

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

TO: Silicon Tetrahydride File (CAS # 7803-62-5)

FROM: Keisha Williams, Air Quality Division (AQD)

SUBJECT: Screening level for silicon tetrahydride

DATE: July 2, 2015

The initial threshold screening level (ITSL) for silicon tetrahydride is 30 $\mu\text{g}/\text{m}^3$ (annual averaging time) based on the study by Omae et al. (1992). This ITSL was established by AQD on August 5, 2010 (MDNR, 2010).

The averaging time was originally set at 24 hours, the default averaging time, per Rule 232 (2). It is being changed at this time to annual, as allowed per Rule 229 (2), because the derivation of the ITSL included an accounting for chronic exposure.

References:

Omae et al. 1992. Acute and subacute inhalation toxicity of silane 1000 ppm in mice. Arch Toxicol 66:750-3.

MDNR. 2010. Memo from Gary Butterfield to File. Subject: Silicon Tetrahydride (CAS# 7803-62-5). August 5, 2010. AQD, MDNR.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENT

INTEROFFICE COMMUNICATION

TO: Silicon Tetrahydride File (CAS # 7803-62-5)

FROM: Gary Butterfield

SUBJECT: Review/update of screening level for silicon tetrahydride

DATE: August 5, 2010

Silicon tetrahydride is also known as silane. The 2002 ITSL for silane was re-evaluated, along with the assessment of screening levels, for some similar chemicals - methylsilane (992-94-9) and dimethylsilane (1111-74-6). The 2002 ITSL was based on 1/100 of the ACGIH TLV for silane under R232(1)(c). Unfortunately the TLV documentation for silane is not based on any toxicity information for silane. The TLV committee assumed silane was less toxic than germanium tetrahydride and adjusted the germanium tetrahydride TLV for the less toxic silicon tetrahydride. The TLV documentation adjusting the ratio of toxicities could not be reproduced by our staff. This led to our conclusion that the TLV reasoning is considered to be less reliable for setting a screening level, rather than basing the silane ITSL upon actual silicon tetrahydride toxicity data.

Most of the silane compounds do not have adequate amounts of toxicity data available or published. The literature review for silane covered the past 15 years but did not find much recent toxicity data available. The EPA is in the process of setting AEGLs for silane, and has published interim acute values and has documentation of the reasoning used to obtain those values. The AEGL documentation briefly discusses a 28-day mouse inhalation study reported by Omae et al (1992). This 4-week study with toxicity information on the chemical of concern, silane, is considered to be a more appropriate basis for setting the screening level, than is the TLV, which assumed comparable toxicity to another questionably related chemical.

In the study by Omae et al (1992), groups of 10 male ICR mice were exposed to a target dose of 1000 ppm (measured dose of 966 ppm) silane for acute (1, 2, 4 and 8 hours) and subacute (6/24x5/7 for 2 and 4 weeks) durations. The 4-week exposure data will be used to establish a new ITSL. Irritation of the nasal cavities following exposure was evident as increased incidence of nasal exudate, and the occurrence of inflammatory and/or necrotic cells in the nasal mucosa.

The ITSL was calculated using the EPA RfC methodology for using a LOAEL, as follows.

$$\text{LOAEL} = 966 \text{ ppm or } 1265 \text{ mg/m}^3$$

$$\text{LOAEL(adj)} = 1265 \times 6/24 \times 5/7 = 226 \text{ mg/m}^3$$

RGDR for nasal effects in 24 g male mice, from category 1 gas

$$\text{RGDR} = \frac{(\text{Ve/SA})_a}{(\text{Ve/SA})_h} = \frac{(0.0276/3)}{(13.8/200)} = 0.13$$

$$\text{LOAEL(hec)} = 226 \text{ mg/m}^3 \times 0.13 = 29.4 \text{ mg/m}^3$$

$$\text{ITSL} = \frac{29.4 \text{ mg / m}^3}{\text{uncertainty factors}} = \frac{29.4 \text{ mg/m}^3}{1000} = 0.0294 \text{ mg/m}^3$$

$$\text{ITSL} = (0.0294 \text{ mg/m}^3) \times \frac{1000 \text{ } \mu\text{g/m}^3}{\text{mg/m}^3} = 29.4 \text{ } \mu\text{g/m}^3$$

$$\text{ITSL} \approx 30 \frac{\mu\text{g}}{\text{m}^3}, 24 \text{ hour averaging time}$$

The total uncertainty factor for the above ITSL calculation includes: factors of 10 for sensitive humans; subacute to chronic (the 10 fold factor is generally used for 90-day to chronic); factors of 3 for animal-to-human (in conjunction with use of RGDR), and LOAEL-to-NOAEL (as the observed adverse effects were considered to be mild). This resulted in a total uncertainty factor of 1000. $\text{UF} = 10 \times 10 \times 3 \times 3 \approx 1000$

References:

ACGIH. 1999. Documentation of threshold limit values (TLV) for silicon tetrahydride.

