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The Crosshairs: When Do You Really Need an Industrial Hygiene Assessment and by Whom?

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Introduction

Industrial hygiene is "the science and art devoted to the anticipation, recognition, evaluation, and control of those environmental factors or stresses arising in or from the workplace which may cause sickness, impaired health and well-being, or significant discomfort among workers or among citizens of the community."[1] The goal of industrial hygiene is to prevent occupational disease, illness, and injury.

Technical expertise and competency are the cornerstone of good industrial hygiene exposure assessment and control programs. Assessment work can be part of a planned compliance or baseline measurement program or a response to a sudden crisis or complaint. Industrial hygiene services are highly sought after, with appreciable resource, time and expense, requirements. Current corporate "belt tightening" during difficult and competitive economic conditions is resulting in close scrutiny of safety and industrial hygiene services as part of resource prioritization efforts. Challenges arise to the position that all assessment concerns have to be answered by exposure measurement numbers. Debates result about the level of expertise required and whether work can be completed "in house" or necessitates third party contractors who market greater expertise. Industrial hygiene assessments are only as good as the expertise and "best practice" adherence that go into them. The conduction of this work entails more than the competent handling of equipment or completion of a menu list, which can, on occasion, appear deceptively simple. Industrial hygiene work is time intensive, as it involves true consultation on assessment needs, survey and research on materials and tasks producing exposures, monitoring and equipment knowledge, representative exposure measurement, results comparison to health protective standards, control evaluation and improvement recommendations, and training and communication. All of that being said, there is a wide range of industrial hygiene consultation tasks that involve different levels of complexity and skill sets. Managing expenses appropriately translates into actions to allocate industrial hygiene resources wisely.

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[1] American Industrial Hygiene Association (AIHA). 2011. *What is an Industrial Hygienist?* (retrieved February 14, 2011) (www.aiha.org/aboutaiha/Pages/WhatIsan IH.aspx).

Occupational Disease Prevalence

How large of a problem is occupational disease? The Bureau of Labor Statistics (BLS) is the U. S. government's fact-finding, statistical agency that acquires, processes, and disseminates statistical data to governmental agencies, including the Department of Labor, and the public.[2] The BLS was authorized under OSHA in 1972 to conduct the Annual Survey of Occupational Injuries and Illnesses. The objective of this survey is to publish the rates of occupational injuries and illnesses among private employers. This data provides critical incidence rate baseline and comparison information for the continuing assessment of workplace safety and workers' compensation insurance computations. Information from employer Occupational Safety and Health Administration Injury and Illness Recordkeeping 300 Form logs is compiled for the survey.

Skin Diseases	**1.0%**
Hearing Loss	**0.6%**
Respiratory Conditions	**0.4%**
Poisoning	**0.1%**
All Other	**3.5%**

Table 1. 2006 Total Nonfatal Occupational Illness Cases by Category.
Source: BLS, U. S. Department of Labor, 2007.

Depicted in Table 1, the BLS reported that occupational illnesses accounted for 5.6% of the 4.1 million recordable injuries and illnesses in 2006[3]. BLS records multiple categories of occupational illness including traumatic disorders, systemic disorders, infectious and parasitic diseases, and neoplasms, tumors, and cancer. Systemic disorders are those which entail toxic or nontoxic diseases or disorders affecting the whole or part of the body system.[4]

Skin diseases accounted for 1% of total injuries and illnesses, while hearing loss was second at 0.6% and respiratory conditions third at 0.4%. Poisonings were fourth at 0.1%. The All Other "catch all" category accounted for 3.5% and includes heat and cold stress, radiation exposures, bloodborne pathogens, and cancers.[5] While occupational illnesses constitute a small percentage of overall injuries, their potential life impact is large due to the chronic nature of many exposures or lasting biological and debilitating effects. Associated medical costs of occupational illnesses are

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[2] Bureau of Labor Statistics (BLS). 2011. *FAQs: What is the Bureau of Labor Statistics?* (retrieved on February 14, 2011) (www.bls.gov/dolfaq/bls_ques26.htm).
[3] Bureau of Labor Statistics (BLS). 2007. *Chart 13, Total Nonfatal Occupational Injury and Illness Cases by Category of Illness, Private Industry, 2006*. (retrieved on February 14, 2011) (www.bls.gov/iif/oshwc/osh/os/osh06_13.pdf).
[4] Bureau of Labor Statistics (BLS). 1992. *Occupational Injury and Illness Classification Manual* (retrieved February 14, 2011) (www.bls.gov/iif/oshwc/oiicm.pdf).
[5] BLS (2007).

significant. The U. S. National Institute of Occupational Safety and Health estimates 49,000 worker deaths from occupational illnesses annually.[6] The estimated annual direct and indirect cost of occupational illnesses in 2005 was 49.6 billion dollars.[7] Direct costs include hospitals and nursing homes, physician care, and drugs. Indirect costs include costs such as lost production, missed wages, and training.

