Environmental, Health, and Safety Guidelines for Breweries

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)[1]. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment. .

Applicability

The EHS Guidelines for Breweries cover the production of beer, from raw material storage to dispatch of the filled bottles, cans, kegs or barrels. **Annex A** contains a description of industry sector activities. This Guideline does not cover malt production nor the production of non-alcoholic beverages and soft drinks. This document is organized according to the following sections:

Section 1.0 — Industry-Specific Impacts and Management
Section 2.0 — Performance Indicators and Monitoring
Section 3.0 — References
Annex A — General Description of Industry Activities

[1] Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

1.0 Industry-Specific Impacts and Management

This section provides a summary of EHS issues associated with breweries that occur during the operations phase, along with recommendations for their management. Recommendations for the management of EHS issues common to most large industrial facilities during the construction and decommissioning phases are provided in the **General EHS Guidelines**.

1.1 Environment

Environmental issues associated with the operation phase of breweries primarily include the following:

- Energy consumption
- Water consumption
- Wastewater
- Solid waste and by-products
- Emissions to air

Energy Consumption

Brewery processes are relatively intensive users of both electrical and thermal energy. Thermal energy is used to raise steam in boilers, which is used largely for wort boiling and water heating in the brewhouse, and in the bottling hall. The process refrigeration system is typically the largest single consumer of electrical energy, but the brewhouse, bottling hall, and waste water treatment plant can account for substantial electricity demand. The specific energy consumption of a brewery is heavily influenced by utility system and process design; however, site-specific variations can arise from differences in product recipe and packaging type, the incoming temperature to the brewery of the brewing water and climatic variations.

Specific energy consumption in a brewery can vary from 100–200 megajoules per hectoliter (MJ/hl), depending on size, sophistication, and the factors listed above.[2] Substantial energy savings in many breweries can be achieved by adopting general guidance for energy management suggested in the **General EHS Guidelines**, in addition to the following techniques which have particular relevance to breweries:

- Install energy and water meters to measure and control consumption throughout the facility;
- Develop a hot water balance for the entire brewery to examine possibilities for heat recovery from production processes or utility systems to process or boil feed water;
- Recover heat from wort cooling to preheat water for mashing the next batch. In wort cooling, it is important to limit cooling water flow to approximately 1.1 times wort flow using refrigeration to supplement cooling if necessary. Wort coolers should have close approach temperatures (3-5 K) between leaving wort and incoming chilling water temperatures;
- Use a heat recovery system to condense vapors from the wort vessel. Recovered energy may be used as hot water in a variety of applications, for example, in the bottling hall as boiler feed water, or to preheat process water;
- Use high-gravity brewing, where beer is produced at greater than sales strength and diluted to the finished product alcohol content before packaging;
- Control and optimize evaporation in wort boiling, where 6 to 10 percent of the wort is deliberately boiled off.[3] Variations from recipe requirements may result in excessive energy use and variable product quality. Energy consumption in wort boiling can be reduced by:
    - o Controlling the inlet gravity to maintain as small a difference as possible between the gravity from the lautering and the final specific wort gravity;

[2] The Brewers of Europe (2002).
[3] Ibid.

- Controlling the gravity throughout boiling, in particular avoiding overboiling, for example by controlling batch size and the mass of steam used to heat the batch;
- Increasing evaporation efficiency for the unwanted flavor components by increasing the surface contact between the heater and wort.

- Ensure effective insulation of steam, hot water and refrigerant pipes, vessels, valves and flanges, brew kettles or parts of brew kettles, tunnel pasteurizers and bottle washers;
- Specify high regeneration ratios (>93%) in flash pasteurizers, for example those used in packaging and in the production of deaerated water; this also reduces refrigeration requirements;
- Limit use, and particularly overflow, of hot water (see the section on water consumption below);
- Optimize heating of tunnel pasteurizers and consider pasteurization unit control;
- Use cogeneration/combined heat and power (CHP)–based utility systems;
- Optimize refrigeration system operations by:
    - Using "high temperature" precooling of warm (approx. >20° Celsius (C)) water used as brewing and deaerated water
    - Elevating the evaporating temperature of the refrigeration system to the maximum extent possible. An evaporating temperature of -6ºC to -8ºC is sufficient, but often the refrigeration system is designed for a much lower evaporating temperature. Increasing the evaporating temperature by 1K will increase compressor cooling capacity and reduce the electricity consumption of the refrigeration system by 3–4 percent
    - Designing and operating the condensing side of the refrigeration system for the lowest possible condensing temperature. A decrease of 1K in condensing temperature will reduce the electricity consumption of the refrigeration system by 2 percent
- Ensure that the pressure in the compressed air system is as low as possible. If the pressure is reduced from 8 bar to 7 bar, electricity consumption should drop by approximately 7 percent;
- Optimize the operation of large electric motors by:
    - Examining opportunities to install variable speed drives, particularly for secondary refrigerant and water pumps
    - Adopting thermosyphon circulation of wort through the wort kettle heater, reducing the need for pumped circulation

