**Supplement**

**to**

**Concentration-Time Extrapolation of Short-Term Inhalation Exposure Levels: Dimethyl Sulfide, a Case Study Using a Chemical-Specific Toxic Load Exponent**

by

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**S1.**  Probit analysis of binomial incidence data for inhaled DMS in rat pooled from Schoenig (1967b), Tansy et al. (1981) and Zieve et al. (1974).

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 Ten Berge Model. (Version: 1.0; Date: 12/26/2006)

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 Dose-Response Analysis

 Method of Maximum Likelihood according to:

 D.J. Finney, 1977. Probit Analysis. Cambridge University Press.

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 Model: P(v1, v2, ...) = Link(B0 + B1\*v1 + B2\*v2 + ...)

 Link is either Logit or Probit

 v1, v2, ... are the variables (transformations of the input parameters)

 Number of input parameters = 2

 Total number of observations = 21

 Total number of records with missing values = 0

 Dose Time N k

 800.00 240.00 10. 0.

 3000.00 240.00 10. 0.

 6000.00 240.00 10. 0.

 12000.00 240.00 10. 0.

 24000.00 240.00 10. 0.

 36000.00 240.00 10. 2.

 39000.00 240.00 10. 5.

 42000.00 240.00 10. 5.

 45000.00 240.00 10. 8.

 48000.00 240.00 10. 9.

 18500.00 180.00 10. 0.

 42100.00 240.00 10. 4.

 81500.00 70.00 10. 10.

 195000.00 18.00 10. 10.

 74643.00 15.00 12. 2.

 85898.00 15.00 6. 1.

 89445.00 15.00 3. 1.

 93527.00 15.00 6. 3.

 100425.00 15.00 5. 4.

 112361.00 15.00 14. 11.

 130468.00 15.00 6. 5.

 Selection of observations from number 1 through 21

 Transformation of input parameters

 Dose is transformed logaritmically!

 Time is transformed logaritmically!

 Probit link used without background response correction!

 Variable 1 = Transformed Dose

 Variable 2 = Transformed Time

 Chi-Square = 7.16

 Degrees of Freedom = 18

 B0 = -5.955e+001 Student t for B0 = -5.22

 B1 = 5.252e+000 Student t for B1 = 5.67

 B2 = 1.609e+000 Student t for B2 = 5.44

 variance B00 = 1.301e+002

 covariance B01 = -1.057e+001

 covariance B02 = -3.229e+000

 variance B11 = 8.593e-001

 covariance B12 = 2.594e-001

 variance B22 = 8.735e-002

 Probability of correct model (p-value) is 0.988661

 The prediction of the model is sufficient. Use for estimation of the

 95% confidence limits the Standard Normal Deviate

 No correction for variances required!

 Estimation of ratio between regression coefficients

 Ratio between regression coefficients

 Dose and Time

 Deviate Corresponding to Confidence Level of Interest = 1.960000

 Ratio = 3.264234

 Confidence limits

 2.885652 3.642816

 Estimation of Dose

 Response = 50.000000 percent

 Time = 2.000000

 Estimated Dose 50.000000 percent = 1.760e+005

 Lower limit Dose 50.000000 percent = 1.760e+005

 Upper limit Dose 50.000000 percent = 1.760e+005

**S2**. Odor intensity of DMS.

|  |  |  |
| --- | --- | --- |
| **Intensity** | **Description** | **Concentration (ppm)** |
| 0 | No odor | 0.00016 |
| 1 | Very faint | 0.0037 |
| 2 | Faint | 0.084 |
| 3 | Easily noticed | 1.9 |
| 4 | Strong | 44 |
| 5 | Very strong | 1000 |

1 reported concentrations “usually agree in order of magnitude” (Katz and Talbert 1930).

Source: adapted from Katz and Talbert (1930).

