# APPENDIX A

## ATSDR MINIMAL RISK LEVEL

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [42 U.S.C. 9601 et seq.], as amended by the Super-fund Amendments and Reauthorization Act (SARA) [Pub. L. 99-4991, requires that the Agency for Toxic Substances and Disease Registry (ATSDR) develop jointly with the U.S. Environmental Protection Agency (EPA), in order of priority, a list of hazardous substances most commonly found at facilities on the CERCLA National Priorities List (NPL); prepare toxicological profiles for each substance included on the priority list of hazardous substances; and assure the initiation of a research program to fill identified data needs associated with the substances.

The toxicological profiles include an examination, summary, and interpretation of available toxicological information and epidemiologic evaluations of a hazardous substance. During the development of toxicological profiles, Minimal Risk Levels (MRLs) are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration for a given route of exposure. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. MRLs are based on noncancer health effects only and are not based on a consideration of cancer effects. These substance-specific estimates, which are intended to serve as screening levels, are used by ATSDR health assessors to identify contaminants and potential health effects that may be of concern at hazardous waste sites. It is important to note that MRLs are not intended to define clean-up or action levels.

MRLs are derived for hazardous substances using the no-observed-adverse-effect level/uncertainty factor approach. They are below levels that might cause adverse health effects in the people most sensitive to such chemical-induced effects. MRLs are derived for acute (I-14 days), intermediate (15-364 days), and chronic (365 days and longer) durations and for the oral and inhalation routes of exposure. Currently, MRLs for the dermal route of exposure are not derived because ATSDR has not yet identified a method suitable for this route of exposure. MRLs are generally based on the most sensitive chemical-induced end point considered to be of relevance to humans. Serious health effects (such as irreparable damage to the liver or kidneys, or birth defects) are not used as a basis for establishing MRLs. Exposure to a level above the MRL does not mean that adverse health effects will occur.

MRLs are intended only to serve as a screening tool to help public health professionals decide where to look more closely. They may also be viewed as a mechanism to identify those hazardous waste sites that are not expected to cause adverse health effects. Most MRLs contain a degree of uncertainty because of the lack of precise toxicological information on the people who might be most sensitive (e.g., infants, elderly, nutritionally or immunologically compromised) to the effects of hazardous substances. ATSDR uses a conservative (i.e., protective) approach to address this uncertainty consistent with the public health principle of prevention. Although human data are preferred, MRLs often must be based on animal studies because relevant human studies are lacking. In the absence of evidence to the contrary, ATSDR assumes that humans are more sensitive to the effects of hazardous substance than animals and that certain persons may be particularly sensitive. Thus, the resulting MRL may be as much as a hundredfold below levels that have been shown to be nontoxic in laboratory animals.

Proposed MRLs undergo a rigorous review process: Health Effects/MRL Workgroup reviews within the Division of Toxicology, expert panel peer reviews, and agencywide MRL Workgroup reviews, with participation from other federal agencies and comments from the public. They are subject to change as new information becomes available concomitant with updating the toxicological profiles. Thus, MRLs in the most recent toxicological profiles supersede previously published levels. For additional information regarding MRLs, please contact the Division of Toxicology, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road, Mailstop E-29, Atlanta, Georgia 30333.

# APPENDIX A

## MINIMAL RISK LEVEL WORKSHEET

Chemical Name: 4,4′-Methylenedianiline
CAS Number: 101-77-9
Date: November 1997
Profile Status: Final Draft Post Public
Route: [ ] Inhalation [X] Oral
Duration: [X] Acute [ ] Intermediate [ ] Chronic
Graph Key: 6r
Species: Rat

Minimal Risk Level: 0.2 [X] mg/kg/day [ ] ppm

Reference: Bailie et al. 1993. Characterization of acute 4,4'-methylenedianiline hepatotoxicity in the rat. Environ Health Perspect 10(2):130–133.

