

REPORT SUBMISSION TO THE MINISTRY OF LABOUR



OCCUPATIONAL EXPOSURE LIMITS – PROPOSED CHANGES 2004

SUBMITTED TO: ONTARIO MINISTRY OF LABOUR
PREPARED BY: OCCUPATIONAL HEALTH CLINICS OF
ONTARIO WORKERS (OHCOW) OHCOW HYGIENISTS
DATE: NOVEMBER 18TH, 2004

OCCUPATIONAL HEALTH CLINICS OF ONTARIO WORKERS REPORT SUBMISSION TO THE MINISTRY OF LABOUR ON:

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Occupational Health Clinics for Ontario Workers
11/25/2004

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Report Submission to the Ministry of Labour on Occupational Exposure Limits – Proposed Changes 2004

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- D. Particulates Not Otherwise Classified (PNOC's)
- E. Fibreglass
- F. Wood Dust
- G. Caprolactam
- H. Rosin Core Solder Thermal Decomposition Products (Colophony)
- I. Metalworking Fluids
- J. Silicon Carbide
- K. n-Butyl Alcohol
- L. Noise
- M. Silica, Crystalline – Quartz

1. EXECUTIVE SUMMARY:

OEL's have been the basis of occupational hygiene practice for many years, however, there are a variety of other means which are being recognized worldwide as having a much greater impact and which represent a far more efficient use of available resources in the efforts to control, reduce and eliminate workplace exposures. OEL's are probably the weakest of tools. With the requirement to sample and to sample in a manner consistent with accepted sampling strategies, it is expected the institution of most of these proposed OEL's will have a very minimal impact for most workers in Ontario (*with the exception of workers exposed to particular substance such as silica, manganese and asphalt fumes*). We would highly recommend the Ministry to investigate these other policy options and only rely on continually updating the OEL's with the ACGIH TLV as a bare minimum from which to strive for improvements in the working conditions for Ontario workers. It is within this context of these concerns that we are putting forward comments on a selected number of specific agents included in the proposed regulation, some agents not included, and further discussion of the issue of regulating sensitizers and carcinogens in the workplace. Given the clinical context the hygienists at OHCOW find themselves in, the question we would attempt to answer with respect to the comments regarding specific chemicals would be: will this proposed change in the OEL be effective in preventing the occupational health conditions associated with the exposure to this specific agent?

The OHCOW Hygienists have tried to answer this question for the following workplace exposures:

- A. Asphalt (bitumen) fumes
- B. Manganese
- C. Wheat Flour Dust (Total dust)
- D. Particulates Not Otherwise Classified (PNOC's)
- E. Fibreglass
- F. Wood Dust
- G. Caprolactam
- H. Rosin Core Solder Thermal Decomposition Products (Colophony)
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2. OVERVIEW OF OCCUPATIONAL EXPOSURE LIMITS AND THEIR IMPACT ON WORKERS:

a. OHCOW Background and Exposure Assessment Experience:

The Occupational Health Clinics for Ontario Workers (OHCOW) were established in 1989 in response to the need for workers to have trusted occupational health resources. OHCOW consists of five clinics throughout the province (*Hamilton, Sarnia, Sudbury, Toronto, Windsor*) along with numerous “satellite” clinics in other locations as demand for services requires. The mandate of the Clinics as funded through the Prevention Branch of the WSIB is the prevention of occupational accidents and disease. OHCOW channels its efforts towards this goal by means of an inter-disciplinary occupational health team consisting of occupational health physicians, occupational health nurses, ergonomists, occupational hygienists and an assortment of support and supervisory staff. Additional disciplines represented within the various teams include epidemiology, toxicology, engineering, health education, and others. With respect to occupational exposure limits, OHCOW deals directly with Joint Health and Safety Committees (JHSC’s), unions, employers, individual workers and others, helping them to interpret exposure assessments, developing assessment strategies, directly assessing exposures, dealing with issues underlying the requests for assessments (*e.g. worker symptoms and health conditions*), questions of toxicology and assessment elimination, substitution and/or control measures. OHCOW has a number of trained occupational hygienists distributed throughout the province servicing client workplaces. Thus, OHCOW has extensive frontline experience with JHSC attempting to assess and with workers who have suffered illness or injury due to exposures in the workplace and have seen the role the OEL play in prevention.

b. OEL History in Ontario:

OHCOW has participated in previous efforts to update the OEL’s, particularly with the Joint Steering Committee from 1987 to 1995. We have commented on specific chemicals which the JSC’s attempted to update. At that point in time the JSC choose not to use the ACGIH TLV’s since they were derived by a committee with bi-partite representation (*labour and management*). Instead 7 jurisdiction with bi-partite input were selected and the lowest OEL from these jurisdictions was chosen for consideration. The process was nearing completion when the new Conservative government came into power in 1995 and scuttled the 8 years of work that went into the process. The bi-partite process after a productive beginning became polarized as it progressed and the MOL was to be the arbitrator of those issues which the committee could not come to consensus. Given the gridlock that this process was susceptible to and the sporadic updates since, maintaining the occupational exposure limits up to date with ACGIH TLV’s appears to be a reasonable default process. It may, however, be even more expedient to follow the Canadian federal government’s practice to simply refer to the ACGIH TLV’s “as amended from time to time” rather than go through the whole consultation process each year when the TLV’s change. An exception should be of course, responding to evidence brought to the Ministry’s attention regarding specific hazards faced by Ontario workers for which the evidence shows workers are not adequately being protected with compliance with a specific ACGIH TLV.

c. Concerns Regarding the ACGIH TLV Committee:

Serious allegations have been leveled in the scientific literature in the past concerning the integrity of the ACGIH TLV’s particularly with the role that industry play in influencing the Committee⁽¹⁻⁵⁾. Systematic reviews have shown that often the level set for the TLV’s where closer to practically achievable levels in industry as opposed to health based levels. The ACGIH TLV Committee responded to these criticisms by tightening up its process and documentation of the TLV’s. However, a different challenge has been launched

against the TLV's in the last few years which also threaten to effect the manner in which they are set. A number of lawsuits were launched against the TLV from both industry and industrial disease victims. These recent legal challenges have had a "chilling" effect on the organization and could conceivably introduce a hesitancy in reacting to new evidence in future deliberations. Also the OEL compliance paradigm of workplace exposure control is "showing its age". New paradigms not based on this one dimensional approach to workplace disease prevention are proving more effective and efficient in reducing workplace exposures.

