Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Use food processing industry terminology accurately.
2. Use industry-standard food processing symbols.

Resources. The following resources may be useful in teaching this lesson:

E-unit(s) corresponding to this lesson plan. CAERT, Inc. [http://www.mycaert.com](http://www.mycaert.com).


Equipment, Tools, Supplies, and Facilities

- Overhead or PowerPoint projector
- Visual(s) from accompanying master(s)
- Copies of sample test, lab sheet(s), and/or other items designed for duplication
- Materials listed on duplicated items
- Computers with printers and Internet access
- Classroom resource and reference materials

Key Terms. The following terms are presented in this lesson (shown in bold italics):

- building information modeling (BIM)
- building/zoning code
- food processing
- food processing industry
- future growth potential
- GWP index
- Hazard Analysis Critical Control Points (HACCP)
- halocarbon (Freon) refrigerants
- high-efficiency particulate air (HEPA) filtration
- Leadership in Energy & Environmental Design (LEED)
- operational support
- process flow
- process flow diagram (PFD)
- site plan
- symbols
- ventilation

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Approach the topic of food processing drafting and design by explaining how important all design steps and sanitary code are to the quality and safety of food. Project the video “Food Plant Engineering” at https://www.youtube.com/watch?v=JuaygbS1-l4 to provide an overview of the design process of a food manufacturer.
Consider bringing in a processed food and all the product’s raw ingredients: energy bars, breakfast cereal, etc. Then ask students to brainstorm the steps to manufacture the raw ingredients for an energy bar into the processed food. The goal is to help students understand how important it is to effectively and clearly communicate with engineers, electricians, technicians, installers/contractors, architects, and drafters.

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Use food processing industry terminology accurately.

Anticipated Problem: What are industry-standard food processing terms?

I. Food processing terminology

A. **Food processing** is the transformation of raw ingredients by physical or chemical means into food or food into other forms. The **food processing industry** is the manufacturers of food products, beverages, condiments, tobacco, soap and detergents, and perfume and cosmetics. According to Johns Hopkins University, food is processed for:

1. Preservation—This process keeps food from spoiling.
2. Food safety—Food safety exists to inhibit pathogens (disease-causing organisms) and toxins (poisons) and to reduce foodborne illness outbreaks.
3. Variety—This has to do with changing the flavor, texture, aroma, color, or form.
4. Convenience—This has to do with shortening the preparation time of some foods.
5. Nutrition—This has to do with increasing/preserving the nutrition levels of some foods.

B. Food processing terminology

1. Canning is a preservation process that places food items in airtight cans or jars. It typically requires the food item to be cooked, cooled, “tinned,” and sealed.
2. Curing is a preservation process that alters the chemical composition of food so nutrients are retained, but the rate of spoilage is reduced. Curing agents must be within the industry standards and include heat, smoke, salt, and other chemical additives.
3. Drying is a food preservation method that removes water from a food item to ensure that harmful bacteria and mold will not grow and cause the food to become inedible. (NOTE: Drying methods include freeze-drying, vacuum-drying, hot-air drying, and dehydration.)
4. Freezing is a food preservation method that keeps food safe from bacterial contamination by keeping the food at a temperature that is not conducive to bacteria, mold, fungi, or parasitic growth. (NOTE: Food quality is reduced under extensive periods of keeping at freezer temperatures. Moisture loss and texture deterioration are the result of freezing a food product.)

5. Frying is a food preparation method in which the food is cooked in hot fat or oil. Cooking in hot fats or oils causes quick coagulation on the food’s surface and results in flavor changes. Frying types are pan-frying (shallow-frying) and deep-frying. Food safety issues are of primary importance in food plant constructions (e.g., location of refrigeration units and freezers, oil filtering, temperature control, and extinguishment equipment and protocols). Frying is used in many snack food processing facilities.

