Hazardous Materials

Industrial Hygiene ABCs

A system for rating and ranking chemical and physical health hazards

By Jonathan M. Haas

INDUSTRIAL HYGIENISTS, much like SH&E professionals, use the phrase "recognition, evaluation and control." They review workplaces, determine what to monitor, evaluate the results and recommend controls when needed. This article reviews the "recognition" basics for chemical and physical health hazards that will help the SH&E professional know when to call an industrial hygiene professional for the "evaluation" step.

Step 1: What Are the Hazards?

The process begins with a review of MSDS and the sections on health effects and toxic effects. As part of this process, it is helpful to document MSDS trade names and health hazard ratings on a spreadsheet. This spreadsheet might resemble Table 1. Hazard information is rated using a rating system such as the one that follows. Note that use of 1, 4, 7 and 10 is arbitrary and selected to produce larger numbers for the eventual ABC multiplication. One could use 1, 2, 3 and 4 and revise the eventual decision logic. Using ratings such as low, medium or high for toxic risk would not produce the sought-after metric.

A = Level of Hazard

A = 1: This level refers to minor temporary or reversible effects, such as mild to moderate irritants to the respiratory system, eyes, skin. Examples include dilute acids and ammonia.

A = 4: This material causes moderate but not life-threatening effects. Harmful by inhalation, skin contact or swallowing, it may have marked irritation or minor central nervous system effects. Examples include naphtha, ethanol and materials identified on the MSDS as skin irritants.

A = 7: This material produces serious effects that are not immediately life-threatening. This category includes acute systemic effects, corrosives and sensitizers. Examples include strong nitric acid, sulfuric acid, acrylates, caustic soda and toluene diisocyanate.

A = 10: This type of material causes very serious effects—with danger of irreversible acute effects and/or death through inhalation, contact with skin or if swallowed. It may present danger of cumulative systemic effects, carcinogenic effects and reproductive effects. Examples include benzene, mercury, crystalline silica, hydrofluoric acid, 2-ethoxy ethanol and lead.

Many chemicals regulated by OSHA with specific requirements for monitoring will fall into this category because of their toxic effects (most are related to cancer in people or animals or very serious toxic effects). However, not all A = 10 materials will need to be monitored, a topic discussed later in the article.

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Table 1

Health Hazard Rating Chart

Product Trade Name	Hazard Rating
Simple Blue	4
Ed's Rug Clean	1
True Grit	7

In *A Strategy for Assessing and Managing Occupational Exposure, Second Edition,* Mulhausen and Damiano describe a similar system for using toxicity in creating a risk matrix (Mulhausen and Damiano). It is also similar to regulations promulgated by the Mexican government (Mexican Secretariat).

Step 2: Who Uses What?

The next step is to create a list of jobs where employees experience much the same level and duration of exposure, as well as a list of potential exposures for each job. In many cases, this can be a list of job titles or positions within a plant area (e.g., operator A poly plant). Plant areas alone are sometimes used to create this list, particularly when workers rotate from machine to machine or station to station routinely during the day throughout that area of the plant. Creating these lists will take time, but it is an essential step

Other risks should be noted as well. For example, noise should be listed (usually A = 4) if it is difficult to communicate at a distance of six feet. Carbon monoxide—a potential component of exhaust from propane-powered forktrucks—should also be included (usually A = 10 because of fatal risk). Heat and cold stress could rate A = 4, 7 or 10 depending on circumstances; these factors are usually best assessed by an industrial hygiene professional. The same holds true for vibration and ionizing or nonionizing radiation.

Step 3: How Is Each Controlled?

At this point, the objective is to rate the workplace control for each material for each job. PPE controls should not be considering in this rating. For example, some gases are so lethal that plant piping may contain no joints; instead, the piping is welded to prevent leaks and cylinders are hooked up inside of exhausted containment chambers (major control). Some materials may be handled inside of negative-pressure containment rooms with robot arms (major control), while others are handled in negative-pressure glove boxes (major control).

Many operations have exhaust trunks directly behind the point of operation where fumes or vapors are released (moderate control or minor control, depending on capture velocity). Laboratory hoods may be used (moderate control or minor control, depending on capture velocity). Some materials are handled in the open with the only general dilution ventilation provided by a wall fan located 50 feet away (relatively uncontrolled). Following is a suggested rating scheme. Again, the choice of 1, 4, 7 and 10 is arbitrary and could be 1, 2, 3 and 4.

B = Level of Control

B = 1: This rating indicates a major control, such as a totally enclosed system with no potential for exposure by any route, is in place. Examples include laboratory glove box operations, welded piping systems and enclosed, negatively-pressured points of operation.

B = 4: This indicates that a moderate control is in place. This category might include an adequately vented open system for all stages of a job that uses only small quantities of A = 1 or 4 material. An example is a fume hood or local exhaust ventilation hood with apparent capture of contaminants with direction away from the employee. Any use of materials should be factored into this rating as well. Materials with an A = 7 or 10 rating cannot be ranked B = 4.

