

**POLICY FOR THE CONTROL OF HAZARDOUS  
AIR POLLUTANT EMISSIONS IN NORTH DAKOTA  
(Air Toxics Policy)**

**PURPOSE**

This document establishes the policy to be used by the North Dakota Department of Health, Division of Air Quality, for the evaluation of sources emitting Hazardous Air Pollutants (HAPs) into the ambient air. This policy document is effective until modified by the Department or until formal rules are promulgated. This policy will be used by the Department to evaluate the need for further review of emissions from a source whose emissions result in an exceedance of the levels established by this policy.

**APPLICABILITY**

This document is applicable to all new or modified air contaminant sources, as designated in 33-15-14-01 of the North Dakota Air Pollution Control Rules, required to submit an application for a Permit to Construct under Section 02 of Chapter 33-15-14. The Department may exempt the following source categories from the requirements of this policy: 1) sources of minor significance as determined by the Department and 2) any source subject to National Emission Standards for Hazardous Air Pollutants for Source Categories (MACT) which has demonstrated compliance with the residual risk provisions of the Clean Air Act.

Certain additional sources of HAPs will be considered for emission control by the Department on a case-by-case basis or as deemed appropriate. These may include "nontraditional" sources such as air strippers for the removal of organic contaminants from groundwater, ethylene oxide sterilizers, or any existing or new source where there is reason to believe that HAPs being emitted pose a significant risk to human health or the environment.

Sources affected by this document are required to complete an Air Pollution Permit Application (AP 100) if an application has not been submitted, a HAP Permit Application (AP-117), and submit any additional information needed by the Department to evaluate the potential risk to human health or the environment from HAP emissions.

## **AUTHORITY**

The Department has authority to control HAP emissions under Section 33-15-02-04, subsection 3 of the North Dakota Air Pollution Control Rules which states, "The ambient air shall not contain air contaminants in concentrations that would be injurious to human health or well-being or unreasonably interfere with the enjoyment of property or that would injure plant or animal life. The Department may establish, on a case-by-case basis, specific limits of concentration for these contaminants."

## **DEFINITIONS**

### **Hazardous Air Pollutant**

For the purpose of this document, a hazardous air pollutant is defined as any air pollutant lacking an applicable ambient air quality standard which may contribute to a significant increase in human mortality, cause serious irreversible or incapacitating reversible illness, pose a significant threat to human health or the environment, or be considered by the Department of Health to pose a community problem. This definition is consistent with Section 33-15-02-04, subsection 03 of the North Dakota Air Pollution Control Rules and with Section 112 of the Federal Clean Air Act.

**Unit risk factor** is an estimate of the probability of developing cancer when exposed to  $1 \mu\text{g}/\text{m}^3$  of a substance for 70 years.

**Maximum individual carcinogenic risk** is an estimate of the probability of developing cancer by an individual exposed to the greatest concentration of a substance in the ambient air over a 70-year period (U.S. EPA 1975). This is obtained by following the procedure outlined in the Dispersion Modeling Section of this document. For example, a maximum individual carcinogenic risk of  $8 \times 10^{-4}$  implies that eight people out of 10,000 would be expected to develop cancer when exposed for 70 years to the maximum concentration of a substance in the ambient air.

**New HAP Emission Unit** is a unit constructed or modified after July 29, 1987 which emits a hazardous air pollutant.

**Existing HAP Emission Unit** is a unit constructed on or before July 29, 1987 which emits a hazardous air pollutant.

**Modified** means to make a physical change to an emission unit which increases the hourly emission rate of any HAP.

## **BACKGROUND**

The control of air pollutants has traditionally concentrated on a relatively few "criteria" pollutants, whose emissions are regulated by various local, state and federal rules. Particulate matter less than 10 microns in diameter (PM<sub>10</sub>), sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead emissions are regulated by placing emission limits on designated air contaminant sources. The Federal NSPS program regulates, in addition to the previously mentioned pollutants, several air contaminants from select sources. Some effort has been made to control HAPs on the federal and state levels through the NESHAP and MACT programs. However, promulgation of new NESHAPs by EPA has been slow, requiring 4-5 years. Also, the NESHAP program has concentrated on pollutants posing a national health risk, not a local health risk. Small population centers are often overlooked in the federal process. The MACT program addresses less than 190 pollutants and generally applies only to major sources of HAPs.

Increased local and national concern about the release of hazardous/toxic substances, the relative slowness of NESHAP and MACT promulgation at the federal level, the wide variety of chemicals released to the atmosphere and increased encouragement at the federal level, are the primary impetuses for a policy document delineating the Department's policy with respect to the control of routine releases of HAPs.

## **APPROACH**

The approach used by the Department to evaluate a permit application for a new emission unit(s) releasing HAPs into the ambient air is to require: a) An analysis of the carcinogenic health effects of emissions.; and b) An analysis of the non-carcinogenic health effects of emissions.

### **Analysis of Carcinogenic Health Effects**

A list of HAPs which are considered to have known or possible carcinogenic health effects is included as Appendix B. This list is compiled by the Department using the following sources: 1) US EPA Integrated Risk Information System (IRIS) database, which is available at: <http://www.epa.gov/iris/>; and 2) US EPA table of Prioritized Chronic Dose-Response Values for Screening Risk Assessments, which is available at: <http://www.epa.gov/ttn/atw/toxsource/table1.pdf>. Other unit risk factors may be used upon approval by the Department.

The maximum individual carcinogenic risk (MICR) shall be calculated as outlined in the "Determination of Compliance" section of this document. For those HAPs with known or possible carcinogenic health effects, an analysis is required to demonstrate that the

combined impact of new HAP emission units does not result in a maximum individual carcinogenic risk (as defined by this policy) of greater than  $1 \times 10^{-5}$  (one in one hundred thousand).

It must be stressed that the acceptable MICR of  $1 \times 10^{-5}$  is not meant to establish a health-based standard. Rather, the acceptable MICR level of  $1 \times 10^{-5}$  will be used by the Department as a mechanism to evaluate the need for further review of emissions from sources emitting HAPs with known or possible carcinogenic health effects.

### **Analysis of Non-Carcinogenic Health Effects**

An analysis is required to demonstrate that the combined impact of all new HAP emission units does not cause an exceedance of an applicable Guideline Concentration (GC) as defined by this policy.

Guideline Concentrations are developed based on the use of the TLV-TWA, the TLV-STEL or the TLV-C developed by the American Conference of Governmental Industrial Hygienists. Substances designated by the ACGIH as simple asphyxiants such as helium whose mechanism of action is primarily through reduction of oxygen and which, upon dilution in ambient air should pose little health risk, are exempt. The following substances for which an ambient standard has been established in Section 33-15-02-04 of the North Dakota Air Pollution Control Rules are also exempt: sulfur dioxide, hydrogen sulfide, carbon monoxide, ozone, nitrogen dioxide and lead. In addition to those substances for which an ambient standard has been established, aluminum oxide, coal dust, grain dust and portland cement are also exempt based on the Department's determination that the ambient standard for  $PM_{10}$  adequately addresses emissions of these substances.

The ACGIH (2007) defines the TLV-TWA as the time-weighted average 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, day after day, for a working lifetime without adverse effect. The TLV-STEL is the concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from: (1) irritation; (2) chronic or irreversible tissue damage; (3) dose-rate-dependent toxic effects; or (4) narcosis of sufficient degree to increase the likelihood of accidental injury, impaired self-rescue or materially reduced work efficiency, and provided that the daily TLV-TWA is not exceeded. The TLV-C is the concentration that should not be exceeded during any part of the working exposure. Eight-hour and 1-hour Guideline Concentrations (GCs) for the pollutants specified in Appendix A are established from the TLV-TWA and TLV-STEL/TLV-C, respectively, of the ACGIH. Also, only certain substances have a 1-hour Guideline Concentration. These substances have been recognized by the ACGIH as having acute effects as well as chronic effects and have an appropriate TLV-STEL or TLV-C. Therefore, the

Department believes an additional shorter averaging period is warranted for these substances.