6. **Hazard Analysis Critical Control Points (HACCP)** is a group of programs used to manage dangers in food and drug production settings. HACCP plans are designed to ensure safe food products (and prevent any injury to a consumer’s health). The regulations require all manufacturers to maintain documentation and record-keeping procedures for the implementation, management, and correction of the manufacturing process in accordance with the plan. Different government agencies oversee each industry’s implementation of HACCP. Although originally a U.S. concept, HACCP concepts and processes have expanded internationally in food manufacturing and engineering. All food manufacturing facility designers must understand and implement HACCP concepts and processes. (NOTE: The USDA’s Food Safety and Inspection Service published the HACCP rules and regulations.) The seven principles of HACCP are:
   a. Conduct a hazard analysis (biological, chemical, and physical).
   b. Identify critical control points (CCPs).
   c. Establish critical limits for preventive measures associated with each identified CCP.
   d. Establish CCP monitoring requirements.
   e. Establish corrective action(s) to be taken when monitoring indicates that there is a deviation from an established critical limit.
   f. Establish effective record-keeping procedures that document the HACCP system.
   g. Establish procedures for verification that the HACCP system is working correctly.

7. **Halocarbon (Freon) refrigerants** are gases that have a certain Global Warming Potential (GWP) index. The **GWP index** is the ratio of potential atmospheric warming caused by a substance measure to the same mass of carbon dioxide. For example, methane is 21, and water vapor is zero. The refrigerant CFC12 is 8.5 or eight and a half times that of carbon dioxide. These refrigerants are used in places where ammonia’s usage is inconvenient (e.g., residences) and/or low capacities. At low capacities, these systems are less expensive to operate than ammonia systems. However, the refrigerant price is high. These sys-
tems are used in the following plants: dairy; meat, poultry, and fish; beverage; fruit and/or vegetable; and in some heat pump applications.

8. **High-efficiency particulate air (HEPA) filtration** is a system that traps microscopic particles and eliminates 99.97 percent of gas particles with a diameter greater than 0.3 micron. The first HEPA filters were designed for the Manhattan Project. HEPA systems remove numerous bacteria and other debris (e.g., dust, insect bits, and hair) from food products. For instance, yogurt-dispensing machines use a closed-cell system of stainless steel and glass chambers. The positive air system pumps filtered air into the chamber where the yogurt is dispensed and then vacuums it out. This removes all contaminants from the air. In the case of a dairy food with live cultures, contaminate-free air assists in the culture production. Industrial air filtration is a method that safely maintains air quality in an industrial setting. Worker safety and consumer safety are essential. According to OSHA, **ventilation** is a method of controlling the environment with airflow. It is one of the most important engineering controls available to the industrial hygienist for improving or maintaining the air quality in the occupational work environment.

9. Milling is grinding grains or other food products in a gradual reduction of the wheat kernels through grinding and sifting processes. Milling is a sequence of breaking, sifting, and rolling to achieve the correct color and consistency. There are about five roller mills or breaks in the system. In wheat milling, the grist (the blended wheat) is passed through a series of fluted “break” rolls rotating at different speeds. Grain milling operations use HACCP plans to identify potential food safety hazards and provide actions to eliminate the risk of any hazards. (NOTE: The North American Millers’ Association Web site provides links to government, industry, and consumer issues at [http://www.namamillers.org/education/wheat-milling-process/](http://www.namamillers.org/education/wheat-milling-process/).

10. Pickling is a preservation method that extends the life of a food through the process of marinating in a brine solution.

11. Slaughtering is the butchering of animals, usually domestic livestock, for meat (food). HACCP protocols are especially important to maintain sanitary and safe slaughter and butchering sites. The following food safety, environmental pollution, and health hazards are elements that must be considered in the design and maintenance of the slaughterhouse: solid waste removal; wastewater removal; wastewater by red meat slaughtering; wastewater by poultry slaughtering; air pollution (hot water and steam for sterilization and cleaning and smoking processes); and wastewater purification, chilling, and cleanup processes.

