TOWN OF MILLIKEN
TOWN BOARD
AGENDA MEMORANDUM

To: Mayor Tokunaga and Board of Trustees From: Martha Perkins, Community Development Director Via: Kent Brown, Town Administrator			Public Hearing Date: March 09, 2016
Agenda Item #	Action: x	Discussion:	Information:
Agenda Title: Possible Approval of Ordinance 723 "An Ordinance of the Town of Milliken Amending Sections 16-1-150 and 16-3-620 of Chapter 16, of the Milliken Municipal Code Concerning Home Occupations".			
Attachments: Ordinance 723 U.S. Department of Labor OSHA Guidance for Hazard Determination			
Staff Recommendation: Staff recommends that the Board deny the passage of Ordinance 723.			

PURPOSE

To consider and approve Ordinance 723 "An Ordinance of the Town of Milliken Amending Sections 16-1-150 and 16-3-620 of Chapter 16, of the Milliken Municipal Code Concerning Home Occupations". The Town Board and the Commission obtained public input at a joint work session with the Town Board on January 20, 2016. The Town Board requested a continuation of the public hearing at their meeting on February 10, 2016 to March 9, 2016 at 7:00 p.m. to allow more time to review staff's proposed text changes and obtain additional public input.

Meanwhile, the Commission held a public hearing on February 17, 2016 and voted to deny the passage of Ordinance 723 based on the testimony, findings of fact, and the documents presented. Thus, the Board has three options at this hearing: approve Ordinance 723 with or without modifications, deny the passage of the Ordinance, or continue the hearing to a date and time certain.

BACKGROUND INFORMATION

Type of Application:	Text Amendment
Location:	Milliken Colorado in Weld County
Applicant:	Town Of Milliken
Comprehensive Plan	Supports the Envision Milliken Comprehensive Plan by balancing the protection of residential neighborhoods with the need to encourage more small businesses.
Notice	The public hearing was noticed/published in the *Johnstown Breeze* on November 26, 2015. Referrals were sent on December 1, 2015. The Planning Commission met on December 16, 2015 and continued the public hearing to 7:00 pm on February 3, 2016 with a request for a joint work

session with the Town Board. The Town Board and Commission met on January 20, 2016 in a work session open to the public. On February 3, 2016, the Commission asked to continue the public hearing to February 17, 2016 at 7:00 pm to provide them and the public additional time for review. The Town Board met on February 10, 2016 and continued the public hearing to March 9, 2016.

COMPLIANCE WITH TOWN LAND USE CODE

On December 16, 2015, the Planning & Zoning Commission opened the public hearing on Ordinance 723 to review staff's code changes to the Land Use Code relating to home occupations. After opening the public hearing, the Commission requested a joint work session with the Town Board to find out how the Board envisions creating a balance between protecting and maintaining the character of residential neighborhoods with commercial activities in these residential neighborhoods.

The Town Board and the Planning Commission met on January 20, 2016 in legislative work session open to the public. After that joint work session, staff revised Ordinance 723 to address the Board's and the Commission's comments during the work session.

On February 3, 2016, this revised Ordinance was presented to the Commission. The Commission voiced concern about the proposed Ordinance's restrictions on home occupations, which may affect existing resident's/business owner's livelihoods. The Commission asserted that as long as the home occupations do not affect their immediate neighbors and fit into the general character of the neighborhood, then they should be allowed to operate. The fear is that if the Town makes the code too rigorous, then no one will register their business with the Town and/or may even leave Town. Several Commission members asked for more time to review and think about the proposed text changes in Ordinance 723. The Commission voted to continue the public hearing to February 17, 2016 at 7:00 pm. On February 17, 2016, staff recommended that the Commission deny the application and allow staff additional time to revise the ordinance based on additional public comment, before resubmitting the application and legally re-advertising it.

On February 10, 2016, the Board met on Ordinance 723 too. The Board opened the public hearing, and continued the public hearing to March 9, 2016. The Board's comments echoed the Commission's concerns with the proposed Ordinance 723. Quite a few of the Board members thought that additional definitions were needed, cross-references to other sections needed to be made, and some of the less enforceable requirements deleted such as home occupations shall not exceed 30% of the total square footage of the building. The Board did not want to duplicate the Town's noise ordinance or other sections of the land use code in the home occupation section of the code. One Trustee suggested having a work session with home occupation business owners and other interested community members to discuss their concerns and create better provisions for obtaining a balance between operating a business in a residential neighborhood while protecting and maintaining the residential neighborhood's character.

Trustee Kidd also suggested using the definition of hazardous materials from Chapter 7 of the Town's Municipal Code as part of the public's discussion on the ordinance. Additionally, staff pulled an Occupational Safety & Health Administration (OHSA) Hazard Determination Guidance document for the Commission and Board to review.

This staff report is prepared using the original proposed Ordinance 723 and the Land Use Code's criteria for text amendments or code changes. Staff waited to make any additional changes to the Ordinance until the Board formally met and decided how to proceed, whether it be text changes to the Ordinance, meeting with community members on possible changes to the existing home occupation text, rewriting the proposed text, and/or legally noticing and hearing the text amendment later as a new application. This is a difficult ordinance to write and implement without possibly having a large impact on the Town's character. Changes to the text can be made once the Town decides what they want to enforce.

Staff compiled the most relevant sections of the Code for the Town Board's review of the application. The applicable Code sections are included at the end of the staff report to enable a Board Trustee to look up sections of the Code and still be able to read through staff's review of the case.

REVIEW CRITERIA

The Land Use Code contains four criteria for amendments to Text Amendments to the Zoning Code (Section 16-3-540), which are intended to establish and maintain sound, stable and desirable development within the Town. These are four criteria are:

(1) To correct a manifest error in the text of this Article;

The current Code is not in error. The Board would just like to clarify what is allowed as a home occupation. After a joint work session with the Town Board and the Planning Commission on January 20, 2016, it became apparent to staff that the Board and the Commission would like to allow additional opportunities for commercial enterprises on residential property as an accessory use without creating a negative impact on neighboring residents.

(2) To provide for changes in administrative practices as may be necessary to accommodate changing needs of the community and the Town Staff;

The Town Board and the Planning Commission wish to amend the Municipal Code home occupation regulations to strike a better balance between the goal of protecting and maintaining the character of residential neighborhoods with residents' need to engage in limited commercial activities in their homes to supplement their incomes and/or try out new business ideas. A text amendment is necessary to accommodate the changing needs of the community, which would allow more entrepreneurial opportunities as an accessory use on residential property. This issue came before the Board due to the Town retaining a Code Enforcement Officer to enforce various sections of the Municipal Code, including home occupations.

(3) To accommodate innovations in land use and development practices that were not contemplated at the adoption of this Article; or

With the adoption of a 2016 Comprehensive Plan and mixed-use zoning proposed for downtown area, staff believes that the community is beginning to embrace the idea that business endeavors may work as an accessory use in residential neighborhoods. The community seems to be more interested in allowing additional small scale business enterprises and mixing uses in one zoning district. These smaller home occupations and businesses will allow additional local economic development in Milliken.

(4) To further the implementation of the goals and objectives of the Comprehensive Plan.

The 2016 Envision Milliken Comprehensive Plan promotes the idea that existing and future residents should be able to live, work, and recreate here. Residents should have access to a range of housing opportunities, complemented with commercial and employment opportunities. The Town does not want to remain a bedroom community. It wants to be a family-oriented, small town community with access to multiple services and amenities.

The Comprehensive Plan recognizes the significant contribution of existing businesses within the community. The Town should support the retention, expansion and entrepreneurial activities of existing local businesses to maintain a positive business environment.

In summary, the Town Board would like to amend the existing regulations governing the operation of home occupations in the Town's Municipal Land Use Code, Section 16-3-620 "Home Occupations", to balance the goal of protecting and maintaining the character of residential neighborhoods with the desire to allow additional commercial activities as an accessory use on residential property. This goal is not easy to implement.

The Commission recommended denying this application and resubmitting a new one, after staff obtains additional public input regarding what to enforce and not enforce. The code change may affect existing resident's/business owner's livelihoods. In addition, the community is electing a new Board in April and the new Board should hear and approve this code change. Thus, the Commission is requesting a new text amendment for a code change or a text amendment after staff and the Board seek additional public input on this topic.

FINDINGS OF FACT

1. The Board of Trustees of the Town of Milliken has the power to adopt zoning regulations pursuant to Section 31-23-301, *et seq.*, C.R.S., and the general ordinance powers conferred by Section 31-15-103, C.R.S.
2. The Board of Trustees previously enacted regulations governing the operation of home occupations in residentially zoned areas of the Town as codified in Section 16-3-620 of the Municipal Code.
3. The Town Board desires to amend its home occupation standards to best strike a balance between the goal of protecting and maintaining the character of residential neighborhoods with the need for residents to engage in limited commercial activities in their homes to supplement incomes, explore new business endeavors, and provide the community with additional local goods and services.

STAFF RECOMMENDATION

Staff recommends that the Town Board deny the passage of this ordinance until the proposed text amendment has been revised and vetted with the public. It can be resubmitted as a new home occupation text amendment application when it ready for possible adoption.

TOWN BOARD APPROVAL

_____The Town Board of Trustees after hearing testimony, examination of the documents presented and the findings of fact finds the application MEETS the provisions of Sections et. seq. of the Town of Milliken's Land Use Development Code (LUDC) and APPROVES Ordinance 723 "An Ordinance of the Town of Milliken Amending Sections 16-1-150 and 16-3-620 of Chapter 16, of the Milliken Municipal Code Concerning Home Occupations" in Weld County Colorado.

or:

_____The Board of Trustees after hearing testimony, examination of the documents presented and the findings of fact finds the application MEETS the provisions of Sections et. seq. of the Town of Milliken's Land Use Development Code (LUDC) and APPROVES Ordinance 723 "An Ordinance of the Town of Milliken Amending Sections 16-1-150 and 16-3-620 of Chapter 16, of the Milliken Municipal Code Concerning Home Occupations" in Weld County Colorado with the following changes:

1.
2.
3.

or:

_____The Board of Trustees after hearing testimony, examination of the documents presented and the findings of fact CONTINUES the Public Hearing on Ordinance 723 "An Ordinance of the Town of Milliken Amending Sections 16-1-150 and 16-3-620 of Chapter 16, of the Milliken Municipal Code Concerning Home Occupations" in Weld County Colorado to _____, 2016 at 7:00 p.m. to facilitate additional public input and discussion with a revision in the proposed text.

or:

_____The Board of Trustees after hearing testimony, examination of the documents presented and the findings of fact finds the application DOES NOT MEET the provisions of Sections et. seq. of the Town of Milliken's Land Use Development Code (LUDC) and DENIES Ordinance 723 "An Ordinance of the Town of Milliken Amending Sections 16-1-150 and 16-3-620 of Chapter 16, of the Milliken Municipal Code Concerning Home Occupations" in Weld County Colorado.

CHAPTER 6 – BUSINESS LICENSES AND REGISTRATIONS

Sec. 6-1-10. - Definitions.

As used in this Article, the following terms shall have the meanings indicated:

Business includes all types of vocations, occupations, professions, enterprises, establishments and all other kinds of activities and matters, together with all devices, machines, vehicles and other appurtenances used therein, any of which are conducted by persons or entities not exempt as nonprofit organizations, either directly or indirectly, on any premises in the Town or anywhere else within its jurisdiction.

Doing business means an act of one (1) of the following:

a. Selling at retail any goods or service;
b. Soliciting or offering goods or services for retail sale or hire; or
c. Acquiring or using any vehicle or any premises in the Town for business purposes.

Nonprofit organizations shall be limited to: political subdivisions of the federal and state governments; and organizations which have obtained tax-exempt status under Code Section 501 from the Internal Revenue Service.

Premises includes all lands, structures, places and also the equipment and appurtenances connected or used therewith in any business, and also any personal property which is either affixed to or is otherwise used in connection with any business conducted on such premises. (Ord. 282 §§1, 4, 1991; Ord. 481 §1, 2003)

Sec. 6-1-20. - License required.

(a) It shall be unlawful for any person to conduct, engage in or carry on any business within the Town without first having complied with the provisions of this Article unless licensed pursuant to Article III of this Chapter and registered as is herein provided. A violation of any section shall be unlawful and shall be punished in accordance with the provisions of Section 1-4-20 of this Code.

(b) The carrying on of any business, profession, vocation or occupation by any person as provided in this Article, without first having procured a registration from the Town to do so, or without complying with any and all regulations of such business, profession, vocation or occupation contained in this Article, shall be deemed a separate violation of this Article for each and every day that such business profession, vocation or occupation is carried on. (Ord. 282 §2, 1991; Ord. 481 §1, 2003)

Sec. 6-1-30. - Persons subject to registration.

Registration is required for the maintenance, operation or conduct of any business or establishment or for conducting or engaging in any business activity or occupation. A person shall be subject to the requirement if, by himself or herself or through an agent, employee or partner, he or she holds himself or herself forth as being engaged in the business or occupation, solicits patronage therefor, either actively or passively, or performs or attempts to perform any part of such business or occupation in the Town. Building contractors are not subject to registration under this Article. When building contractors are registered through the provisions of Article IV of this Chapter, they shall also be registered as a business. (Ord. 685 §1, 2013)

Sec. 6-1-40. - Doing business in multiple locations.
Every person who is the principal or majority owner of a business operating more than one (1) store, stand or other place of business shall register each place of business. (Ord. 282 §5, 1991; Ord. 481 §1, 2003)

Sec. 6-1-50. - Application for registration.
(a) Application for all registrations required by this Article shall be made in writing to the Town.
(b) Each application shall contain the following information:
  (1) The name under which each business is to be conducted.
  (2) The name, address and date of birth of the applicant. (If a corporation, the names, addresses and dates of birth of the president, vice president, treasurer, secretary and majority shareholders; if a partnership, the names, addresses and dates of birth of a minimum of four [4] principal partners).
  (3) The present residence of the applicant as listed in Paragraph (2) above and the persons managing the business.
  (4) The address of the premises on which the business is to be conducted.
  (5) The nature of the business and whether it will use or store significant amounts of flammable, toxic or corrosive substances.
  (6) The residence of the applicant during the past five (5) years, if an individual; if a partnership, such addresses for a minimum of four (4) principal partners.
  (7) Whether the applicant has ever been denied or had revoked a license to conduct any business and, if so, a notation as to the circumstances.
  (8) Details of any arrests or convictions within the last five (5) years for misdemeanors and felonies (no traffic offenses for which fewer than seven [7] points are assessed), including the nature of the offense for which arrested or convicted, the date of conviction and the place where said conviction was obtained.
  (9) The business telephone number of the applicant and at least one (1) emergency phone number.
  (10) The name and address of the applicant's attorney (optional).
  (11) The name and address of the registered agent, if the applicant is a corporation.
  (12) An irrevocable appointment of the Town Clerk as an agent to accept service of process upon the business. (Ord. 282 §6, 1991)

Sec. 6-1-60. - Registration and application forms.
Forms for all registration and applications therefor shall be prepared and kept on file by the Town Clerk. (Ord. 282 §7, 1991)

Sec. 6-1-70. - Issuance of registrations.
All registrations issued under this Article shall be issued by the Town Clerk upon payment of the proper fees herein set forth, provided that where the approval of any department of state, county or Town government is required, or the execution and delivery of any bonds or insurance is required, said approval or execution and delivery must be received in writing by the Town Clerk before the registrations shall be issued. (Ord. 282 §8, 1991)

Sec. 6-1-80. - Investigations.
(a) Upon receipt of an application for a registration, the Town Clerk shall refer such application to the proper governmental officials for appropriate investigation or inspection, if any.
(b) The officials charged with the duty of making the investigation or inspection shall make a report thereon to the Town Clerk, favorably or otherwise, not more than fourteen (14) days

after receiving the application or copy thereof. No registration shall be issued for conduct of any business, and no permit shall be issued for any thing or act, if the premises and building to be used for the purpose do not fully comply with the applicable regulations and ordinances of the Town. If the registration is not granted within fourteen (14) days and no specific reasons for denial have been given to the applicant in writing, the Town Clerk shall issue the registration.

(c) The applicant may request and have issued a fourteen-day interim registration twenty-four (24) hours after completion of the application it the Town Administrator first determines that there will be no danger to the health, safety and welfare of the Town or its citizens. (Ord. 282 §9, 1991)

Sec. 6-1-90. - Grounds for denial of registration.

The Town shall examine the qualifications of any applicant for a license or renewal thereof and shall have the authority to deny the issuance or renewal thereof for the following reasons:

(1) The applicant has not complied with the general laws and statutes of the state or the ordinances of the Town in the application process.

(2) Approval by a governmental official or department is required and said approval has been denied because of concerns with regard to the character of the applicant, the owner or the management; or the business has failed to comply with the requirements of the applicable statutes, ordinances and codes.

(3) Refusal by the Town to register the business shall entitle the applicant business to a public hearing before the Board of Trustees. The hearing shall be requested in writing by the applicant within seven (7) days from the date of denial and shall be held at the next regularly scheduled meeting of the Board of Trustees. (Ord. 282 §10, 1991)

Sec. 6-1-100. - Transferability.

Except where otherwise specifically provided, no registration issued hereunder shall be transferable, except where permitted by state law or the provisions of an ordinance relating to the particular registration, and then only by the Town Clerk after written application therefor and the payment of a fee for the transfer of such license. Such fee shall be in accordance with the fee schedule of the Town. (Ord. 282 §11, 1991)

Sec. 6-1-110. - Expiration of registration.

All registrations hereunder shall expire on December 31 of the year issued. (Ord. 282 §12, 1991; Ord. 481 §, 2003)

Sec. 6-1-120. - Renewals; penalty for nonrenewal.

Any registrant may make application for a new registration for the succeeding year and pay the required fee therefor on or before the expiration date of any registration issued to him or her for the current year. Whenever any application and registration fee payment therefor is not received on or before the expiration date of any registration issued for the current year and the registrant continues to engage in the business activity for which the registration was issued, a penalty of twenty dollars ($20.00) shall be imposed and collected. In addition to the above penalty provision, it shall be unlawful for a registrant to continue to engage in any business or activity after his or her registration therefor has expired, and the general penalty provision of the Code shall apply hereto. (Ord. 282 §13, 1991; Ord. 481 §, 2003)

Sec. 6-1-130. - Posting of registration.

Registrations issued under this Article shall be posted at the place of business shown on said registration, in a conspicuous place. Said registration shall remain posted for the duration of the

registering year when issued and so long as the registered business is in operation. (Ord. 282 §14, 1991)

Sec. 6-1-140. - Record of registrations.

The Town shall keep a record of all registrations issued, setting forth the name of every registrant, the place of business registered, if any, the kind of registration issued and such other information as may be required by the Town Attorney or the Board of Trustees. (Ord. 282 §15, 1991)

Sec. 6-1-150. - Exempt activities.

(a) The provisions of this Article shall not require payment of a fee for registration to conduct, manage or carry on any activity of a nonprofit organization which would qualify as a business if conducted by other than a nonprofit person or entity. No registration fee shall be required for the conducting of any entertainment, dance, concert, exhibition or lecture by a nonprofit organization.

(b) No registration shall be required of any person for any mere delivery in the Town where no intent by such person is shown to exist to evade the provisions of this Article.

(c) No registration shall be required for an individual or incidental transaction which in itself does not constitute the carrying on of business.

(d) It shall be unlawful to conduct any business from any location in the Town from a site other than a permanent structure located on real property within the Town. Businesses and individuals which operate on a temporary basis, such as yard sales, which are conducted not more than two (2) days per calendar month or are conducted in conjunction with a public event, such as Milliken Beef and Bean Day, a public parade, craft show or concert, are exempt. Whenever food is being served, there must be a restroom and hand-washing facility provided by or available to the persons or entities selling the food. (Ord. 282 §16, 1991; Ord. 496 §1, 2004)

Sec. 6-1-160. - Revocation of registration.

(a) Registrations issued under the provisions of this Article may be revoked upon seven (7) days' notice by the Board of Trustees, in writing, for any of the following reasons:
   (1) Fraud, misrepresentation or false statement contained in the application for license or committed or made in the course of conducting the business licensed.
   (2) Any violation of this Article or failure to provide any information or pay the fees required by this Article.
   (3) Conviction of any crime involving fraud or deception by the owner, management or employees of the business.
   (4) Conducting the registered business in an unlawful manner or in such a manner as to constitute a breach of peace or a menace to the health, safety or general welfare of the public.
   (5) The existence of any fact or condition which, if it had been made known to the Town Clerk at the time of the application for such registration, would have warranted the refusal of the issuance of such registration.

(b) The registrant may not operate the business or enterprise registered during the pendency of said appeal.

(c) The appeal shall be conducted as set forth in Section 6-1-90(3) above. (Ord. 282 §17, 1991; Ord. 481 §, 2003)

Sec. 6-1-170. - Fees.

(a) In the absence of provisions to the contrary, the fee and charge for registration shall be paid in advance at the time application therefor is made to the Town. The amount of such fee shall be established by resolution at any regularly scheduled board meeting after notice has been published once at least seven (7) days prior to the meeting.

(b) Where the registrant is engaged in more than one (1) activity as enumerated in this Article at the same location, which may be subject to more than one (1) fee, said registrant shall be required to pay that fee charged for the activity assessed the highest fee.

