MBAA TQ vol. 57, no. 2 • 2020 • pp. 114–117

Industrial Hygiene in Breweries

Jed Douglas
SCS Engineers, Long Beach, CA 90806, U.S.A.

ABSTRACT

Numerous safety hazards exist in the brewing industry, some of which are environmental (grain dust, welding fumes, asbestos fibers, carbon dioxide vapors), biological (fungi/mold, bacteria, venomous insects/reptiles), chemical (lung inhalation, mouth ingestion, and skin absorption of cleaning chemicals), physical (heat, boiling liquids, noise, confined space, illumination), ergonomic (repetitive motion, bending, lifting, pushing, walking, reaching), and organizational (workplace violence, harassment, stress, workload). This article discusses a variety of safety hazards, why they are hazards, and how they can be addressed to reduce the hazard to brewery employees. Every employer is legally obligated to provide a safe and healthy workplace. A healthy and safe workforce is a happier workforce, which in turn yields greater productivity and lower costs for insurance and also leads to a culture of safety in the workplace.

What Is Industrial Hygiene?

Industrial hygiene (IH) is a combination of science and art devoted to the anticipation, recognition, evaluation, control, and prevention of environmental factors or stressors arising in the workplace. These factors may cause acute or chronic sickness, impaired health and well-being, and significant discomfort among workers.

Consider the services of a Certified Industrial Hygienist and their IH staff and technicians, who are dedicated to ensuring the success of your projects through a team-based approach to managing risk and protecting the health and safety of employees. This is accomplished by:

1. Anticipating hazards in the workplace based on the type of operations and the industry.
2. Recognizing hazards that exist in brewing facilities.
3. Evaluating the magnitude of the identified hazards by conducting real-time monitoring/sampling of areas and personnel potentially affected by the hazards.
4. Controlling the hazards through the use of engineering controls (including product/process substitution), work practice controls, administrative controls, and personal protective equipment (PPE).
5. Preventing the hazards in the first place by evaluation of construction plans, new process design, and expansion or purchase of new equipment.

An industrial hygienist should develop cost-effective solutions to a wide variety of IH issues by:

- Identifying hazards in the workplace that put employees at risk by reviewing work practices, performing observation of job tasks, studying work practices, and researching chemical inventory.
- Recommending corrective action to eliminate, reduce, or control hazards by reviewing existing engineering controls, working with the client and/or equipment providers to develop new engineering controls, studying options for administrative controls, and verifying that workers are protected through the use of proper PPE.
- Applying in-depth knowledge of regulations, science, and public policy to provide compliance advice and program management.
- Providing expert support for IH assessments, sampling, analysis, management programs, and corrective design.

IH Issues in a Brewery

Numerous safety hazards exist in the brewing industry:

- Environmental (grain dust, welding fumes, asbestos fibers, carbon dioxide vapors)
- Biological (fungi/mold, bacteria, venomous insects/reptiles)
- Chemical (lung inhalation, mouth ingestion, and skin absorption of cleaning chemicals)
- Physical (heat, boiling liquids, noise, confined space, illumination)
- Ergonomic (repetitive motion, bending, lifting, pushing, walking, reaching)
- Organizational (workplace violence, harassment, stress, workload)

Workers in a brewery are subjected to many hazards that can affect both their short-term health and their long-term wellbeing. Customers that imbibe the breweries' products do not give much thought to the hard labor that goes into making beer; they are there predominantly because of the euphoric effects of ethyl alcohol. But how many people actually consider that ethyl alcohol is a toxic industrial solvent? Let's delve into some common processes at breweries and the hazards they present.

Jed Douglas has been brewing beer predominantly to satisfy his interest in biology and chemistry (and his taste buds) for 28 years, and he has been an environmental consultant in California for 30 years. He studied brewing science at the University of California, Davis, and is certified as a Master Brewer by the London Institute of Brewing. He graduated with Distinction, achieving a final exam score among the top 10% of candidates worldwide. He also is a licensed professional geologist in Arizona, Oregon, Washington, and California. Although his career has always included a safety aspect, 14 years ago he decided to focus on worker health and safety, and he subsequently acquired licenses as a Certified Safety Professional and a Certified Industrial Hygienist. Although he no longer works as a professional brewer, he still brews beer on his homemade 20 gal system, and he is also a certified beer judge through the Beer Judge Certification Program (BJCP).

