NIKE, INC. INDUSTRIAL HYGIENE PLAYBOOK

RESPONSIBLE SUPPLY CHAIN

May 2023

TABLE OF CONTENTS

INTRODUCTION

NIKE'S COMMITMENT TO INDUSTRIAL HYGIENE

Because Nike is committed to the health and safety of our employees and those working within our supply chain, the practice of Industrial Hygiene is non-negotiable. Suppliers must comply with all efforts to mitigate workplace risk as outlined in our Code of Conduct (CoC) and Code Leadership Standards (CLSs).

The code and standards for Occupational Health and Hygiene are defined in the sidebar. To access Nike's CoC and CLSs in their entirety, please refer to https://purpose.nike.com/code-of-conduct.

The Nike Industrial Hygiene Playbook supports the supply chain by providing a framework to develop, implement and sustain an effective Industrial Hygiene and Occupational Health Management Program.

OCCUPATIONAL HEALTH AND HYGIENE HAZARDS ARE CONTROLLED

CODE OF CONDUCT

The supplier anticipates, recognizes, evaluates and controls occupational health and hygiene hazards in the workplace. The supplier uses routine monitoring and analytical methods to determine the potential health effects of hazards that are present in the workplace. Workers are not exposed to physical, chemical, or biological hazards above occupational exposure limits.

CODE LEADERSHIP STANDARDS

- Respiratory Protection
- Laser Safety
- Ergonomics
- Heat Stress Prevention
- Radiation
- Occupational Exposure Limits
- Occupational Noise Exposure
- Personal Protective Equipment (PPE)
- Occupational Health Management
- Bloodborne Pathogens
- Medical Services and First Aid

HOW INDUSTRIAL HYGIENE RELATES TO WORKER HEALTH AND SAFETY

The purpose of Industrial Hygiene (IH) is to prevent injury, illness and disease, which can negatively impact the workforce as well as Nike's business and reputation. For ultimate effectiveness, IH should be fully integrated into business practices. Consider the following data:

- The American Cancer Society estimates that about 4% of cancers in the United States are work-related, and approximately 20,000 cancer deaths and 40,000 new cases of cancer each year can be attributed to occupation.[1]
- The International Labor Organization estimates that, each year, a total of 160 million new cases of work-related illness occur globally — 35 million due to exposure to chemicals — and 2 million lives are lost to occupational disease (3% of all deaths).[2]
- Just four selected occupational risks (workplace carcinogens, airborne particulates, ergonomic stressors, and noise) are responsible worldwide for 37% of back pain, 16% of hearing loss, 13% of chronic obstructive pulmonary disease, 11% of asthma, 9% of lung cancer, and 2% of leukemia, causing 538,000 deaths worldwide.[3]

The effective practice of IH helps to benefit Nike, its employees, its business partners and its customers in numerous ways:

- Improved worker health, morale and increased life expectancy.
- Decreased absenteeism and turnover.
- Reduction in the number of people who need to leave employment early because of injury or illness.
- Reduced social and healthcare costs as well as maximized worker potential.
- More efficient working processes with technological improvements and increased productivity, improved operational efficiency, increased capacity and higher quality products.

1 American Cancer Society

2 https://www.ilo.org/safework/areasofwork/chemical-safety-and-the-environment/WCMS_792104/lang--en/index.htm

3 Fingerhut M., Driscoll T., and Nelson I., et al. (2005) Contribution of occupational risk factors to the global burden of disease — a summary of findings. SJWEH Suppl; 1: 58–61.

DEFINING INDUSTRIAL HYGIENE

Industrial Hygiene or IH — known as "Occupational Hygiene" in most countries outside of the United States — is the art and science of anticipating, recognizing, evaluating and controlling hazards within the workplace. These hazards might be biological, chemical or physical agents that could result in injury or illness, or affect the well-being of workers or the surrounding community.

The American Industrial Hygiene Association (AIHA) proposes that IH be considered an aspect of preventive medicine, in that its goal is to prevent occupational injury, illness and disease. Further, to reduce the risk of exposure to hazards, IH overlaps with other safety-related fields such as risk management, risk assessment, engineering, product stewardship and industrial safety.

A person who practices IH, an industrial hygienist, uses various analytical methods to estimate worker exposure to biological, chemical or physical hazards to determine the need for methods to reduce (or eliminate) these exposures to an acceptable level. In actual practice, IH often requires professional experience beyond technical and scientific methodologies, and this could be considered the "art" of IH.

ROLE OF THE INDUSTRIAL HYGIENIST

PERFORMING EXPOSURE ASSESSMENTS

Exposure assessments should be performed by or under the review of an IH professional — a person qualified by virtue of training and experience to effectively anticipate, assess and control health and safety hazards.

Qualified personnel, who have formal training in sampling methods and instrumentation, should measure chemical, physical and biological agents in the workplace. Adequate training is usually provided by short courses, including seminars sponsored by governmental agencies, professional associations and many universities.

Occupational exposure assessments are directed at achieving two primary objectives:

1 IDENTIFYING HEALTH HAZARDS AND COMMUNICATING EXPOSURE ASSESSMENTS

Through the differentiation of acceptable and unacceptable exposures, industrial hygienists can identify concerns and then convey findings to management, all affected staff (i.e., medical, engineering, etc.) and employees. This provides a foundation for planning engineering controls, implementing medical surveillance, and educating and training employees on health risks and work practice controls.

2 DEVELOPING AND MAINTAINING A DATABASE

This provides the basis for assisting with future questions from various concerned parties including management and technical staff (i.e., medical, legal), employees, labor unions, researchers (e.g., epidemiological studies) and regulatory authorities.

DEVELOPING A CHEMICAL INVENTORY

A comprehensive library of safety data sheets (SDSs) should be established for all potentially hazardous materials, including raw materials, process intermediates, products, by-products, compressed gases, paints, solvents, process lubricants, mechanical lubricants, adhesives and cleaning agents, etc.

Each SDS should be linked to one or more departments with a record of its initial use (i.e., month/year) in the department. The SDSs for materials no longer in use should be archived with a record of when use was discontinued (i.e., month/ year).

An IH professional should establish a site-specific administrative control process. This process should require SDS review and IH approval prior to authorizing the purchase of a new material.

Highly hazardous chemicals must be tightly controlled or eliminated. Examples of chemicals that have been phased out or controlled include:

- Benzene (i.e., hydrocarbons containing greater than 0.1% benzene except for gasoline)
- Chlorinated hydrocarbons, including chloroform, perchloroethylene and trichloroethylene
- Chromium (hexavalent)
- Formaldehyde, including materials generating formaldehyde such as biocides
- Lead in paints and lubricants
- Mercury
- Methylene chloride
- Sensitizers such as toluene diisocyanate

Please reference the Nike Chemistry Playbook at https://about.nike.com/pages/chemistry-restricted-substances-list for further guidance on responsible chemical management and Nike's Restricted Substances List.

BUILDING AN INDUSTRIAL HYGIENE FRAMEWORK

OVERVIEW

Hazardous materials can produce acute (short-term) and chronic (long-term) toxic and irritating effects, skin and/or respiratory system sensitization, and irritation and other occupational illnesses if not properly controlled.

Most human exposure to hazardous materials occurs through three exposure routes:

- **Inhalation** of airborne vapors, mists, dusts, etc.
- **Absorption** through skin contact or other mucous membranes (i.e., eyes)
- **Ingestion** (i.e., eating/handling food or drink with contaminated hands or clothing)

The purpose of IH is to help ensure employee exposures to material hazards are evaluated, and exposures mitigated, through the application of appropriate controls, such as elimination/substitution, engineering (e.g., ventilation, isolation), administrative controls (e.g., work practices) or personal protective equipment (PPE).

ANTICIPATE

Anticipation involves identifying potential hazards before they are introduced. Generally, this means knowing that hazards may exist within processes and using basic knowledge of chemistry, biology and physics to anticipate which types of hazards are likely. Hazards are primarily expected to occur due to both materials (e.g., chemistries, raw materials) and machines or a combination of the two.

Internally at Nike, the Innovation team will review new projects and assess which, if any, IH hazards are present. Identified hazards will be communicated to our suppliers in advance so that control measures can be implemented. Find more information on types of control measures below.

RECOGNIZE

Recognizing involves identifying the potential hazard that chemical, physical or biological agents or an adverse ergonomic situation pose to health. This means evaluating IH risks and determining if a hazard is likely to exist.

OCCUPATIONAL EXPOSURE LIMITS

Occupational exposure limits (OELs) are established for workplace exposures to air contaminants, noise and radiation, etc.

- OELs for air contaminants and noise are expressed as full-shift time-weighted average (TWA) values, short-term exposure limits (STELs), excursion limits and ceiling limits.
- Biological OELs are available for some materials, and they are employed when the main route of exposure is skin absorption and/or inadvertent ingestion.
- OELs for ionizing radiation are generally expressed as a cumulative dose.

In general, the American Conference of Governmental Industrial Hygienists (ACGIH) provides OELs — apart from noise. ACGIH threshold limit valves (TLVs) are internationally accepted and adopted by many countries around the world. National Institutes of Occupational Safety and Health (NIOSH) recommended exposure limits (RELs) may be consulted when neither ACGIH nor country-specific exposure limits are available. Supplier are responsible for adopting OELs for their respective facilities that meet local law or Nike CLS requirements, whichever is more conservative.

OELs FOR NON-TRADITIONAL WORK SCHEDULES

In operations involving non-traditional work schedules, OELs should be reviewed in view of the chemical's toxicity, biological half-life and characteristics of the work schedule.

TWA exposure limits are based on working five eight-hour shifts per week. If employees work longer than eight hours per day, TWA exposure limits must be adjusted to account for extended exposure time and reduced recovery time.

The Brief and Scala model reduces the OEL by a factor that takes into account the hours worked daily and the periods of rest between them. Table 1 provides an example of how OELs are adjusted for the duration of an extended shift.

COMBINED CHEMICAL EXPOSURES

When two or more hazardous substances which act upon the same organ system are present, their combined effect— rather than that of either individually — should usually be given primary consideration. Table 2 provides an example of how to calculate combined exposure limits.

EXCURSION LIMITS

Short-term exposure limits have not been established for most materials with an 8-hour TWA OEL. Nonetheless, excursions should be controlled even when the 8-hour TWA is below the permissible limit. In the absence of a peak exposure limit, consider the ACGIH recommended excursion limit of 3x the OEL for no more than 30 minutes during a work shift, and a general limit of 5x the OEL

Table 1.

