Using the American Conference of Industrial Hygienists (ACGIH)
Threshold Limit Values® (TLVs®) in the
Regulation of
Workplace Chemicals and Substances in British Columbia:
A Scientific Analysis Highlighting Issues to Consider
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Executive Summary

The Occupational Health and Safety Agency for Healthcare in BC (OHSAH) has a mandate to promote health and safety through research, collaborative problem solving, and development of best practices. This brief, prepared by OHSAH’s staff of occupational health specialists and research scientists, provides a critical scientific appraisal that may be useful to the WCB and the public with respect to the proposed changes to the Occupational Health and Safety Regulations (OHSR) regarding occupational exposure limits (OELs).

The brief contains five separate sections, and begins with an introduction, followed by a review of the process of developing OELs in both BC and in the U.S. by the American Conference of Industrial Hygienists (ACGIH). In Section 3, findings from a chemical-by-chemical comparative risk analysis focusing on chemicals of relevance to the healthcare workforce are provided. Specifically included in this comparative analysis are chemicals that were identified in OHSAH’s WHMIS database as being relevant to the healthcare sector in BC, supplemented through consultation with employees and managers in healthcare to determine their list of priority chemicals for assessment. In this section the issue of chemicals that have no TLV or OEL is also discussed and an example provided. Section 4 provides a detailed commentary on the proposed amendments pertaining to the adoption of ACGIH Threshold Limit Values (TLVs) that are contained in a document dated February 11 entitled “Proposed Amendments to the Occupational Health and Safety Regulation RE: OELS”. In Section 5, a summary of the main differences in administrative procedures, policies, and rationale’s between the two processes is provided. Finally, Section 6 summarizes the findings and provides ideas for further consideration regarding the proposed changes.

Of the approximately 100 WCB OELs that are discordant from the 2002 ACGIH TLVs, a total of 36 were identified from OHSAH’s WHMIS database as currently being utilized in healthcare in the province. These 36 compounds differ in terms of one or more of the following: 8 hour Time Weighted Average (TWA), 15 minute Short Term Exposures Limit (STEL), Ceiling value, or any notation or designation including those for reproductive toxicity, sensitization, carcinogenicity, skin absorption, or general toxicity that recommends levels be maintained “as low as reasonably achievable” (ALARA). Upon detailed review of the discordances, the majority were related only to 15 minute STELs with the BC OEL generally listing a STEL when none is listed for the TLV. Critical evaluations of the TLV documentations and the WCB rationale for their OEL were conducted for 7 chemicals in which the 8 hour OEL is lower than the 8 hour TLV and one chemical where the TLV is lower than the existing 8 hour OEL. An additional four chemicals of concern for healthcare in BC were identified with discordant OEL and TLV standards through consultation with occupational health and safety professionals. Critical evaluations were conducted for these four, as well.

The findings of the comparative analysis by chemical provide an indication of the magnitude of the changes in risks between exposures at the existing BC OEL and the 2002 TLV. Unfortunately, for most compounds there are limited data that are applicable to assess the differences in risk levels. For these compounds where data are sparse, the change in the
exposure level may or may not have any health impact on the working population. Examples for this group are: carbon tetrachloride and nitrous oxide, for which there is a difference, however it is impossible to assess the potential impact of the change due to lack of scientific data. Some compounds have large differences in 8-hour TWAs or there are more data that provide some evidence of the potential for differing health effects based on exposures at the respective OELs. These compounds include halothane with an OEL of 2 ppm and a TLV of 50 ppm and studies suggesting an increased risk of reproductive effects at less than 50 ppm; and dichloromethane which has an OEL of 25 ppm and a TLV of 50 ppm, with studies that suggest an increased risk in subtle neurobehavioral effects as well as cardiac effects due to one of its metabolites, carbon monoxide, at levels below 50 ppm.

For a few compounds reviewed, data are available to characterize the change in risk. One example is formaldehyde, for which the TLV of 0.3 ppm ceiling, is lower than the OEL (0.3 ppm 8 hour TWA and 1 ppm ceiling), and there are numerous studies that indicate that workers are not protected at the TLV level. The literature on formaldehyde indicates that up to 20% of exposed workers may adversely respond to levels below the 0.3 ppm ceiling value. In this case there seems to be a multimodal distribution in the response and the TLV level is not low enough to be below the threshold in the most sensitive subgroup. Thus, while there would likely still be some workers who are at risk, the TLV is more protective than the BC OEL, therefore adoption of the TLV should result in fewer acute symptoms and very likely a decrease in risks of chronic adverse health effects.

For chemicals whose critical effects are solely due to sensory irritation, a change in exposure level is likely to have minor health implications. Acetone has an existing 8 hour OEL of 250 ppm, whereas its current TLV-TWA is 500 ppm with the critical effect being irritation. A review of the recent peer reviewed literature provides evidence that both the OEL and the TLV are below the threshold for sensory irritation in humans so no differences in adverse health effects are likely with exposures at either the TLV or the current BC OEL.

Chemicals for which there are no TLVs, yet are used widely in BC, present a special concern. One good example of a chemical product that is used widely in BC hospitals, and which has no TLV, is ortho-phthaldehyde (OPA). In an OHSAS (and Canadian Institute of Health Research) sponsored investigation, it was found that the use of glutaraldehyde alternatives is already widespread in BC hospitals, with OPA being the most commonly used alternative. The study found, ironically, that “concerns about employee health” was the most common reason for using and for not using alternatives. Thus, with no external review of the science pertaining to the health effects of this new compound, decisions had to be made within each workplace without the needed health effect information.

The TLV Committee employs a scientific process for compound selection. However, the decisions as to which chemicals to review for setting or revising TLVs are based on priorities of concern in the United States. Chemical use that may be high priority for BC but not for the US as a whole has little chance of ever having a TLV developed. This supports the utility of having
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a process in place for the review of a chemical that is of interest for use, or indeed already in use in BC that is not considered a priority in the US.

A review of the administrative procedures and policies of the ACGIH TLV Committee for Chemical Substances and the WCB’s Regulation Review Speciality Subcommittee provides some indication of why discordances between the OELs exist. The TLV Committee conducts an in depth review for each chemical, whereas the WCB Subcommittee relies on existing OEL documentations for its decision-making. There are advantages and disadvantages for both process and they are described in detail in the brief. One of the key issues pertains to the policy of the ACGIH that strongly recommends that regulatory agencies do not adopt TLVs for regulatory purposes as they are meant to provide professional guidance to enhance existing occupational health programs. The ACGIH “Statement of Position Regarding the TLVs and BEIs” provides a clear rationale for regulatory agencies to not adopt the TLVs for regulatory purposes and the statement is provided in the appendix. It is, however, noted that the system that had been in place in BC was deemed not to be efficient, and that some changes are therefore needed.

In summary, this brief attempts to shed light on the proposed changes to the OEL process in BC using a comparative analysis approach. The findings are intended to provide information for policy makers and the public to help ensure that informed decisions are made. This brief focuses on healthcare chemicals so may not be generalizable to all chemicals covered by the OHSR. The findings highlight potential changes in worker health, both positive and negative, as a result of adopting the TLVs. Additionally, policy and administrative differences are highlighted and should be a consideration during this regulatory review.

OHSAH takes no position on what the regulators should do regarding the OEL-TLV debate. However, OHSAH does take the position that the decision should be made after careful consideration of the best available scientific evidence. It is in this spirit that this brief is presented.
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1. Introduction

This brief has been prepared by the professional and scientific staff of the Occupational Health & Safety Agency for Healthcare in BC (OHSAH) to assist decision-makers in its review of the Occupational Health and Safety Regulation (OHSR) that is currently underway. It is our understanding that the WCB has been directed by the provincial government to reduce the regulatory burden of its regulations, stemming from the “new era commitment” of the provincial government (WCB of BC 2002). This brief specifically addresses the review that is being conducted regarding replacing the WCB Occupational Exposure Limits (OELs) and designations with the Threshold Limit Values® (TLVs®) and related notations and critical effects published by the American Conference of Governmental and Industrial Hygienists (ACGIH®).

OHSAH was first conceived in the 1998 round of contract negotiations between the healthcare unions and the healthcare employers in British Columbia. OHSAH’s mandate is to work with all members of the healthcare community to develop guidelines and programs to promote best health and safety practices and safe early return-to-work, and to implement pilot programs that could be rigorously evaluated with the knowledge shared and disseminated to create improvement in best practices. It is increasingly well documented that a collaborative problem-solving approach is more effective when addressing workplace health concerns than an adversarial approach; combining this with strategies based on good evidence is key to success (Yassi, A., A. S. Ostry, et al. 2002). All OHSAH programs and initiatives are based on solid scientific evidence and developed with the input of both the unions and the employers, and in consultation with government, healthcare providers, and other interested stakeholders including the WCB. For more information on OHSAH, see www.ohsah.bc.ca.

The working conditions in the healthcare sector are a worldwide concern. Surveys have consistently documented that healthcare workers feel that unsafe working conditions impact their ability to deliver quality care. While stress, back injuries, and exposure to blood and body fluids with the potential of acquiring infectious diseases ranks high on the concerns of healthcare workers, so does the fear of developing illness or disease related to chemical exposures (Yassi, 1998).

OHSAH’s Biological, Chemical and Physical Hazards Control Program is receiving a growing number of requests for assistance to assess and develop best practices to control exposures to a variety of chemicals in the healthcare environment. Prominent in the requests are anesthetic gases (halothane, nitrous oxide, etc.), dermal and respiratory allergens (natural rubber latex, glutaraldehyde, propylene oxide, etc), chemical disinfectants (aldehydes and substitutes such as OPA), cytotoxic drugs, laboratory solvents and chemicals, as well as substances that present indoor air quality concerns. Thus, any modifications to the OEL development process in the province can potentially have important implications for the healthcare industry. It is important for OHSAH to ensure that any legislative changes provide protection to workers in the healthcare industry and minimize to the fullest extent possible the risk of developing work-related diseases.
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OHSAH’s staff consists of individuals with considerable experience in the healthcare sector but also extensive academic and scientific training in matters specifically related to the assessment of WCB OEL and ACGIH TLVs. Dr. Annalee Yassi, MD, MSc, FRCPC, the Executive Director of OHSAH, is a specialist in Occupational Medicine, holds a Canada Research Chair, is a professor in the Department of Healthcare and Epidemiology at the University of British Columbia, is the Director of the Institute for Health Promotion Research, was the editor of the International Labour Organization’s chapter on the healthcare sector in the Encyclopaedia of Occupational Health & Safety, 4th Edition (Yassi, 1997) and as well as having 15-years experience as director of occupational health programs in the healthcare sector. Dr. Philip Bigelow, recently recruited to lead OHSAH’s Biological, Chemical and Physical Hazards Control team, is currently an Associate Professor at Colorado State University, Department of Environmental and Radiological Health Sciences, being recruited to the University of British Columbia. He has extensive experience as an Industrial Hygienist, holds an MSc in Occupational Hygiene and a PhD in Epidemiology. He currently chairs the Hydrogen, Oxygen, and Carbon Subcommittee of the ACGIH TLV Committee for Chemical Substances, and has been participating across the US and internationally in the standards setting process to prevent work-related diseases. Dr. David Moore, a physician in the Community Medicine Residency Program at UBC, presently completing a residency rotation in occupational health at OHSAH, is also an author of this discussion paper. Maryam Sharifnejad, and other staff at OHSAH, also provided assistance in preparing this brief.

Building on Dr. Bigelow’s extensive knowledge of these standard-setting processes, this brief begins by a review of the history, contexts and process of establishing TLVs; we then analyze the OEL process in British Columbia. Using OHSAH’s WHMIS database along with interviews with occupational health professionals in healthcare, we have identified commonly used chemicals in the industry and, based on our independent review of the literature as competent scientists with expertise in this field, we provide a comparative risk analysis in moving from currently enforced OEL to the 2002 TLVs. Additionally, a detailed commentary of the proposed amendments to the OHSR pertaining to OEL is provided. The specific methodology used in various steps of this brief are discussed in subsequent sections. Finally, we offer an analysis comparing and contrasting the approaches taken by the two organizations and provide an overview of many of the issues that relate to the proposed changes to the OHSR, especially as related to the healthcare sector.

2. Background

Chemicals have brought considerable economic and social benefits to society, but with these benefits come health risks associated with exposures. Workers have historically been on the front lines in terms of exposure to chemicals and adverse health effects, as over 1000 compounds per year are introduced into world commerce, sometimes with little toxicity testing. High workplace exposures in the past have led to serious adverse health effects with examples including asbestos, silica, and lead to name just a few. To protect workers, a complex array of legislation and recommended procedures has evolved that range from initial toxicity testing to
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the recommendation and use of OELs to provide occupational health professionals the appropriate guidance to reduce risks to workers.