C. Four key questions that impact the facility design

1. Location: What is the location? This involves analyzing supply and demand issues related to transportation, weather (including wind speed), permitting, and construction material choices based on location.

2. Building structure: What materials would comprise the building structure? Selecting the interior and exterior building materials determines many design elements. For example, concrete can limit the building’s height (because of
weight) and may limit room placements and process openings. Equipment lay-
outs for piping, electrical, lighting, and HVAC ducts are affected by the types of
building materials selected.

3. LEED requirements: What level of LEED is required/desired? Determining the
level of certification impacts the design. LEED affects most aspects of the
design, including the energy model, water and wastewater usage and recovery,
piping systems, and lighting selection. The selection of the LEED level early in
the process avoids costly modifications later. *Leadership in Energy & Envi-
ronmental Design (LEED)* is a green building certification program that recog-
nizes best-in-class building strategies and practices. It is a program of the U.S.
Green Building Council.

4. Insurance: What are the insurance parameters and limitations of the policy?
Meeting the specifications and standards of the commercial insurance provider
must be addressed in the initial design phase.

D. Design requirements and specifications include the following categories:

1. Food facility (e.g., site, civil and building code, green design, BIM and/or 3D/
   4D modeling, and lean manufacturing)
2. Refrigeration (e.g., cold storage, halocarbon/Freon systems, ammonia sys-
tems, and heat recovery)
3. Heating and cooling (e.g., clean rooms, HEPA filtration, exhaust and ventila-
tion, condensation control, airflow, and volume air systems)
4. Food production (e.g., production areas, materials, workflow plans, process
   piping, and dry and wet ingredients)
5. Electrical (e.g., lighting, controls, back-up power, distribution systems, and
   process equipment integration)
6. Piping (e.g., hot and cold water, processing equipment piping, boilers/steam/
   condensate, natural gas, compressed air, and wastewater systems)
7. Equipment (e.g., layout, workflow, and traffic patterns)
8. Sanitation requirements (e.g., local, state, and HACCP regulations)

E. Planning and renovation: Food processing facilities design and drawings must
consider the following:

1. New development, future expansion, and/or renovation must be considered.
The plans must consider any required/mandated updates and renovation for
new products and processes.
2. The production process, product type, and people areas must be considered.
They must consider any raw material requirements (e.g., heating, cooling, and
flooring) and processing needs.
3. Future expansion possibilities are part of the design that communicates the
concept, site review, and a master plan.

F. Utilities, building and zoning, and site plan considerations

1. Utility layout and location is an important design element for any food process-
ing facility. This includes:
a. Capacity and location of water supply
2. Building and zoning plans
   a. Food processing designs require a building and zoning code review. The plans are drafted and sent to the city or local government for review and approval.
   b. A building/zoning code is the local regulation that determines which restrictions exist for buildings and development. These regulations tend to be specific for food processing facilities.

3. Site plan requirements: A site plan is a drawing of the area of a proposed construction operation, including the building outline, parking, work areas, and/or property lines. These plans include a preliminary plan that indicates the locations of:
   a. Roadways
   b. Utilities
   c. Future expansions

4. Building features requirements: The locations of walls, doors, fixtures, and unique features must be addressed. The floor type is an important concern in the design of food processing. (NOTE: OSHA, USDA FSIS, and HACCP standards are applicable to food processing flooring choices.)

5. Operational support and space planning
   a. All facilities have specific areas allocated to different functions, including storage, mechanical equipment, operational support, employee and administrative areas, and delivery and shipping operations.
   b. Operational support is the software/technology and the personnel who analyze operations by controlling production applications. They monitor system resources and response time in addition to providing first-line support for operational problems.
   c. Process flow is the sequence of processing steps required for facility needs. All facilities require designs of the basic process flows as well as the configuration and location of required equipment. The process flow and equipment layout is unique for each type of food processing facility.