Water Consumption

High consumption of good-quality water is characteristic of beer brewing. More than 90 percent of beer is water and an efficient brewery will use between 4–7 liters (l) of water to produce 1l of beer.[4] In addition to water for the product, breweries use water for heating and cooling, cleaning packaging vessels, production machinery and process areas, cleaning vehicles, and sanitary water. Water is also lost through wort boiling and with spent grains. Large quantities of good-quality water are needed for beer brewing. More than 90 percent of beer is water and an efficient brewery will use between 4–7 liters (l) of water to produce one liter of beer.[5] In addition to water for the product, breweries use water for heating and cooling, cleaning packaging vessels, production machinery and process areas, cleaning vehicles, and sanitation. Also water is lost through wort boiling and with spent grains.

Recommendations to reduce water consumption, especially where it may be a limited natural resource, are provided in the

[4] EC (2006)
[5] EC (2006)

General EHS Guidelines. Specific water consumption recommendations for brewery operations include the following:

- Limit water used in wort cooling to the volume needed for mashing, typically around 1.1 times the wort volume;
- Allow the storage level of recovered water tanks to fluctuate, thereby using storage capacity. Maintaining full tanks may lead to overflow and waste;
- Implement water conservation measures in the bottle-washers by:
  - Replacing older bottle washers with new energy and water-efficient bottle washers. New machines use much less water (e.g. 0.5 hectoliters(hl)/hl bottle volume compared with 3–4 hl/hl bottle volume)[6];
  - Installing automatic valve(s) to interrupt the water supply when there is a line stop;
  - Promptly replacing worn and oversized rinsing nozzles, as indicated by water monitoring programs, and using effective low-water use rinsing nozzles;
  - Controlling the rinsing water flow, which is often higher than specified or may vary due to pressure fluctuations in the water supply system;
  - Using fresh water for the last two rinsing nozzles only. Earlier rinsing nozzles should re-use rinse water in a countercurrent rinsing manner;
  - Using recovered water from the bottle washers in the crate washer.
- Optimize cleaning-in-place (CIP) plants and procedures to avoid unnecessary losses of water and cleaning chemicals (e.g. by saving water from the last rinse for use as the first rinsing water in the next CIP cycle);
- Evaluate the feasibility of a closed-loop system for water used in the pasteurization process, where water is recirculated via a cooling tower and returned to the tunnel pasteurizer. This reduces consumption of fresh water for the tunnel pasteurizer and makes up for water lost due to evaporation and potential bleed-off. Treatment of recirculating water is required to prevent growth of algae and microorganisms, and the risk of product contamination from recycled water must be carefully managed. Recycling systems can reduce the water consumption for the tunnel pasteurizers by 80 percent;
- Install a recirculation tank in connection with the vacuum pumps used in the packaging processes, which are continuously supplied with water to replace water discharged with air. A recirculation tank may result in water savings of 50 percent in the operation of the vacuum pump;[7]
- Recover water from process stages and reuse where possible, for example, in cooling and rinsing activities.

Wastewater

Industrial Process Wastewater – Load Reduction Techniques

The pollutant load of brewery effluent is primarily composed of organic material from process activities. Brewery processes also generate liquids such as the weak wort and residual beer which the brewery should reuse rather than allowing to enter the effluent stream. The main sources of residual beer include process tanks, diatomaceous earth filters, pipes, beer rejected in the packaging area, returned beer, and broken bottles in the packaging area.[8]

The following preventive management measures can be taken to reduce the organic load of brewery effluent:

- Collect weak wort in a tank equipped with heating jackets and a slow speed agitator for use in the next brew. This reduces the organic load in the wastewater, saving raw

[6] The Brewers of Europe (2002)

[7] Ibid.

[8] Total beer loss typically ranges between 1 to 5 percent of overall production. Brewers of Europe (2002)

materials and conserving water. Weak wort collection is particularly important for high-gravity brewing;[9]

- Undertake procedural improvements to reduce the amount of residual beer, such as the emptying of tanks, good housekeeping, and efficient monitoring systems;[10]
- Avoid overfilling of fermenting vessels which causes loss of partially-fermented wort and yeast;
- Ensure sedimentation of caustics from the bottle washer;
- Collect and reuse of rinsing water from the last cleaning in the first cleaning-in-place (CIP) cycle.

