Occupational Health Guideline for Inorganic Tin Compounds (as Tin)

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

APPLICABILITY

The general guidelines contained in this document apply to all inorganic tin compounds. Physical and chemical properties of several specific compounds are provided for illustrative purposes.

SUBSTANCE IDENTIFICATION

Tin

- Formula: Sn
- Synonyms: Tin, metallic
- Appearance and odor: Odorless, dull silvery metal.

Stannous chloride

- Formula: $SnCl_2$
- Synonyms: Tin(II) chloride; tin dichloride
- Appearance and odor: Odorless, colorless to brown solid.

Stannic chloride

- Formula: $SnCl_4$
- Synonyms: Tin(IV) chloride; tin tetrachloride
- Appearance and odor: Colorless to yellow fuming liquid with an acrid odor.

Stannous sulfate

- Formula: $SnSO_4$
- Synonyms: Tin(II) sulfate
- Appearance and odor: Odorless, colorless to brown solid.

Potassium stannate

- Formula: $K_2SnO_3 3H_2O$
- Synonyms: Potassium stannate trihydrate
- Appearance and odor: Odorless, colorless to brown solid.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for inorganic tin compounds (as tin) is 2 milligrams of inorganic tin compounds (as tin) per cubic meter of air (mg/m^3) averaged over an eight-hour work shift.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Tin, stannous chloride, stannic chloride, stannous sulfate, or potassium stannate can affect the body if they are inhaled or if they come in contact with the eyes or skin.

- **Effects of overexposure**

1. Short-term Exposure: In general, the toxicity of inorganic tin salts is low. These compounds may cause irritation of the eyes, nose, throat, and skin.

2. Long-term Exposure: None known

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to inorganic tin compounds.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to inorganic tin compounds at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from inorganic tin compounds exposure.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

—Skin disease: Certain inorganic tin compounds other than oxides are primary skin irritants. Persons with pre-existing skin disorders may be more susceptible to the effects of these agents.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of certain inorganic tin compounds might cause exacerbation of symptoms due to their irritant properties.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

• **Summary of toxicology**

Inorganic tin compounds (except the oxides) irritate the eyes and skin. Subcutaneous injection of animals with sodium stannous tartrate at a daily dose of 12.5 mg/kg was fatal; death was preceeded by vomiting, diarrhea, and paralysis with twitching of the limbs. Daily administration to a dog of stannous chloride in milk at a level of 500 mg/kg produced paralysis after 14 months. Some inorganic tin compounds can cause skin or eye irritation because of acid or alkaline reaction produced with water; tin tetrachloride, stannous chloride, and stannous sulfate are strong acids; sodium and potassium stannate are strong alkalis.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data—Tin**

1. Molecular weight: 118.7
2. Boiling point (760 mm Hg): 2689 C (4873 F)
3. Specific gravity (water = 1): 5.8 to 7.3
4. Vapor density (air = 1 at boiling point of tin): Not applicable
5. Melting point: 232 C (450 F)
6. Vapor pressure at 20 C (68 F): Zero
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Stannous chloride**

1. Molecular weight: 189.6
2. Boiling point (760 mm Hg): 605 C (1121 F)
3. Specific gravity (water = 1): 3.95
4. Vapor density (air = 1 at boiling point of stannous chloride): Not applicable
5. Melting point: 247 C (477 F)
6. Vapor pressure at 20 C (68 F): Zero
7. Solubility in water, g/100 g water at 20 C (68 F): 90
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Stannic chloride**

1. Molecular weight: 260.5
2. Boiling point (760 mm Hg): 114 C (237 F)
3. Specific gravity (water = 1): 2.23
4. Vapor density (air = 1 at boiling point of stannic chloride): 9
5. Melting point: −33 C (−27 F)
6. Vapor pressure at 20 C (68 F): 18 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Reacts
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Stannous sulfate**

