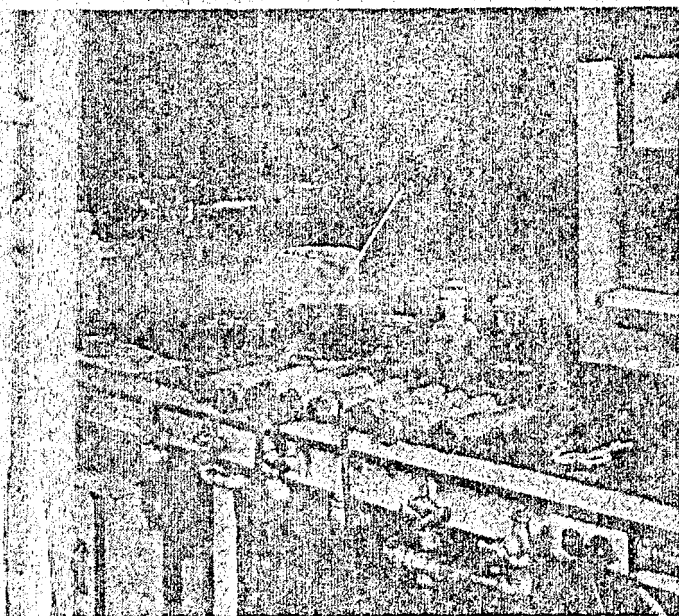
Fume particles are generally small
 in diameter, with the size dependent
 upon the type of fume, the extent of
 flocculation, and other factors. Dust
 particles of hygienic significance are
 those between one and ten microns

in size. (25,400 microns are equiva-
 lent to one inch).

Generally speaking, there are two
 means of entrance of toxic com-
 pounds into the human body—by in-
 gestion or via the respiratory tract
 through inhalation of fumes, dusts,
 mists or gases. Ingestion is of im-
 portance if toxic materials which
 have a systemic effect are used and
 adequate washing facilities are not
 provided, or, where the employees
 are slovenly in personal habits.

Inhalation is considered the most
 important portal of entry of fumes
 or dusts and the particle size, there-
 fore, becomes significant in evaluat-
 ing exposure. The particles which
 cause the physiological changes are
 those which are small enough to re-
 main suspended in the air and not
 those which immediately fall to the
 floor. Flying particles, which may
 cause eye injuries are not of hygienic
 significance since they are not of
 respirable size. To judge the serious-
 ness of an exposure by the quantity
 of detritus adjacent to an operation is
 often misleading. This is especially
 true where mechanical ventilation re-
 moves the fine material but is inade-
 quate to trap or convey the larger
 particles.

In evaluating an exposure it is nec-
 essary to consider the toxicity of the
 material, the duration of the expo-
 sure, the average concentration of the
 contaminant with special attention
 being paid to those operations which
 produce high concentrations at some
 phase of an operating cycle, and the
 measures which have been provided



Fume and Dust Exposure

—From page 21

to control the exposure. Medical records of the individuals subjected to the exposure may be of value if the examinations are thorough and frequent and not of a cursory type. It must be remembered that occupational diseases are slow in development and in some instances lasting in effect. Slow changes may not be detected, and the mere fact that cases have not occurred does not mean that exposures to known toxic materials may be ignored.

Determination of the concentration of the toxic material in the air is important in evaluating the exposure. Tests of this type are indicative not only of the degree of contamination but also, in some instances, which operation is the major offender.

The apparatus used in collecting the contaminant and the method used in estimating the amount present in the atmosphere vary with the type of material. Tests of this type are specialized in nature and are beset with many pitfalls which can lead to erroneous conclusions if done by inexperienced personnel.

Permissible Limits

In a discussion pertaining to toxic materials it is generally necessary to quote permissible concentrations, or as it is sometimes expressed—maximum allowable concentrations—permissible limits, or threshold limits. These terms are used extensively by industrial hygienists to indicate concentrations of a substance in the air which are considered compatible with good health. The limit usually applies to exposures of eight hours duration for a prolonged period.

The limits are, for the most part, advisory standards or bench marks which are practical to meet. In general, these limits are derived from three types of evidence all of which have value and limitations.

1. Animals have been exposed at different concentrations and the effects noted.
2. A few experiments have been made on human subjects for short periods of time.
3. Safe limits have been arrived at by measuring the concentrations of substance in the workroom air and correlating this information with results of medical examinations of workmen.

