# Vanadium (as V2O5), (dust & fume)

| CAS number: | 1314-62-1 |
| --- | --- |
| Synonyms: | Divanadium pentoxide, vanadic anhydride,  vanadium (V) oxide |
| Chemical formula: | V2O5 |

Workplace exposure standard (retained)

| TWA: | **0.05 mg/m3 (as inhalable dust)** |
| --- | --- |
| STEL: | **—** |
| Peak limitation: | **—** |
| Notations: | **Carc. 2** |
| IDLH: | **35 mg V/m3** |
| **Sampling and analysis:** The recommended value is quantifiable through available sampling and analysis techniques. | |

## Recommendation and basis for workplace exposure standard

A TWA of 0.05 mg/m3 is recommended to protect for irritation of the upper respiratory tract (URT) in exposed workers.

## Discussion and conclusions

Vanadium is encountered in the workplace during the maintenance of oil-fired burners (as pentoxide), including residues from vanadium containing oils. It is also used as a catalyst and in the manufacture of alloys, glass, ceramics, textiles dyes and photography developer.

The critical effect of exposure is URT irritation.

In a study in 24 male workers, a statistically significant difference is reported for eye, nose and throat irritation and productive cough and wheezing when vanadium concentrations were between 0.1 and 0.3 mg/m3 compared to 45 age matched controls. No upper respiratory symptoms (URT) reported in a study with subjects exposed at 0.2 to 0.5 mg/m3 (total dust) for 11 years in the vanadium industry. However, exposed workers had increased leukocytes on nasal biopsy and increased self-reported “wheezing” compared to a control group. Differences in nasal biopsy results between the exposed and controls resolved after exposure is reduced to the 0.02 to 0.08 mg/m3 range as inhalable equivalent concentrations (ACGIH,2018). Evidence of carcinogenic activity of inhaled vanadium pentoxide is reported in male and female mice at exposures as low as 1 mg/m3. However, the relevance of carcinogenicity to humans is not known (ACGIH, 2018; NICNAS, 2016).

Given URT irritation occurs in workers at 0.1 mg/m3 and decreases nasal biopsy results at an estimated range of 0.02 to 0.08 mg/m3, a TWA of 0.05 mg/m3 by ACGIH is recommended to be retained. This concentration is sufficiently low to protect for the irritation of the URT.

The measurement of vanadium dust and fume (as vanadium pentoxide) has been changed from respirable to inhalable dust in consideration of URT effects (ACGIH, 2018, DFG, 2005).

## Recommendation for notations

Classified as a carcinogen category 2 according to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

Not classified as a skin sensitiser or respiratory sensitiser according to the GHS.

There are insufficient data to recommend a skin notation.