OELs are developed by numerous agencies and organizations for purposes of protecting workers from the adverse health effects of exposures to airborne contaminants. Although recommendations regarding occupational exposures to individual chemical compounds go as far back as the 1880’s, the systematic setting of OELs began in the mid 1940’s with the first list of OELs developed by the Airborne Contaminants Committee of the American Conference of Governmental Industrial Hygienists (ACGIH). This first listing of compounds, to which it was thought workers could be exposed for eight hours per day for a working lifetime without harm to their physical or mental well being, contained just over 100 compounds. At present, many governments, organizations, and corporations develop OELs, and the lists of compounds with recommendations now exceed 700.

In British Columbia, Exposure Limits (OELs) for airborne substances are regulated by the Workers Compensation Board of BC under Part 5 of the Occupational Health and Safety Regulation. The OELs are contained in Table 5-4 along with their applicable designations and explanations. Part 6 of the regulation contains substance-specific requirements and currently covers asbestos, biohazardous materials, cytotoxic drugs, lead, pesticides, rock dust, and toxic process gases. Parts 5 and 6 of the regulation pertain directly to occupational chemical exposures to workers in BC and although some other sections may also contain rules possibly influencing exposures, they are not considered in this review.

In order to assess the potential impact of the proposed change in OEL development and review in BC, we provide a review of the policies, philosophy, as well as mechanisms of OEL development by both the ACGIH and the Workers Compensation Board of BC.

2.1 The ACGIH Threshold Limit Values (TLVs®)

The American Conference of Governmental Industrial Hygienists (ACGIH) is a scientific association dedicated to promoting health and safety within the workplace. ACGIH is a private not-for-profit, nongovernmental organization whose members are industrial hygienists or other occupational health and safety professionals. ACGIH provides educational and technical services to its members and to other interested parties through various mechanisms. ACGIH publishes annually guidelines known as Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs). Each TLV and BEI is supported by comprehensive information known as the Documentation. For better understanding, the ACGIH strongly encourages the industrial hygienist to consult the Documentation for the specific TLV/BEI being used.

TLVs refer to airborne concentrations of substances for which it is believed that nearly all workers may have repeated daily exposure without adverse health effects. The TLVs are intended for use as guidelines or recommendations to assist the industrial hygiene professional in the control of potential workplace health hazards and for no other use. These values are not fine
lines between the safe and dangerous conditions and should not be used by anyone untrained in the discipline of industrial hygiene. In using these guidelines, industrial hygienists are cautioned that the TLVs and BEIs are only one of multiple factors to be considered in evaluating specific workplace situations and conditions. ACGIH is not a standards setting body and the TLVs are not designed to be used as either regulatory or consensus standards (ACGIH 2002a, pg 3-4).

While the process used to develop a TLV includes public notice and requests for all available and relevant scientific data, the TLV does not represent a consensus position that addresses all issues raised by all interested parties. The TLVs represent a scientific opinion based on a review of existing peer-reviewed scientific literature by committees of experts in industrial hygiene, occupational medicine, epidemiology, and toxicology. ACGIH does not believe that TLVs should be adopted as standards without an analysis of other factors necessary to make appropriate risk management decisions. They believe that standard setting bodies should consider TLVs as valuable input into the risk characterization process and that TLVs and BEIs should be viewed as an expression of scientific opinion (“Statement of Position Regarding the TLVs and BEIs” in Appendix 1).

The ACGIH policy is that TLVs are recommendations and should be used as guidelines for best practices. In spite of the fact that serious adverse health effects are not believed likely as a result of exposure to the threshold limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as practical.

2.1.1 Procedures for Selection of Substances for Review

Substances or agents are selected for review by committee consensus. This review considers two categories of substances or agents: those that do not have a TLV, and those that have a previously established TLV that may need to be updated. Selection for review is prioritized by an assessment of what substances are found most often in American workplaces, what substances pose the greatest potential hazards to worker health, and what substances are produced in large amounts. To the extent possible, information on production volumes and workplace use are evaluated for the United States and other countries throughout the world. The selection process evaluates whether new TLVs for one substance should prompt a review of related substances or agents. The selection process also gives priority to substances or agents for which significant changes in occupational exposure limits have been recommended by other organizations throughout the world (ACGIH 2003c).

When a substance or agent is selected for either the establishment of a TLV, or for the review of an existing TLV, or a change in notations to the TLV, the substance is placed on the “Under Study” list that is published in this booklet each year. The purpose of the published “Under Study” list is to solicit information from the public, including producers, users and others. Information is solicited, especially data, that may assist the TLV Committee in their deliberations regarding the substance or agent. Comments and suggestions from interested parties, accompanied by substantive, supporting data and peer-reviewed articles, are solicited.
2.1.2 Process for Setting Limits

ACGIH TLVs are established through a committee structure designed to involve independent scientists from multiple disciplines, input from all interested parties, and two levels of review. Once the full Committee approves a chemical for TLV development or update, the name of the chemical is sent to one of three Subcommittees – the Dust and Inorganics Subcommittee, the Hydrogen, Oxygen, and Carbon Subcommittee, and the Miscellaneous Substances Subcommittee. These subcommittees consist of scientists whose research and skills are linked to the compounds assigned to their particular subcommittee. At the subcommittee level, the selected chemical is assigned to one or more members of the subcommittee to develop the Documentation. With the assistance of the ACGIH scientific staff and possibly outside consultants, the Subcommittee member(s) assigned to the project collects information, assembles the information, evaluates the information, and then prepares a recommendation for consideration by the TLV Subcommittee. The specific recommendation is accompanied by comprehensive Documentation. The matter is reviewed by the Subcommittee and individual Subcommittee members comment on the proposed TLV level and the Documentation. The Subcommittee discusses the information available, the best means of interpreting the information, and whether or not the information is directly applicable to the workplace.

Once the Subcommittee reaches a decision, the initial Documentation and recommendation are prepared in a form for submission to the full TLV Committee. Again, each member of the TLV Committee gets a copy of the proposal together with the Documentation. The full Committee may accept the recommendation or recommend that the Subcommittee again review its findings. If the full Committee recommends that the Subcommittee proposed TLV be approved, the matter is forwarded to the ACGIH Board of Directors. Each member of the Board has specific information with regard to the proposed TLVs and access to the proposed Documentations. In addition, a member of the Board of Directors serves as a liaison with the TLV Committee and can report to the Board with regard to the deliberations at the Committee and Subcommittee levels (Kennedy, 2001).

After a proposed (or updated) TLV has been prepared, the appropriate Documentation developed, approval received from the full Committee and is ratified by the ACGIH Board of Directors, it is made available to the public. The TLV is put on the public “Notice of Intended Changes” (NIC) list for one year or more and the Documentation made available. During that one year period, any interested party has the opportunity to submit additional information to the TLV Committee. All of the information submitted is carefully reviewed by the Committee and at the end of the one year period (NIC listing period), the TLV may be adopted in the original form proposed, published in a revised form with an additional NIC notice (to remain on the NIC for an additional year), maintained on the NIC list for an additional period of time in order to permit more information to be developed, or withdrawn.

The scientific review described above encompasses a wide variety of published and unpublished studies of health effects in humans or animals and in-vitro studies, industrial hygiene experience, as well as material submitted by interested parties responding to the ACGIH “Under Study” and
NIC lists. The supporting Documentation, however, is a summary of only the information that is most pertinent to the establishment of a TLV. The amount and nature of the information available for establishment of a TLV varies from substance to substance; consequently, the precision of the TLV is also subject to variation and the latest Documentation should be consulted. The Documentation for a given substance or agent may be revised periodically to reflect important new literature even if this does not change the TLV.

TLVs are established by weight of scientific evidence. When a given piece of evidence is considered by the ACGIH TLV Committee, the quality of the toxicological protocol, epidemiologic study design or other study procedures are considered using scientifically accepted principles. The Documentation summarizes the basis on which the TLV is established. The ACGIH strongly encourages persons who utilize TLVs to obtain the appropriate Documentation so that they gain an understanding of strength and limitations of the database supporting the specific TLV and any issues that apply to the particular compounds under the actual conditions of exposure (co-exposures, interactions, unique operations and processes, environmental considerations, etc) (Bigelow, 2000).

2.2 The Workers Compensation Board of BC Exposure Limits (OEL)

Little publicly available information is available on the process for the selection, review, and setting of the BC OELs, however, a brief review is provided in the discussion paper titled “Review of the Occupational Exposure Limits (“OELs”) and Designations” produced by the WCB of BC and dated September 6, 2002. This paper discusses the history of occupational exposure limits in the province and the various committees and panels that have worked on OEL and designations since 1992. Although a complete review of the process is beyond the scope of this paper, a brief overview of the committees, panels and their roles in recommending OEL is provided below.

A subcommittee of the Regulation Review Subcommittee, the Regulation Review Specialty Subcommittee on Occupational Hygiene was formed in 1992 to review and update OEL and designations for chemical and biological substances. This committee obtained documentations from the Dutch Expert Committee on Occupational Standards, the British Health and Safety Executive, the Swedish Work Environment Authority, the German MAK Commission, the ACGIH TLV Committee, the US National Institute for Occupational Safety and Health, the International Agency for Research on Cancer, and the US National Toxicology Program. In reviewing OELs and designations, the committee based their considerations on the OELs that had a scientific basis, involved the participation of management and labour in determining the level, and that the OELs were enforceable (i.e., used by a regulatory agency) (personal communication). The subcommittee’s work between 1992 and 1996 resulted in significant changes to BC’s Industrial Health and Safety Regulations and established Table 5-4 in the Occupational Health and Safety Regulation.
In 1999 the Health and Safety Advisory Committee (HSAC) was created to assist the Board in its ongoing review of the Occupation Health and Safety Regulation. A process for updating the Regulation every five years was established in 1999, using feedback from more than 400 workers and employers. HSAC, together with specialty committees on industry and hazard specific topics, review the Regulation on a part-by-part basis and provide advice and recommendations for drafting new or modified requirements.

In March of 2001, the Health and Safety Advisory Committee (HSAC) directed a new committee be formed to review and update Table 5-4. This committee, called the Standing Committee on Occupational Exposure Limits, used a process similar to the Regulation Review Specialty Subcommittee on Occupational Hygiene. This new committee met only three times and was disbanded.

The meetings of HSAC and its specialty committees were suspended in September 2001 due to the impending announcements from the Government on Core Review and Deregulation. It was felt by the government that the HSAC review process was constrained by its consensus-based approach. Major differences of opinion or unresponsiveness among stakeholders had resulted in impasses and lengthy resolution periods. Employer stakeholders involved in the process commented that the process was slow and adversarial, and suggested that alternative consultation models be developed.

In developing the proposed strategy for the Government’s Deregulation Initiative and review of the OHSR and Agriculture Regulations, the Bureau is proposing a consultative model that builds on lessons learned from the HSAC process to provide stakeholder input into proposed changes to regulations. The proposed review framework would rely on a two-level stakeholder consultation process: macro-level consultation with the Board’s major stakeholders to obtain input on proposed conceptual changes to regulatory process and public policy issues; and focused sector-based consultation to acquire advice of a technical nature for individual regulations. The proposed model solicits advice from stakeholders and establishes timelines for their response. Decisions with respect to regulatory review would be informed by consultation and ultimately made by the Panel.

These issues are discussed in a paper The Workers’ Compensation Board of British Columbia - Resolution Of The Panel Of Administrators, Re: Strategy for Reviewing the Occupational Health & Safety Regulation (BC Regulation 296/97, as amended) and the Regulations for Agricultural Operations (BC Regulation 146/93)
3. Comparing the WCB OEL with TLVs and Assessing the Potential Impact, if any, on the Health of Employees in Healthcare in BC

3.1 Objective
The objective of this section was to examine the standards set for specific chemicals of concern in BC’s healthcare sector, so as to ascertain the likely health implications, positive or negative, if any, that may result from the change from the use of the BC OELs to TLVs, based on a direct assessment of available toxicological and epidemiological information.

3.2 Methodology

3.2.1 Comparing the TLV values with OEL values for chemicals listed on the OHSAH database

In order to determine whether the recommended exposure limits for these chemicals would change with the shift from using WCB-derived OEL to using the TLVs, OHSAH undertook a comparison of the two standards. OHSAH has been developing a Workplace Hazardous Materials Information System (WHMIS) listing information for materials used in healthcare throughout the province. For each chemical on the WHMIS list, the WCB OEL 8 hour exposure limits, 15 minute exposure limits and chemical designations were compared to the 8 hour time-weighted averages, the 15 minute short-term exposure limits and the notations from the TLV list, and the differences were noted. Where significant differences were found between the two lists, the assessment reports from the WCB and the ACGIH were reviewed in order to determine why these discordances existed. Further, literature searches for recently published scientific studies were conducted and a final assessment was made of the likely health implications of the change in standards, using the expert epidemiological and toxicological knowledge of OHSAH personnel.

