

Biological Exposure Index (BEI) review

PHENOL
(*PHENOL CAS NO: 108-95-2*)

March 2020

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1.0

Introduction

This WorkSafe New Zealand (WorkSafe) review considers changes to the Biological Exposure Index (**BEI**) for phenol.

Biological monitoring is an assessment of overall systemic exposure to chemicals by measurement of the chemicals, their metabolites, or conjugates in blood, urine or breath.

The review considers BEIs from other jurisdictions/organisations around the world and includes a recommendation to change the WorkSafe BEI for phenol, which is currently set at 120**mg/g** creatinine of phenol in urine, as published in the special guide *Workplace Exposure Standards and Biological Exposure Indices*, 11th Edition (WorkSafe, 2019).

It is noted that only biological guidance values which have a documented rationale for why they have been set at that level have been considered for this review.

It should be noted that WorkSafe is also proposing to adopt a **WES-TWA** for airborne phenol of 1**ppm** and **WES-STEL** of 2ppm.

Discussion on phenol exposures in New Zealand and its health effects are described in the WorkSafe Workplace Exposure Standards review of phenol (2020) included in this consultation period.

Phenol in urine can be analysed in New Zealand and Australia.

Terms that are **bold** (first occurrence only) are further defined in the Glossary.
Synonyms: Carboic acid; Hydroxybenzene; Oxybenzene; Phenic acid;
Phenylic acid; Phenyl hydroxide; Benzenol; Benzophenol.

2.0

Exposure standards

IN THIS SECTION:

2.1 ACGIH®

2.2 SCOEL

2.3 DFG

The WorkSafe BEI for phenol has been unchanged since it was introduced in 2002.

Table 1 below shows the current WorkSafe, ACGIH®, and SCOEL BEI values for phenol.

JURISDICTION OR ADVISORY BODY	BEI VALUE
WorkSafe New Zealand (2002)	120mg/g creatinine phenol in urine, following hydrolysis
ACGIH® (2006)	250mg/g creatinine phenol in urine, following hydrolysis
SCOEL (2003)	120mg phenol/g creatinine

TABLE 1:
BEI values adopted by WorkSafe, ACGIH® and SCOEL

2.1 ACGIH®

The ACGIH® 2006 review of phenol recommended a BEI of 250mg/g creatinine of phenol in urine, following hydrolysis. They state that:

- “The BEI® for phenol [of 250mg/g creatinine] is based on the relationship between inhalation occupational exposure to phenol at the **TLV-TWA** [of 5ppm] and the expected levels of phenol (with hydrolysis) from a urine specimen collected at the end of the shift.”
- Ohtsuji and Ikeda (1972) studied uptake and urinary excretion of phenol in workers. Their studies indicated that a 7-hour exposure to phenol at 4ppm would produce a urinary concentration of about 300mg phenol/g creatinine.
- Ogata *et al.* (1986), studying workers treating chemical fibres with phenol, concluded that the excretion of total phenol (phenyl glucuronide and phenyl sulphate) at the end of an 8-hour TWA exposure at 5ppm phenol equals 251mg/g creatinine.

(References cited in ACGIH®, 2006).

2.2 SCOEL

The 2003 *Recommendation from the Scientific Expert Group on Occupational Exposure Limits* (SCOEL) recommended a **BLV** of 120mg phenol/g creatinine as being potentially useful to assess occupational exposure to phenol.

They state that “An 8-hour exposure to 2ppm phenol would correspond to a urine concentration, measured at the end of the shift, of 120mg phenol/g creatinine (Piotrowski, 1971; Ohtsuji and Ikeda, 1972; Ogata *et al.*, 1986).” (References cited in SCOEL, 2003).

2.3 DFG

In its 2003 *Addendum to Phenol*, the DFG recommended a BLW of 200mg total phenol/L urine (DFG, 2005). They state that:

“Phenol absorbed by inhalation or through the skin is generally rapidly detoxified by glucuronidation. The critical toxic effects of phenol metabolism in the kidneys are caused mainly by free phenol. Normally only traces of free phenol can be detected in plasma, even after exposure to high phenol levels.” (DFG, 2005).

