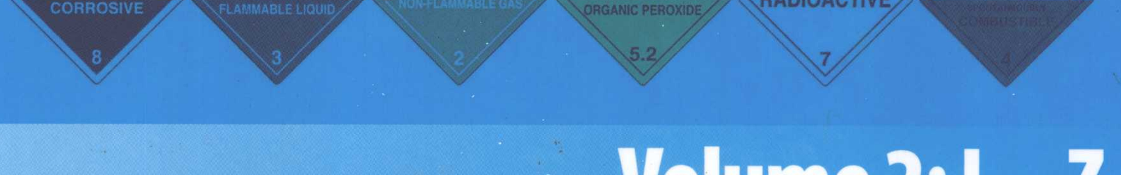
SIXTH EDITION

Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens

Richard P. Pohanish



Volume 2: L – Z

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Sixth Edition

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NOTICE TO BE READ BY ALL USERS OF THIS PUBLICATION

Preface

For more than a quarter century, *Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens* has continued to gather an ever-widening audience of users because it has been proven to be among the most reliable, easy to use, and essential reference works on hazardous materials. The 6th edition has been updated and expanded to keep pace with world events and to answer continuing and expanded need for information.

The 4th edition of *Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens* was published in 2001, shortly before the tragic events of the morning of September 11, 2001. Following 9/11, the United States established the Department of Homeland Security and enacted laws such as the *Chemical Facilities Security Act of 2003* and released the DHS list of Chemicals of Concern, *Appendix to Chemical Facility Antiterrorism Standards; Final Rule, November 20, 2007.* These actions were prompted by concerns about infrastructure protection and the anticipation of another attack, possibly on the nation's chemical facilities or by using trucks or tank cars that transport highly dangerous and possibly lethal chemicals.

These facilities are found around the country in industrial parks, in seaports, and near the major population centers. Dangerous chemicals routinely travel along our highways, inland waterways, and on railcars that pass through the heart of major cities including Washington, D.C., just a short distance from Capitol Hill. Terrorist attacks on the US chemical industry have the potential to kill tens of thousands of Americans and seriously injure many more. In many instances, these attacks hold the potential for having a cascading effect across other infrastructures, particularly in the energy and transportation sectors. This is both because of the damage that can be caused by the attack, and the enormous expense and effort associated with the clean-up to an affected area in its aftermath.[83]

To put it more simply, using the same low tech/high concept approach that turned passenger planes into missiles, terrorists do not need to produce or amass chemical weapons or smuggle them into the United States in order to produce great damage.

"Commercial chemical incidents occur tens of thousands of times each year, often with devastating and exorbitantly expensive consequences. They are indiscriminate in their effects. Workers, companies, the public, emergency response organizations, and all levels of government pay the figurative and literal price. Yet, until now and with few exceptions, chemical incidents have been invisible. Perhaps it is due to their pervasiveness, or to the common tendency to overlook what is taken for granted."[84] This quote is from the highly publicized *600K Report* prepared by the Chemical Safety and Hazard Investigation Board (CSB), an independent, nonpartisan, quasi-legislative US government agency. The CSB described our nation's lack of definitive knowledge of the "big picture" surrounding chemical incidents as "... the industrial equivalent of two 737 airplanes 'crashing' year after year, killing all passengers (256 people) without anyone seeming to notice."[84]

More than 30 years ago, the United States Government Accounting Office (GAO) estimated that 62,000 chemicals were in commercial use. Today, that number has grown to beyond 82,000.

Each year, in the United States, over 2 billion tons of hazardous and toxic chemicals are manufactured. Including imports, more than 3 billion tons are transported employing 800,000 shipments each day. It is estimated that 1.3 billion tons are moved by truck and hundreds of billions of pounds of these hazardous materials are transported through populated areas. The average American household generates approximately 15 lb of hazardous waste per year. Nearly 5 million poisonings occur in the United States annually, resulting in thousands of deaths. Based on 2004, TRI data (publically released April 2006), over 4 billion pounds of toxic chemicals are released into the nation's environment each year, including 72 million pounds of recognized carcinogens from nearly 24,000 industrial facilities. The toxic chemicals problem in the United States; and, indeed, in all the world is frightening to many people. And, over the years, these fears are heightened by news stories about an oil field explosion in Mississippi (2006), a 48,000-lb chlorine release in Missouri (2002), Love Canal in New York, the Valley of the Drums in Kentucky, the Valley of Death in Brazil, major chemical spills, including Bhopal, India, terrorist attacks in Japan...and the like. All of these incidents generate emotional responses, often from people uninformed about science or technology. On the other hand, one encounters some industrialists who tell us that toxic chemicals are present in nature and that industrial contributions are just the price we have to pay for progress. There is little argument about the chemical industry's critical place in the nation's economy. The United States is the number one chemical producer in the world, generating more than $550 billion a year and employing more than 5 million people. So somewhere in between lies the truth—or at least an area in which we can function. Information is vital in a world where virtually every aspect of our lives is touched by chemical hazards.

Given the reality of problems related to chemical hazards, including accidents and spills, the advent of new threats to our way of life, and the challenges of communicating complex data, it is the goal of this book to provide data so that responsible decisions can be made by all who may have contact with chemicals in this reference work. With this in mind, the work can be used by those in the following professions:

- Chemicals manufacturers
- Emergency response personnel
- Protective safety equipment producers
- Environmental management
- Transportation managers
- Toxicologists
- Industrial hygienists
- Industrial safety engineers
- Lawyers
- Occupational doctors and nurses
- Chemists
- Industrial waste disposal operators
- Enforcement officials
- Special, technical, and university librarians
- Legislators
- Homeland security planners

The chemicals chosen for inclusion are officially recognized substances, defined as carcinogens, as belonging to some designated category of hazardous or toxic materials, with numerically defined safe limits in air in the workplace, ambient air, water, waste effluents. For the most part, these are materials of commerce that are heavily used and many are transported in bulk.

The 6th edition contains more regulated chemicals and expanded data on each material. Some material and appendices from the previous edition has been eliminated or moved to more appropriate sections. This was done to limit the work to a pair of handy volumes.

All of this has been done to make the work more relevant, more inclusive, and easier to use. The utility of the work has been enhanced by the addition of three appendices. Additionally there is a table that cross indexes the materials by chemical and trade names and CAS Registry Number.

Appendix 1: the list of oxidizing materials has been expanded. Appendix 2 contains many new confirmed and suspected carcinogens. Also, this edition allows the user to search the carcinogen list by name or CAS Number. Appendix 3 is a glossary of chemical, health, safety, medical, and environmental terms used in the handbook. The glossary was completely reviewed and many narrow interest medical terms were removed. More and new germane terms were added. The Introduction was replaced with the more accurate title, *How to Use this Book.* Following the use section is a revised *Key to the Abbreviations and Acronyms* used in the handbook.

In keeping with the broad changes originally initiated with the 4th edition, contents of the 6th edition are focused on the concept of "regulated chemicals." The carcinogen potential of each chemical was compared to listings and reports from eminent authorities as the International Agency for Research on Cancer (IARC) and the National Toxicology Progam (NTP).