3.2.2 Surveying occupational health and safety professionals for chemicals of concern for healthcare workers

The WHMIS list of chemicals from OHSAH is likely to be incomplete, as it is still under development. In order to ensure that chemicals of high priority in the healthcare sector were not missed, OHSAH asked occupational health and safety representatives from the healthcare unions and the healthcare employers to identify those chemical substances that they felt were of greatest relevance to healthcare workers. Again, these chemicals were sought on both standards lists and differences noted. The same process for determining the cause of the differences and assessing the potential health impacts were followed.
3.3 General Survey Results

Of the 43 chemicals found in the WHMIS database at OHSAH that had existing WCB OELs, 36 were found to have some discordance with the 2002 ACGIH TLV standards. The chemicals and the details of their respective regulations for OELs and TLVs are found in Table 2 within the appendix of this document. Table 1 below summarizes these differences:

### Table 1: Summary of 36 Chemicals from the OHSAH WHMIS System with Discordant WCB OEL and TLVs

<table>
<thead>
<tr>
<th>OEL Values More Stringent</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower 8 hr OEL</td>
<td>11</td>
</tr>
<tr>
<td>15 min OEL is present, but no STEL is set</td>
<td>16</td>
</tr>
<tr>
<td>Absence of chemical designation on TLV list</td>
<td>15</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TLV Values More Stringent</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>lower 8 hr TWA</td>
<td>3</td>
</tr>
<tr>
<td>STEL is present, but no 15 min OEL is set</td>
<td>3</td>
</tr>
<tr>
<td>Absence of chemical designation on OEL list</td>
<td>5</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>13</td>
</tr>
</tbody>
</table>

* Note: totals add to more than 36 due to several chemicals with more than one difference

The majority of the differences between the two standards were found in the chemical designations and 15-minute exposure limits. However, in trying to take a prudent approach to assessing the potential health effects in the switch to TLVs, OHSAH focused attention on the 11 chemicals where the existing 8-hour OELs are lower than the 2002 TLVs. In order to keep the review as relevant as possible, four of the 11 chemicals were not reviewed, as healthcare associated exposures were not thought to be very significant. It is worth noting that three chemicals, including formaldehyde, were found which had lower TLVs than the existing 8-hour OELs from the WCB. Therefore, it is possible that improved worker health outcomes could accrue from the adoption of these standards.

Formaldehyde and glutaraldehyde are important chemicals in healthcare and both would change under the proposed amendments. Formaldehyde is reviewed and is an example of a substance for which the TLV is more protective than the current OEL. It is noteworthy that the WCB in its discussion paper originally indicated that the current OEL would be retained until a review of the health effects and feasibility of workplaces being able to implement the more stringent standards...
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in BC workplace had been carried out. WCB has apparently reversed its position on this chemical from the discussion paper and will be looking for public input on the applicable standard to use. Glutaraldehyde is not reviewed in this brief because the current WCB OEL (ceiling of 0.25 mg/m³ with Z, A designations) is not substantially different from the 2002 TLV ceiling of 0.05 ppm (0.2 mg/m³) with a sensitizer designation.

3.4 Evaluation of Potential Health impact for specific chemicals with discordant TLVs/OELs

a) Acetone:
This chemical is widely used as an industrial solvent. It is found in paints, varnishes and lacquers. It can also be used as a solvent for photography, rubber and fiber industries, and is used as a solvent in laboratories. Commercial maintenance workers are listed among those who may be potentially exposed.

<table>
<thead>
<tr>
<th></th>
<th>8 hr OEL</th>
<th>8 hr TLV</th>
<th>NIOSH REL</th>
<th>OSHA PEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>250 ppm</td>
<td>500 ppm</td>
<td>250 ppm</td>
<td>1000 ppm</td>
</tr>
</tbody>
</table>

ACGIH reviews (2001): Inhalation of acetone in high concentrations produces dryness of the upper respiratory tract, nausea, dizziness, uncoordinated movements, slurring of speech, drowsiness and in extreme cases, coma. It does not have sensitiser or skin notations. It is not classifiable as a human carcinogen (A4 designation).

The Chemical Substances TLV committee reviewed over 20 studies of various human health effects related to acetone exposure in workers. The LOAEL values for nose and throat irritation ranged between 100 ppm (for 5.25 hrs) and 1000 ppm (for 7 days), but the quality of studies appeared to vary greatly. Tolerance seems to develop for the irritant effects of acetone, with newly exposed individuals being more sensitive than those who are chronically exposed. Recent research using techniques that quantify nervous system responses to odours and irritants indicates that irritants that potentially damage tissues stimulate different nerve endings (Wysocki et al. 1997). Thus it is hypothesized that the development of tolerance is most likely the result of individuals who are continuously exposed being more able to differentiate between what is an objectionable odour versus truly irritant effects (Dalton et al. 1997). Neuro-behavioural symptoms including decreased response time, headaches, and lack of energy had been found in some studies with levels in the range of 200 to 300 ppm. However, the ACGIH committee felt that many of the studies showing effects at levels lower than their recommended 500 ppm 8 hr TLV, were more subject to responder bias than those which showed effects at higher levels. Further, they recognized that the interpretation of these studies is subject to controversy within the scientific community.

Occupational Exposure Limits Material (WCB): No change from the existing IH&S standard was proposed in 1996, therefore, the chemical was not included in the review. Information from WCB on the basis for the IH&S standard is not available.
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Medline: A new review of the human response to the irritancy of acetone vapours was found which was not used in the last ACGIH survey of acetone effects (1) (Arts JHE, et al). It concluded that the subjective measures which had been used in establishing the sensory irritation effects of acetone at levels below 1000 ppm were subject to a number of biases—and argue that the threshold level for sensory irritation is more likely to be between 10,000 and 40,000 ppm.

Health effects of change: Adoption of the TLVs would replace an existing 8-hour OEL of 250 ppm, with one of 500 ppm. Many studies have shown irritative and neuro-behavioural effects of acetone at levels below 500 ppm, however there is disagreement over the scientific quality of the studies. It seems likely that workers who are not routinely exposed to acetone may develop complaints if ambient air concentrations were allowed to increase to the TLV standard. However, it seems unlikely that any long-term health consequences would result.

b) Carbon Tetrachloride

This chemical is primarily used as a solvent and dry-cleaning agent, but now has almost been entirely replaced by less toxic solvents. It is currently used primarily in manufacturing some fluorocarbons used as propellants, refrigerants, or as a pesticide. The US National Institute for Occupational Health and Safety (NIOSH, 1984) reported that clinical laboratory technologists and technicians, cleaners, health aides, orderlies, and attendants may be exposed to carbon tetrachloride (NIOSH, 1984).

<table>
<thead>
<tr>
<th></th>
<th>8 hr OEL</th>
<th>8 hr TLV</th>
<th>NIOSH REL</th>
<th>OSHA PEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>2 ppm</td>
<td>5 ppm</td>
<td>2 ppm</td>
<td>10 ppm</td>
</tr>
</tbody>
</table>

ACGIH reviews (2001): The main concerns are related to liver and kidney toxicity. It also has an A2 designation as a suspected carcinogen. The TLV-8 hr time-weighted average is intended to minimize liver damage in workers with normally functioning livers. Human studies that have shown acute effects or where carbon tetrachloride was suspected to be a cause of liver cancer related to acute exposures greater than 30 ppm. No liver toxicity was seen in rats at doses of 10 to 20 mg/kg. Physiologically based pharmacokinetic modeling provides capabilities for improving the reliability of extrapolations across dose, species, and exposure route that are crucial in chemical risk assessment (Thomas et al., 1996). Using pharmacokinetic modeling for carbon tetrachloride it was estimated that no-effect doses in rats for liver toxicity corresponded to a human 8 hour time-weighted average of 10 ppm (Paustenbach, et al., 1990). Carbon tetrachloride has been established as having no or weak genotoxicity and tumours are unlikely to arise at doses that do not induce microscopically visible damage to cells.

Occupational Exposure Limits Material (WCB): In 1996, the OEL was reduced from 10 ppm to 2 ppm primarily on the basis of a similar recommendation from the UK. While it was recognized that liver tumours were only observed at doses that were toxic to the liver, the reduction in the limit was justified to take into account possible inter-species variation.

Medline: No significant recent literature was found.
Health effects of change in regulations: Because there has not been adequate study of the precise toxicity of low dose exposure to carbon tetrachloride in humans, we must rely on estimates and safety factors. The ACGIH estimates that there is no effect in humans at 10 ppm and no liver toxicity effects are seen at this level. This is reassuring in that cancers do not seem to develop in the absence of liver-toxic effects. However, the WCB had previously reviewed the data in 1996 and felt that a safety factor was warranted because of the inconclusive nature of the scientific knowledge to date.

c) Chloroform:
Chloroform historically has been linked to healthcare in its previous use as an anesthetic. It has not been used for this purpose for several decades; however, it continues to be used as a raw material in the manufacture of fluorocarbons for refrigerants, resins, plastics and other chemicals. It is also used as an extractant and industrial solvent in the pharmaceutical industry.

8 hr OEL: 2 ppm   8 hr TLV: 10 ppm   NIOSH REL: 2 ppm   OSHA PEL: 50 ppm

ACGIH reviews: Inhalation of 10 000 ppm of chloroform results in clinical anesthesia in humans. Lower exposures of between 20 and 240 ppm may result in some symptoms of fatigue, digestive disturbances, and mental dullness in chemical plant workers. Very limited data exist on occupational poisoning due to chloroform because of its current limited use. A study from 1967 found that 25% of 68 chemical workers exposed to chloroform concentrations of between 10 to 200 ppm displayed evidence of liver enlargement. No reports on human cancers associated with chloroform exposure have been conducted, therefore, the ACGIH, classifies chloroform as A3, an animal carcinogen with unknown relevance to humans. The TLV level was set at one-fifth of the level at which liver toxicity was observed in animal models. Sufficient data were not available to recommend skin or sensitization notations.

Occupational Exposure Limits Material (WCB): The WCB reviewed the OEL on chloroform in 1996, lowering the previous 8 hour standard of 10 ppm to 2 ppm. This change appears to have been primarily due to similar recommendation from the United Kingdom that estimated that the no-effect level in humans for kidney and liver toxicity was 10 ppm, extrapolating from animal studies. The standard of 2 ppm was set in order to control for inter-species variability. This did not seem to be based on new toxicological studies, but on a different safety factor calculation. A skin designation was added by the WCB based on a similar notation by the UK regulatory agency. The K2 designation was based on the previous ACGIH designation of A2, suspected human carcinogen. However, the ACGIH later revised this designation to the existing A3 in 1996.

Medline: An article published in 2001, Griem & Reuter used several examples to outline a new hazard classification scheme that is now being used by occupational safety regulators in Germany to identify carcinogenic potential for chemicals. Chloroform was classified as having limited carcinogenic risk, as long as the recommended exposure levels were not surpassed. This level was set as 0.5 ppm. All of these estimates were based on animal studies.
Health effects of change in regulations: There are no data on the health effects of long-term exposure to low levels of chloroform in humans. The difference in the current OEL and TLV standards reflect differing safety factors for extrapolating the health effects on humans from animal studies. Carcinogenicity has not been demonstrated with chloroform in the absence of liver toxicity and the TLV level seems unlikely to induce liver toxicity. This makes the likelihood of adverse health effects in workers exposed to chloroform at the TLV limits to be quite low, but not zero. Chloroform exposures are also not likely in healthcare workers in BC.

d) Dichloromethane (methylene chloride) (DCM)
This chemical is used as a solvent in paint removers, as a solvent for plastics, as a degreasing agent, in propellant mixtures for aerosol containers and as a blowing agent in foams.

8 hr OEL: 25 ppm  8 hr TLV: 50 ppm  NIOSH REL: none  OSHA PEL: 25 ppm

ACGIH reviews: The ACGIH committee, in a rather lengthy report, reviewed over 40 studies on the human health effects of DCM. The main concerns related to the ability of DCM to cause neurobehavioural symptoms at doses of 200 ppm or above. The ACGIH committee concluded that a safety factor of four should be adequate to account for individual differences in sensitivity to this effect, leading to the recommendation of a TLV-TWA of 50 ppm. Short-term exposure can result in increased carboxyhaemoglobin levels above 3.5%, which in turn lead to angina or other evidence of cardiac ischemia in non-smokers (ACGIH, 1996; Soden et al. 1996). Exposures of up to 55 ppm appear to be adequately protective of sensitive individuals.