**S3.** Mortality in rats exposed to DMS at several concentrations (in 4-h exposure design experiments).

|  |  |  |  |
| --- | --- | --- | --- |
| **Duration of Exposure (min)** | **Concentration (ppm)** | **Mortality** | **Times of Death After Start of Exposure (min)** |
| 1801 |  18,500 |  0/10 | – |
| 240 |  42,100 |  4/102 | 120–200 |
|  70 |  81,500 | 10/10 | 45–70 |
|  18 | 195,000 | 10/10 | 10–18 |

1 a 4-h experiment was terminated early because of paucity of the DMS exposure material;

2 gender differences are not reported;

Source: adapted from Schoenig (1967b).

**S4**. Inhalation toxicity data for mice exposed to high concentrations of DMS for short periods.

|  |  |
| --- | --- |
| **Concentration1 (1000 ppm)** | **Exposure Duration (min)**for astasis / death in animals #1–5 |
| **#1** | **#2** | **#3** | **#4** | **#5** |
|  68 ± 25 | 0.67 / 7.63 | 0.77 / 3.42 | 0.77 / 4.33 | 0.80 / 7.17 | 1.08 / 7.03 |
| 116 ± 10 | 0.33 / 2.47 | 0.53 / 3.47 | 0.57 / 1.57 | 0.57 / 4.20 | 0.67 / 4.03 |
| 236 ± 73 | 0.33 / 1.08 | 0.35 / 0.80 | 0.35 / 1.27 | 0.37 / 2.35 | 0.47 / 1.47 |
| 340 ± 61 | 0.27 / 1.50 | 0.30 / 1.48 | 0.32 / 1.07 | 0.33 / 1.67 | 0.42 / 2.00 |
| 506 ± 71 | 0.13 / 0.77 | 0.17 / 0.73 | 0.18 / 0.67 | 0.20 / 0.72 | 0.23 / 1.17 |

1 Mean ± 1.96 x SD, (n = 5).

Source: adapted from Terazawa et al. (1991).

**S5.**  Derivation of the benchmark concentration (BMCL05) for mortality caused by 4 h exposure of rats to DMS using combined binomial incidence data of Tansy et al. (1981) and Schoenig (1967b).

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 Probit Model. (Version: 3.4; Date: 5/21/2017)

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BMDS\_Model\_Run

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 The form of the probability function is:

 P[response] = Background

 + (1-Background) \* CumNorm(Intercept+Slope\*Log(Dose)),

 where CumNorm(.) is the cumulative normal distribution function

 Dependent variable = Effect

 Independent variable = Dose

 Slope parameter is not restricted

 Total number of observations = 13

 Total number of records with missing values = 0

 Maximum number of iterations = 500

 Relative Function Convergence has been set to: 1e-008

 Parameter Convergence has been set to: 1e-008

 User has chosen the log transformed model

 Default Initial (and Specified) Parameter Values

 background = 0

 intercept = -7.64081

 slope = 0.731809

 Asymptotic Correlation Matrix of Parameter Estimates

 ( \*\*\* The model parameter(s) -background

 have been estimated at a boundary point, or have been specified by the user,

 and do not appear in the correlation matrix )

 intercept slope

intercept 1 -1

 slope -1 1

 Parameter Estimates

 95.0% Wald Confidence Interval

 Variable Estimate Std. Err. Lower Conf. Limit Upper Conf. Limit

 background 0 NA

 intercept -71.5812 21.2899 -113.309 -29.8537

 slope 6.74063 2.00166 2.81744 10.6638

NA - Indicates that this parameter has hit a bound

 implied by some inequality constraint and thus

 has no standard error.