Experimental design: Groups of male Sprague-Dawley rats (3–5/group) (175–300 g body weight) were administered orally a single dose of 0 (vehicle alone) or 25, 50, 75, 100, 125, or 225 mg 4,4′-methylenedianiline/kg in corn oil. Twenty-four hours after dosing, the rats were anesthetized, the bile duct was cannulated, bile was collected for 30 minutes and then the rats were sacrificed; indicators of liver injury were assessed. Additional groups of rats received a dose of 100 mg/kg and were sacrificed at various intervals for histopathological examination of the liver. The possible involvement of the cytochrome P-450 system in the toxicity of 4,4′-methylenedianiline was investigated. The inhibitors of monooxygenase (MO) function used were aminobenzotriazol (ABT) and SKF-525A (both administered intraperitoneally 2 hours before 4,4′-methylenedianiline). The inducers of MO function used were phenobarbital (PB) and β-naphthoflavone (BNF) (both administered intraperitoneally daily for 3 days before 4,4′-methylenedianiline).

Effects noted in study and corresponding doses: Administration of 4,4′-methylenedianiline caused a dose-dependent change in all markers of hepatic parenchyma injury: increased serum alanine aminotransferase (ALT) and gamma-glutamyl transferase, increased serum bilirubin, decreased bile flow, and increased relative liver weight. The minimal effective dose was between 25 and 75 mg/kg. Histologically, a dose of 100 mg/kg caused hepatocellular necrosis with hemorrhage and moderate neutrophil infiltration. Lesions associated with the portal triads consisted of bile ductular necrosis, portal edema with fibrin exudate, and neutrophil infiltration. The earliest change identified (at 4 hours) was bile ductular necrosis. A segmental necrotizing vasculitis of the portal vein was also observed. The severity of the effects continued to increase over a 16-hour period. Time-course experiments showed that the first significant biochemical markers of liver injury appeared about 8 hours after dosing. Pretreatment with ABT ameliorated the hepatic effects of 4,4′-methylenedianiline, but SKF-525A did not. This according to the authors, may have reflected a difference in the spectrum of cytochrome P-450 isozymes inhibited by the two agents. Pretreatment with PB had no effect after a 100 mg/kg dose of 4,4′-methylenedianiline, but attenuated the hepatotoxicity of a 50 mg/kg dose. BNF had a small attenuating effect.

Dose and end point used for MRL derivation: 25 mg/kg; minimal liver effects.

[ ] NOAEL [X] LOAEL

Uncertainty Factors used in MRL derivation:

[X] 3 for use of a minimal LOAEL
[X] 10 for extrapolation from animals to humans
[X] 10 for human variability

A modifying factor of 0.5 was used in the derivation of the MRL in order to account for the possibility of increased absorption of 4,4'-methylenedianiline due to the corn oil vehicle.

Was a conversion factor used from ppm in food or water to a mg/body weight dose?
No

If an inhalation study in animals, list conversion factors used in determining human equivalent dose:
NA

Was a conversion used from intermittent to continuous exposure?
No

Other additional studies or pertinent information that lend support to this MRL: Several other studies support the findings of Bailie et al. (1993). For example, Bailie et al. (1994) observed cholestasis, biliary epithelial injury, and hepatic parenchymal damage in the livers from rats treated with a single dose of 5 mg 4,4'-methylenedianiline/kg. Schmidt et al. (1980) reported bile duct necrosis and increased serum transaminases in rats also after a single dose of 50 mg/kg. The liver is a known target of 4,4'-methylenedianiline in humans and animals. An outbreak of toxic hepatitis was described in a group of individuals who ate bread contaminated with 4,4'-methylenedianiline (Kopelman et al. 1966). Liver toxicity has also been reported in humans and animals exposed by the dermal route (Brooks et al. 1979; DuPont 1976a; McGill and Motto 1974; Williams et al. 1974)

Agency Contact (Chemical Manager): Zemoria Rosemond

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# MINIMAL RISK LEVEL WORKSHEET

Chemical Name: 4,4′-Methylenedianiline
CAS Number: 101-77-9
Date: November 1997
Profile Status: Final Draft Post Public
Route: [ ] Inhalation [X] Oral
Duration: [ ] Acute [X] Intermediate [ ] Chronic
Graph Key: 23r
Species: Rat

Minimal Risk Level: 0.08 [X] mg/kg/day [ ] ppm

Reference: Pludro et al. 1969. Toxicological and chemical studies of some epoxy resins and hardeners. I Determination of acute and subacute toxicity of phthalic acid anhydride, 4,4'-methylenedianiline, 4,4'-diaminophenylmethane and of the epoxy resin: epilox EG-34. Acta Pol Pharm 26:352–357.