E-mail: JDouglas@scsengineers.com

https://doi.org/10.1094/TQ-57-2-0609-01

Barley Malt and Other Grains

Although many breweries have a silo for their two-row malt, they typically purchase specialty grains in 50–55 lb sacks. There are physical hazards from handling these heavy sacks of grain, and ergonomic issues arise from the lifting, twisting, carrying, and placing of the malt into the grist mill. Pallets of sacks of grain are a great place for insects and animals to hide, especially poisonous spiders, scorpions, snakes, and vermin, depending on where the brewery is located. Workers should always wear gloves for hand protection when handling sacks of grain and be trained in correct lifting and carrying procedures to help avoid acute and chronic musculoskeletal injuries, such as back injuries, muscle strains, and slips/trips/falls.

Milling of the malt also creates copious quantities of grain dust, which presents an inhalation hazard. The Occupational Safety and Health Administration (OSHA) has established an 8 h time-weighted average (TWA). (A TWA is the average exposure throughout the standard work shift. The exposure limit may be exceeded for short times during the shift, as long as the overall average for the shift does not exceed the limit. TWA is equal to the sum of the portion of each time period, multiplied by the exposure levels of the substance during the time period, divided by the hours in the workday.) The permissible exposure limit (PEL) for cereal grain dust is 10 mg/m^3 (milligrams per cubic meter). Grain dust is a complex mixture of husk particles, cellulose hairs and spikes, starch granules, spores of fungi, insect debris, pollens, rat hair, and approximately 5% mineral particles. The mean particle size of the airborne dust may be less than 5 µm (microns), which easily gets deep into your lungs with every breath.

OSHA determined that an exposure limit for grain dust is necessary to reduce the significant risk of adverse respiratory effects associated with exposure to wheat, oat, and barley dust. OSHA's review of the health evidence showed that grain workers experience adverse respiratory symptoms upon exposure to grain dust levels exceeding the nuisance dust limit of 15 mg/m^3 TWA. Occupational exposure to grain dust is associated with both acute and chronic effects on the respiratory tract. The main reported respiratory effects of exposure to grain dust are asthma and acute asthma-like symptoms, reduced lung volume, and symptoms evoking chronic bronchitis.

The adverse effects of inhaling grain dust have been known for at least 300 years. In 1713, Bernardino Ramazzini described the respiratory hazards associated with exposure to cereal grain dust. Epidemiological studies have demonstrated that exposure to grain dust causes organic dust toxic syndrome ("grain fever"): wheezing, chest tightness, productive cough, eye and nasal irritation, and symptoms of chronic respiratory disease. Also, grain dust may induce asthmatic reactions via an allergic mechanism, especially in individuals predisposed to developing allergies. This allergic effect can also be attributed to the various types of fungal spores present in most grain. Analyses of grain samples showed a strong relationship between airborne and grain dust fungal communities, and allergenic and mycotoxigenic species were present in in most samples, so fungal species potentially contribute to work-related respiratory symptoms of grain workers.

Brewing

During the mash, sparge, and boil, the brewing staff are exposed to both high ambient air temperature and high-temperature liquids. High air temperature can lead to heat stress, heat exhaustion, and heat stroke (deadly), especially if the outside air temperature is already elevated during the summer months and if the brewery is in a high-humidity area. Boiling and sub-boiling liquids can cause severe burns if one happens to forget to install a gasket, uses a faulty pipe clamp, or is not paying attention to the kettle. The risk for heat-related injury increases if the worker is hung over from sampling too much beer the night before.

Heat-Related Injuries

Elevated body temperatures can cause serious injury or death. Working outdoors or in the sun increases the chance of heat-related injuries, but they occur indoors as well. This hazard is especially critical when protective clothing is worn, because heat from the body becomes trapped inside clothing. Personnel should drink plenty of liquids and take breaks as needed.

To minimize the potential for heat stress and heat stroke, rest breaks should be taken at 2 h intervals (see Table 1). Heat stress monitoring should be implemented once ambient air temperatures exceed 75°F.

- Visual observations. Coworkers should monitor other personnel through visual observations of breathing rate and redness of skin. If heat stress is suspected, further personnel monitoring should be initiated.
- Heart rate. Count the radial pulse (at the wrist) for 30 s as early as possible in the rest period. If it is over 110 beats per minute, shorten the next work cycle by one-third while keeping the rest period the same. Repeat this procedure at each rest period, shortening the work cycle as needed by one-third.
- Oral temperature. Use a clinical thermometer or similar instrument to measure the oral temperature at the end of the work period (before drinking water). If it is over 99.6°F, shorten the next work cycle by one-third while keeping the rest period the same. Repeat this procedure at each rest period. DO NOT allow a worker to wear a semi-permeable or impermeable garment when their temperature exceeds 100.6° F.