 Analysis of Deviance Table

 Model Log(likelihood) # Param's Deviance Test d.f. P-value

 Full model -33.8519 13

 Fitted model -35.0887 2 2.47349 11 0.996

 Reduced model -87.881 1 108.058 12 <.0001

 AIC: 74.1774

 Goodness of Fit

 Scaled

 Dose Est.\_Prob. Expected Observed Size Residual

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 800.0000 0.0000 0.000 0.000 10.000 -0.000

3000.0000 0.0000 0.000 0.000 10.000 -0.000

6000.0000 0.0000 0.000 0.000 10.000 -0.000

12000.0000 0.0000 0.000 0.000 10.000 -0.000

24000.0000 0.0002 0.002 0.000 10.000 -0.040

36000.0000 0.1939 1.939 2.000 10.000 0.048

39000.0000 0.3730 3.730 5.000 10.000 0.830

42000.0000 0.5697 5.697 5.000 10.000 -0.445

45000.0000 0.7391 7.391 8.000 10.000 0.438

48000.0000 0.8590 8.590 9.000 10.000 0.373

42100.0000 0.5760 5.760 4.000 10.000 -1.126

81500.0000 1.0000 10.000 10.000 10.000 0.004

195000.0000 1.0000 10.000 10.000 10.000 0.000

Chi^2 = 2.49 d.f. = 11 P-value = 0.9959

 Benchmark Dose Computation

Specified effect = 0.05

Risk Type = Extra risk

Confidence level = 0.95

 BMD = 32059.6

 BMDL = 26108.9

 BMDU = 35251.1

**S6**. Acute inhalation toxicity data for rats exposed to DMS for 30 min.

|  |  |  |
| --- | --- | --- |
| **Concentration (ppm)** | **Duration (min)** | **Health Effect(s)** |
|  1,100 | 30 | No effects |
|  5,600 |  2 | Shuts eyes because of irritation |
| 10 | Lays down |
| 30 | Instantly alert after release |
| 13,000 |  0 | Shuts eyes because of irritation |
|  5 | Slow respiration |
| 10 | Irregular, deep breaths |
| 30 | Instantly alert after release |
| 29,000 |  5 | Slow respiration |
| 10 | Irregular deep breaths |
| 25 | Staggered in attempt to rise |
| 30 | Lay on its side, unable to get up by itself, respiration is very fast and superficial (200 per min), but recovered 10 min after release |
| 31,000 |  5 | Staggered in attempt to rise |
| 20 | Lay on its side and unable to get up by itself |
| 30 | Recovered 10 min after release |
| 54,000 |  2 | Dyspnea, staggered, fell down on its side |
|  5 | Irregular slow, deep respiration, fluid bubbled from nose |
| 15 | 1/1 mortality |

Source: adapted from Ljunggren and Norberg (1943).

**S7**. Acute inhalation toxicity data for rats exposed to DMS for up to 4 h.

|  |  |  |  |
| --- | --- | --- | --- |
| **Concentration (ppm)** | **Time of Onset (min)** | **Duration (min)** | **Health Effect(s)** |
| 18,500 | 10–15 | 45–70 | Generalized inactivity |
| 30–45 | 30–50 | Tremors |
| 60-–80 | 120–130 | Unconsciousness |
| 42,100 | 0–2 | 6–10 | Hyperactivity |
| 8–10 | 10–20 | Generalized inactivity |
| 10–15 | 250–260 | Hyperpnea |
| 20–30 | 240–250 | Unconsciousness |
| 120–200 | until death | Cyanosis – only in rats that died |
| 310 | 60–120 | Tremors |
| 81,500 | 0–2 | 6–8 | Hyperactivity |
| 6–8 | 10–15 | Generalized inactivity |
| 8–12 | until death | Hyperpnea |
| 10–20 | until death | Unconsciousness |
| 15–20 | until death | Salivation |
| 15–25 | until death | Frothy nasal discharge |
| 15–25 | until death | Cyanosis |
| 195,000 | 0–1 | 1–4 | Generalized inactivity |
| 1–2 | 5–8 | Hyperpnea |
| 1–5 | until death | Unconsciousness |
| 7–10 | until death | Dyspnea |

Source: adapted from Schoenig (1967b).

**S8**. Derivation of the benchmark concentration (BMCL10) for coma that took place during a 15-min exposure of rats to DMS; incidence data from Ljunggren and Norberg (1943), Schoenig (1967b) and Zieve et al. (1974) studies were pooled.

