# Iron pentacarbonyl (as Fe)

| CAS number: | 13463-40-6 |
| --- | --- |
| Synonyms: | Iron carbonyl, pentacarbonyliron |
| Chemical formula: | FeC5O5 |

Workplace exposure standard (amended)

| TWA: | **0.1 ppm (0.8 mg/m3)** |
| --- | --- |
| STEL: | **—** |
| Peak limitation: | **0.2 ppm (1.6 mg/m3)** |
| Notations: | **Sk.** |
| IDLH: | **0.4 ppm** |
| **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 ppm (0.8 mg/m3) is recommended to protect for lung damage in exposed workers.

A peak limitation of 0.2 ppm (1.6 mg/m3) is recommended to protect for acute and severe lung damage in exposed workers.

## Discussion and conclusions

Iron pentacarbonyl is used as an anti-knock agent in petrol and may form due to the reaction of finely divided iron with carbon monoxide.

Critical effects of exposure are lung damage, cyanosis and at higher concentrations adverse central nervous system (CNS) effects. Inhalational studies of rats demonstrate a steep dose-response relationship. A sub-chronic inalational study of rats reported a NOAEC of 0.3 ppm and a corresponding LOAEC of 1 ppm for lung damage with increased mortality at 3 ppm (DFG, 2012). Accordingly, the IDLH value was recently revised to reflect the sensitivity of these endpoints and their potential latency following acute exposures between 2.9 and 5.2 ppm (NIOSH, 2016).

The recommended TWA of 0.1 ppm (0.8 mg/m3) is based on the NOAEC of 0.3 ppm and divided by an uncertainty factor of three. This is the same as the TWA derived by ACGIH (2018; derivation not described) and DFG (2012). HCOTN (2002) recommended a TWA of 0.01 ppm based on the same NOAEC but divided by an uncertainty factor of 10. The 10-fold difference from the LOAEC is considered sufficiently protective (ECHA, 2019), and due to the severity and sensitivity of the toxic endpoints, a peak limitation of 0.2 ppm is recommended in place of a STEL.

## 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 based on evidence of adverse systemic effects following dermal exposure in animals.

# Appendix

### Primary sources with reports

| Source Year set Standard |
| --- |
| SWA 1991 TWA: 0.1 ppm (0.8 mg/m3); STEL: 0.2 ppm (1.6 mg/m3) | |
|  |
| ACGIH 2001 TLV-TWA: 0.1 ppm (0.8 mg/m3) as Fe  TLV-STEL: 0.2 ppm (1.6 mg/m3) as Fe |
| TLV-TWA and TLV-STEL intended to minimise potential for pulmonary oedema, cyanosis, headache and dizziness and at higher concentrations, paralysis.  Summary of data:  TLV-TWA and TLV-STEL based on weight of evidence including conclusion of a cited article that recommends the use of respiratory protection above 0.1 ppm. The derivation of this value is not discussed.  Human data:   * No human toxicological data available * Acute intoxication expected to have similar endpoints to nickel carbonyl, which are headache, dizziness and after 12–36 h, fever, cyanosis, cough and dyspnoea:   + although nickel carbonyl primarily targets lungs, central nervous system degeneration has also been related to exposure * Cited article recommends 0.1 ppm as an “action point” for occupationally exposed workers, respiratory protection is recommended for levels >0.1 ppm (no further information provided).   Animal data:   * LC50: 275 ppm (mice, 30 min), 115 ppm (rats, 30 min); lethal to rabbits at 250 ppm (45 min):   + respiratory distress, cyanosis, tremors and paralysis noted during exposure   + necropsy showed pulmonary congestion and oedema   + similar toxicity profile to nickel carbonyl * Lethal at single exposure at 33 ppm or 2 exposures at 18 ppm (rats, 5.5 h) * NOAEL: 7 ppm for lung damage in repeat inhalation study (rats, 5.5 h, 18 exposures):   + cited study tentatively recommends 2 ppm as an OEL * No mutagenicity or ADME data presented.   Insufficient data to recommend notations for carcinogenicity, skin absorption and sensitisation. |
| DFG 1970 MAK: 0.1 ppm (0.81 mg/m3) |
| Summary of additional data:  MAK based on NOAEC of 0.3 ppm for elevated COHb levels in a 28d inhalation study in rats. The safety margin of the MAK of 0.1 ppm compared with the NOAEC of 0.3 ppm is considered sufficiently high to protect for this effect.  Skin notation warranted due to low LD50 values in dermal application study.  Sensitisation notation not assigned due to negative results in poorly documented guinea pig sensitisation study.  Human data:   * High concentrations may lead to paralysis of the extremities (no further details).   Animal data:   * Dermal LD50: 56–170 mg/kg (rabbits, occlusive, 1–24 h):   + females were more sensitive than males   + impaired reflexes at 125 mg/kg   + 1% increase in COHb levels in blood at 250 mg/kg (females) * Increased COHb levels in blood after single oral, inhalational or dermal dose (mice, rats, cats, rabbits) * Non-sensitising to skin (guinea pigs) * Pulmonary oedema endpoint caused by Fe metabolite in lungs, co-administration of EDTA reduces Fe-induced toxicity (mice); CO and subsequent COHb metabolites are not present in high enough concentrations to cause lethality at lethal doses of iron pentacarbonyl (rats) * Rapid systemic distribution expected by analogy to nickel carbonyl, expected to bypass Fe homeostasis mechanisms due to high membrane permeability; oxidation and CO dissociation leads to Fe excretion in urine and faeces and exhalation of CO (rabbits) * Subchronic inhalation study with treatment groups 0.1, 0.3, 1, 3 and 10 ppm (rats, n=5/group/sex, 6 h/d, 5 d/wk, 28 d) reported:   + dose-dependent increase in COHb levels in males ≥0.1 ppm and females ≥0.3 ppm   + not considered toxicologically relevant based on small difference with control group COHb concentrations   + NOAEL: 0.3 ppm for lung damage   + increase in relative lung weights above 1 ppm   + mortality at 3 ppm; necropsy showed histopathological signs of irritation in upper respiratory tract and increased lung weight and significant lung damage   + all rats died within 4 d following exposure to 10 ppm * Non-mutagenic *in vitro* in bacterial cells, mammalian cell line or *in vivo* studies were not available.   Not classified as a carcinogen due to lack of information. |
| SCOEL NA NA |
| No report. |
| OARS/AIHA NA NA |
| No report. |
| HCOTN 2002 TWA: 0.01 ppm (0.08 mg/m3) |
| Summary of additional data:  Critical effects expected to be similar to those of nickel carbonyl; lung damage and adverse CNS effects.  Unclear if administrative OEL is measured by Fe content or total mass.  HBROEL derived from NOAEL of 0.3 ppm for lung damage in 28 d inhalation study in rats (also cited in DFG, 2012). An overall assessment factor of 12 is applied to account for sensitivity of the toxic endpoint, inter- and intraspecies differences and translation from experimental conditions to the workplace to afford a proposed TWA of 0.025 ppm (0.2 mg/m3) or 0.0063 ppm (0.05 mg/m3) as Fe.  Insufficient data to evaluate sensitisation potential. |