The "Regulatory Authority and Advisory Bodies" section contains new items including, where available, EPA Gene-Tox Program findings, and many of the individual listings now contain useful advice sought after by the regulated community. As a result, the new volume should be even more practical for those users of specific chemicals and to those concerned with both adherence to and enforcement of regulations.

Data is furnished, to the extent currently available, in a uniform multisection uniform format to make it easy for users who must find information quickly and/or compare the data contained within records, in any or all of these important categories:

Chemical Description
Code Numbers (including CAS, DOT, RTECS, EC)
Synonyms
Regulatory Authority and Advisory Bodies (summary)
Description
Potential Exposure
Incompatibilities
Permissible Exposure Limits in Air
Determination in Air
Permissible Concentration in Water
Determination in Water
Routes of Entry
Short Term Exposure
Long Term Exposure
Points of Attack
Medical Surveillance
Decontamination (selected records)
First Aid
Decontamination (CWAs or WMDs)
Personal Protective Methods
Respirator Selection
Storage
Shipping
Spill Handling
Fire Extinguishing
Disposal Method Suggested
References

The 6th edition of Sittig has new and updated information in nearly every section, including the following: Synonyms, CAS Numbers, UN/NA & ERG (Emergency Response Guide) Number, EC Numbers (Annex I Index Numbers added where assigned), Regulatory Authority and Advisory Bodies (added Rotterdam Convention Annex III [Chemicals Subject to the Prior Informed Consent Procedure (PIC)]; List of Stockholm Convention POPs: Annex A; European/International Hazard Symbol, Risk phrases, Safety phrases; WGK (German Aquatic Hazard Class); Annex II Rotterdam Convention List information; hundreds of Department of the US Homeland Security Chemicals of Interest along with their Screening Threshold Quantities (STQs) [from the US Code of Federal regulations (6CFR Part 27 Appendix A]; California Proposition 65 Carcinogen and Reproduction Toxins; Description, Incompatibilities, Exposure Limits [now includes US Department of Energy (DOE) Protection Action Criteria (PACs)]. Short Term Exposure, Long Term Exposure, First Aid, Decontamination (especially, chemical warfare agents and weapons of mass destruction), Personal Protective Methods, Respirator Selection, Storage, Shipping, Spill Handling [more and updated Initial Isolation and Protective Distances (including both Imperial and Metric) from the *US DOT Emergency Response Guide*], Fire Extinguishing, Disposal. Specifically, additions include regulatory information, identifiers, chemical and physical properties, including explosive limits, NFPA (National Fire Protection Association)-type hazard ratings (based on NFPA-704 M Rating System), water solubility and hazard levels, exposure limits, odor thresholds, DOT isolation and protective distances, and full text of NIOSH respirator recommendations. Many records contain special warnings, including notes and reminders to Emergency Management Service (EMS) personnel, and other health-care professionals.

Although every effort has been made to produce an accurate and highly useful handbook, the author appreciates the need for constant improvement. Any comments, corrections, or advice from users of this book are welcomed by the author who asks that all correspondence be submitted in writing and mailed to the publisher who maintains a file for reprints and future editions.

A Brief history of this work

Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens was first published 30 years ago. This work continues to provide first responders and occupational and environmental health and safety professionals with an accessible and portable reference source. The 6th edition of his handbook contains data on more than 2200 toxic and hazardous chemicals (up from nearly 600 in the first edition, nearly 800 in the second edition, nearly 1300 in the third edition, and 1500 in the 4th edition).

According to the Library of Congress, the history of the project is as follows: 1st edition published in 1981; 2nd edition published in 1985; 3rd edition published in 1991; 4th edition published in 2001; 5th edition published in 2008; 6th edition published in 2011.

Acknowledgments

The author would like to thank some individuals and institutions, without whose expertise and generous help, the 6th edition would not have been possible. In particular, the author wants to acknowledge the good work of the scientists and contract employees associated with NIOSH, US EPA, OSHA, ATSDR, ACGIH, IARC, DFG, CDC, TOXNET, NTP, AIHA, and many others who developed the various documents and databases that provided so much of the data that were compiled for this work. To each, the author is indebted. At the US Coast Guard Headquarters, the author wishes to thank the recently retired Alan Schneider, D.Sc., of the Marine Technical and Hazardous Materials Division.

How to Use This Book

Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens focuses on critical data for more than 2200 commercially important and/or regulated and monitored substances, and many associated substances. Many of these chemicals or substances are found in the workplace; a few are found in the medical and research fields. Importance is defined by inclusion in official, regulatory, and advisory listings. Much of this information, found in US government sources, has been supplemented by a careful search of publications from various countries and other sources including United Nations and World Health Organization (WHO) publications.

This handbook is becoming more encyclopedic in nature. When one looks at most handbooks, one simply expects to find numerical data. Here, we have tried, wherever possible, to provide literature references to review documents which hopefully opens the door for users to a much broader field of published materials. It is recommended that this book be used as a guide. This book is not meant to be a substitute for workplace hazard communication programs required by regulatory bodies such as OSHA, and/or any other US, foreign, or international government agencies. If data are required for legal purposes, the original source documents and appropriate agencies, which are referenced, should be consulted.

In the pages which follow, the following categories of information will be discussed with reference to scope, sources, nomenclature employed, and the like. Omission of a category indicates a lack of available information.

Chemical name: Each record is arranged alphabetically by a chemical name used by regulatory and advisory bodies. In a very few cases the name may be a product name or trade name.

Formula: Generally, this has been limited to a commonly used one-line empirical or atomic formula. In the *Molecular Formula* field, the Hill system has been used showing number of carbons (if present), number of hydrogens (if present), and then alphabetically by element. Multiple carbon–carbon (double and triple) bonds have been displayed where appropriate.

Synonyms: This section contains scientific, product, trade, and other synonym names that are commonly used for each hazardous substance. Some of these names are registered trade names. Some are provided in other major languages other than English, including Spanish, French, and German. In some cases, "trivial" and nicknames (such as MEK for methyl ethyl ketone) have been included because they are commonly used in general communications and in the workplace. This section is important because the various "regulatory" lists published by federal, state, international, and advisory bodies and agencies do not always use the same name for a specific hazardous substance. Every attempt has been made to ensure the accuracy of the synonyms and trade names found in this volume, but errors are inevitable in compilations of this magnitude. Please note that this volume may not include the names of all products currently in commerce, particularly mixtures that may contain regulated chemicals.

The synonym index contains all synonym names listed in alphabetical order. It should be noted that organic chemical prefixes and interpolations, such as (α-) alpha-, (β-) beta-, (γ-) gamma-, delta- (δ-), (*o*-) *ortho*-, (*m*-) *meta*-; (*p*-) *para*-; *sec*- (*secondary*-), *trans*-, *cis*-, (*n*-) *normal*-, and numbers (1-; 1,2-), are not used when searching for a chemical name. In other words, these prefixes are not treated as part of the chemical name for the purposes of alphabetization. Users should use the substance name without the prefix. For example, to locate *n*-Butane, search for Butane; to locate 3,3′-Dichlorobenzidine, search for Dichlorobenzidine; and to locate α-Cyanotoluene or alpha-Cyanotoluene, search for Cyanotoluene.