(c) The fee herein imposed for business registrations is used to cover the costs of inspections of such businesses to ensure compliance with the ordinances of the Town. This registration procedure is intended to provide the residents of the Town with a source of information regarding the businesses within the Town. In certain instances, there are those businesses which warrant additional police surveillance and inspection. There are those businesses which attract unusual amounts of vehicular traffic, necessitating additional regulation and enforcement. These fee provides a reasonable relationship to the costs of regulation and administration. (Ord. 282 §18, 1991; Ord. 481 §1, 2003)

Sec. 6-1-180. - Violation and penalties.

The conviction and punishment of any person for transacting any business without a registration shall not excuse or exempt such person from the payment of such registration fee due or unpaid at the time of such conviction. Nothing in this Section shall prevent a criminal prosecution for any violation of the provisions of this Article. (Ord. 282 §19, 1991)

CHAPTER 7 – HEALTH, SANITATION AND ANIMALS

Sec. 7-1-10. - Definitions.

For the purpose of this Chapter, the following words shall have the following meanings, unless the context indicates otherwise:

Hazardous materials includes but shall not be limited to hot ashes, hot coals, radioactive material, explosive substances, chemical waste, flammable material and other similar substances.

CHAPTER 16 – LAND USE CODE

Sec. 16-1-50. Purpose.

The purpose of this Code is to create a vital, cohesive, well-designed community in order to enhance the Town of Milliken's character and further the citizens' goals as identified in the Comprehensive Plan. This Code is designed to:

(1) Encourage the most appropriate use of land through the Town;
(2) Encourage innovative, quality site design, architecture and landscaping;
(3) Encourage new developments to relate to Milliken's historic development pattern;
(4) Promote compact, well-defined, sustainable neighborhoods that enhance Milliken's character;
(5) Create livable neighborhoods that foster a sense of community and reduce dependency on private vehicles;
(6) Encourage the proper arrangement of streets in relation to existing and planned streets and ensure that streets facilitate safe, efficient and pleasant walking, biking and driving;
(7) Provide a variety of lot sizes and housing types in every neighborhood;
(8) Protect sensitive natural and historic areas and Milliken's environmental quality;
(9) Integrate a high-quality natural environment into the developed portions of the community;

(10) Facilitate the adequate and efficient provision of transportation, water, sewage, schools, parks and other public requirements;
(11) Provide protection from geologic, flood and fire hazards and other dangers; and
(12) Promote the health, safety, morals and general welfare of Milliken residents. (Ord. 480 §1.5, 2003)

Sec. 16-1-60. Interpretation.
In their interpretation and application, the provisions of this Code shall be held to be minimum requirements for the promotion of the public health, safety and welfare. Whenever the requirements of this Code are at variance with the requirements of any other lawfully adopted rules, regulations or ordinances, the more restrictive or that imposing the higher standards shall govern. (Ord. 480 §1.6, 2003)

Sec. 16-1-70. Applicability of Article.
(a) The provisions of this Code shall apply to any and all development of land within the municipal boundaries of the Town, unless expressly and specifically exempted or provided otherwise in this Code. No development shall be undertaken without prior and proper approval or authorization pursuant to the terms of this Code. All development shall comply with the applicable terms, conditions, requirements, standards and procedures established in this Code.
(b) Except as herein provided, no building, structure or land shall be used and no building or structure or part thereof shall be erected, constructed, reconstructed, altered, repaired, moved or structurally altered except in conformance with the regulations herein specified for the zone district in which it is located, nor shall a yard, lot or open space be reduced in dimensions or area to an amount less than the minimum requirements set forth herein.
(c) Whenever both the provisions of this Code and provisions of any other law cover the same subject matter, whichever rule is more restrictive shall govern. This Code establishes procedural and substantive rules for obtaining the necessary approval to develop land and construct buildings and structures. Development applications will be reviewed for compliance with the Comprehensive Plan and with adopted regulations, policies and other guidelines.(Ord. 480 §1.7, 2003)

Sec. 16-1-80. Relationship to existing ordinances.
All ordinances, resolutions or motions of the Board of Trustees or parts thereof in conflict with this Code are to the extent of such conflict hereby superceded and repealed, provided that no such repealer shall repeal the repealer clauses of such ordinance, resolution or motion, nor revive any ordinance, resolution or motion thereby. The adoption of this Code shall not adversely affect the Town's right to seek remedies for any violation of previous ordinances that occurred while those ordinances were in effect. (Ord. 480 §1.8, 2003)

Sec. 16-1-90. Relationship to Comprehensive Plan.
It is the intention of the Town that this Code implement the planning policies adopted in the Comprehensive Plan ("Comprehensive Plan") for the Town and its extraterritorial planning area. While this relationship is reaffirmed, it is the intent of the Town that neither this Code nor any amendment to it may be challenged on the basis of any alleged nonconformity with the Comprehensive Plan.
(1) Requirement for Comprehensive Plan Amendment. Where a development proposal would be in substantial conflict with the Comprehensive Plan, an amendment to the Comprehensive Plan will be required prior to any zoning or subdivision approvals. A substantial conflict will exist when a development proposal would result in changes from the designations of the

Land Use Plan Map, Transportation Plan Map or Parks and Open Space Map in the Comprehensive Plan.

(2) Criteria for Evaluating Amendment Proposals. Amendments to the Comprehensive Plan resulting from development proposals under this Code shall be evaluated according to the criteria and procedure outlined in the Comprehensive Plan. (Ord. 480 §1.9, 2003)

Sec. 16-3-20. Purpose.

The purpose of this Zoning Code is to create a vital, cohesive, well-designed community in order to enhance the Town of Milliken's small-town character and further the citizens' goals as identified in the Comprehensive Plan. These zoning regulations are designed:

(1) To promote the health, safety, aesthetics, morals and general welfare of the community;
(2) To lessen congestion in the streets and enhance pedestrian and vehicular movement with the least detriment to environmental quality;
(3) To secure the safety of the people against fire, panic, flood waters and other dangers;
(4) To provide adequate light and air, to prevent the overcrowding of land and to avoid the undue concentration of population;
(5) To regulate the location of activities and developments which could produce significant changes in population density;
(6) To classify land use and distribute land development and utilize in a way which will benefit the community; to regulate development and activities in hazardous areas; and to regulate the use of land on the basis of the impact thereof on the community and other surrounding areas;
(7) To provide, in conjunction with other laws and regulations, for transportation, water, schools, sewage treatment and other public requirements;
(8) To preserve mineral lands for needed development;
(9) To provide for phased development of government services and facilities and to aid in realizing the policies, objectives and goals of the Comprehensive Plan;
(10) To encourage innovations in land uses in order to take advantage of improvements in the technology of land use and development;
(11) To encourage and facilitate the orderly growth and expansion of the Town, while at the same time protecting the environment in a manner consistent with constitutional rights;
(12) To construct new domestic water and sewer systems in areas which result in minimal environmental damage;
(13) To permit extension of domestic water and sewage systems in those areas in which the anticipated growth and development that may occur as a result of such extension can be accommodated within the environmental and financial capacity of the area;
(14) To encourage traditional neighborhood residential mixed and multiple-use developments, so the growing demand for housing may be met;
(15) To protect the environmental and cultural heritage of the community; and
(16) To ensure quality development that will present and enhance the quality of life for residents of the Town. (Ord. 480 §3.2, 2003)

Sec. 16-3-540. Amendments.

(a) Initiation of Amendments to Text or Official Zoning Map. The Board of Trustees may from time to time amend, supplement, change or repeal the regulations and provisions of this Article. Amendments to the text of this Code may be initiated by the Board of Trustees, Town Staff or Planning Commission, or by written application of any property owner or resident of the Town. Amendments to the zoning district map may be initiated by the Board of Trustees, Town Staff or the Planning Commission, or by a real property owner in the area to be included in the proposed amendment.
(b) General Rezoning of the Town. Whenever the zoning district map is in any way to be changed or amended incidental to or as part of a general revision of this Code, whether such revision is made by repeal of the existing zoning code and enactment of a new zoning code or otherwise, the requirement of an accurate survey map or other sufficient legal description of, and the notice to and listing of names and addresses of owners of real property in, the area of the proposed change, shall be waived. However, the proposed

zoning map shall be available for public inspection in the Town Hall during regular business hours for fifteen (15) days prior to the public hearing on such amendments.

(c) Zoning Amendment Application Process.

(1) Step 1: Optional Preapplication Conference. The applicant may attend a preapplication conference with a representative from the Town. The purpose of the meeting is to discuss the zoning amendment, submittal requirements and review process.

(2) Step 2: Zoning Amendment Application Submittal. The applicant shall submit one (1) copy of the complete zoning amendment application package to the Town Clerk and shall request that the application be reviewed by the Planning Commission and Board of Trustees. Note: In the case of text amendments, only Items a and b are required.

a. Completed Land Use Application Form, Zoning Amendment – Technical Criteria Form (see Workbook), application fee and fee agreement.

b. Application Fee and Fee Agreement. A nonrefundable fee is collected to cover the cost of review by the Town Attorney, Town Engineer, Town Planner and any other expert whom the Town may wish to employ; and notice and publication expenses. Actual costs may exceed the deposit; in this case, the applicant is liable for costs in excess of the deposit. The Town shall provide the applicant with a copy of the most current fee schedule and fee agreement form.

c. Legal Notice Form. The applicant shall prepare the legal notice form and return it to the Town with an electronic copy of the legal description in MSWord format.

d. Mineral Rights Affidavit. The mineral rights affidavit must be current and must be dated no more than thirty (30) days before the date of the sketch plan application submittal.

e. A written description of the proposed change to the text of this Article, including the citation of the portion of the Article to be changed and the wording of the proposed change. The description must provide the rationale for the proposed change, citing specific difficulties with the existing text and similar provisions in zoning codes of other jurisdictions that support the rational of the proposed change. Particular attention should be given to addressing the criteria listed in Subsection (d) below.

f. A legal description for all property to be considered for rezoning.

g. Current proof of ownership in the form of title insurance issued with thirty (30) days of submission of the application (for zoning map amendments only).

h. A zoning amendment map of the area included in the proposed change, twenty-four (24) inches high by thirty-six (36) inches wide, with the following information:

1. North arrow, scale 1" = 100' or 1" = 200', and date of preparation.
2. The subdivision or block and lot name of the area to be zoned (if applicable) at the top of each sheet.
3. Legal description of the area to be zoned (entire area and individual zoning districts). In unsubdivided property, zone boundaries shall be determined by a metes and bounds description.
4. Location and boundaries, including dimensions, of the property proposed for rezoning. Note: Zone boundaries are to be the centerlines of physical streets, roads, highways, alleys, railroad rights-of-way and channelized waterways, or such lines extended.
5. The acreage or square footage contained within the property proposed for rezoning.
6. All existing land uses in the proposed rezoning area.

7. Zoning and existing land uses on all lands adjacent to the proposed rezoning.
8. The location and dimensions for all existing public rights-of-way, including streets, and centerlines of watercourses within and adjacent to the rezoning.
9. The names of all adjoining subdivisions with lines of abutting lots, and departing property lines of adjoining properties not subdivided.
10. Certificate blocks for the Surveyor, Planning Commission, Board of Trustees, and County Clerk and Recorder (see Workbook for examples).
11. An AutoCAD™ drawing file (Release 12 or higher) of the zoning amendment map on 3½" IBM-formatted disk or by other acceptable electronic transfer shall also be provided.

i. A written statement describing the proposal and addressing the following points:
   1. Need for the proposed rezoning.
   2. Present and future impacts on the existing adjacent zone districts, uses and physical character of the surrounding area.
   3. Impact of the proposed zone on area accesses and traffic patterns.
   4. Availability of utilities for any potential development.
   5. Present and future impacts on public facilities and services, including but not limited to fire, police, water, sanitation, roadways, parks, schools and transit.
   6. The relationship between the proposal and the Comprehensive Plan.
   7. Public benefits arising from the proposal.

j. Surrounding and Interested Property Ownership Report. Provide the Town Clerk with a current list (not more than thirty [30] days old) of the names and addresses of the surrounding property owners (within three hundred (300] feet of the property), mineral interest owners of record, mineral and oil and gas lessees for the property and appropriate ditch companies. The applicant shall certify that the report is complete and accurate.

k. Public Hearing Notification Envelopes. Two (2) sets of stamped, addressed, certified (return receipt requested) envelopes. The envelopes shall have the Town's address as the mailing address and return address and the envelopes shall be addressed to the surrounding property owners (within three hundred [300] feet of the property), mineral interest owners of record, oil and gas lessees for the property and the appropriate referral agencies.

l. It is the applicant's responsibility to ensure that accurate and complete information is provided.

(3) Step 3: Zoning Amendment Application Certification of Completion. Within a reasonable period of time, Staff shall either certify that the application is complete and in compliance with all submittal requirements or reject it as incomplete and notify the applicant of any deficiencies. The applicant shall then correct any deficiencies in the application package, if necessary, and submit the required number of copies of the application (as specified in the Zoning Amendment Technical Criteria form) to the Town Clerk. The original application and all documents requiring a signature shall be signed in blue ink.

(4) Step 4: Final Staff Review and Report to Planning Commission. Staff shall complete a final review of the resubmitted materials and prepare a report to the Planning Commission explaining how the application is or is not consistent with the Criteria for Amendments to the Official Zoning Map or Criteria for Amendments to the Text of the Zoning Code.

(5) Step 5: Set Zoning Amendment Public Hearing and Complete Public Notification Process. The Town Clerk shall send notice of public hearing to the applicant, all property owners of record within three hundred (300) feet of the property in question,

all mineral interest owners of record, oil and gas lessees for the property and the appropriate referral agencies no less than twenty-one (21) days before the initial Planning Commission public hearing. Such notice shall not be required for text amendments. The Town Clerk shall also publish notice in a newspaper of general circulation. For zoning map amendments, the Town Clerk shall prepare a public hearing notification sign to be posted on the property by the applicant. The applicant shall furnish to the Town an affidavit of posting on a form provided by the Town Clerk. The hearing may be held no less than thirty (30) days from the date of property posting and newspaper publication. If the zoning amendment request is accompanying another application that is scheduled for public hearings before the Planning Commission and Board of Trustees, one (1) public hearing may be held on both applications.

(6) Step 6: Planning Commission Public Meeting and Action on the Zoning Amendment. The Planning Commission shall hold a public hearing to review the zoning amendment based on the Criteria for Amendments to the Official Zoning Map or the Criteria for Text Amendments to the Zoning Code. The Planning Commission shall then make a recommendation to the Board of Trustees to approve, conditionally approve or deny the zoning amendment application.

(7) Step 7: Finalize Zoning Amendment Based on Planning Commission Comments. The applicant shall revise the zoning amendment application based on the Planning Commission's comments and submit it to the Town.

(8) Step 8: Notify Parties of Interest. Not less than twenty-one (21) days before the date scheduled for the initial Board of Trustees public hearing, Staff shall notify surrounding property owners within three hundred (300) feet, mineral interest owners of record, mineral and oil and gas lessees for the property and other interested parties. The notice shall include the time and place of the public hearing, the nature of the hearing, the location of the subject property and the applicant's name. Such notice shall not be required for text amendments.

(9) Step 9: Set Board of Trustees Public Hearing and Complete Public Notification Process. The Board of Trustees shall schedule a public hearing for the purpose of taking action on the zoning amendment. The Town Clerk shall publish notice in a newspaper of general circulation. The hearing may be held no less than thirty (30) days from the date of advertising.

(10) Step 10: Board of Trustees Public Hearing and Action on the Zoning Amendment. The Board of Trustees shall, after receiving the report and recommendations from the Planning Commission, hold a public hearing and act upon the proposed amendment. Following the required hearing, the Board of Trustees shall consider the comments and evidence presented at the hearing, evaluate the application in accordance with the criteria listed below and approve, approve with conditions or deny the application, in whole or in part. No petition for rezoning shall be granted where, within one (1) year preceding the date of filing of such petition with the Town Clerk, a petition for the same changes of the zoning district on the property described in such petition has been denied.

(11) Step 11: Post Approval Actions.

a. Upon approval of an amendment to the official zoning map by the Board of Trustees, the Town Clerk shall cause an appropriate revision of the official zoning map to be prepared for recording with the County Clerk and Recorder. In the event the zoning amendment was initiated by an interested party, the petitioner shall pay the Town's cost for the preparation of the revision to the official zoning map.

b. Upon approval of an ordinance amending, changing or repealing part of the text of this Article, the Town Clerk shall certify a copy of the ordinance and place it in the official records of the Town and make appropriate supplements to this Article.

c. The applicant initiating the official zoning map amendment shall have thirty (30) days after approval of the amendment by the Board of Trustees to submit to the Town Clerk two (2) Mylar copies and three (3) blueline copies of the approved zoning amendment map for recording, along with the recording fees and all other costs billed by the Town relative to the zoning amendment. A licensed surveyor or engineer shall prepare the zoning amendment map. Inaccurate, incomplete or poorly drawn plans shall be rejected. In addition, the petitioner shall submit one (1) eleven (11) inch by seventeen (17) inch Mylar reduction of the zoning amendment map and an AutoCAD™ drawing file (Release 12 or higher) of the zoning amendment map on 3½" IBM-formatted disk, or by other acceptable electronic transfer.

d. Within thirty (30) days of receipt of the zoning amendment map, the Town Clerk shall review the documents for compliance with the Board of Trustee's approval, obtain the Town officials' signatures and submit the approved zoning amendment map and the ordinance amending the official zoning map to the County Clerk and Recorder's Office for recordation.

(d) Criteria for Amendments to Official Zoning Map. For the purpose of establishing and maintaining sound, stable and desirable development within the Town, the official zoning map shall not be amended except:

(1) To correct a manifest error in an ordinance establishing the zoning for a specific property;

(2) To rezone an area or extend the boundary of an existing district because of changed or changing conditions in a particular area or in the Town generally;

(3) The land to be rezoned was zoned in error and as presently zoned in inconsistent with the policies and goals of the Comprehensive Plan;

(4) To further the implementation of the goals and objectives of the Comprehensive Plan.

(e) Criteria for Text Amendments to the Zoning Code. For the purpose of establishing and maintaining sound, stable and desirable development within the Town, the text of this Chapter shall not be amended except:

(1) To correct a manifest error in the text of this Article;

(2) To provide for changes in administrative practices as may be necessary to accommodate changing needs of the community and the Town Staff;

(3) To accommodate innovations in land use and development practices that were not contemplated at the adoption of this Article; or

(4) To further the implementation of the goals and objectives of the Comprehensive Plan.

(f) Map – Amendment upon Zoning Establishment or Modification. Upon enactment of any ordinance annexing and establishing zoning or modifying existing zoning for any property, and upon final passage thereof, the Town shall amend the prior existing official maps to include the annexed area with the proper zoning classification or show the amended classification, as the case may be. Such updated, current official map shall contain, in table form, the date and number of the ordinance amending it, the date the map was amended to reflect each amendment and the initials of the person who checked and approved the change to the map. (Ord. 480 §3.11, 2003; Ord. 522, 2005)

Sec. 16-1-150. Definitions.
Terms used in this Code are defined as follows:

Accessory building or *accessory structure* means a subordinate building or structure, the use of which is customarily incidental to that of the main building/structure or to the main use of the land, which is located on the same lot (or on a contiguous lot in the same ownership) with the main building, structure or use. *Accessory buildings* or *accessory structures* are only permitted when they are incidental or accessory to an existing and permitted principal or conditional use.

Accessory dwelling means an apartment integrated within a single-family dwelling, or located in a detached accessory building, such as carriage houses or agricultural-type outbuildings, located on the same lot as single-family dwellings.

Accessory use means a subordinate use, clearly incidental and related to the main structure, building or use of land, and located on the same lot (or on a contiguous lot in the same ownership) as that of the main structure, building or use.

Employees means the total number of persons to be employed in a building during normal periods of use.

Family means an individual living alone, or either of the following groups living together as a single housekeeping unit and sharing common living, sleeping, cooking and eating facilities:

a. Any number of persons related by blood, marriage or adoption; or
b. Any unrelated group of persons consisting of:
    1. Not more than three (3) persons; or
    2. Not more than two (2) unrelated adults and their children, if any.

For purposes of this definition, a bona fide employee of the family who resides in the dwelling unit and whose live-in status is required by the nature of his or her employment shall be deemed a member of the family, but this exception shall allow only one (1) employee per dwelling unit.

Home occupation means a business use of the house that is conducted inside the premises of the house or garage, does not change the basic residential character of the neighborhood and is subordinate to the residential use of the dwelling unit.

Mixed use means the development of a lot, tract or parcel of land, building or structure with two (2) or more different uses, including but not limited to residential, office, retail, public uses, personal service or entertainment uses, designed, planned and constructed as a unit.

Mixed use building means a building designed, planned and constructed as a unit, used partially for residential use and partly for commercial uses, including but not limited to office, retail, public uses, personal service or entertainment uses.

Mixed use dwelling unit means the dwelling unit in a mixed use building. For purposes of calculating residential density, each dwelling unit shall count as one-half (½) dwelling unit.

Owner means the person or entity that owns the property under consideration.

Principal use means the main use of land or of a structure as distinguished from a subordinate or accessory use.

Town of Milliken Comprehensive Plan means the plan which was adopted by the Planning Commission and Board of Trustees in accordance with Section 31-23-206, C.R.S., to guide the future growth, protection and development of the Town of Milliken, affording adequate facilities for housing, transportation, comfort, convenience, public health, safety and general welfare of its population.