Omae et al. 1992. Acute and subacute inhalation toxicity of silane 1000 ppm in mice. Arch Toxicol 66:750-3.

GB:lh

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

January 22, 2002

TO: File for Silane (silicon tetrahydride) (7803-62-5)

FROM: Marco Bianchi, Toxics Unit, Air Quality Division

SUBJECT: Initial Threshold Screening Level

The initial threshold screening level (ITSL) for silane (silicon tetrahydride) is $70 \mu\text{g}/\text{m}^3$ based on an 8-hour averaging time.

The following references or databases were searched to identify data to determine the ITSL: IRIS-online, HEAST, NTP Management Status Report-online, RTECS, EPB-CCD, EPB library, CAS-online, NLM-online, IARC-online, NIOSH Pocket Guide, and ACGIH Guide.

A complete chemical literature search was conducted for silane, but information was limited to occupational exposure levels and acute toxicity information. According to the American Conference of Governmental Industrial Hygienists (ACGIH) documentation, silane is a colorless gas with a repulsive odor. It is a dangerous fire risk because it may ignite spontaneously in air. Silane is used in the doping of solid-state devices and as a source of hyperpure silicon for semiconductors.

The toxicological data for silane was extremely limited. Only Japanese acute and subacute mouse studies were available for review. In one study, ICR mice were exposed to silane for 30 minutes, 1 or 4 hours, at concentrations of 2,500, 5,000, 7,500 (30 minute exposure), or 10,000 ppm. The mortality was six out of eight deaths for mice exposed to 10,000 ppm for 4 hours. No deaths were reported in other experiments. Acute renal tubular necrosis was observed at 10,000 ppm (1-hour exposure) or at 2,500 ppm or more (4-hour exposure). Reduction in body weight, increase in relative kidney weight, BUN level, and splenic atrophy and inflammatory changes of the nasal mucosa were also seen in the 10,000 ppm 4-hour exposure group. These results indicate that the LC_{50} of silane in mice is between 5,000 and 10,000 ppm for 4-hour exposure and is greater than 10,000 ppm for 1-hour or 30-minute exposure. The target site of silane toxicity is the renal tubule. The no-observed-effect-level (NOEL) of silane for acute inhalation exposure in mice is 1,000 ppm for 4-hour exposure, 2,500 ppm for 1-hour exposure, and 5,000 ppm for 30-minute exposure. In another Japanese acute inhalation mouse study, silane caused nasal mucosal lesions at 5,000 or 10,000 ppm, but these nasal mucosal lesions were mild after subacute inhalation concentrations of 1,000 ppm for 2 or 4 weeks.

At the time the ACGIH documentation was written for silane, the above Japanese studies were not available for review. Instead, the ACGIH based the Threshold Limit Value (TLV) of 5 ppm ($6.6 \text{ mg}/\text{m}^3$) on the toxicity of germanium and germanium tetrahydride. The acute toxicity of silane is apparently one-tenth as potent as that of germanium tetrahydride ($0.63 \text{ mg}/\text{m}^3$ or

0.2 ppm). Based on this comparison, a TLV of 5 ppm was recommended. Although this value was supported with limited information, it seems appropriate to use because it would provide a more protective ITSL than the Japanese acute and subacute studies. Calculating an ITSL from the TLV would result in a value of 70 µg/m³ with an 8-hour averaging time. The Japanese LC₅₀ and NOEL values based on the studies above (accounting for appropriate formulas and averaging times) would equal 154 µg/m³ and 825 µg/m³ (8-hour averaging), respectively. According to Air Toxics Rule 232(c), if occupational exposure data is available to calculate an ITSL, this data would take precedence over acute or subacute studies.

The ITSL was determined as follows:

$$\text{ACGIH TLV} = 6.6 \text{ mg/m}^3 \text{ or rounding to one significant figure, } 7 \text{ mg/m}^3$$

$$7 \text{ mg/m}^3 \div 100 = 0.07 \text{ mg/m}^3$$

$$0.07 \text{ mg/m}^3 \times \frac{1,000 \text{ } \mu\text{g/m}^3}{1 \text{ mg/m}^3} = 70 \text{ } \mu\text{g/m}^3$$

The ITSL for silane (silicon tetrahydride) = 70 µg/m³ based on 8-hour averaging.

References:

1. Documentation of Threshold Limit Values and Biological Exposure Indices. 1992. Silicon Tetrahydride. American Conference of Governmental Industrial Hygienists (ACGIH), 6th Edition.
2. Abstracts from Japanese studies obtained from National Library of Medicine's Toxline and STN's CAS-online. Search conducted on 11/30/01.

MB:DB

cc: Cathy Simon, AQD
Mary Lee Hultin, AQD
Sheila Blais, AQD