Process Wastewater Treatment

Techniques for treating industrial process wastewater in this sector include flow and load equalization, pH correction; sedimentation for suspended solids reduction using clarifiers; and biological treatment. Biological nutrient removal for reduction in nitrogen and phosphorus and disinfection by chlorination are sometimes required. Dewatering and disposal of residuals; in some instances composting or land application of wastewater treatment residuals of acceptable quality may be possible. Additional engineering controls may be required to contain and neutralize nuisance odors. Adoption of anaerobic biological treatment, followed by aeration is increasingly adopted by breweries worldwide. This technique has the benefits of much reduced footprint, substantial electricity savings and generation of biogas which can be used in boilers or for power generation.

Further guidance on management of industrial wastewater and examples of treatment approaches are discussed in the **General EHS Guidelines**. Through use of these technologies and good practice techniques for wastewater management, facilities should meet the Guideline Values for wastewater discharge as indicated in the relevant table of Section 2 of this industry sector document.

Other Wastewater Streams

Guidance on the management of non-contaminated wastewater from utility operations, non-contaminated stormwater, and sanitary sewage is provided in the **General EHS Guidelines**. Contaminated streams should be routed to the treatment system for industrial process wastewater.

Solid Wastes and By-products

Beer production results in a variety of residues, such as spent grains, which have a commercial value and can be sold as by-products to the agricultural sector. Recommended management measures to reduce solid waste production and increase by-product sales include:

- Optimal use of raw materials to increase yield and reduce generation of solid and liquid waste, including:
  - Avoidance of poor quality raw materials
  - Optimizing milling of the grist
  - Optimizing lautering, including sufficient sparging of the spent grains, to gain as much extract as possible
  - Collection and use of weak wort for mashing in the next brew
  - Optimizing clarification through use of a whirlpool as poor clarification results in a high trub[11] volume
  - Recovery of the wort from the hot trub
  - Recovery of beer from surplus yeast
  - Collection and reuse of residual beer. Pre-run and after-run beer is of high quality, and may be dosed directly into the beer flow in the filter line. Other

[9] The COD value of weak wort is around 10,000 mg/kg. The weak wort volume is 2–6 percent of the wort volume and 1–1.5 percent of the weak wort is extract. Collection of the weak wort will therefore reduce the wastewater load by 20–60 g COD/hl wort produced (The Brewers of Europe 2002).

[10] The COD value of beer is around 120,000 mg/kg depending on its strength and alcohol content. The total amount of residual beer will be in the area 1–5 percent of the total production, sometimes higher. A reduction of 1 percent in the loss of residual beer to the sewer system will reduce the wastewater load by 120 g COD/hl beer (The Brewers of Europe 2002).

[11] A precipitate consisting mainly of proteins (The Brewers of Europe, 2002).

residual beer from the packaging area should be returned to the whirlpool

- Where feasible, the commercial value of the waste streams should be exploited by:
  - Collecting spent brewers grains from mashing for sale as animal feed by-product
  - Avoiding discharge of hot trub into the sewer system. The hot trub should be returned to the mash kettle or lauter tun and mash filter. The trub then forms part of the brewers grains and can in this way be utilized as animal feed[12]
  - Collecting and reusing yeast from the fermentation process as a by-product. Yeast can be collected from fermentation and storage tanks, the yeast storage plant, and the filter line. Only part of the yeast can be reused in the next batch. As much surplus yeast as possible should be collected to avoid high chemical oxygen demand (COD) in the wastewater stream and resold for commercial use. Traditionally, surplus yeast has been sold as feed to pig livestock facilities. Other uses include yeast extract, yeast pills, cosmetics, and use by the pharmaceutical industry[13]
  - Recycling broken glass from returned bottles to produce new glass
  - Disposing of label pulp generated from washing of returned bottles. Where feasible, label pulp should be recycled or composted. Label pulp should be disposed of at a landfill facility if it contains high levels of caustic liquid from the washing process or heavy metals from label ink
  - Utilization of sludge from the brewery wastewater treatment plant through its application as an agricultural fertilizer, or disposal in an appropriate landfill facility

[12] The COD value of trub is around 150,000 milligrams per kilogram (mg/kg) wet trub. The amount of trub from a well-functioning whirlpool is 1 to 3 percent of the wort volume (in the case of insufficient whirlpool function even higher) with dry matter content between 15 and 20 percent. The reduction in wastewater load by returning the trub is therefore 150–450 grams (g) COD/hl wort (The Brewers of Europe 2002).