Computation of both the 8-hour and 1-hour Guideline Concentrations (GCs) are based on the application of certain correction factors to the TLV-TWA and TLV-STEL/TLV-C, respectively. Eight-hour GCs are calculated by first extrapolating the dose incurred during a 40-hour work week to an "equivalent" continuous weekly dose by dividing the TLV-TWA by 4.2 (168/40 hours). The TLV-TWA is then adjusted by dividing by a factor of 1.75 representing the average lung ventilation volume of 10 cubic meters/24 hours for a 6-year old child weighing 20 kg compared to the average ventilation volume of 20 cubic meters/24 hours for an adult weighing 70 kg (Commonwealth of Massachusetts 1985). This is done to protect children, whom for various reasons such as differing ventilation, absorption, and excretion rates, and immature immune systems, may be more susceptible to the effects of these pollutants. Finally, the TLV-TWA is divided by a safety factor of 5 to protect additional portions of the exposed population and to account for the fact that only HAPs from new HAP emission units are addressed by the policy with the use of guideline concentrations. Therefore, the preliminary 8-hour Guideline Concentration (GC) is given by equation 1.

$$\text{Preliminary GC}_{8\text{-hour}} = \text{TLV-TWA} / (4.2 \times 5 \times 1.75) \quad (1)$$

The above equation results in a divisor of 36.75. However, to simplify calculation of the GC and to provide an additional factor of safety, the divisor is adjusted to 50. So, the Guideline Concentration of a HAP for an 8-hour averaging period based on the TLV-TWA is:

$$\text{GC}_{8\text{-hour}} = \text{TLV-TWA} / 50 \quad (2)$$

The same divisor of 50 is applied to the TLV-STEL or TLV-C in calculating the 1-hour GC. This results in a conservative 1-hour GC. The 1-hour GC, based on the TLV-STEL or TLV-C, is:

$$\text{GC}_{1\text{-hour}} = \text{TLV-STEL (or TLV-C)} / 50 \quad (3)$$

When necessary, a GC will be set by the Department for those substances lacking an appropriate TLV. This will be done by applying the appropriate safety factors, determined to be necessary to prevent adverse health effects because of extrapolation from incomplete toxicity data or animal toxicity data, to the No Observable Effect Level (NOEL) or any other measure of toxicity, as deemed appropriate by the Department.

The AGGIH regularly updates the TLV-TWA and TLV-STEL for the various chemicals. The Department will use the latest version of the ACGIH handbook to determine the appropriate GC. Should that

data conflict with a GC listed in this policy, the most current TLV will be used for determining compliance.

It must be stressed that the Guideline Concentration for a substance is not an ambient standard. Rather, the Guideline Concentration will be used by the Department as a mechanism to further evaluate the need for further review of emissions from sources whose predicted concentrations exceed either the 8-hour or 1-hour Guideline Concentration.

## **DETERMINATION OF COMPLIANCE**

To determine compliance with the applicable 8-hour GC, 1-hour GC or carcinogenic risk criteria, the maximum off-property, ground-level ambient concentration of each HAP emitted from an affected HAP source must be calculated using the dispersion modeling procedure outlined in the following section entitled "Dispersion Modeling Procedure." Maximum concentrations for each HAP must be calculated using the maximum potential HAP emission rate for the time period of the GC (i.e., 1-hour, 8-hour or other averaging period). For HAPs with known or possible carcinogenic health effects (i.e., those HAPs for which a unit risk factor has been developed), a maximum annual concentration for each HAP and the maximum individual carcinogenic risk associated with emissions from the source must be calculated. When calculating a maximum annual concentration as part of a Tier 1 or Tier 2 analysis (as described in the Dispersion Modeling Procedure Section), the maximum potential annual average HAP emission rate must be used. The results of these calculations must then be used to determine if emissions from the affected HAP source comply with the GC(s), the hazard index or the carcinogenic risk criteria established by this policy.

Facilities emitting more than one HAP will be given special consideration by the Department because of the possibility of synergism between pollutants. For example, where two or more carcinogenic risk assessments are required, risks from the individual pollutants will be assumed to be additive and the combined maximum individual carcinogenic risk from all HAPs with known or possible carcinogenic health effects must be less than  $1 \times 10^{-5}$ . Similarly, the non-carcinogenic health effects of multiple HAPs emitted from a source are assumed to be additive if the available toxicity data are insufficient to determine otherwise. The non-carcinogenic health effects of multiple HAPs into the ambient air will be evaluated according to equation 4:

$$\text{Hazard Index} = MC_1/GC_1 + MC_2/GC_2 + \dots + MC_n/GC_n \quad (4)$$

where  $MC_1, MC_2, \dots, MC_n$  are the modeled ambient concentrations for HAPs 1, 2, ..., n and  $GC_1, GC_2, \dots, GC_n$  are the Guideline Concentrations for HAPs 1, 2, ..., n. A hazard index less than or equal to 1 will be considered acceptable, whereas a hazard index greater than 1 will trigger further review by the Department.

## **DISPERSION MODELING PROCEDURE**

A three-tiered approach to calculating the maximum off-property, ground-level ambient concentration of each HAP is recommended. The analysis begins with Tier 1, which is the simplest technique and involves the most conservative assumptions. Each successive tier involves more refined, less conservative techniques. If application of the Tier 1 procedure results in predicted compliance with the requirements of this policy, no further analysis is necessary. However, if the subject source is not predicted to comply with this policy after application of the Tier 1 procedure, a Tier 2 analysis will be necessary. Likewise, failure to comply after the Tier 2 procedure mandates a Tier 3 analysis.

The Tier 1 procedure involves the use of simple look-up tables to determine maximum off-property, ground-level ambient concentrations for each HAP with a minimum of source information. The Tier 2 procedure requires use of a computer and the EPA SCREEN3 model. Lastly, the Tier 3 procedure involves use of a refined computer model. Through use of detailed information on source and meteorological conditions, the Tier 3 procedure provides the most realistic (least conservative) HAP concentrations.

### **Tier 1 Procedure**

The Tier 1 procedure utilizes look-up Tables 1 and 2 (see pages 16 and 17), which provide normalized maximum 1-hr concentrations for various stack heights and downwind distances. Table 1 is used to determine HAP impacts from stacks which are good engineering practice (GEP) height with respect to all nearby buildings. Table 2 applies for stacks which are less than GEP height with respect to nearby buildings. In the latter case, maximum ground-level concentrations will generally be higher because of building downwash effects. GEP height, in the context of the present analysis, is defined as follows:

$$H_g = H + 1.5L \quad (5)$$

Where:

- $H_g$  = good engineering practice stack height, measured from the ground-level elevation at the base of the stack,
- $H$  = height of nearby structure, measured from the ground-level elevation at the base of the stack,
- $L$  = lesser dimension, height or projected width, of nearby structure.

"Nearby" is defined as less than  $5L$  distance from the stack. If more than one nearby structure is present, GEP height should be based on the structure which produces the largest  $H_g$  in Equation 5.

The Tier 1 procedure does not apply for highly reactive pollutants or for releases which are heavier than air (dense gas releases). The Tier 1 procedure is not applicable to scenarios involving non-point sources (i.e., area, volume, or line sources). The procedure is also not applicable to scenarios involving significant terrain height variations or complex building downwash, specifically:

1. terrain elevation above stack-base elevation exceeds  $H_s$  within  $50 H_s$  of the stack location, where  $H_s$  = stack height,
2. any building within  $5L$  of the stack location exceeds the stack height.

If either of these conditions exist, or if non-point sources are involved, a Tier 2 analysis will be necessary.

The Tier 1 procedure involves the following steps:

1. Determine the stack height (meters) for the HAP source.
2. Using Equation 5, determine if the stack height is GEP with respect to all nearby structures.
3. Select the appropriate Table 1 or 2, depending on the GEP status of the stack. Table 1 may be used only if the stack height is GEP with respect to all nearby structures.
4. In the table, select the row for the stack height nearest to, but less than or equal to, the actual stack height.
5. Determine the lateral distance (meters) from the HAP release point to the nearest point off-property. (If the property is not bounded by a fence, this distance is zero.)
6. In the table, select the column for the distance nearest to, but less than, the distance determined in Step 5.