Experimental design: Groups of male and female Wistar rats (10/sex/group) were administered 0 (vehicle alone) 8.3, or 83 mg 4,4′-methylenedianiline by gavage in propylene glycol once a day for 12 weeks. End points evaluated included body weight, serum protein profile, hemoglobin levels and erythrocyte counts, and gross and histopathological appearance of liver, kidneys, and spleen.

Effects noted in study and corresponding doses: The only reported effects observed with the 8.3 mg/kg/day dose of 4,4′-methylenedianiline were unspecified histological lesions in the liver of one animal and unspecified lesions in the spleens from all rats. Administration of 83 mg 4,4′-methylene-dianiline/kg/day did not affect body weight, hemoglobin levels, or red blood cell count. Analysis of electrophoretic patterns of serum showed an increase in beta-globulin and a decrease in the albumin fraction. On gross examination, the liver and kidneys appeared enlarged and their relative weights were markedly increased. Flatulence and intestinal occlusion were also described. Microscopical examination of the liver revealed intense degenerative lesions in all animals consisting of atrophy of the parenchyma accompanied by hyperplasia of the stroma, particularly at portal areas. The 8.3 mg/kg/day is considered a NOAEL although the authors noted unspecified spleen lesions in all rats. The significance of these lesions is unknown since a 13-week study conducted by NTP (1983) observed no gross or histopathological alterations in the spleen, thymus, and lymph nodes from rats treated with up to 141 mg 4,4′-methylenedianiline/kg/day in the drinking water. No lesions were observed in the same organs from mice treated similarly with up to 116 mg/kg/day (NTP 1983).

Dose and end point used for MRL derivation: 8.3 mg/kg/day; liver effects.

[X] NOAEL [ ] LOAEL

Uncertainty Factors used in MRL derivation:

[ ] 10 for use of a LOAEL
[X] 10 for extrapolation from animals to humans
[X] 10 for human variability

Was a conversion factor used from ppm in food or water to a mg/body weight dose?
No

If an inhalation study in animals, list conversion factors used in determining human equivalent dose:
NA

Was a conversion used from intermittent to continuous exposure?
No

Other additional studies or pertinent information that lend support to this MRL: The liver is a known target for 4,4′-methylenedianiline toxicity in humans and animals regardless of the route of exposure. The LOAEL of 83 mg/kg/day for liver effects is consistent with LOAELs identified in a number of intermediate-duration studies (Fukushima et al. 1979, 1981; Hagiwara et al. 1993; Miyamoto et al. 1977; NTP 1983). These LOAELs ranged from 67 to 100 mg/kg/day. With the exception of the NTP (1983) study, all of these studies tested only one dose level, therefore, no NOAELs could be established. The NTP (1983) study defined a NOAEL of 35 mg/kg/day for hepatic effects in rats and 58 mg/kg/day for mice.

Agency Contact (Chemical Manager): Zemoria Rosemond

# APPENDIX B

# USER'S GUIDE

## Chapter 1

### Public Health Statement

This chapter of the profile is a health effects summary written in non-technical language. Its intended audience is the general public especially people living in the vicinity of a hazardous waste site or chemical release. If the Public Health Statement were removed from the rest of the document, it would still communicate to the lay public essential information about the chemical.

The major headings in the Public Health Statement are useful to find specific topics of concern. The topics are written in a question and answer format. The answer to each question includes a sentence that will direct the reader to chapters in the profile that will provide more information on the given topic.

