NIOSH/OSHA STANDARDS COMPLETION PROGRAM

DRAFT TECHNICAL STANDARD AND

SUPPORTING DOCUMENTATION FOR

*** THALLIUM, SOLUBLE COMPOUNDS ***

NIOSH/OSHA Draft Technical Standard and Supporting Documentation for THALLIUM, SOLUBLE COMPOUNDS

The basic text of this document contains the draft technical standard approved by the Joint Review Committee of the NIOSH/OSHA Standards Completion Program and the supporting documentation for the substance THALLIUM, SOLUBLE COMPOUNDS.

The SCP draft technical standards are recommendations to the Department of Labor for its consideration in rulemaking and have no legal status until final rules have been promulgated by that agency. This draft standard is provided for your information only.

The References and Sources, Respirator Table Documentation and Use/Exposure and Control Documentation are the working documents used by the various SCP working groups during the development of the draft technical standard and serve as the technical foundation for the standard. The classification for each substance and the regulatory statements were derived following a decision logic established for the various sections of the standard.

NIOSH/OSHA Draft Technical Standard
and Supporting Documentation for THALLIUM, SOLUBLE COMPOUNDS

(a) Definitions. (1) "Permissible exposure" means exposure of employees to airborne concentrations of soluble thallium compounds (as thallium) not in excess of 0.1 milligrams per cubic meter (mg/m3) averaged over an eight-hour work shift (time weighted average), as stated in $ 1910.1000, Table Z-1.

(2) "Action level" means one-half of the permissible exposure for soluble thallium compounds averaged over an eight-hour work shift.

(b) Initial determination and exposure measurement. (1) Each employer who has a place of employment in which soluble thallium compounds is released into the workplace air shall determine if there is any possibility that any employee may be exposed to airborne concentrations of soluble thallium compounds above the permissible level. The initial determination shall be made each time there is a change in production, process, or control measures which may result in an increase in airborne concentrations of soluble thallium compounds.

(2) A written record of the initial determination shall be made and shall contain at least the following information:

(i) Any information, observations, or calculations which may indicate employee exposure to soluble thallium compounds;

(ii) Any measurements of soluble thallium compounds taken;

(iii) Any employee complaints of symptoms which may be attributable to exposure to soluble thallium compounds; and

(iv) Date of initial determination, work being performed at the time, location within work site, and employees considered.

(3) If the employer determines that any employee may be exposed to soluble thallium compounds above the permissible exposure, the exposure of the employee in each work operation who is believed to have the greatest exposure shall be measured. The exposure measurement shall be representative of the maximum eight-hour time weighted average exposure of the employee.

(4) If the exposure measurement taken pursuant to paragraph (b) (3) of this section reveals employee exposure to soluble thallium compounds above the action level, the employer shall:

(i) Identify all employees who may be exposed above the permissible level; and

(ii) Measure the exposure of the employees so identified.

(5) If an employee exposure measurement reveals that an employee is exposed to soluble thallium compounds above the action level, but not above the permissible exposure, the exposure of that employee shall be measured at least every three months.

(6) If an employee exposure measurement reveals that an employee is exposed to soluble thallium compounds above the permissible exposure, the employer shall:

(i) Measure the exposure monthly of the employee so exposed; and

(ii) Institute control measures as required by paragraph (d) of this section; and

(iii) Individually notify, in writing, within five days, every employee who is found to be exposed to soluble thallium compounds above the permissible exposure. The employee shall also be notified of the results of the exposure measurements and of the corrective action being taken to reduce the exposure to below the permissible exposure.

(7) If two consecutive employee exposure measurements taken at least one week apart reveal that the employee is exposed to soluble thallium compounds below the action level, the employer may terminate measurement for the employee.

(8) For purposes of this paragraph, employee exposure is that which would occur if the employee were not using a respirator.

(c) Methods of measurement. (1) An employee's exposure shall be obtained by any combination of long term or short term samples which represents the employee's actual exposure averaged over an eight-hour work shift (See Appendix B (IV) of this section).

(2) The method of measurement shall have an accuracy, to a confidence level of 95 percent, of not less than that given in Table 1.

Table 1

Concentration	Required Accuracy
Above permissible exposure	± 25%
At or below permissible exposure and above the action level	± 35%
At or below the action level	± 50%

(d) Compliance. (1) No employee shall be exposed to soluble thallium compounds above the permissible exposure as defined in paragraph (a)(1) of this section.

(2) Employee exposures to airborne concentrations of soluble thallium compounds shall be controlled to at or below the permissible exposure by engineering and work practice controls.

(i) Engineering and work practice controls shall be instituted to reduce exposures to at or below the permissible exposure, except to the extent that such controls are not feasible.

(ii) Wherever engineering and work practice controls are not sufficient to reduce exposures to at or below the permissible exposure, they shall nonetheless be used to reduce exposure to the lowest level feasible and shall be supplemented by respirators in accordance with paragraph (d)(4) of this section.

(3) Engineering controls. When local exhaust is used to control exposure, measurements which demonstrate system effectiveness, for example, air velocity or static pressure, shall be made at least every three months. Measurements of system effectiveness shall also be made within five days of any change in production, process, or control which might result in an increase in airborne concentrations of soluble thallium compounds.

(4) Compliance with the permissible exposure shall not be achieved by the use of respirators except:

(i) During the time period necessary to install or implement engineering or work practice controls; or

(ii) In work situations in which engineering and work practice controls are not feasible; or

(iii) To supplement engineering and work practice controls when such controls fail to reduce airborne concentrations of soluble thallium compounds to at or below the permissible exposure; or

(iv) For operations which require entry into tanks or closed vessels; or

(v) In emergencies.

(5) Where respirators are needed and permitted under this paragraph to reduce employee exposure, the employer shall select and provide the appropriate respirator from Table 2 and shall ensure that the employee uses the respirator provided.

TABLE 2 RESPIRATORY PROTECTION FOR SOLUBLE THALLIUM COMPOUNDS

CONDITION	PERMISSIBLE RESPIRATORY PROTECTION
Dust or Mist Concentration	
0.5 mg/m3 or less	Any dust and mist respirator, except single-use.
1 mg/m3 or less	Any dust and mist respirator, except single-use or quarter-mask respirator.
Dust, Mist or Fume Concentration	
1 mg/m3 or less	Any fume respirator or high efficiency particulate filter respirator. Any supplied-air respirator. Any self-contained breathing apparatus.
5 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.
20 mg/m3 or less	A powered air-purifying respirator with a full facepiece, helmet or hood, 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 20 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	Any dust and mist respirator, except single-use.
	Any escape self-contained breathing apparatus.