7. Beginning with the value indicated by the intersection of the row from Step 4 and column from Step 6, proceed down the row to the right to find the largest value to the right of and including the intersection value.
8. Multiply the value from Step 7 by the 1-hour emission rate for each HAP from the stack, to estimate the maximum off-property 1-hour concentration for each HAP for this stack.
9. If more than one stack is present, repeat Steps 1-8 for each stack. Then, if any stacks have common HAPs, add the Step 8 results for each stack to determine the total off-property 1-hour concentration for each HAP.
10. Determine the maximum individual carcinogenic risk (MICR) for any HAP with a known or possible carcinogenic effect. First, multiply the Step 9 results for each HAP by the appropriate conversion factor (Table 3) to estimate a 70-year average concentration. Then, multiply the 70-year average concentration by the Unit Risk Factor (from Appendix B) for each HAP to determine the MICR for each HAP. Lastly, sum the MICR for individual HAPs to determine total MICR.
11. Determine the hazard index for all HAPs for which a Guideline Concentration (GC) has been established (see Appendix A). For any HAPs which have 8-hour average GCs, multiply the total 1-hour concentration (Step 9) by the appropriate conversion factor (Table 3) to estimate a maximum 8-hour average concentration. Then, determine the hazard index using Equation 4 and the GCs from Appendix A. Note that for HAPs which have both 1-hour and 8-hour GCs, the higher of the two ratios (MC/GC) should be utilized in Equation 4.

If the total MICR as computed in Step 10 is greater than  $1 \times 10^{-5}$ , a Tier 2 analysis will be necessary for the HAPs with known or possible carcinogenic health effects. Likewise, if the hazard index computed in Step 11 is greater than one, a Tier 2 analysis will be necessary to evaluate the non-carcinogenic health effects.

Tables 1 and 2 were created using the EPA SCREEN3 model (U.S. EPA, 1995). For a given release height and downwind distance, the SCREEN3 model can select the highest predicted concentration from a matrix of predictions for all plausible meteorological conditions. Plume rise was not considered in developing Tables 1 and 2, thus ensuring conservativeness of the resultant entries. Table 2 was created by entering generic building dimensions into SCREEN3 to simulate structural downwash effects. A range of building sizes for each stack height was considered, including dimensions which induced plume entrainment into the building cavity region (i.e., cavity concentrations). Though the range of simulated building dimensions was limited, the entries in Table 2 are likely

conservative for any building configuration, given that plume rise was not accounted for.

## **Tier 2 Procedure**

The Tier 2 procedure involves use of the EPA SCREEN3 computer screening model (U.S. EPA 1995). For a given set of source conditions and downwind distances, the SCREEN3 model selects the highest predicted 1-hour concentration from a matrix of predictions for all plausible meteorological conditions. The SCREEN3 model can simulate point and area sources, and building downwash conditions. Use of SCREEN3 constitutes a less conservative procedure than the Tier 1 analysis because plume rise and building downwash are more realistically treated.

The Tier 2 procedure is not applicable for highly reactive pollutants or for dense gas releases. The Tier 2 procedure may be applied for area sources (as defined in the SCREEN3 Model User's Guide), but is not recommended for volume or line sources.

The Tier 2 procedure involves the following steps:

1. Assemble the source input information necessary for SCREEN3, including:
  - stack height (point source)
  - stack diameter (point source)
  - stack gas exit velocity (point source)
  - stack gas exit temperature (point source)
  - source length (area source, must be square)
  - emission release height (area source)
2. Using Equation 5, determine if the stack height is GEP with respect to all nearby structures. If not, building dimensions (height, length, width) reflective of the most significant nearby structure will be needed (see Tier 1 procedure for a description of "nearby").
3. Execute SCREEN3 using:
  - unit emission rate (1.0 g/sec)
  - source parameters from Step 1
  - all meteorological conditions
  - ambient temperature of 293°K
  - rural dispersion
  - receptor elevation of 0.0
  - a range of receptors which reflects the distance from the stack (source) to the closest property boundary (zero if no fence), out to at least 100  $H_s$  from the stack ( $H_s$  = stack/release height)
  - downwash building dimensions determined in Step 2, if downwash is applicable

- no terrain screening
4. Execute SCREEN3 again using the input conditions in Step 3, but with the simple terrain screening option, and the five receptors described below:
- Receptor 1 - highest terrain feature between the stack location and 25 H<sub>s</sub> from the stack location (any radial direction)
  - Receptor 2 - highest terrain feature between 25 H<sub>s</sub> and 50 H<sub>s</sub> from the stack location
  - Receptor 3 - highest terrain feature between 50 H<sub>s</sub> and 75 H<sub>s</sub> from the stack location
  - Receptor 4 - highest terrain feature between 75 H<sub>s</sub> and 100 H<sub>s</sub> from the stack location
  - Receptor 5 - use the downwind distance associated with the maximum prediction from Step 3, and the maximum elevation for this distance (i.e., in any radial direction)

H<sub>s</sub> = stack height or release height (point or area source, respectively). If the receptor elevation is above stack-top elevation, substitute H<sub>s</sub> - 0.1 meter for receptor height. Do Not use complex terrain screening.

Terrain elevations should be obtained from USGS 7.5 minute topographic maps or digital elevation models. On a case-by-case basis, the Department may determine that terrain screening is not necessary. In this event, the results from Step 3 should be assumed final.

5. Multiply the maximum prediction from Step 4 by the maximum 1-hour emission rate in grams/second for each HAP from the stack, to estimate the maximum off-property 1-hour concentration for each HAP for this stack.
6. If more than one stack is present, repeat Steps 1-5 for each stack. Then, if any stacks have common HAPs, add the Step 5 results for each stack to determine the total off-property 1-hour concentration for each HAP.
7. Determine the MICR for each HAP with a known or possible carcinogenic health effect. First, multiply the Step 6 results for each HAP by the appropriate conversion factor (Table 3) to estimate a 70-year average concentration. Then, multiply the 70-year average concentration by the Unit Risk Factor (from Appendix B) for each HAP to determine the MICR

for each HAP. Lastly, sum the MICR for individual HAPs to determine total MICR.

8. Determine the hazard index for HAPs for which a Guideline Concentration (GC) has been established (see Appendix A). For any HAPs which have 8-hour average GCs, multiply the total 1-hour concentration (Step 6) by the appropriate conversion factor (Table 3) to estimate a maximum 8-hour average concentration. Then, determine the hazard index using Equation 4 and the GCs from Appendix A. Note that for HAPs which have both 1-hour and 8-hour GCs, the higher of the two ratios (MC/GC) should be utilized in Equation 4.

If the total MICR as computed in Step 7 is greater than  $1 \times 10^{-5}$ , a Tier 3 analysis will be necessary for the HAPs with known or possible carcinogenic health effects. Likewise, if the hazard index computed in Step 8 is greater than one, a Tier 3 analysis will be necessary to evaluate the non-carcinogenic health effects.

### **Tier 3 Procedure**

The Tier 3 procedure involves use of refined EPA computer models. The use of refined models constitutes a less conservative procedure than Tier 2 primarily because refined models use actual hour-by-hour meteorological data, and because refined models treat multiple stack scenarios and elevated terrain more realistically than SCREEN3.

Candidate models for the Tier 3 procedure include AERMOD or ISC-PRIME. AERMOD is the preferred tool if the modeling problem is dominated by terrain effects. Other approaches may be needed if highly reactive pollutants or dense gas releases are involved.

The procedure for application of refined models is well-documented elsewhere and, because of its complexity, is not included here. The reader is referred to the EPA "Guideline on Air Quality Models" (U.S. EPA 2005) for instructions on refined modeling analyses. The Department may also be contacted regarding procedures for refined analyses.

Maximum 1-hour and 8-hour HAP concentrations needed to determine compliance with the Guideline Concentrations and the Hazard Index can be obtained directly from refined model output. To emulate the 70-year average concentration needed for the MICR analysis, the refined model should be used to determine a 5-year period average concentration (five years of sequential meteorological data are typically available for refined models). The Department considers this 5-year period average to be representative of the 70-year average for the MICR analysis.