CALCULATING EXPOSURE DURING EXTENDED WORK SHIFTS

EQUATION	EXAMPLE
Adjusted occupational exposure limit (OEL) $\frac{8 \times (24 - h) \times OEL}{16 \times h}$ h = Hours worked each day	TOLUENE 8-hour OEL = 20ppm Adjusted OEL for a 12-hour shift: $\frac{8 \times (24 - 12) \times 20ppm}{16 \times 12}$ Adjusted OEL = 10ppm

Table 2.

CALCULATING EXPOSURE TO MULTIPLE CHEMICALS

EQUATION	EXAMPLE
IF the sum of $\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots + \frac{C_n}{T_n}$ is greater than 1, the threshold limit of the mixture is exceeded. C = Air concentration of the substance (measured or modeled) T = Threshold limit — the occupational exposure limit (OEL)	TOLUENE and STYRENE both have same health impact — respiratory irritation. $\frac{20ppm}{40ppm} + \frac{10ppm}{16ppm} = 1.1$ (0.5) + (0.6) Because 1.1 is greater than 1, the threshold limit of the combined exposure is exceeded.

ABSENCE OF AN OEL

In those instances where an OEL is not available, the IH professional has the option to choose from among the following:

- Request corporate Environment, Health and Safety (EHS) staff to establish an OEL and then proceed with the exposure assessment.
- Acquire more information about the health effects of the environmental agent, and then take one of two actions:
  - Request corporate EHS to establish an OEL.
  - Determine that the exposure is “Acceptable” or “Unacceptable” based upon professional judgment.
- Determine the exposure is “Acceptable” or “Unacceptable” in view of the information available on the health effects of the environmental agent and conditions of exposure. The time and resources needed to acquire more health effects data and/or establish an OEL may not be worthwhile.

CONTROL BANDING

The lack of an OEL does not mean that the substance is safe or that workers can be exposed without harm. When no OEL is available, other methods for determining controls — such as control banding — may be applicable. Other methods exist that use the properties of the material and estimates of the level of exposure to determine controls. One such technique is known as control banding.

According to NIOSH,

> Control banding (CB) is a technique used to guide the assessment and management of workplace risks. It is a generic technique that determines a control measure (for example dilution ventilation, engineering controls, containment, etc.) based on a range or “band” of hazards (such as skin/eye irritant, very toxic, carcinogenic, etc.) and exposures (small, medium, large exposure).

The ranking of the exposure is often grouped in intervals (bands) rather than an actual exposure value, hence the name control “banding.”

EVALUATE

Evaluating hazards essentially means measuring or estimating actual exposures and comparing to an acceptable exposure level such as an OEL. Exposures that exceed this limit will require controls be implemented to prevent such exposure. Evaluation may include both qualitative (based on professional judgment or other strategies that use direct measurement), semi-quantitative (limited direct measurements combined with professional judgment-based tools) or quantitative methods (direct measurements of sufficient quantity to definitively establish an exposure profile).

SIMILAR EXPOSURE GROUPS

Occupational exposure assessments are performed in workplaces that employ from just a handful to thousands of employees. Each employee may be exposed to a few or many environmental agents. The magnitude of exposure to these environmental agents varies from minute to minute, hour to hour and day to day. The goal is to assess the exposures and occupational health risks for all employees on all workdays and for all environmental agents.

The challenge is to do this accurately and efficiently, despite the diversity of exposures across employees and across time.

A commonly used strategy for meeting this challenge is the systematic formation of similar exposure groups (SEGs). The underlying value in this strategy is that once employees are stratified into SEGs, then exposure for a single employee in the group should be representative of the exposures for all employees in the group. The SEG is a tool that supports both the qualitative and quantitative portions of the exposure assessment process.

ESTABLISHING SIMILAR EXPOSURE GROUPS

Exposure groups are established by observation in view of the information gathered on the workplace, workforce and environmental agents. The classification of employees into SEGs is based upon an examination of the activities they perform and a judgment about the expected similarity of exposure. The industrial hygienist reviews this information and uses his or her training and experience to group employees thought to have similar exposures.

If a production facility has multiple, identical assembly lines with workers performing the same task (e.g., applying the same adhesive), samples collected from a select number of these workers can be considered as representative of the typical exposure profile of all workers performing that task.

Figure 1 shows suggested hierarchical strategies for establishing SEGs by observation that should minimize the chance of misclassifying any individual employee. What must be stressed, however, is the importance of thorough information gathering using not only a review of records but, most importantly, observation, knowledge and investigation into what really happens in the workplace. A thorough understanding of the workplace, coupled with training and experience, and honed by sound professional judgment can help to minimize the chance of misclassification.

In establishing SEGs, there can be infinite levels of specificity. The challenge is to select an effective and practical level. In general, exposures approaching OELs warrant a high level of specificity (linkage to a task), and low exposures warrant low specificity (SDS linkage to the process).

Figure 1.

EXAMPLES OF HIERARCHIES FOR CLASSIFYING SIMILAR EXPOSURE GROUPS (SEGs)

When classifying SEGs, industrial hygienists must select an effective and practical level of specificity. In general, low exposures warrant low specificity (SDS linkage to the process), and exposures approaching occupational exposure limits warrant a high level of specificity (linkage to a task).

QUALITATIVE ASSESSMENT

Qualitative and semi-quantitative techniques can be used in cases where limited data is available or where there is a lack of comparison standards for exposure. Some qualitative analysis will undoubtedly be part of the Recognize process, whereas potential risks are determined in absence or measured concentrations. Qualitative and semi-quantitative techniques can then also be used in the evaluate process to determine the need for Control.

Although most exposure assessments utilize both qualitative and quantitative data, initial assessments are based on mostly qualitative information since measured exposure values are not available. Accordingly, the exposure assessment begins with what might be termed a "qualitative exposure assessment." Accordingly, a qualitative assessment is a semi-quantitative exposure rating made in the absence of exposure data.

Nike requires qualitative exposure assessments for the evaluation of potential health risks associated with all chemicals as well as physical and biological agents — including noise, overexertion, vibration, heat and radiation.

The anticipated employee exposures associated with the innovation process, newly planned facilities equipment, hazardous materials and changes to an existing process should be prospectively assessed to ensure the identification of potential health risks. This assessment should be performed at an early stage and, at a minimum, should be performed prior to initial exposure.

Within Nike, the induction of new chemicals is processed through Sphera, in which SMEs review the chemical properties and assess the potential risk to the end user during the footwear and apparel manufacturing process.

An exposure assessment is a judgment about the acceptability of exposure for a SEG. Exposures are judged to be either "Acceptable," "Unacceptable" or "Uncertain." This is consistent with general IH practice.

An exposure is considered Unacceptable if:

- It is expected to give rise to adverse health effects.
- Exposures are expected to exceed an OEL.
- A health hazard is expected in view of dermal contact or inadvertent ingestion.

An Uncertain exposure assessment is one in which the industrial hygienist does not have enough knowledge to estimate the exposure levels or enough confidence in the OEL to judge exposures as Acceptable or Unacceptable. The Uncertain classification is transitional and temporary pending the collection of further information needed to resolve the assessment (i.e., personal monitoring data or toxicological data). Many Uncertain assessments can be quickly resolved with a minimum of sampling data.

See **Appendix B. Handling Treated Fabrics Using the Principles of Industrial Hygiene** and **Appendix C. Using Nike's Industrial Hygiene Framework to Develop a New Material** for case studies demonstrating how to work through the assessment process.

FEATURES OF THE EXPOSURE ASSESSMENT PROCESS

- **Performed by skilled professionals.** Exposure assessments are performed by professional industrial hygienists.
- **Evaluates current conditions.** Exposure assessments evaluate the current conditions in an industrial operation. Exposure assessments assume the absence of PPE.
- **Based on SDS library.** A prerequisite is the availability of a comprehensive inventory of SDSs linked to departments or processes.
- **Comprehensive.** The exposure assessment process should cover all employees on all days for all environmental agents. The exposure assessment should cover each SDS in the site's chemical inventory and specific environmental agents present at Uncertain and Unacceptable levels. In practice, this includes all product-associated agents (e.g., chemical mixtures represented by SDSs), process-associated agents (e.g., by-products, products of combustion, waste products, intermediates, etc.) and significant exposures to physical and biological agents (e.g., noise, heat stress, radiation, pathogenic bacteria, etc.).
- **Household products are only assessed if used in high quantities.** There is no need to assess household consumer products present in the workplace (e.g., aerosol paints, etc.) provided these products are used in a manner similar to household application. Exposure assessments are indicated if consumer products are used in quantities or at a frequency significantly greater than household use or are found to contain a toxic chemical.
- **Measures combined chemical exposures.** The potential for additive or synergistic effects should be identified. In the presence of concurrent and significant exposure to two or more chemicals affecting the same target organ.
- **Considers all significant routes of exposure.** This includes skin contact and inadvertent ingestion where personal hygiene practices are important.
- **Helps identify opportunities to reduce chemical use.** The identification of candidate materials for substitution or elimination is a valuable by-product of the exposure assessment process.
- **Proactively identifies and helps mitigate hazards.** Management systems are required for prospective exposure assessments. The practice of IH requires that anticipated employee exposures associated with the innovation process, newly planned facilities, equipment and hazardous materials be assessed to ensure the identification of potential health risks. This assessment should be performed at an early stage and, at a minimum, must be performed prior to initial exposure. In practice, new materials (and their SDSs) must be reviewed by a professional industrial hygienist, and the associated exposures assessed before initial use. The same requirement applies to physical agents. For example, the noise exposures associated with new equipment must be prospectively assessed.

STRATEGY AND GOOD PRACTICES

Exposure assessment judgments are supported by qualitative and quantitative data. To perform a thorough exposure assessment, the industrial hygienist will need to understand production and maintenance processes, the deployment of workers, the impact of work practices on exposures, and the toxicity associated with the chemical, physical and biological agents present in the workplace. In plants where an IH program is not yet established, exposure assessments generally follow the five steps below.

1 TOUR PLANT

The industrial hygienist will need to tour the operations and become extremely familiar with the key processes associated with operations. Significant task specific exposures must be identified, including exposures that occur intermittently. Work schedules must be considered. The industrial hygienist should consider how well prescribed work practices are followed by employees, which may be a function of training and enforcement. The industrial hygienist must identify the engineering controls in place and consider their reliability in maintaining adequate control of exposures.

2 PERFORM INTERVIEWS

Observations, comments and data from employees, safety staff, medical staff and others regarding the conditions of exposure and health effects (e.g., dermatitis, heat-related illnesses, etc.) must be solicited.

It is essential to interview supervisory and management staff to acquire a full understanding of the division of labor and intermittent significant exposure tasks.