BLS statistics show an overall downward trend in occupational disease reports, but under-reporting has been a continuing problem. BLS statistics have also shown increased occurrence of occupational illness at larger establishments, but this is believed to result from under-reporting from small establishments. The actual rate for small establishments could range from 3 – 6 times the number of cases reported. [8]

Linking a specific common disease of life, such as cancer or osteoarthritis, to workplace exposures is quite difficult, as these diseases have both occupational and nonoccupational causes.[9] The long latency periods and potential interaction of occupational exposures with nonoccupational exposures complicates causation identification or proportionment. While many common workplace chemical exposures have been studied, the majority of all workplace chemicals remain unevaluated.[10] Exposure to harmful substances is one of the six top causes of industrial fatalities. The fatality harmful substances category includes electrocution, temperature extremes, oxygen deficiency, and exposure to caustic, noxious, or allergenic agents.[11]

Diagnosis of occupational disease entails specialized training and experience due to the uniqueness of exposures and biomarkers. Only occupational physicians receive training in the diagnosis of workplace-related disease. In 2001 NIOSH launched a surveillance program to better track and prevent occupational illness due to reporting gaps.[12] BLS may miss as many as 20 – 70% of nonfatal injuries and illnesses.[13] Reasons for non-reporting range from company economic incentives and marketing for government contracts to workers compensation ratings to employees' fear of reprisal. The increasing number of contract workers and continual movement of this

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[6] National Institute of Occupational Safety and Health (NIOSH). 2009. *About NIOSH: Burden of Injury and Illness to Workers, Their Families, and the Nation.* (retrieved February 14, 2011) (www.cdc.gov/niosh/about.html).

[7] Leigh, J. Paul "Costs of Occupational Injury and Illness Combining All Industries." *Seminar for Western Center for Agriculture Health and Safety*, November 3, 2008, 10.

[8] Morse, Dillon T. et al, "Prevalence and Reporting of Occupational Illness by Company Size." *American Journal of Industrial Medicine.* April, 2004, 45(4) 361-70.

[9] Wegman, D. H. and Sellman, S. D., "32.2 Occupational Hazard Surveillance." *Encyclopedia on Occupational Health and Safety.* Geneva: International Labor Organization, 1998.

[10] Markowitz, S. B., *32 Record Systems and Surveillance*, Encyclopedia on Occupational Health and Safety. Geneva: International Labor Organization, 1998.

[11] Haz-Map, Occupational Hazards and Disease: Reported Fatalities and Illnesses. 2007. (retrieved February 14, 2011) (http://hazmap.nlm.nih.gov/)

[12] National Institute of Occupational Safety and Health (NIOSH). 2009. *NIOSH Program Portfolio: Surveillance Strategic Plan.* (retrieved February 14, 2011) (www.cdc.gov/niosh/programs/surv/goals.html).

[13] Leigh, 19.

population makes disease linkage to a specific workplace a moving target.[14] Particular concern exists for accurate accounting of occupational illness deaths such as silicosis, byssinosis, and asthma due to difficulties in distinguishing them from other types of chronic obstructive pulmonary disease (COPD).[15] Up to 66% of medical costs may not be covered by workers compensation due to lack of standardized eligibility requirements and case definition, in addition to diagnosis errors and latency time period.[16] These additional costs are paid "out of pocket" by private health insurance, Medicare, and Social Security.

Competent Professional, Industrial Hygienist, and CIH

The American Industrial Hygiene Association defined a "competent professional" for mold assessments in 2004, due to widely varying experience range and quality of assessment work in this area. Educational credentials included Bachelor of Science in industrial hygiene, environmental health, engineering, life sciences, chemistry, or physics. Experience requirements were minimally two years under the supervision of a certified industrial hygienist, certified safety professional or professional engineer with at least two years of experience in indoor air quality. These are all professional certifications met through experiential and testing requirements. Experience and training requirements for the competent mold professional include indoor air quality, microbial assessment and remediation, HVAC, and exposure assessment, as well as legal and communication aspects.[17] This definition presents foundational criteria which can be extrapolated for the conduction of competent industrial hygiene work.