The mere fact that these limits are exceeded does not necessarily mean that someone will become definitely ill. But there is a good probability that someone will suffer ill effects if the limit is greatly exceeded for a considerable period. There remains much to be learned regarding the toxicity of many substances used in industry.

So much for the general picture. Now let's look at some specific operations.

Welding

Welding processes most commonly used can be divided into three types, arc, gas, and resistance. The safety measures pertaining to clothing, goggles, and helmets are of common knowledge and will not be considered here.

Arc welding when performed on uncoated steel does not produce a condition considered harmful to the welder, provided it is done in a comparatively large open area. The fumes which result from welding consist essentially of the oxides of iron and oxides of metals which may comprise the steel or coating of the welding rod. Some investigators have found characteristic markings on chest x-rays of men who have welded under severe conditions for long periods of time. These markings are presumably due to the deposition of iron fumes within the lungs, but it has not been demonstrated that such fumes have caused physical impairment.

A frequently suggested limit for welding fume is 15 milligrams of iron oxide per cubic meter of air. Concentrations of this magnitude existing in the workroom would materially reduce visibility and thereby become a nuisance or an unsafe condition requiring correction.

Welding within confined areas such as tanks, inside machinery or equipment, or in small rooms presents a condition which can be of concern. The concentration of fume is materially higher under these conditions as there is little opportunity for dilution by natural air currents normally present in a large shop. Nitrogen oxides formed by the electric arc when inhaled in sufficient quantities causes fluids to form in the lung—edema—

with resultant failure of the respiratory system. While welding in large open areas these toxic gases are normally not present in sufficient quantities to cause harmful effects. However, when welding is done in confined areas, the nitrogen oxides may reach a concentration which will be harmful.

Gas welding generally is not productive of harmful fumes. There are, however, in brazing two potentially harmful exposures. While boric acid or borates generally are used in brazing fluxes, some metals require fluxes containing significant quantities of fluoride compounds and fumes from these fluxes have been known to produce significant nasal irritation. Fluorides in general are looked upon with suspicion since they may produce harmful effects upon the bone structure. A limit of 2.5 mg. per cubic meter has been suggested for fluorides, but no standard has been agreed upon. Most industrial hygienists attempt to keep them as low as practicable.

Silver solder is one of the more common alloys used in brazing. Solders of this type vary in composition and may in some instances contain cadmium which, if volatilized in sufficient quantities, is considered harmful. At present the suggested limit for cadmium fume in air is 1 milligram per 10 cubic meters of air.

Resistance, spot, or butt welding of plain steel is of no concern from the physiological standpoint. The fumes arising from such operations generally are caused by the volatilized oil which has come upon the metal stock during previous operations or has been placed upon the metal as a rust preventive.

The preceding discussion of welding operations has been based upon the assumption that the metals being welded are of plain steel. The performance of welding operations, either arc, gas, or resistance, upon metals which have been coated with such toxic materials as lead, cadmium, or mercury may cause harmful exposures. The heat of the flame or of the arc causes volatilization of these metals. Welding or cutting ofterne plate or other metals containing significant quantities of lead can result in the volatilization of lead fume, which if inhaled for a sufficient period of time, may result in lead absorption.

—To page 73

Is Corp.

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1940, to date; 360 em-

16,430 man-hours as of

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without a disabling in-

(weaving).

Section

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of December 22, 1947.

Orleans

Service Inc.

Orleans, La.,—Mechanical

Section. Power Division,

Department—May 17, 1944,

51 employees; 500,000 man-

of December 31, 1947.

Dust

June 52

Ultimate poisoning. The cut-

ing of surfaces which

coated with paint contain-

has caused lead poisoning.

cadmium plated mater-

distributed as the cause of ill-

even death to a number of

during the war. The re-

indicated that death oc-

comparatively short time

exposure.

galvanized metal causes

of the zinc coating.

discomfort associated

fume fever may result

exposure.

control of weld-

generally accomplished

mechanical ventilation

The type of ventilation used

upon the nature of the

When the object to be weld-

in a fixture or jig it

to obtain effective control

by the use of a grill,

flexible duct near the

If the parts are large

necessary to weld more than

fixed point, it is difficult

control of the fume

volumes through

flexible ducts.

effective range of most

is approximately eight

the dust opening, it is

for the welder to move the

the arc is outside this

The practical result is, that

ELIMINATE THIS

ACCIDENT REPORT

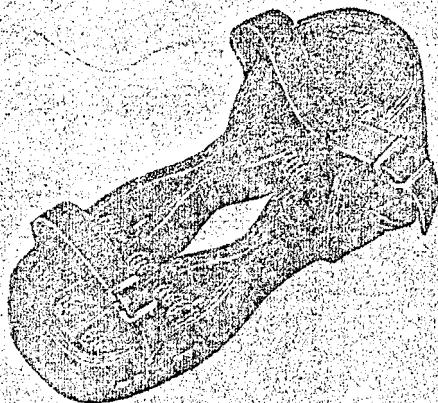
Joe Smith, Lathe Dept., slipped on oil splash, tore knee ligaments—Com-pensation claimed.