3 ESTABLISH SEGs, MAKE JUDGMENTS AND DOCUMENT ASSESSMENTS

Exposure assessments are professional judgments based upon experience. If available, the underlying basis for exposure assessments will be:

- **Sampling data**. Personal monitoring data; area measurements.
- **Surrogate data**. Exposure data from another agent; exposure data from another operation.
- **Predictive modeling.** Based upon chemical/physical properties and usage.

The exposure assessment decision (i.e., Unacceptable, Acceptable, or Uncertain) is a professional judgment based upon many factors including the quantities of materials in use, work practices, ventilation, frequency and duration of exposure and OEL safety factors. Assessments can be made in the absence of monitoring data. Be cautious about being overly conservative and prescribing more sampling than necessary.

4 REVIEW SDSs, MAKE JUDGMENTS AND DOCUMENT ASSESSMENTS

As noted earlier, a comprehensive inventory of SDSs linked to departments or industrial processes is a prerequisite to performing exposure assessments. Verification should be made that the inventory is complete and up to date. The industrial hygienist's review of each SDS should focus on the product's ingredients and their associated toxicity/occupational exposure limits. In reviewing the SDSs, the industrial hygienist should identify candidate materials for substitution or elimination.

5 RECOMMEND EXPOSURE MEASUREMENTS

If the SEG is judged "Unacceptable," collect 5 to 12 samples. A minimum of 5 or 8 samples are required depending upon the variability of the data. If the SEG is judged "Uncertain," collect 1 to 3 samples and review the results. The use of area measurements may be a good first step. If the samples are well below 30% of the OEL, consider reclassifying the SEG as "Acceptable" If one or more samples exceed 30% of the OEL, collect more samples to meet or exceed the minimum baseline requirements.

DOCUMENTATION

Exposure assessments must be documented in order to derive lasting value from the observationally based judgments made by industrial hygienists. The major benefits of an occupational exposure assessment database are:

- **Efficient and sustainable industrial hygiene program.** In the absence of documentation, industrial hygienists will not know which jobs, tasks and materials have been evaluated in past years.
- **Comprehensive assessment of all exposures.** This includes those environmental agents for which a formal OEL has not been established as well as chemical agents posing a health risk from dermal absorption or skin sensitization.
- **Personal monitoring plan**. This helps resolve Uncertain exposure assessments and establish minimum baseline data when an exposure is judged Unacceptable.
- **Identification of employees who tentatively qualify for exposure-specific hazard communication training.** For example, when an exposure assessment is judged "Unacceptable.")
- **Identification of employees who tentatively qualify for medical surveillance.** For example, when an exposure assessment is judged "Unacceptable"
- **Exposure histories.** This helps facilitate the resolution of future questions regarding past exposures that may be voiced by medical staff, employees, labor representatives, governmental authorities and epidemiologists.

The following information should be captured where the exposure is judged Acceptable:

- Location
- Assessment date
- Name of hygienist who performed assessment (i.e., assessor)
- Facility
- Department or process
- SDS
- Begin date of use (estimated if practical)
- Decision (i.e., Acceptable)

In addition, the following information must be captured where the exposure is judged Uncertain or Unacceptable:

- Job
- Task (if peak exposure assessment or non-daily exposure assessed as TWA)
- Environmental agent

QUANTITATIVE ASSESSMENT

The objective of the quantitative assessment is to address Uncertain SEGs and establish baseline exposure data for SEGs judged Unacceptable.

PRIORITIZATION

Where quantitative exposure assessments are indicated, the industrial hygienist prioritizes SEGs for personal monitoring. The highest priority is given to Uncertain SEGs, followed by Unacceptable SEGs. Within each grouping, individual SEGs are prioritized in accordance with the following determinants:

- Number of employees exposed
- Toxicity of the environmental agent
- Frequency of exposure
- Reliability of exposure controls

Unacceptable exposures are generally a high priority. The measurement of Unacceptable exposures may help with the selection of controls or may help gauge the effectiveness of a control. For example, respiratory protection should be selected in view of workplace exposure levels and protection factor criteria. Also, the effectiveness of engineering or work practice controls can be assessed through exposure measurements performed prior to and following implementation of controls.

ADDRESSING SEGs JUDGED UNCERTAIN

An Uncertain exposure assessment is one in which the industrial hygienist does not have enough knowledge to estimate the exposure levels or enough knowledge about potential health effects to judge exposures to be Insignificant, Significant or Unacceptable. The Uncertain classification is transitional and temporary pending the collection of further information needed to resolve the assessment (i.e., personal monitoring data or toxicological data). Many Uncertain assessments can be quickly resolved with a minimum of sampling data, or a review of the literature on the environmental agent's health effects.

The industrial hygienist may be able to resolve the Uncertain exposure assessment with personal, area or bulk samples. Moreover, only a few samples may be necessary to make the assessment if the measured values are very low or very high relative to the OEL. A common practice for SEGs judged Uncertain is to collect two or three personal samples. If the measured values are well below 30% of the OEL, and there is no reason to believe the exposures will approach or exceed 30% of the OEL, the exposure can be judged Insignificant. Otherwise, it is prudent to collect three to five or more additional samples to reassess the exposures in view of the monitoring data.

ESTABLISHING BASELINE DATA FOR SEGs JUDGED UNACCEPTABLE

Minimum baseline data should be established when exposures for a SEG are judged Unacceptable. Five to eight or more samples are required for the initial determination: if sampling results are high or low relative to the OEL, five samples are adequate; otherwise, at least eight samples are required.

To enhance the data set, consider collecting two or more samples for everyone selected for personal monitoring. This additional data provides the capability to analyze "between-worker" and "within-worker" variability in exposure, thereby providing insight into the relative contribution of the process as opposed to individual work practices. This information is valuable when classifying employees into SEGs and fine tuning engineering and work practice controls.

IDENTIFICATION OF MEASUREMENT METHODS

The industrial hygienist performing the exposure assessment identifies analytes of interest. Be cautious about measuring chemical agents in the absence of an OEL. Identification of "Unknown" contaminants can be quite expensive and inconclusive. If available, a standard method should be used to measure occupational exposures to chemical, physical and biological agents.

Various governmental agencies around the world reference standard sampling and analytical methods. NIOSH and OSHA recommend sampling methods (e.g., sampling media, flow rate and minimum air volume) and analytical methods.

If you are unsure, please verify the sampling method, collection media, flow rate and minimum air volume with an analytical laboratory. The recommended methods and/or media may have changed since last requested.

When requesting sampling media, please give the laboratory as much lead time as possible. Certain sampling media have expiration dates (e.g., pre-weighted filters and treated adsorbent tubes). The expiration date will appear on the cassette or in the instructions packed with the media.

SAMPLING MEDIA

For many applications, sampling media can be classified into one of three categories: filters, adsorbent tubes and liquid media samplers.

CALIBRATION

Proper calibration of sampling equipment is essential in order to accurately measure workplace concentrations of air contaminants or physical agents (e.g., noise, radiation, etc.). All calibrations should be traceable to a primary or certified standard. Calibrations should be performed pre- and post-use and should be documented.

STORAGE AND SHIPMENT OF SAMPLES

Most samples do not require special storage. The exception is gas and vapor absorbent tubes (e.g., charcoal, silica gel and XAD-2), which should be refrigerated until shipment. Avoid contact with high temperatures and contamination from bulk samples. Consult with an analytical laboratory on proper packaging and shipping instructions.

METHODOLOGY

Air samples should be acquired through personal monitoring in the breathing or hearing zone of employees, outside of any PPE, thereby evaluating exposures without regard to the use of PPE. There may be a few situations where the industrial hygienist should measure the exposures inside of PPE (e.g., welding hood).

For all TWA exposures, personal samples should be taken for the entire duration of a shift to determine a representative exposure to employees. At minimum, samples taken must not be less than 75% of the shift worked and must be noted on sampling collection data. For example, if an employee works a total of eight hours, the sample taken must not be less than six hours to reflect a representative sample. Similarly, if an employee's works a 10-hour shift, samples taken must be at least 7.5 hours, and if an employee works a 12-hour shift, samples taken must be a minimum of 9 hours. The more samples taken during the shift, the more representative and accurate they are in measuring exposure.

In certain cases however, samples taken could be task-specific and may only require collecting samples for the specific task. Samples such as these are taken to determine potential exposures of hazardous substances to employees as well as informing the industrial hygienist on how to provide adequate protection of employees. Task-specific samples may also be adjusted to an eight-hour TWA to determine the concentrations and dosages employees receive on a daily basis.

Area measurements are often useful to range-find airborne concentrations or noise levels. Area samples are rarely representative of employee exposures and should not replace personal monitoring. The industrial hygienist should be cautious not to over-interpret area data. Airborne concentrations and noise levels will vary with time; variation will occur within days and between days. Short-term spot measurements may not be representative. Area samples are typically taken to determine the general exposure levels within the area sampled and the potential health effects of contaminants and hazards to employees.

Industrial hygiene samples should be collected and analyzed in accordance with regulatory standards and/or methods cited in a reliable source such as NIOSH, ACGIH and AIHA.

NOISE EXPOSURE EVALUATIONS

In addition to the requirement for baseline data acquired through personal noise dosimetry, noise exposures should also be evaluated through sound level meter measurements.

General area noise surveys should be conducted in all plant facilities and then updated periodically. Surveys should be documented in a layout map or detailed list of geographic measurement points. The value of area noise measurements will vary. In facilities with relatively constant noise levels and stationary employees, it may be possible to substitute sound-level meter measurements for personal dosimetry.

On the other hand, in many facilities, the noise levels vary hour to hour and day to day, so sound level meter measurements are of limited value. At a minimum, general area noise measurements should be used to establish jobs and tasks requiring noise dosimetry, and to designate the perimeter of areas requiring hearing protection.

PHYSICAL HAZARDS

As described above, noise is one of the most prevalent physical hazards in the workplace, but can also be accompanied by excessive levels of ionizing/ non-ionizing radiation, vibration, illumination and temperature.

ERGONOMIC HAZARDS

Ergonomic hazards can lead to musculoskeletal disorders (MSDs) such as strains or sprains, tunnel syndrome, tendinitis and more. Repetitive motion leads to a significant number of ergo-related injuries, but issues also arise from pushing-pulling tasks, lifting heavy objects, poor posture, eye strain, poorly designed job tasks or the use of improperly designed tools.

The Rapid Entire Body Assessment (REBA) is a useful screening tool that helps industrial hygienists evaluate the risk of MSDs associated with the specific tasks within a job. It outlines a procedure to assess bio-mechanical and postural loading on the body and can be used to assess any task.