CAS Number: The CAS number is a unique identifier assigned to each chemical registered with the Chemical Abstracts Service (CAS) of the American Chemical Society. This number is used to identify chemicals on the basis of their molecular structure. CAS numbers are given in the format nnn (...)-nn-n [two or more numeric characters (dash) two numeric characters (dash) followed by a single numeric check digit]. CAS numbers should always be used in conjunction with substance names to insure positive identification and avoid confusion with like-sounding names, i.e., benzene (71-43-2) and benzine (8032-32-4). This 6th edition contains some alternate CAS numbers that may now be considered related, retired, obsolete, and/or widely and incorrectly used in the literature. In this section, the first CAS number(s), before the word "alternate," is considered (based on several sources) to be the correct CAS number(s). Ultimately, it is the responsibility of the user to find and use the correct number.

RTECS®Number: The RTECS® numbers (Registry of Toxic Effects of Chemical Substances) are unique identifiers assigned and published by NIOSH. The RTECS® number in the format "AAnnnnnnn" (two alphabetic characters followed by seven numeric characters) may be useful for online searching for additional toxicologic information on specific substances. It can, for example, be used to provide access to the MEDLARS® computerized literature retrieval services of the National Library of Medicine (NLM) in Washington, DC. The RTECS number and the CAS number can serve to narrow down online searches.

DOT ID: The DOT hazard ID number is assigned to the substance by the US Department of Transportation (DOT). The DOT ID number format is "UNnnnn" or "NA nnnn." This ID number identifies substances regulated by DOT and

must appear on shipping documents, the exterior of packages, and on specified containers. Identification numbers containing a UN prefix are also known as United Nations numbers and are authorized for use with all international shipments of hazardous materials. The "NA" prefix is used for shipments between Canada and the United States only, and may not be used for other international shipments.
EC Number: The European Commission number is a 7-digit identification code used by the European Union (EU) for commercially available chemical substances within the EU. An identification number from *European Inventory of Existing Commercial Chemical Substances*, published by the European Environment Agency, Copenhagen, Denmark. Use of these identification numbers for hazardous materials will (a) serve to verify descriptions of chemicals; (b) provide for rapid identification of materials when it might be inappropriate or confusing to require the display of lengthy chemical names on vehicles; (c) aid in speeding communication of information on materials from accident scenes and in the receipt of more accurate emergency response information; and (d) provide a means for quick access to immediate emergency response information in the "*North American Emergency Response Guidebook*."[31] In this latter volume, the various compounds have assigned "ID" numbers (or identification numbers) which correspond closely, but not always precisely, to the UN listing.[20] The EC number supercedes the outmoded EINECS, ELINCS, and NLP numbers. This section also includes Annex I, Index number for the Export and Import of Dangerous Chemicals found in Annex I of Regulation (EC) No. 689/2008.
Regulatory Authority and Advisory Bodies:
This section contains a listing of major regulatory and advisory lists containing the chemical of concern, including OSHA, US EPA, DFG, US DOT, ACGIH, IARC, NTP, WHMIS (Canada), and the EEC. Many law or regulatory references in this work have been abbreviated. For example, Title 40 of the Code of Federal Regulations, Part 261, subpart 32 has been abbreviated as 40CFR261.32. The symbol "§" may be used as well to designate a "section" or "part."

- European/International Hazard Symbols, Risk Phrases, and Safety Phrases. Explanation of these symbols and phrases can be found in the new Appendix 4. In the interim between the 6th and 7th edition, it is expected that the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) will be phased in by many countries. Hazard statements are an essential element under the GHS, and will eventually replace the risk phrases (R-phrases) described earlier in the paragraph. In addition to hazard statements, containers and Material Safety Data Sheets (MSDS) will contain, where necessary, one or multiple pictograms, a signal word such as "Warning" or "Danger," and precautionary statements. The precautionary statements will indicate proper handling procedures aimed at protecting the user and other people who might come in contact with the substance during an accident or in the environment. The container and MSDS will also contain the name of the supplier, manufacturer, or importer. Each hazard statement contains a four-digit code, starting with the letter H (in the form Hxxx). Statements appear under various headings grouped together by code number. The purpose of the four-digit code is for reference only; however, following the code is exact *phrase* as it should appear on labels and MSDS.
- A carcinogen (the agency making such a determination, the nature of the carcinogenicity—whether human or animal and whether positive or suspected, are given in each case). These are frequently cited by IARC (International Agency for Research on Cancer),[12] and are classified as to their carcinogenic risk to humans by IARC as follows: Group 1: Human Carcinogen; Group 2A: Probable Human Carcinogen; Group 2B: Possible Human Carcinogen. Chemicals are classified as to their carcinogenic risk to humans by NTP as follows: Group K: Known Human Carcinogens; Group R: Reasonably Anticipated Human Carcinogens, or the NTP (US National Toxicology Programs).[10] It should be noted that the DFG have designated some substances as carcinogens not so classified by other agencies.
- A banned or severely restricted product as designated by the United Nations[13] or by the US EPA Office of Pesticide Programs under FIFRA (The Federal Insecticide, Fungicide, and Rodenticide Act).[14]
- A substance cited by the World Bank.[15]
- A substance with an air pollutant standard set or recommended by OSHA and/or NIOSH,[58] ACGIH,[1] DFG,[3] or HSE.[33] The OSHA limits are the enforceable pre-1989 PELs. The transitional limits that were vacated by court order have not been included. The NIOSH and ACGIH airborne limits are recommendations that do not carry the force of law.
- A substance whose allowable concentrations in workplace air are adopted or proposed by the American Conference of Government Industrial Hygienists (ACGIH),[1] DFG [Deutsche Forschungsgemeinschaft (German Research Society)].[3] Substances whose allowable concentrations in air and other safety considerations have been considered by OSHA and NIOSH.[2] Substances which have limits set in work-place air, in residential air, in water for domestic purposes, or in water for fishery purposes as set forth by the former USSRUNEP/IRPTC Project.[43]
- Substances that are specifically regulated by OSHA under 29CFR1910.1001 to 29CFR1910.1050.
- Highly hazardous chemicals, toxics, and reactives regulated by OSHA's "*Process Safety Management of Highly Hazardous Chemicals*" under 29CFR1910.119, Appendix A. Substances that are Hazardous Air Pollutants (Title I, Part A, § 112) as amended under 42USC7412. This list provided for regulating at least 189 specific substances using technology-based

standards that employ Maximum Achievable Control Technology (MACT) standards; and, possibly health-based standards if required at a later time. § 112 of the Clean Air Act (CAA) requires emission control by the EPA on a source-by-source basis. Therefore, the emission of substances on this list does not necessarily mean that a firm is subject to regulation.

