CHAPTER | NINE

Facility Layout

Learning Objectives

After reading this chapter, you should be able to:

- Understand the meaning of facility layout and state the objectives of facility layout.
- Discuss the factors influencing facility layout.
- Describe the various types of layouts and their advantages and disadvantages.
- Discuss the importance of facility layout.
- Discuss what is meant by revision of layout.
- Explain layout planning and layout tools and techniques.
- Discuss the criteria for selection and design of layouts.
- Discuss the steps involved in layout design procedure.

I INTRODUCTION

When a new plant is erected, the question of the placement of machinery at different places, the location of stores, inspection cabins, tool rooms, maintenance wings, plating shops, heat treatment chambers, toilets, canteens, and trolleys, cranes and other handling equipments and the like receive a priority consideration. This is so because the efficiency of the production flow depends largely on how well the various machines, production facilities and employee amenities are located in a plant. In a properly laid out plant, the movement of materials, from the raw material stage to the end product stage, is smooth and rapid; the movement is generally in a forward direction: the materials do not crisscross, or go backward and forward for further operations. Moreover, production bottlenecks and delays are few, and materials handling costs are reduced. Such arrangements constitute the subject matter of Plant Layout.

A good deal of expertise is used by managements to secure a proper layout for new or existing plants. The use of expertise is necessary because there is no set pattern of layout for all plants. It differs from plant to plant, from location to location, and from industry to industry. A layout which is good for a processing industry will not to be good for a job industry; a layout which is suitable for a small-sized factory will not be suitable for a giant plant; or a layout fit for a plant located on a flat terrain cannot be suitable for a plant which is located on an uneven terrain. But the basic principles governing plant layout are more or less the same. Moreover, the initial layout is almost never final or permanent. Changes do take place in product design, production methods and the size of the plant. Such changes necessitate a revision of the existing layout.

I MEANING, DEFINITION AND SCOPE

Plant layout refers to the arrangement of machinery, equipment and other industrial facilities for achieving quickest and smooth production.

A plant layout refers to the arrangement of machinery, equipment and other industrial facilities – such as receiving and shipping departments, tool rooms, maintenance rooms and employee amenities – for the purpose of achieving the quickest and smoothest production at the least cost. The subject of plant layout not only covers the initial layout of machines and other facilities but encompasses improvement in, or revisions of, the existing layout in the light of subsequent developments in the methods of production. In other words, a plant layout is a floor plan for determining and arranging the desired machinery and equipment of a plant, whether established or contemplated, in the one best place to permit the quickest flow of material at the lowest cost and with the least amount of handling in processing the product from the receipt of the raw materials to the shipment of the finished products.

A more simple, clear and comprehensive definition is given by Knowles and Thomson. They say that a plant layout involves:

(i) "Planning and arranging manufacturing machinery, equipment, and services for the first time in completely new plants;

(ii) The improvements in layouts already in use in order to introduce new methods and improvements in manufacturing procedures."

Objectives of a Good Layout

Improving productivity is the overall objective of good layout.

Any of the following objectives might be achieved through a good layout:

1. Provide enough production capacity
2. Reduce material handling costs
3. Reduce congestion that impedes the movement of people or material
4. Reduce hazards to personnel
5. Utilize labour efficiently

6. Increase employee morale
7. Reduce accidents
8. Utilize available space efficiently and effectively
9. Provide for volume and product flexibility
10. Provide ease of supervision
11. Facilitate co-ordination and face-to-face communication where appropriate
12. Provide for employee safety and health
13. Allow ease of maintenance
14. Allow high machine/equipment utilisation
15. Improve productivity.

I FACTORS INFLUENCING FACILITY LAYOUT

As pointed out earlier, the pattern of layout varies from industry to industry, location to location, and plant to plant. Different types of layout are in use; and the selection of a particular type to suit the requirements of a plant depends on a number of factors. Primarily, the layout of a plant is influenced by the relationship among materials, machinery and men. Other factors - such as the type of product, the type of workers, the type of industry and management policies - also influence the layout. Some of the factors which influence layout are explained in the following paragraphs.

Type and size of material influence facility layout.

