

Occupational Health Guideline for Vanadium Pentoxide Dust

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: V_2O_5
- Synonyms: None
- Appearance and odor: Yellow-orange powder or dark gray flakes with no odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for vanadium pentoxide dust is a ceiling of 0.5 milligrams of vanadium pentoxide dust per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be reduced to a ceiling level of 0.05 mg/m^3 averaged over a 15-minute period. The NIOSH Criteria Document for Vanadium should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Vanadium pentoxide dust can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

• Effects of overexposure

1. Short-term Exposure: Vanadium pentoxide dust may cause irritation of the eyes, nose, throat, and respiratory tract. It may also cause bronchitis with wheezing and chest pain. A greenish discoloration of the tongue may occur.

2. Long-term Exposure: After symptoms have occurred following short-term exposure, repeated exposure may cause more severe symptoms of the same nature. In

addition, repeated exposure may cause chronic bronchitis. Repeated or prolonged exposure may also cause an allergic skin rash.

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 vanadium pentoxide dust.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to vanadium pentoxide dust 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 system should be stressed. The skin should be examined for evidence of chronic disorders.

—14" x 17" chest roentgenogram: Vanadium pentoxide dust may cause respiratory impairment. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Vanadium pentoxide dust is reported to cause asthmatic-like symptoms. Periodic surveillance is indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, except that an x-ray is considered necessary only when indicated by the results of pulmonary function testing. Vanadium in the urine may be evidence of absorption and excretion of this element since vanadium is not normally found in human urine.

• Summary of toxicology

Vanadium pentoxide dust is a respiratory and eye irritant. Sixteen workers exposed to concentrations of dust (and possibly some fume) in excess of 0.5 mg/m^3 with a mean particle size in the micron and submicron range developed conjunctivitis, nasopharyngitis, hacking cough, fine rales, and wheezing; in three workers exposed to the highest concentrations, the onset of symptoms occurred at the end of the first workday. The

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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bronchospastic element in the more seriously ill persisted for 48 hours after removal from exposure; rales lasted for 3 to 7 days, and in several cases cough lasted for up to 14 days. Among those with acute intoxication there was increased severity of symptoms from subsequent exposures of lesser time and intensity. Urinary vanadium excretion was detectable in 12 of the workers for periods of up to 2 weeks; vanadium in the urine may be evidence of absorption and excretion of this element, since vanadium is not ordinarily found in human urine. Workers exposed to a mixture of ammonium metavanadate and vanadium pentoxide at concentrations near 0.25 mg/m^3 developed green tongue, metallic taste, throat irritation, and cough. Another report of 36 workers examined 8 years after an acute respiratory reaction from vanadium pentoxide exposure indicated no evidence of either pneumoconiosis or emphysema, although six still had bronchitis with rhonchi resembling asthma and bouts of dyspnea. Two volunteers exposed to a concentration of 1 mg/m^3 for 8 hours developed a persistent cough which lasted for 8 days; 21 days after the original exposure, re-exposure for 5 minutes to a heavy cloud of vanadium pentoxide dust occurred, and within 16 hours marked cough developed; the following day, rales and expiratory wheezes were present throughout the entire lung field, but pulmonary functions were normal. Subjects exposed to a concentration of 0.2 mg/m^3 for 8 hours developed a loose cough the following morning; others exposed for 8 hours to 0.1 mg/m^3 developed slight cough with increased mucus which lasted 3 to 4 days. Both eyes and skin are irritated by the dust or by contact with an acid solution of vanadium pentoxide; eczematous lesions have occurred, and in three cases there was an allergic response to patch tests with sodium vanadate.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 181.9
2. Boiling point (760 mm Hg): 1750 C (3182 F) (decomposes)
3. Specific gravity (water = 1): 3.36
4. Vapor density (air = 1 at boiling point of vanadium pentoxide dust): Not applicable
5. Melting point: 690 C (1274 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 0.1
8. Evaporation rate (butyl acetate = 1): Not applicable

• Reactivity

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

• Flammability

1. Not combustible

• Warning properties

According to Grant, vanadium pentoxide dust "causes a sensation of burning and irritation of the eyes, and signs of conjunctivitis . . ." The eye irritation is accompanied by "irritation of the nose and throat. The respiratory irritation occurs at lower concentrations than does the ocular irritation. The local effects on the eye have also been observed in rabbits." The *Documentation of TLV's* states that "Gulko referred to eye and bronchial irritation from exposure at 0.5 to 2.2 mg/m^3 ."

MONITORING AND MEASUREMENT PROCEDURES

• Ceiling Evaluation

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of vanadium pentoxide dust. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of vanadium pentoxide dust on a mixed cellulose ester membrane filter, followed by chemical treatment and atomic desorption spectrophotometric analysis. An analytical method for vanadium pentoxide dust 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). ical Methods for Set 1" (order number PB 271 712).