- Regulated Toxic Substances and Threshold Quantities for Accidental Release Prevention. These appear as Accidental Release Prevention/Flammable Substances, Clean Air Act (CAA) §112(r), Table 3, TQ (threshold quantity) in pounds and kilograms under 40 CFR68.130. The accidental release prevention regulations applies to stationary sources that have present more than a threshold quantity of a CAA § 112(r) regulated substance.
- Clean Air Act (CAA) Public Law 101–549, Title VI, *Protection of Stratospheric Ozone*, Subpart A, Appendix A, class I and Appendix B, Class II, Controlled Substances, (CFCs) Ozone-depleting substances under 40CFR82.
- Clean Water Act (CWA) Priority toxic water pollutants defined by the US Environmental Protection Agency for 65 pollutants and classes of pollutants which yielded 129 specific substances.[6]
- Chemicals designated by EPA as "Hazardous Substances"[4] under the Clean Water Act (CWA) 40CFR116.4, Table 116.4A.
- Clean Water Act (CWA) § 311 Hazardous Materials Discharge Reportable Quantities (RQs). This regulation establishes reportable quantities for substances designated as hazardous (see §116.4, above) and sets forth requirements for notification in the event of discharges into navigable waters. Source: 40CFR117.3, amended at 60FR30937.
- Clean Water Act (CWA) § 307 List of Toxic Pollutants. Source: 40CFR401.15.
- Clean Water Act (CWA) § 307 Priority Pollutant List. This list was developed from the List of Toxic Pollutants classes discussed above and includes substances with known toxic effects on human and aquatic life, and those known to be, or suspected of being, carcinogens, mutagens, or teratogens. Source: 40CFR423, Appendix A.
- Clean Water Act, § 313 Water Priority Chemicals. Source: 57FR41331.
- RCRA Maximum Concentration of Contaminants for the Toxicity Characteristic with Regulatory levels in mg/L. Source: 40CFR261.24.
- RCRA Hazardous Constituents. Source: 40CFR261, Appendix VIII. Substances listed have been shown, in scientific studies, to have carcinogenic, mutagenic, teratogenic, or toxic effects on humans and other life forms. This list also contains RCRA waste codes. The term "waste number not listed" appears when a RCRA number is NOT provided in Appendix VIII.

Characteristic Hazardous Wastes

Ignitability	A nonaqueous solution containing less than 24% alcohol by volume and having a closed cup flashpoint below 60°C/140°F using Pensky-Martens tester or equivalent. An ignitible compressed gas. A nonliquid capable of burning vigorously when ignited or causes fire by friction, moisture absorption, spontaneous chemical changes at standard pressure and temperature. An oxidizer. See §261.21.
Corrosivity	Liquids with a pH equal to or less than 2 or equal to or more than 12.5 or which corrode steel at a rate greater than 6.35 mm (0.25 in) per year at 55°C/130°F. See §261.22.
Reactivity	Unstable substances that undergo violent changes without detonating. Reacts violently with water or other substances to create toxic gases. Forms potentially explosive mixtures with air. See §261.23.
Toxicity	A waste that leaches specified amounts of metals, pesticides, or organic chemicals using Toxicity Characteristic Leaching Procedure (TCLP). See §261, Appendix II, and §268, Appendix I. **Listed Hazardous Wastes.**
"F" wastes	Hazardous wastes from nonspecific sources §261.31.
"K" Wastes	Hazardous wastes from specific sources §261.32.
"U" Wastes	Hazardous wastes from discarded commercial products, off-specification species, container residues §261.34. Covers some 455 compounds and their salts and some isomers of these compounds.
"P" Wastes	Acutely hazardous wastes from discarded commercial products, off-specification species, container residues §261.33. Covers some 203 compounds and their salts plus soluble cyanide salts.

Note: If a waste is not found on any of these lists, it may be found on state hazardous waste lists.

RCRA Maximum Concentration of Contaminants for the Toxicity Characteristic. Source: 40CFR261.24, Table I. These are listed with regulatory level in mg/L and "D" waste numbers representing the broad waste classes of ignitability, corrosivity, and reactivity.

EPA Hazardous Waste code(s), or RCRA number, appears in its own field. Acute hazardous wastes from commercial chemical products are identified with the prefix "P." Nonacutely hazardous wastes from commercial chemical products are identified with the prefix "U."

RCRA Universal Treatment Standards. Lists hazardous wastes that are banned from land disposal unless treated to meet standards established by the regulations. Treatment standard levels for wastewater (reported in mg/L) and

nonwastewater [reported in mg/kg or mg/L TCLP (Toxicity Characteristic Leachability Procedure)] have been provided. Source: 40CFR268.48 and revision, 61FR15654.
RCRA Ground Water Monitoring List. Sets standards for owners and operators of hazardous waste treatment, storage, and disposal facilities, and contains test methods suggested by the EPA (see Report SW-846) followed by the Practical Quantitation Limit (PQL) shown in parentheses. The regulation applies only to the listed chemical; and, although both the test methods and PQL are provided, they are *advisory only*. Source: 40CFR264, Appendix IX.
Safe Drinking Water Act (SDWA) Maximum Contaminant Level Goals (MCLGs) for Organic Contaminants. Source: 40CFR141 and 40CFR141.50, amended 57FR31776.

- Maximum Contaminant Levels (MCLs) for Organic Contaminants. Source: 40CFR141.61.
- Maximum Contaminant Level Goals (MCLGs) for Inorganic Contaminants. Source: 40CFR141.51.
- Maximum Contaminant Levels (MCLs) for Inorganic Contaminants. Source: 40CFR141.62.
- Maximum Contaminant Levels for Inorganic Chemicals. The maximum contaminant level for arsenic applies only to community water systems. Compliance with the MCL for arsenic is calculated pursuant to §141.23. Source: 40CFR141.11.
- Secondary Maximum Contaminant Levels (SMCLs). Federal advisory standards for the states concerning substances that effect physical characteristics (i.e., smell, taste, color, etc.) of public drinking water systems. Source: 40CFR143.3.
- CERCLA Hazardous Substances ("RQ" Chemicals). From Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-to-Know Act (EPCRA) and § 112(r) of the Clean Air Act, as Amended. Source: EPA 550-B-98-017 *Title III List of Lists*.
- Releases of CERCLA hazardous substances in quantities equal to or greater than their reportable quantity (RQ) are subject to reporting to the National Response Center under CERCLA. Such releases are also subject to state and local reporting under §304 of SARA Title III (EPCRA). CERCLA hazardous substances, and their reportable quantities, are listed in 40CFR302, Table 302.4. RQs are shown in pounds and kilograms for chemicals that are CERCLA hazardous substances. For metals listed under CERCLA (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, and zinc), no reporting of releases of the solid is required if the diameter of the pieces of solid metal released is 100 μm (0.004 in.) or greater. The RQs shown apply to smaller particles.
- EPCRA §302 Extremely Hazardous Substances (EHS). From Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-to-Know Act (EPCRA) and § 112(r) of the Clean Air Act, as Amended. Source: EPA 550-B-98-017 *Title III List of Lists*. The presence of Extremely Hazardous Substances in quantities in excess of the Threshold Planning Quantity (TPQ) requires certain emergency planning activities to be conducted. The Extremely Hazardous Substances and their TPQs are listed in 40CFR355, Appendices A & B. For chemicals that are solids, there may be two TPQs given (e.g., 500/10,000). In these cases, the lower quantity applies for solids in powder form with particle size less than 100 μm; or, if the substance is in solution or in molten form. Otherwise, the higher quantity (10,000 pounds in the example) TPQ applies.
- EPCRA §304 Reportable Quantities (RQs). In the event of a release or spill exceeding the reportable quantity, facilities are required to notify State Emergency Response Commissions (SERCs) and Local Emergency Planning Committees (LEPCs). From Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-to-Know Act (EPCRA) and § 112(r) of the Clean Air Act, as Amended. Source: EPA 550-B-98-017 *Title III List of Lists*.
- EPCRA § 313 Toxic Chemicals. From Consolidated List of Chemicals Subject to the Emergency Planning and Community Right-to-Know Act (EPCRA) and § 112(r) of the Clean Air Act, as Amended. Source: EPA 550-B-98-017 *Title III List of Lists*. Chemicals on this list are reportable under §313 and §6607 of the Pollution Prevention Act. Some chemicals are reportable by category under §313. Category codes needed for reporting are provided for the EPCRA§313 categories. Information and Federal Register references have been provided where a chemical is subject to an administrative stay, and not reportable until further notice.
- From "*Toxic Chemical Release Inventory Reporting Form R and Instructions, Revised 2005 Version,*" EPA document 260-B-06-001 was used for *de minimis* concentrations, toxic chemical categories.
- Chemicals which EPA has made the subject of Chemical Hazard Information Profiles or "CHIPS" review documents.
- Chemicals which NIOSH has made the subject of "Information Profile" review documents on "Current Intelligence Bulletins."
- Carcinogens identified by the National Toxicology Program of the US Department of Health and Human Services at Research Triangle Park, NC.[10]
- Substances regulated by EPA[7] under the major environmental laws: Clean Air Act, Clean Water Act, Safe Drinking Water Act, RCRA, CERCLA, EPCRA, etc. A more detailed list appears above. Substances with environmental standards set by some international bodies including those in Europe and Canada.[43]
- New to the 6th edition: United States Department of Homeland Security Chemicals of Interest from the

