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EVALUATING EQUIPMENT FOR HAZARDS BEFORE & AFTER INSTALLATION

By David Ayers

Most know the idiom, "An ounce of prevention is worth a pound of cure." For safety professionals, this means work proactively to address hazard reduction or elimination and do not wait for an incident to occur. In many companies, evaluating equipment, both new and used, for hazards is often an afterthought.

The production department desires to increase widget throughput while the accountants are focused on saving money. The author has found that a few companies look at the entire life cycle of manufacturing equipment to include methods to reduce or eliminate equipment hazards and reduce both hazardous and nonhazardous waste generation, along with the final asset disposal (including potential chemical and heavy metal decontamination before disposal). Another aspect of the equipment life cycle is to look at the process into which it will be integrated. As Hassim and Hurme (2010) state, "Even though process improvement can be done at any process design and operation, the opportunities and the costs are more attractive at development and design stages, especially for incorporating inherent safety features" (p. 476).

If environmental, health and safety (EHS) risk assessments are not proactively applied on new or used equipment, mitigating a hazard discovered after purchase and installation will require more time and resources. Time and money are not endless, so an EHS risk assessment must have the value-added principle of reducing or eliminating hazard potential. Company management teams have different levels of risk appetite, so it is critical that hazard reduction or elimination take that perspective into account. The company management team should make clear what is or is not acceptable risk when it comes to hazard reduction or elimination. Many models are available to assess the equipment's hazard potential and severity. If the company has a preferred model of evaluating hazard potential and severity, use that model. It will not be seen as new or different and will allow for faster dissemination of information. A discussion of the various hazard evaluation models is beyond the scope of this article. The author prefers to look at the equipment and perform a qualitative review rather than using a monetary threshold, such as EHS assessments being conducted only on new or used equipment that costs more than $50,000. An inexpensive piece of equipment may have tremendous hazard potential and severity that could be missed if the equipment did not meet the monetary threshold. Likewise, the company could choose to add language for exemptions to the EHS assessment process, such as a single electrical plug source of 110 V equipped with machine guards and interlocks.

Along with lessons learned from the author's experience, this article presents several ideas to use when performing prepurchase EHS assessments, installation and placement of equipment, and post-purchase EHS assessments. The author has found that creating a checklist has helped immensely to ensure that hazards are addressed.

Prepurchase EHS Assessment & the Hierarchy of Hazard Controls

The goal of performing prepurchase EHS assessments should be to buy safe equipment. Equipment vendors can be contracted to add safeguards to equipment before purchase to help meet the company's risk appetite. It would be faster and cheaper for the equipment manufacturer to offer additional safeguards rather than for companies to buy the equipment and retrofit it to reduce the hazard potential to an acceptable level. As an aspect of the company's risk appetite, a build and acceptance document should be added to the contract. This document spells out the requirements the equipment must "pass" to be considered not only safe to use but also meet established quality expectations. For example, the document could require the equipment to have 99.995% uptime for the first 60 days (excluding planned or predictive maintenance). The document should also spell out the requirements for the vendor to notify the company of any safety alerts, recalls or software upgrades associated with the equipment. Pumps, motors and other components associated with the equipment can fail and must be replaced as opposed to an entire equipment recall.

When assessing the equipment for potential hazards along with potential fixes, the hierarchy of hazard controls is a good starting point. The hierarchy of controls provides a good visual to show management how the safety professional prioritizes the elimination or reduction of equipment hazards. According to Lyon and Popov (2017):

> Successful business leaders realize that to conduct operations and achieve objectives, management must understand and manage the risks associated with the operation. OSH risk professionals who can facilitate risk assessments and effectively communicate risks to management, in essence, reducing uncertainty, will increase their value to the organization. (p. 35)

The safety professional should strive to use prevention through design elements. The prevention through design concept assists with effective hazard communication to management along with risk assessments (NIOSH, 2013). The goal is to eliminate or reduce the hazard to acceptable levels. According to Manuele (2008):

> Engineered safety devices are intended to prevent access to the hazard by workers—to separate hazardous energy from the worker and deter worker error. Examples include machine guards, interlock systems, circuit breakers, start-up alarms, presence-sensing devices, safety nets, ventilation systems, sound enclosures, fall prevention systems, and lift tables, conveyors, and balancers. (p. 39)

The equipment manufacturer should be able to provide operations and maintenance manuals for review before the equipment is purchased. Many of these manuals have a dedicated safety section in which the equipment manufacturer identifies where the equipment hazards are located. The supplied manuals can also provide answers to questions about failure modes, equipment troubleshooting, control of hazardous energy (lockout/tagout), laser usage, radiation shielding (nonionizing and ionizing) and recommended PPE.