Mary Rocco, scrub woman, fell on wet floor, dislocated hip—Compen-sation claimed.

Pat Ryan, Receiving Dept., slipped on wet platform, broke wrist—Com-pensation claimed.

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for buffing and polishing composition. Waxes and various abrasives are the major ingredients. These materials, plus fibers from the wheel, are the major ingredients of the air-borne dust. The toxicity is dependent on the type of abrasive. Generally, the dust is provided to improve the finish and reduce the number of scratches and not because of the harm to health.

Contamination from oily parts is the primary source of air contamination during machining operations. Illness has been attributed to this type of contamination. As is the case with most types of dusts of the nuisance variety, little is known as to what effect these materials have on existing health conditions.

Machining operations on steel produce large chips or turnings; consequently, dust is not a problem. Operations involving the machining of cast iron alloys have been studied, and significant quantities of airborne dust have not been demonstrated.

Graphite, which becomes airborne during the machining of cast iron is, however, physiologically significant and therefore is classified as a health hazard. Frequently management engineers find it advisable to provide ventilation for the machines which are productive of the most dust. Graphite on the clothing and in the surrounding machinery is the cause of many complaints.

Respiratory Protection

The problem is recognized as the control of mineral dusts, and the ventilation system is normally installed at the time of installation of commercially built sand casting equipment. Continuous usage of such equipment result in a lack of adequate control. Visibility of dust is the best evidence that has occurred and it is advised that such a condition be corrected.

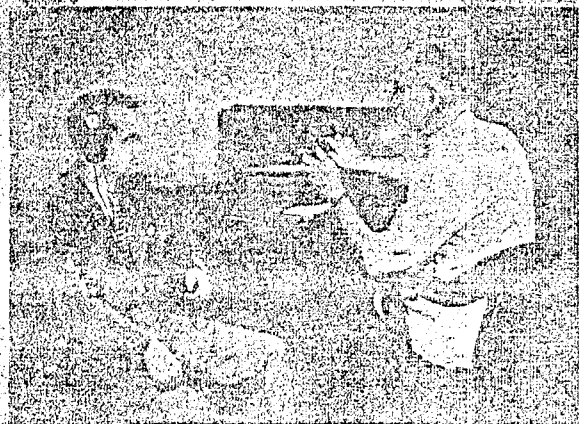
Workers are stationed in the area and are dependent upon personal protective equipment. Devices which supply air to the worker are of the supplied-air type and it is necessary that the air provided be free of harmful contaminants. Air compressors should be maintained free of contamination; otherwise the contaminant will be admitted to the helmet.

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Normally, ventilation within the room is provided so as to improve visibility and to help prevent the escape of dust into the surrounding areas, but excessive concentration of dust in the air is a safe level.

For a rotating-table type of sand blast, units should be provided with efficient ventilation to prevent the escape of silica dust. Leakage due to excessive wear should be remedied.

Small sandblast cabinets, where the operator controls the blast nozzles from outside the cabinet, frequently have faulty seals around the doors or the rubber gaskets are loose or torn. The dust which escapes from the cabinet through these openings is in close proximity to the breathing zone of the employee and in many instances exceeds the permissible limit for silica. This leakage should be corrected and the men should not be required to use respirators.

If the articles being blasted are free of silica or other toxic material, the dust resulting from grit or shot blasting is classified in the nuisance category. It follows that the maintenance of ventilating systems for grit blasting, although desirable, is not always so necessary as for sand blasting.

The use of steel grit or shot in blasting rooms produces excessively high concentrations of dust within the enclosure. It is therefore, necessary to protect the worker within the room. The remarks concerning sandblasting rooms are therefore, pertinent when considering rooms in which steel grit or shot are used as the abrasive.

