HOW CAN I FIND OUT WHAT THE HAZARDS ARE?

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Harry Elston and I published a brief listing of useful sources of hazard information in the January/February, 2001 issue of Chemical Health and Safety (vol. 8, No. 1). Since then and in response to the need for an up-dated and somewhat revised listing, I offer the following information.

The most readily accessible source of hazard information is the label on the container. Necessarily however, it is a condensed summary of the hazards involved, sometimes with errors and omissions, and is usually written in a style involving incomplete sentences which sometimes can be misunderstood; for example DANGER! Avoid breathing vapor. (One might think that if there is DANGER with an exclamation mark, it would be best to *not* breathe the vapor at all.)

In these circumstances, it may be suggested, one should refer to the next most accessible and certainly more complete source of hazard information, the MSDS. If the MSDS is reliable, it will list the PEL and TLV if those limits have been assigned, and also will describe in some detail, for example, the consequences if one does not take the precautions that are prescribed, say, if one breathes the vapor. Then, based on that information, one can determine more precisely what the label intended in the statement DANGER! Avoid breathing vapor.

In considering these matters it is well to keep in mind that labels and MSDSs are tertiary, or worse, sources of information. Not infrequently, they are prepared by persons who are not as well qualified to impart hazard information as one might properly expect.

Before relying on a label or on a material safety data sheet, it is advisable to skeptically scrutinize the information it conveys with more than a five-second glance. In the above, I have barely suggested the kinds of loose information one might look for on labels. MSDSs are a different matter in that there are more opportunities for sloppy preparation.

Here are some examples of errors that have been found in more than a few MSDSs and labels:

(a) *No mention in the MSDS or label of target organs or organ systems*. The MSDS and/or label is silent concerning the fact that the chemical will harm, say, the skin, or the kidney or the central nervous system.

(b) *Incorrect identification in the MSDS or label of target organs or systems.* Organs or organ systems such as: the liver or gastro-intestinal system are incorrectly identified as targets that would be harmed by the chemical but the organs or systems that would be harmed are not named in the MSDS or label.

(c) *Inaccurate PEL statement in the MSDS*. For example, the MSDS may state that the PEL is 50 ppm, but the current 29 CFR 1910.1000 may (in this imaginary example) state that the PEL includes a short-term exposure limit (STEL) of 100 ppm. The correct MSDS information would include both limits, the time-weighted average of 50 ppm and the excursion limit of 100 ppm.

(d) *A declaration, in the MSDS but not in a label, that the percent volatile is "nil" or "not available"*. But the MSDS, in a different location, states that the vapor pressure is, say, 40 mm at 70 F.

(e) *A statement in the MSDS or label that the chemical is not flammable*. But elsewhere the MSDS states that to fight fires, one should not use water as the fire extinguishing agent when that chemical is burning.

(f) *For a chemical that is altered in the heat of a fire and forms toxic products*. The MSDS states that such products "may be toxic" when the correct wording is "will be toxic", are toxic, or is toxic.

(g) *A description in the MSDS or label of certain consequences following overexposure*. But no explanation in the MSDS of the criteria by which an exposure is to be identified as an overexposure.

(h) *A statement in one section of the MSDS that overexposure <u>might</u> cause a certain adverse effect.* But the MSDS states in another section that overexposure <u>will</u> cause those results.

(i) *A recommendation in the MSDS or label to wear impervious gloves or other clothing*. But the MSDS fails to identify the material (e.g., butyl rubber or neoprene or polyethylene or ?) of which the glove or clothing should be made in order that it be impervious.

(j) *A recommendation without qualification in the MSDS or label to wear protective gloves.* The MSDS does not state that protective gloves, no matter what material they are made of, are impervious only for a limited time, that they will resist penetration for only a few hours, at most.

(k) *In the MSDS or label first aid procedures that instruct one not to administer any liquids to an unconscious person.* But the MSDS fails to instruct what to do instead for an unconscious victim.

(l) *Statements in the MSDS or label to keep a chemical away from ignition sources.* But neither the MSDS nor the label explains that the vapors can travel hundreds of feet away from their source or otherwise describe how to determine how many feet constitute a safe distance away from ignition sources.