(6) Respirators shall be approved by the Mining Enforcement and Safety Administration (formerly Bureau of Mines) or by the National Institute for Occupational Safety and Health under the provisions of 30 CFR Part 11.

(7) The employer shall institute a respiratory protection program in accordance with § 1910.134(b), (d), (e), and (f).

(e) Fire and safety. The employer shall familiarize himself with the information contained in the Substance Technical Guidelines (Appendix B of this section) for soluble thallium compounds where skin contact may occur.

(f) Personal protective equipment. (1) Employers shall provide and ensure that employees use appropriate protective clothing and equipment necessary to prevent skin contact with soluble thallium compounds where skin contact may occur. Face shields shall comply with § 1910.133(a)(2),(a)(4), (a)(5), and (a)(6).

(2) Employers shall ensure that employees whose clothing may have become contaminated with soluble thallium compounds change into uncontaminated clothing before leaving the work premises.

(3) Employers shall ensure that clothing contaminated with soluble thallium compounds is placed in closed containers for storage until it can be discarded or until the employer provides for the removal of soluble thallium compounds from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the soluble thallium compounds, the employer shall inform the person performing the operation of the hazardous properties of soluble thallium compounds.

(4) Employers shall ensure that non-impervious clothing which becomes contaminated with soluble thallium compounds be removed promptly and not reworn until the soluble thallium compounds is removed from the clothing.

(5) Employers shall provide and ensure that employees use safety goggles which comply with § 1910.133(a)(2)-(a)(6) where soluble thallium compounds may contact the eyes.

(g) Spills and disposal. In the event that soluble thallium compounds is spilled the employer shall immediately provide available ventilation and then clean up the spill.

(h) Sanitation. (1) Employers shall ensure that employees whose skin becomes contaminated with soluble thallium compounds promptly wash or shower to remove any soluble thallium compounds from the skin.

(2) Employers shall ensure that employees do not eat or smoke in areas where soluble thallium compounds are handled, processed or stored.

(3) Employers shall ensure that employees who handle soluble thallium compounds wash their hands thoroughly before eating, smoking or using toilet facilities.

(i) Training and information. (1) Each employer who has a workplace in which soluble thallium compounds is present shall keep a copy of this regulation with Appendixes A, B and C at the workplace. This material shall be made readily available to affected employees.

(2) Each employer who has employees exposed to soluble thallium compounds above the action level without regard to the use of respirators, or employees who may have skin or eye contact with soluble thallium compounds, or employees who work where a spill of soluble thallium compounds may occur, shall annually:

(i) Inform affected employees of the information contained in the Substance Safety Data Sheet for soluble thallium compounds (Appendix A of this section);

(ii) Advise affected employees as to the signs and symptoms of exposure to soluble thallium compounds.

(iii) Instruct affected employees to advise the employer of the development of signs and symptoms of overexposure to soluble thallium compounds which are listed in Appendix A of the section; and

(iv) Provide training to ensure that employees understand the precautions of safe use, emergency procedures, and the correct use of protective equipment relative to soluble thallium compounds.

(j) Medical surveillance. (1) The employer shall provide medical procedures as required by this paragraph. All medical procedures shall be performed by or under the supervision of a physician at no cost to the employee.

(2) Preplacement medical examination. The employer shall make available to each employee who is exposed, or will be exposed, to airborne concentrations of soluble thallium compounds above the action level, without regard to the use of respirators, or employees who may have skin or eye contact with soluble thallium compounds, a preplacement medical examination which must include the following:

(i) A medical history and physical examination with emphasis on the eyes, nervous system, lungs, liver, kidneys, gastrointestinal system and body hair;

(ii) Urinalysis to include specific gravity, albumin, glucose and a microscopic on centrifuged sediment.

(3) Periodic medical examination. The employer shall make available to each employee exposed to airborne concentrations of soluble thallium compounds above the action level, without regard to the use of respirators, or employees who may have skin or eye contact with soluble thallium compounds, twelve months from the date of the employee's first exposure, and every twelve months thereafter, a periodic medical examination which must include the following:

(i) A medical history and physical examination with emphasis on the eyes, nervous system, lungs, liver, kidneys, gastrointestinal system and body hair;

(ii) Urinalysis to include specific gravity, albumin, glucose and a microscopic on centrifuged sediment.

(4) Alternative medical procedures. If the examining physician chooses to use alternative medical procedures to those specified in paragraphs (j)(2) and (j)(3) of this section, the employer may accept such alternative medical procedures as meeting the requirements of this section provided that the employer:

(i) Obtains a statement from the examining physician setting forth the alternative medical procedures, the rationale for substitution, and evidence that they will be equally effective;

(ii) Informs each exposed worker of the fact that alternative medical procedures to those required in paragraphs (j)(2) and (j)(3) of this section are to be made available.

(5) Interim medical examination. The employer shall provide an interim medical examination for the employee if the employee informs the employer of any of the signs or symptoms of exposure to soluble thallium compounds which are listed in Appendix A which the employee suspects are caused by exposure to soluble thallium compounds.

(6) Informing the physician. The employer shall provide to the physician performing any medical examination required by this section the following information:

(i) A copy of this regulation with Appendixes A, B, and C for soluble thallium compounds;

(ii) A description of the affected employee's duties as they relate to his exposure to soluble thallium compounds;

(iii) A description of any personal protective equipment and respirators required to be used;

(iv) The results of any measurements which may indicate the affected employee's exposure;

(v) The affected employee's anticipated exposure level; and

(vi) Upon request of the physician, any available information from previous medical examinations of the affected employee.

(7) Where a medical examination is required by paragraphs (j)(2), (j)(3), or (j)(5) of this section, following such examination the employer shall obtain from the examining physician a written opinion which conforms with paragraph (j)(8) of this section.