Vapor blasting, a variation of sand blasting, is a comparatively recent development. This process involves the use of fine silica sand under pressure. The silica in the vapor blast units varies in size, but may even be as small as 125 microns (approximately 10 microns). It is generally believed that airborne particles below 5 microns are significant in causing silicosis. It then follows that operations involving the use of silica abrasive where the particle size approaches the order of magnitude are more dangerous, and, require continual vigilance in maintaining good control. Therefore, essential that the sandblast cabinets be maintained so that leakage of mist does not occur.

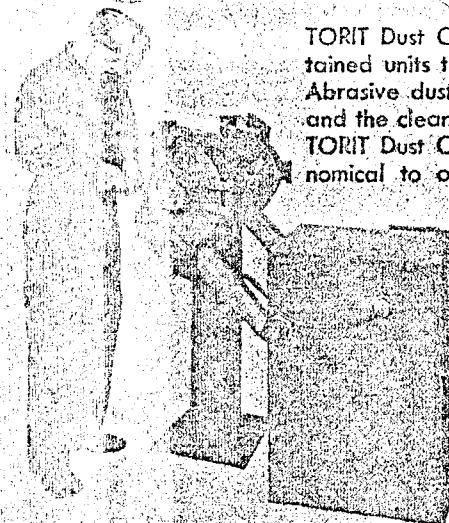
Good housekeeping is also essential as spillage of the sand and sludge upon the floor will be a source for dust dissemination. When the water evaporates, likewise, the dried sludge should not be allowed to stand in the area where they can be influenced by currents of high velocity.

Practically all industrial operations which involve the use of lead base bearing materials



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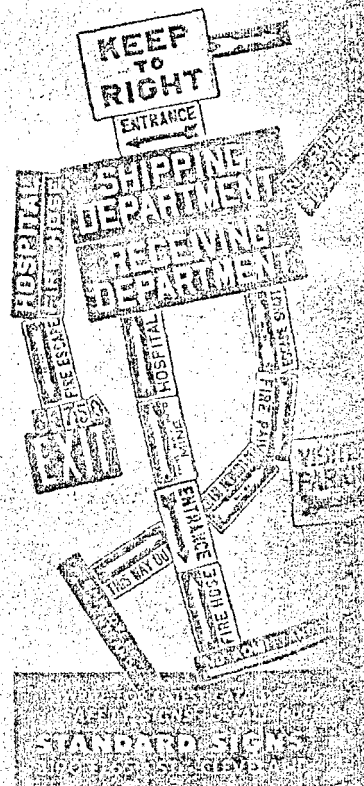


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solder. Babbitt bearing metal containing approximately 75 per cent lead have been encountered. The composition of solder metal is variable and dependent upon the purpose for which it is used, with ordinary soft solder containing a comparatively high percentage of lead.

Assuming that the babbitt or solder contains a significant amount of lead, the question then arises as to whether or not employees working with this material will become ill. The answer could be given by a qualified industrial hygienist after he had seen the operation and considered such factors as the temperature to which the metal is heated, the method of removing excess solder, the length of exposure, and the effectiveness of the control measures provided.

It is a well known fact that lead causes illness if absorbed in excessive amounts, and therefore operations where lead is used have received considerable study. Out of this experience certain practices are known to produce excessive exposure whereas other practices have been proved not to be harmful. It is generally conceded that excessive concentrations do not result from operations where solder is applied by means of an electric soldering iron. This is probably due to the small amounts of solder used and the comparatively low heat of the metal.

When the iron is heated in a small gas-fired furnace, the exposure may be of greater consequence. Solder which remains on the iron coming into contact with the flame or heat is vulnerable for volatilization. Small amounts of solder drop from the iron onto the hot floor of the furnace where it is readily volatilized or oxidized. The oxidized material may become airborne due to disturbances created by the flame or by removing or placing the soldering iron in the furnace.

Frequently industrial hygienists recommend that ventilation be provided for heating units of this type, thereby removing lead fumes and dust from the environment. This is particularly true in small rooms or where many units are in use.

Atmospheric contamination occasioned by the use of either gas or electrically heated pots containing solder is dependent on a number of factors. With higher temperatures more volatilization will occur and the greater will be the exposure. With the

higher temperature the metal is more readily oxidized to produce a dross consisting of a high percentage of lead oxide. The dross may provide a protective coating to reduce the volatilization of the lead; however, disturbance of this coating will create an exposure.