Federal Register, Appendix A, including all provisions of 6 CFR Part 27, including § 27.210(a)(1)(i). In developing the list, the DHS looked to existing expert sources of information including other federal regulations related to chemicals, including the following: Chemicals covered under the Environmental Protection Agency's Risk Management Program. Chemicals included in the Chemical Weapons Convention. Hazardous materials, such as gases, that are poisonous by inhalation. Explosives regulated by the Department of Transportation. The Department of Homeland Security has identified three security issues related to chemicals: *Release*—Toxic, flammable, or explosive chemicals or materials that, if released from a facility, have the potential for significant adverse consequences for human life or health. *Theft or Diversion*—Chemicals or materials that, if stolen or diverted, have the potential to be misused as weapons or easily converted into weapons using simple chemistry, equipment or techniques, in order to create significant adverse consequences for human life or health. *Sabotage or Contamination*—Chemicals or materials that, if mixed with readily available materials, have the potential to create significant adverse consequences for human life or health. Also considered were these security issues as well as to determine their potential future inclusion in Appendix A and/or coverage under Chemical Facility Anti-Terrorism Standards: *Critical to Government Mission*—Chemicals or facilities, the loss of which could create significant adverse consequences for national security or the ability of the government to deliver essential services, and *Critical to National Economy*—Chemicals or facilities, the loss of which could create significant adverse consequences for the national or regional economy.

- Chemicals on California's Proposition 65 List, revised as of January 7, 2011. The Safe Drinking Water and Toxic Enforcement Act of 1986 requires that the Governor revise and republish at least once per year the list of chemicals known to the State to cause cancer or reproductive toxicity.
- Also new in the 6th edition are the water hazard classifications from the German Federal Water Management Act on Water Hazard Classification, *Verwaltungsvorschrift Wassergefährdende Stoffe* (VwVwS). This law requires all chemical substances be evaluated for their detrimental impact on the physical, chemical, or biological characteristics of water. Substances can be classified as nonhazardous to water (*nwg, nicht wassergefährdende*) or assigned to one of three numeric water hazard classes, WGK: 1—low hazard to waters (low polluting to water), WGK: 2—hazard to waters (water pollutant), or WGK: 3—severe hazard to waters (severe pollutant). The English acronym for WGK is WHC (water hazard class). This work uses the German acronym "WGK" so there is no confusion as to its source. Material Safety Data Sheets (MSDS) that use these water hazards also use the German acronym.

Description: This section contains a quick summary of physical properties of the substance including state (solid, liquid, or gas), color, odor description, molecular weight, density, boiling point, freezing/melting point, vapor pressure, flash point, autoignition temperature, explosion limits in air, Hazard Identification (based on NFPA-704 M Rating System) in the format: Health (ranked 1–4), Flammability (ranked 1–4), Reactivity (ranked 1–4) (see also below for a detailed explanation of the System and Fire Diamond), and solubility or miscibility in water. This section may also contain special and relevant comments about the substance. Terms in this section are also defined in the glossary.

Odor threshold: This is the lowest concentration in air that most humans can detect by smell. Some value ranges are reported. The value cannot be relied on to prevent overexposure, because human sensitivity to odors varies over wide limits, some chemicals cannot be smelled at toxic concentrations, odors can be masked by other odors, and some compounds rapidly deaden the sense of smell.

Molecular weight: The MW as calculated from the molecular formula using standard elemental molecular weights (e.g., carbon = 12.1).

Boiling point at 1 atm: The value is the temperature of a liquid when its vapor pressure is 1 atm. For example, when water is heated to 100°C/212°F its vapor pressure rises to 1 atm and the liquid boils. The boiling point at 1 atm indicates whether a liquid will boil and become a gas at any particular temperature and sea-level atmospheric pressure.

Melting/Freezing point: The melting/freezing point is the temperature at which a solid changes to liquid or a liquid changes to a solid. For example, liquid water changes to solid ice at 0°C/32°F. Some liquids solidify very slowly even when cooled below their melting/freezing point. When liquids are not pure (e.g., saltwater) their melting/freezing points are lowered slightly.

Flash point: This is defined as the lowest temperature at which vapors above a volatile combustible substance will ignite in air when exposed to a flame. Depending on the test method used, the values given are either Tag Closed Cup (cc) (ASTM D56) or Cleveland Open Cup (oc) (ASTM D93). The values, along with those in *Flammable Limits in Air* and *Autoignition temperature* below, give an indication of the relative flammability of the chemical. In general, the open cup value is slightly higher (perhaps 10–15°F higher) than the closed cup value. The flash points of flammable gases are often far below 0° (F or C) and these values are of little practical value, so the term "flammable gas" is often used instead of the flash point value.

Autoignition Temperature: This is the minimum temperature at which the material will ignite without a spark or flame being present. Values given are only approximate and may change substantially with changes in geometry, gas, or vapor concentrations, presence of catalysts, or other factors.

Flammable Limits in Air: The percent concentration in air (by volume) is given for the LEL (lower explosive flammable limit in air, % by volume) and UEL (upper explosive flammable limit in air, % by volume), at room temperature, unless other specified. The values along with those in "Flash point" and "Autoignition temperature" give an indication of the relative flammability of the chemical.

NFPA Hazard Classifications: The NFPA 704 Hazard Ratings (Classifications) are based on those found in "*Fire Protection Guide to Hazardous Materials*," 2001 edition, National Fire Protection Association, Quincy, MA, ©1994. The classifications are defined in Table 1 below.