The committee reviewed approximately 10 epidemiological studies involving a total of 5800 male and female workers, which looked at cancer rates in workers exposed to DCM. The exposures ranged between 26 and 700 ppm, which occurred over long intervals between the first exposures and the end of follow-up. Theses studies had consistently found no excess mortality for total malignancies, or for the specific cancers with which DCM had been associated in mice. One cohort study did find an excess of biliary tract cancer, but it was based on small numbers, appeared to decrease with longer follow-up and has not been observed in any other study. The committee concluded then, that DCM could be classified as a weak animal carcinogen (A3), with unknown significance in humans.

Occupational Exposure Limits Material (WCB): The WCB reviewed existing exposure limits for DCM in 1996, and reduced the previous OEL of 200 ppm to the current 25 ppm. This appears to have been done primarily because of a similar recommendation from the US Occupational Safety and Health Administration (OSHA) in 1991, when their PEL was reduced from 500 ppm. There was no documentation as to why the 25 ppm level was chosen over higher levels. Sweden and Norway were noted to have 8 hour exposure limits of 35 ppm, but the WCB committee notes that sufficient toxicological evidence was not presented for this. The WCB committee appeared to place more weight on the study showing an increased incidence of biliary tract tumours.
DCM was also identified as a suspected human carcinogen, as it was classified as A2 from the ACGIH at that time. The ACGIH has subsequently changed their classification to A3.

**Medline:** Two studies were found which provide new information on human health effects of DCM. The first was an update of a large cohort of photographic film base manufacturing employees (Hearne and Pifer 1999), which had produced previous publications reviewed by the ACGIH. In this 1999 publication, the authors presented further data showing no increase in standardized mortality ratios for these workers for any diseases previously thought to be related to DCM exposure, including ischemic heart disease, and cancers. Ambient DCM 8 hour time-weighted averages had ranged between 5 and 100 ppm. However, the comparison population consisted of individuals who were not all working, therefore, some underestimation of negative health effects may be possible, as it is known that working populations are healthier than non-working counterparts of the same age.

In the second study published by Storm and Rozman (1998), the authors attempted to derive an occupational exposure limit for DCM that was based solely on human health effects, recognizing that the OSHA PEL limit was based on mouse tumour results, allowing for safety factors for interspecies, and low-dose variabilities. Starting with the LOAEL of 200 ppm for subtle CNS depression, and including a safety factor range of two to four which had been previously validated for inter-individual variability (Gundert-Remy and Sonich-Mullin, 2002) for compounds structurally related to DCM, the authors concluded that the TWA of 25 ppm was appropriate.

**Health effects of change in regulations:** Given the lack of hard evidence that DCM is associated with an increased risk of malignancy in humans, even at much higher levels than the TLV value, it seems unlikely that more occupational associated cancers would be found in workers if this level were adopted. However, the LOAEL for developing carboxyhaemoglobin levels of greater than 3% is only 55 ppm in non-smokers and if one wishes to include a margin of safety, increasing the OEL to the TLV of 50 ppm would expose more workers to increased risk of cardiac morbidity, if not mortality. The safety factors relating to the CNS effects of DCM also suggest that some workers may experience some neurobehavioural symptoms at levels below 50 ppm, and that these would likely increase if the TLV level is accepted.

e) Ethyl Acetate:
Ethyl acetate is used as a solvent for varnishes, lacquers, nitrocellulose and artificial fruit essences. It is also used in the manufacturing processes of artificial silk and leather, perfumes and photographic films.

| 8 hr OEL: 150 ppm | 8 hr TLV: 400 ppm | NIOSH REL: 400 ppm | OSHA PEL: 400 ppm |

**ACGIH reviews:** Ethyl acetate (EA) is generally regarded as one of the less toxic volatile organic solvents. However, it does cause irritation of the eyes, nose and upper airways, especially in previously non-exposed subjects. Only three studies on human health effects are
found. One found that subjects found the odour of EA to be very strong at 200 ppm. Another found that workers exposed regularly to 375 to 1500 ppm of EA showed no unusual signs or symptoms. However, there is one case report of a chemical worker dying from inhalation of EA, and other case reports of less severe acute toxicities. Animal studies have not demonstrated any long-term health effects at concentrations at an equivalent of 2000 ppm, but again only two studies were available for review. The ACGIH did accept that the TLV level of 400 ppm may prove mildly irritating to some workers not habituated to exposure to EA.

**Occupational Exposure Limits Material (WCB):** The WCB reviewed the existing exposure limit for EA 1996 and recommended a reduction in the previous level of 400 ppm to the current 150 ppm. This was based on a 1990 review of occupational standards by Sweden, which again noted that most individuals experience irritation symptoms at 400 ppm for 3 to 5 minutes, and some experienced symptoms at 200 ppm. These individuals reported that they would be able to tolerate an 8-hour exposure to 100 ppm. This study was included in the ACGIH review, as well. The WCB review also noted that Norway had an existing 8-hour exposure limit of 150 ppm.

**Medline:** Two older studies from the Hazardous Substances Data Bank of the National Library of Medicine in the US were found which were not included in the above reviews. Of note, Larson (1985) which found symptoms of wheezing, coughing, rhinitis or shortness of breath in 17 athletes who were training in a facility under construction and where levels of ethyl acetate and toluene were found to be below the accepted government standards. Another study (Beving, 1984) found that workers exposed to ethyl acetate concentrations of between 34 to 78 ppm and toluene concentrations of between 2 to 68 ppm, had lower platelet counts than controls. No other more recent studies were found on Medline.

**Health effects of change in regulations:** As stated in the ACGIH Threshold Limit Value handbook, the TLV level of 400 ppm may prove mildly irritating to some workers. Therefore replacing the existing OEL with the TLV will likely increase the frequency of these symptoms in workers so exposed. More serious health consequences are unlikely.
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f) Formaldehyde:

Formaldehyde is commonly used in healthcare settings as it is a component of disinfectants, preservatives, and germicides. Commercially, formaldehyde is sold as formalin, a methanol-stabilized water solution containing 37%, 44%, or 50% formaldehyde. Formaldehyde is a high production volume chemical and it is used in manufacturing of phenol-formaldehyde resins, melamine and polyacetal resins, ethylene glycol, pentaerythritol, hexamethylene-tetramine, fertilizer, and dyes.

- **8 hr OEL:** 0.3 ppm,
- **8 hr TLV:** Ceiling, 0.3 ppm with SEN notation
- **NIOSH REL:** TWA, 0.016 ppm; ceiling, 0.1 ppm
- **OSHA PEL:**

ACGIH reviews: The TLV review provides numerous findings from epidemiology and case studies documenting irritation of the eyes, respiratory track, and nasal passages from occupational exposure to formaldehyde. The committee found that animal studies provided sufficient evidence to indicate that the cancer causing potential of formaldehyde is a threshold phenomenon that is eliminated if upper respiratory tract irritation is prevented. They do mention that formaldehyde may act to enhance the oncogenic potency of other agents especially wood dust which is often encountered with formaldehyde. The documentation also provides information indicating that a proportion of workers (10 to 20%) may not be adequately protected by the TLV because they respond adversely at very low levels. Based on reports of allergic reactions/ sensitization following occupational and non-occupational exposures to formaldehyde, the compound is assigned the SEN notation (sensitizer).

Occupational Exposure Limits Material (WCB): The WCB reviewed existing exposure limits for formaldehyde in 1996, and proposed to reduce the previous OEL of a ceiling of 2 ppm to a 0.3 ppm ceiling; however, the OEL value that appears in Table 5-4 of the OHSR is a 0.3 ppm 8 hour time-weighted average and a 1 ppm ceiling. The committee critically reviewed the NIOSH REL documentation and determined it did not support the proposed 8-hour limit of 0.016 ppm or the ceiling of 0.1 ppm. The committee agreed with the TLV recommendation of a ceiling of 0.3 ppm that would likely prevent upper respiratory tract irritation and, for all practical purposes, should eliminate any excess cancer risk. Formaldehyde was also identified as a suspected human carcinogen, based on IARC’s 2A and ACGIH’s A2 classifications.

Medline: A study by Rumchev et al. published in 2002 found an association between household formaldehyde exposure above 0.05 ppm and an increased risk of asthma in children. No other studies on the health effects of low-dose formaldehyde exposure were found that were not reviewed by the ACGIH in 2001.

Health effects of change in regulations: The change from the existing OEL to the TLV-ceiling of 0.3 ppm would likely result in some workers experiencing less upper respiratory tract irritation, and for these workers the risk of cancer would also be reduced. The ceiling value of 0.3 ppm, in practical terms, limits the 8-hour TWA to 0.1 ppm which is significantly lower that the 8-hour
OEL of 0.3 ppm. Numerous human studies have reported concentration-dependent responses from formaldehyde exposures as low as 0.1 ppm (USNRC, 1980; USNRC, 1981; Kulle et al., 1987; Weber-Tschopp et al., 1977). The TLV, for the most part, is protective of these effects. The reduction in cancer risk is related to the mechanism of cancer development that is practically eliminated if respiratory tract irritation is prevented.

g) Halothane:
This chemical is used extensively as a clinical anesthetic and has been in use for more than 40 years.

8 hr OEL: 2 ppm  8 hr TLV: 50 ppm  NIOSH REL: ceiling limit of 2 ppm  OSHA PEL: none

**ACGIH reviews:** The main concern over the negative health effects of anesthetic agents has come from the observed increased incidence of malignancies among operating room staff. However, most of these studies were conducted in the pre-halothane era (Bruce et al. 1968; Corbett et al. 1973). A survey conducted in the US in 1974 found an increased incidence of spontaneous abortions among female operating room staff, increased incidence of spontaneous abortion in wives and increased incidence of congenital anomalies in children of male anaesthetists and increased incidence of hepatic disease among operating room staff. Individual exposures to anesthetic gases were not measured, but the average concentrations in unscavenged rooms were 216 ppm of nitrous oxide and 4.6 ppm of halothane and in scavenged rooms, 77 ppm and 1 ppm, respectively (Milliken, 1976). A study from the UK also found increased risks of adverse reproductive outcomes (Spence et al. 1977), however, a study in Finland that found increased incidence of miscarriages in anaesthetists compared to paediatricians, noted that this was correlated with smoking habits (Rosenberg and Vanttinen, 1978). The NIOSH level was recommended because it was felt that a ceiling limit of 2 ppm was possible to achieve. The TLV-TWA recommendation of 50 ppm was based on comparisons with the TLV for trichloroethane and chloroform and is expected to yield the same risks to human health as these TLVs (based on similar mechanisms of toxicity). They note, however, that as exposure concentrations of nitrous oxide and halothane are usually in a 50:1 ratio, the level of halothane must be kept below 10 ppm in order to meet the TLVs for both gases. Animal studies on the carcinogenicity of halothane are inconclusive and therefore it is given an A4 designation.

**Occupational Exposure Limits Material (WCB):** No change from the existing IH&S standard was proposed in 1996, therefore, the chemical was not included in the review. Information from WCB on the basis for the IH&S standard is not available.

**Medline:** Several new studies on occupational exposures to anesthetic gases have been published, but no new studies documenting the health effects of such exposures were found. One

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1 More specifically, the TLV documentation presents details of the toxicity comparisons and provides the following rationale for the TLV: “1) the anesthetic concentration of halothane is about five times greater than that for trichloroethylene and chloroform; 2) the low carcinogenic potential of halothane in animals; and 3) hepatotoxicity and adverse effect on reproduction of chloroform is more severe than for trichloroethylene or halothane.”
study noted that the UK Committee for Occupational Safety and Health have set a standard of 10 ppm and another noted that the European standard in 1996 was 5 ppm.

Health effects of change in regulations: Evidence of possible negative reproductive health outcomes in operating room personnel was found in two of three studies, but the first two did not control for other possible causes (e.g. smoking). The possibility remains that higher rates of spontaneous abortions could be seen in operating room personnel, if exposures were allowed to increase. However, it seems that the OEL standard was set because this level should be attainable in operating rooms with scavenging systems, not because there was evidence of harm from a higher exposure limit.

h) Hexane:
Hexane is used as a solvent for vegetable oils, coatings, paints, or adhesives. Hexane isomers are present in varying amounts in petroleum ether, rubber solvent and gasoline. Bulk gasoline contains an average of 6% hexane of which just over 25% is in n-hexane isomer.