## **RISK ASSESSMENT PROCEDURE**

Risk assessments should be conducted according to the procedure outlined in the section of this document entitled "Dispersion Modeling Procedure." The Department acknowledges the problem of exposure from multiple environmental pathways, but will presently consider only exposure through the air. Any questions concerning the appropriate models for the risk assessments should be directed to the Department prior to performing these assessments.

## **LIMITATIONS OF THE APPROACH**

There are several limitations to the TLV approach. The ACGIH handbook clearly states that the TLVs "... are guidelines or recommendations for the control of potential health hazards and for no other use, e.g., ... in estimating the toxic potential of continuous, uninterrupted exposures...". This is in part because the TLV-TWA permits excursions above the specified concentration provided equivalent excursions below the limit occur. The TLV approach also ignores possible antagonistic responses between HAPs, frequently provides one TLV for substances with many valences or isomers, assumes an arbitrary safety factor, adjusts the TLV to an appropriate exposure for hypersensitive portions of the exposed population, and assumes a dose incurred during a 40-hour workweek has the same effects as if the dose was incurred continuously for one week. However, the Guideline Concentrations set by this method are being used as a "trigger" for further review of sources where a potential problem may be possible, not as an ambient standard.

Limitations of the risk assessment are directly related to an inability to assign uncertainty to numbers used in the risk assessment process. Because of the assumption of "no threshold dose" for carcinogens and a linear extrapolation of the data to considerably lower risks, the unit risk factor is an upper estimate of the potency. The actual potency may be considerably less.

## SPECIAL CONSIDERATIONS

This policy does not supersede any applicable state or federal rule, regulation or law.

## QUESTIONS

Any questions about this document should be directed to:

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This document is available at:  
<http://www.ndhealth.gov/AQ/Toxics.htm>

## HISTORY

Effective July 29, 1987. Amended November 11, 1989; March 27, 1991; September 15, 1993; October 31, 1994; April 2001; August 2003; June 20, 2007; November 22, 2007

Approved:



Terry L. O'Clair, P.E.  
Director  
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Date: November 22, 2007

## DOCUMENTATION

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TABLE 1  
 MAXIMUM NORMALIZED 1-HOUR CONCENTRATIONS<sup>1</sup> - GEP STACKS (mg/m<sup>3</sup>)

Stack Ht. (meters)	Downwind Distance (meters)													
	10	20	30	40	50	75	100	150	200	300	400	500	750	1000
1	149	156	142	110	85	48	31	16	9.8	5.0	3.1	2.1	1.1	.67
5	.41	4.3	5.0	5.5	5.5	5.4	5.4	5.0	4.8	3.4	2.4	1.8	.97	.63
10	<sup>2</sup> neg.	.007	.64	1.1	1.2	1.3	1.4	1.3	1.2	1.1	1.1	1.0	.72	.52
20	neg.	neg.	neg.	.013	.064	.23	.29	.31	.32	.27	.27	.24	.19	.16
30	neg.	neg.	neg.	neg.	neg.	.025	.078	.13	.13	.14	.13	.11	.10	.080
50	neg.	neg.	neg.	neg.	neg.	neg.	.0012	.022	.045	.048	.084	.046	.041	.034
100	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	.0086	.015	.015	.013	.011
200	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	.0035	.0060	.0048

<sup>1</sup>Normalized with respect to emission rate (1.0 grams/sec used)

<sup>2</sup>neg. = negligible, defined as less than 0.001 milligrams/m<sup>3</sup>

TABLE 2  
 MAXIMUM NORMALIZED 1-HOUR CONCENTRATIONS<sup>1</sup> - NON-GEP STACKS (mg/m<sup>3</sup>)

Stack Ht. (meters)	Downwind Distance (meters)													
	10	20	30	40	50	75	100	150	200	300	400	500	750	1000
1	149	156	142	110	85	48	31	16	9.8	5.0	3.1	2.1	1.1	.67
5	23	17	19	18	16	12	9.3	6.5	4.9	3.4	2.4	1.8	.97	.63
10	5.8	3.8	3.8	4.5	4.9	5.0	4.0	3.0	2.4	1.7	1.3	1.1	.72	.52
20	1.5	1.5	.60	.60	.60	.78	.88	.89	.71	.52	.42	.35	.25	.19
30	.65	.65	.65	.22	.22	.22	.27	.32	.33	.26	.21	.17	.12	.099
50	<sup>2</sup> neg.	neg.	neg.	neg.	neg.	neg.	neg.	.071	.084	.094	.087	.073	.055	.044
100	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	.024	.025	.025	.024	.019
200	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	.0035	.0060	.0049

<sup>1</sup>Normalized with respect to emission rate (1.0 grams/sec used)

<sup>2</sup>neg. = negligible, defined as less than 0.001 milligrams/m<sup>3</sup>

TABLE 3  
CONVERSION OF 1-HOUR CONCENTRATIONS  
TO OTHER AVERAGING TIMES

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<u>Averaging Time</u>	<u>Multiplying Factor*</u>
8 hours	0.7
70 years	0.08

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\* For Tier 3 refined modeling analyses, 8-hour average and 70-year average concentrations should be derived directly from model output, as discussed in "Tier 3 Procedure" on page 12 of this document.