## Chapter 2

### Tables and Figures for Levels of Significant Exposure (LSE)

Tables (2-1, 2-2, and 2-3) and figures (2-1 and 2-2) are used to summarize health effects and illustrate graphically levels of exposure associated with those effects. These levels cover health effects observed at increasing dose concentrations and durations, differences in response by species, minimal risk levels (MRLs) to humans for noncancer end points, and EPA's estimated range associated with an upper-bound individual lifetime cancer risk of 1 in 10,000 to 1 in 10,000,000. Use the LSE tables and figures for a quick review of the health effects and to locate data for a specific exposure scenario. The LSE tables and figures should always be used in conjunction with the text. All entries in these tables and figures represent studies that provide reliable, quantitative estimates of No-Observed-Adverse-Effect Levels (NOAELs), Lowest-Observed-Adverse-Effect Levels (LOAELs), or Cancer Effect Levels (CELs).

The legends presented below demonstrate the application of these tables and figures. Representative examples of LSE Table 2-1 and Figure 2-1 are shown. The numbers in the left column of the legends correspond to the numbers in the example table and figure.

**LEGEND**

**See LSE Table 2-1**

(1) <u>Route of Exposure</u> One of the first considerations when reviewing the toxicity of a substance using these tables and figures should be the relevant and appropriate route of exposure. When sufficient data exists, three LSE tables and two LSE figures are presented in the document. The three LSE tables present data on the three principal routes of exposure, i.e., inhalation, oral, and dermal (LSE Table 2-1, 2-2, and 2-3, respectively). LSE figures are limited to the inhalation (LSE Figure 2-1) and oral (LSE Figure 2-2) routes. Not all substances will have data on each route of exposure and will not therefore have all five of the tables and figures.

(2) Exposure Period Three exposure periods - acute (less than 15 days), intermediate (15–364 days), and chronic (365 days or more) are presented within each relevant route of exposure. In this example, an inhalation study of intermediate exposure duration is reported. For quick reference to health effects occurring from a known length of exposure, locate the applicable exposure period within the LSE table and figure.

(3) Health Effect The major categories of health effects included in LSE tables and figures are death, systemic, immunological, neurological, developmental, reproductive, and cancer. NOAELs and LOAELs can be reported in the tables and figures for all effects but cancer. Systemic effects are further defined in the "System" column of the LSE table (see key number 18).

(4) Key to Figure Each key number in the LSE table links study information to one or more data points using the same key number in the corresponding LSE figure. In this example, the study represented by key number 18 has been used to derive a NOAEL and a Less Serious LOAEL (also see the 2 "18r" data points in Figure 2-1).

(5) Species The test species, whether animal or human, are identified in this column. Section 2.5, "Relevance to Public Health," covers the relevance of animal data to human toxicity and Section 2.3, "Toxicokinetics," contains any available information on comparative toxicokinetics. Although NOAELs and LOAELs are species specific, the levels are extrapolated to equivalent human doses to derive an MRL.

(6) Exposure Frequency/Duration The duration of the study and the weekly and daily exposure regimen are provided in this column. This permits comparison of NOAELs and LOAELs from different studies. In this case (key number 18), rats were exposed to 1,1,2,2-tetrachloroethane via inhalation for 6 hours per day, 5 days per week, for 3 weeks. For a more complete review of the dosing regimen refer to the appropriate sections of the text or the original reference paper, i.e., Nitschke et al. 1981.

(7) System This column further defines the systemic effects. These systems include: respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, hepatic, renal, and dermal/ocular. "Other" refers to any systemic effect (e.g., a decrease in body weight) not covered in these systems. In the example of key number 18, 1 systemic effect (respiratory) was investigated.

(8) NOAEL A No-Observed-Adverse-Effect Level (NOAEL) is the highest exposure level at which no harmful effects were seen in the organ system studied. Key number 18 reports a NOAEL of 3 ppm for the respiratory system which was used to derive an intermediate exposure, inhalation MRL of 0.005 ppm (see footnote "b").