# Appendix

### Primary sources with reports

| Source Year set Standard |
| --- |
| SWA 1991 TWA: 0.05 mg/m3 | |
|  |
| ACGIH 2009 TLV-TWA: 0.05 mg/m3 |
| TLV-TWA recommended to protect for URT irritation.  Measurement from respirable to inhalable fractions made in 2005 as URT the primary critical effect.  Summary of data:   * Statistically significant difference in eye, nose and throat irritation, productive cough and wheezing when vanadium pentoxide (V2O5) concentrations are 0.1–0.3 mg/m3 * Differences in nasal biopsy results between exposed workers and referents resolved after exposure reduced to 0.01–0.04 mg/m3,measured as total dust * a conversion factor of 2 applied to reflect levels that would have been measured had an inhalable particulate matter sampler been used and concentrations measured would have been higher * adjusted range of inhalable-equivalent concentrations not associated with nasal changes is 0.02–0.08 mg/m3 * based on this, a TLV–TWA as inhalable of 0.05 mg/m3 is recommended.   Human data:   * 9 volunteers (27–44 yr) studied after controlled exposures: * sporadic coughing developed after 5th exposure hour believed psychologic at the time reported in 2 volunteers exposed inadvertently at 1 mg/m3 for 8 h, rather than 0.5 mg/m3 as planned, * frequent coughing developed in both volunteers by evening near the end 7th exposure hour and persistent coughing began and remained for 8 d; no other signs of irritation * spirometry performed immediately following exposure and weekly for 3 wk was unchanged from pre-exposure spirometry * no changes in WBC counts, differential cell patterns, urinalysis or microscopy of nasal swabs * at 3 wk post exposure, same 2 volunteers inadvertently exposed to a heavy cloud of V2O5 dust while preparing for another test. Within 16 h, a marked productive cough developed; by the following day, rales and expiratory wheezes reported; spirometry normal * 5 volunteers exposed at 0.2 mg/m3 for 8 h developed a productive cough the following morning, ceased by day 10. Spirometry performed immediately post-test and 2 wk later unchanged from pre-exposure studies * 2 volunteers not previously exposed were exposed at 0.1 mg/m3 for 8 h. No symptoms reported during or immediately after; within 24 h considerable mucous (details unspecified) formed; this mucous easily cleared by slight coughing and disappeared completely after 4 d * An increased prevalence of nasal congestion and throat pain among exposed workers reported in cohort study consisting of 36 vanadium-exposed factory workers compared to a historical control of 703 mine and sawmill workers: * a decreased prevalence of normal nose, pharynx and throat examinations reported * laryngoscopic examination of the trachea showed percentage of normal tracheas approximately equal to the controls (not tested for statistical significance) * workers were at concentrations of 0.03–6.5 mg/m3 with 22% of the dust <8 µm and 39% <12 µm in diameter * In a V2O5 production plant, a cohort of 63 men employed for 11 y average compared to an age and smoking status matched referent group exposed to inert dust only: * subjects exposed to 0.2–0.5 mg/m3 average (as V) measured using total-dust samplers. Subsequent sampling reported the fraction of sampled particles <5 µm to be 20%. * increase in “wheezing” among exposed workers, by questionnaire, but no increase in prevalence of cough or other respiratory symptoms * there was a statistically significant increase in the number of neutrophils noted on nasal smears and plasma and round cells in biopsy specimens in exposed group * differences in nasal biopsy results between the exposed and referents resolved after exposure reduced to 0.01–0.04 mg/m3 (measured as total dust) * The following reported in a study of 24 male workers exposed at 0.1–0.93 mg/m3 V2O5 (as V) compared to 45 controls: * except for one measurement all other concentrations between 0.1–0.3 mg/m3, >92% of particles <5 µm * statistically significant difference in eye, nose and throat irritation; productive cough; and wheezing * on physical exam, statistically significant difference in wheezes, rales, rhonchi, injected pharynx and green tongue between the exposed and referents * Case reports of asthma among exposed workers (*Musk and Tees, 1982*) and small-scale case-control and cross-sectional studies suggest V2O5 exposure associated with increased bronchial responsiveness.   Animal data:   * Cytological, immunological and skin test results indicated absence of allergic sensitisation in a sub chronic inhalation studies of cynomolgus monkeys (no further details) * Observations in rabbits exposed at 0, 77, 109, 205 and 525 mg/m3 (V2O5) for 7, 4, 4 and 1 h, respectively, include: * all animals survived except for 2/4 animals at 205 mg/m3 (115 mg/m3 as V) * on autopsy, animals exhibited chronic inflammatory changes in nasal and tracheal mucosa, slight emphysema of lungs, bronchopneumonia patches, pyelonephritis and hepatitis * Chronic inflammatory changes in nasal and tracheal mucosa, slight emphysema of lungs, bronchopneumonia patches, pyelonephritis and hepatitis in rabbits exposed at 20–40 mg/m3 for 1 h/d for 5–8 mo * Effects reported in rats and mice exposed at 6 h/d, 5 d/wk for 2 yr to V2O5 aerosol (MMAD 1.2–1.3 μm) at 0.5 and 1.2 mg/m3 (rats) and at 1, 2 and 4 mg/m3 (mice) include: * statistically significant increase over chamber controls in alveolar/bronchiolar carcinoma in mice * non-statistically significant increase in alveolar/bronchiolar carcinoma in rats at all studied exposures * evidence of chronic inflammation in lungs in rats at the higher exposures and in mice at all exposures * Evidence of carcinogenic activity of inhaled V2O5 in male and female mice at exposures as low as 1 mg/m3 * Confirmed Animal Carcinogen with Unknown Relevance to Humans.   Insufficient data to recommend a skin or sensitiser notation or a TLV-STEL. |
| DFG 2005 Not assigned |
| No MAK assigned due to carcinogenic and genotoxic effects.  Vanadium and its inorganic compounds (inhalable fraction).  Summary of additional data:   * V2O5 caused a significant increased incidence of bronchioalveolar adenomas and carcinomas in mice and an incidence above historical controls in male rats (cited by ACGIH, 2018) * V2O5 caused DNA strand breaks in human lymphocytes * V(IV) and V(V) compounds caused micronucleus formation *in vitro* and *in vivo.* |
| SCOEL 2004 Not assigned |
| No TWA recommended due to carcinogenic potential as demonstrated in animals.  Summary of additional data:   * Refers to 2-yr inhalation study in mice and rats cited by ACGIH (2018) and DFG (2005); the biological mechanism underlying initiation and promotion of pulmonary disease and lung cancer induced by V2O5 not understood * Weight of evidence from available data suggests vanadium compounds do not produce gene mutations in standard *in vitro* tests in bacterial or mammalian cell. |
| OARS/AIHA NA NA |
| No report. |
| HCOTN NA NA |
| No report. |