6. Future growth potential is an organization’s ability to generate larger profits, to expand its workforce, and to increase production in the future. Most food processing facilities are designed to allow future growth. The potential future growth areas are identified, and the design allows for available expansion opportunities.

Teaching Strategy: Bring in a set of plans for a food processing facility, or use one of the Resource Web sites to project a food processing facility layout. Then lead a class discussion about important applications for the design of a food processing facility. For example, what design features would be required in a poultry processing facility that would not be required in a breakfast cereal packing facility? It is important to explain
how the design and layout affects the efficiency of the production process. Use VM–A, VM–B, and VM–C to review.

**Objective 2:** Use industry-standard food processing symbols.

**Anticipated Problem:** What are industry-standard food processing symbols?

II. Food processing symbols

A. **Symbols** are graphic images or letters that represent and communicate details and/or materials for a food process or product. Symbols and geometries are used to represent instruments and food processing equipment and how they are interconnected in a sequence. These symbols can be abstract graphics or physical simulations of the actual equipment. Symbols and graphics are used to represent:

1. Process flow diagrams—A **process flow diagram (PFD)** is a simplified sketch that uses symbols to identify instruments and vessels and to describe the primary flow path through food (or other) processes.
2. Piping line diagrams
3. Valve diagrams (e.g., heating, cooling, and ventilation)
4. Electrical diagrams
5. Technical drawings and schematics

B. **Design requirements**

1. A range of physical and chemical needs are necessary for food processing facility designs. Facilities must maintain a hygienic processing environment (e.g., HACCP, OSHA, state guidelines, and industry guidelines are followed). Some designs would include areas for high heat and cooking; some would include “below zero” cooling and keeping rooms. The fact that food-handling equipment often moves throughout the facility requires the consideration of specific wall and floor types. Overall facility design needs include:
   a. Architectural and structural drawings
   b. Civil or site plans
   c. Drawings for the building code and zoning review
   d. Space planning
      (1) Location of wet and dry ingredients storage
      (2) Layout of process piping plans
      (3) Material and workflow plans

2. **Building information modeling (BIM)** is digital representations of physical and functional characteristics of a facility. Newer facilities often include sustainable design concepts and BIM plans or models. Many BIM software products are proprietary (copyrighted and privately owned). BIM helps food facilities make better decisions during the design review of the 3D model. Visualizing the space enhances the ability of the stakeholders to make more informed decisions. Decisions in four specific areas:
a. Maintenance: This involves reviewing access to attic/interstitial space, utility rooms, and the maintenance rooms. Visualizing crews navigate through the spaces: 3D makes the spaces easier to visualize than 2D (e.g., clearances between and above steel structural members, ductwork, and pipe runs). The maintenance review focuses on any clean-in-place and steam-in-place equipment and the associated material and energy requirements.

b. Product flow: Following the product flow at “floor level” is an advantage over 2D drawings. It aids in visualizing walls, floors, drains, columns, lighting, etc. in relation to processing stations and sanitation equipment.

c. Coordination: It helps in reviewing the building arrangement and layout as it relates to plant operation. BIM 3D models allow the design team to provide the stakeholders with a better perspective and for the stakeholders to “red flag” any potential conflict in coordination of plant activities.

d. Energy efficiency: Energy efficiency is analyzed. For example, the use of natural and artificial lighting solutions is analyzed.

3. Facility capacity
a. Utilities: Utility plans include the location of boilers, steam pipes, hot, cold, and wastewater piping locations. Some facilities use compressed air and natural gas; this information is required on the design plans.

b. Electrical: Food processing facilities have a high electrical demand. The design and layout of all electrical equipment and supply lines must be strategized on the drawings and BIM models. This includes the location of distribution systems, lighting locations, switching and MCC layouts, power controls, and a backup power system.