(8) Physician's written opinion. (i) The physician's written opinion by the examining physician shall specifically state:

(A) Whether the employee has any detected medical condition which would place the employee at increased risk of material impairment of the employee's health from exposure to soluble thallium compounds;

(B) Any recommended limitations upon the employee's exposure to soluble thallium compounds , including limitations upon the use of personal protective equipment and respirators;

(C) That the employee has been informed by the physician of any detected medical conditions which require further medical examination or treatment.

(ii) The physician's written opinion shall not reveal specific medical findings or diagnoses unrelated to the employee's employment.

(iii) The employer shall provide the employee with a copy of the physician's written opinion.

(9) Results of tests. Where a preplacement or periodic medical examination is required by paragraphs (j)(2) or (j)(3) of this section, following such examination the employer shall obtain from the examining physician for inclusion in the employee's medical record:

(i) A recording of the results of the urinalysis;

(ii) Where alternative medical procedures have been performed in accordance with paragraph (j)(4) of this section, a recording of such alternative procedures.

(10) No employee shall be exposed to soluble thallium compounds in such a way as would put the employee at increased risk of material impairment of his health from such exposure. The employer shall base this decision on any information available including the physician's written opinion.

(11) No medical procedure which would be performed pursuant to paragraphs (j)(2) or (j)(3) of this section need be performed if records of a previous such procedure performed within the past six months are acceptable to the examining physician.

(12) If an employee refuses any required medical examination, the employer shall inform the employee of the possible health consequences of such refusal and obtain a signed statement from the employee indicating that the employee understands the risk involved by refusal to be examined.

(13) The employer shall provide emergency medical treatment for any employee injured through exposure to soluble thallium compounds.

(k) RecordKeeping. (1) Exposure determination. (i) The employer shall keep an accurate record of all determinations required to be made pursuant to paragraph (b)(1) of this section.

(ii) This record shall include the written determination required in paragraph (b)(2) of this section.

(iii) This record shall be maintained until replaced by a more recent record.

(2) Exposure measurements. (i) The employer shall keep an accurate record of all measurements taken to determine employee exposure to soluble thallium compounds.

(ii) This record shall include:

(A) The date of measurement;

(B) Operations involving exposure to soluble thallium compounds which are being monitored;

(C) Sampling and analytical method used and evidence of their accuracy;

(D) Number, duration, and results of samples taken; and

(E) Name, social security number and exposure of the employee monitored.

(iii) This record shall be maintained until replaced by a more recent record but in no event for less than one year.

(3) Mechanical ventilation. (i) When mechanical ventilation is used as an engineering control, the employer shall maintain an accurate record of the measurements demonstrating the effectiveness of such ventilation required by paragraph (d)(3) of this section.

(ii) This record shall include:

(A) Date of measurement;

(B) Type of measurement taken;

(C) Result of measurement.

(iii) These records shall be maintained for at least one year.

(4) Employee training and information. (i) The employer shall keep an accurate record of all employee training and information required by paragraph (i) of this section.

(ii) This record shall include:

(A) Date of training;

(B) Name and social security number of employee trained;

(C) Content or scope of training provided.

(iii) This record shall be maintained until replaced by a more recent record.

(5) Medical surveillance. (i) The employer shall keep an accurate record of employee medical surveillance required by paragraph (j) of this section.

(ii) This record shall include:

(A) The name and social security number of the employee;

(B) Results of tests required by paragraph (j)(2) and (j)(3) of this section and results of any tests conducted pursuant to paragraphs (j)(4) of this section;

(C) Any employee medical complaints relative to exposure to soluble thallium compounds;

(D) A copy of information provided to the physician pursuant to paragraph (j)(6)(ii), (iii), (iv), (v), and (vi) of this section.

(E) Physician's written opinion; and

(F) A signed statement of any refusal to be examined.

(iii) This record shall be maintained for the duration of and for five years after termination of the employment of the affected employee.

(6) Access to records. (i) All records required to be maintained by this section shall be made available upon request to authorized representatives of the Assistant Secretary of Labor for Occupational Safety and Health and the Director of the National Institute for Occupational Safety and Health.

(ii) Each employee or former employee shall have access to the exposure determination and exposure measurement records required to be maintained by this section which indicate his own exposure to soluble thallium compounds.

(iii) Employee medical records required to be maintained by this section shall be made available upon written request to a physician designated by the employee or former employee.

(l) Employee observation of measurement. (1) The employer shall give each employee or his representative an opportunity to observe any measurement of his exposure to soluble thallium compounds which is conducted pursuant to this section.

(2) When observation of measurement of employee exposure to soluble thallium compounds requires entry into an area where the use of personal protective devices, including respirators, is required, the observer shall be provided with and required to use such equipment and comply with all other applicable safety procedures.

(3) Without interfering with the measurement, observers shall be entitled to:

(i) Receive an explanation of the measurement procedure.

(ii) Visually observe all steps related to the measurement of the airborne concentration of soluble thallium compounds that are being performed at the place of exposure; and

(iii) Record the results obtained.

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NOTE: The information contained in the following appendix for soluble thallium compounds is neither intended, by itself, to create any additional obligations not otherwise imposed, nor detract from any existing obligations. To the extent the information supplements this regulation for soluble thallium compounds, it is advisory in nature.

APPENDIX A

SUBSTANCE SAFETY DATA SHEET
FOR SOLUBLE THALLIUM COMPOUNDS

I. SUBSTANCE IDENTIFICATION

A. Substance: Soluble thallium compounds

B. Permissible Exposure: 0.1 milligram of soluble thallium compounds per cubic meter of air (mg/m3) averaged over an eight-hour work shift.

C. Appearance and Odor: Thallium sulfate, thallium acetate and thallium nitrate are all colorless, odorless solids.

II. HEALTH HAZARD DATA

A. Ways in which the chemical affects your body: Soluble thallium compounds can affect your body if you inhale them or if they come in contact with your eyes or skin or if you swallow them. They may enter your body through your skin.

B. Effects of Overexposure:

1. Soluble thallium compounds are very toxic and cause cumulative intoxication. Many deaths have resulted from swallowing these compounds. Poisoning from industrial exposure has been rarely reported--those that have were not fatal. Swallowing soluble thallium may cause nausea, vomiting, diarrhea, abdominal pain and bleeding from the gut. These symptoms are following or accompanied by drooping of the eyelids, crossed eyes, weakness, numbness and tingling of the arms and legs, trembling and pain and tightness in the chest. The hair may fall out after two to three weeks. Severe intoxication may result in prostration, rapid heart beat, convulsions and psychosis. Recovery may be complete but permanent effects such as staggering, visual difficulties, trembling and mental abnormalities have been reported. Liver and kidney damage have occurred. Repeated exposure over a prolonged period may produce variable symptoms. These may include loss of hair, soreness of the mouth, trembling, severe weight loss and emotional disturbance.