(9) LOAEL A Lowest-Observed-Adverse-Effect Level (LOAEL) is the lowest dose used in the study that caused a harmful health effect. LOAELs have been classified into "Less Serious" and "Serious" effects. These distinctions help readers identify the levels of exposure at which adverse health effects first appear and the gradation of effects with increasing dose. A brief description of the specific endpoint used to quantify the adverse effect accompanies the LOAEL. The respiratory effect reported in key number 18 (hyperplasia) is a Less serious LOAEL of 10 ppm. MRLs are not derived from Serious LOAELs.

(10) Reference The complete reference citation is given in chapter 8 of the profile.

(11) CEL A Cancer Effect Level (CEL) is the lowest exposure level associated with the onset of carcinogenesis in experimental or epidemiologic studies. CELs are always considered serious effects. The LSE tables and figures do not contain NOAELs for cancer, but the text may report doses not causing measurable cancer increases.

(12) Footnotes Explanations of abbreviations or reference notes for data in the LSE tables are found in the footnotes. Footnote "b" indicates the NOAEL of 3 ppm in key number 18 was used to derive an MRL of 0.005 ppm.

**LEGEND**

**See Figure 2-1**

LSE figures graphically illustrate the data presented in the corresponding LSE tables. Figures help the reader quickly compare health effects according to exposure concentrations for particular exposure periods.

(13) Exposure Period The same exposure periods appear as in the LSE table. In this example, health effects observed within the intermediate and chronic exposure periods are illustrated.

(14) Health Effect These are the categories of health effects for which reliable quantitative data exists. The same health effects appear in the LSE table.

(15) Levels of Exposure concentrations or doses for each health effect in the LSE tables are graphically displayed in the LSE figures. Exposure concentration or dose is measured on the log scale "y" axis. Inhalation exposure is reported in $mg/m^3$ or ppm and oral exposure is reported in mg/kg/day.

(16) NOAEL In this example, 18r NOAEL is the critical endpoint for which an intermediate inhalation exposure MRL is based. As you can see from the LSE figure key, the open-circle symbol indicates to a NOAEL for the test species-rat. The key number 18 corresponds to the entry in the LSE table. The dashed descending arrow indicates the extrapolation from the exposure level of 3 ppm (see entry 18 in the Table) to the MRL of 0.005 ppm (see footnote "b" in the LSE table).

(17) CEL Key number 38r is 1 of 3 studies for which Cancer Effect Levels were derived. The diamond symbol refers to a Cancer Effect Level for the test species-mouse. The number 38 corresponds to the entry in the LSE table.

(18) Estimated Upper-Bound Human Cancer Risk Levels This is the range associated with the upper-bound for lifetime cancer risk of 1 in 10,000 to 1 in 10,000,000. These risk levels are derived from the EPA's Human Health Assessment Group's upper-bound estimates of the slope of the cancer dose response curve at low dose levels ($q_1$*).

(19) Key to LSE Figure The Key explains the abbreviations and symbols used in the figure.

