

PLANT DESIGN AND LAYOUT

Plant Design refers to the automation technologies, work practices, business rules, supporting the design and engineering of process plants. Such plants can be built for CPG (Consumer Packaged Goods) industries such as Dairy, Food, Home & Personal Care (HPC), Pharmaceuticals, and chemical. Consumers' demand that food products and ingredients introduced into the marketplace be free from contamination and spoilage and based on current trends, consumers will be even more demanding and health-conscious in the future.

General Considerations In Plant Design

1. *Dairy Plant Licensing*
2. *Plant location*
3. *Plant layout*
4. *Plant Construction Standards*
5. *Plant operation and control*
6. *Storage*
7. *Waste disposal*
8. *Health and safety*

1. DAIRY PLANT LICENSING

- The Act and Regulation specify standards for construction and equipment, dairy product quality including strict microbiological and chemical controls, dairy plant worker certification, pasteurization requirements and other operational standards.

2. PLANT LOCATION

- The geographical location of the final plant can have a strong influence on the success of an industrial enterprise.
- The plant should be located where the minimum cost of production and distribution can be obtained.
- The choice of the final site should first be based on a complete survey of the advantages and disadvantages of various geographical areas.

These points should be considered for Plant location,

- a. Raw Materials
- b. Markets
- c. Energy Availability
- d. Climate
- e. Transportation Facilities
- f. Water Supply

- g. Waste Disposal
- h. Labour Supply
- i. Site Characteristics
- j. Flood and Fire Protection
- k. Community Factors

a. Raw Materials

The source of raw materials is one of the most important factors influencing the selection because, location near the raw materials source leads to reduction in transportation and storage charges.

Attention should be given to the;

- purchased price of the raw materials
- distance from the source of supply
- purity of raw materials
- storage requirements

b. Markets

- The location of markets or intermediate distribution centers affects the cost of product distribution and the time required for shipping.

c. Energy Availability

- Power and steam requirements are high in most industrial plants and the fuel is ordinarily required to supply these utilities
- In industrial areas the cost, voltage and availability of electricity is different than in living areas.

d. Climate

- Excessive humidity or extremes of hot or cold weather can have a serious effect on economic operation of a plant and these factors should be examined when selecting a plant site.

e. Transportation Facilities

- The common means of transportation used by major industrial concerns are roads, highways, railroads and water.
- Transportation should be done with a great care and should be fast.

f. Water Supply

- The process industries use large quantities of water for cooling, washing, steam generation, etc... Therefore, the plant must be located where a dependable supply of water is available.

- Water sources can be tap water, rivers, lakes, deep wells and artesian wells. If own sources are to be used the level of existing water, seasonal fluctuations, chemical, bacteriological content and cost for supply and purification must be considered.

g. Waste Disposal

- The site selected for a plant should have adequate capacity and facilities for correct waste disposal.
- In choosing a plant site, the permissible tolerance levels for various methods of waste disposal should be considered carefully and attention should be given to potential requirements for additional waste treatment facilities.

h. Labor Supply

- The type and supply of labor available in the vicinity of a proposed plant site must be examined.
- Consideration should be given to prevailing pay rates, restrictions on number of hours worked per week, competing industries that can cause dissatisfaction or high turnover rates among the workers, and variations in the skill and intelligence of workers.

i. Site Characteristics

- The characteristics of the land at a proposed plant site should be examined carefully (topography and soil structure).
- The cost of land is important as well as local building costs and living conditions.
- The buildings that are constructed as a result detailed land analysis, soil analysis and structural calculations are very resistant to aging as well as natural disasters like earthquakes.

j. Flood and Fire Protection

- Before choosing a plant site, the regional history of natural events like floods or hurricanes should be examined.
- Protection from losses by fire is another important factor for selection of plant location.
- In case of a major fire, assistance from outside fire departments should also be available as well as fire protection systems.

k. Community Factors

- The character and facilities of a community can have effects on the location of the plant.

- Cultural facilities as schools, shops, mosques, cafeterias, kindergartens, cinemas are important for a progressive community.

3. PLANT LAYOUT

After the process flow diagrams are completed and before detailed piping, structural and electrical design can begin, the layout of process units in a plant and the equipment within these process units must be planned. This layout can play an important part in determining construction and manufacturing costs and thus must be planned carefully with attention being given to future problems that may arise.

- *A proper layout in each case will include arrangement of processing areas, storage areas and handling areas in efficient coordination and with regard to the following factors:*
 1. New site development or addition to previously developed site
 2. Type and quantity of products to be produced
 3. Type of process and product control
 4. Operational convenience and accessibility
 5. Economic distribution of utilities and services
 6. Type of buildings and building code requirements
 7. Health and safety considerations
 8. Waste disposal problems
 9. Auxiliary equipment
 10. Space available and space required
 11. Roads and railroads
 12. Possible future expansions.

Preparation of the layout;

- While preparing the layout, three dimensional models are often made. The main advantage of three dimensional models is the possibility of observing the problems that may be missing in two-dimensional drawings. Three-dimensional models are also beneficial for orientation after the plant is completed.

4. PLANT CONSTRUCTION STANDARDS

Floors

- Floor construction should be designed to eliminate future problems.
- The floors of all rooms in which dairy products are processed, pasteurized, manufactured or stored must be constructed of sealed concrete or other impervious material with a smooth surface and sloped 1/4 inch per foot to adequately trapped drains.