d. A Lack of a Legal Requirement to Measure Exposures:

Setting lower OEL's will not necessarily lead to reductions in exposure in Ontario workplaces. (*Raising some OEL's will obviously not have such an effect either and may even increase exposures – a very counterprevention trend!*) In order for an OEL to effectively lower workplace exposures, measurements must take place in workplaces particularly where exposures exceed the new OEL. The proposed changes to the regulation do require employers to take measurements, so naturally if no measurements are taken, no overexposures will be detected and there will be no regulatory inducement to reduce or eliminate exposures. There is a need for a regulatory requirement to perform sampling for the purpose of exposure assessments if the changes in OEL's are to impact Ontario workplaces. Without such a legal requirement, employers fearing being found out of compliance may merely decide not to measure at all.

e. A Lack of a Legal Requirement to Employ Unbiased Sampling Strategies:

Even if measurements are taken, the conditions under which they are taken and the number of measurements taken can be manipulated as to minimize the chances of detecting an over-exposure. In fact it has been shown⁽⁶⁾ that mathematically modeling exposures⁽⁷⁾ is more accurate than a sampling campaign that covers three or fewer

workdays (*most sampling campaigns cover only a single day*). The JSC recognized this situation and brought a draft regulation on exposure assessment strategies which require employers to assess exposure using prescribed methods and sampling strategies which would ensure objective assessments. The AIHA Exposure Assessment Strategy Committee has produced a manual⁽⁸⁾ on procedures and strategies for managing exposure assessments. Stephen Rappaport has also written extensively^(9,10) on statistically valid sampling strategies and was used as a consultant for the JSC's draft regulation on sampling strategy. This manual has become the standard for properly designing exposure assessments strategies. For regulatory purposes, a regulation could simply refer to the test-book and require that sampling strategies would be devised following the procedures outlined in this manual. This would ensure that appropriate exposure assessment strategies are used addressing the common criticisms of biased sampling strategies.

f. Concerns Regarding the Effectiveness of the OEL as a Means for Improving Workplace Conditions:

If these changes in the OEL's were accompanied with legal requirements to perform exposure assessments and be required to follow recognized sampling strategies, would workplace exposures be reduced? This question has been addressed by the author Eileen Senn⁽¹¹⁾ who reviewed the US OSHA experience with measurements taken by OSHA representatives in response to workplace exposure complaints. Her findings based on the OSHA database of workplace measurements showed that over 90% of measurements taken in response to complaints were in compliance. What this means is that quantitative exposure assessment essentially had the effect of reinforcing the status quo (*i.e. no regulatory onus to reduce exposures*) in situations where workers had lodged complaints regarding exposures. While delivering our services, OHCOW has encountered the general frustration workers have with respect to occupational hygiene exposure assessments. Invariably, exposures are in compliance with current standards (*note that most sampling strategies do not follow accepted guidelines as laid out in the AIHA exposure assessment manual*),

and such assessments/reports then become an extra obstacle in the struggle to alleviate symptoms and reduce/eliminate exposures. Ms. Senn also investigated the effect of updating the US OEL's from 1968 to 1989 would have on the percentage of compliance. Her findings were that such a drastic updating (*almost 30 years*) would generally only lower the compliance rate by less than 10% (*from above 90% compliance to above 80% compliance*). Thus the updating of the OEL's would generally have little impact on the level of exposure experienced by most workers. There were some exceptions however, for instance the proposed lowering of the silica and the manganese OEL's in Ontario would significantly impact those workers working with these chemicals since exposures are often at or over the current exposure limit. But outside a few specific exceptions, it is generally expected that if employers would be obliged to measure exposures and if they used appropriate sampling strategies, the number of workplaces found out of compliance would not change significantly.

g. Limitations in OEL's in Preventing Occupational Disease:

Even though most workplaces are in compliance with current OEL's and would be expected to be in compliance with the proposed changes (*with a few notable exceptions*), this does not mean there are little or no hazards due to the exposures among Ontario workers. First of all, the ACGIH in its preamble to the TLV specifically state that not all workers will be protected by complying with these OEL's. In fact if one follows the history of OEL's one will notice a gradual decline in most OEL's over the years as more evidence of workers experience symptoms and diseases are established. What is to say that an exposure which may be legal now, may in the future be considered associated with an occupational disease once the evidence (*i.e. affected workers*) has been collected and assessed. This has been the pattern in the past and there is little reason to suspect it will not continue. This is one of the reasons for the ALARA principle or the precautionary principle, which both suggest that exposures be kept as low as reasonably possible in light of the scientific uncertainty associated with the evidence

(*or lack of evidence*) regarding the association of exposure with disease. Rather than a chemical being assumed to be non-toxic until proven otherwise (*thus the absence of evidence supporting non-toxicity*), we would adhere to the assumption of a chemical's toxicity until valid evidence is produced to the contrary.

The MOL has instituted a policy which recognizes that just because exposure assessments demonstrate compliance is no reason to ignore workers symptoms and health problems associated with such exposures. The fact that there are relatively few reported investigations assessing worker health in relation to exposures in consideration of the number of workers actually exposed. The standard of evidence for the basis of many OEL's is extremely poor by general scientific standards; some merely suggesting limits by analogy or based on animal toxicity experiments despite that fact that thousands of workers are exposed daily to such chemicals.

For other OEL's where there is sufficient human evidence, a conscious decision has been made by the committee to tolerate a specified amount of occupational disease in setting the limit. An example of this calculated risk is the noise regulation, where the documentation of the TLV recognizes that up to 10% of workers exposed to 85 dBA in a working life will suffer noise induced hearing loss (*note that Ontario's OEL for noise is 90 dBA and the proposed regulation does not mention any attempt to adopt the ACGIH noise TLV*). Furthermore, it is well known that workers exposed to sensitizers such as isocyanates are not adequately protected by compliance with the OEL (*a certain percentage of exposed workers will go on to develop asthma in spite of maintaining exposures below the OEL*). Carcinogens often do not have a threshold and thus OEL's are set at an "acceptable" rate of occupational disease (*usually 1 worker in 1000 exposed, despite the environmental standard of risk being 1 citizen in 100,000 to 1,000,000*). Taking all these limitations into consideration, it is very clear that compliance with OEL's is in no way a guarantee that no significant health effects may occur among workers exposed!

h. Exposure Assessment as a Diversion and/or an Inefficient Allocation of Resources:

In the field of occupational hygiene it has been recognized that quantitative exposure assessments performed using appropriate sampling strategies are not necessarily the optimum use of available resources. Hiring a consultant to assess exposures can easily cost \$1000-\$5000. Such resources if allocated to local exhaust ventilation improvements may have a much more efficient and beneficial impact on the workplace than the exposure assessment. It is also well recognized that an experienced hygienist is able to accurately assess the need for exposure reductions with quantitative measurements, or by using simple methods evaluating controls (*i.e. ventilation measurements*). Furthermore, if workers are complaining for instance of odours and early symptoms (*e.g. headache, irritation*) recognized to be associated with the exposure at hand, it is clearly not necessary to quantitatively assess exposures because the cause of the complaints is obvious and the need for control demonstrated by the symptoms experience of those exposed regardless if quantitative assessment would demonstrate compliance or not. Thus, quantitative exposure assessment can represent a serious drain on resources available to control the exposures and a diversion tactic to avoid addressing the concerns which prompted the suggestion to measure the exposures in the first place. Instead of addressing the request to prevent exposures associated with symptoms (*a health and exposure prevention issue*), the issue at hand is changed to determining whether compliance with an OEL has been achieved or not (*a legal compliance issue*). Ensuing contentions often surround issues of the accuracy of the measurements, the appropriateness of sampling strategies, questions of bias, etc. What gets lost in these technical arguments is the symptom experience of the workers which prompted the sampling campaign in the first place. This drains resources from applying improved workplace controls (*i.e. problem solving as opposed to problem verification*).

i. New Paradigms in Exposure Criteria:

The dose-response relationship is more of a continuum than a straight line with a sudden discontinuity at the OEL. The heat stress OEL is graduated response as the WBGT rises. New paradigms in exposure assessment criteria have surpassed the single digit representation of the dose-response relationship which the OEL represents. In indoor air quality investigations, sampling strategies focus on source identification and measurements are interpreted in terms of ranges instead of a single digit threshold. For example, carbon dioxide is used as a surrogate for ventilation performance and is interpreted in a range(12):

< 600 ppm

no problem with the quantity of outdoor air supply

600-800 ppm

possible problem particularly if there are other parameters indicating possible problems
(*select parameter best suited to intervention*)

800-1000 ppm

probable problem with inadequate quantity of outdoor air supply

1000 ppm

definite problem with inadequate quantity of outdoor air supply

Similar graduated ranges have been established for volatile organic compounds (VOC's)⁽¹³⁾, although the main goal of measuring VOC's is more to find the source and eliminate or control it to prevent exposure in the first place.

Thus in the overall scheme of prevention, the single digit threshold concept is a gross reduction of a much more complex dose-response relationship and as such the graduated exposure criteria, such as for VOC's, are a more realistic approach.

j. Exposure Management Initiatives Resulting from ISO Quality Control Management Philosophies:

The ISO quality philosophy of management has also been applied to the area of exposure assessment⁽¹⁴⁾. Setting benchmarks to measure continual improvements in exposure reduction (*e.g. 10% reduction per year*) are consistent with this philosophy of continual improvement. Furthermore, internal policy initiative such as screening new process for potential exposure concerns, policy driven pollution prevention efforts, product stewardship programs, etc., have also been applied to worker exposure prevention.

k. Innovative Qualitative Exposure Techniques to Address Small & Medium Sized Business Enterprises:

It has also been recognized that most small or medium sized enterprises (SME's) do not have the resources to conduct the amount of quantitative sampling required by an appropriate quantitative exposure assessment strategy consistent with the procedures outlined in the AIHA exposure assessment manual (not to mention the concern that those resources would be more productively allocated to control once workers have identified an exposure of concern). In response, the AIHA manual and various European organizations have developed qualitative exposure techniques to help SME identify the needs for exposure control without using significant resources to measure exposures. One of the most recognized techniques is the control banding method espoused by the British HSE (<http://www.coshh-essentials.org.uk/>). Other schemes have also been developed in the Netherlands, Germany, Italy and Spain. All these methods attempt to "automate" the decision logic exposure assessors would use to categorize exposures and recommend controls. The Ontario Ministry of Labour had a preliminary meeting with stakeholders a few years ago (1999-2000) introducing the idea, however, nothing appears to have materialized from these efforts.

Other countries, Italy and Brazil in particular, have established mandatory risk mapping exercises, where workers are asked to identify exposure concerns in a diagram format and these become the basis of an exposure control program^(15,16).

REMARKS:

In the following sections of this report, comments and concerns with regards to select chemicals will be addressed and recommendations offered to the Ministry.

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3. SENSITIZERS AND CARCINOGENS IN THE WORKPLACE:

Workers' health in Ontario would benefit if exposures to sensitizers and carcinogens be avoided through methods including substitution, engineering controls, isolation, local ventilation and protective equipment to prevent exposure by any route.

Any workplace where sensitizers or carcinogens are used should be required to demonstrate, on a regular basis, that it is actively involved in an ongoing process to identify alternative non-toxic chemicals and/or processes, so that these materials are no longer used in the workplace. Until such time that a substitute chemical and/or process replaces the sensitizer or carcinogen, the workplace must demonstrate, using a valid occupational hygiene sampling strategy (*Mulhausen and Damiano, 1998*), that exposures are "as low as possible" and that there is a continuing process of improvement in engineering and occupational hygiene that will result in a further reduction in exposure and that workers are not experiencing symptoms of exposure or are having to leave due to health effects caused by the product. Similar policies are being enacted in Europe (*EU, 2004*).

REFERENCE

EU (2004) Directive 204/37/EC of the European Parliament and of the Council.

4. OHCOW'S SELECTED LIST OF CHEMICALS FOR REVIEW AND RECOMMENDATIONS:

A. ASPHALT (BITUMEN) FUMES

The current Ontario time-weighted average exposure value (TWAEV) for asphalt fumes is set at 5 mg/m³ (*total particulate*). This can be compared to 0.5 mg/m³ (*benzene-soluble fraction*) time-weighted average (TWA) set by the American Conference of Governmental Industrial Hygienists (ACGIH). In year 2000, the ACGIH TWA was set at 5 mg/m³; however, it was reduced to 0.5 mg/m³ based on increases in mucous membrane and eye irritation found in studies. The Ontario TWAEV should be lowered to remain consistent with the McGuinty government mission: to ensure that occupational exposure levels (OEL's) are regularly updated based on limits recommended by the ACGIH.

