Breweries

Industry Description and Practices

Beer is a fermented beverage with low alcohol content made from various types of grain. Barley predominates, but wheat, maize, and other grains can be used. The production steps include:

- *Malt production and handling:* grain delivery and cleaning; steeping of the grain in water to start germination; growth of rootlets and development of enzymes (which convert starch into maltose); kilning and polishing of the malt to remove rootlets; storage of the cleaned malt
- *Wort production:* grinding the malt to grist; mixing grist with water to produce a mash in the mash tun; heating of the mash to activate enzymes; separation of grist residues in the lauter tun to leave a liquid wort; boiling of the wort with hops; separation of the wort from the trub/hot break (precipitated residues), with the liquid part of the trub being returned to the lauter tub and the spent hops going to a collection vessel; and cooling of the wort
- *Beer production:* addition of yeast to cooled wort; fermentation; separation of spent yeast by filtration, centrifugation or settling; bottling or kegging.

Water consumption for breweries generally ranges 4–8 cubic meter per cubic meter (m^3/m^3) of beer produced. Water consumption for individual process stages, as reported for the German brewing industry, is shown in Table 1.

Waste Characteristics

Breweries can achieve an effluent discharge of 3–5 m^3/m^3 of sold beer (exclusive of cooling waters). Untreated effluents typically contain suspended solids in the range 10–60 milligrams per liter (mg/l), biochemical oxygen demand (BOD) in the range 1,000–1,500 mg/l, chemical oxygen demand (COD) in the range 1,800–3,000 mg/l, and nitrogen in the range 30–100 mg/l. Phosphorus can also be present at concentrations of the order of 10–30 mg/l.

Effluents from individual process steps are variable. For example, bottle washing produces a large volume of effluent that, however, contains only a minor part of the total organics discharged from the brewery. Effluents from fermentation and filtering are high in organics and BOD but low in volume, accounting for about 3% of total wastewater volume but 97% of BOD. Effluent pH averages about 7 for the combined effluent but can fluctuate from 3 to 12 depending on the use of acid and alkaline cleaning agents. Effluent temperatures average about 30°C.

Table 1. Water Consumption Reported for the German Brewing Industry

(*m^3/m^3 of sold beer; numbers in parentheses are ranges*)

Process step	*Water consumption*
Gyle (unfermented wort) to whirlpool	2.0 (1.8– 2.2)
Wort cooling	0.0 (0.0– 2.4)
Fermentation cellar and yeast treatment	0.6 (0.5– 0.8)
Filter and pressure tank room	0.3 (0.1– 0.5)
Storage cellar	0.5 (0.3– 0.6)
Bottling (70% of beer produced)	1.1 (0.9– 2.1)
Barrel filling (30% of beer produced)	0.1 (0.1– 0.2)
Wastewater from cleaning of vehicles, sanitary use, etc.	1.5 (1.0– 3.0)
Steam boiler	0.2 (0.1– 0.3)
Air compressor	0.3 (0.1– 0.5)
Total	6.6 (4.9–12.6)

Note: Numbers have been rounded.

Solid wastes for disposal include grit, weed seed, and grain of less than 2.2 millimeters in diameter, removed when grain is cleaned; spent grain and yeast; spent hops; broken bottles or bottles that cannot be recycled to the process; and cardboard and other solid wastes associated with the process, such as kieselguhr (diatomaceous earth used for clarifying).

Breweries do not discharge air pollutants, other than some odors.

Pollution Prevention and Control

Pollution prevention and control are best practiced through effective management, maintenance, and housekeeping in a process that incorporates water conservation and recycling, energy conservation, and disposal of solid wastes as by-products. Some options that may be considered include:

- Clean-in-place (CIP) methods for decontaminating equipment
- High-pressure, low-volume hoses for equipment cleaning
- Recirculating systems on cooling water circuits
- Use of grit, weed seed, and discarded grain as chicken feed
- Use of spent grain as animal feed, either 80% wet, or dry after evaporation
- Disposal of wet hops by adding them to the spent grain
- Disposal of spent hop liquor by mixing with spent grain
- Use for livestock feed of spent yeast that is not reused
- Disposal of trub by adding it to spent grain
- Recovery of spilled beer, adding it to spent grain that is being dried through evaporation
- Filtration of bottom sediments from final fermentation tanks for use as animal feed
- Reduction of energy consumption through reuse of wort-cooling water as the process water for the next mash
- Collection of broken glass, bottles that cannot be used, and waste cardboard for recycling.