## Appendix A. Guideline Concentrations (GCs)

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Acetaldehyde		0.90082
Acetic acid	0.49080	0.73620
Acetic anhydride	0.41755	
Acetone	23.74233	35.61350
Acetone cyanohydrin, as CN		0.10000
Acetonitrile	0.67157	
Acetophenone	0.98282	
Acetylsalicylic acid (aspirin)	0.10000	
Acrolein		0.00459
Acrylamide	0.00060	
Acrylic acid	0.11789	
Acrylonitrile	0.08679	
Adipic acid	0.10000	
Adiponitrile	0.17685	
Alachlor	0.02000	
Aldrin	0.00100	
Allyl alcohol	0.02375	
Allyl chloride	0.06258	0.12515
Allyl glycidyl ether (AGE)	0.09337	
Allyl propyl disulfide	0.06060	
Aluminum and compounds as Al		
Metal dust	0.20000	
Pyro powders, as Al	0.10000	
Soluble salts, as Al	0.04000	
Alkyls, as Al	0.04000	
2-Aminopyridine	0.03726	
Amitrole	0.00400	
Ammonia	0.34826	0.48757
Ammonium chloride fumes	0.20000	0.40000
Ammonium perfluorooctanoate	0.00020	
Ammonium sulfamate	0.20000	
tert-Amyl methyl ether (TAME)	1.67198	
Aniline	0.15234	
Anisidine (o- isomer)	0.01000	
Anisidine ( p- isomer)	0.01000	
Antimony & compounds, as Sb	0.01000	
Antimony hydride	0.01021	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
ANTU	0.00600	
Arsenic	0.00020	
Arsine	0.00032	
Asphalt (petroleum) fumes	0.01000	
Atrazine	0.10000	
Azinphos-methyl	0.00400	
Barium, soluble compounds, as Ba	0.01000	
Barium sulfate	0.20000	
Benomyl	0.20000	
Benzene	0.03195	0.15973
Benzotrichloride		0.01599
Benzoyl chloride		0.05749
Benzoyl peroxide	0.10000	
Benzyl acetate	1.22847	
Benzyl chloride	0.10354	
Beryllium and compounds, as Be	0.00004	0.00020
Biphenyl	0.02523	
Bis(2-dimethylaminoethyl) ether (DMAEE)	0.00655	0.01966
Bismuth telluride Undoped Se-doped(as Bi <sub>2</sub> Te <sub>3</sub> )	0.20000 0.10000	
Borate compounds, Inorganic	0.04000	0.12000
Boron oxide	0.20000	
Boron tribromide (c)		0.20497
Boron trifluoride (c)		0.05548
Bromacil	0.20000	
Bromine	0.01307	0.02614
Bromine pentafluoride	0.01431	
Bromoform	0.10339	
1-Bromopropane	1.00605	
1,3-Butadiene	0.08849	
n-Butanol (c)	1.21260	
sec-Butanol	6.06299	
tert-Butanol	6.06299	
2-Butoxyethanol (EGBE)	1.93325	
2-Butoxyethyl acetate (EGBEA)	2.62086	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Butyl acetate		
n-	14.25276	19.00368
sec-	19.00368	
tert-	19.00368	
n-Butyl acrylate	2.09685	
n-Butylamine (c)		0.90082
Butylated hydroxytoluene (BHT)	0.04000	
tert-Butyl chromate, as CrO <sub>3</sub> (c)		0.00200
n-Butyl glycidyl ether (BGE)	0.31953	
n-Butyl lactate	0.59791	
n-Butyl mercaptan	0.03689	
o-sec-Butylphenol	0.61440	
p-tert-Butyltoluene	0.12121	
Cadmium	0.00020	
compounds, as Cd	0.00004	
Calcium chromate	0.00002	
Calcium cyanamide	0.01000	
Calcium hydroxide	0.10000	
Calcium oxide	0.04000	
Calcium silicate (synthetic)	0.20000	
Calcium sulfate	0.20000	
Camphor, synthetic	0.24921	0.37382
Caprolactam	0.10000	
Captafol	0.00200	
Captan	0.10000	
Carbaryl	0.10000	
Carbofuran	0.00200	
Carbon black	0.07000	
Carbon disulfide	0.06228	
Carbon tetrabromide	0.02713	0.08139
Carbon tetrachloride	0.62920	1.25840
Carbonyl fluoride	0.10799	0.26998
Catechol	0.45035	
Cellulose	0.20000	
Cesium hydroxide	0.04000	
Chlordane	0.01000	
Chlorinated camphene	0.01000	
o-Chlorinated diphenyl oxide	0.01000	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Chlorine	0.02900	0.05800
Chlorine dioxide	0.00552	0.01655
Chlorine trifluoride (c)		0.00756
Chloroacetaldehyde (c)		0.06421
Chloroacetone		0.07569
2-Chloroacetophenone	0.00632	
Chloroacetyl chloride	0.00462	0.01386
Chlorobenzene	0.92074	
o-Chlorobenzylidene malononitrile (c)		0.00771
Chlorobromomethane	21.16810	
Chlorodifluoromethane	70.73211	
Chlorodiphenyl (42% chlorine)	0.02000	
Chlorodiphenyl (54% chlorine)	0.01000	
Chloroform	0.97652	
bis (Chloromethyl) ether	0.00009	
1-Chloro-1-nitropropane	0.20211	
Chloropentafluoroethane	126.35583	
Chloropicrin	0.01345	
1-Chloro-2-propanol and 2-Chloro-1-propanol	0.07733	
beta-Chloroprene	0.72425	
2-Chloropropionic acid	0.00888	
o-Chlorostyrene	5.66871	8.50307
o-Chlorotoluene	5.17751	
Chlorpyrifos	0.00200	
Chromite ore processing (Chromate), as Cr	0.00100	
Chromium, metal, and inorganic compounds, as Cr		
Metal and Cr III compounds	0.01000	
Water-soluble Cr VI compounds	0.00100	
Insoluble Cr VI compounds	0.00020	
Chromyl chloride	0.00317	
Clopidol	0.20000	
Coal tar pitch volatiles, as benzene soluble aerosol	0.00400	
Cobalt, elemental, and inorganic compounds, as Co	0.00040	
Cobalt carbonyl, as Co	0.00200	
Cobalt hydrocarbonyl, as Co	0.00200	
Copper		
Fume	0.00400	
Dusts & mists, as Cu	0.02000	
Cotton dust, raw	0.00400	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Coumaphos	0.00100	
Cresol, all isomers	0.44229	
Crotonaldehyde		0.01720
Crufomate	0.10000	
Cumene	4.91575	
Cyanamide	0.04000	
Cyanogen	0.42569	
Cyanogen chloride (C)		0.01509
Cyclohexane	6.88425	
Cyclohexanol	4.09652	
Cyclohexanone	1.60556	0.90082
Cyclohexene	20.15706	
Cyclohexylamine	0.81121	
Cyclonite	0.01000	
Cyclopentadiene	4.05521	
Cyclopentane	34.41963	
Cyhexatin	0.10000	
2,4-D	0.20000	
DDT	0.02000	
Decaborane	0.00500	0.01501
Demeton	0.00100	
Demeton-S-methyl	0.00100	
Diacetone alcohol	4.75092	
Diazinon	0.00020	
Diazomethane	0.00688	
Diborane	0.00227	
2-N-Dibutylaminoethanol	0.07088	
Dibutyl phenyl phosphate	0.07025	
Dibutyl phosphate	0.17195	0.34390
Dibutyl phthalate	0.10000	
Dichloroacetic acid	0.05274	
Dichloroacetylene (c)		0.00777
o-Dichlorobenzene	3.00634	6.01268
p-Dichlorobenzene	1.20254	
1,4-Dichloro-2-butene		
Dichlorodifluoromethane	98.90389	
1,3-Dichloro-5,5-dimethyl hydantoin	0.00400	0.00800
1,1-Dichloroethane	8.09571	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
1,2-Dichloroethylene	15.86094	
Dichloroethyl ether	0.58495	1.16990
Dichlorofluoromethane	0.84188	
Dichloromethane	3.47362	
1,1-Dichloro-1-nitroethane	0.23552	
1,3-Dichloropropene	0.09078	
2,2-Dichloropropionic acid	0.10000	
Dichlorotetrafluoroethane	139.82004	
Dichlorvos (DDVP)	0.00200	
Dicrotophos	0.00100	
Dicyclopentadiene	0.54074	
Dicyclopentadienyl iron	0.20000	
Dieldrin	0.00500	
Diesel fuel	2.00000	
Diethanolamine	0.04000	
Diethylamine	0.29914	0.89742
2-Diethylaminoethanol	0.19172	
Diethylene triamine	0.08439	
Di(2-ethylhexyl)phthalate (DEHP)	0.10000	
Diethyl ketone	14.09080	21.13620
Diethyl phthalate	0.10000	
Difluorodibromomethane	17.16401	
Diglycidyl ether (DGE)	0.01065	
Diisobutyl ketone	2.90859	
Diisopropylamine	0.41387	
N,N-Dimethylacetamide	0.71264	
Dimethylamine	0.18438	0.55313
Dimethylaniline (N,N-Dimethylaniline)	0.49562	0.99125
Dimethyl carbomoyl chloride	0.00044	
Dimethyl disulfide	0.03853	
Dimethylethoxysilane	0.04262	0.12785
Dimethylformamide	0.59787	
1,1-Dimethylhydrazine	0.00049	
Dimethylphthalate	0.10000	
Dimethyl sulfate	0.01031	
Dimethyl sulfide	0.50830	
Dinitrobenzene (all isomers)	0.02063	
Dinitro-o-cresol	0.00400	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
3,5-Dinitro-o-toluamide	0.02000	
Dinitrotoluene	0.00400	
1,4-Dioxane	1.44131	
Dioxathion	0.00200	
1,3-Dioxolane	1.21194	
Diphenylamine	0.20000	
Dipropyl ketone	4.69530	
Diquat		
Total Dust	0.01000	
Respirable Fraction	0.00200	
Disulfiram	0.04000	
Disulfoton	0.00100	
Diuron	0.20000	
Divinyl benzene	1.06495	
Dodecyl mercaptan	0.01656	
Emery	0.20000	
Endosulfan	0.00200	
Endrin	0.00200	
Enflurane	11.31902	
Epichlorohydrin	0.03784	
EPN	0.00200	
Ethanol	37.68507	
Ethanolamine	0.14989	0.29978
Ethion	0.00100	
2-Ethoxyethanol (EGEE)	0.36859	
2-Ethoxyethyl acetate (EGEEA)	0.54053	
Ethyl acetate	28.82618	
Ethyl acrylate	0.40945	1.22834
Ethylamine	0.18438	0.55313
Ethyl amyl ketone	1.04875	
Ethyl benzene	8.68384	10.85481
Ethyl bromide	0.44573	
Ethyl tert-butyl ether (ETBE)	0.41791	
Ethyl butyl ketone	4.67035	7.00552
Ethyl chloride	5.27771	
Ethyl cyanoacrylate	0.02047	
Ethylene	4.58896	
Ethylene chlorohydrin (c)		0.06587
Ethylenediamine	0.49162	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Ethylene dichloride	0.80949	
Ethylene glycol, aerosol		2.00000
Ethylene glycol dinitrate	0.00622	
Ethylene oxide	0.03603	
Ethylenimine	0.01762	
Ethyl ether	24.25194	30.31493
Ethyl formate	6.05971	
2-Ethylhexanoic acid	0.10000	
Ethylidene norbornene (c)		0.49157
Ethyl mercaptan	0.02541	
N-Ethylmorpholine	0.47108	
Ethyl silicate	1.70389	
Fenamiphos	0.00100	
Fensulfothion	0.00020	
Fenthion	0.00100	
Ferbam	0.20000	
Ferrovandium dust	0.02000	0.06000
Flour dust	0.01000	
Fluorides, as F	0.05000	
Fluorine	0.03108	0.06217
Fonofos	0.00200	
Formaldehyde		0.00737
Formamide	0.36843	
Formic Acid	0.18822	0.37644
Furfural	0.15719	
Furfuryl alcohol	0.80245	1.20368
Gallium arsenide	0.00001	
Gasoline	17.17791	28.62986
Germanium tetrahydride	0.01254	
Glutaraldehyde (c)		0.00409
Glycerin mist	0.20000	
Glycidol	0.12119	
Glyoxal	0.00200	
Graphite, all forms except graphite fibers	0.04000	
Hafnium	0.01000	
Halothane	8.07321	
Heptachlor	0.00100	
Heptachlor epoxide	0.00100	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Heptane (n-Heptane)	32.78528	40.98160
Hexachlorobenzene	0.00004	
Hexachlorobutadiene	0.00427	
Hexachlorocyclopentadiene	0.00223	
Hexachloroethane	0.19365	
Hexachloronaphthalene	0.00400	
Hexafluoroacetone	0.01358	
Hexafluoropropylene	0.01227	
Hexahydrophthalic anhydride, All isomers		0.00010
Hexamethylene diisocyanate	0.00069	
n-Hexane	3.52474	
Other isomers	35.24744	70.49489
1,6-Hexanediamine	0.04753	
1-Hexene	3.44213	
sec-Hexyl acetate	5.89816	
Hexylene glycol (c)		2.41656
Hydrazine	0.00026	
Hydrogenated terphenyls	0.09857	
Hydrogen bromide (c)		0.13238
Hydrogen chloride (c)		0.05966
Hydrogen cyanide (c)		0.10392
Cyanide salts		0.10000
Hydrogen fluoride (c)	0.00818	0.03274
Hydrogen peroxide	0.02783	
Hydrogen selenide	0.00331	
Hydroquinone	0.04000	
2-Hydroxypropyl acrylate	0.05323	
Indene	0.95010	
Indium and compounds, as In	0.00200	
Iodine (c)		0.02076
Iodoform	0.19327	
Iron oxide dust and fume (Fe <sub>2</sub> O <sub>3</sub> ), as Fe	0.10000	
Iron pentacarbonyl, as Fe	0.01602	0.03205
Iron salts, soluble as Fe	0.02000	
Isoamyl alcohol	7.21063	9.01329
Isobutanol	3.03149	
Isobutyl acetate	14.25276	
Isobutyl nitrite		0.08435