ASSE defines a safety and health professional as someone who applies education, work experience, and/or certification skills to property, safety, and environmental injury and damage prevention while adhering to a code of professional conduct. ASSE's membership categories require a combination of education and experience with work experience credit for certifications. Certification is a highly visible competency achievement. Competency is not dependent upon certification or advanced education, but is validated by such.[18]

AIHA defines an industrial hygienist minimally as "a person possessing either a baccalaureate degree in engineering, chemistry, or physics or a baccalaureate degree in a closely related biological or physical science from an accredited college or university, who also has a minimum of three years of industrial hygiene experience."[19] The definition does not include the Certified Industrial Hygienist (CIH) designation, but AIHA recognizes and strongly supports the

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[14] Leigh, 24.

[15] National Institute of Occupational Safety and Health (NIOSH). 2009. *Work Related Lung Disease Surveillance System (WoRLD).* (retrieved February 14, 2011) (www.cdc.gov/drds/WorldReportData/).

[16] Leigh, 22.

[17] Trippler, Aaron, *Letter to Senator Kean and Assemblyman Benson*, February 3, 2011 (retrieved February 14, 2011) (www.njaiha.org/Portals/O/Downloads/News/NJAIHA February 2011 Newsletter . pdf).

[18] Barfield, Gene, "ASSE President's Message December, 2004." Professional Safety-President's Message Archive", December, 2004. (retrieved February 14, 2011) (www.asse.org/professionalsafety/pres-archive/0412.php).

[19] American Industrial Hygiene Association (AIHA). 2011. *What is an Industrial Hygienist (*retrieved February 14, 2011) (www.aiha.org/aboutaiha/Pages/WhatIsanIH.aspx).

value of the credential.[20] The credential validates a higher level of competency and expertise. The CIH designation is conferred by the American Board of Industrial Hygiene (ABIH) based on educational and experience criteria as well as successful full-day exam completion.

Larger companies or those with extensive industrial hygiene exposures usually have an industrial hygienist or environmental health specialist on staff or contract for third-party services. Medium-size plant locations employ safety managers who have additional responsibilities for environmental compliance. These managers typically completed introductory industrial hygiene training as part of their college safety curriculum. Applied industrial hygiene assessment skills are developed through extensive training and field experience. Safety, not industrial hygiene, is just one of the many "hats" worn by human resource/personnel or financial staff at small company locations. Industrial hygiene compliance and complaint issues present resource decision-making challenges for small- to medium-sized company locations.[21] Beyond compliance issues, liability and production issues are often linked to workplace exposure complaints, impacting other company operations.

Many companies have financially "tightened their belts" due to economic conditions and increased competition. This has resulted in the reduction of staff, including safety and industrial hygiene staff, as well as monitoring equipment purchase and maintenance budget restrictions distancing and delaying problem-response capabilities. These impacts on availability of assessment services, once more freely offered, can create conflict and employee concern. Decisions on the extent and continuation of monitoring vs. control implementation or "all clear" determination must be made – the "crosshairs." These conflicts may result in employees reporting complaints to OSHA or visiting their physician, resulting in requests for compliance assessments. Industrial hygiene assessments, unless a compliance issue exists, are seldom a financial priority due to the continuing routine and "invisible" nature of exposures.

So how does a safety manager identify and prioritize the assessment of industrial hygiene exposures and complaints? Industrial hygiene exposures can arise at any occupancy, including industrial facilities, warehouses, retail stores, and office buildings. Industrial hygiene exposures are typically generated within the occupancy, but on occasion may come from an adjacent occupancy or the exterior environment. Safety managers need to make quick decisions sometimes on risk-assessment and response actions. Risk assessment and exposure prioritization are the cornerstone for the development of response plans and proposals for resource expenditure, and NIOSH and AIHA have both developed decision-making frameworks in this area.

NIOSH and AIHA Exposure Assessment Strategies

NIOSH has undertaken an Exposure Assessment Cross Sector Area Program with strategic goals of improving exposure assessments and tools and prevention of occupational disease. Occupational exposure assessment includes identification, characterization and exposure estimation, and overall

[20] AIHA. 2011.