1. Molecular weight: 214.8
2. Boiling point (760 mm Hg): Decomposes
3. Specific gravity (water = 1): Data not available (greater than 1)
4. Vapor density (air = 1 at boiling point of stannous sulfate): Not applicable
5. Melting point: 300 C (572 F) (decomposes)
6. Vapor pressure at 20 C (68 F): Zero
7. Solubility in water, g/100 g water at 20 C (68 F): 33
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Potassium stannate**

1. Molecular weight: 298.9
2. Boiling point (760 mm Hg): Decomposes
3. Specific gravity (water = 1): 3.2
4. Vapor density (air = 1 at boiling point of potassium stannate): Not applicable
5. Melting point: 140 C (284 F) (decomposes)
6. Vapor pressure at 20 C (68 F): Zero
7. Solubility in water, g/100 g water at 20 C (68 F): 110
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Reactivity**

1. Conditions contributing to instability: If moisture enters containers of stannic chloride, pressure may burst containers. At temperatures above 360 C (680 F), stannous sulfate decomposes to form toxic sulfur dioxide.

2. Incompatibilities: Contact of metallic tin with chlorine may cause adjacent combustible material to ignite. Contact of metallic tin with turpentine may cause fires and explosions. Contact of stannic chloride with water, alcohols, and amines may cause fires and explosions.

3. Hazardous decomposition products: Toxic gases and vapors may be released in a fire involving the tin chlorides and stannous sulfate.

4. Special precautions: Stannic chloride will attack some forms of plastics, rubber, and coatings.

• **Flammability**

1. Flash point: Not applicable
2. Minimum ignition temperature: a) Tin: 630 C (1166 F) (cloud); 430 C (806 F) (layer); For the other compounds: Not applicable
3. Flammable limits in air, % by volume: Not applicable
4. Extinguishant: For tin, water; for the other compounds, not applicable.

• **Warning properties**

According to Grant, tin tetrachloride (stannic chloride) is "highly irritating to the eyes and mucous membranes.

The irritation presumably is attributable to the hydrochloric acid which is generated when stannic chloride reacts with water." The threshold of eye irritation is not given.

MONITORING AND MEASUREMENT PROCEDURES

• **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Method**

Sampling and analyses may be performed by collection on a cellulose membrane filter followed by treatment with nitric and sulfuric acids, solution in hydrochloric acid, and analysis with an atomic absorption spectrophotometer. An analytical method for inorganic tin compounds is in the *NIOSH Manual of Analytical Methods,* 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with liquid stannic chloride.

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with stannous sulfate, potassium stannate, or liquids containing these compounds, where skin contact may occur.

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with stannous chloride or liquids containing stannous chloride.

• If employees' clothing may have become contaminated with solid stannous chloride, stannous sulfate, or potassium stannate, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing contaminated with stannous chloride, stannic chloride, stannous sulfate, or potassium stannate should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of contaminant from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the contaminant, the person performing the operation should be informed of contaminant's hazardous properties.

• Where there is any possibility of exposure of an employee's body to liquid stannic chloride, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Where exposure of an employee's body to stannous sulfate, potassium stannate, or liquids containing these compoumay occur, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with stannic chloride, stannous sulfate, or potassium stannate should be removed immediately and not reworn until the contaminant is removed from the clothing.

• Non-impervious clothing which becomes wet with stannous chloride should be removed promptly and not reworn until the stannous chloride is removed from the clothing.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of liquid stannic chloride, stannous sulfate or liquids containing stannous sulfate, or potassium stannate or liquids containing potassium stannate contacting the eyes.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where stannous chloride or liquids containing stannous chloride may contact the eyes.