[13] The amount of this surplus and spent yeast slurry is 2–4 kg (10–15 percent dry matter content) per hl produced beer. The yeast suspension contains yeast and beer and has a high COD value (180,000–220,000 milligrams per liter (mg/l)). Very often the yeast or part of it is sent to the wastewater. The total COD load for the brewery will therefore be reduced by approximately 360–880 g COD/hl beer, if all yeast is collected instead of being led to the sewer system (Ibid.).

Emissions to Air of Odor and Dust

Odor and dust are the most significant air emissions from breweries. Emissions from combustion sources for energy production and boiler houses are covered in the **General EHS Guidelines**.

Odor

The wort boiling process is the main source of odor emissions from a brewery. To reduce odor emissions from wort boiling, a heat recovery system should be used to collect and condense the vapors and the recovered energy used in process or utility systems.

Dust

The main sources of dust emissions are the use and storage of grains, sugar, and kieselguhr. Cyclones and bag filters should be used to collect and recover dust in the following manner:

- Dust generated from the unloading of raw materials and transport of malt and adjuncts should be conveyed to the mash or adjunct kettle and the extract recovered;
- Dust arising from malt and adjuncts may be used as animal feed.

1.2 Occupational Health and Safety

Occupational health and safety issues during the construction and decommissioning of breweries are common to those of other industrial facilities and their prevention and control are discussed in the **General EHS Guidelines**. Occupational health and safety hazards associated with brewery operations include:

- Explosion risk
- Exposure to chemical hazards
- Physical hazards
- Exposure to noise and vibrations

Explosion Risk

Organic dust arising from grain storage, milling, and transport operations presents an explosion risk in the areas of the brewery where these operations occur. In addition to the guidance in the **General EHS Guidelines**, the following management measures should be taken to reduce dust explosion hazards:

- Frequent sweeping to control dust accumulation, and use of dust extraction and recycling systems to remove dust from work areas;
- Provision of electrical grounding, spark detection and prevention, and, if necessary, quenching systems;
- Use of explosion proof electrical motors, lights, switches, and connections in high risk areas;
- Integration of explosion relief vents in facility design and construction;
- Elimination of external ignition sources;
- Implementation of hot-work permits;
- Control of all smoking materials;
- Prohibition of cell phone use.

Exposure to Chemicals

Refrigerant Leakage

Breweries often have large refrigeration systems, typically using ammonia refrigerant which is toxic and can form explosive mixtures in air. Safety and other guidance offered by professional refrigeration institutions[14] should be adopted in refrigeration system siting, design, maintenance, and operation.

Asphyxiation

Carbon dioxide is produced during fermentation and maturation processes, carbon dioxide can be recovered, and carbon dioxide and / or nitrogen are stored and used in many brewery processes where inert atmospheres are required. Uncontrolled release of these gases or inadequate ventilation, particularly in confined or enclosed spaces such as fermentation and maturation rooms can result in accumulation of sufficient concentration to present asphyxiation risk. Appropriate safety measures should be developed based on a risk assessment, and may include enhanced ventilation, guidance on safe working in confined spaces contained within the **General EHS Guidelines**, and the use of personal gas detectors in high risk areas. Exposure to other chemicals typically involves chemical-handling activities related to cleaning, disinfection and maintenance of process areas, pipe work and vessels. Recommendations for the management of exposure to chemicals are presented in the **General EHS Guidelines**.

Physical Hazards

Physical hazards include exposure to same-level fall hazards due to slippery conditions, the use of machines and tools, the handling of glass bottles, and collisions with internal transport equipment, such as forklift trucks. Mills, mixers, grinders, augers and conveyors are potential hazards and may catch fingers, hair, and clothing. Eye injuries are a particular risk prevalent in bottling operations. The **General EHS Guidelines** provides guidance on general workplace conditions, including design and maintenance of working and walking surfaces to prevent slips

[14] For example the British Institute of Refrigeration (www.ior.org.uk) publishes guidelines on the safe design of ammonia (and other) refrigeration systems, safe handling of refrigerants etc. Refrigeration advice can also be obtained from ASHRAE (www.ahsrae.com) or the International Institute of Refrigeration (www.iifiir.org).

and falls, in addition to machine safety and guards, and the use of appropriate personal protective equipment (PPE).

Lifting, Carrying, Repetitive Work & Postures Injuries

Brewery activities that may expose workers to risk of injury typically arise from heavy manual lifting and carrying (for example, crates of bottles); repetitive work including packing and cleaning, and poor work postures caused by inadequate workstation and process activity design. Recommended management approaches to reduce these injuries are presented in the **General EHS Guidelines**.