2. Reporting Signs and Symptoms: You should inform your employer if you develop any signs or symptoms and

suspect that they are caused by exposure to soluble thallium compounds.

III. EMERGENCY FIRST AID PROCEDURES

A. Eye Exposure: If soluble thallium compounds get into your eyes, wash your 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 this chemical.

B. Skin Exposure: If soluble thallium compounds get on your skin, promptly flush the contaminated skin with water. If soluble thallium compounds penetrate your clothing, remove the clothing promptly and flush the skin with water. Get medical attention.

C. Breathing: If you or any other person breathes in large amounts of soluble thallium 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.

D. Swallowing: When soluble thallium 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.

E. Rescue: Move 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 yourself. Understand your emergency rescue procedures and know the locations of the emergency rescue equipment before the need arises.

IV. RESPIRATORS AND PROTECTIVE CLOTHING

A. Respirators: Respirators are not the best way to control exposure to soluble thallium compounds. You can only be required to wear them for routine use if your employer is in the process of installing controls or control measures prove inadequate. You may be required to wear respirators for non-routine activities or in emergencies. If respirators are worn, they must have a Mining Enforcement and Safety Administration (MESA) or National Institute for Occupational Safety and Health (NIOSH) approval label. (Older respirators may have a Bureau of Mines approval label.) For effective protection, respirators must fit your face and head snugly. Respirators should not be loosened or removed in work situations where there use is required. If you experience difficulty breathing while wearing a respirator, tell your employer.

B. Protective Clothing: You must wear appropriate protective clothing and equipment to prevent skin contact with soluble thallium compounds where skin contact may occur. repair impervious clothing that has developed leaks.

C. Eye Protection: You must wear splash-proof safety goggles where liquids containing soluble thallium compounds may

contact your eyes. You must wear dust-resistant safety goggles where soluble thallium compounds compounds may contact your eyes.

V. PRECAUTIONS FOR SAFE USE, HANDLING AND STORAGE

A. Some soluble thallium compounds are combustible solids or strong oxidizers.

B. Soluble thallium compounds must be stored in tightly closed containers in a cool, well ventilated area.

C. If your work clothing may have become contaminated with soluble thallium compounds, you must change into uncontaminated clothing before leaving the work premises.

D. You must promptly remove any non-impervious clothing that becomes contaminated with soluble thallium compounds and this clothing must not be reworn until the soluble thallium compounds are removed from the clothing.

E. If your skin becomes contaminated with soluble thallium compounds, you must promptly wash or shower to remove any soluble thallium compounds from your skin.

F. You must not eat or smoke in areas where soluble thallium compounds are handled, processed or stored.

G. If you handle soluble thallium compounds, you must wash your hand thoroughly before eating, smoking or using toilet facilities.

H. Fire extinguishers, where provided, must be readily available and you should know where they are and how to operate them.

I. Ask your supervisor where soluble thallium compounds are used in your work area and for any additional safety and health rules.

VI. ACCESS TO INFORMATION

A. Each year your employer is required to inform you of the information contained in this Substance Safety Data Sheet for soluble thallium compounds. In addition, your employer must instruct you in the safe use of soluble thallium compounds, emergency procedures, and the correct use of protective equipment.

B. Your employer is required to determine whether you are being exposed to soluble thallium compounds. You or your representative have the right to observe employee exposure measurements and to record the results obtained. If your employer determines that you are being overexposed, he is required to inform you of the exposure and the actions which are being taken to reduce your exposure.

C. Your employer is required to keep records of your exposure and medical examinations. Your employer is required to keep exposure data for at least one year and to keep medical data during your employment, and for a period of five years following your termination of employment. Your employer is required to make the exposure data available to you upon your request. Your employer is also required to release your medical records to your physician upon your written request.

D. Your employer must give you a copy of the physicians written opinion for any physical examination required by this standard.

NOTE: The information contained in the following appendix for soluble thallium compounds is neither intended, by itself, to create any additional obligations not otherwise imposed, nor detract from any existing obligations. To the extent the information supplements this regulation for soluble thallium compounds, it is advisory in nature.

APPENDIX B

SUBSTANCE TECHNICAL GUIDELINES FOR SOLUBLE THALLIUM COMPOUNDS

(This standard for soluble thallium compounds should not be interpreted to appl substances listed below for which substance specific information has been provi

I. PHYSICAL AND CHEMICAL DATA

A. Substance Identification

1. Synonyms: 1) Thallium sulfate; thallous sulfate; 2) Thallium acetate; thallous acetate; 3) Thallium nitrate; thallous nitrate
2. Formula: 1) Tl_2SO_4; 2) $TlC_2H_3O_2$; 3) $TlNO_3$
3. Molecular weight: 1) 504.8; 2) 263.4; 3) 266.4

B. Physical Data

1. Boiling point (760 mm Hg): Decomposes
2. Specific gravity (water = 1): 1) 6.8; 2) 3.7; 3) 5.5
3. Vapor density (air = 1 at boiling point of soluble thallium compounds): Not applicable
4. Melting point: 1) 632 C (1170 F); 2) 110 C (230 F); 3) 206 C (403 F)
5. Vapor pressure at 20 C (68 F): Essentially zero
6. Solubility in water, % by weight at 20 C (68 F): 1) 4.87; 2) Very soluble; 3) 10
7. Evaporation rate (butyl acetate = 1): Not applicable
8. Appearance and odor: All 3 are colorless, odorless solids

II. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. Fire

1. Flash point: Data not available.
2. Autoignition temperature: Data not available
3. Flammable limits in air, % by volume: Data not available
4. Extinguishing media: Water, carbon dioxide, foam, dry chemical
5. Special fire-fighting procedures: Use water spray to cool containers exposed to a fire.

6. Unusual fire and explosion hazards: Some soluble thallium compounds are combustible solids or strong oxidizers.

B. Reactivity
1. Conditions contributing to instability: None
2. Incompatibilites: None.
3. Hazardous decomposition products: None.
4. Special precautions: None.