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 Probit Model. (Version: 3.3; Date: 2/28/2013)

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 BMDS\_Model\_Run

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 The form of the probability function is:

 P[response] = Background

 + (1-Background) \* CumNorm(Intercept+Slope\*Log(Dose)),

 where CumNorm(.) is the cumulative normal distribution function

 Dependent variable = Effect

 Independent variable = Dose

 Background parameter is set to zero

 Slope parameter is not restricted

 Total number of observations = 15

 Total number of records with missing values = 0

 Maximum number of iterations = 500

 Relative Function Convergence has been set to: 1e-008

 Parameter Convergence has been set to: 1e-008

 User has chosen the log transformed model

 Default Initial (and Specified) Parameter Values

 background = 0 Specified

 intercept = -10.5391

 slope = 0.929386

 Asymptotic Correlation Matrix of Parameter Estimates

 ( \*\*\* The model parameter(s) -background

 have been estimated at a boundary point, or have been specified by the user,

 and do not appear in the correlation matrix )

 intercept slope

 intercept 1 -1

 slope -1 1

 Parameter Estimates

 95.0% Wald Confidence Interval

 Variable Estimate Std. Err. Lower Conf. Limit Upper Conf. Limit

 intercept -34.4566 7.65299 -49.4562 -19.457

 slope 3.01362 0.668748 1.70289 4.32434

 Analysis of Deviance Table

 Model Log(likelihood) # Param's Deviance Test d.f. P-value

 Full model -30.009 15

 Fitted model -32.6471 2 5.27614 13 0.9686

 Reduced model -60.1762 1 60.3344 14 <.0001

 AIC: 69.2942

 Goodness of Fit

 Scaled

 Dose Est.\_Prob. Expected Observed Size Residual

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 1100.0000 0.0000 0.000 0.000 1.000 -0.000

 5600.0000 0.0000 0.000 0.000 1.000 -0.000

13000.0000 0.0000 0.000 0.000 1.000 -0.000

29000.0000 0.0002 0.000 0.000 1.000 -0.015

31000.0000 0.0005 0.000 0.000 1.000 -0.022

47680.1846 0.0231 0.254 1.000 11.000 1.496

74643.0000 0.2603 3.124 2.000 12.000 -0.739

85898.0000 0.4133 2.480 1.000 6.000 -1.227

89445.0000 0.4613 1.384 1.000 3.000 -0.445

93527.0000 0.5149 3.089 3.000 6.000 -0.073

100425.0000 0.5994 2.997 4.000 5.000 0.916

112361.0000 0.7225 10.114 11.000 14.000 0.529

130468.0000 0.8509 5.106 5.000 6.000 -0.121

18500.0000 0.0000 0.000 0.000 10.000 -0.003

195000.0000 0.9878 9.878 10.000 10.000 0.351

 Chi^2 = 5.75 d.f. = 13 P-value = 0.9549

 Benchmark Dose Computation

Specified effect = 0.1

Risk Type = Extra risk

Confidence level = 0.95

 BMD = 60378.5

 BMDL = 47408.8

**S9**. Computation of short-term inhalation exposure levels for DMS.

**Worksheet for Tier-3**

Species**:** Rat

Time scaling**:** *Cn* x *t* = const

POD: 26,108.9 ppm (BMCL05 for mortality using pooled data of Tansy et al. (1981) and Schoenig (1967b))