[21] Germond, Nancy, "Should Your Organization Hire a Risk Manager*?"* *All Business*. 2008. (retrieved February 14, 2011) (www.allbusiness.com/labor-employment/human-resources-personnel/6635417-1.html).

evaluation of hazards. Each evaluation step analyzes exposure assessment and resolution strategy, expanding or refining assessment efforts, and addressing or upgrading control measures.[22]

The American Industrial Hygiene Association has developed a fundamental exposure assessment strategy. This strategy covers development of a monitoring strategy for impact assessment in established exposure groups for inhalation and dermal exposures. It also includes statistical concepts more often employed in larger studies. The goals of the exposure assessment program include the efficient application of resources to assess workplace exposures, develop historical exposure record, and validate compliance with governmental regulations and "best practice" exposure guidelines. The likelihood of achieving monitoring results greater than 10% of the occupational exposure limit is the exposure-monitoring driver.[23]

Industrial hygiene assessments usually incorporate both quantitative exposure monitoring and judgment or qualitative factors. Professional judgment plays a strong role during the first investigation of a presented issue, emphasizing the importance of competence, adequate training, experience, and communication. The complete process life cycle and exposure points must be identified and assessed. Uncertainty often arises as an issue in industrial hygiene assessment because specific allowable exposure standards may not exist or exposure substance toxicities or potential health impacts may be undefined. Close investigation of workplace emissions and employee complaints may propel first-response actions to control unquantifiable exposures or non-overexposure discomfort issues. In some cases, the cost to upgrade controls may be less than the air-monitoring assessment.

Existing Resources: Past Assessment Criteria and On-Site Equipment

Verbal summaries of past monitoring efforts should never be accepted as valid information. Past industrial hygiene assessment reports should be subjected to a quality review based on AIHA and ASSE competent professional/industrial hygienist and exposure assessment criteria. Calibration of equipment and accreditation of the sample analysis laboratory should be detailed. Monitoring time frames and operational conditions should be representative of exposure. While many industrial hygiene reports do not incorporate statistical analysis, repeated sampling results through testing of different workers or locations at similar tasks or testing across different days supports results validation.

On-site equipment should be properly maintained and calibrated, both on site and at a facility with traceability to the National Institute of Standards and Technology NIST). Equipment should be stored in a secure location. Equipment users of owned or rented equipment should be properly trained on usage, calibration and maintenance, results interpretation, documentation, and response procedures.

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[22] National Institute of Occupational Safety and Health (NIOSH). 2009. *NIOSH Exposure Assessment Program Description.* (retrieved February 14, 2011) (www.cdc.gov/niosh/programs/expa).

[23] Arnold, Susan, *Short Course On Exposure Assessment*, Florida AIHA PDC. April 3, 2008.

Litigation, Workers Compensation Claims, or Physician-Diagnosed Work-Related Ailments

Litigation, workers' compensation hearing, or physician diagnosed illness scenarios arising from allegations of workplace ill health are best completed by a qualified third party with objectivity in exposure assessments. These services may or may not be covered by the company insurance carrier as part of the claims-handling process. Adherence to proper protocols and procedures, chain of sample and equipment custody validation, and consultant credentials will all be subject to intense scrutiny under deposition. Chain of custody refers to the chronological documentation of physical possession of sample media and equipment throughout all phases of the assessment process. The specific consultant should be a certified industrial hygienist and have deposition experience. Expertise and methods must be able to withstand deposition.

It is still advisable for the contracting employer to review the industrial hygiene assessment proposal to make sure that agreed-upon goals will be met. The named alleged problematic tasks and exposures should be addressed with multiple samples for shift duration. The contractor should remain on site the entire time the assessment is ongoing, maintaining chain of custody. Any air samples taken should be analyzed by an American Industrial Hygiene Association-accredited laboratory. The draft report should be reviewed by the contracting employer before full payment is rendered, not to demand alteration of results, but to make certain report content meets specifications.

Occupational disease diagnoses are best rendered by occupational physicians rather than general practitioners. Both physician groups may request the employer to undertake industrial hygiene assessments looking for the source of health problems. General practitioner inquiries may be more ambiguous and broader in scope. Industrial hygienists cannot diagnose disease, but can assess workplace exposures and compliance or violations of safety and health standards or guidelines.

Example Range of Common Industrial Hygiene Consultation Tasks and Expertise Considerations

Industrial hygiene consultations range widely in complexity and expertise required. There is no substitute for both the judgment ability that accompanies experience and close investigations of all exposure aspects. Even some simple tasks may contain elements of uncertainty needing closer scrutiny, and appropriate time resources must be appropriately employed for questioning, research, and communication. Each safety manager must evaluate industrial hygiene tasks for initial determination of appropriate expertise and time resources. Example consultation tasks are briefly reviewed below to highlight key points.

Mold

The U. S. Environmental Protection Agency emphasizes the production of a mold sampling plan only after the development of a confirmable theory about mold sources and routes of exposure.

