

Occupational Health Guideline for Sulfur Dioxide

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.

SUBSTANCE IDENTIFICATION

- Formula: SO₂
- Synonyms: None
- Appearance and odor: Colorless gas with a characteristic pungent odor. It can be a liquid at temperatures below -10 C (14 F).

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for sulfur dioxide is 5 parts of sulfur dioxide per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 13 milligrams of sulfur dioxide per cubic meter of air (mg/m³). NIOSH has recommended that the permissible exposure limit be reduced to 0.5 ppm as a time-weighted average for up to a 10-hour work shift, 40-hour work week. For more detailed information, the NIOSH Criteria Document for Sulfur Dioxide and the NIOSH testimony presented at the Department of Labor's Public Hearing on a Proposed Standard for Sulfur Dioxide should be consulted.

HEALTH HAZARD INFORMATION

- **Routes of exposure**
Sulfur dioxide can affect the body if it is inhaled or if it comes in contact with the eyes or skin.
- **Effects of overexposure**
Sulfur dioxide gas is intensely irritating to the eyes and respiratory tract causing burning of the eyes and tearing, coughing, and chest tightness. It may cause severe breathing difficulties. Severe exposures to sulfur dioxide

may cause a person to stop breathing. Liquid sulfur dioxide may cause eye burns with loss of vision and skin burns.

- **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 sulfur dioxide.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to sulfur dioxide at potentially hazardous levels:

1. **Initial Medical Examination:**

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the eyes and respiratory tract should be stressed. The skin should be examined for evidence of chronic disorders.

—14" x 17" chest roentgenogram: Sulfur dioxide causes human lung irritation. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Sulfur dioxide is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

2. **Periodic Medical Examination:** The aforementioned medical examinations should be repeated on an annual basis.

- **Summary of toxicology**

Sulfur dioxide gas is a severe irritant of the eyes, mucous membranes, and skin. Its irritant properties are due to the rapidity with which it forms sulfurous acid on contact with moist membranes. In combination with certain particulate matter and/or oxidants, the effects may be markedly increased. Approximately 90% of all sulfur dioxide inhaled is absorbed in the upper respiratory passages, where most effects occur; however, high concentrations may produce respiratory paralysis and pulmonary edema. Exposure to concentrations of 10 to 50 ppm for 5 to 15 minutes causes irritation of the eyes,

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.

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nose, and throat, rhinorrhea, choking, cough, and, in some instances, reflex bronchoconstriction with increased pulmonary resistance. Some 10 to 20% of the healthy young adult population is estimated to be hypersusceptible to the effects of sulfur dioxide, while the phenomenon of adaptation to irritating concentrations is a recognized occurrence in experienced workers. Workers repeatedly exposed to 10 ppm experienced upper respiratory irritation and some nosebleeds, but the symptoms did not occur at 5 ppm; in another study, initial cough and irritation did occur at 5 ppm and 13 ppm, but subsided after 5 minutes of exposure. In a human experimental study with the subjects breathing through the mouth, brief exposure to 13 ppm caused a 73% increase in pulmonary flow resistance; 5 ppm resulted in a 40% increase; 1 ppm produced no effects. Exposure of the eyes to liquid sulfur dioxide from pressurized containers causes corneal burns and opacification resulting in a loss of vision. The liquid on the skin produces skin burns from the freezing effect of rapid evaporation.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 64.1
2. Boiling point (760 mm Hg): -10 C (14 F)
3. Specific gravity (water = 1): 1.46 (liquid)
4. Vapor density (air = 1 at boiling point of sulfur dioxide): 2.26
5. Melting point: -75.5 C (-104 F)
6. Vapor pressure at 20 C (68 F): Greater than 1 atmosphere
7. Solubility in water, g/100 g water at 20 C (68 F): 10
8. Evaporation rate (butyl acetate = 1): Much greater than 1

• Reactivity

1. Conditions contributing to instability: Elevated temperatures may cause containers to burst.
2. Incompatibilities: Contact with some powdered metals and with alkali metals such as sodium or potassium may cause fires and explosions.
3. Hazardous decomposition products: None.
4. Special precautions: Liquid sulfur dioxide will attack some forms of plastics, rubber, and coatings.