B = 7: This level indicates that a minor control is in place. This might include an adequately vented open system for all stages of a job in which large quantities of A = 1 or 4 materials—or any quantity of A = 7 or 10 materials—are consumed. This also applies to relatively uncontrolled bench top operations that use A = 1 or 4 materials. Canopy-type exhaust hoods that do not direct contaminants away from the employee should be classified as a minor control.

B = 10: This category applies to a process that is relatively uncontrolled. It refers to open operations using A = 7 or 10 materials. Examples include general room ventilation or a wall fan.

Step 4: Are Prior Monitoring Results Available?

If available, monitoring results should be used to update the estimated rating for B. Additional numbers can be used to reflect those results. Subsequently, the estimated rating may be reduced or increased. The statistical reason behind this is detailed in the italicized copy that follows each of the scenarios described in the following discussion. (Ihstat.xls is an analysis tool that uses statistics for monitoring results; it is distributed on floppy disk with Mulhausen and Damiano and is not available as a stand-alone product.)

B = Ratings Based on Prior Monitoring

When sufficient industrial hygiene monitoring data are already available, the number assigned to B should be based on that data, since this ABC process is designed to rank those exposures that should be monitored. The term "sufficient" usually equates to seven valid samples. If all seven are below the exposure limit, then the risk of being wrong is 12.5 percent if another sample is taken. Depending on the results of prior monitoring, B can be reduced and monitoring stopped. In this case, the use of 1, 2, 3, 6 and 10 is not arbitrary; these numbers were selected to increase or decrease the estimated B depending on quantitative results as noted in the explanations for statistical inferences.

B = 0: This rating indicates that the laboratory analysis of all seven (or more) samples showed the chemical to be "none detected (n.d.)" or "below detection limits." *Why monitor more?*

B = 1: This rating indicates that all samples showed every exposure to be less than 10 percent of the exposure limit. *Plugging the results into Ihstat.xls and analyzing the data reveals that there is zero probability of exceeding the exposure limit and zero probability of exceeding half of it, even if unlimited samples were taken.*

B = 2: This category indicates that all seven (or more) samples showed each exposure to be less than 50 percent of the exposure limit. *Plugging the results into Ihstat.xls reveals zero probability of exceeding the exposure limit, even if unlimited samples were taken.*

B = 3: This rating indicates that one sample was more than 50 percent of the exposure limit but that no sample exceeded the exposure limit. *Plugging the results into Ihstat.xls and analyzing the data, estimates of the percent of samples that could exceed the exposure limit range from 0.25 percent to 2.5 percent if unlimited samples were taken and the distribution was lognormal.*

B = 6: This rating indicates that two or more samples were more than 50 percent of the exposure limit

Abstract: *Toxicity and handling issues arise whenever a new chemical is used or a manufacturing process is modified. However, many manufacturing sites do not have staff industrial hygienists to monitor these issues. This article describes a system for qualitatively evaluating the combination of toxicity, workplace controls and exposure duration that staff SH&E personnel can use to determine when industrial hygiene expertise may be needed.*

The higher the product of multiplying A, B and C, the higher the priority should be for monitoring. Workplace changes should result in periodic reviews of controls and product use, as well as a new ABC estimate.

but that none exceeded the limit. *Although no sample exceeded the limit, B is now double the preceding example since the percentage of samples that theoretically could exceed the limit is now up to six percent. Although management may feel confident that the hazard is acceptably controlled, an industrial hygienist will look at a predicted five-percent exceedance as an indication that the hazard is not as controlled as it should be. This could mean excessive exposures one day per month (1/20 = five percent).*

B = 10: This rating indicates that one or more samples exceeded the exposure limit. *The estimated B could have been 4 or 7, which increases the priority.*

If one simply considers how dangerous a material is and how it is controlled in the workplace, the very serious materials (A = 10) used in a relatively uncontrolled manner (B = 10) or with minor control (B = 7) would be scheduled for monitoring first. That is the sense that one gets when consulting the risk matrix provided by Mulhausen and Damiano. However, what if the material is used only for a very short time per day, week or month?

Step 5: How Long Is the Material Used?

When asked, most employees can easily estimate the daily, weekly or monthly time spent with a material based on their experience on the job. However, a hard scale (e.g., 1, 2, 3, 4 or 5 with definitions) based on time could create some incentive to underestimate or overestimate the time spent with a material, particularly when the estimate is close to an established break point.

C = Duration of Exposure

To eliminate the potential for bias, a formula can be used to create a sliding scale (1 to 5) for exposure duration. A formula to consider for rating duration of usage can be preprogrammed into the spreadsheet.

C = 1 + 4 (minutes per day divided by 480);
C = 1 + 4 (hours per week divided by 40);
C = 1 + 4 (days per month divided by 20);
C = 1 + 4 (days per year divided by 240).