Consideration should be given to the use of non-phosphate-containing cleaning agents.

Breweries have a favorable steam-to-electricity ratio. Planning for cogeneration of electricity may be advantageous.

Treatment Technologies

If the brewery does not discharge to a municipal sewer, primary and secondary treatment of the effluent is required. Primary treatment facilities may include pH adjustment, roughing screens, grit-settling chambers, and a clarifier. Choices of processes for removing BOD in a secondary treatment stage include anaerobic treatment followed by aerobic treatment and activated sludge systems.

Sludges from the clarifier are dewatered and disposed of through incineration or to an approved landfill.

Where the brewery is permitted to discharge to a municipal sewer, pretreatment may be required to meet municipal by-laws and to lessen the load on the municipal treatment plant. In some cases, sewer discharge fees imposed by the municipality on effluent volume and on the suspended and BOD loads may encourage the brewery to install its own treatment facility.

Modern plants using good industrial practices are able to achieve the following performance in terms of pollutant loads. Water conservation and recycling will allow water consumption to be kept to a minimum. A new brewery should target on achieving an effluent range of 3–5 m^3 / m^3 beer produced. Provision for recycling liquors and reusing wash waters will help reduce the total volume of liquid effluent. A new brewery should set as a target the achievement of a treated effluent that has less than 0.3 kilograms (kg) of BOD / m^3 beer produced and 0.3 kg of suspended solids / m^3 beer produced (assuming discharge to receiving waters).

Odor emissions can be minimized if exhaust vapors are condensed before they are released to the atmosphere or if vapors are sent to the boiler and burned.

Emissions Guidelines

Emissions levels for the design and operation of each project must be established through the environmental assessment (EA) process on the basis of country legislation and the *Pollution Prevention and Abatement Handbook*, as applied to local conditions. The emissions levels selected must be justified in the EA and acceptable to the World Bank Group.

The guidelines given below present emissions levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance. Any deviations from these levels must be described in the World Bank Group project documentation. The emissions levels given here can be consistently achieved by well-designed, well-operated, and well-maintained pollution control systems.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

Liquid Effluents

The effluent levels presented in Table 2 should be achieved.

Ambient Noise

Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

Table 2. Effluents from Breweries

(milligrams per liter, except for pH and temperature)

Parameter	*Maximum value*
pH	6–9
BOD	50
COD	250
TSS	50
Oil and grease	10
Ammonia nitrogen (NH_4–N)	10
Phosphorus	5
Temperature increase	≤ 3° C[a]

Note: Effluent requirements are for direct discharge to surface waters.

a. The effluent should result in a temperature increase of no more than 3°C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge.

	Maximum allowable log equivalent (hourly measurements), in dB(A)	
Receptor	*Day (07:00–22:00)*	*Night (22:00–07:00)*
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Monitoring and Reporting

Monitoring of the final effluent for the parameters listed in this document should be carried out at least once per month, or more frequently if the flows vary significantly.

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. Records of monitoring results should be kept in an acceptable format. The results should be reported to the responsible authorities and relevant parties, as required.

Key Issues

The key production and control practices that will lead to compliance with emissions requirements can be summarized as follows:

- Implement sound maintenance and housekeeping procedures.
- Minimize water consumption and effluent generation through recycling and reuse of process streams.
- Dispose of process solid wastes as by-products for animal feed.
- Send broken and rejected bottles and waste cardboard to recycling plants.
- Maintain effluent treatment facilities to operating design specifications.

Source

World Bank, 1997. "Industrial Pollution Prevention and Abatement: Breweries." Draft Technical Background Document. Environment Department, Washington, D.C.