### Secondary source reports relied upon

| Source |  | Year | Additional information |
| --- | --- | --- | --- |
| HSE |  | 2002 | * TWA: 0.01 ppm (0.08 mg/m3). |
| NICNAS |  | 2018 | * Tier I assessment: no uses in Australia. |
| ECHA |  | 2019 | * Acute exposures to 5.2, 17, 28 and 60 ppm were all lethal except at 5.2 ppm (rats, 2 h) * Steep dose-response relationship recognised in 28 d inhalation study also cited in DFG (2012):   + Fe accumulation from chronic exposures at 1 ppm not discounted   + not proven due to short study duration   + study used to calculate DNEL, factor of 10 applied to the LOAEC of 1 ppm to arrive at 0.1 ppm, no allometric scaling was required due to inhalational administration route * Non-mutagenic *in vitro* in bacteria, no other mutagenicity data presented. |
| US NIOSH |  | 2016 | * 5.2 ppm was non-lethal and caused nasal discharge and lachrymation over 4 h:   + 2.91 ppm was lethal over 6 h (rats) * Small distance between severe non-lethal effects and mortality in acute exposure studies with animals indicates steep dose-response relationship * Delayed onset of death following acute exposure reported * IDLH based on a rat non-lethal concentration of 5.2 ppm (4 h), which corresponds to a concentration of 10.4 ppm following adjustment to 30 min:   + escape impairing effects (lachrymation, nasal discharge) reported at this concentration   + factor of 30 applied to account for extrapolation from a LOAEL to a NOAEL, sensitivity of effects, interspecies differences and human variability to afford IDLH of 0.4 ppm. |

### Carcinogenicity — non-threshold based genotoxic carcinogens

| Is the chemical mutagenic? | Insufficient data |
| --- | --- |
| 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 | NA |
| NICNAS | NA |
| EU Annex | NA |
| ECHA | — |
| ACGIH | — |
| DFG | H (skin) |
| SCOEL | NA |
| HCOTN | — |
| IARC | NA |
| 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: |  |  |  | | Dermal LD50 ≤1000 mg/kg: | yes | 3.00 |  | | Dermal repeat-dose NOAEL ≤200 mg/kg: |  |  |  | | Dermal LD50/Inhalation LD50 <10: | yes | 3.00 |  | | *In vivo* dermal absorption rate >10%: |  |  |  | | Estimated dermal exposure at WES >10%: |  |  |  | |  |  | 3 | **consider assigning a skin notation** | |

### IDLH

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

## Additional information

| Molecular weight: | 195.9 |
| --- | --- |
| Conversion factors at 25°C and 101.3 kPa: | 1 ppm = 8.15 mg/m3; 1 mg/m3 = 0.123 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) (2012) Eisenpentacarbonyl – MAK value documentation, German language edition.

European Chemicals Agency (ECHA) (2019) Pentacarbonyliron – REACH assessment.

Health Council of the Netherlands (HCOTN) (2002) Pentacarbonyliron. Health-based calculated occupational cancer risk values. The Hague: Health Council of the Netherlands; publication no. 2000/15OSH/036.

National Industrial Chemicals Notification and Assessment Scheme (NICNAS) (2016) Iron carbonyl (Fe(CO)5), (TB-5-11)-: Human health tier I assessment – IMAP report.

UK Health and Safety Executive (HSE) (2002) EH40/2005 Workplace exposure limits.

US National Institute for Occupational Safety and Health (NIOSH) (2016) Immediately dangerous to life or health concentrations – Iron Pentacarbonyl.