(m) *Statements in the MSDS or label recommending that a chemical be used only with adequate ventilation.* But the MSDS does not define what is meant by adequate ventilation. (Adequate ventilation is properly defined as ventilation sufficient to maintain the concentration of vapors in the user's breathing air below the PEL or TLV, provided that the vapor concentration is determined by quantitative measurements.)

(n) *Irresponsible disclaimer statements in the MSDS or label*. Paraphrased, these say: The information contained herein might be correct but there is no guarantee that it is correct.

And now we have a problem. In the event that the label and MSDS appear to be less than accurately informative, how can I find out what the hazards are? The answer requires reliance on secondary sources and this will require both time and money.

I make no excuse for the list, below. I have refrained from identifying primary sources and that will save a considerable amount of time and money. But safety is expensive. Make no mistake; ***<u>safety decisions that are based on cost minimization are, by their nature, direly expensive decisions</u>***. The true cost of good safety is negligible compared to the objective: to save lives and limbs (and the factory and laboratory buildings which really means to save jobs). The costs in this instance consist primarily in the cost of acquiring the references listed here (several thousands of dollars) plus the cost of the time that must be spent in transferring that information from the printed pages of the references and the monitor screen into the minds of the safety personnel.

Build your own library or locate a library that has the reliable references, or both, and spend some time investigating the details of the hazardous properties of the chemicals with which you are concerned. The references I have found to be reliable (some of which are unfortunately out of print but are still available on the shelves of good libraries) include the following:

Incompatible and/or unstable chemicals:

The best, all round source of information is the current edition of Brethericks Handbook of Reactive Chemical Hazards, also available in CD ROM format, published by Butterworth-Heinemann.

There are competitive references on the market; some of these contain dangerously erroneous information despite that fact that they have been published by otherwise responsible, well-known, publishers. I know of no reliable alternative

to Brethericks.

Flammable and combustible chemicals:

There is no better broad source of information than the current editions of the NFPA Manuals 49 and 325, Hazardous Chemicals Data and Guide to Fire Hazard Properties of Flammable liquids, Gases, and Volatile Solids, respectively.

For fire hazards in the laboratory, see the NFPA Manual 45 Fire Protection for Laboratories Using chemicals. Apply to the NFPA office in Quincy, MA for recent publication dates of these three references.

Ammonia is a fire hazard because it will burn and is so described in the NFPA manuals, but for obscure reasons the Federal Department of Transportation classifies ammonia as a Nonflammable gas. Do not rely on the Federal DOT regulations for the identification of flammable substances.

Toxic chemicals:

The best, most complete (and expensive) source for toxic information is Pattys Toxicology, a nine volume work, the result of several contributors expertise edited by Eula Bingham, Barbara Cohrssen, and Charles H. Powell. In using this reference be sure to refer to both the cumulative subject index and the cumulative chemical index (both in volume 9); in several instances the pages describing the toxicity of a covered chemical are identified in one of these two indices but not in the other.

Threshold limit values (TLVs) and permissible exposure limits (PELs) are not measures of toxicity; X with a TLV of 100 ppm is not twice as toxic as Y with a TLV of 50 ppm. (For comparative toxicities, use lethal dose data.) TLVs are indications of comparative risks of harm in the opinion of a committee of knowledgeable industrial hygienists and are subject to annual revision; annually, new hazardous chemicals are added to the list. For the most part, PELs are out-dated citations of the TLVs that were established many years ago.

Apropos of the foregoing, for an interesting and toxicologically informative discussion on the toxicity of many of the chemicals included within the OSHA regulations, see 53 FR, 20960 to 21393 (Volume 53 of the Federal Register, pages 20960 to 21393), 54 FR, 2332 to 2983, and 54 FR, 12792 to 12868. That is, it is well recognized that the current PEL exposure limits are, some of them, grossly erroneous. To correct this matter, in 1988 and 1989 OSHA published well-developed, reasonable revisions of those PELs. These are described, along with the toxicological reasons for the changes, in the FR references identified here. A few months later, in an excessive exercise of its wisdom(?), the Supreme Court of the USA negated this responsible and important contribution to the health of those who work with chemicals on a daily basis.