Examples for the formula:

- 240 minutes exposure per day is **C** = 3.0.
- 480 minutes exposure per day is **C** = 5.0.
- One minute exposure per day is **C** = 1.0.

Step 6: Multiply A, B & C to Rank Needs for Monitoring & Review

The higher the product of multiplying A, B and C, the higher the priority should be for monitoring. The highest ABC number possible is 500 (10 x 10 x 5). The lowest estimated number is 1.

It may be reasonable to suggest that any relatively uncontrolled use of a reproductive toxin or cancer-causing material (ABC = 100) should be monitored and to consider ABC = 100 as the cut point. Workplace changes should result in periodic reviews of controls and product use, as well as a new ABC estimate. The frequency of periodic reviews will depend on the value for ABC.

The following systematic approach is suggested.

ABC Less Than 50

At this level, risk from the material is low. No monitoring is suggested. Examples include:

- Serious material (7), adequately vented open system (7), little daily use (1) = 49.
- Minor temporary effects (1), adequately vented open system (4), eight hours (5) = 20.

The process should be reviewed again only when and/or if it changes.

ABC 50 to 99

The risk estimate for this material is nearing concern levels, but monitoring is not yet suggested. Examples include:

- Serious material (7), adequately vented open system (7), two hours (2) = 98.
- More serious effects (4), minor controls (7), four hours (3) = 84.

Review is recommended every six months.

ABC 100 to 199

In this case, the risk estimate exceeds 100 and industrial hygiene monitoring to quantify exposures is recommended. Once the monitoring is performed, ABC should be recalculated based on the new estimate for B. Examples include:

- Serious material (7), adequately vented open system (7), four hours (3) = 147.
- Serious material (7), relatively uncontrolled system (10), two hours (2) = 140.
- Very serious material (10), relatively uncontrolled system (10), one hour (1.5) = 150.

If the ABC calculation remains at this level after B is re-estimated based on monitoring results, review is recommended every 12 months. If some monitoring results exceeded the limit for eight hours exposure despite limited use time, it may be that time or exposure increased. In these cases, the SH&E professional should investigate ways to reduce exposure.

ABC 200 to 299

This level would be cause for increased concern about exposure time and may require a change to work processes and procedures. Industrial hygiene monitoring should be performed, and ABC recalculated based on the new rating for B. Examples include:

- Serious material (7), adequately vented open system (7), eight hours (5) = 245.
- Serious material (7), relatively uncontrolled system (10), four hours (3) = 210.

If ABC remains at this level after recalculating B based on monitoring results, monitoring and review is recommended every six months. Again, measures to reduce exposure should be investigated and implemented where possible.

ABC 300+

This level presents the highest concern and again may require consideration of a change to work processes and procedures. As with the previous steps, a new B rating should be determined based on industrial hygiene monitoring results, then ABC should be recalculated based on new B. Examples include:

•Serious material (7), uncontrolled system(10), eight hours (5) = 350.

•Very serious material (10), uncontrolled system (10), four hours (3) = 300.

An ABC estimate at this level requires monitoring and review every three months. Tables 2 and 3 present this information graphically. For example, in the case of noise, Table 3 shows continuous exposure to noise (it interferes with conversation) that is relatively uncontrolled. Even exposure for half a day (C = 3) would qualify for monitoring (ABC = 120). Also, as Table 3 shows, it appears that some component in True Grit may need to be monitored, and it may or may not have an exposure limit. Industrial hygiene expertise is needed at this point.

It should be noted that this method for ranking and prioritizing exposure monitoring and workplace review needs is not perfect. Similar disclaimers are found in other published works on this subject as well. However, the method does provide a metric and a rationale needed to justify various aspects of decision making.

Table 2

ABC Prioritization Process

Recommended Action	ABC Rating <50	50-99	100-199	200-299	300+
Re-estimate rating	On change	6 months	12 months	6 months	3 months
Monitor exposure	No	No	12 months	6 months	3 months
Investigate exposure reduction controls	No	No	Yes	Yes	Yes
Implement controls	No	No	If exposure can exceed limit	If exposure can exceed limit	Yes

Table 3

Example Listing by Material/Agent for an Exposure Group

Material	A	B	C	ABC
Noise	4	10	5	200
Ed's Rug Clean	1	10	2	20
True Grit	7	10	3	210

Conclusion

Any facility can use this systematic approach to define and document an industrial hygiene qualitative exposure assessment program and to define and rank quantitative exposure monitoring needs.

Such a documented process defines monitoring rationale using metrics—information that can then be more easily reported to management. In addition, the process defines and prioritizes the annual monitoring plan, which may be a management expection. With a plan, laboratory costs for monitoring analysis can be better estimated and justified for the year as well. In addition, the process defines why industrial hygiene monitoring is not conducted for most materials and the plan can be explained to employees as a part of a firm's hazard communication efforts. The process permits a history of site progress from year to year as well. In addition, a qualitative exposure assessment process and annual plan is needed if a site wishes to participate in OSHA's Voluntary Protection Programs. ■

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