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 repeated or prolonged skin contact with vanadium pentoxide dust.
- Non-impervious clothing which becomes contaminated with vanadium pentoxide dust should be removed promptly and not reworn until the vanadium pentoxide dust is removed from the clothing.
- Clothing contaminated with vanadium pentoxide dust should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of vanadium pentoxide dust from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the vanadium pentoxide dust, the person performing the operation should be informed of vanadium pentoxide dust's hazardous properties.
- Employees should be provided with and required to use dust-resistant safety goggles where vanadium pentoxide dust may contact the eyes.

SANITATION

- Skin that becomes contaminated with vanadium pentoxide dust should be promptly washed or showered to remove any vanadium pentoxide dust.
- Eating and smoking should not be permitted in areas where vanadium pentoxide dust is generated in the handling, processing, or storing of vanadium pentoxide.
- Employees who handle vanadium pentoxide dust should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Liberation from cleaning and maintenance of furnaces, boilers, and gas turbines	Local exhaust ventilation; personal protective equipment
Liberation from mining and processing of ores; extraction from slag	Process enclosure; local exhaust ventilation (if possible); personal protective equipment
Liberation from use as a catalyst in the preparation of organic and inorganic compounds	Process enclosure; local exhaust ventilation (if possible); personal protective equipment

Operation

Liberation from chemical synthesis; use in manufacture of ultraviolet filter glass to prevent radiation injury and fading of fabrics

Liberation from use in manufacture of afterburners for automobiles

Liberation from use in textile industry as a catalyst to yield intensive black dyes; use in printing industry as a catalyst for formation of resinous black pigments from tar oils

Liberation from use in ceramics industry in manufacture of ceramic pigments

Liberation from use as a component of special steels in electric furnace steels, welding rods, and permanent magnets

Controls

Process enclosure; local exhaust ventilation (if possible); personal protective equipment

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Local exhaust ventilation

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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 vanadium pentoxide dust gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation persists after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If vanadium pentoxide dust gets on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If vanadium pentoxide dust penetrates through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation is present after washing, get medical attention.

• Breathing

If a person breathes in large amounts of vanadium pentoxide dust, 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 vanadium pentoxide dust has been swallowed, 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 AND DISPOSAL PROCEDURES

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

- If vanadium pentoxide is spilled, the following steps should be taken:

1. Ventilate area of spill.

2. Collect spilled material in the most convenient and safe manner for reclamation, or for disposal in a secured sanitary landfill.

- Waste disposal method:

Vanadium pentoxide dust may be disposed of in a secured sanitary landfill.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Vanadium V," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

- American Industrial Hygiene Association: "Vanadium Pentoxide," *Hygienic Guide Series*, Detroit, Michigan, 1957.

- Browning, E.: *Toxicity of Industrial Metals* (2nd ed.), Butterworths, London, 1969.

- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.

- Elkins, H. B.: *Chemistry of Industrial Toxicology* (2nd ed.), Wiley, New York, 1959.

- Fairhall, L. T.: *Industrial Toxicology* (2nd ed.), Williams and Wilkins, Baltimore, 1957.

- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

- Hudson, T. G. F.: *Vanadium, Toxicology and Biological Significance*, Elsevier, New York, 1964.

- Hunter, D.: *Diseases of Occupations* (4th ed.), Little, Brown, Boston, 1969.

- International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.

- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . Occupational Exposure to Vanadium*, HEW Publication No. (NIOSH) 77-222, U.S. Government Printing Office, Washington, D.C., 1977.

- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.

- Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

- Sjoberg, S. G.: "Health Hazards in the Production and Handling of Vanadium Pentoxide," *Industrial Hygiene and Occupational Medicine*, 3:631, 1951.

- Stauden, A. (exec. ed.): *Kirk-Othmer Encyclopedia of Chemical Technology* (2nd ed.), Interscience, New York, 1972.

- Zenz, C., and Berg, B. A.: "Human Responses to Controlled Vanadium Pentoxide Exposure," *Archives of Environmental Health*, 14:709-712, 1967.

- Zenz, C., et al.: "Acute Vanadium Pentoxide Intoxication," *Archives of Environmental Health*, 5:542-546, 1962.

RESPIRATORY PROTECTION FOR VANADIUM PENTOXIDE DUST

Condition	Minimum Respiratory Protection* Required Above 0.05 mg/m ³
Particulate Concentration	
25 mg/m ³ 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.
70 mg/m ³ 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 70 mg/m ³ 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. Any escape self-contained breathing apparatus.

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