See **Appendix D. Using the REBA Worksheet to Evaluate Ergonomic Hazards** for guidance on how to complete a REBA.

For additional information, visit www.humantech.com/2020/05/how-to-use-the-rapid-entire-body-assessment/.

INHALATION EXPOSURE MEASUREMENTS (CHEMICAL HAZARDS)

The type of sampling and method used is dependent on the type of chemical being measured. There is often more than one method for sampling, and local authorities may require use of specific methodologies for regulatory compliance. Common methods of sampling include the use of passive sampling badges or personal sampling vacuum pumps that draw air through a filter or sampling tube which collect the specific airborne contaminant. (See Figure 2.) Samples are collected at varying times based on the sampling objective (i.e. TWAs or STELs) and should be collected in the breathing zone of the representative worker. In the absence of a local regulation, refer to the Nike CLS.

The number of measurements required to accurately determine whether workers are overexposed depends on several variables, including:

- Number of workers exposed
- Type of exposure
- Statistical significance required

Note: Exposure assessments and sampling programs should be developed and carried out by qualified IH professionals.

DERMAL EXPOSURE ASSESSMENT

Conducting an assessment for dermal exposure is more difficult than for inhalation due to the lack of standardized sampling methods and interpretation guidelines. Estimating exposure from dermal contact is much more complex and requires information on:

- The concentration of the contaminant on the surface that comes into human contact.
- Time frame of the exposure (contact frequency and duration).
- Other factors that affect dermal exposure — for example, skin surface area, adherence to the skin, film thickness of liquids on skin, and/or transfer efficiency.

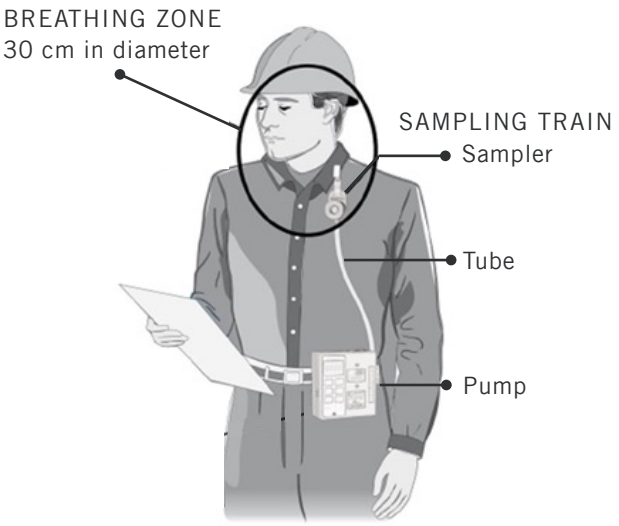
Determining potential skin exposure can be performed through direct (skin sampling) or indirect (e.g., surface sampling) methods. Dermal exposures may also be indirectly estimated using biological monitoring (e.g., blood or urine measurements). Direct methods may include the use of dermal dosimeters (e.g. patches), whole body suits, skin washes and wipes, and video detection of fluorescent tracers. Wipe samples of surfaces may be useful where skin absorption data is available.

Note that OSHA does not have standards specifying surface contamination limits, but some standards do have provisions for control of surface contamination hazards. However, recently the ACGIH has published surface TLVs for the purpose of exposure assessment.

Figure 2.

EQUIPMENT FOR SAMPLING INHALATION EXPOSURE

This image is widely used and reproduced in the field of Industrial Hygiene.



CONTROL

HIERARCHY OF CONTROLS

The Hierarchy of Controls, shown in Figure 3, is a structured process that helps identify the most effective means of controlling hazards.

Health hazard controls are the measures employed to abate Unacceptable exposures. Health hazard controls include elimination of the hazard, material substitution, engineering controls, work-practice controls, administrative controls and PPE.

Moving down the hierarchy, the controls become less reliable and effective at protecting workers. While not all hazards can be eliminated, it is important to evaluate control options at each level and only proceed down the hierarchy when no or only partially effective methods are available in the previous level.

PRIORITIZATION

Upon completing occupational exposure assessments, management must quickly turn to controlling any unacceptable exposures identified. In most workplaces, problems compete for resources, and it is frequently necessary to prioritize health hazard controls based on SEGs.

Once prioritized, the most effective control strategy must be determined for each Unacceptable exposure. The control strategies, or plans for each Unacceptable exposure, are then consolidated into a general health hazard control plan for the workplace. Following implementation, the performance of health hazard controls should be verified through equipment testing and re-assessment of workplace exposures to the environmental agents.

The following factors should be considered in the prioritization:

- Magnitude of exposure
- Variability of exposure
- Frequency of exposure
- Number of workers exposed
- Reliability of existing controls
- Confidence in health effects information and OELs
- Evidence of adverse health effects

HEALTH HAZARD CONTROL STRATEGIES

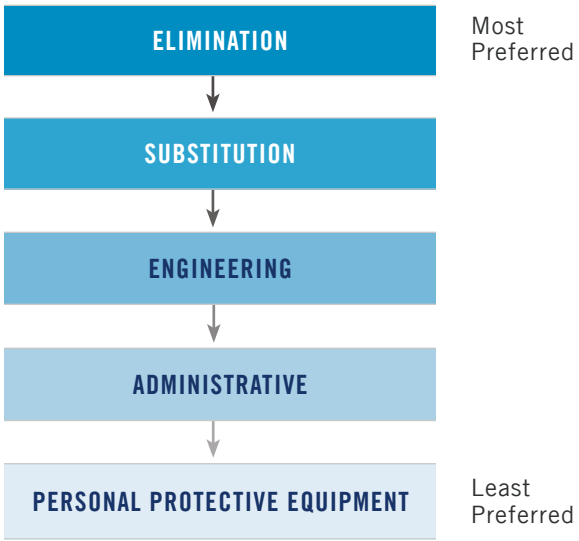
PPE must be employed for the immediate control of Unacceptable exposures. Then the following hierarchy is applied to the development of permanent exposure control strategies:

- **Elimination** of the process, equipment or materials giving rise to the exposure.
- **Substitution** with a less hazardous process, equipment or material.
- **Engineering** controls; for example, process modification, enclosure, exhaust ventilation, shielding, damping, etc.
- **Administrative** controls such as work practices and employee training.
- **PPE** — properly selected, fitted and used.

Figure 3.

HIERARCHY OF CONTROLS

Moving down the hierarchy, the effectiveness and reliability of health hazard controls decrease.



ENGINEERING CONTROLS

Elimination, substitution and/or engineering controls are required to the greatest extent feasible. Feasibility assessments are required, and they should consider:

- The magnitude of the health risk (exposure level, health effects, frequency of exposure, the number of employees at risk, etc.).
- The technical and economic feasibility of various control options.
- The reliability of the control options, employee acceptance, consequences of control failure, maintenance requirements, maintenance employee exposures, contract employee exposures, and any safety concerns introduced by the control options.

Feasible engineering control implementation plans should be established and adopted by management. Engineering control feasibility assessments and implementation plans should be documented. These plans should address health hazard abatement priorities and implementation schedules.

The effectiveness of newly installed engineering controls should be verified through a reassessment of employee exposures and/or other techniques (e.g., performance testing). Initial and periodic testing of engineering controls should be performed where the performance of engineering controls can decline or fail. Performance testing of engineering controls should be documented.

ADMINISTRATIVE CONTROLS

Safe job procedures should be established where prescribed work practices are needed to ensure adequate control of exposures. Safe job procedures should be documented.

Emergency plans should be established to help ensure an effective response to an accidental release of a hazardous material (e.g., corrosive gas, radioactive material, etc.). Emergency plans should be documented.

The effectiveness of newly adopted work practice controls should be verified through a re-assessment of employee exposures and/or other techniques (e.g., job observations, inspections, etc.).

PERSONAL PROTECTIVE EQUIPMENT

PPE rules should be established, and PPE should be selected to reduce effective exposures below OELs.

EXPOSURE REASSESSMENTS

Workplace exposure should be reassessed in a number of circumstances. Reassessments should be comprehensive, starting with information-gathering and working through to decisions and reports.

- Whenever there is a significant change in the process, equipment, material, jobs, tasks or work practices.
- Whenever there are changes in the identity, quantity and physical characteristics of environmental agents.
- Whenever new and significant information becomes available on the health effects or toxicity of a material, or when a change occurs in the OEL for an environmental agent. For example, a change in the OEL may affect the exposure assessment, where an exposure previously deemed Acceptable may now be Unacceptable.
- Whenever there are significant changes in the workforce:
  - **Reorganization of the workforce** can affect the designation of SEGs.
  - **New hires** may experience significantly greater exposures than more experienced workers in operations where exposure levels are largely affected by work practices.
  - **Redistribution of tasks** can significantly change average exposure levels.
  - **Changes in work schedules** may affect the OEL and/or average exposure level. For example, a change from a conventional eight-hour per day work schedule to 12-hour work shifts may lead the hygienist to employ a more conservative OEL, and the more conservative OEL may change the exposure assessment.
- If workers voice complaints or there is evidence of occupational illness or disease.

Note: Industrial hygienists must work closely with the site's medical organization — not only to provide medical staff with insight into workplace exposures but also to learn in a timely and effective fashion about worker complaints and concerns regarding exposure to the site's chemical, physical and biological agents.

FREQUENCY OF REASSESSMENTS

Qualitative reassessments should be performed periodically. A typical default frequency is an annual re-assessment of each workplace. Some sites may require less frequent reassessment and others more frequent reassessment. The amount of change occurring in the workplace is a good guideline; certainly, a workplace with frequent changes in processes, job classifications and environmental agents should be reassessed more frequently.

A designated reassessment interval is not necessary if through administrative and communication channels the industrial hygienist is effectively apprised of changes in the workplace, workforce or environmental agents. In this way, exposure assessments can be reevaluated on an as-needed basis. For example, management systems can be established to assure that the industrial hygienist is aware of changes in the workplace that may affect exposure assessments. The industrial hygienist can keep abreast of changes through review of production, engineering, construction or maintenance work orders and formal health and safety reviews of new projects.

PERIODIC MONITORING

Periodic monitoring is a continuing sampling program. One objective is to determine if changes in exposure levels could put employees at risk. Another objective is to build a historical database that hopefully demonstrates employees have not been overexposed.

In the absence of observable and significant changes in exposure levels, a periodic monitoring schedule should be established in accordance to good IH practice.

The recommended periodic sampling frequency for noise exposures is 18 months, per the Nike CLS.

A sampling schedule should be composed and updated at least annually in order to meet the minimum requirements for periodic monitoring.