Asphalt, also known as bitumen, is a product of nondestructive distillation of crude oil usually dark brown to black in appearance. Asphalt is usually mixed with aggregates (*sand, gravel, crushed stone and slag*) to produce asphalt cement or paving (hot-mix asphalt) materials for roofing. It is made up of a larger proportion of aliphatic (*linear carbon chain*) and a smaller proportion of aromatic (*cyclic carbon structures*) hydrocarbons. The latter component includes polynuclear aromatic hydrocarbons (PAHs), such as benzo[a]pyrene that is known to be carcinogenic.

Asphalt is sometimes mistaken for coal tar products due to their similar appearances and applications in the industry. They are, however, inherently quite different. Coal tar is produced through the pyrolysis of plant products; but mostly from coal. They are heavily loaded with PAHs and as a result of health hazard awareness, the use of tar products has been discontinued. Coal tar and coal tar pitch volatiles (CTPV) have been classified as a human carcinogen by the International Agency for Research on Cancer (IARC).

Even though the heavy use of coal tar has been discontinued, small amounts are still found in the form of "pitch" which is sometimes added as a binder in asphalt road paving. Coal tar can also be found in old roads that were once made from it. This can be cause for concern because much of road construction now involves the heating and grinding of old road paving materials which is then mixed with new material to make the new road. This heating process can release CTPV.

Determining an OEL for asphalt emissions is exceedingly difficult considering the chemical complexity, various methods of application, route of exposure, method of sampling, and the health endpoint at which the limit is to prevent. This is aside from the above mentioned uncertainty of the presence of coal tar products. The following is by no means an exhaustive explanation but rather a brief summary to highlight key points as to why the current Ontario TWAEV should be reduced.

1) Many of the larger PAHs (*4 to 6 carbon rings*), which are considered more "harmful," in asphalt are removed during the vacuum distillation process; however some types of bitumen will contain higher levels formed during cracking operations or re-introduced to form different blends. Although benzopyrenes do not make up a large component in asphalt fumes, there are other polycyclic aromatic compounds such as benz[a]anthracenes that are listed as probable human carcinogens (*IARC designation 2A*); and methylated chrysenes, pyrenes, and fluoranthenes which have chemical structures similar to known carcinogens.

2) The temperature at which the asphalt product is being used will affect the composition of emissions. Generally, roofing employs higher temperatures than road paving. As a rule of thumb, increasing temperatures generate more fumes.

3) When petroleum products are heated, vapors escape into the air that later condense to form fumes. Because this process does not occur instantaneously, workers are exposed to both asphalt vapors and fumes. In addition, dermal absorption can also occur. Currently, the methods used for sampling asphalt fumes (*particulates*)

employ a membrane filter that is not useful in collecting vapors (*gases*). This will underestimate the overall exposure.

4) Acute effects of exposure to asphalt fumes show irritant symptoms of the serous membranes of the conjunctivae (*eye irritation*) and the mucous membranes of the upper respiratory tract. More recently, studies indicate that some workers involved in paving operations are experiencing lower respiratory effects (*e.g. wheezing, coughing and shortness of breath*) at 1.0 mg/m³ total particulates and 0.3 mg/m³ benzene-soluble particulates. Both these values are below the current OEL.

With recent studies indicating workers using asphalt are still experiencing eye and respiratory irritation, it would be prudent to lower the OEL to protect workers. Also, Ontario should adapt the new guidelines set by ACGIH which measures the benzene-soluble fraction as opposed to total particulate.

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B. MANGANESE

The major concern in relation to exposure to manganese is the development of neurological symptoms of hand tremour, reproductive effects, and psychological changes. A review of recent studies over the last 15 years including one conducted in Canada have indicated CNS effects below 0.2 mg/m³⁽¹⁾. A key study which the ACGIH have relied upon for their determination of the TLV has been the study by Roels, et al.⁽²⁾. In this study the authors found that the upper 95th confidence limit of the lifetime integrated exposure metric corresponded to 3.575 mg/m³-yrs of total Mn dust exposure and 0.73 mg/m³-yrs of respirable Mn exposure. Assuming 40 years working life, these values would translate into 0.09 mg/m³ for total Mn dust and 0.02 mg/m³ of respirable Mn dust. If one uses the midpoint of the integrated exposure metric instead of the upper 95th confidence limit (*as would be more appropriate*) these levels would be even lower! In 2003, the ACGIH proposed to further lower the Mn exposure limit to 0.03 mg/m³ in light of a calculated LOAEL of between 0.15 and 0.035 mg/m³, however, they specified that this was only applicable to respirable dust. Upon strong objections to the respirable designation (*in was considered that non-respirable range particles should be included*), they pulled back the recommendation and are in the process of revising it. Despite these ongoing considerations it is quite clear that pre-clinical neurological symptoms can be detected below the current 0.2 mg/m³ TLV, and therefore it is recommended that this level be lowered to at least 0.03 mg/m³ of total Mn dust to prevent the development of such symptoms.

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C. WHEAT FLOUR DUST (TOTAL DUST)

The current Ontario TWAEV for wheat flour dust is 3 mg/m³ (*total dust*). The ACGIH refers to wheat flour dust as to just flour dust and sets a TWA value of 0.5 mg/m³ (inhalable fraction); where the TLV bases its critical effects on asthma, pulmonary functional changes, and bronchitis. ACGIH also recognizes that flour dust is a sensitizer.

Cereal grains (*e.g. wheat, oat, barley, rye, rice and corn*) are collected and stored before it is prepared for human consumption. The grains are then milled to produce starch or flour for grain-based consumer products. Grain elevator workers, millers, flour packers, bakers and pastry chefs are some of the occupations where exposure to flour dust is inevitable. These workers can also be exposed to other sensitizers such as alphaamylase, an enzyme that is found naturally in wheat flour; however, it is also added as a dough improver for baking. As a result of how flour is produced and stored, contaminants such as insects, mites and moulds can also induce respiratory allergy.

Reported illnesses associated with exposure to flour dust include conjunctivitis, rhinitis, dermatitis, and baker's asthma. Changes in lung function and increased risk of chronic bronchitis have also been observed from exposure to total flour dust. The more serious of these is baker's asthma. Currently, bakers along with automotive workers (*exposed to isocyanates*) are ranked amongst the highest occupations with reported numbers of occupational asthma. Aside from the morbidity of the disease, the economic cost and burden of managing asthma is staggering.

