

Sugar Manufacturing

Industry Description and Practices

The sugar industry processes sugar cane and sugar beet to manufacture edible sugar. More than 60% of the world's sugar production is from sugar cane; the balance is from sugar beet. Sugar manufacturing is a highly seasonal industry, with season lengths of about 6 to 18 weeks for beets and 20 to 32 weeks for cane.

Approximately 10% of the sugar cane can be processed to commercial sugar, using approximately 20 cubic meters of water per metric ton (m^3/t) of cane processed. Sugar cane contains 70% water; 14% fiber; 13.3% saccharose (about 10 to 15% sucrose), and 2.7% soluble impurities. Sugar canes are generally washed, after which juice is extracted from them. The juice is clarified to remove mud, evaporated to prepare syrup, crystallized to separate out the liquor, and centrifuged to separate molasses from the crystals. Sugar crystals are then dried and may be further refined before bagging for shipment. In some places (for example, in South Africa), juice is extracted by a diffusion process that can give higher rates of extraction with lower energy consumption and reduced operating and maintenance costs.

For processing sugar beet (water, 75%; sugar, 17%), only the washing, preparation, and extraction processes are different. After washing, the beet is sliced, and the slices are drawn into a slowly rotating diffuser where a countercurrent flow of water is used to remove sugar from the beet slices. Approximately 15 cubic meters (m^3) of water and 28 kilowatt-hours (kWh) of energy are consumed per metric ton of beet processed.

Sugar refining involves removal of impurities and decolorization. The steps generally followed include affination (mingling and centrifugation),

melting, clarification, decolorization, evaporation, crystallization, and finishing. Decolorization methods use granular activated carbon, powdered activated carbon, ion exchange resins, and other materials.

Waste Characteristics

The main air emissions from sugar processing and refining result primarily from the combustion of bagasse (the fiber residue of sugar cane), fuel oil, or coal. Other air emission sources include juice fermentation units, evaporators, and sulfitation units. Approximately 5.5 kilograms of fly ash per metric ton (kg/t) of cane processed (or $4,500 \text{ mg}/\text{m}^3$ of fly ash) are present in the flue gases from the combustion of bagasse.

Sugar manufacturing effluents typically have biochemical oxygen demand (BOD) of 1,700–6,600 milligrams per liter (mg/l) in untreated effluent from cane processing and 4,000–7,000 mg/l from beet processing; chemical oxygen demand (COD) of 2,300–8,000 mg/l from cane processing and up to 10,000 mg/l from beet processing; total suspended solids of up to 5,000 mg/l ; and high ammonium content. The wastewater may contain pathogens from contaminated materials or production processes. A sugar mill often generates odor and dust, which need to be controlled. Most of the solid wastes can be processed into other products and by-products. In some cases, pesticides may be present in the sugar cane rinse liquids.

Pollution Prevention and Control

Good pollution prevention practices in sugar manufacturing focus on the following main areas:

- Reduce product losses to less than 10% by better production control. Perform sugar auditing.
- Discourage spraying of molasses on the ground for disposal.
- Minimize storage time for juice and other intermediate products to reduce product losses and discharge of product into the wastewater stream.
- Give preference to less polluting clarification processes such as those using bentonite instead of sulfite for the manufacture of white sugar.
- Collect waste product for use in other industries—for example, bagasse for use in paper mills and as fuel. Cogeneration systems for large sugar mills generate electricity for sale. Beet chips can be used as animal feed.
- Optimize the use of water and cleaning chemicals. Procure cane washed in the field. Prefer the use of dry cleaning methods.
- Recirculate cooling waters.

Continuous sampling and measurement of key production parameters allow production losses to be identified and reduced, thus reducing the waste load. Fermentation processes and juice handling are the main sources of leakage. Odor problems can usually be prevented with good hygiene and storage practices.

Target Pollution Loads

Since the pollutants generated by the industry are largely losses in production, improvements in production efficiency are recommended to reduce pollutant loads. Approximately 90% of the saccharose should be accounted for, and 85% of the sucrose can be recovered. Recirculation of water should be maximized.

Wastewater loads can be reduced to at least 1.3 m³/t of cane processed, and plant operators should aim at rates of 0.9 m³/t or less through recirculation of wastewater. Wastewater loads from beet processing should be less than 4m³/t of sugar produced or 0.75 m³/t of beet processed, with a target of 0.3 to 0.6 m³/t of beet processed.

Treatment Technologies

Pretreatment of effluents consists of screening and aeration, normally followed by biological

treatment. If space is available, land treatment or pond systems are potential treatment methods. Other possible biological treatment systems include activated sludge and anaerobic systems, which can achieve a reduction in the BOD level of over 95%.

Odor control by ventilation and sanitation may be required for fermentation and juice-processing areas. Biofilters may be used for controlling odor. Cyclones, scrubbers, and electrostatic precipitators are used for dust control.

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.

Air Emissions

Particulate matter and sulfur oxide emissions should be less than 100 milligrams per normal cubic meter (mg/Nm³). In some cases, emissions of particulate matter may be up to 150 mg/Nm³ for small mills with less than 8.7 megawatts (MW) heat input to the boiler, and emissions of sulfur oxides may be up to 2,000 mg/Nm³. Nitrogen oxide emissions should be less than 260 nanograms per joule (ng/J), or 750 mg/Nm³, for solid

Table 1. Effluents from Sugar Manufacturing

(milligrams per liter, except for pH and temperature)

Parameter	Maximum value
pH	6–9
BOD	50
COD	250
TSS	50
Oil and grease	10
Total nitrogen (NH ₄ -N)	10
Total phosphorus	2
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.

fuels and 130 ng/J (460 mg/Nm³) for liquid fuels. Odor controls should be implemented where necessary to achieve acceptable odor quality for nearby residents.

Liquid Effluents

The effluent levels presented in Table 1 should be achieved.

Biocides should not be present above detection levels or should be less than 0.05 mg/l.

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.

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

Monitoring and Reporting

Monitoring of air emissions should be on an annual basis, with continuous monitoring of the fuel used. Only fuels with acceptable levels of ash and sulfur should be used. Monitoring of the final effluent for the parameters listed in this document should be carried out at least daily, or more frequently if the flows vary significantly. Effluents should be sampled annually to ensure that biocides are not present at significant levels.

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 guidelines can be summarized as follows:

- Monitor key production parameters to reduce product losses to less than 10%.
- Design and operate the production system to achieve recommended wastewater loads.
- Recirculate cooling waters.
- Collect wastes for use in low-grade products.

Sources

Economopoulos, Alexander P. 1993. *Assessment of Sources of Air, Water, and Land Pollution: A Guide to Rapid Source Inventory Techniques and their Use in Formulating Environmental Control Strategies*. Part 1: *Rapid Inventory Techniques in Environmental Pollution*. Geneva: World Health Organization.

World Bank. 1995. "Industrial Pollution Prevention and Abatement: Sugar Manufacturing." Draft Technical Background Document. Environment Department, Washington, D.C.