DANGEROUS PROPERTIES of INDUSTRIAL MATERIALS

Second Edition

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REINHOLD PUBLISHING CORPORATION, NEW YORK
CHAPMAN & HALL, LTD., LONDON

PLAINTIFF'S EXHIBIT 1538(2)

Library of Congress Catalog Card No. 63-20370

Photocopy set by

Applied Science Laboratories, Inc.

State College, Pennsylvania

Sax, N. Irving

Dangerous Properties of Industrial materials. 2nd ed. 1963

DATE	ISSUED TO
5-2-64	J. Parsons
7/8/65	B. H. Cooper
7/6/66	Bill Harper
11-21-66	Val Bristol
5-17-67	Harold Nuttall
6/1/67	W. Reily
2-5-68	LIBERTYVILLE
3-13-68	M. Tomberg
2-27-68	[illegible]
15/11/[illegible]	[illegible]
15/[illegible]	[illegible]
1/15/69	W. Reily
2/18/69	W. Reily

DATE	ISSUED TO
3/7/69	W. Reily
8/20/71	K S [illegible]
3/20/72	[illegible]
11/20/80	Cynthia House
8/1/80	Steve ELKINS
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8/11/83	[illegible]
9/1/83	[illegible]

SECTION 2

VENTILATION CONTROL

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When materials are used industrially so that air contaminants are created, generated or released in concentrations which may injure the health of workers, the usual method of providing protection is by means of ventilation, usually local exhaust. There are, however, other methods of protection which should be investigated before consideration of ventilation control.

Control by Methods Other Than Ventilation

The basic principle of industrial hygiene is to prevent dangerous materials from coming into contact with workers.

While ventilation control is the most widely used method of achieving this protection, a number of other, simpler procedures are available. These can often effect considerable operational economies as well as reduce the cost of ventilation or eliminate its need entirely, and are frequently the most practical method of providing such protection.

Design into Plant or Process

It is becoming increasingly common for plant and design engineers to consult with the industrial hygiene engineer at the design stage of a new plant or process. Consideration of industrial hygiene control principles at this point can eliminate or simplify the costly exhaust ventilation which would otherwise be necessary. Automation and automatic operations which require few if any workers are examples of this principle. Other examples include the design of continuous, enclosed chemical processes instead of batch processes, underground trenches for ventilation ductwork and grouping of hazardous operations to localize control, such as central shakeout stations, etc.

Process Change. A simple process change can often not only reduce contaminant dispersion but improve production efficiency. The following are examples of decreasing contaminant dispersal or otherwise reducing exposure: metal joining by welding or crimping instead of soldering; a change in temperature, speed or pressure of a chemical reaction; automatic electrostatic paint spraying instead of manual compressed air paint spraying; mechanical continuous hopper charging instead of manual batch charging.

A change in the physical condition or container specifications of raw materials received by a plant for further processing may be salutary. Thus, use of pelletized or briquetted materials that are ordinarily dusty, such as carbon powder, may drastically reduce atmospheric dust contamination at several steps in a process. Batch charging of slightly wetted materials or in paper bags rather than in a dry bulk state may eliminate or reduce the need for control in storage bins and batch mixers.

Substitution. An often effective and usually inexpensive method of control is the substitution of non toxic or less toxic materials for highly toxic ones. The classic examples of substitution as a control measure include replacing of mercury used in the processing of fur into hatter's felt with non-mercurial compounds; replacement of white lead in paint pigments by zinc, barium or titanium oxides; the use of mixtures of paraffin hydrocarbons instead of benzene (benzol) in the rubber products industries; and the almost complete disappearance of the hazards of carbon tetrachloride from industry by substitution of much less toxic chlorinated hydrocarbons. We may also cite the use of steel shot instead of sand for abrasive blasting; synthetic rather than sandstone grinding wheels; and nonsilica parting compounds in foundry molding operations.