Use means the type of activity for which land or a building is designated, arranged or intended and also means the activity which in fact regularly takes place upon the land.

Sec. 16-3-620. - Home occupations.

(a) Home occupations must meet the following standards:
  (1) Medical and dental offices are not permitted as home occupations.
  (2) In addition to the family occupying the dwelling containing the home occupation, there shall not be more than one (1) outside employee in the home occupation.
  (3) The employee and clients may park in on-street curbside parking spaces.
  (4) The home occupation shall not exceed one thousand (1,000) square feet or thirty (30) percent of the total square footage of the dwelling, whichever is less, or can be located in an accessory building not to exceed seven hundred twenty (720) square feet.
  (5) All aspects of the home occupation operation shall not disrupt the residential character of the neighborhood or create noise or environmental hazards.
  (6) A maximum of ten (10) clients may visit the home occupation per day.
  (7) Home occupations may include state-licensed family child care homes (residential day care facilities) that have received zoning approval from the Town.

(b) Home occupations that cannot meet the above standards are not permitted unless a special use permit is applied for and granted.

(Ord. 480 §3.13, 2003)

ORDINANCE NO. 723

AN ORDINANCE OF THE TOWN OF MILLIKEN AMENDING SECTIONS 16-1-150 AND 16-3-620 OF CHAPTER 16 OF THE MILLIKEN MUNICIPAL CODE CONCERNING HOME OCCUPATIONS

WHEREAS, the Board of Trustees of the Town of Milliken has the power to adopt zoning regulations pursuant to Section 31-23-301, *et seq.,* C.R.S., and the general ordinance powers conferred by Section 31-15-103, C.R.S.; and

WHEREAS, the Board of Trustees previously enacted regulations governing the operation of home occupations in residentially zoned areas of the Town as codified in Section 16-3-620 of the Municipal Code; and

WHEREAS, the Town Board desires to amend its home occupation standards to best strike a balance between the goal of protecting and maintaining the residential character of established neighborhoods and the need for some of its residents to engage in limited commercial activities in their homes to supplement incomes or establish new businesses; and

WHEREAS, the Planning Commission has reviewed proposed changes to the home occupation regulations and has recommended approval of the same to the Board of Trustees; and

WHEREAS, following a duly noticed public hearing, the Town Board of Trustees has considered the proposed home occupation regulations as set forth herein.

NOW THEREFORE, BE IT ORDAINED BY THE BOARD OF TRUSTEES OF THE TOWN OF MILLIKEN, COLORADO:

Section 1: Section 16-1-150, titled *Definitions*, of Chapter 16 of the Milliken Municipal Code is hereby amended to modify the definitions of *home occupation* and *home business* to read as follows:

> *Home occupation* means a business, profession or service conducted and or/operated entirely inside the residential premises of a dwelling, enclosed garage or other permitted accessory structures as an incidental and secondary use to the
>
> *Home business* means a home occupation that is subject to the use by special review process.

Section 2: Subsection (c) of Section 16-3-320, titled *R1 Single Family Residential,* is hereby amended to add a new subsection (c)(13) to read as follows:

(c) Uses by Special Review. Uses by special review in the R-1 District shall be as follows:

(13) Home businesses.

Section 3: Section 16-3-620, titled *Home Occupations*, of Chapter 16 of the Milliken Municipal Code is hereby amended to read in full as follows:

Sec. 16-3-620. Home occupations.

(a) Home occupations must meet the following standards:

(1) The home occupation shall be carried on exclusively within the dwelling, an enclosed garage or other accessory building, or any combination of these, provided the use is allowed by right and incidental and secondary to primary residential use of the property.

(2) The home occupation use must be clearly incidental and secondary to the primary residential use of the lot.

(3) There shall be no exterior (outdoor) display or storage of materials, vehicles, trailers, or equipment used in the home occupation that is visible from a public street, alley, or public open space.

(4) The home occupation shall not exceed thirty (30) percent of the total square footage of the dwelling, enclosed garage and accessory structures combined on the property,

(5) All aspects of the home occupation operation shall not disrupt the residential character of the neighborhood. The home occupation shall not create noise, vibrations, smoke, dust, odor, heat or glare detectable beyond the boundaries of the lot on which the home occupation is located. No hazardous materials shall be stored or used in the operation of the home occupation and no pedestrian, automobile or truck traffic, or parking congestion significantly in excess of the normal amount found in a residential district shall be generated by the home occupation.

(5) The use shall not involve the use of signs or structures other than those permitted in the applicable zone district.

(6) Home occupations that do not meet the criteria set forth in Subsections (a)(1)-(5) above, or as set forth below, may be permitted as a home business subject to compliance with Section 16-3-620 (c):

1. Agricultural service establishments, plant nursery and greenhouses; or
2. Beauty or barber shops; or
3. Commercial kitchens for catering, wholesale food preparation, and/or meal delivery; or
4. Automotive/boat repair; or
5. Automotive/boat body or paint shop; or
6. Research and development; or
7. Animal boarding; or
8. Distillers (for oral and non-oral use); or
9. Wineries, breweries, and tasting rooms.

(b) Interpretations. Any question of whether a particular use is permitted as a home occupation by the provisions of this section shall be determined by the administrative official pursuant to his or her authority to interpret the provisions of this chapter.

(c) Home businesses may be allowed to operate in a dwelling only if a use by special review has been obtained for a home business in accordance with Section 16-3-500.

Section 4: Codification.

The Town Clerk is hereby directed to work with the Town's Municipal Code codifier to ensure that the provisions of this Ordinance are included in the next codification of the Milliken Municipal Code.

Section 5: Severability.

If any part, section, subsection, sentence, clause or phrase of this ordinance is for any reason held to be invalid, such invalidity shall not affect the validity of the remaining sections of the ordinance. The Board of Trustees hereby declares that it would have passed the ordinance including each part, section, subsection, sentence, clause or phrase thereof, irrespective of the fact that one or more parts, sections, subsections, sentence, clauses or phrases be declared invalid.

Section 6: Repeal.

Existing or parts of ordinances covering the same matters as embraced in this Ordinance of the Milliken Municipal Code are hereby repealed and all ordinances or parts of ordinances inconsistent with the provisions of this Ordinance are hereby repealed, except that this shall not affect or prevent the prosecution or punishment of any person for any act done or committed in violation of any ordinance hereby repealed prior to the taking effect of this Ordinance.

Section 7: Effective Date.

This Ordinance shall take effect and be in force thirty (30) days after publication following final adoption.

Introduced, read, adopted, signed and ordered published in full by the Board of Trustees of the Town of Milliken this ___ day of _____, 2016.

TOWN OF MILLIKEN

_____
Milt Tokunaga, Mayor

ATTEST:

_____
Cheryl Powell, Town Clerk

APPROVED AS TO FORM:

_____
Linda Michow, Town Attorney

Published: _____

GUIDANCE FOR HAZARD DETERMINATION

FOR COMPLIANCE WITH THE OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200)

U.S. Department of Labor
Occupational Safety and Health Administration

Edwin G. Foulke, Jr.
Assistant Secretary of Labor for
Occupational Safety and Health

This guidance is not a standard or regulation, and it creates no new legal obligations. It is advisory in nature, informational in content, and is intended to assist employers in providing a safe and healthful workplace. Pursuant to the Occupational Safety and Health Act, employers must comply with safety and health standards promulgated by OSHA or by a state with an OSHA-approved state plan. In addition, pursuant to Section 5(a)(1), the General Duty Clause of the Act, employers must provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. Employers can be cited for violating the General Duty Clause if there is a recognized hazard and they do not take reasonable steps to prevent or abate the hazard. However, failure to implement any specific recommendations in this guidance is not, in itself, a violation of the General Duty Clause. Citations can only be based on standards, regulations, and the General Duty Clause.

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OVERVIEW

This document is designed to help manufacturers and importers of chemicals identify chemical hazards so that employees and downstream users can be informed about these hazards as required by the Occupational Safety and Health Administration's (OSHA) Hazard Communication standard. This guidance may also be useful to employers

who decide to conduct hazard determinations in order to assure the accuracy and completeness of information provided to them by suppliers. Hazard determination is the critically important first stage in the process of establishing an effective hazard communication program. The process of hazard determination consists of four basic steps. These are:

- Selection of chemicals to evaluate;
- Collection of data;
- Analysis of the collected data; and
- Documentation of the hazard determination process and the results obtained.

This document provides guidance as to the processes involved and identifies considerations in the conduct of hazard determinations. Since much of the discussion is of a technical nature, a Glossary of Terms and Definitions is included as Appendix A. Material contained in this publication is in the public domain and may be reproduced, fully or partially, without permission. Source credit is requested but not required.

I. INTRODUCTION

OSHA's Hazard Communication standard (HCS) is designed to protect against chemical source illnesses and injuries by ensuring that employers and employees are provided with sufficient information to anticipate, recognize, evaluate and control chemical hazards and take appropriate protective measures. This information is provided through material safety data sheets (MSDSs), labels, and employee training. In order for MSDSs, labels, and training to be effective, the hazard information they convey must be complete and accurate. Thus, it is critically important to obtain comprehensive and correct information about the hazards associated with particular chemicals.

What is Hazard Determination?

Hazard determination is the process of evaluating available scientific evidence in order to determine if a chemical is hazardous pursuant to the HCS. This evaluation identifies both physical hazards (e.g., flammability or reactivity) and health hazards (e.g., carcinogenicity or sensitization). The hazard determination provides the basis for the hazard information that is provided in MSDSs, labels, and employee training.

Hazard determination does not involve an estimation of risk. The difference between the terms hazard and risk is often poorly understood. Hazard refers to an inherent property of a substance that is capable of causing an adverse effect. Risk, on the other hand, refers to the probability that an adverse effect will occur with specific exposure conditions. Thus, a substance will present the same hazard in all situations due to its innate chemical or physical properties and its actions on cells and tissues. However, considerable differences may exist in the risk posed by a substance, depending on how the substance is contained or handled, personal protective measures used, and other conditions that result in or limit exposure. This document addresses only the hazard determination process, and will not discuss risk assessment, which is not performed under the OSHA HCS.

Who Must Conduct Hazard Determinations?

Only chemical manufacturers and importers are required to perform hazard determinations on the chemicals they produce or import. Under the HCS, an employer that manufactures, processes, formulates, or repackages a hazardous chemical is considered a "chemical manufacturer." Distributors and employers may also choose to conduct hazard determinations if they are concerned about the adequacy of hazard information for the chemicals they use in their business or distribute to others.

Regardless of who performs the hazard determination, the procedures used must be described in writing and made available, upon request, to employees and their designated representatives, as well as to OSHA and National Institute for Occupational Safety and Health (NIOSH) officials.

What Resources are Needed to Conduct a Hazard Determination?

Two primary resources are required for hazard determination. First is the complete, accurate, up-to-date literature and data concerning the chemical in question. Second is the ability to properly understand and interpret the information retrieved in order to identify and document hazards. Manufacturers and importers of hazardous chemicals are responsible for ensuring that hazard information provided to their employees and downstream users is complete and accurate. To achieve this, the person(s) assigned to conduct hazard determinations must have the ability to conduct complete and effective literature and data retrieval. They should also be able to effectively interpret the literature and data in order to determine the nature and extent of physical and health hazards. A lack of qualified employees does not exempt a manufacturer or importer from compliance with the HCS.

How Should This Guidance Document be Used?

The hazard determination requirements of the HCS are performance oriented. That is, chemical manufacturers, importers, and employers evaluating chemicals are not required to follow any specific procedures for determining hazards, but they must be able to demonstrate that they have adequately ascertained and reported the hazards of the chemicals produced or imported in accordance with the criteria set forth in the HCS.

This guidance document will not provide detailed methods that must be followed. However, a basic framework for hazard determination is provided, along with a description of a process that can be used to comply with the requirements of the HCS. The interpretation of information relating to the physical and health hazards associated with a chemical can be a highly technical undertaking, and should be conducted by trained staff such as toxicologists, industrial hygienists, and safety professionals. This document will not replace the need for such professional expertise in certain situations. It is intended to serve only as useful guidance as to the basic considerations and operational aspects involved in the conduct of hazard determinations.

II. THE HAZARD DETERMINATION PROCESS

What is the HCS Definition of a "Chemical"?

The definition of a chemical in the HCS is much broader than that which is commonly used. The HCS definition of chemical is "any element, chemical compound, or mixture of elements and/or compounds." Thus, virtually any product is a "chemical." These various types of chemicals are as follows:

- ***Element*** - the simplest form of matter. There are currently 109 known elements in the periodic table. Examples of elements are aluminum, carbon, chlorine, hydrogen, mercury and oxygen.
- ***Chemical compound*** - a substance consisting of two or more elements combined or bonded together so that its constituent elements are always present in the same proportions.
- ***Mixture*** - any combination of two or more chemicals if the combination is not, in whole or in part, the result of a chemical reaction.

Although virtually all materials are considered chemicals under this definition, the HCS identifies certain categories of chemicals that are not covered by the standard. These categories are:

- Any **hazardous waste** as defined by the *Solid Waste Disposal Act* when subject to regulations issued under that Act by the Environmental Protection Agency;
- Any **hazardous substance** as defined by the *Comprehensive Environmental Response, Compensation and Liability Act* **when the hazardous substance is the focus of remedial or removal action** being conducted under that Act in accordance with Environmental Protection Agency regulations;
- **Tobacco or tobacco products;**
- **Wood or wood products,** including lumber which will not be processed, where the chemical manufacturer or importer can establish that the only hazard they pose to employees is the potential for flammability or combustibility (wood or wood products which have been treated with a hazardous chemical covered by this standard,

and wood which may be subsequently sawed or cut, generating dust, are not exempted);

- **Articles**, defined as a manufactured item other than a fluid or particle: (i) which is formed to a specific shape or design during manufacture; (ii) which has end use function(s) dependent in whole or in part upon its shape or design during end use; and (iii) which under normal conditions of use does not release more than very small quantities, e.g., minute or trace amounts of a hazardous chemical, and does not pose a physical hazard or health risk to employees.
- **Food or alcoholic beverages** which are sold, used, or prepared in a retail establishment (such as a grocery store, restaurant, or drinking place), and foods intended for personal consumption by employees while in the workplace;
- Any drug, as that term is defined in the *Federal Food, Drug, and Cosmetic Act*, when it is in solid, final form for direct administration to the patient (e.g., tablets or pills); drugs which are packaged by the chemical manufacturer for sale to consumers in a retail establishment (e.g., over-the-counter drugs); and drugs intended for personal consumption by employees while in the workplace (e.g., first-aid supplies);
- **Cosmetics** which are packaged for sale to consumers in a retail establishment, and cosmetics intended for personal consumption by employees while in the workplace;
- Any **consumer product or hazardous substance**, as those terms are defined in the *Consumer Product Safety Act* and *Federal Hazardous Substances Act*, respectively, where the employer can show that it is used in the workplace for the purpose intended by the chemical manufacturer or importer of the product, and the use results in a **duration and frequency of exposure which is not greater than the range of exposures that could reasonably be experienced by consumers when used for the purpose intended;**
- **Nuisance particulates** where the chemical manufacturer or importer can establish that they do not pose any physical or health hazard covered under this section;
- **Ionizing and nonionizing radiation;** and
- **Biological hazards.**

How Will I Know if My Chemical is "Hazardous"?

Under the HCS, any chemical that presents a physical hazard or a health hazard is considered a hazardous chemical. The HCS definitions for physical and health hazards are:

- ***Physical hazard*** means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.
- ***Health hazard*** means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes.

These different types of hazards identified in the HCS are presented in Table 1.

Table 1. HCS Listed Hazard Categories

Physical Hazards	**Health Hazards**
Fire Hazards	***Systemic Effects***
Combustible liquid	Carcinogen
Flammable liquid	Toxic agent
Flammable aerosol	Highly toxic agent
Flammable gas	Corrosive
Flammable solid	Irritant
Oxidizer	Sensitizer
Pyrophoric	
Explosion Hazards	***Target Organ Effects***
Compressed gas	Hepatotoxin
Explosive	Nephrotoxin
	Neurotoxin
Reactive Hazards	Blood/hematopoietic toxin
Organic peroxide	Respiratory toxin
Unstable (reactive)	Reproductive toxin
Water-reactive	Cutaneous hazard
	Eye hazard

For a hazard determination to be complete, one must consider all possible hazards, and document any hazards that are identified. While the hazards listed in the HCS represent the majority of potential workplace hazards, the list is not all-inclusive, especially for health hazards. Table 2 is a list of important health hazards that should be evaluated in addition to those specifically listed by the HCS. In conducting the hazard determination, one should be cognizant of all types of physical and health hazards.

Table 2. Other Important Health Hazards

Cardiovascular toxicity	Gastrointestinal toxicity
Immunotoxicity	Skeletal/muscular effects
Connective tissue effects	Endocrine system toxicity
Sensory organ toxicity (sight, hearing, taste)	

Certain chemicals are specifically designated as hazardous by the HCS. The HCS listing of hazardous chemicals has been referred to as the "floor" to which other hazardous chemicals should be added. The HCS base list of these per se hazardous chemicals is provided in the following references:

- OSHA Toxic and Hazardous Substances, 29 CFR part 1910, Subpart Z (see Appendix C);
- Threshold Limit Values for Chemical Substances and Physical Agents (American Conference of Governmental Industrial Hygienists, latest edition); or
- Carcinogens or potential carcinogens according to one or more of the following sources:
  - 29 CFR part 1910, Subpart Z, Toxic and Hazardous Substances (OSHA) (see Appendix D);
  - National Toxicology Program Annual Report on Carcinogens, latest edition.
  - International Agency for Research on Cancer Monographs, latest editions.

The definition for hazardous chemical in the standard is thus very broad, and it is not likely that many chemicals will be considered non-hazardous if they have been adequately tested. However, the standard does not require the testing of chemicals - only the collection and analysis of currently available data. Testing should be considered if hazardous properties are suspected.

Is Hazard Determination the Same for Mixtures as for Individual Elements and Compounds?

Generally speaking, the chemical and physical properties and hazards of pure elements and chemical compounds are precise and constant. For example, benzene has explicit boiling and flashpoints of 176°F and 12°F (at sea level), respectively. In contrast, the properties of the complex mixture, Stoddard Solvent, can vary considerably depending on the manufacturer and lot received, with ranges for boiling and flashpoints of 309-396°F and 102-110°F, respectively.

The process for evaluating mixtures may require additional steps along with those indicated for single chemical agents. The HCS has designated specific requirements for mixtures. These requirements depend upon the availability of test data as indicated below:

- **If a mixture has been tested as a whole**, the results should be used to determine whether the mixture is hazardous.
- If a mixture **has not been tested as a whole for health hazards**, the mixture shall be assumed to present the same hazards as components which comprise 1.0 percent (1%) or more of the mixture. **An exception pertains to carcinogens.** In this case, the mixture shall be assumed to present a carcinogenic hazard if it contains a carcinogenic component which comprises 0.1 percent (0.1%) or more of the mixture.
- If a mixture **has not been tested as a whole to determine whether the mixture is a physical hazard**, the chemical manufacturer or importer may use whatever scientifically valid data are available to evaluate the physical hazards of the mixture.
- If there is evidence that a component is present at less than one percent (< 0.1% for carcinogens) and could be released into the workplace environment in concentrations that would exceed an OSHA permissible exposure limit (PEL) or American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), or present a health risk in those concentrations, the mixture is assumed to present the same hazard.

What is Involved in Conducting a Hazard Determination?

All possible physical or health hazards that might be associated with a chemical's use must be considered. The hazard determination process consists of four main steps:

- Selection of chemicals to evaluate;
- Collection of data;
- Analysis of the collected data; and
- Documentation of the hazard determination process and the results obtained.

Written procedures generally describe the process followed; they do not have to address, individually, each chemical evaluated. If no hazards are found, the manufacturer, importer, or employer is not required to take further action pertaining to the evaluated chemical. Even if no hazards are found, however, documentation of the steps taken to evaluate the chemical (and any retrieved data) may be useful for future reference.

For most of the chemicals specifically designated as hazardous in the HCS, the available information has been compiled in readily available and reliable sources (see Appendix B). If a chemical is not specifically designated as hazardous, you must collect and evaluate the data and determine if the chemical is hazardous. The hazard determination for these chemicals may be more involved since reliable data compilations may not exist. The determination in this case requires a more exhaustive search for information.

In some cases, a chemical may present a single hazard. In other cases, several hazards may be associated with exposure to a chemical. Hazards can range from mild to severe. For example, an identified health hazard for acetic acid, as normally used in industry, is irritation and corrosion (sensory and respiratory). In contrast, exposure to lead may involve a multitude of health hazards, including neurotoxicity, blood effects, cardiovascular and kidney damage, and birth defects.

The hazard evaluation is a process that relies heavily on the professional judgment of the evaluator, particularly in the area of chronic hazards. The performance-orientation of the HCS does not diminish the duty of the chemical manufacturer, importer or employer to conduct a thorough evaluation, examining all relevant data and producing a scientifically defensible evaluation.