Identification and eradication of moisture intrusion sources are emphasized. The EPA indicates that in absence of extensive mold experience, an experienced mold assessment professional should be consulted.[24] AIHA, as earlier indicated, developed the concept of "competent professional" as a prerequisite for mold assessment work. Mold air and surface testing requires specialized equipment and assessment knowledge. Typically indoor air samples are taken at various indoor locations and one or two outdoor samples with results comparison to see if interior results are elevated or contain different types of mold. There are no EPA or federal regulations on allowable mold exposure. With visible mold, air monitoring may not be required according to the EPA unless there is litigation or employee health concerns, or the exact source location is unknown.[25] Air monitoring is also typically accomplished post-abatement as part of "clearance" testing.

Noise and Hearing Conservation

Noise is one of the most common workplace industrial hygiene exposures and the second-highest reported occupational illness.[26] Noise monitoring can be readily accomplished by competent professionals familiar with OSHA 1910.95 and equipment operational instructions. Unprepared use of noise monitoring equipment presents error potential from incorrect calibration or selection of incorrect results readouts options. Other common errors include lack of accounting for shifts longer than 8 hours and lack of site attendance, obliterating chain of custody. Once baseline noise exposures are monitored, repeat noise monitoring is not necessary unless process or production changes occur which impact ambient noise levels. There are costs associated with each employee in the Hearing Conservation program, and the strategy of placing all employees into the program, even those not overexposed to noise, presents inefficient expenditure of resources.

Time resources should be allocated to implementation and audit of the OSHA hearing conservation audiometric testing program. New or existing employees should not "slip between the cracks," resulting in missed pre-existing or developing hearing loss. OSHA Standard Threshold Shifts (STS) have been misdiagnosed due to test booth background noise interference, employees arriving at testing from the noisy plant floor, or employee pre-existing conditions or acute illness. Employees identified with STS should be retested within 30 days, retrained on hearing protection use and fit, and medically reviewed if appropriate.[27]

	U S OSHA	ACGIH/NIOSH/UK HSE
8 Hours	90 dB(A)	85 dB(A)
4 Hours	95 dB(A)	88 dB(A)
2 Hours	100 dB(A)	92 dB(A)
1 Hour	105 dB(A)	94 dB(A)

Table 2. Allowable Time Interval Noise Level Exposures

[24] Environmental Protection Agency (EPA). 2010. *Mold and Moisture* (retrieved February 14, 2011) (www.epa.gov/iedmold1/).
[25] EPA, Ibid.
[26] Hager, L. D. "BLS Occupational Hearing Loss report for 2007". *CAOHC Update*, 21, 7-8.
[27] Occupational Safety and Health Administration (OSHA). 2008. 1910.95 *Occupational Noise Exposure.*

Hearing Conservation Programs should be rigorously maintained for employees exposed to noise above the OSHA Action Level. Table 2 demonstrates that U. S. OSHA regulations allow 2 – 4 times greater exposure than NIOSH, ACGIH, and HSE regulations. Additional concerns exist for the cumulative effects from recreational noise exposure compounding workplace exposure, especially from personal music devices, such as Ipods and MP3s.

Baseline Exposure Measurement and Compliance Programs

The development of assessment plans and completion of progressive steps requires expertise in industrial hygiene exposure and control review and prioritization, exposure monitoring technique, results comparison strategy, and range of feasible control options. This expertise must be coupled with detailed knowledge of process steps, including less visible tasks such as maintenance and cleaning, and familiarity with toxicity and hazard potential of the full range of employee exposures. An industrial hygienist should be an active professional component of baseline exposure and compliance programs. If brought in as a contractor, the industrial hygienist should work closely with location personnel to validate program targets and scope. More complex exposures, such as respirator fit-test programs, ventilation assessment, and potent compounds, require elevated expertise and credentials.

Acute Exposure Injury Potential

Industrial hygiene exposure monitoring programs routinely address time-weighted average exposure levels, short-term exposure levels, and ceiling limits. Accidental acute exposure levels may be the larger concern, and those exposures may be better addressed by fixed-in-place or personal monitoring systems.

Ozone exposure from water sanitizing processes and hydrogen cyanide exposure from electroplating present two good examples. Ozone is notoriously destructive to rubber gaskets and fittings.[28] Over time, ozone generating and distribution systems develop leaks of this strong irritant gas. A fixed monitoring system would provide continuous monitoring of developing or erupting emissions.