• Flammability

1. Not combustible
2. Compressed gas cylinders containing sulfur dioxide should be stored in accordance with 29 CFR 1910.101.

• Warning properties

1. Odor Threshold: The *Documentation of TLV's* reports that "Henderson and Haggard gave the odor threshold as 3 to 5 ppm."
2. Eye Irritation Level: Patty states that "20 ppm is the least amount irritating to the eyes."
3. Other Information: Patty states that "sulfur dioxide is an irritant gas: 6 to 12 ppm causes immediate

irritation to nose and throat. Three tenths to 1 ppm can be detected by the average individual, probably by taste rather than by odor, and 3 ppm has an easily noticeable odor."

4. Evaluation of Warning Properties: Through odor and taste, sulfur dioxide can be detected at or below the permissible exposure limit. Nose and throat irritation occur within three times the permissible exposure limit. For the purposes of this guideline, therefore, sulfur dioxide is treated as a material with good warning properties.

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 of gas in a hydrogen peroxide-filled impinger with a subsequent chemical analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure sulfur dioxide may be used. An analytical method for sulfur dioxide is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 5, 1979, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00349-1).

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 the skin from becoming frozen from contact with liquid sulfur dioxide or from contact with vessels containing liquid sulfur dioxide.
- Any clothing which becomes wet with liquid sulfur dioxide should be removed immediately and not reworn until the sulfur dioxide has evaporated.
- Employees should be provided with and required to use splash-proof safety goggles where there is any possibility of liquid sulfur dioxide contacting the eyes.
- Where there is any possibility that employees' eyes may be exposed to liquid sulfur dioxide, an eye-wash fountain should be provided within the immediate work area for emergency use.

COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Use as bleaching and preservative agent in wood and pulp, sugar and food preparation industries; as a selective antiseptic in food industry and as a fumigating agent in ships	Process enclosure and/or local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as solvent in oil refineries; during synthesis in chemical, petroleum, textile, pharmaceutical, tanning, photography, metal, and rubber industries	Process enclosure and/or local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as refrigerant in commercial refrigerators	Process enclosure and/or local exhaust ventilation; general dilution ventilation; personal protective equipment
Use during extraction, enrichment, and recovery processes in mining and metallurgy industry	Process enclosure and/or local exhaust ventilation; general dilution ventilation; personal protective equipment

Operation

Use in miscellaneous processes during leather tanning, special glass manufacture, water treatment, textile processing, and chrome waste treatment

Controls

Process enclosure and/or local exhaust ventilation; 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 liquid sulfur dioxide or strong concentrations of sulfur dioxide gas get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If liquid sulfur dioxide gets on the skin, immediately flush the contaminated skin with water. If liquid sulfur dioxide penetrates through the clothing, remove the clothing immediately and flush the skin with water. If irritation or burns are present after washing, get medical attention.

• Breathing

If a person breathes in large amounts of sulfur dioxide, 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.

• 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 AND LEAK PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
- If sulfur dioxide is spilled or leaked, the following steps should be taken:
 1. Ventilate area of spill or leak to disperse gas.
 2. If in gaseous form, stop flow of gas. If source of leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to a safe place in the open air, and repair the leak or allow the cylinder to empty.
 3. If in liquid form, allow to vaporize.

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RESPIRATORY PROTECTION FOR SULFUR DIOXIDE

Condition	Minimum Respiratory Protection* Required Above 5 ppm
Gas Concentration	
20 ppm or less	Any chemical cartridge respirator with a cartridge(s) providing protection against sulfur dioxide.** Any supplied-air respirator.** Any self-contained breathing apparatus.**
100 ppm or less	A chemical cartridge respirator with a full facepiece and cartridge(s) providing protection against sulfur dioxide. A gas mask with a chin-style or a front- or back-mounted canister providing protection against sulfur dioxide. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 100 ppm 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 gas mask providing protection against sulfur dioxide. Any escape self-contained breathing apparatus.

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

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