UF

for LOAEL: N/A

for interspecies variation: 3

for intraspecies variation: 3

Total UF: 10

Modifying Factor: None

Calculations: 26,108.9 ppm / 10 = 2,610.89 ppm

C2.89 x t = k

(2,610.89 ppm)2.89 x 240 min = 1.7978E+12

C3.64 x t = k

(2,610.89 ppm)3.64 x 240 min = 6.5663E+14

10-minute tier-3 value = 30-minute tier-3 value

 C = 4,622.6416 ppm

30-minute tier-3 value C3.64 x 30 min = 6.5663E+14

 C = 4,622.6416 ppm

1-hour tier-3 value C3.64 x 60 min = 6.5663E+14

 C = 3,821.1112 ppm

4-hour tier-3 value the study concentration-time point

 C = 26,108.9 ppm / 10 = 2,610.89 ppm

8-hour tier-3 value C2.89 x 480 min = 1.7978E+12

 C = 2,054.1206 ppm

**Worksheet for Tier-2**

Species**:** Rat

Time scaling**:** *Cn* x *t* = const

POD: 47,408.8 ppm (BMCL10 for coma using combined data of Zieve et al. (1974), Ljunggren and Norberg (1943), Schoenig (1967b))

UF

for LOAEL: N/A

for interspecies variation: 10

for intraspecies variation: 3

Total UF: 30

Modifying Factor: None

Calculations: 47,408.8 ppm / 30 = 1,580.29333 ppm

C2.89 x t = k

(1,580.29333 ppm)2.89 x 15 min = 2.63295E+10

C3.64 x t = k

(1,580.29333 ppm)3.64 x 15 min = 6.59928E+12

10-minute tier-2 value C3.64 x 10 min = 6.59928E+12

 C = 1766.503196 ppm

30-minute tier-2 value C2.89 x 30 min = 2.63295E+10

 C = 1243.297555 ppm

1-hour tier-2 value C2.89 x 60 min = 2.63295E+10

 C = 978.1657485 ppm

4-hour tier-2 value C2.89 x 240 min = 2.63295E+10

 C = 605.4624235 ppm

8-hour tier-2 value C2.89 x 480 min = 2.63295E+10

 C = 476.3482419 ppm

**Worksheet for Tier-1**

Species**:** Human

Time scaling**:** None

POD: 1.9 ppm (NOAEL for nausea interpreted from Katz and Talbert (1930))

UF

for LOAEL: None

for interspecies variation: None

for intraspecies variation: 3

Total UF: 3

Modifying Factor**:** None

Calculations: 1.9 ppm / 3 = 0.633

10-minute tier-1 value C = 0.633 ppm

30-minute tier-1 value C = 0.633 ppm

1-hour tier-1 value C = 0.633 ppm

4-hour tier-1 value C = 0.633 ppm

8-hour tier-1 value C = 0.633 ppm

**S10**. AEGL values for hydrogen sulfide (ppm).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Severity Tier** | **10 min** | **30 min** | **1 h** | **4 h** | **8 h** | **UF** | **POD** | **Effect** |
| AEGL-1 (discomfort) | 0.75 | 0.60 | 0.51 | 0.36 | 0.33 | 3modifying | 2 ppm, 30 min | Headache |
| AEGL-2 (disabling) | 41 | 32 | 27 | 20 | 17 | 3inter x 3intra | 200 ppm, 4 h | Perivascular edema |
| AEGL-3 (lethal) | 76 | 59 | 50 | 37 | 31 | 3inter x 3intra | 504 ppm, 1 h | No mortality |

Source: adapted from NRC (2010).

**S11**. AEGL values for methyl mercaptan (ppm).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Severity Tier** | **10 min** | **30 min** | **1 h** | **4 h** | **8 h** | **UF** | **POD** | **Effect** |
| AEGL-1 (discomfort) | NR | NR | NR | NR | NR | N/A | Insufficient data | N/A |
| AEGL-2 (disabling) | 40 | 29 | 23 | 14 | 7.3 | 3scaling | AEGL-3 | N/A |
| AEGL-3 (lethal) | 120 | 86 | 68 | 43 | 22 | 3inter x 3intra | 430 ppm, 4 h | LC01 |

Source: adapted from NRC (2013).

**S12**. Computation of alternative short-term inhalation exposure levels for DMS.

Following the National Academy of Sciences guidelines (NRC 2001), tier-2 short-term inhalation exposure levels can be derived by scaling down tier-3 values by a factor of three. These calculations provide surrogate threshold levels for inability to escape or permanent injury. They are especially appropriate when the mortality concentration-response relationship is steep, as in the case of DMS.