Electroplating operations which use cyanide salts present a potential for hydrogen cyanide (HCN) gas release when inadvertently mixed with acids.[29] Typically ambient HCN levels are very low. Acids and cyanides could accidentally mix during chemical processes and chemical handling, waste treatment, or in storage areas. The sudden and deadly release of HCN should be detected by a fixed monitoring system.

Oftentimes there is a greater likelihood, from a frequency standpoint, of injury from chemical contact during handling and processing. Dermal and eye exposure potential are critical components of industrial hygiene assessments.

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[28] Shakhashiri, B., Chemical of the Week: Ozone, University of Wisconsin-Madison. (retrieved February 14, 2011) (http://scifun.chem.wisc.edu/chemweek/ozone.html).

[29] Occupational Safety and health Administration (OSHA). 2011. Occupational Safety and Health Guidelines for Hydrogen Cyanide. (retrieved February 14, 2011). (www.osha.gov/SLTC/healthguidelines/hydrogencyanide/recognition.html).

Confined spaces are subject to varying conditions related to production and processes, materials, and even seasonal weather. OSHA standard 1910.146 Permit-Required Confined Spaces details compliance steps for these exposures.[30] In the rush to qualify a confined space as non-permit required, concerns exist that validated repeat monitoring may be short-changed. The permit and non-permit decisions should be made by an industrial hygienist with a high level of expertise adhering to the standard's confined space decision flow chart, being cognizant of any potential for variable conditions. Properly calibrated and maintained personal monitoring equipment and the appropriate pre-entry flow chart hazard review will alert the employee and attendant to dangerous arising conditions. Infrequently entered confined spaces, such as water valve pits and electrical vaults, may drift off from vigilance resulting in entry low oxygen incidents or death. Regular inspection of signage, checks on adherence to procedures and training, and monitoring equipment maintenance should occur and be audited.

Unknown Products of Combustion Constituents

Wire or cable plastic coatings burned in assembly and test or plastics molding operations often generate irritant effects from products of combustion. This smoky plume or haze exemplifies an exposure in which many toxic constituents are given off which cannot be readily analyzed and do not have occupational exposure limits.[31] Employees often complain about respiratory irritation.

This type of exposure can be addressed by enclosure and local exhaust ventilation. While specific constituents can be monitored, such as carbon monoxide and plastic monomers, these results often show low levels, while irritating plume properties exist. In these cases, symptom complaints take precedence over air sampling results due to lack of monitoring exposure representativeness.

Indoor Air Quality

Office building HVAC systems are designed for specific occupant and equipment loading. Many jurisdictions require a pre-opening IAQ evaluation for the certificate of occupancy which includes air quality monitoring. In addition to occupant loading, adjustments for seasonal temperature requirements and ambient exterior air conditions impact indoor air quality. Most complaints relate to temperature or insufficient fresh air, especially during the change of season time period when system adjustments are in progress. Other common problems include contaminants from renovation or water intrusion. Quick identification and repair of these arising problems should be a priority and may eliminate the need for monitoring.

While mold evaluations require extensive expertise, routine follow-up on discomfort IAQ complaints can be assessed by competent professionals with an IAQ meter which monitors carbon monoxide, carbon dioxide, temperature, and humidity. This equipment has calibration and maintenance requirements which must be adhered to for sensing cell accuracy. The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) developed building

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[30] Occupational Safety and Health Administration (OSHA). *1910.146 Permit-Required Confined Spaces.* (retrieved February 14, 2011) (www.osha.gov/).

[31] Simoneit, B. R. et al, "Combustion Products of Plastics as Indicators for Refuse Burning in the Atmosphere", *Environmental Science and technology*, 2005, 39 (18), p.6961-6970, August 6, 2006.

indoor environmental and HVAC standards 62 and 55 which are designed for office occupancies and office populations.[32] Office populations may include more sensitive individuals than industrial, including those with heart conditions, cancer, pregnancy, etc. These standards have greater relevancy for office occupancies than OSHA and are incorporated into many building codes. The EPA has produced numerous helpful references and checklists on Indoor Air Quality.[33]

Should a carbon monoxide problem be suspected, all efforts should be taken to immediately assess and address the situation. Local fire departments and public health departments can assist with air monitoring. Should ongoing monitoring be necessary as a precaution, carbon monoxide monitors are available in most retail outlets. While carbon dioxide is frequently monitored during IAQ investigations as an indicator of fresh air and ventilation adequacy, improperly vented combustion byproducts contain elevated levels of carbon dioxide and carbon monoxide. Adding more fresh air to the recirculating HVAC system, typically done to increase fresh air, would increase heating demand and products of combustion. Indoor air quality surveys should always incorporate both, carbon dioxide and carbon monoxide.