III. SPILL AND DISPOSAL PROCEDURES

A. If soluble thallium compounds are spilled, the following steps should be taken:
1. Ventilate area of spill.
2. For small quantities, sweep onto paper or other suitable material, place in a sealed container for disposal. Large quantities may be reclaimed, nowever, if this is not practical collect spilled material in the most convenient and safe manner and deposit in sealed containers for disposal.
3. Liquids containing soluble thallium compounds may be absorbed on vermiculite, dry sand, earth or other similar material and deposited in sealed containers for disposal.

B. Persons not wearing protective equipment should be restricted from areas of spills until cleanup has been completed.

C. Waste disposal methods: Soluble thallium compounds may be disposed of in sealed containers in a secured sanitary landfill.

IV. MONITORING AND MEASUREMENT PROCEDURES

A. EXPOSURE ABOVE THE ACTION LEVEL: Measurements taken for the purpose of determining employee exposure under this section are best taken such that the eight-hour exposure may be determined from a single eight-hour sample or 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). Sampling and analyses of particulates may be performed by instruments such as detector tubes certified by NIOSH under 42 CFR part 84, portable direct-reading instruments, dosimeters, or by collection of particulates using a high efficiency membrane filter with subsequent chemical analysis. The method of measurement must determine the concentration of soluble thallium compounds to plus or minus 35%.

B. EXPOSURE ABOVE THE PERMISSIBLE EXPOSURE: The monitoring and measurements under this section should be essentially the same as described under paragraph IV. A. Laboratories performing chemical analyses should be accredited in Industrial Hygiene Chemistry by the American Industrial Hygiene Association. The method of measurement must determine the concentration of soluble thallium compounds to plus or minus 25%.

C. METHODS: Methods meeting these accuracy requirements are available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161 under the title "NIOSH Analytical Methods for Set U" (Order number XXXXXXXXXX).

D. QUALIFIED PERSONS: Since many of the duties relating to employee protection are dependent on the results of monitoring and measuring procedures, employers should assure that the evaluation of employee exposures is performed by a competent industrial hygienist or other technically qualified person.

V. MISCELLANEOUS PRECAUTIONS

A. Store soluble thallium compounds in tightly closed containers in a cool, well ventilated area.

B. Employers should advise employees of all areas and operations where their exposure to soluble thallium compounds could occur.

VI. COMMON OPERATIONS

Common operations in which exposure to soluble thallium compounds is likely to occur are: During their production and use as reagents in analytical chemistry; in the manufacture of green pyrotechnic flares; in the manufacture of special optical glass and as pesticides (obsolete); and in the manufacture of medicinals.

NOTE: The information contained in the following appendix for thallium is neither intended, by itself, to create any additional obligations not otherwise imposed, nor detract from any existing obligations. To the extent the information supplements this regulation for thallium, it is advisory in nature.

APPENDIX C - MEDICAL SURVEILLANCE GUIDELINES

I. ROUTE OF ENTRY

Inhalation; skin absorption; ingestion.

II. TOXICOLOGY

Soluble thallium compounds are extremely toxic and cause a cumulative intoxication affecting primarily the nervous system and the body hair. Many deaths have resulted from ingestion. The lethal oral dose of thallium acetate for humans is estimated to be about 12 mg/kg body weight. Ingestion causes nausea, vomiting, diarrhea, abdominal pain and gastrointestinal hemorrhage which usually occur within 1 to 3 days. These are followed or accompanied by ptosis, strabismus; peripheral neuritis, pain, weakness, and paresthesias in the legs, tremor; retrosternal tightness and chest pain. Severe alopecia usually occurs after 2 to 3 weeks and is pathognomonic of the toxic effects of thallium. Severe intoxication may result in prostration, tachycardia, blood pressure fluctuations, convulsive seizures, choreiform movements, and psychosis. Recovery may be complete, but permanent residual effects such

as ataxia, optic atrophy, tremor, mental abnormalities, and footdrop have been reported. In cases of fatal intoxication, typical autopsy findings include pulmonary edema, necrosis of the liver, nephritis, and degenerative changes in peripheral axons. Prolonged ingestion of thallium produces a variable clinical picture which includes stomatitis, tremor, cachexia, polyneuropathy, alopecia, and emotional disturbance. In a study of 15 workers who had handled solutions of organic thallium salts over a 7.5 year period, 6 workers suffered thallium intoxication; chief complaints were abdominal pain, fatigue, weight loss, pain in the legs, and nervous irritability; 3 of the workers had albuminuria and 1 had hematuria.

III. SIGNS AND SYMPTOMS

Nausea, vomiting, diarrhea, abdominal pain; ptosis, strabismus; peripheral neuritis, tremor; pain, weakness, and paresthesia in the legs; retrosternal tightness, chest pain, pulmonary edema; seizures, chorea, psychosis; liver and kidney damage; alopecia.

IV. SPECIAL TESTS

Determination of thallium in the urine. Urinary excretion of thallium does not occur in unexposed persons. No relationship between excretion rate and either exposure or appearance of symptoms has been established.

V. TREATMENT

Remove from exposure. Immediately flush eyes and skin with water. If swallowed and the person is conscious, induce vomiting. Give artificial resuscitation and administer oxygen if indicated. Consideration should be given to hospitalization and observation for the possible delayed onset of pulmonary edema. Observe for convulsions and initiate appropriate treatment. A variety of chelating agents have been suggested for treatment; results have been inconsistent and controversial.

VI. SURVEILLANCE AND PREVENTIVE CONSIDERATIONS

A. GENERAL

Soluble thallium compounds can cause severe nervous system damage. Alopecia is pathognomonic but does not always occur. Skin absorption is known to occur. It is important that the physician become familiar with plant operating conditions in which exposure to thallium occurs. Those with skin disease may not tolerate the wearing of protective clothing and those with chronic respiratory disease may not tolerate the wearing of negative pressure respirators.

B. PREPLACEMENT

The following medical procedures must be made available to each employee who is exposed to thallium:

1. A complete history and physical examination -- The purpose is to detect preexisting conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the eyes, nervous system, lungs, liver, kidneys, gastrointestinal tract, and body hair should be stressed.