Periodic IH monitoring is not necessary if all exposure values are less than 30% of the OEL for air contaminants or 50% of the OEL for noise.

PERIODICITY

The sampling frequency is influenced by:

- Exposure level, the geometric mean (GM) of the baseline relative to the OEL.
- Toxicity (health effects)

EXPOSURE LEVEL

Baselines represented by GMs less than 50% of the OEL and greater than 100% of the OEL are assigned a low sampling frequency (two to three years).

Baselines represented by GMs at or above 50% of the OEL, but less than or equal to the OEL, may be the greatest concern. Employees are generally unprotected, and exposures may slowly rise to exceed permissible limits. A higher sampling frequency is therefore assigned.

TOXICITY

The higher the toxicity, the more frequently exposures should be checked. Two toxicity classifications can be established, “high” and “low.” Materials classified as high toxicity include but are not limited to mutagens, carcinogens, teratogens, chemicals that affect the nervous system and chemicals exhibiting serious chronic health effects or organ system damage.

The periodic sampling frequencies are time intervals; the minimum number of samples can be collected at any time during the interval. At least two randomly selected dates should be planned. Random sampling is necessary to minimize bias in the database. Autocorrelation and a distorted database can occur if samples are collected at the same time each year; for example, if periodic surveillance samples are collected each summer, the values may underestimate the long-term average exposure due to increased ventilation and lower exposure levels than may present in winter months.

MAINTAINING BASELINES

Once workplace exposures are controlled to an acceptable level, some analysis of the trend of exposures over time may be appropriate. This time trend may be reviewed periodically to assure that control is being maintained. Such review may allow early detection of problems.

The data from each periodic survey should be pooled with the existing baseline data to form a new baseline. The effect of a slow increase or decrease in exposure levels will be diminished by pooling the most recent sampling campaign data with the previous (periodic and baseline) data. The industrial hygienist should be alert to such trends and establish a new baseline when there has been a significant change in exposure levels.

CONTINUOUS MONITORING

Consideration should be given to employing continuous monitoring instrumentation and alarms in work areas where a significant potential exists for exposure to a toxic gas from combustion or chemical processes. For example, carbon monoxide monitors should be positioned around inert gas generators. Continuous monitoring instrumentation is advisable in operations utilizing toxic compressed gases with poor warning properties.

DATA RECORDING & RETENTION

CALIBRATION RECORDS

The preferred method of maintaining calibration records would be in bound notebooks with numbered pages. This type of documentation provides an audit trail of instrument performance. Alternatively, calibration records could be maintained electronically. However, electronic storage lacks the audit trail associated with hard copy. For confined space entries, calibration information could be maintained on the entry permits.

While additional information may be appropriate for some instrumentation, the following should be recorded as a minimum:

- Instrument identification number/serial number.
- Date of calibration.
- Time of calibration (to distinguish pre- and post-use calibrations).
- Calibration results.
- Problems and/or errors and their resolution.
- Signature of person performing calibration.

For instruments that require factory calibration, the instrument number/serial number, date of calibration and any certificate of calibration should be maintained. Replacement dates for electrochemical sensors should also be documented

The performance of each instrument or pump can also be tracked over time, either electronically or in notebooks. This simplifies the identification of performance problems and helps schedule maintenance and repairs.

INDUSTRIAL HYGIENE RECORDS MANAGEMENT

Generally, IH records are considered personnel records and are managed in accordance with the site policy for such data. Site policies for personnel records may reflect law.

IH records and medical records should be maintained in separate files. Exposure records include exposure assessment data, exposure measurement data including biological monitoring data (e.g., blood lead, urine fluoride, etc.) collected specifically to assess the magnitude of employee exposure to an environmental agent.

IH records should be maintained indefinitely.

INDUSTRIAL HYGIENE SKILLS MATURITY MATRIX

The Industrial Hygiene Skills Maturity Matrix provides a framework to help facilities develop capabilities for assessing IH hazards in the workplace. This is not at exhaustive list of resources, and others should be consulted based on the practice adopted and experience levels of those responsible for implementation.

LEVEL	1	2	3	4
KNOWLEDGE	**INDUSTRIAL HYGIENE AWARENESS**	**BASIC PRINCIPLES OF INDUSTRIAL HYGIENE**	**COURSES BASED ON SPECIFIC INDUSTRIAL HYGIENE RISKS** **Risk-based**	**ACADEMIC DEGREE IN INDUSTRIAL HYGIENE AT THE BACHELOR'S LEVEL** **Risk-based**
SKILLS	FUNDAMENTALS OF INDUSTRIAL HYGIENE Course provides non-technical individuals with a high-level overview of Industrial Hygiene (IH) to clarify how the discipline impacts the business. https://phylmar.learningcart.com/products/Fundamentals-of-Industrial-Hygiene.aspx Discount Code: Nike4321	OHTA W201 BASIC PRINCIPLES OF OCCUPATIONAL HYGIENE Technical professionals attend this online course to acquire the foundational practices of IH to begin building their programs internally. https://www.aiha.org/education/elearning/online-courses/basic-principles-of-occupational-hygiene	OHTA W501–507 NOISE; ASBESTOS; HAZARDOUS SUBSTANCES—Measure, Control, Effects; ERGONOMICS; THERMAL Courses provide technical professionals and IH leaders who oversee programs with risk-specific training to manage applicable programs within their facilities. https://www.ohtatraining.org/training-resources/courses	Ensures IH program leaders have an educational background in IH to oversee programs at multiple facilities — in addition to developing IH strategy, managing technical staff or third parties, tracking metrics and adjusting the IH program as needed.
TARGET AUDIENCE	Managers, supervisors, employees, nurses, practitioners of Occupational Medicine	IH-responsible technicians	IH-responsible practitioners	Multi-site IH leaders
PERFORMANCE	 25% — In training "I can talk about IH."	 50% "I can perform IH with help."	 75% "I can perform IH independently."	 100% "I can teach IH to others."

RISK-BASED

Note that the levels of knowledge, skills and training implemented at a facility is based on the risk of the IH hazards present. Complex facilities with chemical, physical and biological hazards present, such as material vendors, need Level-3 capabilities at a minimum. Manufacturers of finished-goods need to assess their hazards, but at a minimum have a Level-2 resource.

CONTACTS

NIKE INDUSTRIAL HYGIENE RESOURCES

Please reach out to the team with questions regarding the Nike Industrial Hygiene Playbook or for assistance with other IH-related issues.

CONTACTS

All IH-related questions	IHSupport@nike.com
Christopher Hicks	Nike Responsible Supply Chain
Sittichoke Huckuntod	Nike Responsible Supply Chain
Khawar Khan	Nike Innovation / Resilience

APPENDICES

APPENDIX A. ACRONYMS & DEFINITIONS

Code of Conduct (CoC)
Code Leadership Standards (CLSs)
The Nike Code of Conduct and Code Leadership Standards lay out the minimum standards we expect each supplier facility to meet. Nike expects all suppliers to share our commitment to the welfare of workers and to use natural resources responsibly and efficiently. These minimum standards are integral to Nike's supplier strategies — how Nike evaluates baseline performance and determines which suppliers Nike will continue to engage with to grow our business.

To access Nike's CoC and CLSs, please refer to https://purpose.nike.com/code-of-conduct.

control banding (CB)
A technique used to guide the assessment and management of workplace risks (for example, dilution ventilation, engineering controls, containment, etc.) based on a range or "band" of hazards (such as skin/eye irritant, very toxic, carcinogenic, etc.) and exposures (small, medium, large).

Environment, Health and Safety (EHS)
Based on regulatory compliance and industry best practices, EHS is the organization within a facility responsible for policies and programs that protect the health and safety of employees, the public and the environment from workplace hazards.

geometric mean (GM)
The central number in a geometric progression, calculable as the "n^{th}" root of a product of "n" numbers.

Industrial Hygiene (IH)
The art and science of anticipating, recognizing, evaluating and controlling biological, chemical or physical hazards within the workplace. Also known as "Occupational Hygiene" outside the United States.

maximum allowable concentration (MAC)
Limit or "ceiling" of the concentration of a chemical or level of hazard that should not be exceeded for any given period of time.

musculoskeletal disorders (MSDs)
Injuries or pain in the joints, ligaments, muscles, nerves, tendons and structures that support a person's limbs, neck and back.

occupational exposure limit (OEL)
The maximum concentration of a substance or level of hazard to which a worker may be exposed to over a given period of time. Chemical or other hazards (e.g., noise) may have more than one OEL for different "averaging" or exposure times. OELs may be generated by government agencies or other consensus groups.

Examples of available OELs include:

- **OSHA permissible exposure limits (PELs)**
  Legally enforceable limits issued by the U.S. Occupational Safety and Health Administration (OSHA).
- **ACGIH threshold limit values (TLVs)®**
  Limits issued by the American Conference of Governmental Industrial Hygienists (ACGIH).
- **NIOSH recommended exposure limits (RELs)**
  Limits recommended by the National Institute for Occupational Safety and Health (NIOSH).

personal protective equipment (PPE)
Gear worn to minimize exposure to hazards that cause serious workplace injuries.

Rapid Entire Body Assessment (REBA)
A screening tool that helps industrial hygienists evaluate the risk of MSDs associated with the specific tasks within a job.

safety data sheet (SDS)
A document, typically provided by the manufacturer, that summarizes the hazards of a product and provides guidance on appropriate safety precautions.

short-term exposure limit (STEL)
Limit for the average exposure over a shorter period of time, typically 15 minutes. These limits often apply to substances that produce acute (or fast-acting) effects on the human body. Many organic solvents have both STEL and TWA exposure limits.

similar exposure group (SEG)
One or more individuals who perform similar work and can be expected to have similar exposures over time.

time-weighted average (TWA)
Limit for the average exposure over a specified period, typically eight (8) hours, which represents a standard work shift.

APPENDIX B. HANDLING TREATED FABRICS USING THE PRINCIPLES OF INDUSTRIAL HYGIENE

ANTICIPATION, RECOGNITION, EVALUATION & CONTROL

Source for case study content: https://www.hse.gov.uk/textiles/fabric-finishes.htm

HANDLING TREATED FABRICS

Fabrics are often treated with various chemical finishes to give or enhance specific properties; for example, crease-resistance, fire-resistance and anti-static properties. In the case study, workers sometimes develop health problems when handling and using fabrics treated in this way — the most common being skin disorders and respiratory tract irritation.