8 hr OEL: 20 ppm 8 hr TLV: 50 ppm NIOSH REL: 50 ppm OSHA PEL: 500 ppm

ACGIH reviews: The 2002 TLV of 50 ppm for n-hexane in order to minimize the potential for neurotoxicity. Acute symptoms of dizziness, headaches and irritation of the eyes and throat have been found with exposures of 1400 ppm. Chronic neurotoxicity in the form of polyneuropathies has been documented in workers exposed to 500 or greater of 95% n-hexane. In a one study of Italian shoe workers, some workers were found to have symptoms of polyneuropathy even though their exposures were likely less than 500 ppm. The lowest 8 hour TWA exposure that has been documented to cause polyneuropathy is 325 ppm, however the ACGIH does note that the minimum levels has not been established. Based on these data and the assumption that the n-hexane content of these exposures could have been as low as 30%, the ACGIH proposed a lower TLV of 25 ppm in 1979. However, a subsequent review of the data in 1980 suggested that the likely n-hexane content in these studies was more likely between 50 and 70%. For this reason, the TLV was re-established as 50 ppm in 1982. There is no data to support carcinogen or sensitization notations. A skin notation is assigned, however.

Occupational Exposure Limits Material (WCB): In 1996 the WCB reviewed the existing OEL on n-hexane, which had been set at 100 ppm. The committee reviewed documentation from the UK that stated that clinical overt neuropathy has resulted from exposures as low as 30 ppm and several studies have reported sub-clinical effects such as electrophysiological changes in peripheral nerves in workers exposed to between 20 and 100 ppm. The OEL was changed to 20 ppm as this was felt likely to be a no-effect level for neurotoxicity.

Medline: A recent review of industry guidelines and federal standards for chemical toxicity (Lanska, 1999) used the OSHA and TLV limits set for n-hexane as an example of how regulatory policy lags behind current scientific knowledge. The article states that a number of clinical reports have identified clinical and sub-clinical neurotoxicity from n-hexane even below
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the current TLV of 50 ppm. The author concluded that the TLV level was too high to protect all workers.

Health effects of change in regulations: In light of the reports cited in the UK regulation review and those referred to in the 1999 review article, it is reasonable to assume that some workers may suffer chronic neurotoxicity with the adoption of the TLV standard. No mention of these reports were found in the TLV documentation, so a more careful review of the quality of these studies should be undertaken before adopting this conclusion.

3.5 Potential health impacts from key chemicals identified by OH&S professionals

Occupational health and safety personnel from the healthcare unions and from the employer provided lists of chemicals of concern for healthcare workers. From the submitted lists, a final list of 18 chemicals was derived (see Table 2). Of these chemicals, 17 of them were found to have some discordance between the OEL and the TLV regulations. However, as for the chemicals found in section 3.3.1, most of these discordances related to differences in the 15-minute exposure limits and some differences in designations. Only seven chemicals were found to have differences between the 8-hour OEL and the 8-hour TLV. Three of these, acetone, halothane and carbon tetrachloride have already been discussed in section 3.3.1. The remaining 4 chemicals will be discussed here.

a) Enflurane

Enflurane has been used extensively as an anesthetic agent since the early 1970s. It was introduced as it was felt to be a safer alternative to halothane.

<table>
<thead>
<tr>
<th>8 hr OEL: 2 ppm</th>
<th>8 hr TLV: 75 ppm</th>
<th>NIOSH REL: c. 2 ppm</th>
<th>OSHA PEL: none</th>
</tr>
</thead>
</table>

ACGIH reviews: The TLV was set as 75 ppm to minimize the potential for CNS depression and cardiovascular system effects. Exposure to 15 000 to 20 000 ppm induces general anaesthesia. Exposure to 2000 ppm for 30 minutes was not found to affect study subjects’ behaviour, reaction time or ability to perform a pegboard test. There have been no long-term studies on the human health effects of exposure to enflurane. Concentrations of enflurane and operating rooms in the US averaged between 5 and 10 ppm in unsavaged rooms and between 0 and 1,6 ppm in scavaged rooms. The level of 75 ppm was recommended based on the assumption that enflurane is safer than halothane and no effects of halothane have been documented at sub-anesthetic levels. There have been no experimental studies conducted on enflurane to assess its potential as a carcinogen or sensitizer. Therefore it was classified as A4, not classifiable as a human carcinogen without any other designations.

Occupational Exposure Limits Material (WCB): No change from the existing IH&S standard was proposed in 1996, therefore, the chemical was not included in this review. Information from WCB on the basis for the IH&S standard was not available.
Medline: No new studies documenting human health effects of chronic exposure to enflurane were found. A recent review article on occupational exposure to volatile anesthetics (Byhanh, Wilke & Westphahl, 2001) noted that most exposure limits for enflurane in Western countries are in the range of 2 to 10 ppm and that these levels are unlikely to be exceeded in modern operating theatres. The authors did raise concerns about possible exposures over these limits in other settings such as bronchoscopy suites, post-anesthetic care units or intensive care units.

Health effects of change in regulations: As there have been no studies looking at the effects of long-term exposure to enflurane, the health effects of adopting the much higher TLV value as the standard are unknown. As was the case for halothane, it seems that the OEL standard had been set because this level should be attainable in operating rooms with scavenging systems, not because there was evidence of harm from a higher exposure limit.

b) Ethylene oxide:
Ethylene oxide (EtO) is primarily used as a sterilizing agent in healthcare. It is also used as an intermediate in the production of some medical products, such as fibres, films and bottles, nonionic surface active agents, but exposures through handling these products should not be significant.

8 hr OEL: 0.1 ppm  8 hr TLV: 1 ppm  NIOSH REL: <0.1 ppm  OSHA PEL: 1 ppm

ACGIH reviews: The TLV of 1 ppm was set in order to reduce the potential increased risks of cancer and potential toxicities for the lungs, liver, kidneys, endocrine system, blood and CNS. Based on animal studies and some earlier epidemiologic studies of workers, EtO is classified as A2, a suspected human carcinogen. The largest study of workers exposed to EtO found no significant increase in mortality of any cause including cancer. The study involved over 18 000 workers with an average of 5 years of exposure to 4.3 ppm (8 hour time-weighted averages) EtO and an average of 16 years of follow-up. However, given the rarity of the cancers of interest (leukemia and stomach cancer) and the small number of cases that were found, the authors felt the study was inconclusive. The US Occupational Health and Safety Agency developed a risk assessment model for EtO based on toxicological data from rats. OSHA estimated that exposing workers to 1 ppm of EtO on a long term basis may result in an excess cancer mortality rate of 12 to 23 deaths per 10 000 workers. However, other authors have criticized this risk assessment process as being too fraught with uncertainty. Using such a model, they estimate that a virtually safe exposure limit could range between 0.005 ppb (parts per billion) to 1.3 ppm. In the 2001 Chemical Substances TLV Committee felt that there was no evidence to justify a lowering of the TLV below 1 ppm, but called for more studies to be conducted looking at human exposure and health effects.

Occupational Exposure Limits Material (WCB): No change from the existing IH&S standard was proposed in 1996, therefore, the chemical was not included in this review. Information from WCB on the basis for the IH&S standard was not available.
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Medline: The Hazardous Substances Data Bank of the NLM refers to a meta-analysis that combined the results of several studies, including the large cohort mentioned above. In all, nearly 30,000 subjects were observed and no increase in leukemias or other cancers were found. A study from France (Sobaszek et al. 1999) noted that the exposure limit for that country was 1 ppm.

Health effects of change in regulations: Again, as there is no long-term data on exposures at or below 1 ppm, the effect of adopting the TLV standard on worker health is unknown. It appears that the OEL standard was adopted on the basis of the risk assessment model developed by the US OSHA, and it is noted that this methodology has been criticized.

c) Nitrogen dioxide:
The majority of occupational exposure is the result of nitrate decomposition from various processes in which air is heated to a high temperature or in the exhaust of internal combustion engines.

OEL: ceiling 1 ppm 8 hr TLV: 3 ppm NIOSH REL: 1 ppm OSHA PEL: ceiling 5 ppm

ACGIH reviews: Inhalation of high concentrations of NO2 can lead to pulmonary edema and death. The effects of long-term exposure at low concentrations are less well defined. Russian workers exposed to 2.8 ppm or below over a period of 3 to 5 years were reported have developed chronic bronchitis and emphysema from this exposure. However, a later study found that workers exposed for several years to concentrations of NO2 between 30 and 50 ppm suffered no adverse effects. The odour of NO2 is detectable at 0.22 ppm for most people, but for some it is as low as 0.11 ppm. Another study, which used spirometric testing, found slight changes in respiratory vital capacity among workers exposed to concentrations of NO2 of between 0.4 and 2.7 ppm. The ACGIH committee recommends a TLV of 3 ppm, which it feels, should reduce the potential for acute effects or adverse physiologic effects from prolonged daily exposures. The committee felt that the studies that found effects at levels less than these values were not sufficiently precise to be conclusive. NO2 is assigned an A4 classification, not classifiable as a human carcinogen. There was not sufficient data to recommend a skin or sensitization notation.

Occupational Exposure Limits Material (WCB): No change from the existing IH&S standard was proposed in 1996, therefore, the chemical was not included in this review. Information from WCB on the basis for the IH&S standard was not available.

Medline: No new studies looking at the health effects of NO2 exposure in the workplace could be found, but over 150 studies looking at environmental NO2 exposures and health effects had been published since 1997. NO2 is one of the criterion air pollutants and is known to be associated with increases in respiratory and cardiovascular mortality. Of abstracts where exposure data were mentioned, one (Rosenlund & Bluhm, 1999) found acute respiratory effects...
at exposures of approximately 1.2 ppm and other found an association of increasing incidence of symptoms in asthmatics exposed to 0.011 ppm (Mukala et al, 1999).

Health effects of change in regulations: Given the evidence of health effects of environmental exposures to NO2 below the 1 ppm TLV, it seems likely that adopting this standard will increase symptoms in workers with pre-existing asthma and may cause the development of short-term respiratory illness even in non-asthmatics. However, the long-term consequences of such exposures are unknown and therefore the health effects of adopting the TLV are also uncertain.

d) Nitrous oxide:
Nitrous oxide has a long history of use as an anesthetic. Other primary uses are as a foaming agent in whipped cream, an oxidant for organic compounds, nitration of alkali metals and in some rocket fuel. Occupational exposure to operating room personnel from waste anesthetic gas ranges between 400 and 3000 ppm if no scavenging system is in place, and to less than 50 ppm with gas scavenging. Concentrations tend to be higher in dental offices, but exposures tend to be longer in hospitals.

8 hr OEL: 25 ppm 8 hr TLV: 50 ppm NIOSH REL: 25 ppm OSHA PEL: none

ACGIH reviews: The main health concerns relate to the increased rate of spontaneous abortions found in some studies of female workers directly exposed to waste anesthetic gases. Only one study (Cohen, et al., 1980) looked specifically at the role of nitrous oxide in this regard, but it found a 50% increase in congenital anomalies and a 100% increase in spontaneous abortions in female dental assistants who were exposed to inhalational anaesthetics, compared to those who were not. However, the TLV Committee cautioned that the design of this study, which was a mail survey of 30,650 dentists and 30,547 chairside assistants, may have been subject to a response bias (those with adverse health conditions may have been more likely to respond to the questionnaire). Nevertheless, the committee did conclude that it poses a reproductive hazard. The OSHA REL of 25 ppm was based on the results of a single study (NIOSH, 1977) which showed audiovisual performance deficits in subjects who were exposed to 50 ppm of nitrous oxide, but not at 25 ppm. The ACGIH notes that other similar studies (Frankhuizen, et al., 1978; Smith et al. 1977) have failed to find such an effect. Dentists with heavy exposures to nitrous oxide (greater than 3000 hours over 10 years) had a three to four-fold increase in vague neurological symptoms such as numbness, tingling and weakness. Nitrous oxide does not increase the development of tumours in rats or mice and epidemiologic studies have failed to find consistent associations with increased carcinogenisis. It is therefore classified as A4, not classifiable as a human carcinogen.

Occupational Exposure Limits Material (WCB): No change from the existing IH&S standard was proposed in 1996, therefore, the chemical was not included in the review. Information from WCB on the basis for the IH&S standard is not available.

Medline: No new studies on the human health effects of nitrous oxide were found.
Health effects of change in regulations: While there may be good evidence to suggest that neurobehavioural symptoms may not develop at levels of 50 ppm, there may still be some concern with reproductive health in female healthcare workers at this level, as the no-effect-level in humans has not been established. Until further epidemiological investigations establish the threshold level for reproductive effects in humans, the actual risk of increased rates of spontaneous abortions (or other adverse reproductive effects) from replacing the OEL of 25 ppm with the TLV of 50 ppm cannot be ascertained.