“Damage to the kidneys is observed when the plasma creatinine levels increase to above 1mg/dl and the proportion of free phenol detectable in urine exceeds 150µg/g creatinine (Lewalter and Neumann 1998). A value based on free phenol that could be used as a threshold value in biological material, has, to date, however, not yet been adequately validated. A value of 150µg free phenol/g creatinine is generally not exceeded by 95% of persons exposed to phenol with values up to 200mg total phenol/g creatinine, corresponding to a value of 200mg total phenol/l urine. In view of this, a BLW value has been set of 200mg total phenol/l urine.

“Sampling should be carried out at the end of exposure or the end of the shift.

“For 5% of persons exposed to phenol (UDPG-deficient persons), the determination of total phenol alone is, however, not sufficient protection. In such cases, additional determination of free phenol is recommended. The BLW value for total phenol should therefore be regarded as provisional until there are sufficient data available to be able to evaluate a threshold limit value for free phenol.” (DFG, 2005).“

There are data available from occupational-medical studies for the correlation between external and internal exposure to phenol (see Table 1). Since the last BAT documentation from 1994 of this series, the previous correlation data have been supplemented for the low dose range by a study with coking plant workers (Bieniek 1997) and by personal communications to the Commission.” (DFG, 2005).

AIR PHENOL (mean shift value) ml/m ³		URINE TOTAL PHENOL (mean)	REFERENCES
ppm	mg/m ³	mg/L urine	
0.08	0.3	10	Bieniek 1997
0.8	3	75 [50-91]	Lewalter, personal communication to the Commission
1.3	5	100	Piotrowski 1971
2.1	8	160 [135-189]	Lewalter, personal communication to the Commission
3.9	15	300	Ohtsuji and Ikeda 1972
5	19	451	Ogata <i>et al.</i> 1986

(DFG, 2005)

Based on the above table, at the proposed WES-TWA of 1ppm for phenol, the corresponding mean total phenol in urine is between 75-100mg/L.

TABLE 2:
Correlation between external and internal exposure to phenol after occupational exposure

3.0

Discussion

WorkSafe's BEI for phenol has been unchanged since adoption in 2002.

Based on the aforementioned documentation, informed by the conclusions of the ACGIH®, SCOEL and DFG reviews, and in particular the findings listed below, WorkSafe considers its current BEI of 120mg/g creatinine of phenol in urine to be inadequate to manage health risks from possible workplace exposure:

- The excretion of total phenol (phenyl glucuronide and phenyl sulphate) at the end of an 8-hour TWA exposure at 5ppm phenol equals 251mg/g creatinine (Ogata *et al.*, 1986, reported in ACGIH®, 2006).
- “An 8-hour exposure to 2ppm phenol would correspond to a urine concentration, measured at the end of the shift, of 120mg phenol/g creatinine (Piotrowski, 1971; Ohtsuji and Ikeda, 1972; Ogata *et al.*, 1986).” (References cited in SCOEL, 2003).
- “Damage to the kidneys is observed when the plasma creatinine levels increase to above 1mg/dl and the proportion of free phenol detectable in urine exceeds 150µg/g creatinine (Lewalter and Neumann 1998).” This corresponded with 190mg/g creatinine of total phenol (References cited in DFG, 2005).
- “A value of 150µg free phenol/g creatinine is generally not exceeded by 95% of persons exposed to phenol with values up to 200mg total phenol/g creatinine, corresponding to a value of 200mg total phenol/l urine” (DFG, 2005).
- Based on data available from occupational-medical studies for the correlation between external and internal exposure to phenol in the DFG review, the proposed WES-TWA of 1ppm for phenol would correspond to a mean total phenol in urine between 75-100mg/L (DFG, 2005).

4.0 Recommendations

WorkSafe considers its BEI of 120mg/g creatinine of phenol in urine (following hydrolysis) to be inadequate to manage health risks from possible workplace exposure, based on current knowledge.

It is proposed that WorkSafe adopt a BEI of 100mg/L total phenol in urine, taken at the end of exposure or the end of the shift, for assessing exposure to phenol.

