

# Occupational Health Guideline for Vanadium Pentoxide Fume

## 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: Finely divided particulates dispersed in air.

## PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for vanadium pentoxide fume is a ceiling of 0.1 milligrams of vanadium pentoxide fume 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 fume can affect the body if it is inhaled or if it comes in contact with the eyes.

### • Effects of overexposure

**1. Short-term Exposure:** Vanadium pentoxide fume 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 acute exposure, repeated exposure may cause more severe symptoms of the same nature. In addition, repeated exposure may cause chronic bronchitis. Re-

peated or prolonged exposure may 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 fume.

### • Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to vanadium pentoxide fume 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 fume may cause respiratory impairment. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Vanadium pentoxide fume 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.

### • Summary of toxicology

Vanadium pentoxide fume is a respiratory and eye irritant; the fume is recognized as being generally more toxic than dust of larger particle size, so similar effects from fume could be expected at lower concentrations. 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

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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 it is not ordinarily found in human urine. Workers exposed to a mixture of ammonium metavanadate and vanadium pentoxide at concentrations near  $0.25 \text{ mg/m}^3$  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 dust at a concentration of  $1 \text{ mg/m}^3$  for 8 hours developed 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 dust at a concentration of  $0.2 \text{ mg/m}^3$  for 8 hours developed a loose cough the following morning; others exposed for 8 hours to  $0.1 \text{ mg/m}^3$  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) (for solid)
  3. Specific gravity (water = 1): 3.36 (for solid)
  4. Vapor density (air = 1 at boiling point of vanadium pentoxide fume): Not applicable
  5. Melting point: 690 C (1274 F) (for solid)
  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**

By analogy to vanadium pentoxide dust, which "causes a sensation of burning and irritation of the eyes and signs of conjunctivitis," according to Grant, vanadium pentoxide fume is treated as an eye irritant for the purposes of this guideline. The *Documentation of TLV's* states that "Gulko referred to eye . . . irritation from exposures at 0.5 to 2.2  $\text{mg/m}^3$ "  $\text{V}_2\text{O}_5$  dust.

## 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 fume. 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 fume on a mixed cellulose ester membrane filter, followed by chemical treatment and atomic desorption spectrophotometric analysis. An analytical method for vanadium pentoxide fume 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).

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

## 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 fume.
- Employees should be provided with and required to use dust-resistant safety goggles where vanadium pentoxide fume may contact the eyes.

## SANITATION

- Eating and smoking should not be permitted in areas where vanadium pentoxide fume is generated in the handling, processing, or storing of vanadium pentoxide.

## COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Liberation from production of pellets from electric furnaces	Local exhaust ventilation; personal protective equipment
Liberation from fabrication of alloys for use as an additive in special steels	Local exhaust ventilation; personal protective equipment
Liberation from metallurgical processes in furnaces	Process enclosure
Liberation from manufacture of semi-conductors fused with sodium oxide	Process enclosure; local exhaust ventilation

## EMERGENCY FIRST AID PROCEDURES

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

### • Breathing

If a person breathes in large amounts of vanadium pentoxide fume, 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 PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of releases until cleanup has been completed.
- If potentially hazardous amounts of vanadium pentoxide fume are inadvertently released, ventilate the area of the release to disperse the fume.

## ADDITIONAL INFORMATION

To find additional information on vanadium pentoxide fume, look up vanadium pentoxide fume in the following documents:

- Medical Surveillance for Chemical Hazards
- Respiratory Protection for Chemical Hazards
- Personal Protection and Sanitation for Chemical Hazards
- NIOSH Criteria Document for Vanadium (August 1977)

These documents are available through the NIOSH Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226.

## 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.
- 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.
- 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.
- Zenz, C., and Berg, B. A.: "Human Responses to Controlled Vanadium Pentoxide Exposure," *Archives of EnviroHealth*, 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 FUME

Condition	Minimum Respiratory Protection* Required Above 0.05 mg/m <sup>3</sup>
Particulate Concentration	
5 mg/m <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> 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.