**SAMPLE**

1 →

## TABLE 2-1. Levels of Significant Exposure to [Chemical x] – Inhalation

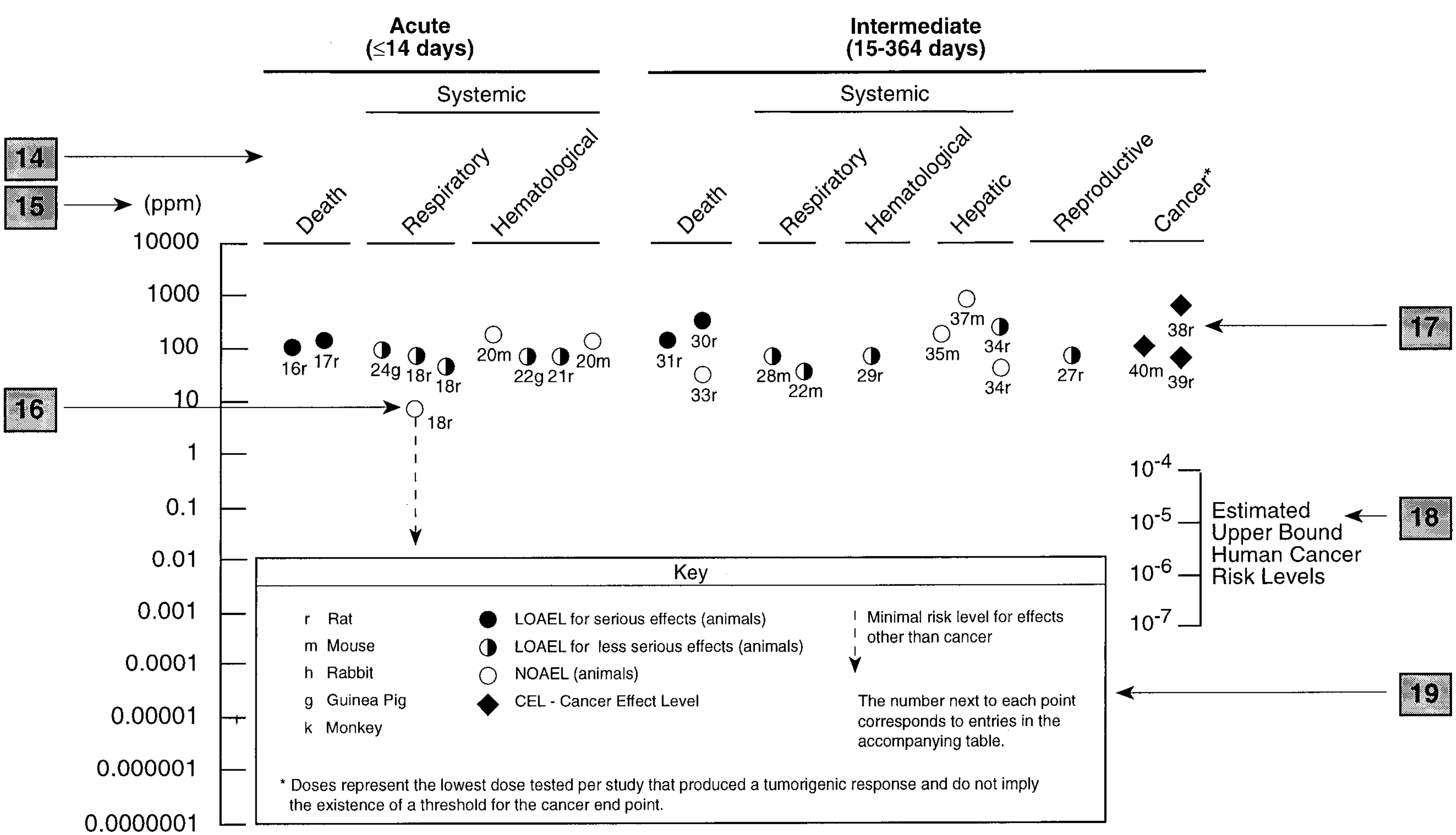
| Key to figure[a] | Species | Exposure frequency/ duration | System | NOAEL (ppm) | LOAEL (effect) Less serious (ppm) | LOAEL (effect) Serious (ppm) | Reference |
|---|---|---|---|---|---|---|---|
| 2 → INTERMEDIATE EXPOSURE | | | | | | | |
| | 5 ↓ | 6 ↓ | 7 ↓ | 8 ↓ | 9 ↓ | | 10 ↓ |
| 3 → Systemic | | | | | | | |
| 4 → 18 | Rat | 13 wk 5d/wk 6hr/d | Resp | 3[b] | 10 (hyperplasia) | | Nitschke et al. 1981 |
| CHRONIC EXPOSURE | | | | | | | |
| | | | | | | 11 ↓ | |
| Cancer | | | | | | | |
| 38 | Rat | 18 mo 5d/wk 7hr/d | | | | 20 (CEL, multiple organs) | Wong et al. 1982 |
| 39 | Rat | 89–104 wk 5d/wk 6hr/d | | | | 10 (CEL, lung tumors, nasal tumors) | NTP 1982 |
| 40 | Mouse | 79–103 wk 5d/wk 6hr/d | | | | 10 (CEL, lung tumors, hemangiosarcomas) | NTP 1982 |

[a] The number corresponds to entries in Figure 2-1.