Table 1. Explanation of NFPA Hazard Classifications

Classification	*Definition*
HEALTH HAZARD (blue)	
4	Materials which on very short exposure could cause death or major residual injury (even though prompt medical treatment was given), including those that are too dangerous to be approached without specialized protective equipment.
3	Materials which on short exposure could cause serious temporary or residual injury (even though prompt medical treatment was given), including those requiring protection from all bodily contact.
2	Materials that, on intense or continued (but not chronic) exposure, could cause temporary incapacitation or possible residual injury, including those requiring the use of protective clothing that has an independent air supply.
1	Materials which on exposure would cause irritation but only minor residual injury, including those requiring the use of an approved air-purifying respirator.
0	Materials that, on exposure under fire conditions, offer no hazard beyond that of ordinary combustible material.
FLAMMABILITY (red)	
4	This degree includes flammable gases, pyrophoric liquids, and Class IA flammable liquids. Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.
3	Includes Class IB and IC flammable liquids and materials that can be easily ignited under almost all normal temperature conditions.
2	Materials that must be moderately heated before ignition will occur and includes Class II and Class IIIA combustible liquids and solids and semisolids that readily give off ignitable vapors.
1	Materials that must be preheated before ignition will occur, such as Class IIIB combustible liquids, and solids and semisolids whose flash point exceeds 200°F/93.4°C, as well as most ordinary combustible materials.
0	Materials that will not burn.
REACTIVITY (yellow)	
4	Materials that, in themselves, are readily capable of detonation, explosive decomposition, or explosive reaction at normal temperatures and pressures.
3	Materials that, in themselves, are capable of detonation, or explosive reaction, but require a strong initiating source or heating under confinement. This includes materials that are sensitive to thermal and mechanical shock at elevated temperatures and pressures and materials that react explosively with water.
2	Materials that are normally unstable and readily undergo violent chemical change, but are not capable of detonation. This includes materials that can undergo chemical change with rapid release of energy at normal temperatures and pressures. This also includes materials that may react violently with water or that may form potentially explosive mixtures in water.
1	Materials that are normally stable, but that may become unstable at elevated temperatures and pressures and materials that will react with water with some release of energy, but not violently.
0	Materials that are normally stable, even under fire exposure conditions, and that do not react with water.
OTHER (white)	
₩	Materials which react so violently with water that a possible hazard results when they come in contact with water, as in a fire situation. Similar to Reactivity Classification 2.Oxy—Oxidizing material; any solid or liquid that readily yields oxygen or other oxidizing gas, or that readily reacts to oxidize combustible materials.

It should be noted that OSHA and DOT have differing definitions for the term "flammable liquid" and "combustible liquid." DOT defines a flammable liquid as one which, under specified procedures, has a flashpoint of 140°F/60°C or less. A combustible liquid is defined as "having a flashpoint above 140°F/60°C and below 200°F/93°C." OSHA defines a combustible liquid as having a flash point above 100°F/37.7°C.

Potential Exposure: A brief indication is given of the nature of exposure to each compound in the industrial environment. Where pertinent, some indications are given of background concentration and occurrence from other than industrial discharges such as water purification plants. Obviously in a volume of this size, this coverage must be very brief. It is of course recognized that nonoccupational exposures may be important as well. This 6th edition contains a brief summary called a Compound Description (Toxicity evaluation),[77] such as Agricultural Chemical, Mutagen, Tumorigen, Mutagen, Reproductive Effector, Primary Irritant, Human Data, etc. Compound descriptors define the types of toxicity data found in a record or uses or applications of the chemical if they are recognized by NIOSH. The Compound Descriptor does not represent an evaluation of the toxicity of a substance, nor are the descriptors all-inclusive (i.e., there may be some substances that should be, but are not, coded as belonging to certain application classes). The codes must be interpreted only in conjunction with the other information found in each record.[77]

Incompatibilities: Potentially hazardous incompatibilities of each substance are listed where available. Where a hazard with water exists, it is described. Reactivity with other materials are described including structural materials such as metal, wood, plastics, cement, and glass. The nature of the hazard, such as severe corrosion formation of a flammable gas, is described. This list is by no means complete or all inclusive. In some cases a very small quantity of material can act as a catalyst and produce violent reactions such as polymerization, disassociation, and condensation. Some chemicals can undergo rapid polymerization to form sticky, resinous materials, with the liberation of much heat. The containers may explode. For these chemicals the conditions under which the reaction can occur are given.

Permissible Exposure Limits in Air: The permissible exposure limit (PEL) has been cited as the federal standard where one exists. Inasmuch as OSHA has made the decision to enforce only pre-1989 PELs, we decided to use these values rather than the transitional limits that were vacated by court order. Except where otherwise noted, the PELs are 8-h work-shift time-weighted average (TWA) levels. Ceiling limits, Short-Term Exposure Limits (STELs), and TWAs that are averaged over other than full work shifts are noted.

The Short-Term Exposure Limit (STEL) values are derived from NIOSH,[58] ACGIH,[1] and HSE[33] publications. This value is the maximal concentration to which workers can be exposed for a period up to 15 min continuously without suffering from: irritation; chronic or irreversible tissue change; or narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 min between exposure periods, and provided that the daily TWA also is not exceeded. The "Immediately Dangerous to Life or Health" (IDLH) concentration represents a maximum level from which one could escape within 30 min without any impairing symptoms or any irreversible health effects. However, the 30-min period is meant to represent a MARGIN OF SAFETY and is NOT meant to imply that any person should stay in the work environments any longer than necessary. In fact, every effort should be made to exit immediately. The concentrations are reported in either parts per million (ppm) or milligrams per cubic meter (mg/m^3).

Most US specifications on permissible exposure limits in air have come from ACGIH[1] or NIOSH.[2] In the United Kingdom, the Health and Safety Executive has set forth Occupational Exposure Limits.[33] In Germany, the DFG has established Maximum Concentrations in the workplace[3] and the former USSR-UNEP/IRPTC project has set maximum allowable concentrations and tentative safe exposure levels of harmful substance in work-place air and residential air for many substances.[43] This section also contains numerical values for allowable limits of various materials in ambient air[60] as assembled by the US EPA. Where available, this field contains legally enforceable airborne Permissible Exposure Limits (PELs) from OSHA. It also contains recommended airborne exposure limits from NIOSH, ACGIH, and international sources and special warnings when a chemical substance is a Special Health Hazard Substance. Each are described below. TLVs have not been developed as legal standards and the ACGIH does not advocate their use as such. The TLV is defined as the time-weighted average (TWA) concentration for a normal 8-h workday and a 40-h workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effects. A ceiling value (TLV-C) is the concentration that should not be exceeded during any part of the working exposure. If instantaneous monitoring is not feasible, then the TLV-C can be assessed by sampling over a 15-min period except for those substances that may cause immediate irritation when exposures are short. As some people become ill after exposure to concentrations lower than the exposure limits, this value cannot be used to define exactly what is a "safe" or "dangerous" concentration. ACGIH threshold limit values (TLVs) are reprinted with permission of the American Conference of Governmental Industrial Hygienists, Inc., from the booklet entitled, *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.* This booklet is revised on an annual basis. No entry appears when the chemical is a mixture; it is possible to calculate the TLV for a mixture only when the TLV for each component of the mixture is known and the composition of the mixture by weight is also known. According to ACGIH, "Documentation of the Threshold Limit Values and Biological Exposure Indices, 7th Edition" is necessary to fully interpret and implement the TLVs.