III. SELECTION OF CHEMICALS

The ultimate goal in the hazard determination process is to know and document the hazards of all covered chemicals you manufacture or import. In order to achieve this you must first determine which chemicals require a hazard determination. The logical way to do this is to first prepare an inventory of all chemicals manufactured or imported. Items exempted from coverage under the HCS may be excluded from the inventory. For chemicals obtained from suppliers, you may rely upon the MSDSs and labels provided by the chemical manufacturer or importer. However, you may choose to conduct hazard determinations for those chemicals if you are concerned about the adequacy of the hazard information you have received.

If a chemical inventory is not already in place, a good start would be to review purchase orders and receipts to create an initial inventory. Next, the workplace should be inspected to identify any additional chemicals present. It would be ideal to note the location and quantity of each chemical found. Chemical inventories are often maintained as computer files for ease and efficiency in keeping them current. With knowledge of the chemicals in your possession, hazard determinations can now be performed for chemicals in the inventory. The chemical inventory or survey can also be used to decide which chemicals to dispose of as well as to identify potentially unsafe storage areas and techniques. Some chemicals should not be stored near each other due to incompatibilities and potential reactions.

IV. DATA COLLECTION

The second step in the hazard determination process is data collection. There are two main questions to be answered: 1) what type of data should be searched for and collected; and 2) how do I go about finding sources that might contain the desired data? You should recognize that the hazard determination process involves the identification of all of the hazards associated with a chemical, not just some of them. This process must be completed even though some data elements may be difficult to locate. Any hazard that exists for the chemical must be identified and communicated to downstream employers and employees.

To complete the hazard identification, information is needed in three categories:

- chemical identity;
- chemical and physical properties; and
- health effects.

There are numerous sources that could be searched for this information. A list of commonly used data sources is provided in Appendix B, although other sources exist and new sources continue to appear online and in print. For new or less commonly used chemicals, there may not be much data available from any of these sources. While the HCS does not require testing, you may choose to test chemicals to determine chemical and physical properties and identify hazards. Testing may be particularly useful for new chemicals, since it may no longer be assumed that the new chemical has the same intrinsic hazards as its components.

In the sections that follow, a discussion of data needs for the three categories of information is provided. Also, a few recommended key references for the various types of data are listed. You should recognize that complete and reliable data must be entered on MSDSs and labels in order to meet HCS requirements. Before the search for hazard data can begin, however, you must identify the exact chemical composition of the chemical(s) or products manufactured or imported. For mixtures or products, this chemical search includes the name of each chemical in the mixture, including active ingredients, inactive ingredients, and impurities.

The specific chemical identity of all chemicals on your Chemical Inventory should be carefully and completely compiled. The specific chemical identity should include:

- the chemical name along with common name and synonyms;
- the Chemical Abstracts Services (CAS) Registry Number (if available); and
- any other information that reveals the precise chemical designation and composition of the substance.

Correct identification of chemicals is critical for data retrieval. Use the precise chemical name and CAS number when searching for information. A problem with the use of common names or abbreviations is that they may be used for more than one molecular entity. For example, TCE is sometimes used as an acronym for tetrachloroethylene, although it more frequently refers to trichloroethylene. To avoid confusion, literature is often indexed using the CAS number or the primary chemical name. An example of the type of chemical identification data that is needed is presented for Perclene®, a widely used industrial solvent. Perclean® is a trade name for perchloroethylene or Perc

(common name), or more specifically tetrachloroethylene (CAS Number 127-18-4). Thus, the most effective search of computerized databases is conducted using tetrachloroethylene and/or CAS Number 127-18-4. Several databases exist that can be searched for the CAS number or chemical name if one only has a trade or common name(s) or abbreviation(s). CAS numbers are assigned by the Chemical Abstract Service of the American Chemical Society.

The percent composition should be available in-house for all chemicals and products manufactured or imported. The chemical composition information should be based on an analysis of the final or technical product. A technical grade product is not usually a pure substance and often contains other chemicals such as stabilizers, solvents, carriers, "inert" ingredients, or impurities. For the hazard evaluation process, these other chemicals must also be listed if they are more than 1.0% of the composition for non-carcinogenic substances or 0.1% of the product if the substance is a carcinogen.

Thus, the initial step is to collect as much data as possible pertaining to the physical and chemical properties and toxicity data for chemicals on your chemical inventory.

Key sources of information related to chemical identification are:

- Company records;
- MSDSs and product safety bulletins from manufacturers or suppliers;
- OSHA Chemical Sampling Information pages;
- The Merck Index;
- ChemID; and
- Trade associations.

Physical and Chemical Properties

The physical properties of a substance can be directly related, in many cases, to the probability of the substance representing a physical hazard. However, the fact that a substance has a certain physical property cannot necessarily be used to predict a physical hazard. For example, all volatile substances are not necessarily explosive. Some solids can also be explosive (e.g., TNT or grain dust particles). Nevertheless, knowing the physical properties has great value in predicting whether a substance may pose a physical hazard.

Key sources of information related to physical and chemical properties include:

- Fire Protection Guide to Hazardous Materials;
- Department of Transportation 2000 Emergency Response Guidebook;
- Hazardous Substances Data Bank (HSDB);
- Product safety bulletins from manufacturers or suppliers;
- The Merck Index;
- NIOSH Pocket Guide to Chemical Hazards;
- CRC Handbook of Chemistry and Physics;
- Bretherick's Handbook of Reactive Chemicals Hazards; and
- Trade associations.

Health Effects

All potential health hazards must be determined - not just those identified by OSHA

The HCS includes a list of 14 potential health hazards, as well as the criteria for determining when a chemical represents a health hazard (see Section 3). In many cases, a chemical may pose more than one type of health hazard. If your company is manufacturing a new chemical you may be required to submit premanufacturing health effects data to the Environmental Protection Agency (EPA) to comply with the Toxic Substances Control Act (TSCA). Data submitted to EPA by other companies may be available to you by contacting the EPA. This data should be used to assist with hazard determination and the preparation of MSDSs and labels. For chemicals that have not been studied in-house or via company-sponsored toxicology studies, the company should seek toxicity data from the literature, government, or private sources. Some recommended reference sources are listed below.

- Company-sponsored research;
- MSDSs and product safety bulletins from manufacturers, suppliers, or Internet sites;
- Hazardous Substances Data Bank (HSDB);
- Registry of Toxic Effects of Chemical Substances (RTECS®);
- NIOSH Pocket Guide to Chemical Hazards;
- OSHA Chemical Sampling Information pages;
- IARC Monographs on the Evaluation of Carcinogenic Risks to Humans;
- NTP Annual Report on Carcinogens;
- TLVs and BEIs (ACGIH);
- Hawley's Condensed Chemical Dictionary, latest edition;
- Sax's Dangerous Properties of Industrial Materials, latest edition;
- Published literature; and
- Trade associations.

V. DATA ANALYSIS

The third step in the hazard determination process is data analysis. This step is the most demanding in terms of technical expertise. The HCS requires that chemical manufacturers and importers conduct a hazard determination to determine whether physical or health hazards exist. In some cases, especially for physical hazards, a definition in the HCS establishes the criteria to be followed. For example, if a liquid has a flashpoint below 100°F, it is by definition a "flammable liquid". This type of procedure is a simple data analysis. You can look up the flashpoint in a standard reference and accept it at face value. In the event that your company is manufacturing or importing a chemical for which there is no information on the flashpoint, you may choose to determine the flashpoint by laboratory testing, but testing is not required by the HCS.

As a rule, the HCS attempts to minimize the burden of literature search and review while satisfying the need to provide information required to protect employees who are exposed to hazardous chemicals. For this reason, a suggested approach is to go to the most likely sources first to obtain the needed data, and then proceed to additional sources, if necessary.

For health hazards, explicit criteria are provided in the HCS for some health hazards. For example, criteria are given for classifying a chemical as highly toxic or toxic based on acute effects, and for designating a chemical as a carcinogen. For other health hazards, a simple generic requirement is provided for the determination of a specific health hazard. The HCS states that "evidence that is statistically significant and which is based on at least one positive study conducted in accordance with established scientific principles is considered to be sufficient to establish a hazardous effect if the results of the study meet the [HCS] definitions of health hazards."

Let us examine this requirement further. There are three key criteria that must be met, namely "statistically significant", "positive study", and "established scientific principles". Thus, the evaluation of study results requires some knowledge of statistics, commonly accepted scientific test methodology, and the definitions of health hazards.

Statistical significance is a mathematical determination of the confidence in the outcome of a test. The usual criterion for establishing statistical significance is the p-value (probability value). A statistically significant difference in results is generally indicated by $p<0.05$, meaning there is less than a 5% probability that the toxic effects observed were due to chance and were not caused by the chemical. Another way of looking at it is that there is a 95% probability that the effect is real, i.e., the effect seen was the

result of the chemical exposure.

The other major measure of statistical significance is the 95% confidence level for a specific data point. Most reports of toxicity testing will include some information on the confidence in the data. For example, for a study with a stated confidence level of 95%, an LD_{50} with a listed value of 9.5 ± 1.2 indicates that if the same study were to be repeated many times, the LD_{50} would be expected to be within the range of 8.3 - 10.7 on 95 out of every 100 times.

Most toxicity and epidemiology reports will provide an analysis of the data and conclude whether the results were positive or negative, or will describe the adverse effects observed at specific dose levels. Positive results mean that the exposed humans or animals were more likely to develop toxic effects than the non-exposed population.

Hazard evaluation relies on professional judgment, particularly in the area of chronic hazards. The performance-orientation of the HCS does not diminish the duty of the chemical manufacturer, importer or employer to conduct a thorough evaluation, examining all relevant data and producing a scientifically defensible determination.

In the remainder of this section, an overview is presented of the HCS designated hazards and their definitions. In addition, a brief discussion is presented to further explain the specific hazard as well as procedures that can be used to analyze the data. Because this document can only present a limited discussion of the various hazards, you are encouraged to consult references that go into greater detail (see Appendix B of this document).

Physical Hazards

A chemical is a physical hazard if it:

- is likely to burn or support fire;
- may explode or release high pressures that can inflict bodily injury; or
- can spontaneously react on its own, or when exposed to water.

Fire Hazards

Combustible and Flammable Liquids

The ability of a chemical to either burn or support burning is a potentially disastrous physical hazard. The two primary measures of the ease with which a liquid will burn are the flashpoint and autoignition temperature. The flashpoint is the lowest temperature at which a liquid will emit sufficient vapors to form an ignitable mixture with air. In contrast, autoignition is the characteristic of a material in which it will spontaneously burn without the aid of an ignition source, such as a spark or flame. Many agents will burn when ignited whereas there are only a few that will spontaneously erupt into flames. While no single measure of flammability is sufficient for all purposes, the most commonly found measure in the literature is the flashpoint. For this reason, HCS uses flashpoint in classifying the fire hazard of a chemical.

Flammable liquids and combustible liquids are discussed together since flashpoint is the criterion for classification of both. The only difference between a "flammable" and "combustible" liquid is the relative ease (temperature) with which the substance burns or supports burning. The data analysis and hazard categorization are clear. For a pure chemical compound, the assignment to combustible or flammable liquid categories is quite simple:

- If the flashpoint is between 100°F - 200°F (37.8°C - 93.3°C), it is a combustible liquid;
- If the flashpoint is below 100°F (38°C), it is a flammable liquid.

The HCS definition for *combustible liquid* is "any liquid having a flashpoint at or above 100°F (37.8°C), but below 200°F (93.3°C), except any mixture having components with flashpoints of 200°F (93.3°C) or higher, the total volume of which makes up 99 percent or more of the total volume of the mixture."

The HCS definition for *flammable liquid* is "any liquid having a flashpoint below 100°F (37.8°C), except any mixture having components with flashpoints of 100°F (37.8°C) or higher, the total of which make up 99 percent or more of the total volume of the mixture."

You see that the HCS has made exceptions for chemical mixtures. A mixture will not be categorized as a combustible liquid so long as less than 1% of the total volume of components have flashpoints between 100° and 200°F. For example, if Chemical A has a flashpoint of 180°F and represents 0.5% of the mixture and all other chemicals have flashpoints above 200°F, then the mixture is not considered a combustible liquid. Similarly, a mixture will not be categorized as a flammable liquid if it is composed of at least 99% (by volume) of components with flashpoints above 100°F (38°C). Many mixtures will contain more than 1% of a flammable liquid and the mixture will have a flashpoint above 100°F. Where data indicating the flashpoint of a chemical are not available, you may choose to test the chemical to determine the flashpoint.

The HCS specifies that the testing should be conducted by one of the following methods:

(a) Tagliabue Closed Tester (see American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24 1979 [ASTM D 56-79]).

(b) Pensky-Martens Closed Tester (see American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7-1979 ASTM D 93-79]).

(c) Setaflash Closed Tester (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester [ASTM D 3278-78]).

If data are available that were derived from another testing method, a description of the method should be provided along with the results of the testing.

When a substance flashes, the resulting flame will spread through the vapor from the ignition source to the nearby surface of the liquid. From a practical viewpoint, a flammable liquid is potentially more hazardous than a combustible liquid. A flammable liquid presents a fire hazard if present in an open container near an ignition source in an environment in which the temperature is near or below normal room temperature. Examples of flammable liquids (with flashpoint temperatures) are: acetone (0°F), ethyl ether (-49°F), ethyl alcohol (55°F), and gasoline (-45°F). For a combustible liquid to present a fire hazard it must be above normal room temperature. Examples of combustible liquids are kerosene (100°-162°F) and Stoddard solvent (102°-110°F).

The lower flammability limit (LFL) is the minimal concentration of vapor below which combustion will not occur even in the presence of an external ignition source, whereas the upper flammability limit (UFL) is the maximum vapor concentration above which combustion cannot take place. To understand the concept, that at a certain concentration combustion will occur whereas it will not if the concentration is too low or too high, consider the carburetor of an automobile. The carburetor must be correctly adjusted so that the gasoline/air mixture is not too lean or too rich, or the gasoline/air vapor mixture will not burn in the automobile engine. Gasoline has an LFL of 1.4% and an UFL of 7.6%.

Flammable Aerosol

The HCS definition for *flammable aerosol* is "an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening."

The analysis as to whether the chemical is a flammable aerosol is more difficult and usually must be based upon laboratory testing of the aerosol as emitted from a pressurized container. In practice, most aerosols are mixtures, usually in air, and are primarily propellant formulations of droplets, particles, gases, and/or vapors. Their flammability is highly dependent on the nature of the propellant formulation. Therefore, data obtained from a literature search that does not pertain to the exact mixture of ingredients in the product may not be relevant when determining the flammability of the product. In the event that you choose to test a chemical product to determine if it is a flammable aerosol, the method described in 16 CFR 1500.45 should be used. A positive test is obtained if a flame is projected at least 18 inches at full valve opening, or if there is a flashback (i.e., a flame extends back to the valve) at any degree of valve opening.

Flammable Gas

The HCS definition for flammable gas is "a gas that, at ambient temperatures and pressures, forms a flammable mixture with air at a concentration of less than thirteen (13) percent by volume; or forms a range of flammable mixtures with air wider than twelve (12) percent by volume."

Thus, a gas can be categorized as flammable if the gas:

- burns in air at a concentration of less than 13%; or
- has an LFL of 13% or more with a concentration range for burning in air greater than 12%. The range is the difference between the LFL and the UFL.

Methane and butane are examples of flammable gases that burn at less than 13% concentration in air. Acetone is an example of a flammable liquid that volatilizes but does not represent a flammable gas. This is true because the LFL is 16% and the UFL is 25%, which is a range of only 9% (the definition requires a range of greater than 12%). On the other hand, ammonia is categorized as flammable since it has a LFL of 15% and an UFL of 28%, a range of 13%.

Flammable Solid

The HCS definition of a flammable solid is "a solid, other than a blasting agent or explosive as defined in [29 CFR] 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one tenth of an inch per second along its major axis."

The analysis as to whether a solid chemical will burn with such intensity to be classified as a flammable solid usually must be based upon the results of laboratory testing. If you choose to test a chemical to determine if it is a flammable solid, such testing should be conducted by the method described in 16 CFR 1500.44. A flammable solid can be ignited readily and then will burn so vigorously as to create a serious fire hazard. Blasting agents or explosives may be solids that burn but with an intensity so great that they are classified as explosives. An example of a flammable solid that can be ignited by friction is the chemical formulation on the head of matches. Some metal powders (such as magnesium) can react with moisture and burn and are thus classified as flammable solids.

Oxidizer

The HCS classifies a chemical as an oxidizer if it is a "chemical other than a blasting agent or explosive as defined in [29 CFR] 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases."

An oxidizing agent is a chemical or substance that brings about an oxidation reaction. The agent may provide the oxygen to the substance being oxidized (in which case the agent has to be oxygen or contain oxygen), or it may receive electrons being transferred from the substance undergoing oxidation (e.g., chlorine is a good oxidizing agent for electron-transfer purposes, even though it contains no oxygen).

Oxidation materials can initiate or greatly accelerate the burning of fuels. The most common oxidizer is atmospheric oxygen. Oxygen-containing chemicals (e.g., hydrogen peroxide and nitrous oxide) and halogens (e.g., bromine, chlorine, and fluorine) can also be strong oxidizers. Some chemicals may be oxidizers with such an extremely fast burning potential that they are classified as explosives or blasting agents rather than oxidizers. Often the fact that a chemical possesses oxidizing potential can be determined by an examination of its chemical structure. For example, oxidizing substances usually include recognizable functional chemical groups, e.g., perchlorate (ClO_4-), chlorate (ClO_3-), chlorite (ClO_2-), hypochlorite (ClO-), peroxide (-O-O-), nitrate (NO_3-), nitrite (NO_2-), dichromate (Cr_2O_7), persulfate (S_2O_8), and permanganate (MnO_4).

While the potential for oxidizing can often be inferred by chemical structure, absolute certainty can only be properly established in the laboratory since oxidation involves not only the oxidizing potential of the oxidizer, but also the chemical formulation of the fuel with which it comes in contact. Oxidizers are classified by comparison with the oxidizing properties of a standard test chemical, ammonium persulfate, applied to dry, conditioned sawdust. A solid that promotes combustion of the conditioned sawdust at a greater rate than ammonium persulfate is classified as an oxidizer.

Pyrophoric Hazards

The HCS definition for a pyrophoric chemical is "a chemical that will ignite spontaneously in air at a temperature of 130° F (54.4°C) or below." Fortunately, there are only a few chemicals that have the ability to catch fire without an ignition source when exposed to air. Many of these are elements (e.g., lithium, powdered aluminum, magnesium) or organometallic compounds (such as lithium hydride, diethyl zinc and arsine). Moisture in the air often increases the probability of spontaneous ignition of pyrophoric materials.

Explosive Hazards

Compressed Gas

The HCS definition for Compressed Gas is:

(i) "a gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70°F (21.1°C): or

(ii) a gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130°F (54.4°C) regardless of the pressure at 70°F (21.1°C); or

(iii) a liquid having a vapor pressure exceeding 40 psi at 100°F (37.8°C) as determined by ASTM D-323-72."

All compressed gases are potentially hazardous since they are under great pressure in a container. Accidental rupture of the container and the rapid release of the pressurized gas can result in injury to persons and damage to objects in the vicinity. Not only can the gas be released with great force, but the force of the release may propel the container for a long distance. In addition to the mechanical hazard from the pressure or propelled container, other hazards may exist from the released gas. The hazard from some compressed gases may be strictly mechanical (e.g., compressed air), others may possess other types of hazards, such as being flammable (e.g., methane and propane) or toxic (e.g., ammonia and chlorine).

Explosive

The HCS definition for explosive is "a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature."

Explosives are unstable materials and are of two types. One type consists of material capable of supersonic reactions (detonation), for example, nitroglycerine and TNT. The other type consists of materials (usually mixtures) that burn rapidly but at a subsonic rate. Examples of this type are gunpowder, rocket propellants, and pyrotechnic mixtures (fireworks). The difference between fire and explosion is the rate at which high temperature gases are produced and the physical containment of the burning gases. When high temperature gases build up extremely fast, there can be such a sudden release of energy from the gases that a shock wave or explosion is created. Confining the build-up of high pressure gases in a drum or vessel, which prevents venting of the gases, may promote an increase in the pressure within the restricted volume until an explosion occurs. Such is the principle behind some munitions, which confine high pressure gases until the pressure exceeds the strength of the casing.

Most explosives have a chemical structure that contains both oxidizing and fuel functional groups. Examples of functional groups contained in explosives are: azides, diazonium, and styphnate. While the presence of such functional groups suggests explosive potential, it is usually necessary to confirm this hazard via experimental studies.

Reactive Hazards

These reactive materials can cause damage to the human body by the release of gases that will burn, explode, or produce high pressure that can inflict injury to a person

nearby. In some cases, the reactive materials may release substances that are considerably more toxic than themselves. HCS has defined three types of reactive hazards: organic peroxides, unstable (reactive) materials, and water-reactive materials. However, in addition to these three categories there are other types of reactive hazards that should be determined, especially those involving other organic heteroatomic bonds that may be unstable and chemicals that might be involved in slow decomposition processes that give rise to reactive materials or increased pressure in containment vessels.

While there are classes of chemicals that in themselves may be reactive, there are also stable chemicals which are not reactive but when combined may interact, resulting in an explosive reaction. Good sources for information about chemical interactions are Bretherick (1999), Sax (Lewis, 2004), and the U.S. Chemical Safety and Hazard Investigation Board (2002). Mixing incompatible materials may result in the formation of unstable/reactive materials; therefore, the literature search should document incompatible materials. In addition to discrete chemicals, it should be realized that certain dusts might be combustible and explosive, such as that produced by bakeries, sawmills, and in grain handling.