3.6 Substances with no Assigned TLVs – How Changes to the OHSR may Impact the Health of Workers Exposed to Newly Introduced Chemicals

One good example of a chemical product that is used widely in BC hospitals which has no TLV is ortho-phthaldehyde (OPA). OPA is the most commonly used alternative for glutaraldehyde in BC hospitals, despite lack of knowledge regarding employee health impact. Glutaraldehyde and OPA belong to the category of chemical high-level disinfectants (CHLDs), which are used most commonly in operating rooms, sterile processing, medical imaging, and gastroenterology departments. OHSAH is working together with scientists from the University of British Columbia’s School of Occupational and Environmental Hygiene (SOEH) to evaluate risks from substitution of glutaraldehyde with other CHLDs.

It was learned in our study that the use of glutaraldehyde alternatives is already widespread in BC hospitals, with the OPA being the most commonly used alternative. A total of 64 hospitals responded to the survey. Of these, 51 (80%) of the hospitals used high level disinfection (some small hospitals do not use HLD), 26 (51%) of the hospitals were already using alternatives, with 18 (35%) of these using only alternatives. Use of alternatives was found to be significantly associated with hospital size (less common in small hospitals, p < 0.05), but not with location or the availability of OH&S personnel; ironically, concerns about employee health was found to be the most common reason for using (42%) and for not using alternatives (26%). In addition, it was found that administrative issues were the most common reason for deciding which alternative to choose. Also, when infection control personnel were involved in the decision-making process, alternatives were less likely to be chosen; on the other hand, when senior administrators made decisions, alternatives were more commonly chosen. In BC hospitals, it was found that HLD use is most common in operating rooms, sterile processing, medical imaging, and gastroenterology departments. Results of the comparative toxicity assessment strongly suggest that OPA may be a respiratory sensitizer, unlike Compliance, another alternative product. The lack of a TLV- or OEL - has created uncertainly, and therefore concern amongst workers, employers and regulators – resulting in workplaces having to make decisions with insufficient guidance as to the potential health impacts.
4.0 Detailed Commentary on “Proposed Amendments to the Occupational Health and Safety Regulation Re: OELs”

Given our familiarity with the TLV process and the application of OELs in the healthcare setting and other industries, a review of all the proposed amendments was conducted and is presented in this section. This review is based on the “Proposed amendments to occupational health and safety requirements” (WorkSafe Online, February 25, 2003) report that details both the existing OHSRs as well as the proposed changes. The sections of the proposed wording changes within the OHSR are italicized and our comments provided directly below.

Part 1: Definitions

“ppm” – “means parts of a vapour or gas per million part of contaminated air…” (page 1) -
There should be further explanation of the methodology for comparing sampling results for gases and vapours that were not obtained at normal temperature and pressure conditions to the new exposure limits. The 2002 TLV book does not adequately describe these methods and in a review of the literature we have found that an article by Stephenson and Lillquist (2001) provides approaches that are correct and well explained. Very briefly, one method is as follows: 1) determine the exposure concentration, expressed in terms of mass per volume, at the sampling site using the sample volume not adjusted to NTP conditions, 2) if required, convert the TLV to mg/m³ (or other mass per volume measure) using a molar volume of 24.45 L/mole, and 3) compare the site exposure concentration to the TLV, both in units of mass per volume.

Part 5: Chemical and Biological Substances

"The employer must ensure that a worker’s exposure to a substance does not exceed the established exposure limits”. Page 5.
The TLVs are established without regard to sampling techniques and in some instances to evaluate a TLV a method is not available or is not typically used in a particular jurisdiction. For example, in Canada diesel exhaust particulate has been measured using a respirable combustion technique and the proposed TLV would require a completely different sampling and analytical method that may pose unique problems for exposure assessment for workers in BC. It is highly recommended that a process be in place to review the sampling and analytical techniques to ensure that the adopted exposure limits are quantifiable given the possibility that unique exposures and process may exist in BC.

Part 5: Chemical and Biological Substances

"Controlling Exposures, Additive effects”. Page 8.
The inclusion of the statement, “which exhibit similar toxicological effects,” is a major modification to the regulation and has an impact on enforcement and the interpretation of the exposure limits. In the past, the regulation required all components of a mixed exposure to be included in the mixture calculation much the same as is done by the US Department of Labour, when the OSHA Permissible Exposure Limits are enforced. The listing of critical effects in the TLV book may provide some guidance in this regard, but
should only be used as a starting point. Without further guidance on the interpretation/application of the additive effects computation (AE), workers in the province may not be adequately protected. In the healthcare field most exposures are to mixtures or co-exposure to individual compounds and this change presents a major health concern. Research being conducted at the Institute de Recherche en Sante et en Securite du Travail (IRSST) on the toxicological interactions of components of mixtures may be very useful and that organization is working to develop an internet-based tool to determine whether agents should be considered additive in toxicological effect. This may help provide the needed guidance on this issue.

Part 5: Chemical and Biological Substances

"Controlling Exposures, Skin designation – If skin absorption may contribute to the overall exposure, effective...”.” Page 9.

This definition of the skin designation does not correspond to the current application of the skin designation for the TLVs. As an example, 2-butoxyethanol (EGBE) is on the 2002 TLV Notice of Intended Changes at a TWA of 20 ppm with no skin designation, whereas the current WCB OEL is 25 ppm with a skin notation. The TLV Documentation for EGBE provides evidence for rapid percutaneous absorption but no expected adverse systemic effects (i.e., red cell hemolysis) related to the dermal absorbed dose. Thus the TLV Committee’s application of the skin designation requires both absorption and the requirement that the dose from the skin route has implication in terms of systemic toxicity (Kennedy et al. 199326). The current WCB OEL with its skin notation, reflects the different definitions as well as application of the notation. This issue has a direct impact on the health of BC workers and needs resolution. A suggested reference to assist in resolving this issue is ECETOC (1998) that provides a framework for addressing data in the interpretation of risks from percutaneous absorption of chemicals.

Part 5: Chemical and Biological Substances

"Controlling Exposures, Designated Substance; (b) reproductive critical effects.... (c) sensitization critical effect or SEN notation”. Page 11.

To our understanding, the “TLV Basis – Critical Effects” listing in the TLV book is intended to provide the occupational health professional with guidance in protecting workers and in highlighting chemicals for which there may be overlap in adverse health consequences (i.e., to apply the mixture formula for additive effects). In these cases the ACGIH recommends that the hygienist consult the Documentation for the specific chemicals to obtain more detailed information for risk assessment purposes. To use the TLV Basis – Critical Effects listing to define designated/ALARA substances is placing too much scientific weight on a list that is not intended for such use.

Another problem with defining designated substances using the TLV Basis – Critical Effects listing relates to differences in definitions. Reviewing various TLV Documentations and their associated critical effects listings, we have found that critical effects associated with the NOELs/LOELs that are drivers of the TLV number (i.e., uncertainty factors applied to these LOELs/NOELs determine the TLV) are always
listed, while other effects seen at higher exposure levels are less likely to be listed. One example is dimethylformamide (DMF), a chemical commonly used in laboratories and the healthcare industry. DMF, under current WCB regulations has a R2 designation, whereas there is no reproductive listing under the TLV’s TLV Basis – Critical Effects. However, the TLV Documentation does describe the teratogenic effects of DMF in mice and rabbits but at doses above the NOEL/LOELs used to establish the TLV. Thus, DMF with its known reproductive effects will no longer be regulated based on its reproductive health effects because of the definitions used by the TLV Committee for their TLV Basis – Critical Effects listing which is not intended for purposes of identifying or assigning risks related to reproductive toxicity.

A similar concern is raised in the use of the TLV SEN notation or a sensitization critical effect in the TLV Basis – Critical Effects listing. Although the TLV SEN designation is based on peer review of the literature available for specific compounds, the committee has been assigning SEN designations using a formalized protocol for only a few years (Bigelow, 2000); thus for substances that have not been recently updated there may not be appropriate scientific rigor in SEN notation assignments. There is special concern for potential sensitizers for which only recent literature is available on this critical effect.

For both reproductive and sensitization health effects it is highly recommended that more than the ACGIH TLVs be reviewed in order to assign designations.

Part 5: Chemical and Biological Substances
"Controlling Exposures, Protective policy”. Page 12.
Relying solely on the TLV listings for determining which worksite must develop protective policies and program for potential reproductive toxins and sensitizers may not be appropriate. Other listings designed for purposes more closely matched to this purpose should be evaluated. This is especially important for reproductive health programs where the identification of potential reproductive toxins is crucial and requires the consideration of multiple data sources (Kayman, 1990).

Part 5: Chemical and Biological Substances
"Controlling Exposures, Discharge Air; Table 5-1 …a nuisance particulate with an 8-hour TWA of a least 10 mg/m3”. Page 13.
This reference to “nuisance particulate” is incongruent with the Appendix E within the Notice of Intended Changes in the 2002 TLV book. The statement is not appropriate even as compared to the current “Introduction to the Chemical Substances” section of the book that indicates nuisance dusts are in fact not biologically inert and suggest exposures remain below 10 mg/m3, inhalable particulate.

“ACGIH® believes that even biologically inert, insoluble, or poorly soluble particles may have adverse effects and recommends that airborne concentrations should be kept below 3 mg/m^3, respirable particles, and 10 mg/m^3, inhalable particles, until such time as a TLV® is set.” (page 66 of the 2002 TLV book)
Given the TLV Committee’s beliefs, it is likely that few substances for which the predominant exposure is to the aerosol will be assigned a TLV-TWA exceeding 10 mg/m³, inhalable. Thus this section of the regulation needs to be re-evaluated.

Confined Spaces
“and that the oxygen concentration is greater than 19.5% by volume...”. Page 2.

Similar to the discussion of the definition of “ppm” in Part 1, the methods for evaluating compliance with the minimal concentration of 19.5 percent oxygen should be provided. The US DOL, OSHA provides a table of allowable oxygen percentages with altitude that ensures that workers at 10,000 feet elevation are provided adequate mass of oxygen per unit volume of air breathed. Supplying information on the minimum partial pressure of oxygen, along with the computational method for determining the oxygen partial pressure would be appropriate. Again, a review of the publication by Stephenson and Lillquist (2001) would be helpful.
5. Analysis

5.1 Potential Health Impacts of the Proposed Changes based on the Comparative Risk Analysis

In reviewing discordances between the 2002 TLVs and the WCB OEL for chemicals for which exposures are common in healthcare, in most cases the existing OELs were found to be lower than the corresponding TLV. Of 55 discordances, the OEL values were more stringent for 43 (78%) of the total (Table 1). Assuming the null hypothesis that there is equal probability of an OEL being higher or lower than the TLV, the finding of 43 of 55 changes in which the OEL was less than the TLV was determined to be unlikely due to chance using standard statistical tests. Given the number of discordances in which the OEL is lower than the TLV there is likely some added risk in adopting the TLVs in the proposed regulations.

Our comparative analysis by chemical provides an indication of the magnitude of the changes in risks between exposures at the two exposure levels. Unfortunately, for most compounds there are limited data that are applicable to assess the risk level differences. For these compounds where data are sparse, the change in the exposure level may or may not have any health impact on the working population. For some compounds data are available to characterize the change in risk. One example is formaldehyde, for which the TLV is lower than the OEL, and there are numerous studies that indicate increased symptoms at the higher level. Data are not directly available pertaining to the likely increased cancer risk, but that added risk can be predicted based on mechanistic studies.

When considering changes in risk from different exposure levels, the consideration of threshold versus non-threshold effects is important. In our critical review of acetone, we highlight new research that indicates that the sensory irritation levels of this compound are well above the OEL or TLV and are more likely in the thousands of ppm range. In fact, these contemporary studies that use techniques that are able to clearly evaluate the stimulation of nerves that are responsive to irritants are able to accurately measure thresholds of irritant responses in populations. Thus, for this threshold effect, changes in the OEL or TLV below the threshold have no impact on the health of exposed workers. However, for some compounds the threshold is either unknown or lower than the current exposure limits. For example, the literature on formaldehyde indicates that up to 20% of exposed workers may adversely respond to levels below the current TLV. In this case the TLV level is not low enough to be below the threshold for symptoms in the most sensitive subgroup. Thus, while the adoption of the TLV adds more protection than the current BC OEL, what is important is to encourage the lowest possible level of exposure.

For many of the chemicals whose critical effects are listed as “irritation” only (see Table 2), a change in exposure level is likely to have very minor health implications. However, for compounds with more significant critical effects a change in the exposure level may have more serious health consequences and public health impact. Formaldehyde, carbon tetrachloride, dichloromethane, halothane, and nitrous oxide are the healthcare exposures that, in our review,
have effects that have the potential for more significant health implications with changes in exposure levels. As indicated in the comparative review, with a few exceptions, there are insufficient data to determine threshold levels for workers or the magnitude of increased risks with differing exposure levels.