### Secondary source reports relied upon

| Source |  | Year | Additional information |
| --- | --- | --- | --- |
| NICNAS |  | 2016 | * Acute respiratory symptoms (cough, sore and inflamed throat, wheezing, nasopharyngitis) observed in male workers (n=18) exposed at >0.5 mg/m3 for up to 2 wk; even after exposure had ceased * Refers to inhalation study in workers exposed for at least 6 mo at 0.2–0.9 mg/m3 cited by ACGIH (2018): * increased incidences of eye/nose/throat irritation, coughing, sputum production, wheezing and green discolouration of the tongue (likely from accumulation of chemical dusts on the tongue or the formation of tetravalent or trivalent vanadium complexes) compared to 45 age-matched controls. |

### Carcinogenicity — non-threshold based genotoxic carcinogens

| Is the chemical mutagenic? | No |
| --- | --- |
| **The chemical is not a non-threshold based genotoxic carcinogen.** |  |

## Notations

| Source | Notations |
| --- | --- |
| SWA | — |
| HCIS | Carcinogenicity – category 2 |
| NICNAS | NA |
| EU Annex | NA |
| ECHA | — |
| ACGIH | Carcinogenicity – A3 |
| DFG | Carcinogenicity – 2 |
| SCOEL | — |
| HCOTN | NA |
| IARC | Carcinogenicity – Group 2B |
| US NIOSH | NA |

NA = not applicable (a recommendation has not been made by this Agency); — = the Agency has assessed available data for this chemical but has not recommended any notations

### Skin notation assessment

Insufficient data to recommend a skin notation.

### IDLH

| Is there a suitable IDLH value available? | Yes |
| --- | --- |

## Additional information

| Molecular weight: | 181.88 |
| --- | --- |
| Conversion factors at 25°C and 101.3 kPa: | 1 ppm = 7.44 mg/m3; 1 mg/m3 = 0.13 ppm |
| This chemical is used as a pesticide: |  |
| This chemical is a biological product: |  |
| This chemical is a by-product of a process: |  |
| A biological exposure index has been recommended by these agencies: | ACGIH  DFG  SCOEL |

## Workplace exposure standard history

| Year | Standard |
| --- | --- |
| Click here to enter year |  |

## References

American Conference of Industrial Hygienists (ACGIH®) (2018) TLVs® and BEIs® with 7th Edition Documentation, CD-ROM, Single User Version. Copyright 2018. Reprinted with permission. See the [*TLVs® and BEIs® Guidelines section*](http://www.acgih.org/tlv-bei-guidelines/policies-procedures-presentations) on the ACGIH website.

Deutsche Forschungsgemeinschaft (DFG) (2009) Vanadium and its inorganic compounds (inhalable fraction) – MAK value documentation.

European Chemicals Agency (ECHA) (2019) divanadium pentaoxide; vanadium pentoxide – REACH assessment.

International Agency for Research on Cancer (IARC) (2006) Vanadium pentoxide. IARC Monographs on the evaluation of the carcinogenic risk to humans.

US National Institute for Occupational Safety and Health (NIOSH) (1994) Immediately dangerous to life or health concentrations – Vanadium dust & fume.