Organic Peroxide

The HCS definition for organic peroxide is "an organic compound that contains the bivalent -O-O structure and which may be considered a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical."

The peroxide functional group (-O-O) is relatively unstable and most organic peroxides will spontaneously decompose at a slow rate. Some organic peroxides, however, are capable of very violent reactions with detonation at environmental temperatures, causing fires and explosions. Several organic peroxides are used in the plastics industry to initiate polymerization and serve as cross-linking agents. Recognizing an organic peroxide is quite simple - the presence of the peroxide group (-O-O) in its chemical structure. However, the characterization of the severity of the hazard is usually based upon fairly extensive laboratory testing. Examples of organic peroxides are benzoyl peroxide and allyl hydroperoxide.

Note: In addition to simple peroxide groups, other heteroatomic bonds may also be reactive, in particular -N-O- and -N-N- bonds, such as hydroxylamine, hydrazine, and their derivatives.

Unstable (Reactive) Material

The HCS definition for an unstable (reactive) material is a "chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature."

The main difference between an unstable material and an explosive is the rate of the reaction. While the rate of reaction for unstable materials is less than that in the case of explosives, the unstable materials can still present a serious hazard due to the generation of high temperatures and pressures. In some cases, the reaction may be rapid enough to approach explosive potential.

Polymerization is a reaction in which small molecules (usually monomers) react with each other to form larger molecules (polymers). In the chemical process, a large amount of heat may be released. This raises the temperature of the monomer mixture that further accelerates the polymerization process until the reaction runs away or explodes.

Decomposition reactions can occur with many chemicals and mixtures. In this process, complex molecules dissociate to form simpler substances. This process may require input of heat or there may be a release of heat during the chemical reaction. The most hazardous reactions are those in which heat is released. If the reactions take place within a vessel, the high temperature may increase the vessel pressure to the point that it ruptures or explodes. Examples of unstable materials are acrylonitrile and butadiene.

It should be noted, however, that slower reactions such as slow decomposition processes may also create serious hazards. A number of such reactions have been observed by the U.S. Chemical Safety and Hazard Investigation Board (2002). Analyses of such reactions should be reviewed by those preparing MSDSs to gain an understanding of how such reactions can occur. The CSB and CCPS reports provide several examples of slow, oxygen-generating chemical reactions that may gradually produce a highly dangerous fuel-oxygen atmosphere, such as in a waste tank. Another example of a slow chemical reaction is with slow, endothermic polymer decomposition reactions resulting in pressure build-up within enclosed tanks. The potential for decomposition reactions that might lead to production of an explosive substance should also be considered.

Water-Reactive Material

The HCS definition for water-reactive material is a "chemical that reacts with water to release a gas that is either flammable or presents a health hazard."

Many chemicals fall in this category. For example, sodium and potassium, when exposed to water, will react and release hydrogen, presenting an explosive hazard. Carbides (e.g., calcium carbide) can generate acetylene, a flammable gas, when exposed to water. In other cases, the gases released may be highly toxic, as in the case of cyanide that can be released when an inorganic salt containing cyanide (e.g., potassium cyanide) comes in contact with water.

Health Hazards

To define with precision every possible health effect that can occur in the workplace as the result of chemical exposure is an unrealistic goal. There can be a variety of toxic effects on different organs, which may depend upon dose level, frequency, duration, and route of exposure. This does not negate the need for employees to be informed of such effects and be protected from them. The HCS provides a list of the most common health hazards. However, it should be stressed that the list does not include all health hazards.

Some of the health hazard definitions provide for an extremely precise testing procedure (e.g., test species or weight range). This is because those test protocols had been codified in previous government regulations. However, other test methods have been developed and are acceptable for hazard determination. In view of this, Appendix A of the HCS indicates that if there are available scientific data that involve other animal species or test methods, they must also be evaluated to determine their applicability.

Assigning chemicals to discrete health hazard categories is not precise, and several schemes have been proposed. Separation into acute and chronic health hazards is used by the American National Standards Institute (ANSI) in its labeling standard (ANSI Z129.1) and its guidance for preparation of MSDSs (Z400.1-2004). The main difference between acute and chronic is related to duration of exposure and to the rapidity of onset after exposure.

In some exposure situations, the effects may occur rapidly after a single or short-term exposure (acute effects); in other cases, the damage may accumulate after multiple exposures or over a long exposure period, or arise long after earlier exposures (chronic effects). Examples of chronic effects are cancer and cirrhosis of the liver. A chemical may have the ability to cause both acute and chronic effects. For example, ethyl alcohol can cause death when consumed in large amounts at one time, birth defects when consumed for only a few days by a pregnant woman, and cirrhosis of the liver if consumed for several years. OSHA has listed a number of health hazards, some general or systemic (whole-body) effects, and others that are specific to certain organs (known as target organs).

Following is a brief description of the HCS identified health hazards. In many cases, the determination is based on data obtained from standard experiments with laboratory animals. Reliable human data are preferred to animal data. However, in many cases, reliable human data are not available, and animal data must be used. The search strategy previously discussed should attempt to obtain human data, animal data, and cell and tissue studies, as well as data on the mechanisms by which a chemical causes toxicity.

Systemic Effects

Carcinogens

Under the HCS, "a chemical is considered to be a carcinogen if:

(a) It has been evaluated by the International Agency for Research on Cancer (IARC), and found to be a carcinogen or potential carcinogen; or

(b) It is listed as a carcinogen or potential carcinogen in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or,

(c) It is regulated by OSHA as a carcinogen."

A chemical classified by IARC in Group 1 (i.e., the agent is carcinogenic to humans), Group 2A (i.e., the agent is probably carcinogenic to humans) or Group 2B (i.e., the agent is possibly carcinogenic to humans) or identified by NTP as being "known to be carcinogenic" or "reasonably anticipated to be carcinogenic" is considered a carcinogen under the HCS. In addition to the determinations of these organizations, all available scientific data on carcinogenicity must be considered. As with other health hazards, the results of any studies which are designed and conducted according to established scientific principles, and which report statistically significant conclusions regarding the carcinogenicity of a chemical, are sufficient for determining that the chemical is a carcinogen under the HCS. Some examples of workplace carcinogens are asbestos, benzene, hexavalent chromium, and vinyl chloride.

The simple definition of a carcinogen is "a substance that has the potential to cause cancer." The terminology used to describe cancer may be confusing. Cancer is a type of tumor. A tumor (also known as a neoplasm) is simply an uncontrolled growth of cells. Tumors may be benign or malignant. Benign tumors grow only at the site of origin, and do not invade adjacent tissues or go to distant sites in the body (known as "metastasis"). Except for those that develop deep in vital organs (such as the brain), benign tumors can be successfully treated (usually by surgical removal) and the potential for causing death is low. Malignant tumors are cancers and can grow outside their original site in an organ, invade surrounding tissue, or metastasize to distant organs where they can start new growths of the cancerous tissue. Malignant tumors (cancer) are difficult to treat and frequently cause death of the patient.

Cancers vary greatly in type and behavior in the body. Some cancers grow slowly and rarely metastasize. Others are highly invasive and metastasize rapidly. Cancers are usually named for the specific cell type or organ of origination. For example, squamous cell carcinoma of the lung is a cancer that arose from a squamous cell in the lung. A hepatocellular carcinoma is a cancer arising from a liver cell (hepatocyte). Sometimes the name given to a cancer also reflects its nature. For example, chronic lymphocytic leukemia is a cancer involving lymphocytes (a type of blood cell) in which the leukemia is chronic or long-lasting in nature. OSHA, NTP, and IARC report the specific types of cancer caused by chemicals that they list.

Toxic Agents

The HCS classifies chemical agents as toxic or highly toxic based on the number of deaths that occur following brief (acute) exposure of rodents. The difference in the two categories is strictly the dose at which the toxicity (death) occurs. Exposure is by the three major workplace exposure routes, mouth (oral), skin (dermal), or breathing (inhalation). The analysis is based on the LD_{50} (median lethal dose by oral or dermal exposure) and LC_{50} (median lethal inhalation concentration for a one-hour exposure. The LD_{50} and LC_{50} represent the dose or concentration, respectively, at which 50% of the test animals (and supposedly humans) will be expected to die.

Under the HCS, a toxic chemical is "a chemical falling within any of the following categories:

(a) A chemical that has a median lethal dose (LD_{50}) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

(b) A chemical that has a median lethal dose (LD_{50}) of more than 200 milligrams per kilogram but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

(c) A chemical that has a median lethal concentration (LC_{50}) in air of more than 200 parts per million but not more than 2,000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each."

The following table illustrates how a chemical can be classified as a Highly Toxic or Toxic, depending on the results of the appropriate animal tests.

Animal Test	Highly Toxic	Toxic
Oral LD_{50}	< 50 mg/kg	50-500 mg/kg
Dermal LD_{50}	< 200 mg/kg	200-1000 mg/kg
Inhalation LC_{50} - gases, vapors	< 200 ppm	200-2000 ppm
Inhalation LC_{50} - mists, fumes or dust	2 mg/L	2-20 mg/L

Remember the HCS instructions pertaining to whether a study is scientifically acceptable for hazard determination. While only one positive study is required, it must be:

- conducted in accordance with established scientific principles; and
- the results must be statistically significant.

As can be seen, the acute toxicity for a *toxic* agent is considerably less than with the *highly toxic* agents. For example, the break point for oral exposures is 50 mg/kg. Below 50 mg/kg, the chemical is *highly toxic* whereas if the LD_{50} is above 50 mg/kg, it is only *toxic*. Examples of *highly toxic* chemicals are parathion (with an oral rat LD_{50} of 2 mg/kg and a dermal LD_{50} of 22 mg/kg) and methyl isocyanate (with an inhalation one-hour LC_{50} in rats of 45 ppm). Examples of *toxic* chemicals are chloroform (with an LD_{50} of 140 mg/kg), acrylonitrile (with a 24-hour dermal LD_{50} between 200 and 2000 mg/kg), and ammonia (with an inhalation one-hour LC_{50} in rats between 200 ppm and 2000 ppm). Agents having an oral LD_{50} greater than 500 mg/kg are not classified as *toxic*. This does not mean that they do not represent a health hazard (e.g., the chemical could present a chronic hazard, such as cancer or hepatotoxicity), but only that they are not classified as *toxic* under the HCS.

While these criteria are based on laboratory animals that are quite different than humans, the relative response between animals and humans is generally comparable on a per body weight basis. Thus, expressing the effect in terms of kilogram of body weight provides a satisfactory basis for determining potential human effects based on animal research results. Translating a 50 mg/kg LD_{50} to an understandable situation in humans, if a group of 150-pound humans ingested about one-half teaspoon of such a chemical, approximately 50% would be expected to die.

The HCS provides criteria for classifying chemicals as *highly toxic* and *toxic* based on experiments that used 200-300 gram albino rats or 2-3 kilogram albino rabbits. However, current testing procedures accept other species and do not prescribe exact weights. Although specific criteria are provided, the HCS also indicates that information pertaining to other species and test methods is also relevant. In determining hazards, you need to search for and analyze all data pertaining to toxicity and make judgments as to whether the tests were conducted using appropriate and accepted methodology. If the studies are acceptable, the data should be used as appropriate to determine whether the chemical is *highly toxic*, *toxic*, or belongs to another health hazard category (e.g., hepatotoxicity or irritant).

Irritant

Under the HCS, an irritant is "A chemical, which is not corrosive, but which causes a **reversible inflammatory effect** on living tissue by chemical action at the site of contact. A chemical is a skin irritant if, when tested on the intact skin of albino rabbits by the methods of 16 CFR 1500.41 for four hours exposure or by other appropriate techniques, it results in an empirical score of five or more. A chemical is an eye irritant if so determined under the procedure listed in 16 CFR 1500.42 or other appropriate techniques."

The difference between an irritant and a corrosive is the ability of the body to repair the tissue reaction. With irritants the inflammatory reaction can be reversed whereas with corrosive damage it is permanent or irreparable. The site of irritation is often the skin or eye but can also be any mucous membrane or other tissue that the chemical

comes in contact with. This could include the mouth or throat if the irritant is swallowed, and the nose or lungs if the irritant is inhaled. If an immunologic mechanism (allergy) is responsible for the tissue reaction, the material will be classified as a sensitizer rather than an irritant. Examples of irritants are acetic acid, ammonia, and isopropyl alcohol. The standard toxicology test for inflammation consists of the application of a substance to the shaved skin of white rabbits. White rabbits have been widely used as the irritation is easy to detect and the results have been shown to be highly predictive of potential skin effects in humans. Data obtained with other strains or species can also be used in the determination of irritation potential.

Corrosive

The HCS definition for corrosive is "A chemical that causes visible destruction of, or **irreversible alterations in, living tissue by chemical action at the site of contact.** For example, a chemical is considered to be corrosive if, when tested on the intact skin of albino rabbits by the method described by the U.S. Department of Transportation in appendix A to 49 CFR part 173, it destroys or changes irreversibly the structure of the tissue at the site of contact following an exposure period of four hours. This term shall not refer to action on inanimate surfaces."

Corrosion is manifested by ulcers, cell death, and scar formation. The site of a corrosive effect can be any place on the body that the chemical contacts. This is often the skin or eye but can also be any mucous membrane (such as the mouth or esophagus if swallowed and the nose and trachea if inhaled).

Generally speaking, corrosive materials have a very low pH (acids) or a very high pH (bases). Strong bases are usually more corrosive than acids. Examples of corrosive materials are sodium hydroxide (lye) and sulfuric acid.

The standard toxicology test for corrosivity uses white rabbits with the material applied to the shaved (but not damaged) skin. Experience has shown that results obtained with white rabbits are highly predictive of potential skin effects in humans. Corrosion determined using other species and procedures must also be considered in the decision as to classification as a corrosive.

Sensitizer

The HCS definition for sensitizer is "A chemical that causes a substantial proportion of exposed people or animals to **develop an allergic reaction in normal tissue after repeated exposure** to the chemical."

A sensitizer (allergen) causes little or no reaction in man or test animals on first exposure. The problem arises on subsequent exposures when a marked immunological response occurs. The response is not necessarily limited to the contact site as it may be a generalized body condition. Skin sensitization is common in industry. Respiratory sensitization and generalized hyperallergy to a few chemicals has also been known to occur. Well-known examples of sensitizers are toluene diisocyanate, nickel compounds, and poison ivy.

Target Organ Effects

Hepatotoxin

The HCS definition for **hepatotoxins** is "chemicals which produce **liver damage**". Signs of hepatotoxicity may include jaundice and liver enlargement. Hepatotoxicity includes not only the liver but also the gallbladder and bile duct. The liver is particularly susceptible to foreign chemicals because of its large blood supply and the major role it plays in metabolism. These factors can result in exposure to high doses of a toxicant and the production and immediate exposure to potentially toxic metabolites.

The primary forms of hepatotoxicity are: chemical hepatitis (inflammation of the liver), fatty liver or steatosis (lipid accumulation in hepatocytes), hepatic necrosis (death of the hepatocytes), cholestasis (stoppage of bile flow and backup of bile salts in the liver), cirrhosis (chronic fibrosis, often due to alcohol), hypersensitivity (immune reaction resulting in hepatic necrosis) and hepatic cancer (cancer of the liver). Examples of hepatotoxins are arsenic, carbon tetrachloride, ethyl alcohol, halothane, and vinyl chloride.

Nephrotoxin

The HCS definition for **nephrotoxins** is "chemicals which produce **kidney damage**". Signs often include edema and proteinuria. The kidney is highly susceptible to toxicants for two reasons. There is a very high volume of blood flow through the kidney, and the kidney can filter large amounts of toxins that can concentrate in the kidney tubules. The kidney eliminates body wastes, maintains body levels of electrolytes and fluids, and produces special enzymes and hormones that regulate blood pressure, pH, calcium, and the production of red blood cells. Thus, the effects of nephrotoxicity are systemic in nature, such as hypertension, body fluid and electrolyte imbalance, and anemia. The primary forms of nephrotoxicity are nephritis (inflammation of the kidneys), glomerulonephritis (damage to the glomerulus portion of the nephron), and acute or chronic renal failure.

Examples of nephrotoxins are heavy metals (e.g., chromium, lead, mercury, and uranium) and halogenated hydrocarbons (e.g., carbon tetrachloride and chloroform). While some toxins cause acute effects, many exert their toxicity by long-term exposure at lower levels.

Neurotoxins

The HCS definition for neurotoxins is "chemicals which produce their primary **toxic effects on the nervous system.**" The nervous system directs many of the body's activities so that changes in the nervous system may be apparent throughout the body. Electrical impulses move through the body via neurons (nerve fibers). Toxins can damage cells of the central nervous system (brain and spinal cord) or the peripheral nervous system (nerves outside the central nervous system).

The primary types of neurotoxicity are: neuronopathies (neuron injury), axonopathies (axon injury), demyelination (loss of axon insulation), and interference with neurotransmission. Signs and symptoms of neurotoxicity include narcoses, behavioral changes, and decreases in motor function. Examples of neurotoxins are carbon disulfide, ethylene oxide, hexane, lead, and mercury.

Blood/Hematopoietic Toxin

Blood/hematopoietic toxins are also referred to as hemotoxins or hematotoxins. The HCS defines these chemicals as "Agents which **act on the blood or hematopoietic system:** Decrease hemoglobin function; deprive the body tissues of oxygen."

While one might consider the blood and hematopoietic system as independent tissues, they are intimately related. The hematopoietic system gives rise to the blood elements (cells and platelets). Toxins can act at various points in the hematopoietic/blood system. Some affect the circulating blood elements, interfering with their function. Others damage the hematopoietic system and may prevent it from producing the blood elements.

The formed elements (cells and platelets) in the circulating blood are usually not directly affected by toxins. An exception are the red blood cells (erythrocytes). Several toxic agents can bind with the hemoglobin of the red blood cells and interfere with transport of oxygen to body tissues (hypoxia). Examples of chemicals that bind with hemoglobin and cause hypoxia, by interfering with the oxygen transporting capability of the blood, are carbon monoxide, sodium nitrite, and hydrogen sulfide. Cyanides also cause hypoxia by interfering with the tissue cell's ability to utilize oxygen.

The more common form of hemotoxicity results from chemicals acting directly on the hematopoietic tissues (blood-forming tissue). The primary effect is a decrease in formation of specific blood cells so that the number in the circulating blood is reduced, impairing their ability to function normally. For example, phenothiazine and anticonvulsant drugs can damage the bone marrow cells that give rise to the granulocytes and decreased ability to fight infections. Aspirin and nitroglycerin can be toxic to megakaryocytes that produce blood platelets. The decrease in platelets impairs blood-clotting capability. Other toxins, e.g., arsenic, benzene, and chlordane, can cause a decrease in the formation of all blood elements, a condition known as aplastic anemia. Cancer of the hematopoietic tissues (primarily acute myelogenous leukemia) also occurs due to exposure to some industrial chemicals and drugs, for example, benzene, chloramphenicol, and phenylbutazone.

Respiratory Toxin

The HCS definition for agents which damage the lung is "chemicals which **irritate or damage pulmonary tissue.**" These are commonly known as respiratory toxins. The primary function of the respiratory system is to deliver oxygen to the bloodstream and remove carbon dioxide from the blood. Thus, damage to the respiratory tissues interferes with blood/gas exchange that may cause serious malfunction of all tissues of the body, especially the brain and heart. Respiratory toxicity can occur in the upper respiratory system (nose, pharynx, larynx, and trachea) or in the lower respiratory system (bronchi, bronchioles, and lung alveoli). The primary types of respiratory toxicity are pulmonary irritation, asthma/bronchitis, reactive airway disease, emphysema, allergic alveolitis, fibrotic lung disease, pneumoconiosis, and lung cancer. Some exert their toxicity quickly (acute effects, such as pulmonary irritation) while others act over a long period to time (chronic effects, such as pulmonary fibrosis). Examples of respiratory toxins are asbestos, formaldehyde, ozone, nitrogen dioxide, and silica.

Reproductive Toxin

The HCS definition for **reproductive toxins** is "chemicals which **affect the reproductive capabilities** including chromosomal damage (mutations) and effects on fetuses (teratogenesis)." This definition is comprehensive and incorporates toxic effects on **all** elements of the process of reproduction, including damage to the germ cells of both males and females (sperm and ova).

Thus, a wide variety of effects can occur, including sterility, decreased libido, impotence, interrupted pregnancy (abortion, fetal death, or premature delivery), birth defects in the offspring, altered sex ratio and multiple births, chromosome abnormalities, childhood morbidity, and childhood cancer. Both male and female reproductive effects should be determined. Examples of reproductive toxins are lead and 1,2-Dibromo-3-chloropropane (DBCP). Reproductive toxicity can involve toxicant damage to either the male or female reproductive system. Those substances that can cause birth defects are referred to as teratogens.

The term developmental toxicity refers to adverse effects observed in the embryo, fetus or newborn. In testing, these reproductive effects are usually considered separately from those effects on an adult animal's capacity to successfully mate (fertility) and deliver and nurture offspring (perinatal and postnatal development and maternal function). Developmental toxicity can result from toxicant exposure to either parent before conception or to the mother and her developing embryo-fetus. The three basic types of developmental toxicity are: *Embryolethality* which is the failure to conceive, spontaneous abortion or stillbirth; *embryotoxicity* which is the growth retardation or delayed growth of specific organ systems, and teratogenicity which pertains to irreversible conditions that leave permanent birth defects in live offspring (e.g., cleft palate, missing limbs).