Dust

Dust inhalation is an occupational health and safety risk, particularly in areas where dry grains, yeast, and kieselguhr are handled. Risk mitigation guidance described the **General EHS Guidelines** should be followed.

Pressurized Gas Systems

Brewery process activities involve the use of pressurized gases, such as carbon dioxide (CO_2) and nitrogen, refrigerants and compressed air. All these gases present hazards arising from over pressurization and tank ruptures, frostbite from CO_2, nitrogen or refrigerants, and physical injury due to mishandled or damaged cylinders and pipelines. Recommended measures for handling pressurized gas tanks and other fixtures are addressed in the **General EHS Guidelines**.

Exposure to Noise and Vibrations

Brewery workers may be exposed to noise arising from transport of raw materials and finished products, and from process and utility machinery. Recommendations for managing exposure to noise and vibration, including use of appropriate PPE, are presented in the **General EHS Guidelines**.

1.3 Community Health and Safety

Community health and safety issues for breweries are common to those of other industrial facilities and are discussed in the **General EHS Guidelines**.

Product Safety Impacts and Management

Brewery operations should follow internationally-recognized food safety standards consistent with the principles and practice of Hazard Analysis and Critical Control Point (HACCP)[15] and Codex Alimentarius.[16]

[15] ISO (2005).
[16] FAO and WHO (1962–2005).

2.0 Performance Indicators and Monitoring

2.1 Environment

Emissions and Effluent Guidelines

Table 1 presents effluent guidelines for the breweries sector. Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks. Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks. These guidelines are achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques, as discussed in preceding sections of this document. These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels in consideration of specific local project conditions should be justified in the environmental assessment.

Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in use of publicly operated sewage collection and treatment systems. If discharged directly to surface waters, discharge levels should be based on the receiving water use classification, as described in the **General EHS Guidelines**.

Combustion source emissions guidelines associated with steam- and power-generation activities from sources with a heat input capacity equal to or lower than 50 megawatts (MW) are addressed in the **General EHS Guidelines**. Larger power source emissions are addressed in the **EHS Guidelines for Thermal Power**. Guidance on ambient considerations based on the total load of emissions is provided in the **General EHS Guidelines**.

Table 1. Effluent levels for breweries

Pollutants	Units	Guideline Value
pH	pH	6 – 9
BOD_5	mg/l	25
COD	mg/l	125
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Temperature increase	°C	<3[b]
Total coliform bacteria	MPN[a] / 100 ml	400
Active Ingredients / Antibiotics	To be determined on a case specific basis	

Notes:
[a] MPN = Most Probable Number
[b] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Table 2. By-products and Waste Generation

Outputs per Unit of Product	Unit	Benchmark
By-products [a]		
Spent Grains	kg/hl beer	16-19
Yeast & Lees	kg/hl beer	1.7 - 2.9
Kieselguhr	kg/hl beer	0.4 – 0.7
Liquid Wastes		
Liquid Effluents	hl/hl beer	3 – 6
Beer Loss	%	1 - 5

Notes:
[a] Input and Output Figures for Large German Breweries (capacity over 1 million hl beer) EC (2006

Resource Use

Tables 2 and 3 provide examples of waste and by-product production and energy and water consumption indicators for efficient breweries. Industry benchmark values are provided for comparative purposes only and individual projects should target continual improvement in these areas.

Table 3. Energy and Water Consumption

Outputs per Unit of Product	Unit	Benchmark
Energy [a]		
Heat	MJ/hl	85–120
Electricity	kWh/hl	7.5–11.5
Total Energy	MJ/hl	100-160
Water [a]		
Water consumption	hl/hl beer	4 - 7

Notes: [a] Input and Output Figures for Large German Breweries (capacity over 1 million hl beer) EC (2006)

Environmental Monitoring

Monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant environmental impacts during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures, and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),[17] the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),[18] Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),[19] Indicative Occupational Exposure Limit Values published by European Union member states,[20] or other similar sources.

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)[21].

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be

[17] Available at: http://www.acgih.org/TLV/ and http://www.acgih.org/store/
[18] Available at: http://www.cdc.gov/niosh/npg/
[19] Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992
[20] Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/
[21] Available at: http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm

designed and implemented by accredited professionals,[22] as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents, diseases, and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

[22] Accredited professionals may include certified industrial hygienists, registered occupational hygienists, or certified safety professionals or their equivalent.

3.0 References and Additional Sources

Curtin University of Technology, Centre of Excellence in Cleaner Production (CECP). 2002. Swan Brewery: Water and Energy Efficiency. Western Australia Case Studies. Perth: CECP. Available at http://cleanerproduction.curtin.edu.au/cecp/cecpcasestudyhome.htm

Dansk Standard. 2004. DS/OHSAS 18001:2004. Occupational health and safety management systems – Specification. 1 udgave. 2004–11-08. Copenhagen: Dansk Standard.

