

# PHOSPHINE

**CAS number:** 7803-51-2

**Synonyms:** Hydrogen phosphide, phosphorated hydrogen, phosphorus trihydride, phosphorus hydride

**Chemical formula:**  $\text{PH}_3$

**Structural formula:** —

## Workplace exposure standard (amended)

**TWA:** 0.05 ppm (0.07 mg/m<sup>3</sup>)

**STEL:** —

**Peak limitation:** 0.15 ppm (0.21 mg/m<sup>3</sup>)

**Notations:** —

**IDLH:** 50 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 0.05 ppm (0.07 mg/m<sup>3</sup>) is recommended to protect for breathing difficulties and headaches in exposed workers.

A peak limitation of 0.15 ppm (0.21 mg/m<sup>3</sup>) is recommended to protect for acute respiratory tract irritation and pulmonary oedema in exposed workers.

## Discussion and conclusions

Phosphine is used as a fumigant and intermediate in pharmaceutical and polymer manufacture. It may be generated from the hydrolysis of metal phosphides.

Critical effects of exposure are breathing difficulties and headaches, with respiratory irritation at higher concentrations.

The onset of critical effects is reported above 0.17 ppm with a shift average of approximately 0.5 ppm in fumigation workers (ACGIH, 2018; DFG, 2010; SCOEL 1998). Additional symptoms of nausea and gastrointestinal pain are reported at 1 ppm (SCOEL, 1998). In animals, NOAEC for systemic haematological, liver and kidney effects range between 0.3 and 1 ppm (ACGIH, 2018; DFG, 2010). The dose-response relationship appears steep with respect to a LOAEC of 3 ppm for haematological changes (ACGIH, 2018; DFG, 2010), increased mortality at 5 ppm is reported in subchronic inhalation studies in rats (DFG, 2010) and one case of fatal pulmonary oedema is reported in a worker from exposure at 8 ppm (ACGIH, 2018).

Based on the onset of critical effects in occupationally exposed humans reported at average concentrations of 0.5 ppm, the TWA of 0.05 ppm derived by ACGIH (2019) is recommended to protect breathing difficulties and headaches in exposed workers.



In view of the steep dose-response relationship, a peak limitation of 0.15 ppm is recommended instead of a STEL. This is supported by ACGIH (2018) evaluation and is expected to protect for acute respiratory tract irritation and pulmonary oedema in exposed workers.

## **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.

There are insufficient data to recommend a skin notation.

DRAFT

## APPENDIX

### Primary sources with reports

Source	Year set	Standard
<b>SWA</b>	<b>1991</b>	<b>TWA: 0.3 ppm (0.42 mg/m<sup>3</sup>); STEL: 1 ppm (1.4 mg/m<sup>3</sup>)</b>
<b>ACGIH</b>	<b>2018</b>	<b>TLV-TWA: 0.05 ppm (0.07 mg/m<sup>3</sup>); TLV-Ceiling: 0.15 ppm (0.21 mg/m<sup>3</sup>)</b>
<p>TLV-TWA and TLV-Ceiling recommended to protect for breathing difficulties and adverse neurological effects.</p> <p>Summary of data:</p> <p>TLV-TWA and TLV-Ceiling derived from onset of breathing difficulty and headache at average shift exposure of 0.5 ppm and acute exposure of 1.5 ppm in fumigation workers. Presumably, a factor of 10 is applied to get a margin of safety.</p> <p>Human data:</p> <ul style="list-style-type: none"> <li>Generated in the gut from ingestion of metal phosphides and can cause heart and liver damage, e.g. aluminium phosphide (AP), which causes adverse cardiac effects</li> <li>Steep exposure-response relationship, acute overexposures cause GIT distress, liver damage, headache and breathing difficulties within 12–24 h</li> <li>Headache and difficulty breathing in fumigation workers (n=22) at average concentrations of 0.65–0.98 ppm (range: 0.17–2.11 ppm): <ul style="list-style-type: none"> <li>onset of adverse effects at average exposures of 0.5 ppm and acute exposures at 1.5 ppm, which are used as basis for TLV</li> </ul> </li> <li>1 fatal case of pulmonary oedema potentially due to exposure at 8 ppm 1–2 h/d (no further details)</li> <li>Neurological birth defects in 3.8% of children (n=14) from parents exposed to phosphine-generating pesticides compared to 1.5% from non-exposed parents (OR: 2.5).</li> </ul> <p>Animal data:</p> <ul style="list-style-type: none"> <li>LC<sub>50</sub>: 11 ppm (rats, 4 h); respiratory irritation, lachrymation and dyspnoea observed</li> <li>No histopathological changes (organs unspecified), mild clinical signs of sensory irritation and reversible reduced bw gain at 4 ppm (rats, 4 h/d, 9 d over 12 d period)</li> <li>No neurotoxicity at 0.3–3 ppm (rats, 13 wk, duration and frequency not specified)</li> <li>Decreased bw gain reported at 1–3 ppm and adverse haematological changes at 3 ppm (species and experimental details unspecified, 13 wk): <ul style="list-style-type: none"> <li>NOAEC: 0.37 ppm</li> </ul> </li> <li>No effects on body weight, haematology, clinical chemistry, urinalysis or ophthalmology at 0.3–3 ppm in controlled chronic inhalation study (rats, 6 h/d, 5 d/wk, 2 yr)</li> <li>No maternal or developmental toxicity at 0.03–4.9 ppm in controlled inhalation study (rats, 6 h/d, GD 6–15)</li> <li>Dose-related chromosomal damage <i>in vitro</i> with human lymphocytes also observed in pesticide workers</li> <li>Equivocal evidence for weak mutagenicity <i>in vivo</i>: <ul style="list-style-type: none"> <li>no increased micronucleus formation ≤5 ppm in repeat inhalation study (rats, mice, 6 h/d, 9 d over 11 d period); no effect on male germ cells in dominant lethal test under similar conditions</li> </ul> </li> </ul>		