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Isooctyl alcohol	5.32638	
Isophorone (c)		0.56528
Isophorone diisocyanate	0.00091	
2-Isopropoxyethanol	2.12986	
Isopropyl acetate	8.35419	16.70838
Isopropanol (2-Propanol)	9.83067	19.66135
Isopropylamine	0.24164	0.48327
N-isopropylaniline	0.22120	
Isopropyl ether	20.89366	25.90814
Isopropyl glycidyl ether (IGE)	4.75174	7.12761
Kaolin	0.04000	
Kerosene / Jet fuels	4.00000	
Ketene	0.01719	0.05158
Lead arsenate, as Pb <sub>3</sub> (AsO <sub>4</sub> ) <sub>2</sub>	0.00300	
Lead chromate as Pb as Cr	0.00100 0.00024	
Lindane	0.01000	
Lithium hydride	0.00050	
L.P.G. (liquified petroleum gas)	40.89980	
Magnesium oxide	0.20000	
Malathion	0.02000	
Maleic anhydride	0.00802	
Manganese, elemental and inorganic compounds, as Mn	0.00400	
Manganese cyclopentadienyl tricarbonyl, as Mn	0.00200	
Mercury, as Hg Alkyl compounds Aryl compounds Inorganic and elemental mercury	0.00020 0.00200 0.00050	0.00060
Mesityl oxide	1.20417	2.00695
Methacrylic acid	1.40843	
Methanol	5.24172	6.55215
Methomyl	0.05000	
Methoxychlor	0.20000	
2-Methoxyethanol (EGME)	0.00622	
2-Methoxyethyl acetate (EGMEA)	0.00966	
bis-(2-Methoxypropyl) ether (DPGME)	12.12270	18.18405
4-Methoxyphenol	0.10000	
1-Methoxy-2-propanol (PGME)	7.37178	11.05767

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Methyl acetate	12.76728	15.95910
Methyl acetylene	32.77710	
Methyl acetylene-propadiene mixture (MAPP)	32.77710	40.97137
Methyl acrylate	0.14084	
Methylacrylonitrile	0.05488	
Methylal	62.24949	
Methylamine	0.12703	0.38110
Methyl n-amyl ketone	4.66994	
N-Methyl aniline	0.04382	
Methyl bromide	0.07767	
Methyl-tert butyl ether	3.60613	
Methyl n-butyl ketone	0.40965	0.81930
Methyl chloride	2.06503	4.13006
Methyl chloroform	38.19796	49.11166
Methyl 2-cyanoacrylate	0.01818	
Methylcyclohexane	32.12761	
Methylcyclohexanol	4.67035	
o-Methylcyclohexanone	4.58773	6.88160
2- Methylcyclopentadienyl manganese tricarbonyl, as Mn	0.00400	
Methyl demeton	0.00100	
Methylene bisphenyl isocyanate (MDI)	0.00102	
4,4-Methylene bis(2-chloroaniline)	0.00219	
Methylene bis (4-cyclo-hexylisocyanate)	0.00107	
4,4-Methylene dianiline	0.01622	
Methyl ethyl ketone (MEK)	11.79550	17.69325
Methyl ethyl ketone peroxide (c)		0.02883
Methyl formate	5.32106	7.98160
Methyl hydrazine	0.00038	
Methyl iodide	0.23223	
Methyl isoamyl ketone	4.67076	
Methyl isobutyl carbinol	2.08957	3.34331
Methyl isobutyl ketone	4.09652	6.14479
Methyl isocyanate	0.00093	
Methyl isopropyl ketone	14.09243	
Methyl mercaptan	0.01968	
Methyl methacrylate	4.09530	8.19059
1-Methyl naphthalene and 2-Methyl naphthalene	0.05816	
Methyl parathion	0.00400	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Methyl propyl ketone		10.57301
Methyl silicate	0.12452	
alpha-Methyl styrene	4.83354	9.66708
Methyl vinyl ketone		0.01147
Metribuzin	0.10000	
Mevinphos	0.00020	
Mica	0.06000	
Molybdenum, as Mo		
Soluble compounds	0.01000	
Metal and Insoluble compounds (respirable fraction)	0.06000	
Metal and Insoluble compounds (total)	0.20000	
Monochloroacetic acid	0.03865	
Monocrotophos	0.00100	
Morpholine	1.42528	
Naled	0.00200	
Naphthalene	1.04859	1.57288
Natural rubber latex (as Total proteins)	0.00002	
Nickel, as Ni		
Elemental	0.03000	
Soluble inorganic compounds (NOS)	0.00200	
Insoluble inorganic compounds (NOS)	0.00400	
Nickel subsulfide, as Ni	0.00200	
Nickel carbonyl, as Ni	0.00698	
Nicotine	0.01000	
Nitrapyrin	0.20000	0.40000
Nitric acid	0.10310	0.20620
Nitric oxide	0.61370	
p-Nitroanaline	0.06000	
Nitrobenzene	0.10070	
p-Nitrochlorobenzene	0.01289	
Nitroethane	6.14070	
Nitrogen trifluoride	0.58078	
Nitroglycerin (NG)	0.00929	
Nitromethane	0.99861	
1-Nitropropane	1.82188	
2-Nitropropane	0.72875	
Nitrotoluene	0.22434	
5-Nitro-o-toluidine	0.02000	
Nitrous oxide	1.80041	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Nonane	20.98323	
Octachloronaphthalene	0.00200	0.00600
Octane	28.02945	
Oil mist, mineral	0.10000	0.20000
Osmium tetroxide, as Os	0.00004	0.00012
Oxalic acid	0.02000	0.04000
p,p-Oxybis(benzenesulfonyl hydrazine)	0.00200	
Oxygen difluoride (c)		0.00221
Paraffin wax fume	0.04000	
Paraquat, Total dust Respirable fraction	0.01000 0.00200	
Parathion	0.00100	
Pentaborane	0.00026	0.00078
Pentachloronaphthalene	0.01000	
Pentachloronitrobenzene	0.01000	
Pentachlorophenol	0.01000	
Pentaerythritol	0.20000	
Pentane, all isomers	35.41104	
Pentyl acetate, all isomers	5.32515	10.65031
Perchloromethyl mercaptan	0.01520	
Perchloryl fluoride	0.25144	0.50287
Perfluorobutyl ethylene	20.13088	
Perfluoroisobutylene		0.00164
Persulfates, as persulfate	0.00200	
Phenol	0.38491	
Phenothiazine	0.10000	
m-Phenylenediamine	0.00200	
o-Phenylenediamine	0.00200	
p-Phenylenediamine	0.00200	
Phenyl ether vapor	0.13922	0.27845
Phenyl glycidyl ether (PGE)	0.01228	
Phenylhydrazine	0.00885	
Phenyl mercaptan	0.00901	
Phenylphosphine (c)		0.00450
Phorate	0.00100	0.00400
Phosgene	0.00808	
Phosphine	0.00834	0.02781
Phosphoric acid	0.02000	0.06000