12 → [b] Used to derive an intermediate inhalation Minimal Risk Level (MRL) of $5 \times 10^{-3}$ ppm; dose adjusted for intermittent exposure and divided by an uncertainty factor of 100 (10 for extrapolation from animal to humans, 10 for human variability).

SAMPLE

13 → **Figure 2-1. Levels of Significant Exposure to [Chemical X] – Inhalation**



## Chapter 2 (Section 2.5)

## Relevance to Public Health

The Relevance to Public Health section provides a health effects summary based on evaluations of existing toxicologic, epidemiologic, and toxicokinetic information. This summary is designed to present interpretive, weight-of-evidence discussions for human health end points by addressing the following questions.

1. What effects are known to occur in humans?

2. What effects observed in animals are likely to be of concern to humans?

3. What exposure conditions are likely to be of concern to humans, especial1 around hazardous waste sites

The section covers end points in the same order they appear within the Discussion of Health Effects by Route of Exposure section, by route (inhalation, oral, dermal) and within route by effect. Human data are presented first, then animal data. Both are organized by duration (acute, intermediate, chronic). *In vitro* data and data from parenteral routes (intramuscular, intravenous, subcutaneous, etc.) are also considered in this section. If data are located in the scientific literature, a table of genotoxicity information is included.

The carcinogenic potential of the profiled substance is qualitatively evaluated, when appropriate, using existing toxicokinetic, genotoxic, and carcinogenic data. ATSDR does not currently assess cancer potency or perform cancer risk assessments. Minimal risk levels (MRLs) for noncancer end points (if derived) and the end points from which they were derived are indicated and discussed.

Limitations to existing scientific literature that prevent a satisfactory evaluation of the relevance to public health are identified in the Data Needs section.

## Interpretation of Minimal Risk Levels

Where sufficient toxicologic information is available, we have derived minimal risk levels (MRLs) for inhalation and oral routes of entry at each duration of exposure (acute, intermediate, and chronic). These MRLs are not meant to support regulatory action; but to acquaint health professionals with exposure levels at which adverse health effects are not expected to occur in humans. They should help physicians and public health officials determine the safety of a community living near a chemical emission, given the concentration of a contaminant in air or the estimated daily dose in water. MRLs are based largely on toxicological studies in animals and on reports of human occupational exposure.

MRL users should be familiar with the toxicologic information on which the number is based. Chapter 2.5, “Relevance to Public Health,” contains basic information known about the substance. Other sections such as 2.7, “Interactions with Other Substances,” and 2.8, “Populations that are Unusually Susceptible” provide important supplemental information.

MRL users should also understand the MRL derivation methodology. MRLs are derived using a modified version of the risk assessment methodology the Environmental Protection Agency (EPA) provides (Barnes and Dourson 1988) to determine reference doses for lifetime exposure (RfDs).

To derive an MRL, ATSDR generally selects the most sensitive endpoint which, in its best judgement, represents the most sensitive human health effect for a given exposure route and duration. ATSDR cannot make this judgement or derive an MRL unless information (quantitative or qualitative) is available for all potential systemic, neurological, and developmental effects. If this information and reliable quantitative data on the chosen endpoint are available, ATSDR derives an MRL using the most sensitive species (when information from multiple species is available) with the highest NOAEL that does not exceed any adverse effect levels. When a NOAEL is not available, a lowest-observedadverse-effect level (LOAEL) can be used to derive an MRL, and an uncertainty factor (UF) of 10 must be employed. Additional uncertainty factors of 10 must be used both for human variability to protect sensitive subpopulations (people who are most susceptible to the health effects caused by the substance) and for interspecies variability (extrapolation from animals to humans). In deriving an MRL, these individual uncertainty factors are multiplied together. The product is then divided into the inhalation concentration or oral dosage selected from the study. Uncertainty factors used in developing a substance-specific MRL are provided in the footnotes of the LSE Tables.