Appendices

IN THIS SECTION:

Appendix 1: Glossary

Appendix 2: References

Appendix 1: Glossary

TERM	MEANING
ACGIH®	The American Conference of Governmental Industrial Hygienists (ACGIH®) is a member-based organisation, established in 1938, that advances occupational and environmental health. Examples of this include their annual edition of the TLVs® and BEIs® book and work practice guides. Store at: www.acgih.org/store
BEI	Biological Exposure Index. BEI® when referring to ACGIH Biological Exposure Index.
BLV	Biological Limit Value.
BLW	Biologische Leit-Werte are derived for carcinogenic substances and for substances without sufficient data to establish a BAT, a DFG term.
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation), the Permanent Senate Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, Federal Republic of Germany. The science-based MAK values are recommended to the German Minister of Labour and Social Affairs for possible adoption under the German Hazardous Substances Ordinance.
g	Gram.
mg	Milligram or one thousandth of a gram.
mg/g	Milligrams of substance per gram.
ml/m ³	Millilitres of substance per cubic metre of air; equivalent to ppm.
ppm	Parts of vapour or gas per million parts of air.
SCOEL	The Scientific Committee on Occupational Exposure Limits is a committee of the European Commission, established in 1995 to advise on occupational health limits for chemicals in the workplace within the framework of Directive 98/24/EC, the chemical agents directive, and Directive 90/394/EEC, the carcinogens at work directive.
SMR	Threshold Limit Value (see TLV-TWA below). An ACGIH® term. Please see the Statement of Position Regarding the TLVs® and BEIs® and Policy Statement on the Uses of TLVs® and BEIs®.
TLV®	Threshold Limit Value (see TLV-TWA below). An ACGIH® term. Please see the Statement of Position Regarding the TLVs® and BEIs® and Policy Statement on the Uses of TLVs® and BEIs®
TLV-TWA	TLV® - Time-Weighted Average; the TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed to, day after day, for a working lifetime without adverse effect. An ACGIH® term.
WES	Workplace Exposure Standard - WESs are values that refer to the airborne concentration of substances, at which it is believed that nearly all workers can be repeatedly exposed to, day after day, without coming to harm. The values are normally calculated on work schedules of five shifts of eight hours duration over a 40 hour week. A WorkSafe term.
WES-STEL	The 15-minute time-weighted average exposure standard. Applies to any 15-minute period in the working day and is designed to protect the worker against adverse effects of irritation, chronic or irreversible tissue change, or narcosis that may increase the likelihood of accidents. The WES-STEL is not an alternative to the WES-TWA; both the short-term and time-weighted average exposures apply. Exposures at concentrations between the WES-TWA and the WES-STEL should be less than 15 minutes, should occur no more than four times per day, and there should be at least 60 minutes between successive exposures in this range. A WorkSafe term.
WES-TWA	The average airborne concentration of a substance calculated over an eight-hour working day. A WorkSafe term.

Appendix 2: References

American Conference of Governmental Industrial Hygienists (ACGIH®). (2006). *Phenol BEI*. Chemical Substances (7th Ed.) Documentation. Cincinnati, Ohio: ACGIH®. From ACGIH®, *Documentation of the Threshold Limit Values and Biological Exposure Indices*, 7th Edition. Copyright 2001. Reprinted with permission.

Deutsche Forschungsgemeinschaft (DFG, German Research Foundation). (2005). *Addendum to Phenol*. The MAK Collection for Occupational Health and Safety, Vol.: 4 No. 1; pp 201-205. <https://onlinelibrary.wiley.com/doi/pdf/10.1002/3527600418.bb10895e0004>

Scientific Committee on Occupational Exposure Limits (SCOEL). (2003). *Recommendation from the scientific expert group on occupational exposure limits for phenol*. SCOEL/SUM/16. www.ser.nl/api/Mfiles/DownloadFirstDocument?id=3f275f11-52b4-4b4e-a3d9-38e9ba757f53

WorkSafe New Zealand. (2019). *Workplace Exposure Standards and Biological Exposure Indices*, (11th Ed.) November 2019. worksafe.govt.nz/topic-and-industry/work-related-health/monitoring/exposure-standards-and-biological-exposure-indices

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