Frequently, such substitution carries with it a bonus in the form of an operational improvement. For example, the replacement of benzene by toluene in the manufacture of self-sealing aircraft gasoline tanks during World War II resulted in elimination of the troublesome problem of too rapid drying of the benzene between the various steps of the process.

Substitution often requires a good selling job to overcome the reluctance of production engineers to change the status quo. Fortunately, it can usually be demonstrated that substitution can result in an overall increase in economy.

Isolation in Time or Space

Many operations which do not readily lend themselves to ventilation control because of their nature or extent may generate contaminants in such quantities as to permeate an entire workroom or building and expose all the workers to a hazard, although only a few of them are actually engaged in the operations. In such instances, an attempt should be made to perform the operation so that only those workers immediately concerned with it need be within its influence.

One such method is isolation in time or space. In a foundry without central shakeout this operation may be performed after the regular shift has gone for the day. The three or four shakeout workers can be provided with suitable respirators for the one or two hours during which they are exposed to the silica dust. Blasting in mines at the end of or between shifts and housekeeping procedures or plant painting at night are other examples of work that can be scheduled so as to minimize the number of workers exposed to a hazard.

An operation can also be isolated in space. The ordinary furnace is a prime example of such isolation. Complete enclosure of a sand blast operation with an air-line respirator for the worker within the enclosure is another instance. Some operations require complete enclosure and remote control so that nobody is exposed, as in many processes involving nuclear radiation.

Enclosing a dangerous operation or locating one or more dangerous operations together in a separate room or building not only sharply reduces the number of workers exposed but greatly simplifies the necessary control procedures. Plating tanks, lead melting pots, paint dipping operations and similar processes, when located in a separate room and grouped together, can usually be provided with efficient and relatively inexpensive, local exhaust systems. Where continuous supervision of an operation by a worker is not necessary, only general ventilation may be required to prevent escape of contaminants into the main workroom. If necessary, the exposed worker can in such a case be provided with a respirator for use during his brief periods of exposure.

Segregation of Personnel. An opposite approach, where contaminant-producing operations must be carried out over a large area, is to segregate the worker from the operation. The crane operator in a large foundry, bulk material storage building or cement clinker shed can be provided with a completely enclosed cab ventilated under positive pressure to keep contaminants out. In automatic stone crushing, grinding and conveying

SECTION 3

RESPIRATORY PROTECTION AND PERSONAL HYGIENE

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RESPIRATORY PROTECTION

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Personal respiratory protection is one of the classical methods of control in industrial hygiene. However, the importance of this technique is often misunderstood. All the other methods of control, when properly designed and applied, can provide adequate continuous protection of a worker against harmful contaminants under normal working conditions. Personal respiratory protection, however, finds its chief usefulness as an emergency or short-term means of protection. It should be used as a primary protective device for normal operations only when no other method of control is possible. At times, it may be useful as an adjunct to exhaust ventilation or other control measures.

Respirators are thus emergency devices. They are needed when it is necessary to enter a highly contaminated atmosphere for a short time for rescue or emergency repair work; as a means of escape from a suddenly highly contaminated atmosphere; for periodic, short-term inspection, maintenance or repair of equipment located in a contaminated atmosphere; and for normal operations in conjunction with other control measures where the contaminant is so toxic that a single control measure such as ventilation cannot safely be relied on.

A respirator must be designed and selected for the particular environment in which it is to be used. The type of contaminant, its probable maximum concentration, the possibility of oxygen deficiency, the useful life of the respirator, the escape routes available; all these and other factors must be considered in selecting a respirator for emergency use, for periodic use, or for stand-by purposes. Where these factors are not known with certainty, the device providing the widest spectrum of protection must be used.

Respirators must fit well, if possible without discomfort, should permit breathing without undue effort, should not interfere with vision, and should permit complete freedom of movement where danger may otherwise result. Respirators should be cleaned after each use and sterilized frequently; be assigned to individual workers; stored in dust free cabinets readily available for use; where necessary, they should be available both in the workroom for escape and just outside the workroom in a safe atmosphere for rescue. Careful records should be kept of length of time in use, the remaining oxygen or air supply or condition of purifying element, and they should be renewed when necessary.