# APPENDIX C

## ACRONYMS, ABBREVIATIONS, AND SYMBOLS

| | |
|---|---|
| ACGIH | American Conference of Governmental Industrial Hygienists |
| ADME | Absorption, Distribution, Metabolism, and Excretion |
| atm | atmosphere |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BCF | bioconcentration factor |
| BSC | Board of Scientific Counselors |
| C | Centigrade |
| CDC | Centers for Disease Control |
| CEL | Cancer Effect Level |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CLP | Contract Laboratory Program |
| cm | centimeter |
| CNS | central nervous system |
| d | day |
| DHEW | Department of Health, Education, and Welfare |
| DHHS | Department of Health and Human Services |
| DOL | Department of Labor |
| ECG | electrocardiogram |
| EEG | electroencephalogram |
| EPA | Environmental Protection Agency |
| EKG | see ECG |
| F | Fahrenheit |
| $F_1$ | first filial generation |
| FAO | Food and Agricultural Organization of the United Nations |
| FEMA | Federal Emergency Management Agency |
| FIFRA | Federal Insecticide, Fungicide, and Rodenticide Act |
| fpm | feet per minute |
| ft | foot |
| FR | *Federal Register* |
| g | gram |
| GC | gas chromatography |
| gen | generation |
| HPLC | high-performance liquid chromatography |
| hr | hour |
| IDLH | Immediately Dangerous to Life and Health |
| IARC | International Agency for Research on Cancer |
| ILO | International Labor Organization |
| in | inch |
| Kd | adsorption ratio |
| kg | kilogram |
| kkg | metric ton |
| $K_{oc}$ | organic carbon partition coefficient |
| $K_{ow}$ | octanol-water partition coefficient |

| | |
|---|---|
| L | liter |
| LC | liquid chromatography |
| LCLO | lethal concentration, low |
| $LC_{50}$ | lethal concentration, 50% kill |
| LDLO | lethal dose, low |
| $LD_{50}$ | lethal dose, 50% kill |
| LOAEL | lowest-observed-adverse-effect level |
| LSE | Levels of Significant Exposure |
| m | meter |
| mg | milligram |
| min | minute |
| mL | milliliter |
| mm | millimeter |
| mmHg | millimeters of mercury |
| mmol | millimole |
| mo | month |
| mppcf | millions of particles per cubic foot |
| MRL | Minimal Risk Level |
| MS | mass spectrometry |
| NIEHS | National Institute of Environmental Health Sciences |
| NIOSH | National Institute for Occupational Safety and Health |
| NIOSHTIC | NIOSH's Computerized Information Retrieval System |
| ng | nanogram |
| nm | nanometer |
| NHANES | National Health and Nutrition Examination Survey |
| nmol | nanomole |
| NOAEL | no-observed-adverse-effect level |
| NOES | National Occupational Exposure Survey |
| NOHS | National Occupational Hazard Survey |
| NPL | National Priorities List |
| NRC | National Research Council |
| NTIS | National Technical Information Service |
| NTP | National Toxicology Program |
| OSHA | Occupational Safety and Health Administration |
| PEL | permissible exposure limit |
| pg | picogram |
| pmol | picomole |
| PHS | Public Health Service |
| PMR | proportionate mortality ratio |
| ppb | parts per billion |
| ppm | parts per million |
| ppt | parts per trillion |
| REL | recommended exposure limit |
| RfD | Reference Dose |
| RTECS | Registry of Toxic Effects of Chemical Substances |
| sec | second |
| SCE | sister chromatid exchange |
| SIC | Standard Industrial Classification |
| SMR | standard mortality ratio |

APPENDIX C

| | |
|---|---|
| STEL | short term exposure limit |
| STORET | STORAGE and RETRIEVAL |
| TLV | threshold limit value |
| TSCA | Toxic Substances Control Act |
| TRI | Toxics Release Inventory |
| TWA | time-weighted average |
| U.S. | United States |
| UF | uncertainty factor |
| yr | year |
| WHO | World Health Organization |
| wk | week |
| | |
| > | greater than |
| ≥ | greater than or equal to |
| = | equal to |
| < | less than |
| ≤ | less than or equal to |
| % | percent |
| α | alpha |
| β | beta |
| δ | delta |
| γ | gamma |
| μm | micrometer |
| μg | microgram |