2. Urinalysis -- Since kidney damage has been observed in humans exposed to thallium, a urinalysis shall be obtained to include at a minimum specific gravity, albumin, glucose and a microscopic on centrifuged sediment.

C. PERIODIC EXAMINATIONS

The above medical examinations are to be repeated on an annual basis.

VII. REFERENCES

1. American Conference of Governmental Industrial Hygienists: "Thallium," Documentation of the Threshold Limit Values for Substances in Workroom Air (3d ed., 2d printing), Cincinnati, 1974, p. 256.

2. Patty, Frank A.: Industrial Hygiene and Toxicology, Vol. II - Toxicology (2d ed. revised), Interscience Publishing Company, New York, 1963, pp. 1138-1143.

3. Browning, Ethel: Toxicity of Industrial Metals (2d ed.), Butterworths, London, 1969, pp. 317-322.

4. Bank, W.J., et al: "Thallium Poisoning," Archives of Neurology, 26:456-464, 1972.

5. Paulson, G., et al: "Thallium Intoxication Treated with Dithizone and Hemodialysis," Archives of Internal Medicine, 129:100-103, 1972.

6. Richeson, E.M.: "Industrial Thallium Intoxication," Industrial Medicine and Surgery, 27:607-619, 1958.

REFERENCES AND SOURCES
SOLUBLE THALLIUM COMPOUNDS
1910.1000

(f) Personal Protective Equipment, and, (h) Sanitation

Eye: Grant, "Toxicology of the Eye"

Skin: Spector, "Handbook of Toxicology;" International Labour Office, "Encyclopedia of Occupational Health and Safety;" American Conference of Governmental Industrial Hygienists, "Documentation of the Threshold Limit Values for Substances in Workroom Air;" Patty, "Industrial Hygiene and Toxicology;" Grant, "Toxicology of the Eye"

Ingestion: Browning, "Toxicology of Industrial Metals;" Gleason, "Clinical Toxicology of Commercial Products;" Thienes and Haley, "Clinical Toxicology;" American Conference of Governmental Hygienists, "Documentation of the Threshold Limit Values for Substances in the Workroom Air;" Hunter, "The Diseases of Occupations;" Spector, "Handbook of Toxicology;" Christensen, "NIOSH Toxic Substances List"

COMMENTS

Eye - Classifications: 2 and 6
Output statement numbers: 10 and 12 combined
Exceptions: None

According to Grant, "experiments concerned with the local effects of thallium on the eye suggest that contact of thallium salts with the eye, such as by accidental splash contamination, is unlikely to cause serious damage, especially if promptly washed away with water. Experimentally, a rather drastic exposur of rabbit eye for ten minutes to a neutral saturated solution of thallium chloride, with the epithelium preliminarily removed to facilitate penetration, caused moderate edema and haze in the cornea, which gradually cleared from the periphery, but left a nebulous area axially. Splash contact with intact epithelium presumably would be even less damaging."

Classifications of 2 and 6 are concluded to be most appropriate for these compounds.

Skin - Classifications: 2 and 6
Output statement numbers: 2, 5b, 7a, 17g, 17i, 20a
Exceptions: See below

Spector reports that "when applied in depilatory ointments to the skin it enters the circulation. In the body, thallium is widely distributed and very slowly excreted over months by the kidneys and intestine. Thallium is cumulative. Essentially, all thallium poisoning appears to be chronic poisoning, similar to lead poisoning. Acute toxicity follows, ordinarily, only relatively massive doses. The element is regarded as being more toxic than lead. The element tends to concentrate in liver, brain and skeletal muscle. . . Characteristic of chronic poisoning is complete loss of body hair, with potentially severe damage to many organs notably the central nervous system. The depilatory action is reversible . . . ."

According to the ILO, the substance is both "a skin sensitizer and cumulative poison which is toxic by . . .

skin absorption. Occupational . . . poisoning is normally the result of moderate, long term exposure, and the symptoms are usually far less marked than those observed in acute . . . intoxications."

The ACGIH notes "occupational poisoning was reported in connection with the preparation and use of thallium containing pesticides. Richeson described 12 cases of varying severity among 15 men using organic thallium salts. Absorption through the skin was postulated . . . ." Patty reports "six cases of . . intoxication were reported . . . among men working with solutions of organic thallium compounds . . . the intoxications resulted purely from skin contact."

Grant states that "irreversible damage to the optic nerves and the central nervous system is most likely to occur in chronic poisoning resulting from repeated or continuous intake of thallium, although in exceptional cases optic atrophy has been known to develop as a result of acute poisoning . . . Mahoney described three young women who had applied this cream to their face and arms daily for several months, and had gradually failing vision, accompanied by pains in the feet and legs, weakness, and loss of hair. They were found to have large central scotomas. Stine described a women who had similar experience;" however, her vision was improved after discontinuation of the thallium containing cream.

Thallium sulfate, acetate and nitrate were chosen as representative samples of the soluble compounds. They have melting points of 1170 degrees F, 268 degrees F and 403 degrees F respectively. The vapor pressure at 20 degrees C is given as essentially zero for all. Thallium sulfate is 4.87% soluble i water; the acetate "very soluble" and the nitrate 10% soluble.

Classifications of 2 and 6 are concluded to be satisfactory to prevent chronic poisoning, however, statement 2 is modified to include situations where contact with thallium compounds "may occur".

Ingestion - Classifications: 1 and 5
Output statement numbers: 5b, 19, 20a
Exceptions: 5b used instead of 5a since chronic poisoning is essential concern

Browning states that "thallium is an extremely toxic cumulative poison . . . absorption is rapid by the intestinal route . . . retention is fairly uniform by all parts of the animal body, though the kidneys usually contain the highest amount . . . In chronic poisoning one of the most striking features is loss of hair. Honslik et al. giving thallium acetate to rats in a dosage by mouth of about 0.45 mg/kg daily, found they all died suddenly at the end of 4 months, all having shown the typical depilatory action at the end of 6 weeks. . . Buschke and Peiser had had similar results from feeding 0.1 mg of the acetate daily to young rats . . . ." Browning adds that "one of the most striking instances of an outbreak of accidental poisoning is that described by Munch et al. in California,

due to the misuse of a preparation of barley grain, containing 1 per cent thallium sulfate . . . the grain . . . was cooked and eaten by at least 31" people, "of whom 6 died of acute thallitoxicosis within 16 days, one about 2 months later and 20 developed symptoms of poisoning with 1 - 3 days."