Atmospheric Hazards

The type and degree of hazard to be encountered will govern the kind of respiratory protective device to be used. Several classifications may be described to assist in proper selection of a device:

- Oxygen deficiency.
- Gases or vapors immediately dangerous to life.
- Gases or vapors not immediately dangerous to life.
- Particulates.
- Combination of particulates and gases or vapors immediately dangerous to life.
- Combination of particulates and gases or vapors not immediately dangerous to life.

Where the degree of hazard is not known, it must be assumed to be immediately dangerous to life.

Oxygen Deficiency. Normal air contains approximately 21% of oxygen by volume. This oxygen content may be reduced by such factors as dilution or displacement of oxygen by other gases, loss of oxygen by reaction with other substances or by absorption in certain materials. These conditions are usually found in such confined spaces as storage bins or silos, tanks, sewers, wells, mines and ships' holds, and may also exist in burning rooms and in closed areas where natural oxidation of materials can occur.

Atmospheres containing 16% or less of oxygen may cause serious injury or death to people breathing them, depending on the actual concentration, length of exposure and physical activity of the exposed persons. In such atmospheres, the respiratory protective device must be of a type which supplies fresh air or oxygen to the wearer. If the atmosphere is such that the wearer cannot safely escape, from the remotest location he is likely to be in, to an uncontaminated location without respiratory protection, the device chosen must be a self-contained type.

Gas or Vapors. Gases and vapors may be classified as toxic or inert. Toxic gases and vapors may cause injury or death depending on the concentration present. Inert gases can displace oxygen and are dangerous only under the conditions described above.

Where gases are so toxic that even in low concentrations they may be immediately dangerous to life, the respiratory protective device must be chosen to provide positive, reliable control for the conditions to be encountered.

Particulates. Particulates may assume the form of dispersions of solids, such as dusts, fumes and smokes; liquids, such as mists and fogs; and combinations of the two, such as mists created by sprays of suspensions of dusts and paints. With rare exceptions, such as the organic phosphorus insecticides and, possibly, massive concentrations of the more highly toxic metals, particulate contaminants are not immediately dangerous to life. Mechanical filtration of inspired air is the usual protection method used.

Particulates may be classified as toxic, pneumoconiosis-producing, and non-specific or nuisance. The design of a respirator depends on the type of dust to be encountered. Toxic particulates, such as lead, fluoride and phosphorus dusts, enter the blood stream directly from the lungs and cause systemic poisoning. Pneumoconiosis-producing dusts (silica, asbestos) remain in the lungs and cause localized fibrotic diseases. Nuisance dusts (flour, wool, wood) may do either, but usually do not produce local or systemic effects. However, they may be irritating or allergenic and, in massive concentrations, may cause debility by their physical presence in the lungs.

Combination of Particulates and Gases. Special respiratory devices designed to protect against mixtures of more than one type of contaminant are available. These should be selected to provide protection against the maximum expected concentration of each contaminant. Where one of the contaminants may be immediately

ARSPHENAMINE

General Information

Synonym: 3-Diamino-4-dihydroxy-1-arsenobenzene hydrochloride.
Description: Light yellow, hygroscopic powder.
Formula: $C_{12}H_{12}As_2N_2O_2 \cdot 2HCl \cdot 2H_2O$.
Constant: Mol wt: 475.0.

Hazard Analysis

Toxicity: See arsenic compounds.
Disaster Hazard: See arsenic compounds.

Countermeasures

Ventilation Control: Section 2, p. 31.
Personnel Protection: Section 3, p. 59.
First Aid: Section 1, p. 1.
Storage and Handling: Section 7, p. 179.

ARSYSODILA. See sodium cacodylate.

ARTHRYTIN. See amiodoxyl benzoate.

ARTIFICIAL ALMOND OIL. See benzaldehyde.

ASBESTOS DUST. See asbestos particles.