OSHA Permissible Exposure Limits (PELs) are found in Tables Z-1, Z-2, and Z-3 of OSHA, "General Industry Air Contaminants Standard (29CFR1910.1000)" that were effective on July 1, 2001 and which are currently enforced by OSHA.

Unless otherwise noted, PELs are the Time-Weighted Average (TWA) concentrations that must not be exceeded during any 8-h shift of a 40-h workweek. An OSHA ceiling concentration must not be exceeded during any part of the workday; if instantaneous monitoring is not feasible, the ceiling must be assessed as a 15-min TWA exposure. In addition, there are a number of substances from Table Z-2 that have PEL ceiling values that must not be exceeded except for a maximum peak over a specified period (e.g., a 5-min maximum peak in any 2 h).

NIOSH Recommended Exposure Limits (RELs) are Time-Weighted Average (TWA) concentrations for up to a 10-h workday during a 40-h workweek. A ceiling REL should not be exceeded at any time. Exposure limits are usually expressed in units of parts per million (ppm), i.e., the parts of vapor (gas) per million parts of contaminated air by volume at 25°C/77°F and one atmosphere pressure. For a chemical that forms a fine mist or dust, the concentration is given in milligrams per cubic meter (mg/m^3).

Protective Action Criteria (PAC) are emergency exposure limits developed by the US Department of Energy (DOE) for 3388 chemicals in revision 26, published September 2010. These exposure limits can be used to estimate the consequences of the uncontrolled release of hazardous materials and to plan for emergency response. These PACs have been added to the 6th edition of Sittig because other well-established exposure limits in air are available for only a limited number of chemicals from other governmental and advisory sources. PAC values are given in parts per million (ppm) for volatile liquids and gases; in milligrams per cubic meter (mg/m^3) for solids, particulates, and nonvolatile liquids. Chemicals for which TEELs (Temporary Emergency Exposure Limits) are available have their values displayed using a regular (non-bold) font. Chemicals for which Acute Emergency Guideline Levels (AEGLs) and Emergency Response Planning Guidelines (ERPGs) have their values displayed in **bold** font. TEELs are intended for use until AEGLs or ERPGs are adopted for chemicals.

PAC Definitions:[SCAPA]

There are subtle difference in the definitions of AEGLs, ERPGs, and TEELs and major differences in how they are developed and issued. Differences in their definitions include: AEGLs pertain to the "general population, including susceptible individuals," but ERPGs and TEELs pertain to "nearly all individuals."

AEGLs are defined as the level "above which" certain health effects are expected, while ERPGs and TEELs are defined as the level "below which" certain health effects are not expected.

Acute Emergency Guideline Levels (AEGLs) are defined as follows:

- *AEGL-1:* the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, nonsensory effects. However, these effects are not disabling and are transient and reversible upon cessation of exposure.
- *AEGL-2:* the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- *AEGL-3:* the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.

Emergency Response Planning Guidelines (ERPGs) are defined as follows:

- *ERPG-1*: the maximum concentration in air below which it is believed nearly all individuals could be exposed for up to 1 h without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
- *ERPG-2*: the maximum concentration in air below which it is believed nearly all individuals could be exposed for up to 1 h without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
- *ERPG-3*: the maximum concentration in air below which it is believed nearly all individuals could be exposed for up to 1 h without experiencing or developing life-threatening health effects.

Temporary Emergency Exposure Limits (TEELs) are defined as follows:

- *TEEL-0*: the threshold concentration below which most people will experience no adverse health effects.
- *TEEL-1:* the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, nonsensory effects. However, these effects are not disabling and are transient and reversible upon cessation of exposure.
- *TEEL-2:* the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- *TEEL-3:* the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening adverse health effects or death.
- TEELs are intended for use until AEGLs or ERPGs are adopted for chemicals.

Additional information on PAC values, TEEL values, and links to other sources of information can be found on the webpage for the *Subcommittee for Consequence Assessment and Protective Action (SCAPA)*: http://orise.orau.gov/emi/scapa/teels.htm

The German MAK (DFG MAK) values are conceived and applied as 8-h time-weighted average (TWA) values.[3]

Short-Term Exposure Limits (15-min TWA): This field contains Short-Term Exposure Limits (STELs) from ACGIH, NIOSH, and OSHA. The parts of vapor (gas) per million parts of contaminated air by volume at 25°C/77°F and one atmosphere pressure is given. The limits are given in milligrams per cubic meter (mg/m^3) for chemicals that can form a fine mist or dust. Unless otherwise specified, the STEL is a 15-min TWA exposure that should not be exceeded at any time during the workday.

Determination in Air: The citations to analytical methods are drawn from various sources, such as the *NIOSH Manual of Analytical Methods.*[18] In addition, methods have been cited in the latest US Department of Health and Human Services publications including the *"NIOSH Pocket Guide to Chemical Hazards"* August, 2006.

Permissible Concentrations in Water: The permissible concentrations in water are drawn from various sources also, including: The National Academy of Sciences/National Research Council, Safe Drinking Water Committee Board on Toxicology and Environmental Health Hazards, *Drinking Water and Health,* 1980.[16]

The priority toxic pollutant criteria published by US EPA 1980.[6]

The multimedia environmental goals for environmental assessment study conducted by EPA.[32] Values are cited from this source when not available from other sources.

The US EPA has come forth with a variety of allowable concentration levels:

For allowable concentrations in "California List" wastes.[38] The California List consists of liquid hazardous wastes containing certain metals, free cyanides, polychlorinated biphenyls (PCBs), corrosives with a pH of less than or equal to 2.0, and liquid and nonliquid hazardous wastes containing halogenated organic compounds (HOCs).

For regulatory levels in leachates from landfills.[37]

For concentrations of various materials in effluents from the organic chemicals and plastics and synthetic fiber industries.[51]

For contaminants in drinking water.[36]

For National Primary and Secondary Drinking Water Regulations.[62]

In the form of health advisories for 16 pesticides,[47] 25 organics,[48] and 7 inorganics.[49]

For primary drinking water standards starting with a priority list of 8 Volatile Organic Chemicals.[40]

State drinking water standards and guidelines[61] as assembled by the US EPA.

Determination in Water: The sources of information in this field have been primarily US EPA publications including the test procedures for priority pollutant analysis[25] and later modifications.[42]

Routes of Entry: The toxicologically important routes of entry of each substance are listed. In other words, the way in which the people or experimental animals were exposed to the chemical is listed, e.g., eye contact, skin contact, inhalation, intraperitoneal, intravenous. Many of these are taken from the *NIOSH Pocket Guide,*[2] but are drawn from other sources as well.

Harmful Effects and Symptoms: These are primarily drawn from NIOSH, EPA publications, and New Jersey and New York State fact sheets on individual chemicals, and are supplemented from information from the draft criteria documents for priority toxic pollutants[26] and from other sources. The other sources include:

EPA Chemical Hazard Information Profiles (CHIPS) cited under individual entries.

NIOSH Information Profiles cited under individual entries.

EPA Health and Environmental Effect Profiles cited under individual entries.

Particular attention has been paid to cancer as a "harmful effect" and special effort has been expended to include the latest data on carcinogenicity. See also "Regulatory Authority and Advisory Bodies" section.