European Commission. 2006. European Integrated Pollution Prevention and Control Bureau (EIPPCB). Reference Document on Best Available Techniques (BAT) in the Food, Drink and Milk Industries. Seville: EIPPCB. Available at http://eippcb.jrc.es/pages/FActivities.htm

Health and Safety Commission (HSC). 2005a. Food Manufacture – Beer, Spirit and Soft Drink Manufacture. Injury Rate Comparison. London: National Statistics. Available at http://www.hse.gov.uk/food/drink.htm

HSC. 2005b. Health and Safety Statistics 2004/05. London: National Statistics. Available at http://www.hse.gov.uk/statistics/overall/hssh0405.pdf

HSC. 2005c. Rates of reported fatal injury to workers, non fatal injuries to employees and LFS rates of reportable injury to workers in manufacturing. London: National Statistics. Available at http://www.hse.gov.uk/statistics/industry/manufacturing-ld1.htm#notes

HSC. 2005d. Statistics of fatal injuries 2004/05. Fatal injuries to workers in manufacturing. London: National Statistics. Available at www.hse.gov.uk/statistics/overall/fatl0405.pdf

Indian Environmental Protection Agency (EPA). 1992. Central Pollution Control Board (CPCB). Notification May 5, 1992. 27.0 Fermentation Industry: Wastewater Discharge Standards (Distilleries, Maltries & Breweries). Delhi: Indian EPA. Available at http://www.cpcb.nic.in/standard27.htm

Irish Environmental Protection Agency (EPA). 1996. Best Available Technology Not Entailing Excessive Costs (BATNEEC) Guidance Note for Malting, Brewing & Distilling. Co. Wexford: Irish EPA. Available at http://www.epa.ie/TechnicalGuidanceandAdvice/GuidanceDocuments/

International Organization for Standardization (ISO). 2005. ISO 22000: 2005: Food Safety Management Systems - Requirements for any organization in the food chain. Geneva: ISO. Available at http://www.iso.org

ISO. 2004a. ISO 14001: 2004: Environmental Management Systems - Requirements with guidance for use. Geneva: ISO. Available at http://www.iso.org

ISO. 2004b. ISO 9001: 2000: Quality Management System. Geneva: ISO. Available at http://www.iso.org

Thailand Ministry of Natural Resources, Science and Environment. Pollution Control Department (PCD). 1996. Water Quality Standards: Industrial Effluent Standards. Bangkok: PCD. Available at http://www.pcd.go.th/info_serv/en_reg_std_water04.html#s1

The Brewers of Europe. 2002. Guidance Note for Establishing BAT in the Brewing Industry. October 2002. Brussels: Brewers of Europe. Available at http://www.brewersofeurope.org/asp/publications/publications.asp

United Nations Environment Programme (UNEP). 1996. Division of Technology, Industry and Economics (DTIE). Cleaner Production in Breweries: A Workbook for Trainers. First Edition. Paris: UNEP. Available at http://www.uneptie.org/pc/cp/library/catalogue/cp_training.htm

United States Bureau of Labor Statistics (BLS). 2004a. Census of Fatal Occupational Injuries Charts, 1992–2004. Number and rate of fatal occupational injuries by private industry sector, 2004. (Table page 10). Washington DC: BLS. Available at http://www.bls.gov/iif/oshwc/cfoi/cfch0003.pdf

US BLS. 2004b. Industry Injury and Illness Data – 2004. Supplemental News Release Tables. Table SNR05: Incident rate and number of nonfatal occupational injuries by industry, 2004. Washington D.C.: BLS. Available at http://www.bls.gov/iif/oshwc/osh/os/ostb1479.pdf.

Annex A: General Description of Industry Activities

Beer is a low alcohol content beverage produced by fermenting sugars extracted from various types of cereals. A large number of different beer types exist that vary in the use of raw material, and the strength, taste profile, and packing of the final product. Each brewery generally has its own specific product and container mix.

Production methods differ by brewery, as well as according to beer types, equipment, and national legislation. Historically beer was produced from malted barley. However, there is a trend toward a more diverse group of cereals, with modern large breweries increasingly using maize and rice. The sugar is extracted from the cereal into the water, hops are added, and the mixture boiled. After cooling, the mix is fermented with yeast to produce alcohol. This raw beer is then matured and packed. Some beers are filtered and pasteurized.