One study indicates wheat flour sensitization may occur at total dust levels as low as 0.5 mg/m³. Other studies looking at exposure-response relationships, found that there are increased prevalence rates of sensitization at 1 mg/m³. These studies indicate that the current TWAEV of 3 mg/m³ is no longer sufficient to protect workers from becoming sensitized. Although these studies are usually based on exposures to wheat aeroallergens,

studies indicate that there is cross-reactivity between different cereals – suggesting the likely chance of multiple sensitizations. Therefore ACGIH recommends a TLV-TWA of 0.5 mg/m³ for all types of flours.

Aside from sensitization, several studies noted increased prevalence of respiratory and asthmatic symptoms with exposures to total flour dust at levels approximately ranging from 1.35 to 3.57 mg/m³. One other study also found that the frequency of symptoms generally increased with exposure intensity.

To protect workers who are exposed to flour dust, workplace exposures should be kept as low as reasonably achievable. Furthermore, the TWAEV should not exceed 0.5 mg/m³.

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D. PARTICULATES NOT OTHERWISE CLASSIFIED (PNOC'S)

An unpublished paper by Mermelstein and Kilpper titled "Xerox Exposure Limit for Respirable Dust (N.O.S.))" suggests that in order to prevent this overloading of the lung's defences, the exposure level to "nuisance" dust should be kept below 0.4 mg/m³ of respirable dust^(1,2).

In another paper⁽³⁾, the researchers retained by Xerox, calculated a 1 mg/m³ respirable dust OEL but then suggested lowering this value by applying a safety factor since the calculation is conservative and leaves no allowance for errors in the assumptions. This would result in a greater than 10 fold reduction in the present OEL (*occupational exposure limit*). This paper also references Xerox's exposure limit for respirable dust of 0.4 mg/m³. While Xerox internally experienced much apprehension when it stated its intent to implement this much reduced OEL for respirable PNOC's, they have largely been successful in implementing it and have even noticed a side benefit of improved morale due to the stringent housekeeping and exposure control needed to achieve this limit. There have been reports however, of workers who still experience symptoms even when this lower exposure limit is achieved.

Susan Woskie⁽⁴⁾ reviewed the issues around the exposure standards for particulate in an article. In this review she suggests that using established models, 4 years of exposure to 0.25 mg/m³ would lead to an accumulated dust burden in the lungs equivalent to the amount causing a 50% decline in lung clearance. Similarly, J. N. Pritchard⁽⁵⁾ suggested the TLV of 10 mg/m³ is two orders of magnitude (i.e. 100 X) too large.

An article by Chestnut et al.⁽⁶⁾ provides some environmental epidemiological support for the recommendations to lower the nuisance dust OEL. This paper suggests that a significant decrease in forced vital capacity (FVC) is associated with exposures to total suspended particulate 121 µg/m³ (i.e. 0.121 mg/m³) and suggested the threshold for this health effect was at a level of 60 µg/m³ (i.e. 0.06 mg/m³). It should be emphasized that

these dust measurements include materials other than insoluble mineral dust. It should also be noted that these levels are total dust concentrations. These findings have since been corroborated by numerous other studies⁽⁷⁾ of ambient particulate and various health parameters.

An occupational epidemiological study related to this issue was published by N.S. Seixas et al.⁽⁸⁾, in which they reviewed the exposure of coal miners to respirable coal dust since 1970. The authors found a significant association of obstructive lung disease with cumulative respirable dust exposures of 20 mg/m³-years or more. Assuming a 45 year working life this cumulative respirable dust exposure would translate into a 0.44 mg/m³ average lifetime exposure after which a significant health effect would be expected. Again it should be noted that coal dust is not considered a "nuisance" dust due to its silica content. However, it does seem to corroborate well with the animal study-based OEL recommendations. As a note of interest, the ACGIH in 1997 adopted a change to its TLV for coal dust lowering it from 2.0 mg/m³ to 0.4 mg/m³ for anthracite, and, to 0.9 mg/m³ for bituminous coal (*assuming less than 5% silica content*).

The proposed change to the existing OEL does not lower the previous OEL at all.

Given the evidence highlighted, the Ministry of Labour should seriously consider the need to lower the PNOC respirable dust OEL for the protection of the health of Ontario workers.

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E. FIBREGLASS

Fibreglass has been reviewed by many independent researchers and regulatory bodies for over 15 years. The concept of fibreglass and its capability to harm human health remains unsolved as there are thousands of employees who have worked with some form of fibreglass or presently working with fibreglass and have incurred occupational diseases that may be attributed to their exposure to fibreglass or fibreglass reinforced products.

A. DEFINITION AND CLASSIFICATION:

The definition of fibreglass in and of itself is confusing, as different regulatory bodies have varying definitions, some of which are clearly defined, others which overlap within those definitions.

Comparisons between standards or regulations becomes confusing and trying to identify compliance becomes a challenge when the classifications are not clearly defined (Siemiatycki, J et al, 2004; OHS, 2001). Most of the categories include a broad range of fibre types, with different physical and chemical properties, and indeed some of the characteristics overlap between categories (OSH, 2001).

For this reason, it is suggested that the definition and subdivision of fibres (*such as E-glass, 475 glass fibre, man-made vitreous fibre 10 etc.*), be more clearly defined and listed in the OEL documentation, to assure that readers are not misled.

Western Australia's Occupational Safety and Health Regulations set an exposure standard for all synthetic mineral fibres including traditional fibreglass (*versus the current day biosoluble fibreglass used in Australia*) at 0.5 respirable fibres/ml. This standard is the most stringent in the world at present. (WA, OSH, 2004).

In terms of actual exposure limits, a more stringent exposure limit should also be adopted by the Ontario Government, similar to that of the Western Australian Government, to ensure protection of worker's health.

When more research is conducted and health related effects are studied further, then at a later date, the OEL's should be re-evaluated. We should err on the side of safety/caution rather than the reverse at this stage

B. CONCLUDING REMARKS:

Many manufacturing sites, which OHCOW is currently servicing, have exhibited signs of health deterrence with regards to the respiratory system and an association with fibreglass and fibreglass reinforced plastics.

Several clients who have used and are using fibreglass as a primary or secondary component in the equipment they fabricate, state that there a number of methods utilized in which fibreglass is actually manufactured, coated, sealed etc. Fibreglass sheets, pieces, boards, components can be coated with resins that contain benzene, silica and other harmful ingredients that are worth mentioning here and are definitely contributors to ill health amongst our workers. Fibreglass reinforced plastics are coated with resins which contain polyester, or epoxies or both can prove to be hazardous to human health, especially if the fibres are respirable or inhalable to some degree (*Government of South Australia, GS8, 2000*). Fibres may act as carriers of chemical carcinogens to the target organ (*taken from IARC, 1996*).