As a safeguard against excessive contamination, pots containing solder or babbitt are usually ventilated. Wherever possible, it is advisable to enclose the pot as completely as possible and provide sufficient air volume to overcome the thermal effects

of the molten metal. Attempts have been made to use natural draft ventilation systems to control these fumes and in those instances where the ducts were not of sufficient diameter the system was inadequate. A preferable method is the use of mechanical systems.

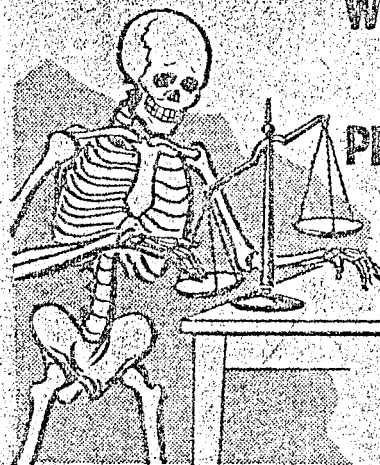
The removal of excess solder with power-driven tools, such as grinding wheels, discs, or wire wheels, creates airborne dust which may contaminate large areas if the operation is extensive. Diligent use of abrasive cloth will also result in excessive concen-

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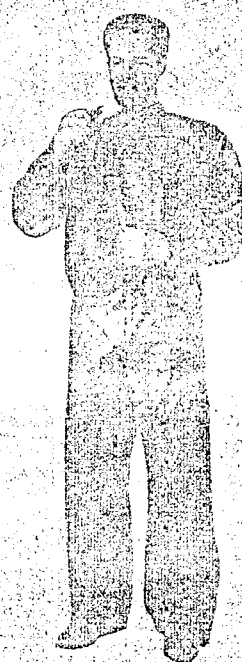
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lutions of lead dust. Filing, however, is not productive of small particles and is preferred over the use of power driven tools.

If filing is not practicable, it will be necessary to provide some type of mechanical ventilation system for the solder removal operations involving the use of power tools. Since the permissible limit generally accepted for lead is 1.5 milligrams per 10 cubic inches of air (353 cubic feet) it will be necessary to have an effective system to provide adequate control. Engineers experienced in designing ven-

tilation systems to control toxic materials should be consulted, otherwise a costly system might be erected and later found entirely ineffective.

Frequently solder removal operations require the use of portable tools on large objects and a local exhaust system would not be effective, as is the case in the fabrication of automobile bodies. General contamination of the factory with lead dust has been eliminated by enclosing the entire operation in a large booth and exhausting a sufficient quantity of air from the enclosure to insure a constant in-

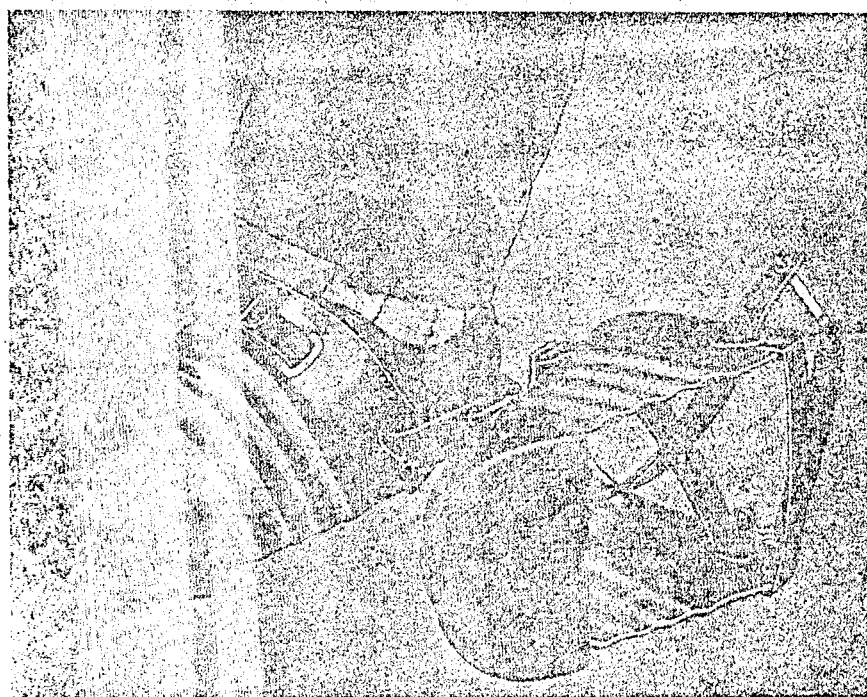
ward flow of air from the factory into the booth. Under these circumstances no practical amount of air could be removed from the booth to reduce the lead concentration to a safe level, and therefore it is necessary that the men working therein be provided with adequate personal protective devices.