Raw Material Handling and Storage

The raw materials for beer production generally include cereal (barley malt, rice or maize), hops, water, and yeast. The malting process converts the starch in the cereal into fermentable sugar which is extracted from the malt during mashing. Extracts from the hop are used as a preservative and to add bitterness to the sugar solution. Yeast converts the sugars into alcohol during fermentation. Brewery operations require heating and cooling, cleaning agents, and packaging materials.

Wort Production

The delivered cereal is weighed, conveyed, cleaned, and stored in silos until it is made available for wort production. Cleaning and grinding / milling activities are used to prepare the cereal for mashing. Mashing, lautering and wort boiling together are the brewing stages of the beer-making process.

Milling

The cereal is milled to produce a mixture of flour and husks known as grist. The fineness to which the malt is milled is a balance between best extract yield, the chosen technology, and ability to filter the wort. The cereal handling areas should be designed to control excessive dust production and minimize sources of ignition including sparks to prevent explosions.

Mashing

After milling, the grist is mixed with hot water, to form a "mash" and left to stand in a process known as mashing. The purpose of mashing is to obtain a high yield of fermentable extract from the malt grist and adjuncts by extraction into the brewing water. This extract is "wort." Only a minor part of the extract is obtained by being dissolved, while the remainder is extracted by means of the enzymatic breakdown of complex insoluble substances to simple water-soluble substances. Physical parameters such as temperature, pH, and the length of mashing time should be carefully controlled to obtain optimum extraction.

Mash Filtration

Wort is separated from the solid portion of the mash, known as "brewers grains" by filtration. This process is called lautering and takes place in a lauter tun or in a mash filter at a temperature of about 75ºC to 78ºC.[23] After lautering, the spent brewers grains are discharged to silos and traditionally sold to farmers for use as cattle feed. Brewers grains from lauter tuns have a dry matter content of 19–22 percent and from mash filters a dry matter content of 35–40 percent. The remaining wort in the lauter tun will have a low content of extract and is called weak "wort".

[23] The Brewers of Europe (2002).

Wort Boiling

Following removal of the spent brewers grains, the wort is transferred to the wort kettle. The wort is heated to boiling in the wort kettle and hops are added. and the wort is boiled for 1 to 1.5 hours with a boiling intensity of 5–8 percent evaporation of casting volume[24] per hour. Total evaporation is generally 6–10 percent. Heating and boiling of wort are highly energy intensive.

Wort Clarification and Cooling

Following boiling, the wort is cleaned, typically by passing it through a "whirlpool" which separates clean wort from residual solids known as trub. After clarification, the wort is cooled to the "pitching temperature" (the temperature at which the cooled wort enters the fermentation vessel) in a heat exchanger (the "wort cooler") which is cooled by chilled water. Wort cooling can be achieved with a volume of cooling water around 1.1 times the wort volume. Hot water (75ºC to 85ºC) arising from the wort cooler is collected and used as brewing water for the next batch. Discharge of organic matter (trub) can occur through the clarification process.

High Gravity Brewing

High gravity brewing is often used to produce wort that contains sufficient concentration of extract that complete fermentation will result in a beer with a higher alcohol content than that of as-sold beer. Sales strength is achieved by dilution with de-aerated brewing quality water. This technique results in energy savings because dilution water is not heated in the mashing and wort boiling processes. It also enables brewhouse and fermenting vessels to produce a higher quantity of sales strength beer than would otherwise result.

Fermentation and Maturation

After the wort has been cooled to the pitching temperature, oxygen is added. The wort is then pumped to the fermentation vessels (FVs) where yeast is added and fermentation starts. During fermentation, yeast converts sugar in wort to alcohol and carbon dioxide. The fermentation process is exothermic, and temperatures are carefully controlled according to process needs which often vary according to the nature of the product and region of production. The duration of the fermentation is determined by the product recipe. Carbon dioxide produced during fermentation may be collected for use in various brewery processes.

Fermentation is stopped through rapid cooling of the FV, at which time the yeast is harvested and pumped to the storage tank. Fermentation produces more yeast than is typically required for the next batch. Therefore, part of the harvested yeast is disposed of, often being used as animal feed.

After fermentation, the beer is pumped into tanks for maturation under controlled temperature conditions for several weeks.

Beer Processing

Filtration

Following maturation, most beer is filtered to remove remaining yeast to obtain "bright beer" which has the specified level of clarity and prolonged shelf life. The filtration takes place in a kieselguhr (diatomaceous earth) filter using frame, candle, or mesh filters. Spent kieselguhr can be used in farming, reprocessed, or as building material. Following filtration beer is stored in "bright beer tanks" and is ready for packaging in the bottling hall.

[24] Ibid.

