# Selenium compounds (as Se) excluding hydrogen selenide

| CAS number: | 7782-49-2 |
| --- | --- |
| Synonyms: | — |
| Chemical formula: | Se |
| Structural formula: | — |

Workplace exposure standard (retained)

| TWA: | **0.1 mg/m3 as Se** |
| --- | --- |
| STEL: | **—** |
| Peak limitation: | **—** |
| Notations: | **Sk.** |
| IDLH: | **1 mg/m3 as Se** |
| **Sampling and analysis:** The recommended value is quantifiable through available sampling and analysis techniques. | |

## Recommendation and basis for workplace exposure standard

A TWA of 0.1 mg/m3 (as Se) is recommended to protect for irritation and chronic systemic toxicity in exposed workers.

## Discussion and conclusions

Selenium (Se) is an essential nutrient necessary for amino acid synthesis. Commercial selenium supplies are generated as a by-product of copper ore refinement. It is used in the manufacture of glass, pigments, ceramics, electronics and rubber.

Critical effects of exposure are irritation of the upper respiratory tract, garlic odour on breath, headache, gastrointestinal (GI) distress, skin rashes and alopecia.

Quantitative occupational exposure data are limited and are presented in combination with dietary supplementation studies (ACGIH, 2018; DFG, 2011). A urinary concentration of 0.1 mg/L, corresponding to an air concentration of 0.1 mg/m3, was not associated with adverse effects in a workplace study and was recommended as a maximum allowable urinary concentration by the cited authors (ACGIH, 2018) (ACGIH, 2018). Cross-sectional studies of populations given dietary selenium supplements provide equivocal evidence for carcinogenicity and an association with the development of type 2 diabetes (DFG, 2011). Carcinogenicity studies with animals have produced insufficient evidence for carcinogenic activity (ACGIH, 2018; IARC, 1987; US EPA, 1991).

Based on the maximum allowable urinary level of 0.1 mg/L associated with an air concentration of 0.1 mg/m3 in a workplace study, the current TWA of 0.1 mg/m3 is recommended to be retained. This TWA is considered protective of irritation and chronic systemic toxicity from exposure to selenium and its compounds. Equivocal evidence for the development of type 2 diabetes in the available source material is not considered sufficiently robust to recommend a TWA on this basis.

## Recommendation for notations

Not classified as a carcinogen 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.

A skin notation is recommended due to evidence of adverse systemic effects following dermal absorption in humans and animals.