Carbon monoxide monitoring on forklift drivers is a common industrial hygiene assessment. Ongoing periodic emissions testing and maintenance are key "best practices" to reduce exposures to drivers and ambient plant air. Forklift drivers driving into small spaces such as truck trailers or storage rooms may be subjected to rapidly building carbon monoxide levels that exceed OSHA's 5 minute Short Term Exposure Limit of 200 ppm (parts per million). Carbon monoxide monitoring for forklift drivers should include average, STEL, and peak exposure assessments and forklift emissions testing.[34]

Potent Compounds and Pathogens

Active pharmaceutical compounds and pathogens research and manufacturing exposures present unique challenges, as there are no specific regulatory exposure guidelines and companies often develop their own exposure limits based on a fraction of effect levels in clinical trials or research. Life Sciences exposures may additionally include radiation, cryogenics, lasers, and animal contact. Monitoring for these exposures and contamination spread requires a high level of expertise, suitable contaminant collection method, and location of unique analytical services as analysis is outside the scope of AIHA accredited laboratories. Also assessment work has to be carried out in a manner which does not contaminate sanitary conditions, requiring protective clothing and restricted access. Many of these operations adopt a control banding approach and utilize high-level controls including special containment rooms, robotics, isolators and closed transfers, laminar flow hoods, glove boxes, etc., along with specialized ventilation and clean-room parameters. Advisory groups

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[32] Trane, "*Indoor Air Quality: A Guide to Understanding ASHRAE Standard 62-2001"*. 2002.

[33] Environmental Protection Agency (EPA). 2011. *Indoor Air Quality (retrieved February 14, 2011)* (*www.epa.gov/iaq/*).

[34] Washington State Department of Labor and Industries. 2011. *Carbon Monoxide Poisoning From Forklifts – Bad for Workers, Bad For Business*. (retrieved February 14, 2011) (www.lni.wa.gov/Safety/Research/HazardousChem/CarbonMonoxide/Default.asp).

have developed specific criteria for the control of potent compounds and pathogens in research and Life Sciences settings.[35]

Regulated Inspector/Assessor/Management Planner Requirements

Asbestos, lead paint, and mold have specific federal or state requirements for training and/or professional certification and assessments. These requirements include initial and continuing training and in-depth regulatory knowledge. Outside expertise is often employed for the assessment and control of these exposures. Experience and detailed regulations knowledge, beyond classroom training, are critical for accurate assessments. AIHA when developing their competent professional definition emphasized that attendance at a training course does not alone imbue expertise necessary to conduct an adequate consultation.[36]

Silica

Silica assessments are complex and the potential for error is great attempting to reconcile both OSHA's calculated 1900.1000 Table Z-3Mineral Dusts results and ACGIH TLVs. The OSHA Silica E-Tool Advisor provides helpful insight, but the calculator can be confusing to new users.[37] The laboratory analytical limit of quantization is close to ACGIH's TLVs and adequate sampling time period is crucial to valid exposure determination. Shorter time periods could result in a "Less Than the Limit of Quantization" results determination which is higher than OSHA standards or TLVs resulting in actual exposure results interpretation confusion. Silica assessments require elevated expertise and even more with increasing OSHA attention.

OSHA Complaint Follow-Up

OSHA complaints can range from nuisance issues from disgruntled employees to serious, neglected problems. Response to OSHA=generated letters is usually requested within 21 - 30 days, which is not a lot of time if external resources need to be engaged. The complaint filing process can be easily completed by any employee online, via mail, or by telephone. OSHA may send a letter asking the employer to have the situation reviewed and assessed/corrected or make a partial inspection visit, depending upon the potential scope and severity of the problem. OSHA may specify the minimum assessor credentials or assessment steps considered necessary or leave that to the employer to determine. Assessments for OSHA should be conscientiously completed and employ appropriate expertise levels. OSHA expectations regarding extent of assessment steps should be clearly understood, and the employer should discuss any clarifications with the assigned inspector as soon as possible. OSHA has developed an internet page on their web site detailing the complaint-handling process steps.[38]

OSHA industrial hygiene reports should be scrutinized in the same manner as past assessment reports by third parties in terms of representativeness, exposure time period, industrial hygienist

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[35] Gould, J. C., "Strategies for Preventing Occupational Exposures to Potent Compounds." *Toxicology Mechanisms and Methods*, February, 2011, Vol 21, No. 93-96.