Calculations: Ctier-2 = Ctier-3 / 3

10-minute tier-2 value Ctier-3 = 4,584.770 ppm

 Ctier-2 = 4,584.770 ppm / 3

C = 1,528.257 ppm

30-minute tier-2 value Ctier-3 = 4,584.770 ppm

 Ctier-2 = 4,584.770 ppm / 3

C = 1,528.257 ppm

1-hour tier-2 value Ctier-3 = 3,789.806 ppm

 Ctier-2 = 3,789.806 ppm / 3

C = 1,263.269 ppm

4-hour tier-2 value Ctier-3 = 2,589.5 ppm

 Ctier-2 = 2,589.5 ppm / 3

C = 863.167 ppm

8-hour tier-2 value Ctier-3 = 2,037.292 ppm

 Ctier-2 = 2,037.292 ppm / 3

C = 679.097 ppm

**S13**. Laboratory data mapped on the LTE plot of tier-3 effects caused by DMS exposures.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Species** | **Duration (min)** | **Concentration (ppm)** | **NOEL?** | **Comments** |
| Tansy et al. (1981) | rat | 240 | 36,000 | N | 2/10 mortality |
| 240 | 24,000 | Y | 0/10 mortality |
| Schoenig (1967b) | rat | 18 | 195,000 | N | 10/10 mortality |
| 70 | 81,500 |
| 240 | 42,100 | 4/10 mortality |
| 180 | 18,500 | Y | 0/10 mortality |
| Ljunggren & Norberg (1943) | rat | 15 | 54,000 | N | 1/1 mortality |
| 30 | 31,000 | Y | recovered |
| Dow (1957) | rat | 3 | 218,500 | Y | recovered |
| 9 | N | 2/4 mortality |
| Terazawa et al. (1991) | mouse | 0.67 | 506,000 | N | 1/5 mortality |
| 0.8 | 236,000 |
| 1.07 | 340,000 |
| 1.57 | 116,000 |
| 3.42 | 68,000 |
| AIHA (2016 ) | human | 60 | 5,000 | N/A | ERPG-3 |

**S14**. Laboratory data mapped on the LTE plot of tier-2 effects caused by DMS exposures.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **Species** | **Duration (min)** | **Concentration (ppm)** | **NOEL?** | **Comments** |
| Tansy et al. (1981) | rat | 240 | 36,000 | N | 2/10 mortality |
| Schoenig (1967b) | rat | 1 | 195,000 | N | onset of unconsciousness |
| 10 | 81,500 |
| 20 | 42,100 |
| 60 | 18,500 |
| 8 | 81,500 | Y | onset of hyperpnea |
| 15 | 42,100 | last onset of hyperpnea |
| 30 | 18,500 | last onset of tremors |
| 18 | 195,000 | N | 10/10 mortality |
| 70 | 81,500 |
| 240 | 42,100 | 4/10 mortality |
| Ljunggren and Norberg (1943) | rat | 2 | 54,000 | N | 1/1 unconsciousness |
| 20 | 31,000 |
| 30 | 29,000 |
| 5 | 31,000 | Y | staggered in attempt to rise |
| 25 | 29,000 |
| 30 | 13,000 | immediately alert upon release |
| 15 | 54,000 | N | 1/1 mortality |
| Zieve et al. (1974) | rat | 15 | 74,643 | N | 2/12 coma |
| 74,400 | Y | no coma |
| Dow (1957) | rat | 3 | 218,500 | N | unconsciousness |
| 9 | 2/4 mortality |
| Terazawa et al. (1991) | mouse | 0.13 | 506,000 | N | 1/5 coma |
| 0.27 | 340,000 |
| 0.33 | 236,000 |
| 0.33 | 116,000 |
| 0.67 | 68,000 |
| 0.67 | 506,000 | 1/5 mortality |
| 1.07 | 340,000 |
| 0.8 | 236,000 |
| 1.57 | 116,000 |
| 3.42 | 68,000 |
| AIHA (2016) | human | 60 | 1,000 | N/A | ERPG-2 |