The manufacturer's supplied manuals also contain any information on chemicals and lubricants the equipment uses. Once the chemical list is compiled, research can be conducted on OSHA permissible exposure limits (PELs), and any data on ceiling or short-term exposure limits can be compiled for any associated chemicals and lubricants the equipment uses (OSHA, 2016a). With this chemical data compiled, move onto other areas of the EHS assessment including any toxic gas monitoring, flammable gas monitoring or oxygen deficient atmospheres created by the process or whether the equipment has a catastrophic chemical line failure. Not all chemicals will have a PEL. If a PEL is not available, consult the NIOSH recommended exposure limits, American Conference of Governmental Industrial Hygienists threshold limit values or other company internal exposure limits. "Many of the PELs have not been updated since 1971, and current scientific data suggests that, in many instances, the outdated PELs are not sufficiently protective of worker health" (OSHA, 2016b). OSHA (n.d.) has published a seven-step process for evaluating alternative chemicals, however, a detailed discussion is beyond the scope of this article.

The equipment manufacturer's supplied manuals should identify all forms of hazardous energy associated with the equipment. Some forms of hazardous energy are electrical, mechanical, pneumatic, chemical thermal (both hot and cold), hydraulic and potential energy. The equipment manufacturer should be able to supply a general lockout/tagout procedure identifying all the hazardous energy sources and their control measures.

The equipment should be manufactured following equipment safety standards. The specific language will vary (e.g., "tested to," "complies with," "in accordance with"). ANSI, the American Society of Mechanical Engineers and National Fire Protection Association (NFPA) produce equipment safety standards. Safety standards can be general in nature as well as industry specific. Semiconductor Equipment and Materials International (SEMI), Robotics Industry Association (RIA) and the Association for Packaging and Processing Technologies (PMMI) are examples of industry-specific safety standards. Equipment safety standards include:

- SEMI S2-0821, Environmental, Health and Safety Guideline for Semiconductor Manufacturing Equipment
- ANSI/RIA R15.08-1-2020, Industrial Mobile Robots—Safety Requirements—Part 1: Requirements for the Industrial Mobile Robot
- ANSI/ASSP A10.21-2018, Safety Requirements for Safe Construction and Demolition of Wind Generation/Turbine Facilities
- ANSI B11.13-2020, Safety Requirements for Single-Spindle or Multiple-Spindle Automatic Bar and Chucking Machine
- ANSI B11.21-2006, Safety Requirements for Machine Tools Using Lasers for Processing Materials
- NFPA 79, Electrical Standard for Industrial Machinery
- ANSI/PMMI B155.1-2016, Safety Requirements for Packaging and Processing Equipment

It is critical to understand which equipment safety standards were used and how the equipment manufacturer produced this "safe piece of equipment." The equipment vendor should also be able to supply any test data (e.g., safety standard, noise, laser, nonionizing radiation). Some equipment is built to a safety standard but never tested against that standard. The author has found that some manufacturers post videos of their equipment running, which is another data point to consider in the EHS assessment.

Facility Design, Equipment Placement

Before purchasing equipment, the employer should have a place to put it. A good deal is not a good deal if the new equipment sits in a warehouse for 6 months. A thorough inspection of the equipment (and support equipment such as pumps, motors or transformers) should commence immediately upon delivery. This will help to discover any shipping-related damage and address it immediately. It is better to find issues right away than to trust that there is no damage, only to discover that the equipment is not functional when taken out of the crate 6 months later.

The company should consult building architects and facility personnel (whether internal or external), as well as the building codes in use for the site's jurisdiction. The building may require upgrading to meet the latest building codes for the equipment to be installed. The equipment design package will show the details for the routing of piping, fire protection devices and any associated wastes. This helps the company understand the true cost and scope of the new equipment purchase.

It is not only production equipment that is overlooked. The addition and placement of support equipment (e.g., voltage transformers, vacuum pumps, chillers) is often an overlooked detail as well. Support equipment needs a home as well as a source of power, water and clean dry air (CDA), among other requirements.

As part of the design phase, it is critical to understand all the equipment's specific needs and ask questions such as whether the current building can support the new equipment. Equipment installations require the coordination of many departments, and for high-visibility projects, important questions may not be asked for the sake of speed of installation. A common requirement in certain industries is that the new equipment requires CDA dried to -40 °F. If the building cannot support this requirement, the company must provide it or choose not to buy the equipment. If any waste is produced (hazardous or nonhazardous) does the company need to alter its current environmental operating permit? Does the company need to contact its hazardous waste vendor to get a new profile?