c. Refrigeration: Most food processing and packaging facilities require refrigeration capacity during the process flow. The layout and organization of all refrigeration equipment—from intake to output—must be incorporated into the facility design, including:
   (1) Halocarbon (Freon) systems
   (2) Cold storage (including walk-in or drive-in coolers)
   (3) Freezer storage
   (4) Ammonia and glycol systems
   (5) Heat recovery

d. Mechanical: The mechanical systems—heating and cooling—are integrated into the designs, drawings, and models. Some areas of the facility may require heating; others may require cooling. Consider the following:
   (1) Plant airflow studies
   (2) Condensation control
   (3) Exhaust and ventilation plans
   (4) HEPA filtration and clean air rooms
   (5) Chilled water or glycol for cooling
   (6) Variable air volume systems (as required)

- **Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may be used in the Review/Summary.

- **Application.** Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

- **Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

**Answers to Sample Test:**

**Part One: Matching**

1. c  
2. e  
3. d  
4. a  
5. b  
6. f

**Part Two: True/False**

1. T  
2. F  
3. F  
4. T  
5. T  
6. T

**Part Three: Short Answer**

The four key question categories a designer asks prior to the initial design are location, building structure, LEED requirements, and insurance.
Part One: Matching

Instructions: Match the term with the correct definition.

a. building/zoning code  
d. operational support  
b. food processing  
e. process flow diagram (PFD)  
c. future growth potential  
f. site plan

_____1. An organization’s ability to generate larger profits, to expand its workforce, and to increase production in the future

_____2. A simplified sketch that uses symbols to identify instruments and vessels and to describe the primary flow path through food (or other) processes

_____3. The software/technology and the personnel who analyze operations by controlling production applications

_____4. The local regulation that determines which restrictions exist for buildings and development

_____5. The transformation of raw ingredients by physical or chemical means into food or food into other forms

_____6. A drawing of the area of a proposed construction operation, including the building outline, parking, work areas, and/or property lines

Part Two: True/False

Instructions: Write T for true or F for false.

_____1. HEPA systems remove numerous bacteria and other debris (e.g., dust, insect bits, and hair) from food products.
2. An advantage of designing food processing facilities is the low electrical demand requirements.

3. The fact that food-handling equipment rarely moves throughout the facility eliminates the need for the designer to consider specific wall and floor types.

4. BIMs is digital representations of physical and functional characteristics of a facility.

5. HACCP is a group of programs used to manage dangers in food and drug production settings.

6. The mechanical systems—heating and cooling—are integrated into designs and drawings.

Part Three: Short Answer

Instructions: Answer the following.

What are the four key question categories a designer asks prior to the initial design?
Hazard Analysis Critical Control Points (HACCP) is a group of programs used to manage dangers in food and drug production settings. HACCP plans are designed to ensure safe food products (and prevent injuries to consumer health). HACCP concepts and processes have expanded from the United States to international standards in food manufacturing and engineering. All food manufacturing facility designers must understand and implement HACCP concepts and processes.
Halocarbon (Freon) refrigerants are gases that have a certain global warming potential (GWP) index. GWP is the ratio of potential atmospheric warming caused by a substance measure to the same mass of carbon dioxide. For example, methane is 21, and water vapor is zero. The refrigerant CFC12 is 8.5 or eight and a half times that of carbon dioxide. These systems are used in the following plants: dairy; meat, poultry, and fish; beverage; fruit and/or vegetable; and some heat pump applications.
A site plan is a drawing of the area of a proposed construction operation, including the building outline, parking, work areas, and/or property lines. These plans include a preliminary plan that indicates the locations of roadways, parking, utilities, and future expansion.
A pump is a mechanical apparatus that uses suction or pressure to move liquids, compress gases, or force air into spaces. Symbols for pumps closely resemble those for compressors. A valve is any device for halting or controlling the flow of a liquid, gas, or other material through a passage, pipe, inlet, outlet, etc.
This technical diagram is of a water supply system plan and includes a siphon fluid intake and an incision.
Food processing facilities have a high electrical demand. The design and layout of all electrical equipment and supply lines must be strategized on the drawings and BIMs. This includes the location of distribution systems, lighting locations, switching and MCC layouts, power controls, and a backup power system.