The Documentation Volumes published by the ACGIH (American Conference of Governmental Industrial Hygienists) describe the detailed toxicity of, and the reasons for determining the particular TLV values that are assigned to, the several hundred chemicals that now have TLVs. Apply to the ACGIH in Cincinnati, Ohio for the current (7^{th}, 2001) edition and make sure that you also subscribe to receive the up-dating supplements to be issued in the future. This reference is also available in CD ROM format.

You may also wish to obtain the current edition of TLVs and BEIs (Biological Exposure Indices) from the ACGIH; this pocket-sized publication is a handy reference. Also available from the ACGIH is a publication that would only fit in a much larger pocket, Guide to Occupational Exposure Values in which, in addition to TLVs, carcinogenic and other information is also included.

The list of chemicals for which PELs have been established is of course found in the Federal Regulations, specifically in 29 CFR 1910.1000 (Title 29 of the Code of Federal Regulations, part 1910, section 1000). Printed copies can be found in any good library, or obtained from the Government Printing Office, and are also available on line: *http://www.osha.gov*; click on Standards under Regulations and Compliance and scroll down to Part 1000. (While

there you also might wish to look at Part 1200 and Part 1450 which deal with the application of Part 1000.)

NIOSH publishes a useful compendium that wont quite fit in a small pocket, NIOSH Pocket Guide to Chemical Hazards. It contains, in addition to NIOSH RELs and OSHA PELs, for example, the NIOSH estimated IDLH (Immediately Dangerous to Life or Health) concentrations. These concentration values identify the estimated maximum concentration from which a person without a respirator could escape within 30 minutes with no escape-impairing or irreversible health effects. The IDLH value for HCl, for example, is 100 ppm, equivalent to a partial pressure of 0.076 torr a mere trace of vapor.

NIOSH publishes the above information in useful CD ROM format. There are two publications, NIOSH Criteria Documents Plus, a key word searchable two-disc set, and NIOSH Pocket Guide to Chemical Hazards, a truly loaded single disc containing not only the Pocket Guide but also the set of International Chemical Safety Cards, information on types of protective clothing, and much more.

And there also is from NIOSH the very useful collection of Occupational Health Guidelines. Each Occupational Health Guideline addresses the toxicity of one of several hundred common industrial chemicals. Some of the Guidelines are not recently prepared but nevertheless contain helpful toxic information.

No discussion of toxic hazard information resources can be complete without including the Merck Index. This reference is revised at frequent intervals and although the current edition might be expected to be more up to date than an older edition, this is not always the case. I prefer the tenth edition, which by now is quite old, published in 1983. A comparison of the entries for many, not all, of the chemicals that are described in the tenth edition with the description of the same chemicals in any recent, including the current, edition will reveal some interesting differences. For reasons that are obvious to discerning and thoughtful skeptics, the tenth edition description of the toxic effects of more than a few of these duplicates is more thorough, more revealing, than that which appears in a more recent edition.

Except for the Merck Index and Pattys toxicology, the above references to the toxicological literature are deficient in that for the most part, they emphasize the toxic effects resulting from the inhalation of a vaporous, gaseous, dusty, or misty toxin and say little or nothing about the toxic effects resulting from other routes of exposure. Unfortunately, Gosselin et al.s extensive treatise, Clinical Toxicology of Commercial Products, 5th edition, Williams and Wilkins (1984), the major reliable reference that addresses other routes of exposure, almost to the exclusion of the inhalation route, is out of print. But if you can find a copy, it will be found useful, indeed.

Reproductive toxins such as mutagens and teratogens are problematic. There is only limited information available on this topic. The two best references that I have found are the current editions of Frazier and Hage, Reproductive Hazards of the Workplace, Wiley; and Shepard, Catalog of Teratogenic Agents, Johns Hopkins University Press. In both of these, the authors take care to critically evaluate the literature reports and consequently reject some and include other reports that a given chemical is a reproductive hazard. For a current as possible list of all literature reports of reproductive toxins whether or not the reports are reliable, refer to DART/ETIC in *http://www.sis.nlm.nih.gov* and click on Toxicology Search.