# Appendix

### Primary sources with reports

| Source Year set Standard |
| --- |
| SWA 2002 TWA: 0.1 mg/m3 | |
| Sourced from HSE. |
| ACGIH 2001 TLV-TWA: 0.2 mg/m3 |
| TLV-TWA intended to protect for eye and upper respiratory tract irritation, headache, garlic odour on breath, metallic taste and skin rashes. SeF6 and H2Se assessed separately.  Summary of information:  Essential nutrient, Se deficiency manifests in reduced glutathione activity; maximum activity achieved at a daily intake of 40 µg/d; maximum tolerable Se intake is 400 µg/d. Based on absence of reports of chronic toxicity (selenosis) in available workplace studies, TLV-TWA of 0.2 mg/m3 considered protective of potential systemic effects (derivation and discrepancy with the recommended OEL of 0.1 mg/m3 from a cited article are not discussed).  Human data:   * Several studies associated reduced malignant morbidity and mortality with serum Se concentrations (e.g. with dietary supplementation):   + reduced incidence of liver cancer (from 42% to 28%) in healthy population (no further details) given 15 ppm (Na2SeO4) in table salt as dietary supplement (3 yr) * Garlic odour on breath, skin rash, GIT distress, metallic taste and psychological effects (not specified) associated with SeO2 exposure in workplace study (n=200–300): * high exposure group at 3.6 mg/m3 had average urine concentrations 0.25–0.43 mg/L, * most other groups (not specified) exposed at 0.2–0.4 mg/m3 * cited article recommends maximum allowable urinary concentration of 0.1 mg/L, which is considered equivalent to 0.1 mg/m3 * Intense irritation of eyes, nose and throat and headache in workers briefly exposed to high concentrations as fumes (concentration and duration not specified) * Application of SeS2 to damaged human skin resulted in systemic toxicity (no further details).   Animal data:   * Na2SeO3 and Na2SeO4 are the most soluble and toxic common Se compounds: * LD50: 4.8–7.0 mg Se/kg (rats) for Na2SeO3 * Dose-dependent increases in plasma, erythrocyte, liver, cardiac and skeletal muscle Se concentrations in repeat feeding study at 2.5–10 ppm Na2SeO3 or Na2SeO4 of diet (rats, 6 wk): * all rats died at 10 ppm of diet by 29 d * Dose-dependent emesis, anorexia, lethargy, dyspnoea and hypothermia at 0.1–100 ppm Na2SeO3 of diet (pigs, 84 d): * Se accumulated dose-dependently in liver and kidneys * Equivocal evidence for carcinogenicity in chronic animal feeding/gavage studies:   + US National Cancer Institute concluded SeS2 caused increased liver and alveolar/bronchiolar carcinomas at 3–15 mg/kg/d in male mice, but not in female mice or rats (rats, mice, gavage, 7 d/wk, 103 wk); dose-dependent deposition of Se in lungs in rats   + high concentrations of Se (e.g. 16 ppm Na2SeO3 in diet) associated with chronic liver toxicity, but also tumour suppression in chronically exposed model species (no further details) * Weakly mutagenic *in vitro* in bacterial and mammalian cell lines.   Insufficient data to assign TLV-STEL or notations for carcinogenicity, skin, or sensitisation. |
| DFG 2010 MAK: 0.02 mg/m3 |
| Summary of additional information:  A daily intake of 200 µg/d of Se corresponds to a serum concentration increase of 75 µg/L; serum Se concentration of 147 µg/L is not associated with an increased risk of diabetes as concluded from cross-sectional study. Average Se serum levels in German populations is 75 µg/L, MAK therefore provisionally set at 0.02 mg/m3, equates to an additional daily intake of 200 µg/d and is expected to maximally increase serum Se concentrations to a level that does not appreciably increase the risk of diabetes in German populations.  Classified as category 3B carcinogen based on positive *in vivo* clastogenicity and weak evidence for carcinogenicity in rats chronically exposed to Na2SeO4 and mice and rats exposed to SeS2.  Skin notation warranted based on reports of systemic effects from dermal exposure reported in humans and animals, which are supported by model calculations.  Human data:   * Calculated dermal penetration rate of saturated aqueous solution of Se from 3 models: 0.002, 0.004 and 0.012 mg/cm2/h * Skin rash and alopecia associated with blood concentration of 500 µg/L in exposed worker (no exposure details provided): * unexposed colleagues had blood concentrations of 50 µg/L * No effect on development of prostate cancer in men (n=35,533) given 200 µg/d of Se-containing amino acid: * study terminated prematurely due to possible increase of type 2 diabetes in participants * Slightly, but significantly, higher serum concentrations found in participants with type 2 diabetes diagnosis in cross-sectional study (n=8,876); increased OR for diabetes incidence in participants with serum concentrations ≥147 µg/L:   + cited article states that it is not possible to derive causality of diabetes incidence from serum Se concentrations from the available data * No statistically significant correlation between serum levels and fasting glucose levels or diabetes prevalence in cross-sectional studies in France and Singapore * No increase in risk of skin cancer observed in study participants (n=1,312) receiving 200 µg/d in baker’s yeast (containing 60% same amino acid as prostate cancer study).   Animal data:   * Cyanosis, tremor, lassitude and mortality above 25 mg SeS2 in 0.1 mL carboxymethylcellulose in repeat dermal application study with dose groups 0, 1, 5, 10, 25, 50 mg (mice, n=10/sex/dose, 5 /wk, 13 wk):   + 8/10 males and 10/10 females died at 50 mg   + nephritis in 1 female and liver calcification in another at 5 mg   + liver necrosis in 2 mice of each 5, 10, 25 and 50 mg dose group * Increased incidence of oesophageal cancer compared to controls (90% compared with 68%) at 0.13 mg/kg/d in feeding study with rats that had their duodenum surgically attached to their oesophagus (rats, 40 wk); study not considered in agency’s evaluation due to unconventional design * NOAEL: 0.28 mg/kg/d of Na2SeO4 for increased gestation and reduced birth weight reported in drinking water study (rats, GD 6 to birth): * LOAEL 0.46 mg/kg/d * Se compounds considered genotoxic *in vitro* based on positive results in bacterial and mammalian cell assays: * considered genotoxic *in vivo* based on evidence for micronucleus formation in mice administered ip doses of various Se compounds close to LD50 (1.2–14.2 mg).   Available sensitisation studies are inadequate to recommend a sensitiser notation. |
| SCOEL NA NA |
| No report. |
| OARS/AIHA NA NA |
| No report. |
| HCOTN NA NA |
| No report. |