According to Gleason, "the ingestion of any thallous salt is followed, after a latent period of 12 to 24 hours, by a severe hemorrhagic gastroenteritis . . . Delirrium (sic), convulsions, and coma may appear rapidly, but more often the acute reaction subsides, only to be replaced by the gradual development of mild gastrointestinal disturbances, polyneuritis, encephalopathy, skin eruptions and hepatorenal injury. The mean lethal dose in an adult is probably about 1 gm . . . Two patients survived 1.3 gm. but another died after 3.2 gm." Thienes and Haley list 0.2 - 1 gm as fatal for adults and 8 - 10 mg will cause "epilation. Thallium sulfate and thallium acetate are the principal compounds responsible for poisoning."

The ACGIH reports that "Truhaut made extensive studies of thallium toxicity, and Downs and co-workers showed that thallium and thallic compounds were both extremely toxic."

Hunter says that "thallium is well recognized as a very pois substance and is considered to be more toxic than lead and almost as toxic as arsenic. Its effect is cumulative."

Spector lists the rat oral LD50 for thallium sulfate as 25 mg/kg; the single minimum dose for sheep as 8 mg/kg; for thallium acetate, Spector lists the dog oral MLD as 18.5 mg/kg with death occurring in 9 days. The oral dog LD for thallium nitrate is given as 45 mg/kg with death in 4 days.

Christensen lists the LDLo for thallium acetate for the rat as 25 mg/kg, and the LDLo for the dog as 19 mg/kg; thallium chloxide LD50 for the mouse is given as 24 mg/kg.

Classifications of 1 and 5 are concluded to be clearly warranted in view of the high toxicity and cumulative action of these compounds.

SUBSTANCE TECHNICAL GUIDELINES

The references cited for this document include:

Kirk-Othmer, "Encyclopedia of Chemical Technology," 2nd edition, Vol. 20, p. 63 (K-O)
"Lange's Handbook of Chemistry," 11th edition (Lange)
"Merck Index," 8th edition, 1968 (Merck)
Patty, F.A., "Industrial Hygiene and Toxicology," (Patty)

Sources of data items used:

I. A.
1. Synonyms: K-O, Merck
2. Formula: K-O, Lange
3. Molecular weight: Lange

B.
1. Boiling point: ADL
2. Specific gravity: Lange, Merck
3. Vapor density: Not applicable
4. Melting point: Lange, Patty
5. Vapor pressure: ADL
6. Solubility in water: Merck
7. Evaporation rate: Not applicable

8. Appearance and odor: Merck

II. A. 1. Flash point: Not applicable
2. Autoignition temperature: Not applicable
3. Flammable limits: Not applicable
4. Extinguishing media: ADL
5. Special fire fighting procedures: ADL
6. Unusual fire and explosion hazards: None

B. 1. Conditions contributing to instability: ADL
2. Incompatibilities: None
3. Hazardous decomposition products: None
4. Special precautions: None

III. A. Steps if released or spilled: ADL

C. Waste disposal method: ADL

V. Miscellaneous precautions: ADL

USE/EXPOSURE AND CONTROL DOCUMENT

References used in the preparation of this document include:

Browning, E., "Toxicity of Industrial Metals," Butterworths, 1969 (Browning)
Downs, W. L. et al., "Acute and Sub-Acute Toxicity Studies of Thallium Compounds," J.A.I.H.A., 21(5), p. 399, 1960 (Downs)
Gleason, M. N. et al., "Chemical Toxicology of Commercial Products," Williams and Wilkins Co., Baltimore, 1969 (Gleason)
Hunter, D., "The Disease of Occupations," 4th edition, Little, Brown and Company, Boston, 1969 (Hunter)
International Labour Office, "Encyclopedia of Occupational Health and Safety," Geneva, 1972 (ILO)
Kirk, R. and Othmer, D., "Encyclopedia of Chemical Technology," Interscience Publishers, 2nd edition, vol. 20, 1969 (K-O)
Lisella, F. A., Long, K. R. and Scott, H. G., "Toxicology of Rodenticides and their Relation to Human Health," J. Environ. Health, 33(3), p. 231 - 7, 1970 (Lisella)
"Mineral Facts and Problems," Bureau of Mines Bulletin 650, U. S. Dept. Interior, 1970 (Mineral Facts)
"Minerals Yearbook 1971," vol. I, U. S. Dept. Interior, Bureau of Mines (Yearbook)
Patty, F. A., "Industrial Hygiene and Toxicology," vol. II, Interscience Publishers, 1962 (Patty)
Spector, W. S., "Handbook of Toxicology," Saunders, Philadelphia, 1956 - 1959 (Spector)
Thienes, C. H. and Haley, T. J., "Clinical Toxicology," 5th edition, Lea and Febiger, 1972 (T/H)
Tikhova, T. S., "Problems of Labor Hygiene in the Production of Metallic Thallium and Its Salts," Hygiene and Sanitation, 29, p. 26 - 32, 1964 (NIOSH Technical Information Service NIOSH 33273)

References for Specific Use/Exposure

1. ILO, Yearbook, Mineral Facts, Tikhova (33273), K-O
2. Patty, K-O
3. Downs, Browning, Patty, Mineral Facts
4. K-O, ILO, Lisella, Browning, Gleason, Spector, Patty
5. Lisella, Browning, Gleason, K-O
6. K-O
7. Mineral Facts

References for Specific Control Methods

NIOSH/OSHA Draft Technical Standard
and Supporting Documentation for THALLIUM, SOLUBLE COMPOUNDS

1. ILO, Hunter, Lisella, Browning, T/H, Spector

RESPIRATOR TABLE DOCUMENTATION

SUBSTANCE: Soluble thallium compounds

D. O. L. STANDARD: 0.1 mg/M3

Eye Irritation Level: Grant describes some effects on the eye produced by systemic thallium poisoning. In addition, Grant states that "experiments concerned with the local effects of thallium on the eye suggest that contact of thallium salts with the eye, such as by accidental splash contamination, is unlikely to cause serious damage, especially if promptly washed away with water. Experimentally, a rather drastic exposure of a rabbit eye for ten minutes to a neutral saturated solution of thallium chloride, with the epithelium preliminarily removed to facilitate penetration, caused moderate edema and haze in the cornea, which gradually cleared from the periphery, but left a nebulous area axially. Splash contact with intact epithelium presumably would be even less damaging."