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F. Wood dust

The Ontario Occupational Health and Safety Act (2004) and the ACGIH (2004) separate wood dust into two groups; 1) certain hard woods as beech and oak with an eight hour exposure limit of 1 mg/m³; and 2) soft woods with an eight hour exposure limit of 5 mg/m³ and a short-term exposure limit (STEL) of 10 mg/m³. ACGIH does however list wood dust under its Notice of Intended Changes. The intended change is to add Western Red Cedar, a softwood species but allergenic, with a TWA of 0.5 mg/m³; in addition, lowering the TWA for softwoods (non-allergenic species) from 5 mg/m³ to 1 mg/m³ and removing the STEL.

Wood dust can result from the process of cutting, milling, sawing, sanding and so forth of natural or processed wood. Wood is composed of polymeric compounds such as cellulose, polyoses, lignin, and a variety of smaller molecules known as extractives. These extractives are often defense mechanisms for trees to survive; however, some are toxic and allergenic to humans.

Exposure to wood dust can often be in combination with a variety of other hazards such as fungi, bacteria and pesticides. In other wood-related industries, workers can also be exposed to formaldehyde from adhesives and resins. Although the focus is on wood dust exposure, it is important to consider other exposures that may have potential ill health effects.

In 1965, an excess of sino-nasal adenocarcinoma was observed among furniture workers exposed to wood dust. This prompted further research which found an excess risk among other workers employed in wood-related industries such as logging, sawmills, furniture making, and carpentry. The highest risk of sino-nasal adenocarcinoma was observed in workers who were exposed to hardwoods such as beech and oak. However, a majority of the research, although examining the risk of cancer, did not specify the type of wood. Furthermore, wood workers are often exposed to mixed woods – not just one. Based on this information, IARC classifies wood dust as a

Group 1 human carcinogen. IARC further states that this evaluation was based on workers exposed to hardwood dusts.

Several case-control studies indicate that there may be an excess risk of cancer of sino-nasal adenocarcinoma among workers exposed to softwood dusts. Unfortunately, in some cases there was confounding exposure to hard wood dusts. At this time, studies examining the exposure of softwood dusts and the risk of cancer are inadequate to estimate an OEL. There is however, sufficient data regarding nonmalignant respiratory effects of wood dust.

Upper and lower respiratory symptoms, airflow obstruction (*other than asthma*), and asthma have been reported in workers exposed to softwood species – particularly Western Red Cedar. Several studies found eye, upper and lower respiratory tract irritation, and altered lung function in sawmill workers exposed to concentrations of softwood dust at levels as low as 0.5 mg/m³ up to a high of 32 mg/m³. One other study of 315 sawmill workers exposed to other softwood dust (*such as Douglas fir, Western hemlock, spruce, and balsam*) experienced pulmonary function abnormalities and respiratory symptoms at dust levels ranging from 0.1 to 2.7 mg/m³. Other studies have demonstrated that the risk of developing asthma to cedar dust increases as wood dust exposure levels increase. For the workers who developed asthma, the levels of exposure were on average less than 2 mg/m³.

Based on these studies, workers exposed to softwood dust are still experiencing ill health effects at levels below the recommended TWAEV. It appears the intended changes presented by the ACGIH are founded. In addition, exposures levels to allergenic species of wood dust should be kept as low as reasonably achievable.

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G. CAPROLACTAM

To bring Ontario's TWAEVs for caprolactam vapour and aerosol in line with the ACGIH TLVs would mean increasing them to 20 times and 5 times, respectively. In the USA, the standards for particles (OSHA and NIOSH) and the recommended standard for vapour (NIOSH) are the same as they are in Ontario and have been for more than a decade.

The NIOSH REL considers that workers exposed to caprolactam are at significant risk of respiratory irritation, adverse nervous system effects, and possible cardiovascular effects (OSHA, 2004). According to NIOSH, the health effects of exposure to caprolactam vapor and dust are the same except that contact with the vapor is reported to be even more irritating (NIOSH 2004) and the REL is intended to prevent early signs of irritation in some workers. Guirguis (1990) has reported respiratory problems (*bronchial hyperreactivity, asthmatic responses, and deficits in pulmonary functions tests*) in a case control study of workers exposed to substances including caprolactam at 0.46 mg/m³.

The US EPA's Integrated Risk Information System (IRIS) has reviewed the health effects data for caprolactam and concluded it was inadequate for setting an inhalation reference concentration citing a lack of adequate long-term studies and a lack of inhalation pharmacokinetic data (IRIS, 2004). Existing studies involving workers were considered to have significant deficiencies with regard to exposure determination, methods and (*small*) sample sizes. With regard to studies having reproductive endpoints in both humans and animals, IRIS notes reports of alterations in ovarian-menstrual functions and condition, pregnancy/birth complications and altered sperm parameters.

The TLV recommendation focuses on symptoms of irritation and is largely based on the findings of Ferguson and Wheeler (1973), a study that has been criticized for inadequate exposure estimation. In addition to skin and respiratory tract irritation, there are reports in the literature of effects on the nervous system, cardiovascular system,

reproductive effects in both male and females as well as birth complications.

The literature pertaining to caprolactam is insufficient at this time for standard setting. The current Ontario standard has been in use for many years and offers greater protection for workers than the proposed change. In the absence of anything more compelling than harmonizing with the ACGIH, the more protective existing standards should be retained.

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H. ROSIN CORE SOLDER THERMAL DECOMPOSITION PRODUCTS (COLOPHONY)

Colophony or rosin is a pine tree product that is used in an unmodified form in many industrial products including soldering flux. When heated, soldering flux produces fume composed of both particulate and volatile components that include resin acids, oxidized resin acids and aldehydes (Smith et al, 2000, 1998 and 1997; Pengelly et al, 1994)

Soldering flux, solder fume and residues have been reported to be a cause of both allergic and irritant contact dermatitis (Yokota, 2004; Widstrom, 1983) and soldering fume is a cause of occupational asthma due to both allergic and non-allergic mechanisms as well as eye, nose and throat symptoms (Palmer and Crane, 1997). Workers who develop allergies cannot continue to work where there is continued exposure.