Short Term Exposure: These are brief descriptions of the effects observed in humans when the vapor (gas) is inhaled, when the liquid or solid is ingested (swallowed), and when the liquid or solid comes in contact with the eyes or skin. The term LD_{50} signifies that about 50% of the animals given the specified dose by mouth will die. Thus, for a Grade 4 chemical (below 50 mg/kg), the toxic dose for 50% of animals weighing 70 kg (150 lb) is $70 \times 50 = 3500$ mg = 3.5 g, or less than 1 teaspoonful; it might be as little as a few drops. For a Grade 1 chemical (5–15 g/kg), the LD_{50} would be between a pint and a quart for a 150-lb man. All LD_{50} values have been obtained using small laboratory animals such as rodents, cats, and dogs. The substantial risks taken in using these values for estimating human toxicity are the same as those taken when new drugs are administered to humans for the first time.

Long Term Exposure: Where there is evidence that the chemical can cause cancer, mutagenic effects, teratogenic effects, or a delayed injury to vital organs such as the liver or kidney, a description of the effect is given.

Points of Attack: This category is based, in part, on the "Target Organs" in the *NIOSH Pocket Guide*[2] but the title has been changed as many of the points of attack are not organs (e.g., blood). This is human data unless otherwise noted.

Medical Surveillance: This information is often drawn from a NIOSH publication[27] but also from *New Jersey State Fact Sheets*[70] on individual chemicals. Where additional information is desired in areas of diagnosis, treatment, and medical control, the reader is referred to a private publication[28] which is adapted from the products of the NIOSH Standards Completion Program.

First Aid: Guides and guidance to first aid found in this work should not be construed as authorization to emergency personnel to perform the procedures or activities indicated or implied. Care of persons exposed to toxic chemicals must be directed by a physician or other recognized professional or authority. Simple first aid procedures are listed for response to eye contact, skin contact, inhalation, and ingestion of the toxic substance as drawn to a large extent from the *NIOSH Pocket Guide*[2] but supplemented by information from recent commercially available volumes in the United States,[29] in the United Kingdom, and in Japan[24] as well as from state fact sheets. They deal with exposure to the vapor (gas), liquid, or solid and include inhalation, ingestion (swallowing), and contact with eyes or skin. The instruction "Do NOT induce vomiting" is given if an unusual hazard is associated with the chemical being sucked into the lungs (aspiration) while the patient is vomiting.

"*Seek medical attention*" or "*Call a doctor*" is recommended in those cases where only competent medical personnel can treat the injury properly. In all cases of human exposure, seek medical assistance as soon as possible. In many cases, medical advice has been included for guidance only.

Personal Protective Methods: This information is drawn heavily from NIOSH publications[2, 77] and supplemented by information from the United States,[29] the United Kingdom, and Japan.[24] There are indeed other "personal protective methods" which space limitations prohibit describing here in full. One of these involves limiting the quantities of carcinogens to which a worker is exposed in the laboratory. The items listed are those recommended by (a) NIOSH and/or OSHA, (b) manufacturers, either in technical bulletins or in material safety data sheets (MSDS), (c) the Chemical Manufacturers Association (CMA), or (d) the National Safety Council (NSC), for use by personnel while responding to fire or accidental discharge of the chemical. They are intended to protect the lungs, eyes, and skin.

Respirator Selection: The 6th edition, like its predecessors, presents respirator selection with a full text description. For each line a maximum use concentration (in ppm, mg/m^3, $\mu g/m^3$, $fibers/m^3$, or mppcf) condition (e.g., escape) followed by the NIOSH code and full text related to respirator recommendations. All recommended respirators of a given class can be utilized at any concentration equal to or less than the class's listed maximum use concentration. Respirator selection should follow recommendations that provide the greatest degree of protection. Respirator codes found in the *NIOSH Pocket Guide* have been included to ease updating.

All respirators selected must be approved by NIOSH under the provisions of 42CFR84. The current listing of NIOSH/MSHA-certified respirators can be found in the *NIOSH Certified Equipment List*, which is available on www.cdc.gov/niosh/npptl/topics/respirators/cel (NIOSH Web site).

For firefighting, only self-contained breathing apparatuses with full facepieces operated in pressure-demand or other positive-pressure modes are recommended for all chemicals in the *NIOSH Pocket Guide*. In the case of chemical warfare agents, use only SCBA Respirator certified by NIOSH for CBRN environments. CBRN stands for "Chemical, Biological, Radiological, and Nuclear."

Pesticides are not identified as such in the respirator selection tables. For those substances that are pesticides, the recommended air-purifying respirator must be specifically approved by NIOSH/MSHA. Specific information on choosing the appropriate respirator will be provided on pesticide labels. Approved respirators will carry a "TC" number prefix, which signifies they have been tested and certified for a specific level of protection. New respirators may carry a "TC-84A" prefix in compliance with 42CFR84 for testing and certifying nonpowered, air-purifying, particulate-filter respirators. The new Part 84 respirators have passed a more demanding certification test than the old respirators (e.g., dust and mist [DM], dust, fume, and mist [DFM], spray paint, and pesticide) certified under 30CFR11. Additionally, a complete respirator protection program should be implemented including all requirements in 29CFR1910.134 and 42CFR84. At a minimum, a respirator protection program should include regular training, fit-testing, periodic environmental monitoring, maintenance inspection, and cleaning. The selection of the actual respirator to be used within the classes of recommended respirators depends on the particular use situation, and should only be made by a knowledgeable person. Remember, air-purifying respirators will not protect from oxygen-deficient atmospheres. For firefighting, only self-contained breathing apparatuses with full facepieces operated in pressure-demand or other positive-pressure modes are recommended for all chemicals in the *NIOSH Pocket Guide*.

Storage: The 6th edition now provides, as general guidance, a color-coded classification system similar to those often found in commerce and laboratories. It is the objective of any chemical storage classification system to prevent accidental combination of two or more incompatible materials that might be stored in the same space. To prevent an unwanted and possibly dangerous reaction, chemicals must be separated by space and/or physical barriers. Chemical storage areas should be appropriately labeled. Users must be careful to check the MSDS for both additional and specific information. Some chemical entries contain multiple storage codes because the chemical profile fits more than a single category.

Code	***Hazard***
Red	Flammables (flash point $<100°F$)
Blue	Health hazards/toxics/poisons
Yellow	Reactives/oxidizers
White	Contact hazards
Green*	General storage

*For general storage, the colors Gray and Orange are also used by some companies.

- Chemical containers that are not color coded should contain hazard information on the label.
- Check the MSDS to learn what personal protective equipment is required when using the substance
- *Red*: Flammability Hazard: Store in a flammable (liquid or materials) storage area or approved cabinet away from ignition sources and corrosive and reactive materials.
- *Blue*: Health Hazard/Toxics/Poisons: Store in a secure poison location.
- *Yellow*: Reactive Hazard; Store in a location separate from other materials, especially flammables and combustibles.
- *White*: Corrosive or Contact Hazard; Store separately in a corrosion-resistant location.
- *Green (or Gray or Orange)*: General storage may be used. Generally, for flammability, health, and corrosivity with an NFPA rating of no higher than "2."