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Phosphorus (yellow)	0.00200	
Phosphorus oxychloride	0.01254	
Phosphorus pentachloride	0.01703	
Phosphorus pentasulfide	0.02000	0.06000
Phosphorus trichloride	0.02247	0.05618
Phthalic anhydride	0.12115	
m-Phthalodinitrile	0.10000	
Picloram	0.20000	
Picric acid	0.00200	
Pindone	0.00200	
Piperazine dihydrochloride	0.10000	
Platinum Metal	0.02000	
Soluble salts, as Pt	0.00004	
Potassium hydroxide (c)		0.04000
Propargyl alcohol	0.04586	
beta-Propiolactone	0.02947	
Propionaldehyde	0.95051	
Propionic acid	0.60597	
Propoxur	0.01000	
n-Propyl acetate	16.70838	20.88548
n-Propyl alcohol	9.83067	12.28834
Propylene dichloride	0.92425	
Propyl glycol dinitrate	0.00679	
Propylene oxide	0.09502	
Propylenimine	0.09340	
n-Propyl nitrate	2.14908	3.43853
Pyrethrum	0.10000	
Pyridine	0.06470	
Quinone	0.00884	
Resorcinol	0.90070	1.80139
Rhodium Metal	0.02000	
Insoluble compounds, as Rh	0.02000	
Soluble compounds, as Rh	0.00020	
Ronnel	0.10000	
Rotenone (commercial)	0.10000	
Rubber solvent (Naphtha)	31.73824	
Selenium and compounds, as Se	0.00400	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Selenium hexafluoride, as Se	0.00789	
Sesone	0.20000	
Silica-crystalline Cristobalite	0.00050	
Silicon carbide (nonfibrous) Total dust Repirable fraction	0.20000 0.06000	
Silicon tetrahydride	0.13137	
Silver Metal Soluble compounds, as Ag	0.00200 0.00020	
Soapstone Total dust Repirable fraction	0.12000 0.06000	
Sodium azide as sodium azide (c) as Hydrazoic acid vapor (c)		0.00580 0.00220
Sodium bisulfite	0.10000	
Sodium fluoroacetate	0.00100	
Sodium hydroxide (c)		0.04000
Sodium metabisulfite	0.10000	
Starch	0.20000	
Stearates	0.20000	
Stoddard solvent	11.45194	
Strontium chromate	0.00001	
Strychnine	0.00300	
Styrene, monomer	1.70405	3.40810
Subtilisins, crystalline active enzyme		0.0000012
Sucrose	0.20000	
Sulfometuron methyl	0.10000	
Sulfotep	0.00200	
Sulfur hexafluoride	119.48466	
Sulfuric acid	0.00400	
Sulfur monochloride (c)		0.11045
Sulfur pentafluoride (c)		0.00208
Sulfur tetrafluoride (c)		0.00884
Sulfuryl fluoride	0.41746	0.83493
Sulprofos	0.02000	
Synthetic vitreous fibers Continuous filament glass fibers	0.10000	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
2,4,5-T	0.20000	
Talc containing no asbestos fibers	0.04000	
Tantalum, metal and oxide dusts, as Ta	0.10000	
Tellurium and compounds, as Te	0.00200	
Tellurium hexafluoride	0.00395	
Temephos	0.02000	
Terbufos	0.00020	
Terephthalic acid	0.20000	
Terphenyls (c)		0.10000
1,1,2,2-Tetrabromoethane	0.02828	
1,1,1,2-Tetrachloro-2,2-difluoroethane	83.36605	
1,1,2,2-Tetrachloro-1,2-difluoroethane	83.36605	
1,1,2,2,-Tetrachloroethane	0.13731	
Tetrachloroethylene	3.39059	13.56237
Tetrachloronaphthlene	0.04000	
Tetraethyl lead, as Pb	0.00200	
Tetraethyl pyrophosphate	0.00020	
Tetrafluoroethylene	0.16393	
Tetrahydrofuran	2.94888	5.89775
Tetrakis (hydroxymethyl) phosphonium salts Phosphonium chloride Phosphonium sulfate	0.04000 0.04000	
Tetramethyl lead, as Pb	0.00300	
Tetramethyl succinonitrile	0.05571	
Tetranitromethane	0.00080	
Tetryl	0.03000	
Thallium, elemental and soluble compounds, as TI	0.00200	
4,4'-Thiobis(6-tert,butyl-m-cresol)	0.20000	
Thioglycolic acid	0.07535	
Thionyl chloride (c)		0.09733
Thiram	0.02000	
Tin Metal Oxide & inorganic compounds, except tin hydride Organic compounds, as Sn	0.04000 0.04000 0.00200	0.00400
Titanium dioxide	0.20000	
Toluene	1.50724	
Toluene-2,4-diisocyanate (TDI)	0.00071	0.00285
Toluidine	0.17530	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Tributyl phosphate	0.04357	
Trichloroacetic acid	0.13365	
1,2,4-Trichlorobenzene (c)		0.74217
1,1,2-Trichloroethane	1.09129	
Trichloroethylene	1.07485	2.68712
Trichloroflouromethane (c)		112.37628
Trichloronaphthalene	0.10000	
1,2,3-Trichloropropane	1.20597	
1,1,2-Trichloro-1,2,2 trifluoroethane	153.29243	191.61554
Trichlorphon	0.02000	
Triethanolamine	0.10000	
Triethylamine	0.08277	0.24832
Trifluorobromomethane	121.81595	
1,3,5-Triglycidyl-s-triazinetrione	0.00100	
Trimellitic anhydride		0.00080
Trimethylamine	0.24176	0.72528
Trimethyl benzene	2.45787	
Trimethyl phosphite	0.20299	
2,4,6-Trinitrotoluene (TNT)	0.00200	
Triorthocresyl phosphate	0.00200	
Triphenyl amine	0.10000	
Triphenyl phosphate	0.06000	
Tungsten, as W		
Metal and Insoluble compounds	0.10000	0.20000
Soluble compounds	0.02000	0.06000
Turpentine	2.22495	
Uranium (natural)		
Soluble & Insoluble compounds, as U	0.00400	0.01200
n-Valeraldehyde	3.52270	
Vanadium pentoxide, as V2O5, dust or fumes	0.00100	
Vinyl acetate	0.70421	1.05632
Vinyl bromide	0.04375	
Vinyl chloride	0.05112	
4-Vinyl cyclohexene	0.00885	
Vinyl cyclohexene dioxide	0.01147	
Vinyl fluoride	0.03767	
n-Vinyl-2-pyrrolidone	0.00455	
Vinylidene chloride	0.39652	
Vinylidene fluoride	26.19223	