5.2 Main Differences in Procedures, Policies, and Rationales between the ACGIH TLVs and the WCB of BC Process of OEL Review and Update

5.2.1 Differences in selection procedures for OEL reviews/updates

Although the TLV Committee now has an objective and transparent method of selecting chemicals for new TLV or updating old values, the method is heavily weighted to concerns of American workers. BC is a relatively small jurisdiction in North America and would have limited input in advancing chemicals to be selected by the TLV committee for review. Thus, the proposed changes to the Occupational Health and Safety Regulations, which would solely adopt TLVs as OELs, could serve to limit the WCB’s ability to respond to the exposures that may be of major concern for BC workers.

5.2.2 Policies regarding worker protection

According to our discussion with members of the Regulation Review Specialty Subcommittee on Occupational Hygiene, who were responsible for the major review of BC OEL and who largely developed Table 5-4, an important consideration was to provide the greatest possible protection to BC workers using the OEL. In reviewing OELs from numerous OEL-developing organizations, the group tended to choose an OEL that, most often, was more protective of employees than the TLV. This, in part, reflects a philosophical difference in the approaches of the BC Committee and the TLV Committee.

This philosophical difference in OEL setting approaches is most often reflected in the uncertainty factors that are applied. Most occupational and environmental standard setting groups are tending to adopt more contemporary approaches (as described previously in the analysis of carbon tetrachloride) as opposed to applying the standard 10-100-1000 factors when extrapolating from species to human, dose route to inhalation, LOAEL to NOAEL, (see Gundert-Remy and Sonich-Mullin 2002). Since the database of available literature for OEL development is not different between organizations, differences in the numeric OELs most often were due to differences in these extrapolations. It appears as though the WCB, in setting their OEL, has adopted a more conservative approach in the application of uncertainty factors as compared to the TLV Committee. Unfortunately, the WCB provides little discussion of their approach to uncertainty factors, thus it is difficult to comment further.

It is recognized by all OEL setting organizations that there will be considerable variation in the level of human response to a particular chemical substance, regardless of the airborne
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concentration. Thus the OEL, regardless of the level adopted, will not adequately protect all members of the workforce. In the “Introduction to the Chemical Substances” section of the TLV book it is stated “a small percentage of workers may experience discomfort from some substances at or below the TLV”. This section goes on to explain that some individuals may experience more serious health effects below the TLV and that there are numerous possible reasons for increased susceptibility to a chemical substance, including age, gender, race, ethnicity, genetic factors (predisposition), lifestyle choices (e.g., diet, smoking, abuse of alcohol and other drugs), medications, and pre-existing medical conditions (e.g., aggravation of asthma or cardiovascular disease). Some individuals may become more responsive to one or more chemical substances following previous exposures (e.g., chemically-sensitized workers). Some changes in susceptibility may also occur at different work levels (e.g., light vs. heavy work) or at exercise - situations in which there is increased cardio-pulmonary demand. Thus the ACGIH recommends, for a given TLV, it is important to consult its respective Documentation to determine if any of these susceptibility issues need to be addressed. Thus, the ACGIH policy of using both the numeric TLVs along with the appropriate Documentation in providing additional information to supplement an existing risk reduction program is strongly advised in addressing this issue of individual susceptibility.

The issue of susceptibility has practical applications with respect to the application of OELs, and in particular, the WCB OEL. The TLV Committee and ACGIH strongly recommend consulting the individual Documentation along with special attention being paid to individuals who may be at added risk because of unusual susceptibility. The proposed amendments to the OHSR specifies that, “Except as otherwise determined, the exposure limits established are the ceiling limit, short-term exposure limit and 8-hour TWA limit as adopted by the ACGIH”. However no mention is made of the Documentations that support the TLVs and are crucial to ensure that extra care is taken to protect workers who may be at increased risk. The TLV Committee uses the Documentation as a mechanism to provide the field occupational health professional with information on susceptibility issues and the proposed amendments appear not to provide such a mechanism for those in BC.

An additional consideration with regard to susceptibility pertains to the diversity of the population of province. Immigration to the United States, on a per capita basis, is far lower than Canada, making this country more ethnically diverse. This diversity may not be reflected in the TLVs because most studies have not included subjects from such a wide variety of ethnic and racial backgrounds. Although this is a limitation of all literature available for OEL development, extreme care must be taken in interpreting data that must be extrapolated to diverse populations.

The healthcare workforce has great diversity and workers are not typical of those included in occupational studies that have provided data for OEL development. Although research on the health effects of chemicals is expanding to include minorities and women, most OELs that have the benefit of human observational research are based on studies within industrial settings with mostly male subjects. As is the case with laboratory workers, employees in healthcare are most often exposed to a wide variety of chemicals, and while not appearing to have been injured, have been hardened to the effects of any single exposure (Bigelow, 2000). Thus, both healthcare and
laboratory workers are likely to be more highly susceptible and respond more adversely to any single chemical exposure as compared to their industrial counterparts. Added to this is the multiplicity of exposures found in laboratories and healthcare settings, making the adequacy of TLVs or any OELs, for that matter, questionable.

5.2.3 Procedural differences in standard setting

In addition to philosophical differences in OEL setting, differences in procedures employed by the Regulation Review Specialty Subcommittee on Occupational Hygiene and the TLV Committee may have lead to the discordances between numeric values for specific substances. Since the Regulation Review Specialty Subcommittee on Occupational Hygiene reviewed existing OELs from 5 organizations in addition to the TLVs, there is the likelihood that one of the 5 organizations had a more recent OEL than the TLV. Thus the process allowed BC workers in effect to have the benefit of the most recent review of the literature. Additionally, OEL setting bodies are now cooperating with one another to avoid duplication of effort, meaning that they often agree to focus on different compounds making it more important to review OELs for multiple organizations to determine the most appropriate level.

The Regulation Review Specialty Subcommittee on Occupational Hygiene was composed of both union and employer representatives along with technical experts from the WCB. This tripartite process was supplemented by the fact that OELs from organizations that developed OELs with active input from union and management representatives were eligible for review. Tripartite review is not part of the TLV process, as individuals may work at various agencies, companies, or organizations but they do not represent their employers during TLV deliberations. Tripartite review does allow the expression a wider variety of opinions as compared to the likely narrower perspective of TLV committee members selected on the basis of their scientific expertise.

Unfortunately, little information was available pertaining to the level of peer review that was part of the WCB of BC’s OEL development process either from 1992-1996 or more recently. The report titled “Draft Occupational Limits Material (1996)” from the WCB, provides brief rationales for the OEL that were reviewed and modified in the development of Table 5-4. For example, the report on n-butanol, which was reviewed by the Regulation Review Specialty Subcommittee on Occupational Hygiene, provides a very concise summary of the Subcommittee’s discussion that led to the adoption of an 8-hour OEL of 15 ppm along with a ceiling OEL of 30 ppm with a skin designation. The discussion focused on the Swedish documentation that utilized 1940’s studies by Nelson and Tabershaw pertaining to upper airway irritation in exposed workers and volunteers. However, the rationale fails to present more contemporary data related to the interpretation of sensory irritation effects that are available in the peer reviewed literature but were not written into OEL documentations in the mid 1990s (Cain 1974; Berglund et al., 1978). This indicates that the Subcommittee’s scientific review for this n-butanol was not complete or that arguments not supportive of the acceptance of the 1940s studies were not presented or aired, leading to what some people may argue was a needlessly stringent regulation based on refuted science.
5.2.4 Legal, liability, and duty of care issues

The ACGIH is cognizant of the importance of stakeholder input and local decision-making in developing OELs for enforcement purposes. They argue that TLVs are meant to aid the occupational health professional in the recognition, evaluation, and control of workplace hazards. The ACGIH strongly recommends that enforcement agencies not adopt the TLVs, but use them along with other OELs in recommending their own exposure values. Additionally, the ACGIH considers the Documentation of the TLVs to serve as companion literature to the specific numeric TLVs and both should be used as guidance. In fact, ACGIH states in a special note to TLV and BEI users on their website (http://www.acgih.org/TLV/PolicyStmt.htm): “It is imperative that the user of these values read the Introduction to each section of the TLV/BEI Book and be familiar with the Documentation of the TLVs and BEIs before applying the recommendations.” Thus, regulatory agencies should consider this recommendation and institute policies and programs to address this issue.

The ACGIH, notes that unlike regulatory bodies, it does not owe a duty of care to workers in specific jurisdictions and they recognize “…that in certain circumstances individuals or organizations may wish to make use of these recommendations or guidelines as a supplement to their occupational safety and health program. ACGIH will not oppose their use in this manner, if the use of TLVs and BEIs in these instances will contribute to the overall improvement in worker protection.” (ACGIH 2003a). The ACGIH’s policy statement, along with previous court decisions in the US (Marasco, 2000), support the supposition that the ACGIH does not owe a duty of care to workers (consumers) in other jurisdictions. This responsibility in BC would thus fall to the BC WCB, not ACGIH.

In the ACGIH’s “Statement of Position Regarding the TLVs® and BEIs®” the rationale for regulatory agencies not to adopt TLVs or BEIs is clearly laid out (ACGIH 2003b)

- ACGIH® is not a standards setting body.
- Regulatory bodies should view TLVs and BEIs as an expression of scientific opinion.
- TLVs and BEIs are not consensus standards.
- ACGIH® TLVs and BEIs are based solely on health factors; there is no consideration given to economic or technical feasibility. Regulatory agencies should not assume that it is economically or technically feasible to meet established TLVs or BEIs.
- ACGIH believes that TLVs and BEIs should NOT be adopted as standards without an analysis of other factors necessary to make appropriate risk management decisions.
- TLVs and BEIs can provide valuable input into the risk characterization process. Regulatory agencies dealing with hazards addressed by a TLV or BEI should review the full written Documentation for the numerical TLV or BEI.
6. Concluding Remarks

It has been identified by some of the stakeholders that the process of setting regulatory standards in BC was inefficient, and it has been recommended that BC adopt TLVs in place of made-in-BC occupational exposure limits. In as much as the current process is perceived to not be working well, it is understandable that changes are warranted. Moreover, the scientific basis for the BC OELs has generally not been well documented, further leading to questioning of the process and the standards that have emerged.

We found that the number of discordances between the TLVs and the BC OELs was not huge, and in fact, in some cases, the TLVs are more protective than the current BC OELs. However, we note that the ACGIH explicitly indicates that the TLVs set in the US are not designed to be used in place of OELs, for reasons provided in this brief. The WCB did, as one time, allude to a consultative process for addressing BC-based exposure concerns. We have not been able to ascertain the details of this proposal, or its current status, and thus we are not able to offer any comments in this regard.

In this brief we also highlighted technical details that require further attention. We hope that this brief is, therefore, useful to decision-makers in drawing attention to the implications of the proposed changes and the desirability of some clarifications and amendments.
Using the American Conference of Industrial Hygienists (ACGIH) Threshold Limit Values® (TLVs®) in the Regulation of Workplace Chemicals and Substances in British Columbia: A Scientific Analysis Highlighting Issues to Consider

Table 2 - List of Discordant OEL and TLV for Chemicals Used in Healthcare as Identified Through the WHMIS Database of OHSAAH.