### Secondary source reports relied upon

| Source |  | Year | Additional information |
| --- | --- | --- | --- |
| NICNAS |  | 2018 | * Tier I: not assessed. |
| IARC |  | 1987 | * Not classifiable as human carcinogen (Group 3) due to inadequate evidence in human and animal studies. |
| Nordic Council |  | 1993 | * Garlic odour on breath, irritation of the eyes, nose and throat and GIT disturbances in workers (n=29–31) of a copper smelter exposed above the TLV-TWA of 0.2 mg/m3. |
| US EPA |  | 1991 | * Inhalational RfD not evaluated * Available epidemiological data inadequate to assess carcinogenicity risk in humans due to non-specificity of studied Se compounds and lack of correlation between exposure and cancer risk. |
| ECHA |  | 2020 | * Long-term DNEL adopted from DFG (1999) MAK value of 0.05 mg/m3, based on no signs of toxicity in dietary studies of human populations consuming Se-containing vegetables leading to a daily intake of 0.91 mg/d. |
| US NIOSH |  | 1994 | * IDLH based on acute toxicity data in animals. |

### Carcinogenicity — non-threshold based genotoxic carcinogens

| Is the chemical mutagenic? | Yes |
| --- | --- |
| Is the chemical carcinogenic with a mutagenic mechanism of action? | Insufficient data |
| **Insufficient data are available to determine if the chemical is a non-threshold based genotoxic carcinogen.** | |

## Notations

| Source | Notations |
| --- | --- |
| SWA | — |
| HCIS | — |
| NICNAS | NA |
| EU Annex | — |
| ECHA | — |
| ACGIH | — |
| DFG | Carcinogenicity – 3B, H (skin) |
| SCOEL | NA |
| HCOTN | NA |
| IARC | Carcinogenicity – Group 3 |
| 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

| Calculation |
| --- |
| |  |  |  |  | | --- | --- | --- | --- | | Adverse effects in human case study: | yes | 4.00 |  | | Dermal LD50 ≤1000 mg/kg: |  |  |  | | Dermal repeat-dose NOAEL ≤200 mg/kg: | yes | 3.00 |  | | Dermal LD50/Inhalation LD50 <10: |  |  |  | | *In vivo* dermal absorption rate >10%: |  |  |  | | Estimated dermal exposure at WES >10%: | yes | 2.00 |  | |  |  | 2.5 | **a skin notation is warranted** | |

### IDLH

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

## Additional information

| Molecular weight: | 78.96 |
| --- | --- |
| Conversion factors at 25°C and 101.3 kPa: | 1 ppm = Number mg/m3; 1 mg/m3 = Number 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) (2011) Selenium and its inorganic compounds – MAK value documentation.

European Chemicals Agency (ECHA) (2020) Selenium – REACH assessment.

International Agency for Research on Cancer (IARC) (1987), Supplement 7, Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs Volume 1 to 42.

Nordic Expert Group for Criteria Documentation of Health Risks of Chemicals (1993) Criteria Documents from the Nordic Expert Group 1992. NR 1993:01.

US Environmental Protection Authority (US EPA) (1991) Integrated Risk Information System (IRIS) Chemical Assessment Summary – Selenium and compounds.

US National Institute for Occupational Safety and Health (NIOSH) (1994) Immediately dangerous to life or health concentrations – Selenium compounds (as Se).