HEALTH PROBLEMS

Workers handling fabrics or exposed to dust from machining, sewing and cutting processes/operations are at risk of skin irritation. Some workers in the case study have also developed eye, nose and throat irritation. In a very small number of cases, sensitization to specific chemicals occurs. The effects recorded are probably due to skin abrasion, the effects of irritant chemicals, and/or a combination of both abrasive and chemical effects.

Skin abrasion is caused by fabrics that are rough to handle. This roughness could be due to the nature of the fibers used in the fabric, by chemical treatments or by the singeing of fabrics that contain synthetic fibers (this can make fiber ends brittle). The most common irritant chemical implicated is formaldehyde, but other chemicals and dyestuffs have also caused problems.

Many fire-resistant and crease-resistant formulations are based on urea-formaldehyde resins. Unreacted formaldehyde present in these resins may be carried in the dust created by machining or may be released from the treated textile in gaseous form. Skin abrasion removes some of its natural resistance and permits such free formaldehyde or other irritant chemicals to cause chemical irritation. Gaseous formaldehyde can cause eye, nose and throat irritation in some people at comparatively low concentrations.

WORKPLACE EXPOSURE LIMIT

The current workplace exposure limit (WEL) for formaldehyde is two parts per million (2ppm), time-weighted average (TWA) over eight hours. A worker's exposure to formaldehyde should not exceed this WEL but the exposure should be as low as is reasonably practicable and, in any case, below the WEL.

ANTICIPATION

- New chemical review process
- New equipment reviews
- Lessons learned
- Chemical inventory
- Industry data

CASE STUDY EXAMPLE

Given the various chemicals being used, one can anticipate potential Industrial Hygiene (IH) hazards by applying training and knowledge about the chemicals and their constituents, how they will be used and worker interface with during use. Investigate the parameters of exposure (worker interface, methods of use, and what chemicals are used when). Understand the toxicological effects each chemical may pose on an exposed individual and what constitutes an overexposure (OELs used for reference).

RECOGNITION

- Begin review of safety data sheets (SDSs) for each chemical and highlight constituents based on their toxicity (acute vs. chronic), routes of exposure and health effects.
- Review job standard operating procedures (SOPs).
- Interview employees about their job tasks.
- Become familiar with the processes and the layout of the facility.
- Review injury/illness database.

CASE STUDY EXAMPLE

Based on the information provided, one of the constituents of concern is formaldehyde. Review the health effects associated with exposure, in addition to gathering information on what processes involve the chemical and how might workers be exposed. Review the history of illnesses to see if any documented cases could have been attributed to formaldehyde exposure and, if so, review the task(s) being performed during that time.

EVALUATION

- Accounting for the information collected during the "Recognition" phase, perform a qualitative exposure assessment (QEA) to determine which exposures are "Uncertain" or "Unacceptable."
  - Utilize data collected and professional judgment
- Formulate a sampling plan to collect quantitative exposure data.
  - Determine analytical methods.
  - Determine sampling equipment needs.
- Compare results vs. OELs to determine true exposure.
- Document findings and communicate to key stakeholders.

CASE STUDY EXAMPLE

Based on the information provided in the case study, the exposure to formaldehyde is "Uncertain." Begin constructing your quantitative sampling plan to assess true exposure. The analytical method selected is National Institute for Occupational Safety and Health (NIOSH) 2541 (see page 3 for specifics and sampling equipment needed). Discuss NIOSH 2541 with your accredited laboratory to ensure they can run the analysis; if not, ask them to specify an equivalent analysis. If these options are not available, seek another lab.

Based on Uncertainty, three Personal Breathing Zone samples (dependent on your organization's IH practice) will be collected and assessed according to the OEL adopted and the internal IH practice of the organization. Communicate the findings from your sampling campaign to the key stakeholders and arrive at the decision of if this exposure in Acceptable or Unacceptable.

CONTROL

Referencing the Hierarchy of Controls (Figure 3 in the Nike Industrial Hygiene Playbook), determine which control is best suited for the application and is both feasible and sustainable in protecting workers' health.

- Elimination
- Substitution
- Engineering
- Administrative
- Personal protective equipment

CASE STUDY EXAMPLE

Based on the sampling results for formaldehyde, decide if controls are warranted; if so, assess which controls are currently in place and the effectiveness, in addition to which new controls may be feasible (adhering to the Hierarchy of Controls).

If the exposure is Acceptable, then no further controls may be needed, but a reassessment of the exposure should be scheduled in accordance to your IH program.

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH) 2541 TEST METHOD FOR FORMALDEHYDE

FORMALDEHYDE by GC 2541

$H_2C=0$ MW: 30.03 CAS: 50-00-0 RTECS: LP8925000

METHOD: 2541, Issue 2 **EVALUATION: PARTIAL** **Issue 1: 15 May 1989**
Issue 2: 15 August 1994

OSHA : 0.75 ppm; 2 ppm STEL
NIOSH: 0.016 ppm; C 0.1 ppm; carcinogen
ACGIH: C 0.3 ppm; suspected human carcinogen
(1 ppm = 1.23 mg/m^3 @ NTP)

PROPERTIES: gas; vapor density 1.067 (air = 1); BP 19.5 °C; explosive range 7 to 73% v/v in air

SYNONYMS: methanal; formalin (aqueous 30 to 60% w/v HCHO); methylene oxide

SAMPLING

SAMPLER:	SOLID SORBENT TUBE (10% (2-hydroxymethyl)piperdine on XAD-2, 120 mg/60 mg
FLOW RATE:	0.01 to 0.10 L/min
VOL-MIN:	1 @ 3 ppm
-MAX:	36 L
SHIPMENT:	routine
SAMPLE STABILITY:	3 weeks @ 25 °C [1]
FIELD BLANKS:	2 to 10 field blanks per set
MEDIA BLANKS:	10 per sample set

ACCURACY

RANGE STUDIED:	not determined
BIAS:	not determined
OVERALL PRECISION ($\hat{S}_{rT}$):	not determined
ACCURACY:	not determined

MEASUREMENT

TECHNIQUE:	GAS CHROMATOGRAPHY, FID
ANALYTE:	oxazolidine derivative of formaldehyde
DESORPTION:	1 mL toluene; 60 min ultrasonic
INJECTION VOLUME:	1 µL splitless; split vent time 30 sec
TEMPERATURE-INJECTOR:	250 °C
-DETECTOR:	300 °C
-COLUMN:	70 °C for 1 min; 15 °C/min; hold @ 240 °C for 10 min
CARRIER GAS:	He, 1 to 2 mL/min: makeup flow 29 mL/min
COLUMN:	capillary, 30 m x 0.32-mm ID, 0.5-µm film, DB-Wax or equivalent
CALIBRATION:	formalin solution spiked on sorbent
RANGE:	3 to 200 µg per sample [2,3]
ESTIMATED LOD:	1 µg per sample [2]
PRECISION ($\hat{S}_r$):	0.0052 @ 38 to 194 µg per sample [2]

APPLICABILITY: The working range is 0.24 to 16 ppm (0.3 to 20 mg/m^3) for a 10-L air sample. The method is suitable for the simultaneous determinations of acrolein and formaldehyde.

INTERFERENCES: None have been observed. Acid mists may inactivate the sorbent leading to inefficient collection of formaldehyde. A 15 m x 0.32-mm ID DB-1301 fused silica capillary column can also be used. This column will also separate the acetaldehyde and acrolein oxazolidines. A nitrogen-specific detector (NPD) can be used for improved sensitivity.

OTHER METHODS: OSHA Method 52 is similar but uses slightly larger sampling tubes [2]. This method has improved sample stability and ease of personal sampling compared to NIOSH Methods 2502 (which has been withdrawn), 3500 and 3501. However, Method 3500 (chromotropic acid) is the most sensitive.

NIOSH Manual of Analytical Methods (NMAM), Fourth Edition, 8/15/94

REAGENTS:

1. Toluene, chromatographic quality.
2. 2-(Hydroxymethyl)piperidine (2-HMP). Recrystallize several times from isooctane until there is one major peak (>95% of area) by GC analysis. Store in desiccator.
3. Formalin solution, 37%*.
4. Formaldehyde* stock solution, 1 mg/mL (see Appendix A).
5. Sulfuric acid, 0.02 N.
6. Sodium hydroxide, 0.01 N.
7. Sodium sulfite (Na_2SO_3), 1.13 M. Prepare fresh immediately before use.
8. Water, deionized, distilled
9. Hydrogen, prepurified.
10. Air, filtered.
11. Helium, purified
12. Magnesium sulfate.

* See SPECIAL PRECAUTIONS

EQUIPMENT:

1. Sampler: glass tube, 10 cm long, 6-mm OD, 4-mm ID, with flame-sealed ends and plastic caps, containing two sections of 2-(hydroxymethyl) piperidine-coated XAD-2 (see APPENDIX B) (front = 120 mg; back = 60 mg) retained and separated by small plugs of silanized glass wool. Pressure drop across the tube at 0.10 L/min airflow must be less than 760 kPa (5.7 mm Hg). Tubes are commercially available (Supelco ORBO-23; SKC 226-118; or equivalent).
2. Personal sampling pump, 0.01 to 0.10 L/min, with flexible connecting tubing.
3. Gas chromatograph, flame ionization detector, integrator and column (page 2541-1).
4. Ultrasonic water bath.
5. Vials, glass, 2-mL, with PTFE-lined crimp caps.
6. Flasks, volumetric, 10-, 25-, and 50-mL.
7. Pipets, volumetric, 1-, 2-, and 10-mL with pipet bulb.
8. Syringes, 10-mL (readable to 0.1 mL), 25-, and 50-mL.
9. File.
10. Beakers, 50-mL.
11. pH meter.
12. Magnetic stirrer.
13. Burets, 50-mL.
14. Flasks, round-bottomed, 100-mL.
15. Soxhlet extraction apparatus.
16. Vacuum oven.
17. Distillation apparatus.

SPECIAL PRECAUTIONS: Formaldehyde is viewed as a potential occupational carcinogen [4,5].

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Break ends of the sampler immediately before sampling. Attach sampler to personal sampling pump with flexible tubing.
3. Sample at an accurately known flow rate between 0.01 and 0.10 L/min for a total sample size of 1 to 36 L.
   NOTE: Formaldehyde reacts with 2-(hydroxymethyl)piperidine on the sorbent bed during sampling. Sampling rate is limited by the speed of this reaction. Sampling above 0.10 L/min may cause appreciable breakthrough owing to incomplete reaction, possibly invalidating the sample. Further discussion of this reaction is included in Ref. [6].
4. Cap the samplers and pack securely for shipment.

SAMPLE PREPARATION:

5. Score each sampler with a file in front of the first sorbent section.
6. Break sampler at score line. Remove and place front glass wool plug and front sorbent section

in a vial.