- Ammeter
- And Gate
- Antenna
- Attenuator
- Attenuator, Variable
- Battery
- Capacitor, Feedthrough
- Cathode, Cold
- Cathode, Directly Heated
- Cathode, Indirectly Heated
- Cavity Resonator
- Cell
- Circuit Breaker
- Diode, General
- Diode, Light-Emitting
- Diode, Photosensitive
- Diode, Pin
- Female Contact
- Fuse
- Galvanometer
- Diode, General
- Integrated Circuit
- Inverter
- Lamp, Neon
- Male Contact
- Microphone
- Outlet
- Probe, Radio Frequency
- Shielding
- Speaker
- Switch, Rotary
- Terminals, Balanced
- Test Point
- Voltmeter
- Wattmeter
Food processing is the transformation of raw ingredients by physical or chemical means into food or food into other forms. The food processing industry is the manufacturers of food products, beverages, condiments, tobacco, soap and detergents, and perfume and cosmetics.
Food Processing Industry: Facility Design Requirements

Purpose

The purpose of this activity is to research design requirements for a food processing facility.

Objectives

1. Trace the steps from raw material to processed product.
2. Research workflow food processing steps.
3. Research HACCP and OSHA quality and safety requirements.
4. Present your findings to the class.

Materials

♦ lab sheet
♦ class notes
♦ processed food topic list from instructor
♦ writing utensil
♦ paper
♦ device with Internet access

Procedure

1. Work in pairs to complete this lab sheet. Review your notes about food processing industry design requirements.
2. Select a processed food topic from the list provided by your instructor. Task: Research the design requirements for one food processing facility. On your paper, list the food processing topic selected.

3. Begin your research with the U.S. governing and monitoring agencies Web site information. Then search specific food processing industry Web sites. Agency examples are:
   b. USDA’s Food Safety and Inspection Service HACCP pages at http://www.fsis.usda.gov/wps/portal/fsis/topics/regulatory-compliance/haccp
   c. Department of Labor’s OSHA worker safety pages at https://www.osha.gov/workers/index.html (or select a specific processing topic, such as “Poultry Processing”) at https://www.osha.gov/SLTC/poultryprocessing/index.html
   d. On your paper, list the specific food processing pages accessed in your research.

4. STEP 1: Trace the route from raw material(s) to the final food product.

5. STEP 2: List all the workflow food processing steps (e.g., grinding, sifting, heating, drying, and frying). This process may be displayed as a flow chart or as a listing of materials and equipment required to process this food item.

6. STEP 3: Describe the HACCP and OSHA quality standards for the selected food product. (NOTE: This section may include any HEPA filtration, cooling (Freon) and/or heating standards, airflow standards, etc.)

7. Present your findings to the class.

8. Turn in your completed lab sheet to your instructor.
Potential food processing research topics are:

1. Poultry, beef, fish, and/or pork processing
2. Frozen dessert processing
3. Breakfast cereal processing
4. Candies and confections processing
5. Vegetable and/or fruit processing (e.g., canning and juicing)
6. Vegetable and/or fruit processing (e.g., freezing)
7. Coffee processing (e.g., K-cup, bean roasting, and grinding)
8. Dairy processing (e.g., milk, cheese, and yogurt)
9. Egg processing (organic and non-organic)
10. Pickling processes (e.g., cucumbers, mushrooms, and olives)
11. Drying (dehydration) processes (e.g., fruit leathers and dried fruits)
12. Brining processes (e.g., turkey and pork)
13. Curing processes (e.g., bacon, ham, and sausage)
14. Snack food frying/cooking and packaging (e.g., chips and other snacks)
15. Canning processing (e.g., fruits, vegetables, and fish)
16. Milling processing (e.g., breads and crackers)
17. Soft drink processing