Chemicals can cause developmental toxicity by two mechanisms. They can act directly on cells of the embryo causing cell death or cell damage that leads to abnormal organ development. A chemical might also induce a mutation in a parent's germ cell that is transmitted to the fertilized ovum. Some mutated fertilized ova develop into abnormal embryos.

Genetic toxicity has also been included in the HCS definition of reproductive toxins. Genetic effects result from damage to DNA and altered genetic expression. This process is known as *mutagenesis*. The genetic change is referred to as a mutation and the agent causing the change as a *mutagen*. There are three types of genetic change: *Gene mutation* is a change in DNA sequence within a gene. *Chromosome aberrations* are changes in the chromosome structure. *Aneuploidy/polyploidy* is an increase or decrease in the number of chromosomes

If the mutation occurs in a germ cell (sperm and ova) the effect can be heritable. There is no effect on the exposed person, rather the effect is passed on to future generations. If the mutation occurs in a somatic cell (all body cells except sperm and ova), it can cause altered cell growth (e.g., cancer) or cell death (e.g., teratogenesis) in the exposed person.

Cutaneous Hazard

The HCS definition for **cutaneous hazards** is "chemicals which affect the dermal layer of the body." This overlaps to a certain extent with the previously described hazards, irritant and corrosive. However, here we are concerned only with effects of toxins on the skin. A variety of skin conditions can arise from exposure to toxic substances. Contact dermatitis or inflammation of the skin can be of two types, irritant dermatitis and allergic contact dermatitis. The basic inflammatory reaction is the same but the cause and progress of the dermatitis differs. With irritant dermatitis the effect is immediate without prior exposure, whereas the allergic dermatitis requires previous exposure with the development of allergy or sensitization. Contact dermatitis is common in industry and usually consists of redness (erythema), thickening and firmness of skin (induration), flaking (scaling), and blisters (vesiculation). Normally, the contact dermatitis is reversible if the irritant or allergen is removed.

In contrast, chemical burns can sometimes occur in which immediate necrosis, ulceration, and sloughing of the skin occurs. This injury may be permanent and can leave deep wounds that scar or require transplanted skin to repair the damaged area. Some chemicals can cause irritation by defatting of the skin; for example, commonly used ketones or chlorinated compounds, such as the solvents trichloroethylene, methylene chloride, and gasoline.

Cutaneous hazards may cause skin reactions that are neither irritation or allergic reactions. Oils and halogenated aromatic hydrocarbons can cause acne, mercury and lead can cause increased pigmentation of the skin, hydroquinone can cause decreased pigmentation, and skin cancer can be induced by workplace exposure to arsenic.

Eye Hazard

The HCS definition for eye hazards is "chemicals which affect the eye or visual capacity." The primary toxic effects from direct exposure of chemicals to the eye are conjunctivitis or corneal damage. Conjunctivitis is inflammation of the conjunctiva, the delicate membrane that lines the eyelids and covers the eyeballs. The cornea is the transparent front surface of the eyeball.

Chemicals that accidentally splash onto the face can directly contact either of these eye structures. Acids and strong alkalis (such as lye) may cause severe corneal corrosion and may result in permanent blindness. Organic solvents (such as acetone) and detergents can cause temporary clouding of vision, primarily due to dissolving of fats from the cornea.

Some chemicals can cause toxic effects to the eye even if they do not directly contact the eye. Chemicals that are inhaled or ingested may move to the eye through the blood circulation and produce eye damage. 2-4-Dinitrophenol (a wood preservative) can cause cataracts after ingestion. The ingestion of thallium salts (found in some pesticides) and methanol (wood alcohol) has been associated with blindness due to damage to the optic nerve. Retina damage has been associated with exposures to arsenicals and carbon disulfide.

While animal ocular tests are routinely conducted during the safety testing of new chemicals, detection of damage to the optic nerve and retina are difficult to detect. Unfortunately, this information results from case reports of humans exposed to toxic substances. Irritation and corrosion may be predicted on the basis of the pH of the chemical substance. However, pH has little value in predicting other types of ocular toxicity.

Other Types of Target Organ Hazards

As previously indicated, the HCS does not identify all possible target organ effects due to exposure to toxic agents. Certain chemicals may target one or more specific organs not listed in the HCS. Based on the chemistry of the toxin and how it is metabolized and distributed in the body, virtually any organ or organ system may potentially be at risk. Therefore, data found in the literature search pertaining to other organs must also be evaluated and documented. Of the other important health hazards listed in Table 2, effects on the cardiovascular system and immune system are most likely to be reported for industrial chemicals.

Cardiovascular toxicity has been reported for several industrial chemicals. The effects on the heart are primarily interference with cardiac nerve transmissions or damage to the heart musculature (cardiomyopathy). Either type of affect can prevent the heart from contracting (beating) normally so that the blood is not adequately circulated through the body, resulting in multiple organ damage and dysfunction. Some chemicals can also affect the circulatory vessels (veins, arteries and capillaries). Examples of cardiovascular toxins are ethanol and cobalt (cardiomyopathy); arsenic (arteriosclerosis and vascular lesions); toluene and halogenated alkanes (arrhythmias); and mercury (aortic lesions).

Toxicity to the immune system can lead to several different effects, depending on which cells are damaged, and whether the toxic effects are due to impairment of the immune system (immunosuppression) or the effects are caused by an altered or enhanced immune system (e.g., allergy/hypersensitivity and autoimmunity). A wide variety of industrial chemicals are known to be immunotoxins, including toluene diisocyanate, formaldehyde, silicone, benzene, heavy metals, halogenated aromatic hydrocarbons, and insecticides.

VI. DOCUMENTATION

The fourth and **final step in the hazard determination process** is very important. All the other steps will be wasted if you do not document your findings carefully. If a chemical is found to be hazardous, it is recommended that the findings be documented in order to assist in preparing labels and MSDSs, and to maintain a record for future reference and updating. In addition, the HCS requires data documentation of the hazard determination as follows:

Chemical manufacturers, importers, or employers evaluating chemicals shall describe in writing the procedures they use to determine the hazards of the chemical they evaluate. The written procedures are to be made available, upon request, to employees, their designated representatives, the Assistant Secretary and the Director [OSHA and NIOSH officials]. The written description may be incorporated into the written hazard communication program required under paragraph (e) of this section [the HCS].

To meet the HCS requirements, it is recommended that a structured approach to data retrieval and compilation be adopted. This structured approach applies to preparation of MSDSs and labels.

Compilations of four types of data are considered essential:

- Initial chemical inventory;
- Description of procedures used for hazard determination;
- Specific data retrieved for each chemical; and
- Hazardous chemicals list.

Chemical Inventory

The **chemical inventory** should consist of all chemicals that are produced, imported, or used by the company. The chemical inventory should be complete and contain, at a minimum, the following:

- chemical name;
- CAS Number;
- common name;
- synonyms;
- product/mixture name (if applicable); and
- percentage of ingredients in product/mixture (if applicable).

It is recommended that this chemical inventory be computerized for future sorting, additions, deletions, and status reports.

Description of Procedures Used for Hazard Determination

As indicated previously, the procedures used to determine hazards of chemicals are to be written down and made available upon request to employees as well as to OSHA and NIOSH officials. This written description of procedures should be incorporated into the company's written hazard communication program.

The procedures used for the following hazard determination steps should be described in detail:

- Development of chemical inventory;
- Search strategy and sources used to obtain data on chemicals for which hazard determinations are conducted;
- References retrieved and used to identify each specific physical or health hazard;
- Summary for each retrieved reference that contained relevant data (retrieved computer abstracts can be used);
- Summary of important data that were used for hazard determination; and
- Identification of hazards.

Specific Data Retrieved for Each Chemical

It is recommended that data be organized so as to facilitate the preparation of MSDSs and labels. Listing all the hazard categories and the relevant data obtained for each hazard will also facilitate the gathering of data and document the effectiveness and completeness of the hazard determination process. When data are not located for a specific type of hazard or when a specific hazard would not occur due to the chemical or physical form of the chemical, this should be indicated.

The retrieved data should be listed in the basic format of the MSDS in order to facilitate preparation of MSDSs and labels, as well as to allow for future updating as the need arises. It is highly recommended that the data be computerized and archived in a secure location for future use. A commonly used title for hazard data compilations for specific chemicals is **hazards profile**. A suggested organization for the documentation is provided in Table 3.

Table 3. LIST OF DATA RECOMMENDED FOR INCLUSION IN THE HAZARDS PROFILE FOR A CHEMICAL
(Reference source should be included for each item, where appropriate. In the event that no information on an item is known or it is not applicable, this should be so indicated.)

COMPANY INFORMATION

- Company Name
- Name of Responsible Company Official
- Date Prepared

HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

- Chemical Name
- CAS Number
- Common Name
- Synonyms
- Product/Mixture Name (If Applicable)
- Percentage of Ingredients in Product/Mixture (If Applicable)

PHYSICAL/CHEMICAL CHARACTERISTICS

- Boiling Point
- Freezing Point
- Vapor Pressure (mm Hg.)
- Vapor Density (air = 1)
- Specific Gravity (H_2O = 1)

- Melting Point
- Evaporation Rate (Butyl Acetate = 1)
- Solubility in Water
- Appearance and Odor

FLAMMABILITY/EXPLOSIVITY DATA

- Autoignition Temperature
- Flammable Range
- Flashpoint (Indicate method used)
- Lower Explosive Limit (LEL)
- Upper Explosive Limit (UEL)
- Extinguishing Media
- Special Fire Fighting Procedures
- Unusual Fire and Explosion Hazards
- Extinguishant

REACTIVITY DATA

- Stability - conditions to avoid
- Incompatibilities - materials to avoid
- Hazardous Decomposition or Byproducts
- Hazardous Polymerization - conditions to avoid

SUMMARY of Physical/Chemical Information

- Chemical/Product Identity Information
- List of Potentially Hazardous Properties
- Description of controls that should be employed

HEALTH HAZARD DATA

- Routes of Entry
- Odor Threshold
- Government Exposure Regulations and Guidance
  - OSHA PEL
  - ACGIH TLV
  - NIOSH IDLH
  - NIOSH REL
- Cancer Classifications:
  - OSHA
  - NTP
  - IARC

SUMMARY of Known or Suspected Health Effects Systemic Effects

- Carcinogen
- Toxic
- Highly toxic
- Irritant
- Corrosive
- Sensitizer

Target Organ Effects

- Hepatotoxicity
- Nephrotoxicity
- Neurotoxicity
- Blood/hematopoietic toxicity
- Respiratory toxicity
- Reproductive effects
- Cutaneous hazard
- Eye hazard

Other Important Health Effects

- Cardiovascular toxicity
- Immune toxicity
- Others

APPENDIX A
GLOSSARY OF TERMS AND DEFINITIONS

The following glossary presents brief explanations of acronyms and common terms used in this document.

Absorbed Dose. The amount of a substance that actually enters into the body, usually expressed as milligrams of substance per kilogram of body weight (mg/kg).

ACGIH. The American Conference of Governmental Industrial Hygienists is an organization of government and academic professionals engaged in occupational safety and health programs. ACGIH establishes recommended occupational exposure limits for chemical substances and physical agents known as Threshold Limit Values; see TLV.

Acid. A compound that undergoes dissociation in water with the formation of hydrogen ions. Acids have pH values below 7 and will neutralize bases or alkaline media. Acids will react with bases to form salts. Acids have a sour taste and with a pH in the 0 to 2 range cause severe skin and eye burns.

Acute Dose. The amount of a substance administered or received over a very short period of time (minutes or hours), usually within 24 hours.

Acute Toxicity. The toxic effects resulting from a single dose or short exposure to a substance.

Alkali. (Also referred to as a base) - A compound that has the ability to neutralize an acid and form a salt. Alkali also forms a soluble soap with a fatty acid. Alkalis have pH values above 7 to 14. They are bitter in a water solution. Alkalis with pH values between 12 to14 are considered to be corrosive (caustic) and will cause severe damage to the skin, eyes and mucous membranes. Common strong alkalis are sodium and potassium hydroxide.

Allergic Reaction. An abnormal immunologic response in a person who has become hypersensitive to a specific substance. Some forms of dermatitis and asthma may be caused by allergic reactions to chemicals.

ANSI. The American National Standards Institute is a privately funded, voluntary membership organization that identifies industrial and public needs for national consensus standards and coordinates development of such standards.

ASTM. The American Society for Testing and Materials develops voluntary consensus standards for materials, products, systems, and services. ASTM is a resource for sampling and testing methods, information on health and safety aspects of materials, safe performance guidelines, and effects of physical agents, biological agents, and chemicals.

Autoignition Temperature. The lowest temperature at which a flammable gas or vapor-air mixture will spontaneously ignite without spark or flame. Vapors and gases will spontaneously ignite at a lower temperature in oxygen than in the air. The autoignition temperature may also be influenced by the presence of catalytic substances. Materials should not be heated to greater than 80% of the autoignition temperature.

Benign. Not recurrent or not tending to progress; not cancerous.

Boiling Point (BP). The temperature at which a liquid changes to a vapor state, at a given pressure; usually expressed in degrees of Fahrenheit or Centigrade at sea level pressure (760 mm Hg or one atmosphere). Flammable materials with low boiling points generally present special fire hazards.

CAS Number. A number assigned to a specific chemical by the Chemical Abstracts Service, an organization operated by the American Chemical Society. CAS Numbers are used internationally to identify specific chemicals or mixtures.

Carcinogenicity. The complex process whereby normal body cells are transformed to cancer cells.

cc. Cubic centimeter is a volume measurement in the metric system that is equal in capacity to one milliliter (ml). One quart is approximately 946 cubic centimeters.

CFR. Code of Federal Regulations. A collection of the regulations that have been promulgated under United States Law.

Chemical Name. The name given to a chemical in the nomenclature system developed by the International Union of Pure and Applied Chemistry (IUPAC) or the Chemical Abstracts Service (CAS) or a name which will clearly identify the chemical for hazard evaluation purposes.

Chronic Toxicity. Adverse effects resulting from repeated doses or exposures to a substance over a relatively prolonged period of time.

Decomposition. Breakdown of a material or substance into simpler substances by heat, chemical reaction, electrolysis, decay, or other processes

Dermal. Relating to the skin.

DNA. Deoxyribonucleic acid; the molecules in the nucleus of the cell that contain genetic information.

Dose. The amount of a substance received at one time. Dose is usually expressed as administered or absorbed dose (e.g., milligrams material/kilogram of body weight).

DOT. U.S. Department of Transportation; the Federal agency that regulates transportation of chemicals and other hazardous and non-hazardous substances.

Epidemiology. The branch of science concerned with the study of human disease in specific populations, in order to develop information about the causes of disease and identify preventive measures.

Evaporation Rate. The ratio of the time required to evaporate a measured volume of a liquid to the time required to evaporate the same volume of a reference liquid (butyl acetate, ethyl ether) under ideal test conditions; The higher the ratio, the slower the evaporation rate. The evaporation rate can be useful in evaluating the health and fire hazards of a material.

Explosive Limits. The range of concentrations of a flammable gas or vapor (percent by volume in air) in which explosion can occur if an ignition source is present. Also see Flammable Limits, LEL, and UEL.

Flammable. A material which is easily ignited and burns with extreme rapidity. The two primary measures of this physical hazard are the flashpoint and the autoignition temperature. For specific information on the definition and test methods of flammable materials, refer to 29 CFR 1910.1200. Also see: Flammable Aerosol, Flammable Gas, Flammable Liquid, and Flammable Solid.

Flammable Aerosol. An aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of a valve opening.

Flashback. Occurs when flame from a torch burns back into the tip, the torch, or the hose. It is often accompanied by a hissing or squealing sound with a smoky or sharp-pointed flame.

Flashpoint. The minimum temperature at which a liquid gives off a vapor in sufficient concentration to form an ignitable mixture in air or oxygen. There are several flash point test methods, and flash points may vary for the same material depending on the method used, so the test method is indicated when the flash point is given. See 29 CFR 1910.1200(c) for further information.

Genetic. Pertaining to or carried by genes; hereditary.

Hazard. The inherent capacity of a substance to cause an adverse effect.

IARC. International Agency for Research on Cancer, a component of the World Health Organization, located in Lyon, France.

Ignitable. A solid, liquid or compressed gas which is capable of being set afire.

In Vitro. Outside a living organism (e.g., in a test tube).

Inhalation. Breathing in of a substance in the form of a gas, vapor, fume, mist, or dust.

Latency Period. The time that elapses between exposure and the first manifestations of disease or illness.

LC_{50} - Lethal Concentration 50, Median Lethal Concentration. The calculated concentration of a material in air, which based on laboratory tests (respiratory route) is expected to kill 50% of a group of test animals when administered as a single exposure in a specific time period, usually 1 hour. The LC_{50} can be expressed in several manners:

- as parts of material per million parts of air by volume (ppm) for gases and vapors,
- as micrograms of material per liter of air (mg/l), or

- as milligrams of material per cubic meter of air (mg/m^3) for dusts and mists, as well as for gases and vapors.

LD_{50} - Lethal Dose 50, Median Lethal Dose. The estimated single dose of material which, based on laboratory tests, is expected to kill 50% of a group of test animals. The material may be administered orally or applied to the skin. The LD_{50} dose is usually expressed as milligrams or grams of material per kilogram of animal body weight (mg/kg or g/kg).

LEL or LFL - Lower Explosive Limit or Lower Flammable Limit. Lowest concentration of the substance in air (usually expressed in percent by volume) that will produce a flash or fire when an ignition source (heat, electric arc, or flame) is present. At concentrations lower than the LEL, propagation of a flame will not occur in the presence of an ignition source. Also see UEL.

m3. Cubic meter; a metric measure of volume, approximately 35.3 cubic feet or 1.3 cubic yards.

Malignant Tumor. A tumor that can invade surrounding tissues or metastasize to distant sites resulting in life-threatening consequences.

Melting Point. The temperature at which a solid substance changes to a liquid state.

Metabolism (biotransformation). The conversion of a chemical from one form to another within the body.

Metabolite. A chemical produced during metabolism.

mg/kg. Milligrams of substance per kilogram of body weight, commonly used as an expression of toxicological dose (e.g., 15 mg/kg).

mg/m3. Milligrams per cubic meter; a unit for measuring concentrations of particulates or gases in the air (a weight per unit volume). For example, 20 mg/m3.

milligram (mg). The most commonly used unit of measure in medicine and toxicity consisting of one thousandth of a gram (1x10-3 g).

Mixture. Any combination of two or more substances, if the combination is not, in whole or part, the result of chemical reaction.

ml. Milliliter; a metric unit of volume. There are 1,000 milliliters in one liter. 1 teaspoon = 5 milliliters.

Mutagen. A substance or agent capable of altering the genetic material in a living cell (mutation).

NFPA. The National Fire Protection Association is an international membership organization which promotes fire protection and prevention and establishes safeguards against loss of life and property by fire.

NIOSH. The National Institute for Occupational Safety and Health is a part of the Centers for Disease Control and Prevention, U.S. Public Health Service, U.S. Department of Health and Human Services.

NTP. The National Toxicology Program is a component of the U.S. Public Health Service. The NTP publishes the Annual Report on Carcinogens.

Odor Threshold. The lowest concentration of a substance in air that can be detected by smell.

Oxidation. A change in a chemical characterized by the loss of electrons. In a literal sense, oxidation is a reaction in which a substance combines with oxygen.

PEL - Permissible Exposure Limit. A legally enforceable occupational exposure limit established by OSHA, usually measured as an eight-hour time-weighted average, but also may be expressed as a ceiling concentration exposure limit.

ppm. Parts per million; the proportion (by volume) of a gas or vapor per million parts of air; also the concentration of a chemical in a liquid or solid form.

Reactivity. A substance's susceptibility to undergo a chemical reaction or change that may result in dangerous side effects, such as an explosion, burning, and corrosive or toxic emissions.

Risk. The probability that an adverse effect will occur.

Solubility. The ability of a substance to be dissolved in a solvent. Solubility is expressed according to the solvent (e.g., solubility in water, solubility in acetone, etc.).

STEL. Short-Term Exposure Limit (ACGIH terminology); see TLV.

Synonym. Another name or names by which a material is known. Methyl alcohol, for example, is also known as methanol or wood alcohol.

Target Organ. An organ on which a substance exerts a toxic effect.

Teratogen. A substance that can cause malformations or alterations in the appearance or function of a developing embryo.

TLV - Threshold Limit Value. The occupational exposure limit published by the American Conferences of Governmental Industrial Hygienists (ACGIH). ACGIH expresses Threshold Limit Values in four ways:

- **TLV-TWA: The allowable Time-Weighted Average** - A concentration for a normal 8-hour workday or 40-hour workweek.
- **TLV-STEL: Short-Term Exposure Limit** - A maximum concentration for a continuous 15-minute exposure period (maximum of four such periods per day, with at least 60 minutes between exposure periods, and provided the daily TLV-TWA is not exceeded).
- **TLV-C - Ceiling limit** - A concentration that should not be exceeded even instantaneously.
- **TLV-Skin** - The skin designation refers to the potential contribution to the overall exposure by the cutaneous route, including mucous membranes and the eye. Exposure can be either by airborne or direct contact with the substance. This designation indicates that appropriate measures should be taken to prevent skin absorption.