Other constituents of flux such as hydrazine and aminoethylethanolamine are also contact allergens (Goh and SK, 1987) There is a need for effective local exhaust ventilation systems (Watson et al, 2001; Johnson and Brown, 1998; Pengelly et al, 1998) to protect those who are working with soldering flux from exposure to fume. Effective ventilation must be in place, be used appropriately and be maintained appropriately.

In some cases, soldering fluxes using substitute chemicals have been found also to cause respiratory problems in exposed workers (Convery, 1997; Greaves et al, 1984)

Citing a lack of reliable workplace colophony air concentration data, the ACGIH (2001) does not recommend a numerical TLV and instead recommends maintaining exposure to airborne concentrations that are “as low as possible”.

Workers would benefit from avoiding exposures to rosin products though engineering controls including isolation of the process, local ventilation to prevent respiratory tract exposure as well as protective equipment to prevent skin exposure in the case of airborne exposures and protective equipment to prevent skin exposure in the

case of contact with rosin and residues. Furthermore, the workplace using this chemical, because of the risk of sensitization, should demonstrate that it is involved in an ongoing process to identifying alternative non-toxic chemicals and/or processes, so that the rosin product is no longer used in the workplace. Until such time that a substitute chemical and/or process replaces soldering with rosin products, the workplace must demonstrate, using a valid occupational hygiene sampling strategy (Mulhausen and Damiano, 1998), that exposures are “as low as possible” and that there is a continuing process of improvement in engineering and occupational hygiene that will result in a further reduction in exposure and that workers are not experiencing symptoms of exposure or are having to leave due to health effects caused by sensitization to the product.

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I. METALWORKING FLUIDS

Metalworking fluids were not on the list for updating, however, OHCOW's experience with workers affected by MWF and our own participation in MWF research has brought the need for a new OEL to our attention.

There have been three main published studies of cross-shift decrements of FEV1 among metalworking exposed workers. Kennedy et al. found effects (5% cross-shift decrement) above a threshold of 0.2 mg/m³ ⁽¹⁾. Kriebel et al., found effects (5% cross-shift decrement) at exposures above 0.15 mg/m³ ⁽²⁾. Robbins et al. found effects (10% cross-shift decrement) among a group of workers exposed to an average of 0.41 mg/m³ ⁽³⁾.

With respect to occupational asthma, Kennedy et al. found significant new bronchial hyper-reactivity among apprentices after two years of exposure to an average exposure of 0.46 mg/m³ ⁽⁴⁾. Rosenman et al. reporting from data from an occupational asthma surveillance system in Michigan found metalworking fluids to be one of the major causes of reported occupational asthma ⁽⁵⁾. Follow-up sampling showed all workplaces were below the 5 mg/m³ exposure limit. Eisen et al. ⁽⁶⁾ found that exposure to 1 mg/m³ of mineral oil mist had the same impact as smoking on FVC.

Our own work has shown similar comparisons with respect to respiratory symptoms ⁽⁷⁾. NIOSH has recommended an exposure limit of 0.5 mg/m³ ⁽⁸⁾ recognizing that health effects have been confirmed below this level. GM Canada has an agreement with the CAW that all new metalworking process installed will meet a 0.5 mg/m³ exposure standard and that exposures related to existing processes will not exceed 1 mg/m³. Given the current Ontario OEL of 5 mg/m³, and given the large number of Ontario workers exposed to metalworking fluids, furthermore, given the OHCOW clinics experience with patients with lung problems due to metalworking fluids, we would strongly recommend adopting the new proposed ACGIH TLV of 0.2 mg/m³ for mineral oil and also apply it to metalworking fluids in general.

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J. SILICON CARBIDE

The major change for silicon carbide is the separation of OELs for fibrous and nonfibrous silicon carbide. The proposed OEL for fibrous (including whiskers) is more protective than the current total dust OEL for silicon carbide. There was little change for its nonfibrous exposure limits.

However, there are some serious concerns about the toxicity of both fibrous and nonfibrous silicon carbide. Studies showed that the fibrous silicon carbide causes similar pulmonary responses including mesotheliomas as what asbestos does. The most concern for nonfibrous silicon carbide has been focused on the inhalation of the substance during its manufacture or use as an abrasive, which may result in pneumoconiosis.

Therefore, in line with good manufacturing practice, fibrous silicon carbide should be treated as asbestos and similar OEL's should be applied to. Exposure to nonfibrous silicon carbide should be minimized to 1/10 of the proposed OEL's for nonfibrous silicon carbide or to the same level as what we recommended for PNOC to prevent its potential pulmonary damage.

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K. N-BUTYL ALCOHOL

The change for n-butanol from the current CEV=50ppm to TWA EV=20ppm reflects the more understanding of the toxicity on long-term exposure to the substance. The proposed OEL is more protective for long-term exposure to n-butanol than its current OEL. There was little change for its short-term exposure limit.

However, there are still some concerns about the toxicity of the substance. The most difficult challenge is lack of sufficient data to establish guidelines for setting occupational exposure limits.

n-Butanol is a flammable, colourless liquid with a rancid sweet odour. It occurs naturally as a product of fermentation of carbohydrates. It is also synthesized from petrochemicals and is widely used as an organic solvent and as an intermediate in the manufacture of other organic chemicals. Human exposure to n-butanol is mainly occupational. Butanol is readily absorbed through the skin, lungs, and gastrointestinal tract. It is rapidly metabolized and does not bioaccumulate. n-butanol liquid or vapour can cause moderate skin irritation and severe eye irritation manifested as a burning sensation, lachrymation, blurring of vision, and photophobia. Ingestion of the liquid or inhalation of the vapour may result in headache, drowsiness, and narcosis. The occurrence of vertigo under conditions of severe and prolonged exposure to vapour mixtures of n-butanol and isobutanol has been reported. The small amount of information available suggests that occupational human exposure to air concentrations below 307.8 mg/m³ (100 ppm) is not associated with any adverse symptoms. However, studies on human volunteers have indicated that the light-sensitivity of dark-adapted eyes and electrical activity of the brain may be influenced by air concentrations as low as 0.092 mg/m³ (0.03 ppm). Therefore, in line with good manufacturing practice, exposure to n-butanol should be minimized.

