**Substance name: trichloroethylene**

Reviewer: Will Forest, 3/11/09

**CAS:** 79-01-06 **MW:** 131.4 **Synonyms**: TCE; trichloroethene; trichlor; tri

**Molecular formula:** C2HCl3 **Structural formula**: CHCl=CCl2

**Conversion:** 1 ppm = 5.37 mg/M3 and 1 mg/M3 = 0.19 ppm at 25 oC and 760 mm/Hg

**Vapor pressure** = 77 torr (about 100,000 ppm) at 25 oC

**Physical characteristics at room temp:** volatile colorless liquid

**Special physical characteristics if any:** vapor density = 4.5 (air = 1)

**Flammability and other hazards:** combustion products include phosgene, HCl, and perhaps dioxin-like compounds

**Uses/applications:** solvent – primarily in degreasing, also in the rubber and paper industries and in adhesives; ingredient in some pesticides

## Standards and Recommendations

**Title 8 PEL:**  25 ppm; 100 ppm STEL; 300 ppm ceiling

**ACGIH TLV (2007):** 10 ppm; 25 ppm STEL

**NIOSH REL (1996):** 25 ppm (except 2 ppm 60-minute “ceiling” during anesthetic use)

**Other OELs:** WEEL (none?), MAK (none?)

## Organizational assessments

**IARC (1995):** Probable Human Carcinogen
(sufficient animal evidence, limited human evidence)

**NTP (11th Report, 2005):** Reasonably Anticipated to be a Human Carcinogen
(sufficient animal evidence, limited human evidence)

**EPA (2001):** Highly Likely to Produce Cancer in Humans, *or* B1 Probable Human Carcinogen
(sufficient animal evidence, limited human evidence), depending on guidelines used

**European Union: Category 2**

**(**substances which should be regarded as if they are carcinogenic to man)

**Prop 65 (1988):** Known to Cause Cancer

**OEHHA NSRLs:** 80 g/day (inhalation); 50 g/day (oral)

**OEHHA Inhalation Unit Risk:** .002 (mg/m3)-1

**OEHHA Inhalation Slope Factor:** .007 (mg/kg/day)-1 (revised down from .01 on 12/20/02)

**OEHHA Oral Slope Factor:** 0.013 (mg/kg-day)-1 (revised from .0153 (mg/kg-day)-1on 9/24/03)

**OEHHA Chronic REL:** 0.1 ppm = 0.6 mg/m3, based on eye irritation, drowsiness, heart palpitations, cough, weakness, and dizziness in workers (Vandervort & Polnkoff, 1973)

**OEHHA Public Health Goal (1999):** .0008 mg/L (i.e., .8 ppb)

**DHS MCL (updated 2004):** .005 mg/L (i.e., 5 ppb – the federal MCL)

## Peer-reviewed journal articles and other studies

### Krishnadasan 2007

nested case-control prostate cancer study in American aerospace workers; 362 cases, 1805 matched controls, 1950-1992; job-exposure matrix exposure assessment

low-TCE-exposure group had OR 1.3; high-exposure group OR 2.1, significant; positive trend, p=.02

### Bruning 2003

German hospital-based case-control study; 134 renal cell cancer (RCC) cases and 401 controls

exposure was self-assessed and job history was analyzed, using expert-based exposure information

OR 1.80 (CI 1.01-3.20) for longest-held job in TCE-exposing industries

OR 5.57 (CI 2.33-13.32) any exposure in “metal degreasing”

OR 3.71 (CI 1.80-7.54) self-reported narcotic symptoms, indicative of peak exposures

### Sun 2007

cohort study on breast cancer; 23-year follow-up; 286 cases

63,982 female former workers at a Taiwanese electronics factory, 1973-1997, compared to gen’l population

SIR close to 1

SIR 1.38 (1.11-1.70) for cohort first employed before 1974

SIR 1.62 for 10 years of employment

### Charbotel 2006

French case-control renal cell cancer study; 86 cases and 316 controls matched for age and gender

three types of exposure assessment: exposure for at least one job period (minimum 1 year); cumulative dose (ppm TCE \* years in job period); and exposure to peaks.

OR = 2.16 (1.02-4.60) for high cumulative doses

dose-response relationship

OR for highest exposure 2.73 (1.06-7.07)

after adjusting for exposure to cutting fluids, ORs remained high but were not significant

### Raaschou-Nielsen 2003

cohort study of 40,049 blue-collar workers in 347 Danish companies, 1968-1997

SIRs for total cancer 1.1 (1.04, 1.12) in men and 1.2 (1.14, 1.33) in women

SIRs for non-Hodgkin's lymphoma and renal cell carcinoma 1.2 (1.0, 1.5) and 1.2 (0.9, 1.5), respectively

SIRs increased with duration of employment, and elevated standardized incidence ratios were limited to workers first employed before 1980 for non-Hodgkin's lymphoma and before 1970 for renal cell carcinoma

SIR for esophageal adenocarcinoma 1.8 (1.2, 2.7); higher in companies with the highest probability of TCE exposure

In a subcohort of 14,360 presumably highly exposed workers, the SIRs for non-Hodgkin's lymphoma, renal cell carcinoma, and esophageal adenocarcinoma were 1.5 (95% CI: 1.2, 2.0), 1.4 (95% CI: 1.0, 1.8), and 1.7 (95% CI: 0.9, 2.9), respectively.