Toxic Substance. Any substance that can cause injury or illness, or which is suspected of being able to cause injury or illness under some conditions.

Toxicity. A relative property of a chemical agent that refers to a harmful effect on some biological mechanism and the conditions under which this effect occurs.

Toxicology. The study of the harmful interactions of chemicals on living organisms and biological systems.

Trade Name. The trademark name or commercial trade name for a material or product.

TWA. Time-Weighted Average; the concentration of a material to which a person is exposed, averaged over the total exposure time--generally the total workday (8 to12 hours); also see TLV.

UEL or UFL. Upper explosive limit or upper flammable limit; the highest concentration of a vapor or gas (highest percentage of the substance in air) that will produce a flash of fire when an ignition source (e.g., heat, arc, or flame) is present. At higher concentrations, the mixture is too "rich" to burn; also see LEL.

Unstable. Tending toward decomposition or other unwanted chemical change during normal handling or storage.

Vapor density. The weight of a vapor or gas compared to the weight of an equal volume of air is an expression of the density of the vapor or gas. Materials lighter than air (e.g., acetylene, methane, hydrogen) have vapor densities less than 1.0. Materials heavier than air (e.g., propane, hydrogen sulfide, and ethane) have vapor densities greater than 1.0. All vapors and gases will mix with air, but the lighter materials will tend to rise and dissipate (unless confined). Heavier vapors and gases are likely to concentrate in low places along or under floors, in sumps, sewers, manholes, trenches, and ditches where they may create fire or health hazards.

Vapor pressure. Pressure exerted by a saturated vapor above its liquid in a closed container. Three facts are important to remember:

- Vapor pressure of a substance at 100° F will always be higher than the vapor pressure of the substance at 68° F (20° C),
- Vapor pressures reported on MSDS/s in millimeters of mercury (mmHg) are usually very low pressures; 760 mmHg is equivalent to 14.7 pound per square inch (psi).
- The lower the boiling point of a substance, the higher its vapor pressure.

Volatility. The tendency or ability of a liquid or solid material to form a gaseous form at ordinary temperatures. Liquids such as alcohol and gasoline, because of their tendency to evaporate rapidly, are called volatile liquids.

APPENDIX B
Information Sources to Assist with Hazard Determination

This compilation is not intended to be a complete listing of the many literature sources and computerized databases that include information on the physical/chemical and health hazards of chemical substances. Researchers should conduct their own literature search and use the most recent editions of the literature, even though a date is provided in this list for some books and documents.

Documents and Books:

I. Sources for Specific Chemical Data:

A Comprehensive Guide to the Hazardous Properties of Chemical Substances, 2nd Edition. Pradyot Patnaik. Wiley & Sons, New York. 1999.

A Guide to Hazardous Materials Management. Physical Characteristics, Federal Regulations, and Response Alternatives. Aileen Schumacher. Greenwood Press, Westport, CT. 1988.

A Guide to OSHA Regulations on Storing and Handling Flammable and Combustible Liquids. Matthew M. Carmel. 1991.

ATSDR's Toxicological Profiles 2004 on CD-ROM. U.S. Public Health Service, Atlanta, Georgia, USA. 2005.

Bretherick's Handbook of Reactive Chemicals Hazards: An Indexed Guide to Published Data, 6th Edition. L. Bretherick, P. L. Urben, and M. Pitt. Butterworth-Heinemann, Boston. 1999. Also on CD-ROM.

Canadian Centre for Occupational Health and Safety (CCOHS). CD-ROMs containing the complete text of more than 80,000 MSDSs on chemical products contributed by over 600 manufacturers and suppliers.

Chemical Hazards in the Workplace. Ronald M. Scott. Lewis Publishers, Inc., Chelsea, Michigan. 1989.

Chemical Reaction Hazards, 2nd Edition. John Barton and Richard Rogers. Gulf Professional Publishing. 1997.

Chemical Safety Manual for Small Business. American Chemical Society, Washington, D.C.

Chemically Induced Birth Defects, 2nd Edition. James L. Schardein. Marcel Dekker, Inc., New York. 1993.

Chemistry of Hazardous Materials. 4th Edition. Eugene Meyer. Prentice-Hall, Inc., Englewood Cliffs, NJ. 2005.

Clinical Toxicology of Commercial Products. Gleason, Gosselin, and Hodge. The Williams and Wilkins Co., Baltimore. 1984.

Cooper's Toxic Exposures Desk Reference with CD-ROM. Andre R. Cooper, Sr, editor. CRC Press/Lewis Publishers, Inc., Boca Raton, Florida. 1996.

CRC Handbook of Chemistry and Physics, 83rd Edition. David R. Lide, editor. CRC Press, Boca Raton, Florida. 2003. Also on CD-ROM.

Dangerous Properties of Industrial and Consumer Chemicals. Nicholas P. Cheremisinoff. Marcel Dekker, Inc., New York. 1994.

Dictionary of Chemical Names and Synonyms. Philip H. Howard and Michael Neal. ACGIH Publication 9422. ACGIH, Cincinnati. 1992.

Dictionary of Toxicology. Robert A. Lewis, editor. Lewis Publishers, Inc., Boca Raton, Florida. 1998.

Documentation of the Threshold Limit Values and Biological Exposure Indices, 7th Edition. ACGIH, Cincinnati. 2005.

Emergency Responder Training Manual for the Hazardous Material Technician. Center for Labor Education and Research. Van Nostrand Reinhold Co., New York. 1992.

Emergency Response to Chemical Spills. W. Brock Neely. Lewis Publishers, Inc., Boca Raton, Florida. 1992.

Emergency Response Guidebook (2004): A Guidebook for First Responders During the Initial Phase of a Hazardous Materials/Dangerous Goods Incident. DOT, Washington, DC. 2004.

Emergency Toxicology. Peter Viccellio, editor. Lippincott-Raven, 1998.

Encyclopedia of Toxicology. Second Edition. Philip Wexler, editor-in-chief. Elsevier Academic Press, San Diego. 2005.

Environmental and Occupational Medicine, 3rd Edition. William N. Rom, editor. Little, Brown and Co., Boston. 1998.

Ethel Browning's Toxicity and Metabolism of Industrial Solvents. Three volumes. Elsevier Science Publishing Co., New York. 1992.

Explosives Identification Guide. Mike Pickett and Delmar Learning. 1998.

Fire Protection Guide to Hazardous Materials, 13th Edition. National Fire Protection Association (NFPA), Quincy, MA, USA. 2001.

General and Applied Toxicology, 2nd edition. Bryan Ballantyne, Timothy Marrs and Tore Syverson, editors. McMillan References, Ltd., London. 1999.

Guide to Occupational Exposure Values. ACGIH, Cincinnati. 2005.

Guidelines for Safe Storage and Handling of Reactive Materials. Center for Chemical Process Safety (CCPS). American Institute of Chemical Engineering. 1995.

Guidelines for Chemical Reactivity Evaluation and Application to Process Design. Center for Chemical Process Safety (CCPS), American Institute of Chemical Engineering. 1995.

Hamilton and Hardy's Industrial Toxicology, 5th Edition. Raymond D. Harbison. Mosby, Inc., St. Louis. 1998.

Handbook of Chemical Health and Safety. Robert Alaimo, editor. 2001.

Handbook of Hazard Communication and OSHA Requirements. George G. Lowry and Robert C. Lowry. Lewis Publishers, Inc., Chelsea, Michigan. 1988.

Handbook of Hazardous Chemical Properties. Nicholas P. Cheremisinoff. Butterworth-Heinemann. 2000.

Handbook of Hazardous Materials. Morton Corn. Academic Press, San Diego. 1993.

Handbook of Highly Toxic Materials Handling and Management. Stanley S. Grossel and Daniel A. Crowl, editors. Marcel Dekker, Inc., New York. 1994.

Handbook of Industrial Toxicology, 3rd Edition. E.R. Plunkett, editor, Chemical Publishing Co., Inc., New York. 1987.

Handbook of Organic Solvent Properties. Ian Smallwood. Butterworth-Heinemann. 1996.

Handbook of Physical Properties of Organic Chemicals. Philip H. Howard and William M. Meylan, editors. Lewis Publishers, Inc. 1997.

Handbook of Toxic and Hazardous Chemicals and Carcinogens, 4th Edition. Marshall Sittig. Noyes Data Corp., Park Ridge, New Jersey. 2001.

Handbook of Toxicology, 2nd Edition. Michael J. Derelanko and Mannfred A. Hollinger. CRC Press. 2002.

Hawley's Condensed Chemical Dictionary, 14th Edition. Richard J. Lewis, editor. Van Nostrand Reinhold, New York. 2001.

Hazardous and Toxic Materials: Safe Handling and Disposal, 2nd edition. Howard Fawcett. 1988.

Hazardous Chemicals Desk Reference, 5th Edition. Richard J. Lewis, Jr., John Wiley & Sons/Van Nostrand Reinhold, New York. 2002.

Hazardous Chemicals Handbook, 2nd Edition. P. Carson and C. J. Mumford. Butterworth-Heinemann. 2002.

Hazardous Industrial Chemicals - Material Safety Data Sheets - Preparation. ANSI Z400.1 Standard American National Standards Institute, Washington D.C. 2004.

Hazardous Materials Behavior and Emergency Response Operations. Denis Zelmet and David Ballard. ASSE. 2000.

Hazardous Materials Chemistry, 2nd Edition. A. Bevelacqua. 2005.

Hazardous Materials Chemistry for Emergency Responders: 2nd Edition. Robert Burke. 2002.

Hazardous Materials Handbook. Richard P. Pohanish and Stanley A. Greene, John Wiley & Sons. 1996.

Hazardous Materials Response Handbook, 2nd Edition. National Fire Protection Association. Quincy, Massachusetts. 1992.

Hazardous Materials Toxicology: Clinical Principles of Environmental Health. John B. Sullivan and Gary R. Krieger. William and Wilkins, Baltimore. 1992.

Hazardous Substances Resource Guide. Richard P. Pohanish and Stanley A. Green, editors. Gale Research, Inc., Detroit. 1993.

Health Protection from Chemicals in the Workplace. P. Lewis. Englewood Cliffs, Prentice Hall, New Jersey. 1993.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. International Agency for Research on Cancer, WHO, Lyon, France.

Improving Reactive Hazard Management. U.S. Chemical Safety and Hazard Investigation Board, Report No. 2001-01-H. 2002.

Industrial Organic Chemicals, 2nd edition. Harold A. Wittcoff, Bryan Reuben, and Jeffery Plotkin. 2004.

Kirk Othmer Encyclopedia of Chemical Technology, Fifth edition. 15 volumes. Wiley-Interscience. 2005.

Material Safety Data Sheets. The Writer's Desk Reference. Richard P. Molinelli, Michael J. Reale, and Ralph I. Freudenthal, editors. Hill and Garnett Publishing, Inc., Boca Raton, Florida. 1992.

MERCK Index. Full text of the printed edition. Gives concise information on over 10,000 chemicals.

MSDS Pocket Dictionary, 3rd edition. Genium Publishing. 1998.

NIOSH Pocket Guide to Chemical Hazards. National Institute for Occupational Safety and Health, U.S. Public Health Service. NIOSH Pub. 2005-151. U.S. Government Printing Office, Washington, D.C. 2005. Available online at

NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards. Original plus 4 supplements. NIOSH/OSHA. 1981-1995.

NTP's Annual Report on Carcinogens. National Toxicology Program, Research Triangle Park, NC.

Occupational Health and Safety, 2nd Edition. Joseph LaDou, editor. National Safety Council, Chicago, Illinois. 1993.

Occupational Health Guidelines for Chemical Hazards. NIOSH/OSHA. NIOSH Pub. No. 81-123. 1981.

Occupational Health Risk Assessment and Management. Blackwell Science, Ltd., Oxford, England. 1999.

Occupational Medicine, 3rd Edition. Carl Zenz, O. Bruce Dickerson and Edward P. Horvath, Jr., Mosby - Year Book, Inc., St. Louis. 1994.

Occupational Toxicology, 2nd edition. Neil H. Stacey and Chris Winder, editors. Taylor & Francis, Inc., Bristol, Pennsylvania. 2002.

OSHA Technical Manual, 5th edition. OSHA. 1999.

Patty's Hygiene and Toxicology, 5th Edition, 13 Volume Set. Eula Bingham, Barbara Cohrssen, and Charles H. Powell. John Wiley & Sons, New York. 2001.

Patty's Industrial Hygiene and Toxicology, 5th edition. Robert Harris. John Wiley & Sons, New York. 2000.

Patty's Toxicology Mini Set Volume Two and Three - Metals. Eula Bingham and Barbara Cohrssen, editors. John Wiley & Sons, New York. 2001.

Patty's Toxicology, 8 Volume + Index Set. Eula Bingham, Barbara Cohrssen, and Charles H. Powell. 2001.

Proctor and Hughes' Chemical Hazards of the Workplace, 5th Edition. Gloria J. Hathaway and Nick H. Proctor. Van Nostrand Reinhold, New York. 2004.

Product Safety Management and Engineering, 2nd Edition. Willie Hammer. ASSE.

Rapid Guide to Chemical Incompatibilities. Richard Pohanish and Stanley Greene. 1997.

Rapid Guide to Hazardous Chemicals in the Workplace, 3rd Edition. Richard J. Lewis, Sr., Van Nostrand Reinhold. 1994.

Recognition of Health Hazards in Industry, 2nd Edition. William A. Burgess. John Wiley and Sons, New York. 1995.

Reproductively Active Chemicals; A Reference Guide. Richard J. Lewis. Van Nostrand Reinhold, New York. 1997.

Sax's Dangerous Properties of Industrial Materials, 11th edition. 3 volume set. Richard J. Lewis. Wiley-Interscience. 2004.

Sittig's Handbook of Toxic and Hazardous Chemicals and Carcinogens, 4th edition. 2 Volume Set. Richard P. Pohanish, editor. Noyes Publications. 2002.

Storage and Handling of Petroleum Liquids, 3rd edition. Hughes, John R., Center for Chemical Process Safety (CCPS), American Institute of Chemical Engineering. John Wiley & Sons. 1988.

The Chemistry of Explosives. Jacqueline Akhavan, Springer Verlag. 1998.

The Comprehensive Handbook of Hazardous Materials. H.L.A. Sacarello. Lewis Publishers, Inc., Boca Raton, Florida. 1994.

The Merck Index: An Encyclopedia of Chemicals, Drugs and Biologicals, 13th Edition. Maryadele J. O'Neil, Ann Smith, Patricia E. Heckelman, John R. Obenchain, Jo Ann R. Gallipeau , and Mary Ann D'Arecca, editors. Merck Co. 2001.

TLVs and BEIs (2006). ACGIH, Cincinnati. 2006.

Toxicology Desk Reference. The Toxic Exposure and Medical Monitoring Index, 5th edition. Robert P. Ryan and Claude E. Terry, editors. Taylor & Francis. 1999.

Toxicology of Industrial Compounds. Hemut Thomas, Robert Hess and Felix Waechter. Taylor & Francis, London. 1996.

Wiley Guide to Chemical Incompatibilities, 2nd Edition. Richard P. Pohanish and Stanley A. Greene. John Wiley & Sons. 2003.

II. Useful References on Principles and Procedures:

A Textbook of Modern Toxicology, 2nd Edition. Ernest Hodgson and Patricia E. Levi. McGraw-Hill Professional. 1997.

Basic Concepts of Industrial Hygiene. Ronald M. Scott. 1997.

Basic Environmental Toxicology. Lorris G. Cockerham and Barbara S. Shane. CRC Press, Boca Raton, Florida. 1994.

Basic Toxicology: Fundamentals, Target Organs, and Risk Assessment, 3rd Edition. Frank C. Lu. Taylor and Francis, Washington DC. 1996.

Casarett and Doull's Toxicology: The Basic Science of Poisons, 6th Edition. Louis J. Casarett, Curtis D. Klaasen, and John Doull, editors. McGraw-Hill Professional, New York. 2001.

Chemical Hazard Communication Guidebook, 2nd Edition. Andrew B. Waldo. McGraw Hill Book Company, Highstown, New Jersey. 1993.

Comprehensive Review in Toxicology, 2nd Edition. Peter D. Bryson. Aspen Publishers, Rockville, Maryland. 1989.

Comprehensive Toxicology. I. Glenn Sipes, A. Jay Gaddolfi, and Charlene A. McQueen, Elsevier Science. 1997.

Dictionary of Toxicology, 2nd edition. Ernest Hodgson, Richard Mailman, and Robert Dow. McMillan References, Ltd. London. 1998.

Essentials of Environmental Toxicology. W. William Hughes. Taylor and Francis, Washington D.C. 1996.

Fundamentals of Industrial Hygiene. Barbara A. Plog and Patricia J. Quinlan, Nat! Safety Council. 2001.

Handbook of Chemical Industry Labeling. Charles J. O'Connor and Sidney I. Lirtzman, editors. Noyes Publications, Park Ridge, New Jersey. 1984.

Hazard Communication Compliance Manual - A User's Guide to OSHA's Hazard Communication Standard. J.C. Silk and M.B. Kent, editors. Society for Chemical Hazard Communication. The Bureau of National Affairs, Inc., Washington D.C. 1995.

Industrial Toxicology. Philip L. Williams and James L. Burson. Van Nostrand Reinhold, New York. 1989.

Information Resources in Toxicology, 3rd edition. P.J. Hakkinen, Gerald Kennedy, Frederick Stoss, and Philip Wexler, editors. Academic Press. 1999.

International Directory of Testing Laboratories, 1997 Edition. ASTM, West Conshohocken, Pennsylvania. 1997.

Loomis's Essentials of Toxicology, 4th Edition. Ted A. Loomis. Academic Press, San Diego, California. 1996.

Principles and Methods of Toxicology, 3rd Edition. A. Wallace Hayes, editor. Raven Press, New York. 1994.

Principles of Toxicology: Environmental and Industrial Applications, 2nd Edition. Phillip L. Williams, Robert C. James and Stephen M. Roberts, editors. 2000.

The Occupational Environment: Its Evaluation and Control. Second Edition. Salvatore R. Dinardi, editor. AIHA. 2003.

Toxicology. Thomas J. Haley and William O. Berndt, editors. Hemisphere Publishing Corp., New York. 1988.

Toxicology: A Primer on Toxicology Principles and Applications. Michael A. Kamrin. Lewis Publishers, Inc., Boca Raton, Florida. 1988.

III. Comprehensive Bibliographic and Factual Databases

Chemical Hazard Response Information System (CHRIS). This online database developed by the U.S. Coast Guard contains physical and chemical properties and health hazards for over 1,000 chemical substances. U.S. Coast Guard. Department of Transportation.

Chemical Information Systems (CIS). CIS is a collection of 33 databases from various sources like EPA, NIOSH, NLM that contains references to literature including: toxicological and/or carcinogenic research data; information on handling hazardous materials; chemical/physical property information; regulations; safety and health effects information; and pharmaceutical data. It is operated by the **National Information Services Corporation (NISC USA)**, Baltimore, Maryland.

CHEMTREC Hazard Information Transmission. Chemical profiles represent a synthesis of information from reference materials and MSDSs submitted by industry. The database is for use of groups which respond to chemical emergencies.

Immediately Dangerous to Life or Health (IDLHs). The "immediately dangerous to life or health air concentration values (IDLHs)" are used by NIOSH as respirator selection criteria. They were first developed in the mid-1970s, and reviewed and revised in 1994. Available via NIOSH.

International Chemical Safety Cards (ICSCs). ICSC cards summarize essential health and safety information on chemicals for their use at the "shop floor" level by employees and employers in factories, agriculture, construction and other work places. The ICSCs project is an undertaking of the International Programme on Chemical Safety (IPCS). The U.S. version of the ICSCs has been modified by the National Institute for Occupational Safety and Health (NIOSH) to include the following: Occupational Safety and Health Administration Permissible Exposure Limits (OSHA PELs); National Institute for Occupational Safety and Health Recommended Exposure Limits (NIOSH RELs); IDLHs, and links to the NIOSH Pocket Guide to Chemical Hazards. Available via NIOSH.

NIOSH Pocket Guide to Chemical Hazards (NPG). The NPG is intended as a source of general industrial hygiene information on several hundred chemicals/classes for employees, employers, and occupational health professionals. Available via NIOSH.

Occupational Safety and Health Guidelines for Chemical Hazards. Summarizes information on permissible exposure limits, chemical and physical properties, and health hazards. It provides recommendations for medical surveillance, respiratory protection, and personal protection and sanitation practices for specific chemicals that have Federal occupational safety and health regulations. Available via NIOSH.

Registry of Toxic Effects of Chemical Substances (RTECS®). This is an extensive chemical database originally developed and published by NIOSH that serves as an important reference for the identification of health hazards literature. It is now maintained and marketed by MDL Information Systems.

TSCATS. An index of unpublished health and safety studies and test data for over 2,700 chemicals submitted to EPA under the Toxic Substances Control Act (TSCA).