Heat Treating

High temperatures are a frequent source of complaint from employees in heat treat departments but such conditions and their control are not within the subject under discussion.

Fumes from cyanide pots are often associated with cyanides used as fumigants or as the lethal agent in death chambers, and supervision as well as the employee becomes apprehensive. Fumes from such a source are irritating and because of this property should be adequately ventilated. The irritant nature of the fume is caused by alkali formed upon decomposition of the cyanide.

Molten lead is sometimes used as a hardening medium for metals. Frequently charcoal or some similar material is placed on the surface of the metal to conserve heat and prevent



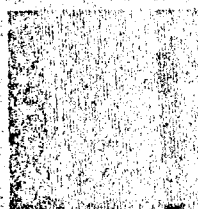
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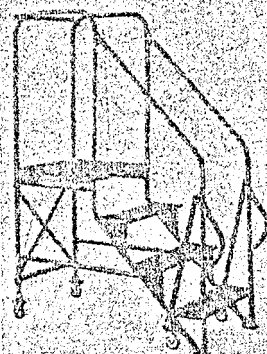
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covering of this type the volatilization of lead is quiescent, but has while the bath is in use. ventilation should therefore be provided for baths of this type. As an enclosure as is practical operation being performed is with air quantities depending on the open areas in the hood. contamination resulting from volatilization of lead accumulation in the combustion chambers of combustion from gas and hot pots should be vented to the outside and not be allowed to dissipate into the workroom.

Asbestos

Asbestos used in the formulation of brake lining is a potentially harmful compound. This material is the principal agent in the production of the ailment known as asbestosis. The harmful effect is comparable to that of silica and a permissible limit of 5,000,000 particles of asbestos dust per cubic foot of air is generally accepted.

Exposures to asbestos and the ingredients of the brake lining when the dry materials are loaded and emptied into the mixers and in the subsequent operations of grinding, or surfacing. Compounds of asbestos are sometimes used in brake linings, and contamination from this source should not be ignored. Local exhaust systems with specially designed hoods or enclosures are used to remove the dust from these operations.

The principal ingredients of foundry sand are silica, sea coal, clays, and binding compounds. The predominant material will be dependent on which phase of the foundry operation is being studied and what operation is being performed. The dust of sand is the major problem, and the issue is of secondary importance.

In a survey of all the aspects of industrial hygiene problems in foundries would require a separate discussion. For the present discussion it is sufficient to state that all sources of dust dispersion should be reduced to a minimum by localized exhaust systems. In such a foundry such places as sand conditioning and mixing equipment, tumbling mills, shake-

tions, transfer points of dry sand, abrasive blasting operations, and all grinding operations performed on castings containing appreciable quantities of sand.

Maintenance of ventilation equipment is a major item in foundries because of the abrasive action of the dust. It is imperative that a good program be maintained so as to keep the equipment functioning at maximum efficiency.

Because of the heat associated with large scale foundry activities it is a common sight to see pedestal fans or

air cooling ducts directed in such a manner as to create cross drafts which interfere with the efficient removal of dust. Better placement of these fans or ducts will go far in reducing dust concentrations in the areas where they are used.

Respiratory Protective Devices

After the obvious has been corrected, it is advisable that a survey of the foundry be made by an industrial hygienist so that an accurate evaluation of the exposure may be obtained.

As has been stated, the atmospheric

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The weight of two Safe-T-vis lenses, made from a new allyl casting resin, is approximately the same as that of *one* case hardened glass lens of the same size.

3-HOUR Comfort

Workers find Safe-T-vis lightweight, attractive and comfortable. What a change from old type goggles whose weight causes workers to remove them, chancing exposure to hazard!

3-HOUR Protection

Real protection comes only when goggles are worn *throughout* the period of exposure. And complete protection is the *only* function of any safety goggle.

And they are SAFE

Standard drop-ball tests prove Safe-T-vis' superiority over ordinary eye protection. Safe-T-vis offers greater resistance to abrasion than do other plastic lenses. It resists the stresses of high velocity impact, corrosion and other causes of industrial eye injury to the most exacting specifications.

Write for booklet giving complete details.



Safe-T-vis

Lightweight protective spectacles

A product of THE UNIVIS LENS COMPANY, Dayton 1, Ohio

OAK PARK, ILL.