Carcinogens on the other hand are well identified. The best lists of known carcinogens are the IARC (International Agency for Research on Cancer) and NTP (National Toxicology Program) listings, both of which are derived from consensus determinations among experts in the field. For the current edition of IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans apply to the International Agency for Research on Cancer in Lyon, France. For the NTP listings, see *http://ehis.niehs.nih.gov/roc/toc9.html#toc*

Alert readers will by now have noticed the absence of any mention of RTECS (Registry of Toxic Effects of Chemical Substances). Although this is indeed an important resource for many purposes, I mention it here only because it is, on purpose, an unreliable toxicity resource. As the editors state in their prefatory declarations, RTECS is an attempt to compile references to, and the results of, any and all published toxic information, whether or not that information is correct and useful. In this paper, as I am sure is evident, I have tried to present my personal determinations identifying those references that I think are particularly reliable (at least for the most part). Consequently, I am not recommending

RTECS.

Related topics:

As discussed more fully below, most of the other topics considered to be within the general heading of literature sources related to the handling of hazardous chemicals can be found as chapters or sections in various collections. However, there are a few separate publications that should be mentioned here:

For **Storage of Chemicals**, see Pipitone Safe Storage of Laboratory Chemicals, Wiley. Despite the title, the information in this reference also applies to the storage of chemicals that are used in an industrial setting.

To learn how to manage a safety inspection or an audit, see the Safety Audit and Inspection Manual published by the American Chemical Society Committee on Chemical Safety.

For Emergency Response Information when a hazardous chemical has been spilled, in preference to the U.S. Department of Transportation publication, Emergency Response Guidebook, go instead to Emergency Handling of Hazardous Materials in Surface Transportation, which is available from the Bureau of Explosives of the Association of American Railroads

In some respects, the safe use of chemicals in an industrial setting differs in detail from the safe use of the same chemicals in a laboratory setting. For a thorough discussion of the safe handling of chemicals in an industrial setting, see the current edition of Lees, Loss Prevention in the Process Industries, Butterworth Heinemann. Similarly, for the laboratory refer to the somewhat stuffy work of a National Research Council committee, Prudent Practices in the Laboratory, 1995 edition (not the earlier 1981 edition with a similar title), to Youngs Improving Safety in the Chemical Laboratory, 2nd edition, Wiley, and to the work of the American Chemical Society Committee on Chemical Safety, Safety in Academic Chemistry Laboratories, volume 2 of the 7th edition. Despite the title, much of the information in volume 2 pertains to the safe use of chemicals in other than academic institutions, and for those who would like information about even more chemical safety references than those provided here, this resource will probably serve to sate that appetite.

General references:

It now remains to undertake a brief discussion on general references. I have found the International Labor Organizations Encyclopedia of Occupational Health and Safety to be a useful resource. It is available both in printed and in CD-ROM format from the International Labor Office in Geneva. The fourth edition is now current.

I also recommend the Kirk-Othmer Concise Encyclopedia of Chemical Technology, Wiley. It is surprising perhaps to realize that within a technical discussion on paper coating, for example, there resides some competent information about a chemical hazard.

You may wish to refer to the six-volume work (volumes 1, 2, 3, 4a, 4b, and 5) titled Chemical Safety Data Sheets and published by the Royal Society of Chemistry, Cambridge, UK. As the title implies, the hazards of each of the more than 600 chemicals included in the six volumes are described in a format not dissimilar to that of the familiar MSDSs in this country with a notable, and delightful, difference. These descriptions are clearly written; they are understandable. Moreover, where appropriate, the information includes references to the scientific literature.

Finally, readers will note that the references to important safety topics such as the disposal of waste chemicals, the handling of cryogenic liquids, of compressed gases, and corrosives, on how to use a hood properly, on radiation hazards, and the criteria for good ventilation remain to be identified. For this information I suggest the American Chemical Society publication, Handbook of Chemical Health and Safety, R. Alaimo, Editor, Oxford University Press, 2001. In general, the information in this reference is both reliable and useful, but there are some disappointments. Two to be mentioned here are: the regrettable lack of a really useful index and the uneven character of, fortunately, only a

few chapters. For example, Chapter 80 titled The Disposal of Chemical Wastes is an excellent introduction into the handling of chemical waste with a superb clarification of the convoluted EPA regulations, but Alas, I defy you to find it in the index. As an example of the second deficiency, the chapter on Reproductive Hazards in the Workplace recommends that employers obtain information and that this may require additional information beyond that included on MSDSs but offers little advice as to either where that necessarily reliable additional information can be obtained or that such reliability is not yet achievable.