ASBESTOS PARTICLES

General Information

Synonym: Asbestos dust.
Toxic Hazard Rating:
Acute Local: Irritant 1; Inhalation 2.
Acute Systemic: 0.
Chronic Local: Inhalation 3.
Chronic Systemic: U.
TLV: ACGIH (accepted); 5 million particles per cubic foot of air.

Hazard Analysis

Toxicology: The essential lesion produced by asbestos dust is a diffuse fibrosis which probably begins as a "collar" about the terminal bronchioles. Usually, at least 4 to 7 years of exposure are required before a serious degree of fibrosis results. There is apparently less predisposition to tuberculosis than is the case with silicosis.

Clinically, the most striking sign is shortness of breath of gradually increasing intensity, often associated with a dry cough. In the early stages physical signs are absent or slight; in the later stages rales may be heard, and in long-standing cases there is frequently clubbing of the fingers. In early stages of the disease the chest x-ray reveals a groundglass or granular change, chiefly in the lower lung fields; as the condition progresses the heart outline becomes "shaggy" and irregular patches of mottled shadowing may be seen. Asbestos bodies may be found in the sputum.

At autopsy, the pleurae are thickened and adherent and thick subpleural fibrous plaques are often present. Where the disease is far advanced there are usually large areas of fibrosis, with emphysematous changes in the apices and bases. The alveolar walls are thickened, and the characteristic "asbestos bodies" are found.

Countermeasures

Ventilation Control: Section 2, p. 31.
Personal Hygiene: Section 3, p. 59.

ASCARIDOLE

General Information

Synonym: Ascarisin.
Description: Liquid.
Formula: $C_{10}H_{16}O_2$.
Constants: Mol wt: 168.2, bp: 115°C at 15 mm, d: 1.011 at 13°/15°C.

Hazard Analysis

Toxicity: Details unknown. See oil of chenopodium. See also peroxides, organic.
Fire Hazard: Moderate, by spontaneous chemical reaction (Section 6, p. 161).
Caution: An oxidizer.
Explosion Hazard: Explodes at 250°C.
Disaster Hazard: Dangerous; when heated, it emits toxic fumes and may explode; it reacts with reducing materials.

Countermeasures

Storage and Handling: Section 7, p. 179.

ASCARISIN. See ascaridole.

ASPERIN. See acetol.

ASPHALT

General Information

Synonyms: Bitumen; petroleum pitch.
Description: Black or dark brown mass.
Constants: Bp: <470°C, flash p: 400+°F (C.C.), d: 0.95-1.1, autoign. temp.: 905°F.

Hazard Analysis

Toxic Hazard Rating:
Acute Local: Irritant 2.
Acute Systemic: U.
Chronic Local: Irritant 2.
Chronic Systemic: U.
Fire Hazard: Slight, when exposed to heat or flame.
Spontaneous Heating: No.

Countermeasures

To Fight Fire: Foam, carbon dioxide, dry chemical or carbon tetrachloride (Section 6, p. 161).
Personnel Protection: Section 3, p. 59.
Storage and Handling: Section 7, p. 179.
Shipping Regulations: Section 11, p. 317.
Coast Guard Classification: Hazardous article.

ASPIDIUM

General Information

Synonym: Male fern.

Hazard Analysis

Toxic Hazard Rating:
Acute Local: Irritant 1; Allergen 1.
Acute Systemic: Ingestion 2.
Chronic Local: Allergen 1.
Chronic Systemic: U.

Fire Hazard: Slight; when heated, it emits acrid fumes (Section 6, p. 161).
Countermeasures
Personal Hygiene: Section 3, p. 59.
Storage and Handling: Section 7, p. 179.

ASPIRIN. See acetol.

ATABRINE DIHYDROCHLORIDE. See "atabrine" hydrochloride.