The following section describes the various effects of heat-related injuries.

Heat Disorders and Health Effects

- **Heat stroke:** This disorder occurs when the body's system of temperature regulation (e.g., sweating and evaporation) fails and body temperature rises to critical levels. It is caused by a combination of highly variable factors and is difficult to predict. Heat stroke is a serious hazard. Signs and symptoms are confusion, irrational behavior, loss of consciousness, convulsions, a lack of sweating (usually), hot, dry skin, and an abnormally high body temperature. If a worker shows signs of possible heat stroke, call 911 to obtain *immediate* medical assistance. The worker should be placed in a shady area, and their outer clothing should be removed. Their skin should be wetted and air movement increased to improve evaporative cooling until help arrives. Fluids should be replaced as soon as possible (by mouth only if the worker is conscious). The medical out-

Table 1. Summary of work/rest periods based on ambient air temperature

Temperature (°F)	Work (min)	Rest (min)
75 to 80	120	15
80 to 85	90	15
85 to 90	60	15
90 to 95+	30	15

come depends on the victim's physical fitness and the timing and effectiveness of first aid. Employees suspected of being ill from heat stroke should NOT be sent home or left unattended unless directed by a physician.

- **Heat exhaustion:** The signs and symptoms of heat exhaustion include clammy skin, headache, nausea, vertigo, weakness, thirst, and giddiness. Fortunately, heat exhaustion responds readily to prompt treatment. This condition, however, should not be dismissed lightly, for several reasons. One is that fainting associated with heat exhaustion can be dangerous; for example, the victim may be operating machinery or controlling an operation that should not be left unattended. The victim could also be injured by fainting and falling. Although the signs and symptoms associated with heat exhaustion are similar to those of heat stroke, the notable difference (with heat exhaustion) is clammy skin. Workers suffering from heat exhaustion should be removed from hot environments and given fluid replacement (by mouth only if the workers are conscious). They should also be encouraged to get adequate rest.
- **Heat rashes:** The most common problem occurring in hot work environments is heat rash. Prickly heat appears as red papules, usually in areas where clothing is restrictive. As sweating increases, there is a prickling sensation. Prickly heat occurs in skin that is persistently wetted by unevaporated sweat, and papules may become infected if they are not treated. In most cases, heat rash will disappear when the worker returns to a cool environment.
- **Heat fatigue:** One factor that predisposes individuals to heat fatigue is the lack of acclimatization. Use of a program of acclimatization and training for work in hot environments is advisable. The signs and symptoms of heat fatigue include impaired performance of skilled sensorimotor, high-concentration, or high-vigilance activities. The sole treatment available for heat fatigue is to remove heat stress and increase fluid replacement before a more serious heat-related condition develops.

Confined Spaces

Special considerations are necessary during the fermentation, aging, and cellaring processes. A critical safety consideration is permit-required confined spaces. Most of the brewery vessels are considered confined spaces, as they meet the standard definition:

- Has limited or restricted means of entry or exit
- Is large enough for a person to enter to perform tasks
- Is not designed or configured for continuous occupancy

A permit-required confined space is one that has an additional hazard, including:

- Contains or has the potential to contain a hazardous atmosphere
- Contains a material with the potential to engulf someone who enters the space
- Has an internal configuration that might cause an entrant to be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section
- Contains any other recognized serious safety or health hazards

People often inquire about where to get a permit to enter a confined space; however, it is not like a permit issued by a governmental agency. Instead, the permit is issued by the business as a way to ensure the safety and health of their employees. Because fermenters and bright tanks are both confined spaces, and a hazardous atmosphere (carbon dioxide, CO_2) is present, for workers to enter these vessels you need to issue a permit. Remember that according to OSHA, merely breaking the plane of the opening into a confined space with any part of the body qualifies as "entry." Don't think that you can just stick your head and arm through the hatch to clean the yeast off the top of the hatch flange, as this can kill you, since CO_2 is an asphyxiant. Either the atmosphere inside the tank has to be measured with an oxygen meter to ensure that the concentration of oxygen is above 19.5% or the tank has to be purged with air a sufficient number of times to ensure that the atmosphere inside is no longer hazardous.