### Hansen 2001

cancer incidence study; 803 Danish workers; historical files of individual air and urinary measurements of TCE exposure

SIR for cancer overall not elevated

SIR = 3.5 for non-Hodgkin's lymphoma in men, significant

SIR = 4.2 for cancer of the esophagus in men, significant

SIR = 3.8 for cervical cancer in women, significant

no clear dose-response relationship

no increased risk for kidney cancer

### Zhao 2005

retrospective cancer incidence and mortality cohort studies of 6,107 male aerospace workers

employed for at least two years between 1950 and 1980, followed up until 2001

exposure to TCE and other substances assessed by job exposure matrix (none, low, medium, or high)

RR = 4.90 (1.23 - 19.6) for kidney cancer incidence in high exposure group

RR = 1.87 (0.56 - 6.20) for kidney cancer incidence in medium exposure group

P = 0.023 for kidney cancer incidence trend

RR = 2.03 (0.50 - 8.32) for kidney cancer mortality in high exposure group

RR = 1.43 (0.49 - 4.16) for kidney cancer mortality in medium exposure group

P = 0.307 for kidney cancer mortality trend

RR = 1.98 (0.93 - 4.22) for bladder cancer incidence in high exposure group

### Dubosq 2005

case study; 51-year-old man with renal cell carcinoma and a history of TCE abuse

## HEAC Health-based assessment and recommendation

Most sources agree that TCE should be considered a probable human carcinogen, based on considerable human as well as extensive animal evidence. OEHHA’s inhalation No Significant Risk Level, calculated to induce one excess cancer per 100,000 persons exposed full-time for a lifetime, is 80 g/day. Here’s one way to describe the calculation of a workplace exposure limit that should pose a 1/1000 risk:

*To go from risk of 1/100,000 to risk of 1/1000:*

80 g/day \* 100 = 8000 g/day, or 8 mg/day

*To condense that lifetime daily exposure into a working lifetime daily exposure:*

8 mg/day \* 70/40 (years/lifetime) \* (52/50 weeks/year) \* 7/5 (days/week) = 20.384 mg/day

*Assuming inhalation of 10 m3/day:*

20.384 mg/day / 10 m3/day = 2.0384 mg/m3

*By the conversion factor:*

2.0384 mg/m3 \* 1 ppm/5.37 mg/m3 = 0.38 ppm

**Thus, linear calculation from the OEHHA NSRL indicates that the working lifetime exposure associated with a 1/1000 cancer risk is 0.38 ppm**.

From OEHHA’s inhalation Unit Risk Factor of .002 (mg/m3)-1, I did this comparable calculation:

Working lifetime exposure / lifetime exposure = 40/70 \* 50/52 \* 5/7 \* 10/20 = 0.196

Working lifetime fraction \* Unit Risk Factor = .196 \* .002 (mg/m3)-1 = .000392 (mg/m3)-1

By the conversion factor, .000392 (mg/m3)-1 = .002105 ppm-1

So, the PEL for a cancer risk level of 1/1000 is .001 / .002105 ppm-1 = .475 ppm

OEHHA’s Chronic REL is based on a worker LOAEL, with an average exposure (for “approximately 100 ‘affected employees’”) of 32 ppm, 8 hours/day, 5 days/week, over an 8-year period. OEHHA used uncertainty factors of 10 for the use of a LOAEL, and 10 for intraspecies variation, for a cumulative uncertainty factor of 100. OEHHA transformed the exposure periods to environmental periods, but since we’re looking at workplace exposure we don’t need to; we simply divide the 32-ppm exposure by 100, giving 0.32 ppm.

**HEAC Reviewer responses to comments of the Halogenated Solvents Industy Alliance (HSIA) on TCE cancer risk assessment in their letter of May 23, 2008 (icon link may take a few seconds to appear below):**



## Usage information:

High Volume Chemical, over a million pounds per year produced (~6 million pounds per year released or disposed of on-site or off-site, per TRI)

## Measurement information

**OSHA Method -** Lists reliable limit of quantitation at 0.81 ug/sample or 0.013 ppm (13 ppb) in a 240 minute sample <http://www.osha.gov/dts/sltc/methods/mdt/mdt1001/1001.html>

**NIOSH Manual of Analytical Methods 1022** – estimated LOD 0.01 mg/sample translates to 0.067 ppm

(67 ppb) in the maximum recommended 30 liter sample at 0.2 liter/minute flow rate

<http://www.cdc.gov/niosh/nmam/pdfs/1022.pdf>

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