"ATABRINE" HYDROCHLORIDE
General Information
Synonym: Quinacrine hydrochloride.
Description: Bright yellow crystals.
Formula: $C_{23}H_{30}ClN_3O \cdot 2HCl \cdot 2H_2O$.
Constants: Mol wt: 508.9, mp: decomposes 248-250°C.
Hazard Analysis
Toxic Hazard Rating:
Acute Local: Allergen 1.
Acute Systemic: Ingestion 2.
Chronic Local: Allergen 1.
Chronic Systemic: Ingestion 2.
Disaster Hazard: Dangerous; when heated to decomposition, it emits highly toxic fumes of chlorine.
Countermeasures
Personal Hygiene: Section 3, p. 59.
Storage and Handling: Section 7, p. 179.

ATOXYL. See sodium arsanilate.

ATROPAMINE. See apoatropine.

ATROPINE
General Information
Synonym: Daturine.
Description: Colorless, crystalline alkaloid.
Formula: $C_{17}H_{23}NO_3$.
Constants: Mol wt: 289.4, mp: 115.5°C; sublimes at 118°C.
Hazard Analysis
Toxic Hazard Rating:
Acute Local: Allergen 1.
Acute Systemic: Ingestion 3; Inhalation 3.
Chronic Local: Allergen 1.
Chronic Systemic: Ingestion 2.
Fire Hazard: Slight; on decomposition it emits toxic fumes.
Countermeasures
Ventilation Control: Section 2, p. 31.
Personal Hygiene: Section 3, p. 59.
First Aid: Section 1, p. 1.
Storage and Handling: Section 7, p. 179.

ATROPINE METHYL BROMIDE. See atropine.

ATROPINE METHYL NITRATE. See atropine.

ATROPINE SULFATE. See atropine.

AURIC BROMIDE
General Information
Description: Gray powder; crystals brown.
Formula: $AuBr_3$.
Constants: Mol wt: 436.95, mp: $-Br_2$ at 160°C
Hazard Analysis
Toxicity: See gold compounds and bromides.
Disaster Hazard: See bromides.
Countermeasures
Storage and Handling: Section 7, p. 179.

AURIC CHLORIDE
General Information
Synonym: Gold chloride.
Description: Claret red crystals.
Formula: $AuCl_3$.
Constants: Mol wt: 303.57, mp: 254°C decomposes, bp: sublimes 265°C, d: 3.9.
Hazard Analysis
Toxicity: See gold compounds.
Disaster Hazard: See chlorides.
Countermeasures
Storage and Handling: Section 7, p. 179.

AURIC CYANIDE. See cyanoauric acid.

AURIC HYDROGEN NITRATE
General Information
Synonym: Gold nitrate.
Description: Yellow crystals.
Formula: $AuH(NO_3)_4 \cdot 3H_2O$.
Constants: Mol wt: 500.29, mp: 72°C decomposes, d: 2.84.
Hazard Analysis
Toxicity: See gold compounds and nitrates.
Fire Hazard: See nitrates.
Disaster Hazard: See nitrates.
Countermeasures
Storage and Handling: Section 7, p. 179.

AURIC IODIDE
General Information
Synonym: Gold iodide.
Description: Dark green crystals.
Formula: AuI_3.
Constant: Mol wt: 577.96.
Hazard Analysis
Toxicity: See gold compounds.
Countermeasures
Storage and Handling: Section 7, p. 179.

AURIC OXIDE
General Information
Synonym: Gold oxide.
Description: Brown black powder.
Formula: Au_2O_3.
Constants: Molecular weight: 442.40, melting point: $-O_2$ at 160°C, boiling point: $-3O_2$ at 250°C.
Hazard Analysis
Toxicity: See gold compounds.

TOXIC HAZARD RATING CODE (For detailed discussion, see Section 1.)

0 NONE: (a) No harm under any conditions; (b) Harmful only under unusual conditions or overwhelming dosage.
1 SLIGHT: Causes readily reversible changes which disappear after end of exposure.
2 MODERATE: May involve both irreversible and reversible changes; not severe enough to cause death or permanent injury.
3 HIGH: May cause death or permanent injury after very short exposure to small quantities.
U UNKNOWN: No information on humans considered valid by authors.