If an employee needs to enter a confined space, the permit ensures that both the entrant and the attendant (two different people) are trained and qualified for the task. The attendant cannot leave their post while the entrant is inside, and they have to have a way to communicate with the entrant and to call for help if necessary. Your local fire department should be contacted in advance of any confined space entry to inquire as to whether they have a trained rescue crew available. If the fire department cannot respond to a confined space emergency, you need to have a contract in place with a private emergency response company.

Training your staff on confined space awareness is considered an important and necessary part of the brewery's health and safety program. Too many injuries and deaths have occurred in the past to disregard the importance of training your employees. Many deaths have occurred by a would-be rescuer entering a confined space trying to help the person who is hurt or incapacitated inside, only to succumb to the hazardous atmosphere inside and become a victim themselves.

Refrigeration

Most modern refrigeration systems use glycol as a cooling medium. Occasionally, an older building may already have a walk-in cooler or other type of refrigerator that is chilled using an ammonia-based system. Ammonia is highly toxic and regularly kills people exposed to it.

Anhydrous ammonia was previously used as a refrigerant in many industrial facilities. Under ambient conditions ammonia is a toxic gas, and many parts of such a refrigeration system contain ammonia liquefied under pressure. Release of ammonia can be harmful or fatal to workers and the public. If the ammonia is under pressure, the risk increases because larger quantities of it have the potential for rapid release into the air. Also, some explosions have been attributed to releases of ammonia contaminated with lubricating oil.

Ammonia can safely be used as a refrigerant if the system is properly designed, constructed, operated, and maintained. However, ammonia may be harmful if inhaled. OSHA has a PEL of 50 ppm. Effects of inhalation range from irritation to severe respiratory injuries; it can be fatal at higher concentrations. For the purposes of respirator selection, the National Institute for Occupational Safety and Health has established a level of 300 ppm as immediately dangerous to life and health. Ammonia is corrosive, and exposure will result in a chemical-type burn. Because ammonia is extremely hygroscopic, it migrates to moist areas of the body such as the eyes, nose, throat, and moist skin areas. Exposure to liquid ammonia will also result in frostbite, because its temperature at atmospheric pressure is –28°F.

Cleaning

Brewers use many different types of cleaning chemicals, because being a brewer is primarily being a janitor. Many mi-

crobes are waiting to spoil your beer. Although there are a number of environmentally friendly cleaning compounds available, just because they are safe for the environment does not mean they are safe for humans or animals. Caustics and acids used to clean and disinfect brewing vessels can remove the skin from your body, cause eye damage, and even kill you if you drink them. The common coolant used in breweries is ethylene glycol, the same stuff that is in your car radiator. Due to the "sweet" taste of this coolant, cats and dogs will drink any spills on the floor, which can prove fatal to your favorite brewery mascot. Be sure to read and understand the Safety Data Sheet (SDS) that accompanies chemical containers. If you buy a single gallon of something from a store, you can request a copy of the SDS, or find it online for free from the chemical manufacturer. The SDS has 16 sections of information that inform you of everything you need to know related to ingredients, handling, use, exposure, first aid, and disposing of the chemical.

REFERENCES

1. National Institute for Occupational Safety and Health. 1988 OSHA PEL Project Documentation. Grain dust. https://www.cdc.gov/niosh/pel88/graindst.html.
2. Occupational Safety and Health Administration. Heat stress guide. https://www.osha.gov/SLTC/emergencypreparedness/guides/heat.html.
3. Occupational Safety and Health Administration. Monitoring workers at risk of heat-related illness. https://www.osha.gov/SLTC/heatillness/heat_index/monitoring_workers.html.
4. Occupational Safety and Health Administration. 2004. Permit-required confined spaces. https://www.osha.gov/Publications/osha3138.html.
5. Pellissier, L., Oppliger, A., Hirzel, A. H., Savova-Bianchi, D., Mbayo, G., Mascher, F., Kellenberger, S., and Niculita-Hirzel, H. 2016. Airborne and grain dust fungal community compositions are shaped regionally by plant genotypes and farming practices. Appl. Environ. Microbiol. 82: 2121-2131. https://doi.org/10.1128/AEM.03336-15.
6. U.S. Environmental Protection Agency. 2001. Hazards of ammonia releases at ammonia refrigeration facilities. https://www.epa.gov/sites/production/files/2013-11/documents/ ammonia.pdf.