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L. NOISE

The threshold at which one can begin to detect hearing loss corresponds to chronic exposures to noise of anything above 65 dBA. Since much of western society involves extended periods of time of exposure to noise levels above this level, there is a certain amount of hearing loss which is associated with living in industrial society. Once the average noise level exceeds 80 dBA one can begin to detect occupationally related noise-induced hearing loss after sustained exposures. The legal exposure limit for Ontario at this time is 90 dBA for 8 hours. Since 1978, the Ministry of Labour has been suggesting this limit be lowered, however, the proposals have never been implemented.

The American Conference of Governmental Industrial Hygienists (ACGIH) estimates that at 85 dBA for eight hours a day anywhere from 3% to 10% of workers can expect to have significant impairment of hearing after 30 years or more of exposure. Thus, the ACGIH recognizes that only about 90% of exposed workers will be adequately protected by the 85 dBA limit. At 90 dBA the proportion of workers expected to accumulate significant hearing loss ranges from 10-18%.

Since the 1996 version of the noise TLV, the ACGIH has used a 3 dB doubling in its exposure criteria. This means that for every increase of 3 dB, the allowable exposure time is cut in half, i.e., if one is allowed eight hours of exposure at 85 dBA, and then if we double the noise level to 88 dBA the allowable exposure time gets cut in half to 4 hours. The differences in the exposure criteria between the TLV and section 123 of O. Reg 851 are two-fold; a lower 8 hour TWA criteria (*85 instead of 90 dBA*), and 3 dB doubling instead of 5 dB doubling.

This inability of the MOL to change the noise OEL in Ontario since it announced its first proposal in 1979 represents a major obstacle (*among others*) in reducing the incidence of noise induced hearing loss in Ontario.

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M. SILICA, CRYSTALLINE – QUARTZ

Exposure to respirable crystalline silica occurs in a variety of industries and occupations, including cultured (*synthetic*) quartz crystals, construction, sandblasting, pottery workers, granite workers, refractory brick, diatomaceous earth and mining.¹ Occupational exposures to respirable crystalline silica are associated with the development of silicosis, lung cancer, pulmonary tuberculosis, COPD, and airways diseases. There is also some evidence that silica exposures may be related to the development of autoimmune disorders², chronic renal disease, and other adverse health effects.³

Currently there are scientific and regulatory bodies that recommend an occupational exposure limit for respirable silica quartz well below 0.1 mg/m³. The most notable of these include;

- NIOSH (1974) REL 0.05 mg/m³ (*for up to 10 hr workday, 40hr workweek*)
- ACGIH (2001)⁴ 0.05 mg/m³ (*8-hr TWA*)
- WHO study group (1986)⁵ recommended a limit 0.04 mg/m³ (*8-h shift*)
- NOHSC (2002)⁶ equivalent to 0.067 mg/m³ when sampling criteria are considered

Research over the past decade has been reviewed by many organizations, and it is generally agreed that an OEL of 0.1 mg/m³ is not as protective as once thought. In 2000 ACGIH reduced the TWA for alpha quartz crystalline silica to 0.05 mg/m³. This reduction from the previously value of 0.1 mg/m³ was in recognition of the fact that fibrosis undetected by chest X-ray, probably does occur in workers exposed at levels near the 0.1 mg/m³ level. It is the concern for the fibrosis of silicosis and the role of fibrosis as a risk factor for lung cancer that caused ACGIH to recommend the lowering of the TLV from 0.1 mg/m³ to 0.05 mg/m³. Whether the reduction is enough is a subject for debate. Currently respirable silica quartz is on the ACGIH (2004) Notice of Intended Change. The proposed limit is 0.025 mg/m³.

Numerous studies have noted adverse health effects such as silicosis in workers exposed to a quartz concentration below the current OEL.^{7, 8} There is mounting evidence that an OEL of 0.1 mg/m³ is not protective against silicosis. Calvert et al. found an average exposure of 0.1 mg/m³ for 15 years resulted in an estimated silicosis risk of 5%. Finkelstein et al.⁹ indicated a lifetime silicosis risk greater than 25% for 30 years exposure at 0.10 mg/m³.

Although many jurisdictions currently advocate a limit of 0.05 mg/m³ several studies have shown that the estimated risk of silicosis for a 45-year working lifetime is 10% to 30% at concentrations equal to 0.05 mg/m³.^{10,11,12} Park et al.¹³ conducted a risk assessment for silicosis and reported 6.8-7.5 percent lifetime (*45 years exposure*) risk for silicosis at 0.05 mg/m³. Many other studies^{14,15,16} also add weight to the already persuasive evidence that a silica exposure limit of 0.05mg/m³ is associated with a generally unacceptably high risk.

Although the carcinogenicity of crystalline silica in humans has been debated in the scientific community, there is mounting evidence that lung cancer is associated with occupational exposures to crystalline silica. In 1996, the International Agency for Research on Cancer (IARC)¹⁷ reviewed the published experimental and epidemiologic studies of cancer in animals and workers exposed to respirable crystalline silica. They concluded that there was “sufficient evidence in humans for the carcinogenicity of inhaled crystalline silica in the form of quartz or cristobalite from occupational sources” A meta-analysis of epidemiologic studies of silica exposure and lung cancer have reported a moderate summary relative risk of lung cancer at 1.3 for silica-exposed workers and a higher summary relative risks of 2.2 to 2.8 for silicotic workers.^{18,19, 20} Some of the studies of silica-exposed workers controlled for the effects of smoking and others did not. In 1997 the American Thoracic Society (ATS) also confirmed an association between occupational silica exposure and lung cancer.²¹ NIOSH reviewed the studies considered by IARC and ATS and concurs with their conclusions. More recent studies have produced similar but more reliable associations.^{22, 23}

In conclusion, consideration of this extensive documentation would suggest that an OEL for crystalline silica –quartz set at 0.05 mg/m³ would be more appropriate than the current limit of 0.1 mg/m³. However, serious consideration should be given to an even lower level, possibly in the order of 0.025 mg/m³. It is also advisable that every means available should be used to keep silica exposures well below any OEL. In addition, consideration should be given to the reports that indicate the risk of silicosis over a working lifetime can rise dramatically with even brief exposure to high quartz concentrations.^{24, 25.}

Consideration must also be given to sampling and analytical techniques used to measure airborne crystalline silica exposures. To date they are limited in their ability to accurately quantify exposures below the OEL. Also many studies support the need for continued medical and epidemiologic surveillance of workers after they leave employment. There is a number of epidemiologic studies which have found that chronic silicosis may develop or progress after occupational exposure has ceased.^{26,27,28, 29,30,31.} Longer periods of follow up might identify further associations.

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