For the purposes of this standard, half- and quarter-facepiece respirators are permitted unless eye irritation occurs.

IDLH: 20 mg/M3

Basis for IDLH Value: Since there are no acute inhalation toxicity data avai upon which to base the IDLH for the soluble salts of thallium, research in this area is needed. The chosen IDLH has been estimated from the inf given in the Documentation of TLV's that "LD50 values for different compounds, by various routes of administration and for several species of animals ranged from 3 to 92 mg/kg." Further support for the chosen IDLH can be gained from the statement by Deichmann and Gerarde that "a dose of 0.2 gm (inorganic salts of thallium) may be lethal unless treatment is started promptly."

Other Toxicological Information: The Documentation of TLV's states that "according to Patty, thallium is one of the more toxic elements from the standpoint of both acute and chronic poisoning, and regardless of the rate of intake, LD50 values for different compounds, by various routes of administration and for several species of animals ranged from 3 to 92 mg/kg. The most characteristic symptom of intoxicat is alopecia (loss of hair). Other symptoms in acute poisoning relate chiefly to the gastrointestinal tract or nervous system. In chronic poisoning such manifestations as incoordination, paralysis of extremities, endocrine disorders and psychoses may develop.

"Heyroth, in a 1947 review of the literature, noted reports of 778 cases, 46 of them fatal, prior to 1933, and several more in the following 14 years. Most of these cases were caused by the ingestion of thallium salts, many of the victims being children. Reed et al. in a follow-up of 72 of over 130 children poisoned by thallium in Texas between 1954 and 1959, stated that since 1932 hundreds of cases of thallotoxicosis due to the ingestion of pesticides had been reported. In 26 of 48 children poisoned by thallium who were examined later, neurological abnormalities were found, with mental retardation and psychoses the most common findings.

"Occupational poisoning was reported in connection with the preparation and use of thallium containing pesticides. Richeson described 12 cases of varying severity among 15 men using organic thallium salts. Absorption through the skin was postulated, since

tests revealed no thallium in the air. The chief complaints were abdominal pain, fatigue, irritability, weight loss, and pains in the legs. Loss of hair was noted by only four men. In one of the worst cases a urinary thallium concentration of about 1 mg/liter was found.

"Truhaut made extensive studies of thallium toxicity, and Downs and co-workers showed that thallium and thallic compounds were both extremely toxic. Despite these investigations and reports, no satisfactory data exist from which to derive a threshold limit for thallium. The value of 0.1 mg/M3 is based largely on analogy with other highly toxic heavy metals. Truhaut considered this a satisfactory value to protect against systemic toxicity. The Soviet limit was 0.01 mg/M3."

Patty states that "the most characteristic symptom of Tl intoxication is the development of alopecia. Symptoms of acute poisoning are variable but are referable to the gastrointestinal tract and nervous system. Symptoms develop slowly, from several hours to 2 days. Digestive disturbances include metallic taste, salivation, stomatitis, nausea, vomiting, and abdominal pain. Vasomotor disturbances appear as puffiness of the cheek, eyelids and lips. Tingling pain in the extremities, muscular weakness, delirium, convulsions, and coma may ensue. Death may occur in a few days or after several weeks. Recovery is slow, requiring 6 or more months. Sequelae in the form of sensory and nervous disorders, such as ataxia and choreiform movements, blindness and paralyses of the special senses, psychoses, peripheral neuritis, and renal damage, are common."

The ILO states that "thallium is a skin sensitizer and cumulative poison which is toxic by ingestion, inhalation or skin absorption. Occupational exposure may occur during the extraction of the metal from thallium-bearing ores and, in particular, in the manufacture and use of thallium-salt vermin exterminators; nevertheless, occupational thallium poisoning is rare . . .

"Occupational thallium poisoning is normally the result of moderate, long-term exposure, and the symptoms are usually far less marked than those observed in acute accidental, suicidal or homicidal intoxication. The course is usually unremarkable and characterized by subjective symptoms; objective symptoms of polyneuritis may not be demonstrable for quite some time."

VAPOR PRESSURE AT 20 C: Thallium sulfate; thallium acetate; thallium nitrate; thallium oxide; thallium carbonate: Essentially zero

USE/EXPOSURE AND CONTROL DOCUMENT
SOLUBLE THALLIUM COMPOUNDS

	Use/Exposure	Principal Route of Entry	Currently Used Control Methods
1.	Inhalation of dust and skin contact with solid or liquid during manufacture, distribution, and maintenance of equipment. Production of thallium and compounds is an integral part of zinc production. Thallium sulfate is shipped in powder or crystalline form in glass bottles packed in wooden boxes.	A,B,D	Local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing, gloves); good personal hygiene practice
2.	Inhalation of dust and skin contact with solid or liquid during laboratory use for analytical purposes and for research	A,B,D	Local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing, gloves); good personal hygiene practice
3.	Inhalation of dust and skin contact with solid or liquid during use for manufacture of special lenses, plates, and prisms	A,B,D	Local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing, gloves); good personal hygiene practice
4.	Inhalation of dust and skin contact with solid during limited manufacture and rodenticidal use: federal restrictions in 1965 prohibiting use except by qualified governmental personnel and prohibiting household use	A,B,D	Local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing, gloves); good personal hygiene practice product substitution
5.	Inhalation of dust and skin contact with solid or liquid during use in manufacture of medicinals. Medical use of thallium compounds have been limited by the narrow margin between toxicity and therapeutic benefits.	A,B,D	Local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing, gloves); good personal hygiene practice

6.	Inhalation of dust and skin contact with solid or liquid during use in manufacture of pyrotechnic products (thallium compounds produce a bright green flame).	A,B,D	Local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing, gloves); good personal hygiene practice
7.	Inhalation of dust and skin contact with solid or liquid during use for manufacture of fuel additives for internal combustion engines	A,B,D	Local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing, gloves); good personal hygiene practice

A -- Inhalation
B -- Skin and eye contact resulting in localized irritation
C -- Ingestion
D -- Skin contact resulting in absorption and subsequent systemic poisoning

------ JES2 JOB STATISTICS ------

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