7. Transfer back section with remaining glass wool plugs to a second vial.
8. Add 1.0 mL toluene to each vial. Crimp cap tightly onto each vial.
   NOTE: An appropriate internal standard, such as 1 µL/mL dimethylformamide, may be added at this point [3].
9. Agitate vials in an ultrasonic water bath for 60 min.

CALIBRATION AND QUALITY CONTROL:

10. Calibrate daily with at least six working standards, in duplicate, covering the range of interest.
    a. Weigh ten 120-mg portions of the coated sorbent into 4-mL vials with septum caps. If the bulk coated sorbent is not available, remove the front section from ten unused samplers (media blanks).
    b. Inject aliquots of formaldehyde stock solution into the vials at six different levels and allow to sit overnight at room temperature. Use serial dilutions of the calibration stock solutions to spike the absorbent in the range of interest.
    c. Desorb (steps 7 through 9) and analyze (steps 12 and 13) with samples and blanks.
    d. Prepare calibration graph (peak area or peak height) vs. µg of formaldehyde.
11. Analyze three quality control blind spikes and three analyst spikes to ensure that the calibration graph is in control.

MEASUREMENT:

12. Set gas chromatograph to manufacturer's recommendations and to conditions given on page 2541-1. Inject 1-µL sample aliquot.
    NOTE: If the amount of oxazolidine in the aliquot exceeds the capacity of the column, dilute the sample with toluene, reanalyze, and apply the appropriate correction factor in calculations.
13. Measure peak area or peak height. For formaldehyde derivative t_r = 6.4 min and for 2-(hydroxymethyl)piperidine t_r = 9.4 min under these conditions.
    NOTE: If necessary, verify the identity of the formaldehyde oxazolidine by comparison of retention time with an authentic sample (see APPENDIX C).

CALCULATIONS:

14. Determine the mass, µg (corrected for DE) of oxazolidine derivative found in the sample front (W_f) and back (W_b) sorbent sections from the calibration graph.
    NOTE: if $W_b > W_f/10$, report breakthrough and possible sample loss.
15. Calculate concentration, C (mg/m ^{3}), of formaldehyde in the air volume sampled, V (L):

$$C = \frac{(W_f + W_b)}{V}, \text{ mg/m}^3.$$

NOTE: Because the working standards are prepared on media blanks, no additional blank correction is necessary. Report field blanks as samples.

EVALUATION OF METHOD:

This method is similar to OSHA Method 52 [2]; however, the OSHA samplers contained 20% more coated sorbent than the samplers used in this method. In a study by OSHA, 5% breakthrough occurred after 396 min at a flow rate of 0.1 L/min and a test atmosphere concentration of 5.3 mg/m ^{3}. The relative

humidity in the study was 49% at 24 °C. A storage study was done by NIOSH/MRSB [1] by spiking samplers at two concentrations, 10.0 and 61.0 µg/sample [1]. Three spikes at each concentration were stored at different temperatures for seven days. The storage conditions were as follows:

Sample set no.	Storage temp.	Storage time
1	20 °C	7 days
2 (a)	20 ° and 40 ° C	1 day
(b)	20 ° C	6 days
3	4 ° C (refrigeration)	7 days

The recovery of formaldehyde was essentially 100% for all of the storage temperatures.

REFERENCES:

[1] Williams, K. J. Methods Development Efforts, NIOSH/MRSB, (NIOSH, Unpublished, 1989).

[2] "OSHA Analytical Methods Manual, method #52", U. S. Department of Labor, Occupational Safety and Health Administration, OSHA Analytical Laboratory, Salt Lake City, UT, March, 1985.

[3] User Check, DataChem Inc., NIOSH Seq. #6701-J (unpublished, June 1, 1989).

[4] NIOSH testimony on the OSHA Proposed Rules on Air Contaminants, Docket #H-020, August 1, 1988.

[5] NIOSH/OSHA Occupational Health Guidelines for Occupational Hazards, U. S. Department of Health and Human Services, Publ. (NIOSH) 81-123 (1981), available as GPO Stock #017-033-00337-8 from Superintendent of Documents, Washington, DC 20402.

[6] Kennedy, E.R., Ashley, K. Appl. Spectrosc., 46, 266-272 (1992).

METHOD WRITTEN BY:

Eugene R. Kennedy, Ph.D., and Karen J. Williams, NIOSH/DPSE.

APPENDIX A: PREPARATION AND STANDARDIZATION OF FORMALDEHYDE STOCK SOLUTION (ca. 1 mg/mL)

Dilute 2.7 mL 37% aqueous formalin solution to 1 L with distilled, deionized water. This solution is stable for at least three months. Standardize by placing 5.0 mL of freshly prepared 1.13 M sodium sulfite solution in a 50-mL beaker and stir magnetically. Adjust pH to between 8.5 and 10 with base or acid. Record the pH. Add 10.0 mL formaldehyde stock solution. The pH should now be greater than 11. Titrate the solution back to its original pH with 0.02 N sulfuric acid (1 mL acid = 0.600 mg HCHO; about 17 mL acid needed). If the endpoint pH is overrun, back-titrate to the endpoint with 0.01 N sodium hydroxide. Calculate the concentration, C_s (mg/mL), of the formaldehyde stock solution:

$$C_s = \frac{30.0\ (N_a \cdot V_a - N_b \cdot V_b)}{V_s}.$$

where 30.0 = 30.0 g/equivalent of formaldehyde
N_a = normality of sulfuric acid (0.02 N)
V_a = volume of sulfuric acid (mL) used for titration
N_b = normality of NaOH (0.01 N)
V_b = volume of NaOH (mL) used for back-titration
V_s = volume of formaldehyde stock solution (10.0 mL)

APPENDIX B: SORBENT PREPARATION (optional if commercially-prepared tubes are used)

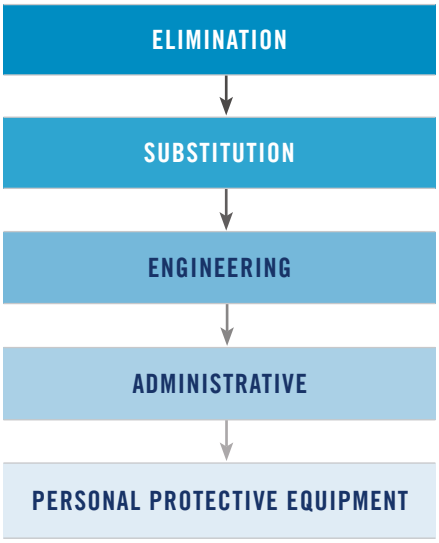
Extract 4 h in Soxhlet with 50/50 (v/v) acetone/methylene chloride. Replace with fresh solvent and repeat. Vacuum dry overnight. Add 1 g purified 2-(hydroxymethyl)piperidine in 50 mL toluene for each 9 g extracted XAD-2 sorbent. Allow this mixture to stand 1 h with occasional swirling. Remove the solvent by rotary evaporation at 37 °C and dry at 130 kPa (1 mm Hg) at ambient temperature for ca. 1 h. To determine the amount of background for each batch, desorb several 120-mg portions of the coated sorbent with toluene and analyze (steps 12 and 13). No blank peak is expected for any aldehydes other than formaldehyde and possibly acetaldehyde.

APPENDIX C: SYNTHESIS OF FORMALDEHYDE OXAZOLIDINE

Place a solution of purified 2-(hydroxymethyl)piperidine (0.57 g, 5 mmol) in 10 mL of toluene in a 50-mL round-bottomed flask. Use several 2-mL portions of toluene to rinse residual 2-(hydroxymethyl) piperidine from the container used for weighing. Add magnesium sulfate (2.5 g) to the round-bottomed flask to dry the aldehyde solution as it is added and to remove the water which forms during the reaction. Add a solution of 1 mL 37% aqueous formaldehyde in 10 mL toluene to the 2-(hydroxymethyl)piperidine solution dropwise with stirring over 1 h. Stir the solution overnight, then filter to remove the magnesium sulfate. Remove the toluene from the solution at reduced pressure by rotary evaporation.

HIERARCHY OF CONTROLS

Moving down the hierarchy, the effectiveness and reliability of health hazard controls decrease.



Most Preferred

Least Preferred

- **Elimination** of the process, equipment or materials giving rise to the exposure.
- **Substitution** with a less hazardous process, equipment or material.
- **Engineering** controls; for example, process modification, enclosure, exhaust ventilation, shielding, damping, etc.
- **Administrative** controls such as work practices and employee training.
- **Personal protective equipment** — properly selected, fitted and used.

APPENDIX C. USING NIKE'S INDUSTRIAL HYGIENE FRAMEWORK TO DEVELOP A NEW MATERIAL

CASE STUDY

Nike is developing a new material that uses a yarn-coating technology typically found in another industry. To determine if a potential hazard poses a risk to health in the production or use of this material, the project team asks and answers a sequence of questions, as outlined in Tables 1 through 6.

ANTICIPATE & RECOGNIZE QUESTIONS

Table 1.

PRIMARY QUESTIONS FOR ANTICIPATING & RECOGNIZING RISKS TO HEALTH & SAFETY

	PRIMARY QUESTIONS	ANSWERS	SOURCES OF INFORMATION	ACTIONS
1	Are the materials used potentially hazardous? Are there chemistries of concern?	YES	Review of safety data sheets (SDSs) for components indicates the presence of a "sensitizer."	Move to secondary questions 3 and 4 in Table 2.
2	Does the process require heating or combustion of raw materials — such as laser cutting, singeing, melting, etc.?	YES	Review of the process flow indicates that the materials are heated in a heat press.	Move to secondary questions 3 and 4 in Table 2.
3	Do the materials have the potential to come into physical contact with persons during use?	YES	Review of the process flow indicates that the materials must be handled to place them in the heat press.	Move to secondary questions 1 and 2 in Table 2.
4	Does this process use or produce a water-mix fluid?	NO	Review of the mixing process does not indicate the use of water.	Move to secondary question 5 in Table 2.
5	Are the materials potentially contaminated with infectious or other harmful biological agents?	NO	Review of the process does not indicate the possibility of contamination.	Conduct or provide specifications for biological agent risk assessment.

Table 2.