[36] Trippler.

[37] Occupational Safety and Health Administration (OSHA). 2011. *OSHA Silica eTool*. (retrieved February 14, 2011) (www.osha.gov/SLTC/etools/silica/index.html).

[38] Occupational Safety and Health Administration (OSHA). (2011). Federal *OSHA Complaint Handling Process.* (retrieved February 14, 2011) (www.osha.gov/as/opa/worker/handling.html).

credentials, equipment calibration and chain of custody, and analysis laboratory accreditation. If possible, side by side monitoring is suggested in case unusual and unexpected results return.

Welding Fume, including Hexavalent Chromium

With the advent of the OSHA hexavalent chromium standard and National Emphasis Program, a surge in industrial hygiene welding assessments has occurred, particularly for stainless steel and chromium alloy work or that involving chromium-containing consumables.[39] OSHA requires welding samples be taken with the filter placed inside the welding helmet which requires a smaller 25 mm PVC filter and holder, as research has shown less fume in the worker's helmet interior breathing zone.[40] Hexavalent chromium samples should be analyzed within 6 days post monitoring to prevent conversion of hexavalent chromium to trivalent. Hexavalent chromium wipe samples should only be taken with PVC or binderless quartz fiber filters.[41] While pump and filter air monitoring is a basic industrial hygienist skill, helmet positioning and knowledge of exposure metals, wipe sample criteria, and sample speedy delivery to the analytical laboratory are important refining service points.

Nanotechnology and Nanomaterials

This new "Industrial Revolution" brings the double challenge of measurement of nanometer sized air contaminants along with an "in progress" determination of new reactivity and toxicity features. NIOSH is partnering with nanotechnology developers and users for risk assessment and is heavily engaged in research and educational efforts. The NIOSH Nanotechnology web site offers a wide range of helpful documents including "Approaches to Safe Nanotechnology."[42] Nanotechnology industrial hygiene assessments require elevated expertise and should not be handled as routine industrial hygiene work in a similar matter as larger-sized contaminants.

Looking Forward—2020

With the completion of the Human Genome Project in 2003, much new research is being conducted on the identification of initial impact of toxic materials on human DNA, long before disease manifests. Diseases have genetic components, both from inherited traits and/or the impact of environmental toxins or pathogens.[43] Genetic susceptibility to diseases is being identified as are new promising potentials for gene therapy drugs. Thousands of new medical interventions are anticipated.

By 2020 human genetic profiles will be part of medical records. Privacy issues will likely be contested as employers and insurers may seek to identify genetically susceptible or resistant workers. Debates will arise regarding the source and possible impacts of contaminant contact or

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[39] Occupational Safety and Health Administration (OSHA). (2008). 1910. *Hexavalent Chromium*. (retrieved February 14, 2011) (www.osha.gov/SLTC/hexavalentchromium/index.html).

[40] Occupational Safety and Health Administration (OSHA), *Hexavalent Chromium VI, National Emphasis Program* PPT. (retrieved February 14, 2011) (http://www.aiha.org).

[41] Ibid.

[42] National Institute of Occupational Safety and Health (NIOSH). 2010. *Approaches to Safe Nanotechnology*. (retrieved February 14, 2011) (www.cdc.gov/niosh/topics/nanotech/).

[43] Human Genome Project. 2011. Human Genome Project Information (retrieved February 14, 2011) (www.ornl.gov/sci/techresources/Human_Genome/medicine.html).

damage to DNA. [44] Determinations on what constitutes the beginning of an injury or illness will likely be decided in litigation. "Take home toxics" will be another area of controversy if family members' DNA shows workplace-related contaminant impact.

Industrial hygiene exposure assessment, along with long term recordkeeping, will be alive and well in the future because prevention is still preferable over illness or biomarker manifestation. New exposure measurement parameters and techniques will arise, making assessment tasks more accurate and simpler, but judgment and experience remain irreplaceable.

The American Industrial Hygiene Association (AIHA) has included tracking and responding to emerging trends and sound, science-based risk assessment as strategic goals for 2011 -2015.[45] The continual development and refinement of core competencies and capabilities of competent professionals and industrial hygienists supports the impact and critical recognition of present and future contributions.

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[44] Ibid. Fast Forward to 2020:What to Expect in Molecular Medicine.

[45] American Industrial Hygiene Association (AIHA). 2011 Plan. The AIHA 2011-2015 Strategic. (retrieved on February 28, 2011) (www.aiha.org/aboutaiha/Pages/StrategicPlan/aspx).

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