Contaminant	Guideline Concentrations	
	8-HR mg/m <sup>3</sup>	1-HR mg/m <sup>3</sup>
Vinyl toluene	4.83354	9.66708
VM & P Naphtha	27.97546	
Warfarin	0.00200	
Wood dust		
Western red cedar	0.01000	
All other species	0.02000	
Xylene	8.68384	13.02577
m-Xylene a,a'-diamine (c)		0.00200
Xylidine (mixed isomers)	0.04956	
Yttrium, metal and compounds, as Y	0.02000	
Zinc chloride fume	0.02000	0.04000
Zinc chromates, as Cr	0.00020	
Zinc oxide	0.04000	0.20000
Zirconium and compounds, as Zr	0.10000	0.20000

## Appendix B. Unit risk factors

Contaminant	Unit Risk Factor* (m <sup>3</sup> /μg)
Acetaldehyde	2.2E-06
Acetamide	2.0E-05
Acrylamide	1.3 E-03
Acrylonitrile	6.8 E-05
Aldrin	4.9 E-03
Allyl chloride	6.0E-06
Aniline	1.6 E-06
Aramite	7.1 E-06
Arsenic	4.3 E-03
Azobenzene	3.1E-05
Benzene	7.8 E-06
Benzidine	6.7 E-02
Benzo(a)anthracene	1.1 E-04
Benzo(a)pyrene	1.1 E-03
Benzo(b)fluoranthene	1.1E-04
Benzo(j)fluoranthene	1.1E-04
Benzo(k)fluoranthene	1.1E-04
Benzotrichloride	3.7E-03
Benzyl choride	4.9E-05
Beryllium	2.4 E-03
Bis(chloroethyl)ether (BCEE)	3.3 E-04
Bis(chloromethyl)ether	6.2 E-02
Bis(2-ethylhexyl)phthalate	2.4 E-06
Bromoform	1.1 E-06
1,3-butadiene	3.0E-05
Cadmium and cadmium compounds	1.8 E-03
Captan	1.0E-06
Carbazole	5.7E-06
Carbon Tetrachloride	1.5 E-05
Chlordane	1.0 E-04
Chlorobenzilate	7.8E-05
Chloroform	2.3 E-05
Chromium VI compounds	1.2 E-02
Chrysene	1.1E-05
Coke Oven Emissions	6.2 E-04
Cyanazine	2.4E-04
DDE	9.7E-05
Dibenz(a,h)anthracene	1.2E-03
Dibenz(a,h)acridine	1.1E-04
Dibenz(a,j)acridine	1.1E-04
7H-Dibenzo[c,g]carbazole	1.1E-03
Dibenzo(a,e)pyrene	1.1E-03
Dibenzo(a,h)pyrene	1.1E-02
Dibenzo(a,i)pyrene	1.1E-02
Dibenzo(a,l)pyrene	1.1E-02
p,p'-Dichlorodiphenyltrichloroethane (DDT)	9.7 E-05

Contaminant	Unit Risk Factor* (m <sup>3</sup> /μg)
Dichloromethane	4.7 E-07
7,12-Dimethylbenz(a)anthracene	7.1E-02
1,2-dibromo-3-chloropropane	2.0 E-03
1,2-dibromoethane	6.0 E-04
p-Dichlorobenzene	1.1E-05
3,3'-Dichlorobenzidine	3.4E-04
1,2-dichloroethane	2.6 E-05
Dichloroethyl ether	3.3E-04
1,3-dichloropropene	4.0 E-06
Dichlorvos	8.3E-05
Dieldrin	4.6 E-03
3,3'-Dimethoxybenzidine	4.0E-06
p-Dimethylaminoazobenzene	1.3E-03
3,3'-Dimethylbenzidine	2.6E-03
1,8-Dinitropyrene	1.1E-03
2,4-dinitrotoluene	8.9 E-05
2,4/2,6-Dintrotoluene mixture	1.9E-04
1,4-dioxane	3.1 E-06
1,2-diphenylhydrazine	2.2 E-04
Epichlorohydrin	1.2 E-06
Ethyl carbamate	2.9E-04
Ethylene Dibromide	6.0E-04
Ethylene Dichloride	2.6E-05
Ethylene Oxide	8.8E-05
Ethylene Thiourea	1.3E-05
Ethylidene Dichloride (1,1-Dichloroethane)	1.6E-06
Formaldehyde	5.5 E-09
Heptachlor	1.3 E-03
Heptachlor Epoxide	2.6 E-03
Hexachlorobenzene	4.6 E-04
Hexachlorobutadiene	2.2 E-05
Alpha-hexachlorocyclohexane (α-HCH)	1.8 E-03
Beta-hexachlorocyclohexane (β-HCH)	5.3 E-04
Hexachlorocyclohexane, Technical (HCH)	5.1 E-04
Hexachlorodibenzo-p-dioxin, mixture	1.3 E+00
Hexachloroethane	4.0 E-06
Hydrazine	4.9 E-03
Hydrazine Sulfate	4.9 E-03
Indeno(1,2,3-cd)pyrene	1.1E-04
Isophorone	2.7E-07
Lindane (gamma HCH)	3.1E-04
3-methylcholanthrene	6.3 E-03
5-Methylchrysene	1.1E-03
Methyl Hydrazine	3.1 E-04
Methylene Chloride (dichloromethane)	4.7 E-07
4,4'-methylene-bis-2-chloroaniline	4.3E-04
4,4'-Methylenedianiline	4.6E-04
Methyl tert-butyl ether	2.6 E-07

Contaminant	Unit Risk Factor* (m <sup>3</sup> /μg)
Naphthalene	3.4E-05
Nickel Refinery Dust	2.4 E-04
Nickel Subsulfide	4.8 E-04
5-Nitroacenaphthene	3.7E-05
6-Nitrochrysene	1.1E-02
2-Nitrofluorene	1.1E-05
1-Nitropyrene	1.1E-04
4-Nitropyrene	1.1E-04
2-nitropropane	5.6 E-06
N-nitroso-di-n-butylamine	1.6 E-03
N-nitrosodiethylamine	4.3 E-02
Nitrosodimethylamine	1.4E-02
N'-Nitrosomorpholine	1.9E-03
N-nitrosopyrrolidine	6.1 E-04
Pentachloronitrobenzene	7.4 E-05
Pentachlorophenol	5.1E-06
Polychlorinated Biphenyls (PCBs)	1.0 E-04
1,3-Propane Sultone	6.9E-04
Propylene Dichloride	1.9E-05
Propylene Oxide	3.7E-06
2,3,7,8-tetrachloro-dibenzo-p-dioxin	3.3 E+01
1,1,1,2-tetrachloroethane	7.4 E-06
1,1,2,2-tetrachloroethane	5.8 E-05
Tetrachloroethene	5.9E-06
2,4-Toluene Diamine	1.1E-03
2,4/2,6-Toluene diisocyanate mixture (TDI)	1.1E-05
o-Toluidine	5.1E-05
1,1,2-trichloroethane	1.6 E-05
Trichloroethylene	2.0 E-06
2,4,6-trichlorophenol	3.1 E-06
Toxaphene	3.2 E-04
Trifluralin	2.2E-06
Vinyl Bromide	3.2E-05
Vinyl Chloride	8.8 E-06

\* Note that the unit risk factors are in units of m<sup>3</sup>/μg. When calculating the maximum individual carcinogenic risk (MICR) for a pollutant, the estimated 70-year average concentration must be in units of μg/m<sup>3</sup> prior to multiplying by the unit risk factor to obtain the MICR.