Carbonation

The beer may be carbonated before being sent to the bright beer tanks. Nitrogen gas may also be used in small quantities to enhance foam performance.

Dilution

High alcohol content beer resulting from high-gravity brewing is diluted to final product strength with de-aerated brewing-quality water before packaging.

Cleaning-in-Place (CIP)

It is important that all process equipment and pipes are kept clean and disinfected. Cleaning is carried out by means of CIP systems, where cleaning agents are circulated through the equipment or sprinkled over the surface of the tanks. Caustic soda or acid are often used as cleaning agents. The cleaning and disinfection of the brewery equipment may use a substantial amount of energy, water, cleaning agents, and disinfectants. The design of CIP systems can vary greatly, ranging from simple systems in which a batch of cleaning solutions is prepared and pumped through the system and drained, to fully automatic systems consisting of tanks for water and cleaning solutions that make it possible to reuse some water and cleaning solutions.

Packaging Operations

Beer is pumped from the bright beer tanks and after dilution to sales strength is bottled, canned, or kegged in the packaging area. During these operations, it is important that the beer is protected from oxygen contact and carbonation loss. Packaging lines may have different packaging materials and levels of automation, and typically produce high noise levels.

Bottle Washing and Control

Returned bottles are sorted electronically. Foreign bottles are returned to their respective manufacturers or crushed and sent to recycling. After sorting, bottles are sent to a bottle washer where all internal and external impurities are removed. Bottle washer operations typically include soaking and washing, high – temperature sterilization, and rinsing. The bottle washer consumes large quantities of energy, water, and caustic soda. Substantial quantities of wastewater are discharged and the effluent may have a high organic load. When a bottle has been cleaned, it is inspected for damage and residual dirt.

Bottle Filling

The bottles are transported by conveyor belts from the bottle washer to the filling machine. They are filled under pressure according to the quantity of dissolved carbon dioxide in the beer. An important function of the filling machine is to prevent oxygen from coming into contact with the beer. The bottles are sealed immediately after filling (usually with crown corks) and the filling volume is checked. The sealed bottles are then conveyed to the tunnel pasteurizer.

Can Filling

Can filling is based on the same principles as bottle filling. Because of their low weight, it is necessary to convey the cans gently to ensure constant spacing. Furthermore, special attention should be paid to the thin wall thickness and resulting low stability of the cans. Filling lines consume large quantities of electricity. Beer loss can occur on the filling line, contributing to the organic load of the effluent.

Pasteurization

Beer is usually pasteurized to kill any remaining live yeasts or other microorganisms and so prolong the shelf life. Two alternative methods are used for pasteurization:

- Tunnel pasteurization, during which the beer is pasteurized in bottles or cans (i.e. the beer and container are pasteurized as a closed, assembled unit);
- Flash pasteurization, which employs a heat exchanger in which the beer is pasteurized before it is filled into kegs.

Labeling

Following tunnel pasteurization, the bottles are conveyed to the labeler. Starch- or protein-based glues are used as adhesives to ensure labels come off easily when the returnable bottles are cleaned. Labeling lines consume large quantities of electricity. High noise levels can arise from the labeling line.

Packing

Bottles and cans are packed in crates, cartons, or other forms of transport packaging and palletized. Kegs are transported on pallets.

Utilities

Brewery processes have a high energy demand for heating and cooling purposes, in addition to high water consumption. Utility installations are therefore a key factor in this sector. Brewery processes are typically supplied with heat from a steam boiler plant. Process cooling is usually provided by central ammonia-based refrigeration systems, which circulate ammonia or a secondary fluid (e.g. chilled water, brines or glycols) to the points where cooling is required. Compressed air is mainly used for instruments, actuators, pressurizing of tanks, and sometimes the transport of spent brewers grain.

Water Treatment Plant

Breweries typically draw water from wells or from surface intake at a lake or river, and use several different qualities of water, for example, brewing quality water for mashing, deaerated brewing water for dilution, softened water for utility systems and tunnel pasteurizers, washdown water etc. For this reason, breweries often have several sophisticated water treatment facilities.

CO_2 Recovery Plant

The CO_2 generated during the fermentation process can be collected, cleaned and stored before being used in the process. CO_2 is necessary for carbonation and to provide inert atmospheres as required by the process.

Nitrogen Generation

Breweries may use nitrogen instead of CO_2 to provide inert atmospheres. Nitrogen can be generated on site from atmospheric air through a thermal or membrane separation technique or can be supplied in bulk from external sources.

Electricity Supply

Most breweries purchase electricity from the national grid, although some use cogeneration/combined heat and power (CHP) plants that produce both electricity and heat/steam.

Figure A.1: Supply Chain Process for Beer Production