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>8hr EL</th>
<th>15 Min EL</th>
<th>Ceiling EL</th>
<th>Designation</th>
<th>TWA</th>
<th>STEL</th>
<th>Notation</th>
<th>Notice of Intended</th>
<th>TLV Basis - Critical Effect(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetamide</td>
<td></td>
<td></td>
<td></td>
<td>K3</td>
<td>3ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetic Acid</td>
<td>250ppm</td>
<td>50ppm</td>
<td>60ppm</td>
<td>2ppm</td>
<td>2ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetone</td>
<td>750ppm</td>
<td>750ppm</td>
<td></td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetonitrile</td>
<td>5ppm</td>
<td>10ppm</td>
<td>20ppm</td>
<td>A4;SKIN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetylene tetrafluoride</td>
<td>1ppm</td>
<td>1.5ppm</td>
<td>2ppm</td>
<td>A4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum Oxide</td>
<td>10ppm</td>
<td>10ppm</td>
<td>10ppm</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzene Chloride</td>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td>0.5ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzyl Peroxide</td>
<td>5mg/m³</td>
<td></td>
<td></td>
<td>A4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butane</td>
<td>1500ppm</td>
<td>3000ppm</td>
<td>1500ppm</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>10ppm</td>
<td>20ppm</td>
<td>20mg/m³</td>
<td>A4;SKIN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>5000ppm</td>
<td>30000ppm</td>
<td>5000ppm</td>
<td>Asphyxiation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>25ppm</td>
<td>10ppm</td>
<td>R2</td>
<td>BEI</td>
<td></td>
<td></td>
<td></td>
<td>Anoxia; CNS; OCS; reproductive</td>
<td></td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>2ppm</td>
<td></td>
<td>skin, K3</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Catechol</td>
<td>5ppm</td>
<td>10ppm</td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer; lung</td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>3ppm</td>
<td></td>
<td>Skin; K2;R2</td>
<td>A3</td>
<td></td>
<td></td>
<td></td>
<td>Liver; nasal; reproductive</td>
<td></td>
</tr>
<tr>
<td>Copper (dust)</td>
<td>1mg/m³</td>
<td>2mg/m³</td>
<td>Dust and Mist; Total Dust, as Cu</td>
<td>1mg/m³</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cresol (all isomers)</td>
<td>10mg/m³</td>
<td></td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>100ppm</td>
<td>300ppm</td>
<td></td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>25ppm</td>
<td></td>
<td>skin;K2</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Diethylamine</td>
<td>1ppm</td>
<td></td>
<td>skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer; kidney; liver</td>
<td></td>
</tr>
<tr>
<td>Dimethylformamide</td>
<td>10ppm</td>
<td>25ppm</td>
<td>skin;K3;R2</td>
<td>A3</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Ethanol</td>
<td>100ppm</td>
<td></td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer; kidney; liver</td>
<td></td>
</tr>
<tr>
<td>Ethyl Acetate</td>
<td>150ppm</td>
<td></td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>10mg/m³</td>
<td>20mg/m³</td>
<td>Skin – particulate</td>
<td>C 100mg/m³</td>
<td>A4</td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>1ppm</td>
<td></td>
<td></td>
<td>K;Z;A</td>
<td>0.05ppm</td>
<td></td>
<td></td>
<td>CNS, cancer</td>
<td></td>
</tr>
<tr>
<td>Glutaraldehyde</td>
<td>2ppm</td>
<td>5ppm</td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>2ppm</td>
<td>50ppm</td>
<td>Skin; BEI</td>
<td>A3;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer; kidney; liver</td>
<td></td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>1ppm</td>
<td>1ppm</td>
<td>Skin; BEI</td>
<td>A3;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Hydroquinone</td>
<td>2mg/m³</td>
<td></td>
<td>A3</td>
<td>A3;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Isopropanol</td>
<td>400ppm</td>
<td>500ppm</td>
<td>Skin</td>
<td>400ppm (500ppm)</td>
<td>(I)</td>
<td></td>
<td></td>
<td>CNS; dermatitis; ocular</td>
<td></td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>2ppm</td>
<td>5ppm</td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Phenol</td>
<td>5ppm</td>
<td>10ppm</td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Propylene Oxide</td>
<td>5ppm</td>
<td>10ppm</td>
<td>Skin;K;Z;A</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Pyridine</td>
<td>5ppm</td>
<td>10ppm</td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Rubber Solvent</td>
<td>160mg/m³</td>
<td></td>
<td>400ppm</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Sodium bisulfite</td>
<td>5mg/m³</td>
<td></td>
<td>A4</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td>1mg/m³</td>
<td></td>
<td>K1 (The K1 designation, and hence ALARA, only applies to sulfuric acid contained in a strong inorganic acid mist)</td>
<td>1mg/m³; A2;M;I</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Toluene</td>
<td>30ppm</td>
<td>100ppm</td>
<td>Skin;K2</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
<tr>
<td>Xylene</td>
<td>100ppm</td>
<td>150ppm</td>
<td>Skin</td>
<td>A4;BEI</td>
<td></td>
<td></td>
<td></td>
<td>CNS; cancer</td>
<td></td>
</tr>
</tbody>
</table>
Using the American Conference of Industrial Hygienists (ACGIH) Threshold Limit Values® (TLVs®) in the Regulation of Workplace Chemicals and Substances in British Columbia: A Scientific Analysis Highlighting Issues to Consider

Table 3 – List of Discordant OEL and TLV for Chemicals Identified by Occupational Health and Safety Professionals in Healthcare

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>WCB 8hr EL</th>
<th>WCB 15 Min EL</th>
<th>WCB Ceiling EL</th>
<th>Designation</th>
<th>ACGIH 8hr TWA</th>
<th>ACGIH STEL</th>
<th>Notice of Intended Changes</th>
<th>TLV Basis - Critical Effect(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>250ppm</td>
<td>500ppm</td>
<td>500ppm</td>
<td></td>
<td>500ppm</td>
<td>750ppm</td>
<td>A4;BEI</td>
<td>Irritation</td>
</tr>
<tr>
<td>Benzene</td>
<td>0.5 ppm</td>
<td>2.5 ppm</td>
<td>SKIN, K1, A</td>
<td></td>
<td>0.5 ppm</td>
<td>2.5 ppm</td>
<td>SKIN, A1</td>
<td>Cancer</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>500ppm</td>
<td>15000ppm</td>
<td>5000ppm</td>
<td></td>
<td>5000ppm</td>
<td>30000ppm</td>
<td>Asphyxiation</td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>25ppm</td>
<td>100ppm</td>
<td>R2</td>
<td></td>
<td>25ppm</td>
<td></td>
<td>BEI</td>
<td></td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>2ppm</td>
<td>skin, K3</td>
<td>5ppm</td>
<td>10ppm</td>
<td>Skin, A2</td>
<td>Liver, cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorine bleach</td>
<td>0.5 ppm</td>
<td>1 mg/m³</td>
<td>SKIN</td>
<td></td>
<td>0.5 ppm</td>
<td>1 mg/m³</td>
<td>A4</td>
<td></td>
</tr>
<tr>
<td>Enfluorane</td>
<td>2 ppm</td>
<td></td>
<td></td>
<td></td>
<td>75 ppm</td>
<td></td>
<td>A4</td>
<td></td>
</tr>
<tr>
<td>Ethylene oxide</td>
<td>0.1 ppm</td>
<td>1 ppm</td>
<td>SKIN, K1, A</td>
<td></td>
<td>1 ppm</td>
<td></td>
<td>A2</td>
<td>Cancer, reproductive</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>3 ppm</td>
<td>1 ppm</td>
<td>K2ZA</td>
<td></td>
<td>C0.3 ppm</td>
<td>SEN, A2</td>
<td></td>
<td>Imitation, cancer</td>
</tr>
<tr>
<td>Glutaraldehyde</td>
<td>0.25 mg/m³</td>
<td>Z, A</td>
<td></td>
<td></td>
<td>C0.05 ppm</td>
<td>SEN, A4</td>
<td></td>
<td>Imitation, sensitization (activated and inactivated)</td>
</tr>
<tr>
<td>Halothane</td>
<td>2ppm</td>
<td>R2</td>
<td></td>
<td></td>
<td>50ppm</td>
<td></td>
<td>A4</td>
<td></td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>1 ppm</td>
<td>4 ppm</td>
<td></td>
<td></td>
<td>1 ppm</td>
<td></td>
<td>A3</td>
<td></td>
</tr>
<tr>
<td>Nitric acid</td>
<td>25ppm</td>
<td></td>
<td></td>
<td></td>
<td>50 ppm</td>
<td></td>
<td>A4</td>
<td>Reproductive, blood, CNS</td>
</tr>
<tr>
<td>Peroxide</td>
<td>not found</td>
<td>not found</td>
<td></td>
<td></td>
<td>not found</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toluene</td>
<td>50ppm</td>
<td>100ppm</td>
<td>Skin, R2</td>
<td></td>
<td>50ppm</td>
<td></td>
<td>SEN, A4;BEI</td>
<td>CNS</td>
</tr>
<tr>
<td>Xylene</td>
<td>100ppm</td>
<td>150ppm</td>
<td>Skin</td>
<td></td>
<td>100ppm</td>
<td>150ppm</td>
<td>A4;BEI</td>
<td>Imitation</td>
</tr>
</tbody>
</table>

Notice of Intended Changes: Critical Effect(s)

- 8hr EL: 8-hour exposure level
- 15 Min EL: 15-minute exposure level
- Ceiling EL: Ceiling exposure level
- TWA: Time-weighted average
- STEL: Short-term exposure limit
- ACGIH: American Conference of Industrial Hygienists
- WCB: Workplace Safety and Health Board
Appendix 1 - Statement of Position Regarding the TLVs® and BEIs®

The American Conference of Governmental Industrial Hygienists (ACGIH) is a private not-for-profit, nongovernmental corporation whose members are industrial hygienists or other occupational health and safety professionals dedicated to promoting health and safety within the workplace. ACGIH is a scientific association. ACGIH is not a standards setting body. As a scientific organization, it has established committees that review the existing published, peer-reviewed scientific literature. ACGIH publishes guidelines known as Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs) for use by industrial hygienists in making decisions regarding safe levels of exposure to various chemical and physical agents found in the workplace. In using these guidelines, industrial hygienists are cautioned that the TLVs and BEIs are only one of multiple factors to be considered in evaluating specific workplace situations and conditions.

Each year ACGIH publishes its TLVs and BEIs in a book. In the introduction to the book, ACGIH states that the TLVs and BEIs are guidelines to be used by professionals trained in the practice of industrial hygiene. The TLVs and BEIs are not designed to be used as standards. Nevertheless, ACGIH is aware that in certain instances the TLVs and the BEIs are used as standards by national, state, or local governments.

Governmental bodies establish public health standards based on statutory and legal frameworks that include definitions and criteria concerning the approach to be used in assessing and managing risk. In most instances, governmental bodies that set workplace health and safety standards are required to evaluate health effects, economic and technical feasibility, and the availability of acceptable methods to determine compliance.

ACGIH TLVs and BEIs are not consensus standards. Voluntary consensus standards are developed or adopted by voluntary consensus standards bodies. The consensus standards process involves canvassing the opinions, views and positions of all interested parties and then developing a consensus position that is acceptable to these parties. While the process used to develop a TLV or BEI includes public notice and requests for all available and relevant scientific data, the TLV or BEI does not represent a consensus position that addresses all issues raised by all interested parties (e.g., issues of technical or economic feasibility). The TLVs and BEIs represent a scientific opinion based on a review of existing peer-reviewed scientific literature by committees of experts in public health and related sciences.

ACGIH TLVs and BEIs are health-based values. ACGIH TLVs and BEIs are established by committees that review existing published and peer-reviewed literature in various scientific disciplines (e.g., industrial hygiene, toxicology, occupational medicine, and epidemiology). Based on the available information, ACGIH formulates a conclusion on the level of exposure that the typical worker can experience without adverse health effects. The TLVs and BEIs are not quantitative estimates of risk at different exposure levels or by different routes of exposure.
Since ACGIH TLVs and BEIs are based solely on health factors, there is no consideration given to economic or technical feasibility. Regulatory agencies should not assume that it is economically or technically feasible for an industry or employer to meet TLVs or BEIs. Similarly, although there are usually valid methods to measure workplace exposures at TLVs and BEIs, there can be instances where such reliable test methods have not yet been validated. Obviously, such a situation can create major enforcement difficulties if a TLV or BEI was adopted as a standard.

ACGIH does not believe that TLVs and BEIs should be adopted as standards without an analysis of other factors necessary to make appropriate risk management decisions (e.g., control options, technical and economic factors, etc.). However, ACGIH does believe that regulatory bodies should consider TLVs or BEIs as valuable input into the risk characterization process (hazard identification, dose-response relationships, and exposure assessment). Regulatory bodies should view TLVs and BEIs as an expression of scientific opinion.

ACGIH is proud of the scientists and the many members who volunteer their time to work on the TLV and BEI Committees. These experts develop written Documentation that include an expression of scientific opinion and a description of the basis, rationale, and limitations of the conclusions reached by ACGIH. The Documentation provides a comprehensive list and analysis of all the major published peer-reviewed studies that ACGIH relied upon in formulating its scientific opinion. Regulatory agencies dealing with hazards addressed by a TLV or BEI should obtain a copy of the full written Documentation for the TLV or BEI. Any use of a TLV or BEI in a regulatory context should include a careful evaluation of the information in the written Documentation and consideration of all other factors as required by the statutes that govern the regulatory process of the governmental body involved.
Using the American Conference of Industrial Hygienists (ACGIH) Threshold Limit Values® (TLVs®) in the Regulation of Workplace Chemicals and Substances in British Columbia: A Scientific Analysis Highlighting Issues to Consider

References

1. ACGIH (1996). American Conference of Governmental and Industrial Hygienists: Carbon Monoxide—Recommended BEI.

2. ACGIH (2002a) Two Thousand Two TLVs and BEIs: Threshold Limit Values for Chemicals Substances and Physical Agents & Biological Exposure Indices. ACGIH Worldwide, Cincinnati, USA.


Using the American Conference of Industrial Hygienists (ACGIH) Threshold Limit Values® (TLVs®) in the Regulation of Workplace Chemicals and Substances in British Columbia: A Scientific Analysis Highlighting Issues to Consider