In the author's experience, overlooked areas and questions include:

- Will the equipment fit through the doors or would a wall need to be knocked down and rebuilt?
- Will the floor or roof support the weight?
- Does the facility need to add or adjust training and capabilities for the on-site emergency response team?
- Is the equipment U.S. or European voltage and is a voltage transformer needed? What type of plug and outlet does the equipment have and is it part of the purchase or a company purchase? Is an electrical disconnect needed?
- Is the equipment vibration sensitive and to what level?
- What additional infrastructure will be needed (e.g., CDA, nitrogen, deionized water, exhaust for chemical fumes, exhaust for heat, equipment cooling water)?
- If compressed gases are used, can a reduced flow orifice be used to feed the equipment and reduce the amount lost in the event of a leak?
- Do the sprinkler heads (spacing or heat rating) need to be changed with an increase or decrease of fuel or fire load?
- How will hazardous waste storage (dedicated area, inspection, training, new waste stream) be handled?

TABLE 1
EXAMPLE INSTALLATION FOLLOW-UP LIST

Item	Owner	Date completed
Affix nitric acid HazCom label	Ayers	
Register equipment with vendor safety alert system	Jones	
Label drains with waste and direction of flow	Smith	
Update and post new panel schedule	Coyote	
Complete equipment-specific lockout/tagout	Ayers/Smith/Coyote	
Label photohelics for proper exhaust flow (low and high)	Smith	
Create initial operations standard operating procedure and finalize with on-site vendor training	Jones	
Create initial maintenance standard operating procedure and finalize with on-site vendor training	Smith	

•Think about solid waste generation and recycling. For example, should the company increase or decrease the number of dumpsters?

The company should also capture and document hazard reduction and costs associated with the new equipment. Buying new equipment can be beneficial, but be sure to weigh the positives with the negatives.

Post-Installation EHS Assessment

No equipment installation effort goes exactly according to plan. Consider using a checklist to help keep track of the details. As Fleming and Fischer (2017) note, "All people have the potential to make errors, whether from missed subtleties in their view of a job or process operation, lack of knowledge or outright errors. Therefore, a checklist can be a valuable tool" (p. 55). The checklist should be flexible enough to allow adding new areas of concern and should include an "NA" column to indicate items that do not apply. As part of the checklist, the various responsibilities should be listed such as facilities, maintenance, engineering and EHS. Potential site-specific items to check include:

•chemical monitoring (oxygen deficiency, flammability or toxic gas monitoring)
•sensor calibration schedule (and vendor lead time)
•lockout/tagout assessments
•job hazard (or safety) analysis
•noise sampling
•liquid drains (e.g., acid, solvent, water) attached correctly and labeled with direction of flow labels
•process gas line labeled every 5 ft along with arrows indicating direction of flow
•laser, pinch points, pacemaker labels
•exhaust flow indicators along with low and high ranges labeled
•electrical panel schedules updated with new and support equipment labeled; outlets labeled
•registration of laser and radiation sources (ionizing and nonionizing); radiation measurements by calibrated meters
•incipient smoke detection
•sprinkler head (style and spacing)
•additional emergency response team training or spill/gas leak abilities

After installation, any outstanding items that must be addressed should be documented and tracked to completion. Table 1 shows a sample equipment installation follow-up list. When most of the actions are complete, the equipment vendor can begin the process of starting up the equipment along with training new operators and maintenance technicians (as part of the build and acceptance document). Training on the new equipment is often an overlooked item, and companies may assume that the operators could simply read the manual. Creating standard operating procedures for operations and maintenance personnel is critical to operating the equipment as is providing training for new personnel. The equipment vendor should also have a checklist to help verify that personnel are trained. Training abilities will vary, so vendor-provided checklists help to ensure training consistency.

Conclusion

The ideas and concepts presented here can help the safety professional review equipment for hazards before purchase, questions to ask during the design and installation phase, and the concept of a flexible checklist to help ensure that equipment is as safe as possible for operators and maintenance personnel. Readers can modify the sample follow-up action list (Table 1) for site's needs. The safety professional should work proactively with site and corporate partners to eliminate and reduce hazards to an acceptable level. Management support is important to ensure program buy-in. Work with the operations, maintenance and purchasing departments along with vendors to get the appropriate equipment materials to review before the equipment is purchased. The author has not encountered an equipment vendor that was willing to lose a sale over review of potential equipment hazards before purchase.

Proactively eliminating or reducing hazards can prevent an incident from occurring and can eliminate or reduce hazardous waste generation. Proactively addressing hazards is also less costly than retrofitting equipment to make it safe after an incident occurs. **PSJ**

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