- The floor /wall joints are to be covered for ease of cleaning and maintenance.

Walls and Ceilings

- Walls and ceiling of rooms in which dairy products are processed, pasteurized, manufactured, packaged or stored shall be smooth, light coloured and impervious to moisture.

Overhead Utility Lines

- All overhead utility lines should be installed in such a manner as to avoid contamination of products below.
- They should be insulated where necessary and be designed and finished to prevent the accumulation of dirt and minimize condensation.
- They must be easy to clean.

Lighting

- All plants shall provide adequate lighting, which is shielded with shatterproof coverings to ensure clean and efficient plant operation.

Ventilation

- Adequate ventilation is required in all plants to prevent excessive heat, dust accumulation, odours or condensation and to provide a proper work environment for employees.
- The direction of airflow should be from the processing area outward to other areas of the plant.

Dry Storage Area

- A separate dry storage area shall be provided in all dairy plants.

Refrigeration

- Refrigerated storage facilities must be provided for all dairy products. Temperature requirements for coolers and raw milk storage tanks shall be 4°C (40°F) or less but above 0°C (32°F); for freezers less than -18°C (0°F).

Equipment

- Equipment used in the receiving, processing, pasteurizing, manufacturing, packaging, storing, dispensing, transporting or marketing of a dairy product shall be of an approved type or where applicable be based on 3A Standards. The equipment must not be defective, unsuitable or unsanitary.

Staff Facilities

- Employee's facilities shall include a suitably designed dressing room and lunchroom.

- Conveniently located sanitary toilets for male and female employees shall be provided exclusively for the use of dairy plant personnel and shall not open directly into an area used for the processing or packaging of dairy products.

Hand Washing Facilities

- Adequate and conveniently located facilities for hand washing and drying must be provided wherever the process demands. Where appropriate, facilities for hand disinfection should also be provided.

5. PLANT OPERATION AND CONTROL

- It should be remembered that maintenance work will be necessary to keep the installed equipment and facilities in good operating condition.

Instrumentation

- Instruments are used in an industrial plant to measure process variables such as; temperature, pressure, density, viscosity, specific heat, conductivity, pH, humidity, liquid level, flow rate, chemical composition, moisture content, etc.
- the values of these variables can be recorded continuously and controlled within narrow limits.
- Automatic control is widely used with resulting savings in labor combined with improved ease and efficiency of operations.

Maintenance

Maintenance work includes; repairs, equipment upgrading, testing, field adjustment, etc.

Many of the problems involved in maintenance are caused by the original design and layout of the plant and the equipment.

Sufficient space for maintenance work on equipment and facilities must be provided in the plant layout and the engineer needs to consider maintenance requirements when making decisions on equipment.

6. STORAGE

- In the operation of a process plant adequate storage facilities for raw materials, intermediate products, final products, recycle materials, off-grade materials, fuels, cleaning agents, packaging materials and other items.
- Storage of raw materials permits operation of the process plant regardless of temporary supply of delivery difficulties.
- Storage of intermediate products may be necessary during plant shutdown for emergency repairs.

- Storage of products makes it possible to supply the customer even during a plant difficulty or unforeseen shutdown.
- Depending on the physical and chemical properties of the materials storage conditions should be determined.
- High-pressure gas is stored in spherical or horizontal cylindrical pressure vessels.
- Solid products and raw materials are either stored in air-tight tanks with sloping floors or in outdoor bins or mounds.
- Solid products are mostly packed directly on retail packages.

7. WASTE DISPOSAL

- Waste from an industrial plant in form of gas, liquid or solid cause to pollution.
- In order to control this pollution several factors should be evaluated as;
 - ❖ Pollution source (pollutants and the total volume dispersed)
 - ❖ Properties of pollution emissions
 - ❖ Design of the collection and transfer systems
 - ❖ Selection of the control device
 - ❖ Dispersion of the exhaust to meet applicable regulations.

Air Pollution Abatement:

Air pollution control equipments suitable for removing particulates and those associated with removing gaseous pollutants.

Noxious Gas removal

Gaseous pollutants can be removed from air streams either by absorption, adsorption, condensation or incineration.

Water pollution Abatement:

Since waste liquid may contain dissolved gases or solids or it may be in a form of slurry, physical, chemical or biological treatment methods can be used.

Solid Waste Disposal:

Solid wastes differ from air and water pollutants since the wastes remain at the point of origin until they are collected and disposed.

8. HEALTH AND SAFETY

- There are several health and safety hazards encountered in the process industries.
- The design engineer should consider all those items and should have precautions against them.

☞ **Chemical Hazards**

Many chemicals can cause damages when come into contact with living tissues. If such chemicals are used in the process the time and amount of exposure should be determined and controlled by the design engineer. Sources should be eliminated.

☞ **Fire and Explosion Hazards**

- The design and construction of high pressure tanks should follow the standards and should be tested at 1.5 to 2 times the design pressure.
- In order to prevent fire, smoking, welding and cutting machines, open electrical connections, heated materials and other ignition .

☞ **Personnel Safety**

- In the design project, health and safety of plant personnel should be considered.
- All machinery must be equipped with control and warning devices.
- Physical hazards if unavoidable must be clearly defined.
- Protected walkways, platforms, stairs and work areas should be provided.
- Medical services and first aid must be readily available.