NLM Databases:

- **CCRIS.** Chemical Carcinogenesis Research Information System - carcinogenicity, mutagenicity, tumor promotion, and tumor inhibition data provided by the National Cancer Institute (NCI). Contains coverage of literature on cancer research and testing from 1963 to the present.
- **ChemIDplus.** This is an online data file of the NLM that contains names, synonyms, CAS registry numbers, and a locator for other databases that contain information for thousands of chemicals.
- **CHEMID/SUPERLIST.** This file maintained by the NLM serves as a locator for NLM databases containing information for over 180,000 compounds. It also lists chemicals regulated by other government agencies.
- **DART.** A bibliographic database covering teratology and other aspects of developmental and reproductive toxicology. Serves as a continuation of ETIC, below.
- **DERMAL.** Contains toxic effects, absorption, distribution, metabolism, and excretion data related to dermal absorption of 650+ chemicals.
- **DIRLINE.** A database containing information about information resource centers, primarily health and biomedical organizations.
- **EMIC.** A bibliographic database on chemical agents that have been tested for mutagenic activity.
- **ETIC.** A bibliographic database on chemical agents that have been tested for mutagenic activity.
- **GENETOX.** Peer-reviewed mutagenicity test data from the Environmental Protection Agency (EPA).
- **ITER.** Integrated search of any or all of the following databases: Hazardous Substances Data Bank (HSDB), Integrated Risk Information System (IRIS), International Toxicity Estimates for Risk (ITER), Chemical Carcinogenesis Research Information (CCRIS), and Genetic Toxicology (GENE-TOX).
- **IRIS.** Integrated Risk Information System - data from the Environmental Protection Agency (EPA) in support of human health risk assessment, focusing on hazard identification and dose-response assessment.
- **Haz-Map.** Haz-Map is an occupational health database designed for health and safety professionals and for consumers seeking information about the health effects of exposure to chemicals and biological at work.
- **Household Products.** This database links over 5,000 consumer brands to health effects from Material Safety Data Sheets (MSDS) provided by the manufacturers and allows scientists and consumers to research products based on chemical ingredients.
- **HSDB. Hazardous Substances Data Bank.** This is peer-reviewed database which contains chemical and physical properties for over 4,200 chemicals. It is available from the NLM.
- **PubMed/MEDLINE.** Indexes articles from 3,200+ biomedical journals published in the U.S. and abroad. It is a major source of biomedical literature with coverage from 1966 to the present. Produced by the NLM.
- **TERIS.** Produced by the University of Washington and deals with the risks of prenatal exposure to hazardous substances.
- **Toxicology Tutorials.** Three college-level tutorials covering the principles of toxicology, toxicokinetics, and cellular toxicology.
- **TOXLINE.** Contains comprehensive bibliographic coverage of toxicology information in published literature.
- **TRI.** Toxics Release Inventory, an annual report of the EPA that estimates releases of toxic chemicals to the environment.

IV. Internet Access Addresses for Information or Publications Related to Chemical Hazards and HazComm:

American Conference of Governmental Industrial Hygienists (ACGIH)

American Industrial Hygiene Association (AIHA)

American Society of Safety Engineers (ASSE)

Canadian Centre for Occupational Safety and Health

Center for Chemical Process Safety

Center for Environmental and Regulatory Services

Environmental Protection Agency (EPA)

MSDSOnline.com

MSDSSearch.com

National Institute for Occupational Safety and Health (NIOSH)

National Library of Medicine (NLM) Data Bases

Occupational Safety and Health Administration (OSHA)

OSHA Chemical Sampling Information pages

Society for Chemical Hazard Communication (SCHC)

TOXTUTOR

U. Kentucky MSDS Locator

Trade Associations:

American Chemistry Council (ACC). Arlington, VA.

American Petroleum Institute (API). Washington D.C.

Chemical Producers and Distributors Association. Alexandria, VA.

National Safety Council.

Synthetic Organic Chemical Manufacturers Association (SOCMA). Washington D.C.

APPENDIX C
Materials Regulated by OSHA as Toxic and Hazardous Substances

29 CFR 1910, Subpart Z - Toxic and Hazardous Substances. Occupational Safety and Health Administration. This list may be updated periodically, so the most current list should be consulted.

2,4,5-T
2,4-D (Dichlorophenoxyacetic acid)
Acetaldehyde
Acetic acid
Acetic anhydride
Acetone
Acetonitrile
Acetylene tetrabromide
Acetylsalicylic acid (Aspirin)
Acrolein
Acrylamide
Acrylic acid
Aldrin
Allyl alcohol
Allyl chloride
Allyl glycidyl ether
Allyl propyl disulfide
alpha-Alumina
Aluminum metal
Aluminum, alkyls
Aluminum, pyro powders
Aluminum, soluble salts
Aluminum, welding fumes
2-Aminopyridine
Amitrole
Ammonia
Ammonium chloride fume
Ammonium sulfamate
sec-Amyl acetate
n-Amyl acetate
Aniline and homologs
Anisidine (o-, p- isomers)
Antimony
Antimony compounds
ANTU (alpha-Naphthyl thiourea)
Arsenic

Arsine
Atrazine
Azinphos-methyl
Barium
Barium sulfate
Barium, soluble compounds
Benomyl
Benzene
Benzoyl peroxide
Benzyl chloride
Beryllium
Beryllium compounds, n.o.s.
Bismuth telluride (Se doped)
Bismuth telluride, undoped
Borates, tetra, sodium salts, anhydrous
Borates, tetra, sodium salts, decahydrate
Borates, tetra, sodium salts, pentahydrate
Boron oxide
Boron tribromide
Boron trifluoride
Bromacil
Bromine
Bromine pentafluoride
Bromoform
Butadiene (1,3-Butadiene)
Butane
2-Butanone (Methyl ethyl ketone)
2-Butoxyethanol
n-Butyl acetate
tert-Butyl acetate
sec-Butyl acetate
Butyl acrylate
tert-Butyl alcohol
sec-Butyl alcohol
n-Butyl alcohol
tert-Butyl chromate
n-Butyl glycidyl ether (BGE)
n-Butyl lactate
Butyl mercaptan
Butylamine (n-)
o-sec-Butylphenol
p-tert-Butyltoluene
Cadmium
Cadmium fume
Calcium carbonate
Calcium cyanamide
Calcium hydroxide
Calcium oxide
Calcium silicate
Calcium sulfate
Camphor, synthetic
Caprolactam
Captafol (Difolatan)
Captan
Carbaryl (Sevin)
Carbofuran (Furadan)
Carbon black
Carbon dioxide
Carbon disulfide
Carbon monoxide
Carbon tetrabromide
Carbon tetrachloride
Carbonyl fluoride
Catechol (pyrocatechol)
Cellulose
Cesium hydroxide
Chlordane
Chlorinated camphene
Chlorinated diphenyl oxide
Chlorine
Chlorine dioxide
Chlorine trifluoride
1-Chloro-1-nitropropane
2-Chloro-6-(trichloromethyl)pyridine
Chloroacetaldehyde
alpha-Chloroacetophenone (Phenacyl chloride)
Chloroacetyl chloride
Chlorobenzene
o-Chlorobenzylidene malonitrile
Chlorobromomethane
Chlorodifluoromethane
Chlorodiphenyl (42% chlorine) (PCB)
Chlorodiphenyl (54% chlorine) (PCB)
Chloroform (Trichloromethane)
Chloropentafluoroethane
Chloropicrin
Chloropicrin/methyl chloride
beta-Chloroprene

o-Chlorostyrene
o-Chlorotoluene
Chlorpyrifos
Chromates
Chromic acid
Chromium
Chromium (III) compounds, soluble
Chromium insoluble salts
Clopidol
Coal dust (greater than or equal to 5% SiO_2), respirable quartz fraction
Coal tar pitch volatiles
Cobalt carbonyl
Cobalt hydrocarbonyl
Cobalt metal, dust and fume
Copper
Copper dusts and mists
Cotton dust (raw)
Crag herbicide (Sesone)
Cresol, all isomers
Crotonaldehyde
Crotonaldehyde, (E)-
Cruformate
Cumene
Cyanamide
Cyanides
Cyanogen
Cyanogen chloride
Cyclohexane
Cyclohexanol
Cyclohexanone
Cyclohexene
Cyclohexylamine
Cyclonite
Cyclopentadiene
Cyclopentane
Cyhexatin
Decaborane
Demeton (Systox)
Di-sec octyl phthalate (Di-2-ethylhexyl-phthalate)
2,6-Di-tert-butyl-p-cresol
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)
Diazinon
Diazomethane
Diborane
Dibutyl phosphate
Dibutyl phthalate
2-N-Dibutylaminoethanol
Dichloro diphenyl trichloroethane (DDT)
1,1-Dichloro-1-nitroethane
1,3-Dichloro-5,5-dimethyl hydantoin
Dichloroacetylene
o-Dichlorobenzene
p-Dichlorobenzene
Dichlorodifluoromethane
1,1-Dichloroethane
Dichloroethyl ether
1,2-Dichloroethylene
Dichlorofluoromethane
1,3-Dichloropropene
2,2-Dichloropropionic acid
1,2-Dichlorotetrafluoroethane
Dichlorvos (DDVP)
Dicrotophos
Dicyclopentadiene
Dicyclopentadienyl iron
Dieldrin
Diethanolamine
Diethyl ketone
Diethyl phthalate
Diethylamine
2-Diethylaminoethanol
Diethylene triamine
Difluorodibromomethane
Diglycidyl ether (DGE)
Diisobutylketone
Diisopropylamine
Dimethyl 1,2-dibromo-2,2-dichloroethyl phosphate
Dimethyl acetamide
Dimethyl aniline (N,N-dimethylaniline)
1,1-Dimethyl hydrazine
Dimethyl phthalate
Dimethyl sulfate
Dimethylamine
Dimethylformamide
Dinitolmide (3,5-Dinitro-o-toluamide)
Dinitro-o-cresol
Dinitrobenzene (alpha-)
Dinitrobenzene (meta-)

Dinitrobenzene (para-)
Dinitrobenzene, all isomers
Dinitrotoluene
Dioxane (Diethylene dioxide)
Dioxathion (Delnav)
Diphenyl (Biphenyl)
Diphenylamine
Dipropyl ketone
Dipropylene glycol, methyl ether
Diquat
Disulfiram
Disulfoton
Diuron
Divinyl benzene
Emery
Endosulfan
Endrin
Epichlorohydrin
EPN
Ethanolamine
Ethion
2-Ethoxyethanol
2-Ethoxyethyl acetate (Cellosolve acetate)
Ethyl acrylate
Ethyl alcohol (Ethanol)
Ethyl amyl ketone (5-Methyl-3-heptanone)
Ethyl benzene
Ethyl bromide
Ethyl butyl ketone (3-Heptanone)
Ethyl chloride
Ethyl ether
Ethyl formate
Ethyl mercaptan
Ethyl silicate
Ethylacetate
Ethylamine
Ethylene chlorohydrin
Ethylene diamine
Ethylene dibromide (1,2-Dibromoethane)
Ethylene dichloride
Ethylene glycol
Ethylene glycol, dinitrate
Ethylidene norbornene
N-Ethylmorpholine
Fenaminphos
Fensulfothion (Dasanit)
Fenthion
Ferbam
Ferrovanadium dust
Fluorides
Fluorine
Fluorotrichloromethane (Trichlorofluoromethane)
Fonofos
Formaldehyde
Formamide
Formic acid
Furfural
Furfuryl alcohol
Gasoline
Germanium tetrahydride
Glutaraldehyde
Glycerin mist
Glycidol
Grain dust (oat, wheat, barley)
Graphite, natural
Graphite, synthetic
Gypsum
Hafnium
Heptachlor
Heptane (n-Heptane)
Hexachlorobutadiene
Hexachlorocyclo-pentadiene
Hexachloroethane
Hexachloronaphthalene
Hexafluoroacetone
n-Hexane
Hexane isomers
2-Hexanone (Methyl n-butyl ketone)
Hexone (Methyl isobutyl ketone)
sec-Hexyl acetate
Hexylene glycol
Hydrazine
Hydrogen bromide
Hydrogen chloride
Hydrogen cyanide
Hydrogen fluoride
Hydrogen peroxide
Hydrogen selenide

Hydrogen sulfide
Hydrogenated terphenyls
Hydroquinone
2-Hydroxypropyl acrylate
Indene
Indium
Indium compounds, n.o.s.
Iodine
Iodoform
Iron oxide fume
Iron salts (soluble)
Iron, pentacarbonyl-
Isoamyl acetate
Isoamyl alcohol (primary and secondary)
Isobutyl acetate
Isobutyl alcohol
Isooctyl alcohol
Isophorone
Isophoronediisocyanate
2-Isopropoxyethanol
Isopropyl acetate
Isopropyl alcohol
Isopropyl ether
Isopropyl glycidyl ether (IGE)
Isopropylamine
N-Isopropylaniline
Kaolin
Ketene
L.P.G. (liquified petroleum gas)
Lindane
Lithium hydride
Magnesite
Magnesium oxide fume
Malathion
Maleic anhydride
Manganese
Manganese cyclopentadienyl tricarbonyl
Manganese fume
Manganese tetroxide
Mercury
Mercury (organo) alkyl compounds
Mesityl oxide
Methacrylic acid
Methomyl (Lannate)
Methoxychlor
4-Methoxyphenol
Methyl 2-cyanoacrylate
Methyl acetate
Methyl acetylene (Propyne)
Methyl acetylene - Propadiene mixture (MAPP)
Methyl acrylate
Methyl acrylonitrile
Methyl alcohol
Methyl bromide (Bromomethane)
Methyl cellosolve (2-methoxyethanol)
Methyl cellosolve acetate (2-Methoxyethyl acetate)
Methyl chloride
Methyl chloroform (1,1,1-Trichloroethane)
Methyl cyclopentadienyl manganese tricarbonyl
Methyl demeton
Methyl ethyl ketone peroxide (MEKP)
Methyl formate
Methyl hydrazine (Monomethyl hydrazine)
Methyl iodide
Methyl isoamyl ketone
Methyl isocyanate
Methyl isopropyl ketone
Methyl methacrylate
Methyl n-amyl ketone
Methyl parathion
Methyl silicate
alpha-Methyl styrene
Methylal (Dimethoxymethane)
Methylamine
Methylcyclohexane
Methylcyclohexanol
o-Methylcyclohexanone
Methylene bis (4-cyclohexylisocyanate)
Methylene bisphenol isocyanate (MDI)
Methylene chloride
4,4'-Methylenebis (2-chloroaniline) (MBOCA)
Methylisobutyl carbinol
Methylmercaptan
Metribuzin
Mica
Molybdenum
Molybdenum insoluble compounds
Molybdenum soluble compounds

Monocrotophos (Azodrin)
Monomethylaniline
Morpholine
Naphtha (coal tar)
Naphthalene
Nickel
Nickel carbonyl
Nickel insoluble compounds
Nickel soluble compounds
Nicotine
Nitric acid
Nitric oxide
p-Nitroaniline
Nitrobenzene
p-Nitrochlorobenzene
Nitroethane
Nitrogen dioxide
Nitrogen trifluoride
Nitroglycerin
Nitromethane
2-Nitropropane
1-Nitropropane
o-Nitrotoluene
m-Nitrotoluene
p-Nitrotoluene
Nonane
Octachloronaphthalene
Octane
Oil mist, mineral
Osmium tetroxide
Oxalic acid
Oxygen difluoride
Ozone
Paraffin wax fume
Paraquat
Paraquat
Paraquat methosulfate
Parathion
Particulates not otherwise regulated
Pentaborane
Pentachloronaphthalene
Pentachlorophenol
Pentaerythritol
Pentane
2-Pentanone (Methyl propyl ketone)
Perchloroethylene (Tetrachloroethylene)
Perchloryl fluoride
Perlite
Petroleum distillates (naphtha) (rubber solvent)
Phenol
Phenothiazine
Phenyl ether
Phenyl ether-Biphenyl mixture vapor
Phenyl glycidyl ether (PGE)
Phenyl mercaptan
p-Phenylene diamine
Phenylhydrazine
Phenylphosphine
Phorate
Phosdrin (Mevinphos)
Phosgene (Carbonyl chloride)
Phosphine
Phosphoric acid
Phosphorus (yellow)
Phosphorus oxychloride
Phosphorus pentachloride
Phosphorus pentasulfide
Phosphorus trichloride
Phthalic anhydride
m-Phthalodinitrile
Picloram
Picric acid
Pindone (2-pivalyl-1,3-indandione)
Piperazine dihydrochloride
Plaster of paris
Platinum
Platinum soluble salts
Portland cement
Potassium hydroxide
Propane
Propargyl alcohol
Propionic acid
Propoxur (Baygon)
n-Propyl acetate
n-Propyl alcohol
n-Propyl nitrate
Propylene dichloride
Propylene glycol dinitrate

Propylene glycol monomethyl ether
Propylene imine
Propylene oxide
Pyrethrum
Pyridine
Quinone
Resorcinol
Rhodium
Rhodium soluble compounds
Rhodium, insoluble compounds
Ronnel
Rosin core solder pyrolysis products, as formaldehyde
Rotenone
Rouge
Selenium
Selenium compounds
Selenium hexafluoride
Silica, amorphous, diatomaceous earth, containing less than1% crystalline silica
Silica, amorphous, precipitated and gel
Silica, crystalline, tridymite
Silica, fused
Silica-crystalline, cristobalite
Silica-crystalline, quartz
Silica-crystalline, tripoli
Silicon
Silicon carbide
Silicon tetrahydride
Silver soluble compounds
Silver, metal
Soapstone
Sodium azide
Sodium bisulfite
Sodium fluoroacetate
Sodium hydroxide
Sodium metabisulfite
Starch
Stibine
Stoddard solvent
Strychnine
Styrene
Subtilisins (proteolytic enzymes)
Sucrose
Sulfur dioxide
Sulfur hexafluoride
Sulfur monochloride
Sulfur pentafluoride
Sulfur tetrafluoride
Sulfuric acid
Sulfuryl fluoride
Sulprofos
Talc (containing no asbestos)
Tantalum metal
Tantalum, oxide dusts
TEDP (Sulfotep)
Tellurium
Tellurium compounds, n.o.s.
Tellurium hexafluoride
Temephos
TEPP
Terphenyls
1,1,2,2-Tetrachloro-1,2-difluoroethane
1,1,1,2-Tetrachloro-2,2-difluoroethane
1,1,2,2-Tetrachloroethane
Tetrachloronaphthalene
Tetraethyllead
Tetrahydrofuran
Tetramethyl lead
Tetramethyl succinonitrile
Tetranitromethane
Tetrasodium pyrophosphate
Tetryl (2,4,6-Trinitro-phenylmethylnitramine)
Thallium soluble compounds
Thallium soluble compounds
4,4'-Thiobis (6-tert-butyl-m-cresol)
Thioglycolic acid
Thionyl chloride
Thiram
Tin
Tin inorganic compounds
Tin organic compounds
Tin oxide
Titanium dioxide
Toluene
Toluene 2,4-diisocyanate (TDI)
p-Toluidine
o-Toluidine
m-Toluidine
Tributyl phosphate

1,1,2-Trichloro-1,2,2-trifluoroethane
Trichloroacetic acid
1,2,4-Trichlorobenzene
1,1,2-Trichloroethane
Trichloroethylene
Trichloromethanesulphenyl chloride
Trichloronaphthalene
1,2,3-Trichloropropane
Triethylamine
Trifluorobromomethane
Trimellitic anhydride
Trimethyl benzene
Trimethyl phosphite
Trimethylamine
2,4,6-Trinitrotoluene (TNT)
Triorthocresyl phosphate
Triphenyl amine
Triphenyl phosphate
Tungsten
Tungsten, insoluble compounds
Tungsten, soluble compounds
Turpentine
Uranium
Uranium insoluble compounds
Uranium soluble compounds
n-Valeraldehyde
Vanadium
Vegetable oil mist
Vinyl acetate
Vinyl bromide
Vinyl cyclohexane dioxide
Vinyl toluene
Vinylidene chloride (1,1-Dichloroethylene)
VM&P Naphtha
Warfarin
Welding fumes (total particulate)
Wood dust, all soft and hard woods, except western red cedar
Wood dust, western red cedar
m-Xylene-alpha, alpha'-diamine
Xylenes (o-, m-, p- isomers)
Xylidine
Ytrium
Zinc chloride fume
Zinc chromate
Zinc oxide
Zinc stearate
Zirconium
Zirconium compounds, n.o.s.

APPENDIX D
OSHA Designated Carcinogens

29 CFR 1910, Subpart Z - Toxic and Hazardous Substances. Occupational Safety and Health Administration.

Chemical Name
1,2-Dibromo-3-chloropropane
1,3-Butadiene
2-Acetylaminofluorene
3,3'-Dichlorobenzidine (and its salts)
4-Aminodiphenyl
4-Dimethylaminoazobenzene
4-Nitrobiphenyl
Acrylonitrile
alpha-Naphthylamine
Asbestos
Benzene
Benzidine
beta-Naphthylamine
beta-Propiolactone
bis-Chloromethyl ether
Cadmium
Chromium (VI) compounds
Coke oven emissions
Ethylene oxide
Ethyleneimine.
Formaldehyde
Inorganic arsenic
Methyl chloromethyl ether
Methylene chloride
Methylenedianiline
N-Nitrosodimethylamine
Vinyl chloride

U.S. Department of Labor | Occupational Safety & Health Administration | 200 Constitution Ave., NW, Washington, DC 20210
Telephone: 800-321-OSHA (6742) | TTY
www.OSHA.gov