Source	Year set	Standard
<ul style="list-style-type: none"> <li>○ increased micronucleus formation at 4.5 ppm (13 wk) and 5.5 ppm (2 wk) reported in separate studies with mice; evidence for genotoxicity not ruled out, but high concentrations, near the LD<sub>50</sub>, noted by cited article</li> </ul> <p>Not classified as a human carcinogen (A4) based on lack of carcinogenicity in chronically exposed rats.</p> <p>Insufficient data to recommend notations for skin absorption or sensitisation.</p>		
<b>DFG</b>	<b>1958</b>	<b>MAK: 0.1 ppm (0.14 mg/m<sup>3</sup>)</b>
<p>Summary of additional data:</p> <p>Assessment grouped with phosphine-generating metal phosphides. MAK retained precautionarily based on reported onset of headache and breathing difficulty in exposed fumigation workers at 0.17 ppm (also cited in ACGIH, 2018) and is expected to also protect for systemic haematological changes observed above a NOAEC of 0.37 ppm in rats in a subchronic inhalation study (also cited in ACGIH, 2018).</p> <p>Not classified as a carcinogen due to negative results in chronic carcinogenicity study with rats and lack of appreciable clastogenicity <i>in vivo</i> in humans.</p> <p>Human data:</p> <ul style="list-style-type: none"> <li>• Can inhibit cytochrome-c-oxidase causing oxidative stress</li> <li>• Evidence for chromosomal damage in exposed workers (n=12, follow-up n=6); no change in frequency of chromosomal breaks, but higher incidence of rearrangements, which were not detectable 8–12 mo post-exposure: <ul style="list-style-type: none"> <li>○ agency considers study indicative of genotoxicity in humans but requires further information for complete assessment due to mixed exposures to other pesticides</li> </ul> </li> <li>• Increased mortality from NHL, pancreatic cancer and leukaemia in grain mill workers (n=22,938) between 1955–1985 reported in 1 study: <ul style="list-style-type: none"> <li>○ increased mortality in male grain mill workers (n=1,114) reported in second study</li> <li>○ neither study used in carcinogenicity assessment due to lack of exposure data.</li> </ul> </li> </ul> <p>Animal data:</p> <ul style="list-style-type: none"> <li>• Haemoglobin, haematocrit and erythrocyte decrease at 1 ppm in repeat inhalation study (rats, 6 h/d, 5 d/wk, 13 wk, also cited in ACGIH, 2018)</li> <li>• Increased mortality and blood congestion, but no pulmonary, liver or kidney changes at 5 ppm (rats, 6 h/d, 8 d, then 8 h/d, 4 d, 12 d total)</li> <li>• Inflammation of the nasal cavity at 24–25 ppm (mice, 2–8 h); slight irritation (not specified) at 40 ppm (rats, 6 h), no effects on behaviour or neurological damage after 4 h,</li> <li>• Dyspnoea, ataxia, pulmonary oedema and organ hyperaemia at 54 ppm (cats, guinea pigs, 6.5 h).</li> </ul> <p>Insufficient data to recommend notations for skin absorption or sensitisation.</p>		
<b>SCOEL</b>	<b>1998</b>	<b>TWA: 0.1 ppm (0.14 mg/m<sup>3</sup>); STEL: 0.2 ppm (0.28 mg/m<sup>3</sup>)</b>
<p>Summary of additional information:</p> <p>OEL based on NOAEL between 0.3–1 ppm for systemic effects reported repeat inhalation studies with animals. UF of 3 applied to lowest NOAEL to account for concentration range, which results in TWA of 0.1 ppm. STEL of 0.2 ppm expected to be protective of acute effects, including irritation, from peak exposures.</p> <p>Available evidence does not warrant a skin notation.</p> <p>Human data:</p>		