 **S15**. Laboratory data mapped on the LTE plot of tier-1 effects caused by DMS exposures.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **Species** | **Duration (min)** | **Concentration (ppm)** | **Graph Effect** | **NOEL?** | **Comments** |
| Ljunggren and Norberg (1943) | rat | 30 | 1,100 | tier-1 | Y | 1/1 shows no effect |
| 2 | 5,600 | N | 1/1 shuts eyes because of irritation |
| Katz and Talbert (1930) | human | 0.167 | 6,200 | tier-1 | N | faint eye irritation, (level 1/4) reported by 4/6 observers1 |
| AIHA (2016) | human | 60 | 0.5 | ERPG-1 | N/A | ERPG-1 |
| ACGIH (2004) | human | 480 | 10 | TLV-TWA2 | N/A | ACGIH threshold limit value |
| Footnote3 | human | 480 | 1 | NGV3 (TWA) | N/A | occupational exposure limit –Sweden |
| Pohanish (2012) | human | 480 | 0.39 | NDS4 (TWA) | N/A | occupational exposure limit –Poland (converted from 1 mg/m3) |
| Footnote5 | human | 30 | 20 | PDK5 | N/A | occupational exposure limit – Russia (converted from 50 mg/m3) |
| Footnote6 | human | 30 | 0.03 | PDK6 | N/A | residential exposure limit – Russia (converted from 0.08 mg/m3) |

1 HS & MM do not show effect at this concentration (Katz and Talbert 1930).

2 TLV-TWA is the threshold limit value – time weighted average, as given by the American Conference of Governmental Industrial Hygienists (ACGIH 2004). It is the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effects.

3 NGV (nivågränsvärde [level threshold]) by the Swedish Work Environment Authority is defined analogous to the ACGIH TLV-TWA. Source – Arbetsmiljöverket. 2015. Hygieniska gränsvärden, AFS 2015:7 [Occupational exposure limit values, AFS 2015:7]. Stockholm (Sweden): Elanders. Swedish.

4 NDS (najwyższe dopuszczalne stężenie [maximum allowable concentration]) by the Interdepartmental Commission for Maximum Admissible Concentrations and Intensities for Agents Harmful to Health in the Working Environment at the Polish Central Institute for Labor Protection is defined analogous to the ACGIH TLV-TWA (Pohanish 2012).

5 PDK (predelno dopustimaia koncentracia [maximum allowable concentration]) in the workplace air (with skin and eye protection) established for a short-term exposure (20–30 min, i.e. similar to the ACGIH short-term exposure limit, TLV-STEL). Source – Onischenko GG, chief approving public health officer. 2003. Gigienicheskie normativy GN-2.2.5.1313-03: Predelno dopustimye koncentracii (PDK) vrednyh veschestv v vozduhe rabochei zony [Hygienic standards GN-2.2.5.1313-03: Maximum allowable concentrations (MACs) of hazardous substances in occupational air]. Moscow (RF): RF Health Department. Russian.

6 PDK (predelno dopustimaia koncentracia [maximum allowable concentration]) in ambient air of residential areas established for a short-term exposure (20–30 min, i.e. similar to the ACGIH short-term exposure limit, TLV-STEL) approved by the Chief Public Health Officer of the Russian Federation. This PDK is established for a reflex MOA, i.e. when involvement of the CNS is minimal following receptor stimulation in the upper respiratory tract, including the perception of smell, mucosa irritation, and holding of breath. Source – Onischenko GG, chief approving public health officer. 2003. Gigienicheskie normativy GN-2.1.6.1338-03: Predelno dopustimye koncentracii (PDK) zagriazniaiuschih veschestv v atmosfernom vozduhe naselionnyh mest [Hygienic standards GN-2.1.6.1338-03: Maximum allowable concentrations (MACs) of pollutants in the air of residential areas]. Moscow (RF): RF Health Department. Russian.