SECONDARY QUESTIONS FOR ANTICIPATING & RECOGNIZING RISKS TO HEALTH & SAFETY

	SECONDARY QUESTIONS	ACTIONS
1	Are the materials known to be absorbed through skin or skin sensitizers?	Conduct or provide specifications for dermal exposure risk assessment.
2	Do the materials have hazardous physical properties (e.g. cryogenic liquids, high heat, strong acids/bases)?	Conduct or provide specifications for dermal exposure risk assessment.
3	Are the chemistries expected to be present in gas/vapor form at any operating temperatures?	Move to additional questions 1, 2 and 3 in Table 3.
4	Does the process have the potential to generate particulate?	Move to additional questions 1, 2 and 4 in Table 3.
5	Is the water-mix fluid known to support the growth of harmful microorganisms (e.g. bacteria, mold)?	Conduct or provide specifications for biological agent risk assessment.

Table 3.

ADDITIONAL QUESTIONS FOR ANTICIPATING & RECOGNIZING RISKS TO HEALTH & SAFETY

	ADDITIONAL QUESTIONS	ACTIONS
1	Do any contaminant(s) of concern have full-shift exposure limits?	Conduct or provide specifications for quantitative inhalation exposure measurements/modeling.
2	Do any contaminant(s) of concern have short-term exposure limits?	Conduct or provide specifications for quantitative inhalation exposure measurements/modeling.
3	Are there any contaminant(s) of concern that do not have OELs?	Conduct or provide specifications for qualitative inhalation exposure risk assessment (e.g. control banding).
4	Is the particulate generated considered a harmful biological agent?	Conduct or provide specifications for biological agent risk assessment.

EVALUATION QUESTIONS

Table 4.

PRIMARY QUESTIONS FOR EVALUATING RISKS TO HEALTH & SAFETY

	PRIMARY QUESTIONS	ANSWERS	SOURCES OF INFORMATION	ACTIONS
1	Are the materials used potentially hazardous? Are there chemistries of concern?	YES	Review of safety data sheets (SDSs) for components indicates the presence of a "sensitizer."	Move to secondary questions 3 and 4 in Table 5.
2	Does the process require heating or combustion of raw materials — such as laser cutting, singeing, melting, etc.?	YES	Review of the process flow indicates that the materials are heated in a heat press.	Move to secondary questions 3 and 4 in Table 5.
3	Do the materials have the potential to come into physical contact with persons during use?	YES	Review of the process flow indicates that the materials must be handled to place them in the heat press.	Move to secondary questions 1 and 2 in Table 5.
4	Does this process use or produce a water-mix fluid?	NO	Review of the mixing process does not indicate the use of water.	Move to secondary question 5 in Table 5.
5	Are the materials potentially contaminated with infectious or other harmful biological agents?	NO	Review of the process does not indicate the possibility of contamination.	Conduct or provide specifications for biological agent risk assessment.

Table 5.

SECONDARY QUESTIONS FOR EVALUATING RISKS TO HEALTH & SAFETY

	SECONDARY QUESTIONS	ACTIONS
1	Are the materials known to be absorbed through skin or skin sensitizers?	Conduct or provide specifications for dermal exposure risk assessment.
2	Do the materials have hazardous physical properties (e.g. cryogenic liquids, high heat, strong acids/bases)?	Conduct or provide specifications for dermal exposure risk assessment.
3	Are the chemistries expected to be present in gas/vapor form at any operating temperatures?	Move to additional questions 1, 2 and 3 in Table 6.
4	Does the process have the potential to generate particulate?	Move to additional questions 1, 2 and 4 in Table 6.
5	Is the water-mix fluid known to support the growth of harmful microorganisms (e.g. bacteria, mold)?	Conduct or provide specifications for biological agent risk assessment.

Table 6.

ADDITIONAL QUESTIONS FOR EVALUATING RISKS TO HEALTH & SAFETY

	ADDITIONAL QUESTIONS	ACTIONS
1	Do any contaminant(s) of concern have full-shift exposure limits?	Conduct or provide specifications for quantitative inhalation exposure measurements/modeling.
2	Do any contaminant(s) of concern have short-term exposure limits?	Conduct or provide specifications for quantitative inhalation exposure measurements/modeling.
3	Are there any contaminant(s) of concern that do not have OELs?	Conduct or provide specifications for qualitative inhalation exposure risk assessment (e.g. control banding).
4	Is the particulate generated considered a harmful biological agent?	Conduct or provide specifications for biological agent risk assessment.

APPENDIX D. USING THE REBA WORKSHEET TO EVALUATE ERGONOMIC HAZARDS

Source: https://www.ehs.com/2020/05/how-to-use-the-rapid-entire-body-assessment/

The Rapid Entire Body Assessment (REBA) worksheet (see page 2) helps industrial hygienists evaluate the risk of musculoskeletal disorders (MSDs) associated with specific tasks within a job. The REBA evaluates the whole body and can be used to assess any task.

HOW TO COMPLETE THE REBA

IDENTIFY A JOB

Identify a job to assess by reviewing where past injuries have occurred, operators have reported complaints or quality issues are a concern.

DEFINE AND UNDERSTAND THE TASKS WITHIN THE JOB

Interview the operator to gain an understanding of the main job tasks, the task demands and what the operator perceives to be the most difficult elements of the job.

IDENTIFY THE TASKS WITHIN THE JOB YOU INTUITIVELY BELIEVE HAVE THE HIGHEST MSD RISK

From personal observation and the information gathered from the operator interview, select the "worst" parts of the task for the assessment. This should be based on the highest force exerted, the most awkward postures present, awkward postures held for an extended period or awkward postures that are repeated multiple times.

CAPTURE THE "WORST" MOMENT WITH A PHOTO

For example, take a photo of an operator lifting a 50-pound box from a pallet located on the floor or of an operator reaching across the width of a worktable to retrieve a 25-pound bundle.

COMPLETE THE REBA DATA COLLECTION FORM

The REBA evaluates the whole body, including the upper arms, lower arms, wrists, neck, back and legs. From the photo, compare the position or postures of each body segment to those outlined on the REBA data collection form. The REBA provides a score for each body segment based on these postures. Note that the upper limbs must be analyzed separately (both right and left) if they are performing different actions.

DETERMINE THE REBA SCORE

The REBA provides a single final score based on posture, force requirements, type of movement, frequency of movement and coupling observed within the task. This single value, ranging from 1 to 15, represents the work-related MSD risk to the operator. It also provides a level of urgency for engineering changes to the workstation. A score greater or equal to 8 indicates that there is high MSD risk to workers completing the task and that engineering controls are recommended.

CONTINUE THE JOB IMPROVEMENT PROCESS

Low- to very high-risk REBA scores may require new solutions to reduce MSD risk to workers. To generate solutions effectively:

- **Identify where the main issues are.** Analyze the REBA data collection form to see which areas contributed the most points to the REBA score.
- **Determine why you got this score.** For each high-risk factor identified, complete a "5-Why" analysis to find the true root cause of the problem.
- **Focus on fixing the problem.** Brainstorm improvements and implement them when it is financially feasible to do so.

  Tip: The solution should be the natural inverse of the true root cause.
- **Check your work.** After implementing the improvement(s), complete another REBA data collection form; if your improvements were effective, you should see a lower REBA score. This step is very important because it allows the evaluator to check in with operators — do they like the change, or are they merely adapting to it — and helps ensure that the improvement hasn't introduced new MSD risk factors.
- **Sustain the improvement.** If needed, train the operators, update the standard operating procedure and gather employee feedback. Also, look for opportunities to expand the benefits from this improvement to other workstations.

RAPID ENTIRE BODY ASSESSMENT (REBA) WORKSHEET

Source: https://www.ehs.com/2020/05/how-to-use-the-rapid-entire-body-assessment/

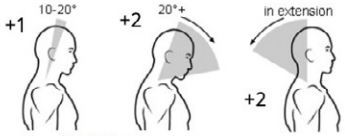
ERGONOMICS PLUS

REBA Employee Assessment Worksheet

Task Name: Date:

A. Neck, Trunk and Leg Analysis

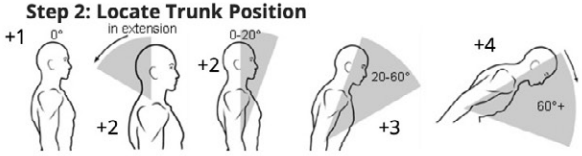
Step 1: Locate Neck Position



Neck Score

Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

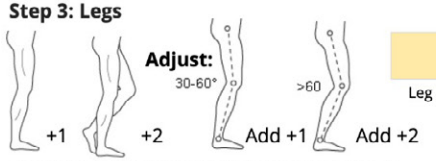
Step 2: Locate Trunk Position



Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 3: Legs



Leg Score

Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above,
Locate score in Table A

Posture Score A

+

Step 5: Add Force/Load Score
If load < 11 lbs. : +0
If load 11 to 22 lbs. : +1
If load > 22 lbs.: +2
Adjust: If shock or rapid build up of force: add +1

Force / Load Score

=

Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A.
Find Row in **Table C**.

Score A

Scoring
1 = Negligible Risk
2-3 = Low Risk. Change may be needed.
4-7 = Medium Risk. Further Investigate. Change Soon.
8-10 = High Risk. Investigate and Implement Change
11+ = Very High Risk. Implement Change

Scores

Table A

		Neck											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table B

		Lower Arm					
		1			2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

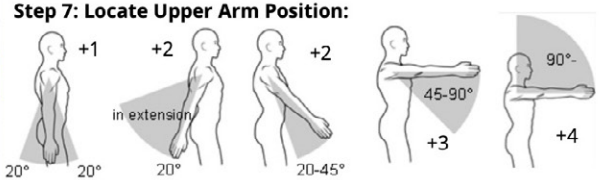
Table C

Score A	Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score + Activity Score = REBA Score

B. Arm and Wrist Analysis

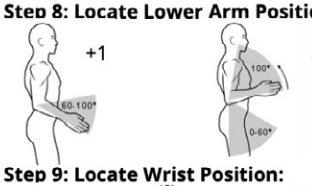
Step 7: Locate Upper Arm Position:



Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

Step 8: Locate Lower Arm Position:



Lower Arm Score

Step 9: Locate Wrist Position:

Wrist Score

Step 9a: Adjust...
If wrist is bent from midline or twisted : Add +1

Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B

Posture Score B

+

Step 11: Add Coupling Score
Well fitting Handle and mid rang power grip, ***good: +0***
Acceptable but not ideal hand hold or coupling acceptable with another body part, ***fair: +1***
Hand hold not acceptable but possible, ***poor: +2***
No handles, awkward, unsafe with any body part, ***Unacceptable: +3***

Coupling Score

=

Step 12: Score B, Find Column in Table C
Add values from steps 10 &11 to obtain Score B. Find column in **Table C** and match with Score A in row from step 6 to obtain Table C Score.

Score B

Step 13: Activity Score
+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

Original Worksheet Developed by Dr. Alan Hedge. Based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205