Source	Year set	Standard
<ul style="list-style-type: none"> <li>Headache, nausea, respiratory irritation and gastrointestinal pain at 1 ppm reported in shipyard workers (no further details provided).</li> </ul> <p>Animal data:</p> <ul style="list-style-type: none"> <li>No effects on body weight gain, haematology, clinical chemistry or urinalysis at 1 ppm (rats, guinea pigs, cats, 4–6 h/d, 6 d/wk); severe toxicity and mortality at 5 ppm (no further details)</li> <li>Non-genotoxic based on overall evidence; weak genotoxicity at high doses likely due to generation of reactive oxygen species.</li> </ul> <p>Insufficient data to recommend a carcinogenicity notation.</p>		
<b>OARS/AIHA</b>	<b>NA</b>	<b>NA</b>
No report.		
<b>HCOTN</b>	<b>NA</b>	<b>NA</b>
No report.		

## Secondary source reports relied upon

Source	Year	Additional information
ECHA	✓ 2020	<ul style="list-style-type: none"> <li>OEL recommendation provided by SCOEL (1998) expected to be sufficiently protective of acute effects.</li> </ul>
US NIOSH	✓ 1994	<ul style="list-style-type: none"> <li>IDLH based on acute inhalation toxicity data in humans.</li> </ul>

## 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	—
NICNAS	NA
EU Annex	—
ECHA	—
ACGIH	Carcinogenicity – A4
DFG	—
SCOEL	—



Source	Notations
HCOTN	NA
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

Insufficient data to assign a skin notation.

## IDLH

Is there a suitable IDLH value available? Yes

## Additional information

Molecular weight:	33.99
Conversion factors at 25°C and 101.3 kPa:	1 ppm = 1.39 mg/m <sup>3</sup> ; 1 mg/m <sup>3</sup> = 0.719 ppm
This chemical is used as a pesticide:	<input checked="" type="checkbox"/>
This chemical is a biological product:	<input type="checkbox"/>
This chemical is a by-product of a process:	<input type="checkbox"/>
A biological exposure index has been recommended by these agencies:	<input type="checkbox"/> ACGIH <input type="checkbox"/> DFG <input type="checkbox"/> SCOEL

## Workplace exposure standard history

Year	Standard
Click here to enter year	

## References

American Conference of Industrial Hygienists (ACGIH®) (2018) TLVs® and BEIs® with 7<sup>th</sup> Edition Documentation, CD-ROM, Single User Version. Copyright 2018. Reprinted with permission. See the [TLVs® and BEIs® Guidelines section](#) on the ACGIH website.

Deutsche Forschungsgemeinschaft (DFG) (2010) Phosphorwasserstoff und Metallphosphide (AIP, Ca<sub>3</sub>P<sub>2</sub>, Mg<sub>3</sub>P<sub>2</sub>, Zn<sub>3</sub>P<sub>2</sub>) – MAK value documentation, German language edition.

EU Scientific Committee on Occupational Exposure Limits (SCOEL) (1998) Recommendation from the Scientific Committee on Occupational Exposure Limits for phosphine. SCOEL/SUM/58.

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

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