• Where there is any possibility that employees' eyes may be exposed to liquid stannic chloride, stannous sulfate or liquids containing stannous sulfate, or potassium stannate or liquids containing potassium stannate,

an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with stannic chloride, stannous sulfate, or potassium stannate should be immediately washed or showered to remove any contaminant.
- Skin that becomes wet with stannous chloride should be promptly washed or showered to remove any stannous chloride.
- Employees who handle stannous chloride, stannic chloride, stannous sulfate, or potassium stannate should wash their hands thoroughly before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to inorganic tin compounds may occur and control methods which may be effective in each case:

Operation	Controls
Liberation from mining, roasting, and smelting of cassiterite ore; during foundry operations and finishing operations	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment
Use of stannic chloride in dyeing silk; manufacture of blueprint paper; as a perfume stabilizer in soap; in the preparation of lubricating oil additives; in treating glass surfaces; as a catalyst in manufacture of pharmaceuticals; and as a bleaching agent for sugar	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment
Use of stannous chloride in acidic electrotinning baths; manufacture of blueprint paper; as an antisludge agent in lubricating oils; as a perfume stabilizer in soap; as a catalyst in organic reactions; as an additive in drilling mud; in silvering of mirrors; and as a food additive	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment
Use in production of stannous fluoride or stannous pyrophosphate for use tinning baths and for formulations for remineralization of teeth; use of stannous fluorborate in commercial tin-plating baths; use in production of sodium stannate	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment
Use in production of potassium stannate; use of stannous perchlorate in tin-plating solutions; use of stannic chromate as a ceramic pigment	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment
Use of tin hydride to gas-phase plate tin on metal and ceramic surfaces; use of stannous sulfide as a pigment, as a catalyst, and in manufacture of bearing materials	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment
Use in production of stannous sulfate for use in acidic electrotinning baths and in dyeing textiles	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment
Use of stannous oleate or stannous 2-ethyl hexoate as a catalyst for urethane and other polymer foams and as a fabric water-repellant	Personal protective equipment
Use of stannous acetate as a catalyst and agent to promote exhaustion of dyes	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment
Liberation during use of heavy metal stannates as additives to ceramic dielectric materials	Process enclosure; local exhaust ventilation; personal protective equipment
Use of stannous tartrate in printing and dyeing of textiles	General dilution ventilation; process enclosure; local exhaust ventilation; personal protective equipment

Use of stannous oxalate as a catalyst in esterification reactions and in coal hydrogenation; use of stannic bromide for metallurgical separation of minerals in the laboratory	General dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Eye Exposure**

If tin, stannous sulfate, or potassium stannate get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with these chemicals.

• **Skin Exposure**

If inorganic tin compounds get on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If inorganic tin compounds penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

• **Breathing**

If a person breathes in large amounts of inorganic tin compounds, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• **Swallowing**

When inorganic tin compounds have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If tin, stannous chloride, stannic chloride, stannous sulfate, or potassium stannate are spilled or leaked, the following steps should be taken:

1. Ventilate area of spill or leak.
2. Collect spilled or leaked material in the most convenient and safe manner for reclamation or for disposal in a secured sanitary landfill. Liquid containing inorganic tin compounds should be absorbed in vermiculite, dry sand, earth, or a similar material.

• Waste disposal method:

Inorganic tin compounds may be disposed of in sealed containers in a secured sanitary landfill.

REFERENCES

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RESPIRATORY PROTECTION FOR INORGANIC TIN COMPOUNDS (AS TIN)

Condition	Minimum Respiratory Protection* Required Above 2 mg/m³
Particulate Concentration	
10 mg/m³ or less	Any dust and mist respirator, except single-use.**
20 mg/m³ or less	Any dust and mist respirator, except single-use or quarter-mask respirator.** Any fume or high efficiency particulate filter respirator.** Any supplied-air respirator.** Any self-contained breathing apparatus.**
100 mg/m³ or less	A high efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
400 mg/m³ or less	A powered air-purifying respirator with a full facepiece and a high efficiency particulate filter. A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 400 mg/m³ or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	A high efficiency particulate filter respirator with a full facepiece. Any escape self-contained breathing apparatus with a full facepiece.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**If eye irritation occurs, full-facepiece respiratory protective equipment should be used.