Materials : When it is said that materials influence plant layout, what is meant is that there is a need to provide for the storage and movement of raw materials in a plant until they are converted into finished products. Every factory should buy raw materials economically when they are available; they should be stored properly and moved through production centres efficiently for manual or mechanical operations or chemical processing. The storage and movement of raw materials require properly placed storage rooms and materials movement or handling equipment. These involve initial investment and recurring costs. The type and size of storage, as also the type of materials equipment cranes, trolleys and pipelines depend upon:

(a) The type of raw materials used, *i.e.*, whether the raw materials are liquid or solid, light or heavy, small or large; and

(b) The availability or scarcity of materials even when this is affected by seasonal variations and market conditions.

In certain manufacturing concerns which use heavy raw materials, as in the manufacture of road-rollers, heavy overhead cranes are required. Pipelines are used to transport iron ore, crude oil, wheat and salt. *For example,* a 67 km slurry pipeline carries iron ore from the Kudremukh Iron Ore Project to Mangalore Port. Gravity or airflow moves the materials ahead in the pipelines. Similarly, roller conveyors, belt conveyors, and chain conveyors are used to move materials during various stages of production. It is, therefore, essential that a plant layout should be planned after bearing in mind the particular handling or moving equipment which may be required in the manufacturing process.

The usual way of taking the raw material factor into account is to draw flow charts to visualise the paths of materials flow or movements, and then to eliminate cross-covers, long distances and back trackings. The best path is thus determined, around which the layout is planned.

Product : A layout is designed with the ultimate purpose of producing a product. The type of product – that is, whether the product is heavy or light, big or small, liquid or

Type of product whether it is heavier or light, big or small, liquid or solid influence facility layout.

solid – and its position in relation to the plant location influence the layout. In a majority of cases, the product moves from work station to work station. In some cases, as in the manufacture of locomotives and in ship-building, the product is stationary; but machinery and men are moved to the product. Thus, the position of the product in relation to the other factors of production deserves consideration in planning a layout. In the same way, the size of the product should be considered in planning the layout of a plant. The requirements of a layout meant for a heavy product are different from the requirements of that for a light product. Again, the layout requirements for assembling a watch are different from those for the assembly of an aeroplane. The manufacture of certain products involves wet operations, as in leather tanning or textile dyeing.

The sales/demand also exercises some influence on the plant layout. The sales/demand for a product determines the volume of production and therefore the quality and size of the equipment, the area of the storage space, and other facilities which, in turn, determine the type of layout. A product with a relatively inelastic demand should be produced on a mass scale by using specialised equipment in contrast to a luxury article which is produced on a small-scale with less specialised equipment. For these reasons, experts are of the opinion that a plant layout should begin with the product.

A plant layout must be the expression of a purpose. This purpose is the efficient and effective production of a product or product line. The purpose then dictates that the point at which the analyst for layout must start is with the product to be produced.

Worker : The layout designer should also consider the type, position and requirements of employees. If women workers are employed, the layout must be planned after keeping in mind their particular requirements. The position of employees, that is, whether they remain stationary or moving, also influences the layout.

Employee facilities, such as health and related services, feeding and related services, locker rooms and lavatories influence the layout significantly. Employee safety, too, must receive due consideration.

Machinery : The type of product, the volume of its production, the type of process and management policy determines the size and type of the machinery to be installed which, in turn, influences the plant layout. Production is the combination and manipulation of men, materials and machines. These elements may be combined in various ratios and in various ways in the course of the production activity. The ratio in which these elements are used depends on their relative costs and on the production processes selected. Before laying out a plant, it is necessary to determine which of these elements are to be stationary or fixed as to location in the plant and which will be mobile during the process of production. Various alternatives are available in determining which factor to move:

Based on the manufacturing process, industries are classified as synthetic, analytical conditioning and extractive.

(a) To move the product and the workers from work station to work station;

(b) To move the product from work station to work station, keeping the machines and workers stationary; or

(c) To move the worker and the machine to the product, which is held at the location. The layout or arrangement of machines should be planned to suit the alternative used in a plant.

Type of Industry : The type of industry and the method of the manufacturing process exercise a significant influence on plant layout.

Industries in this context may be broadly classified into four types:

(a) Synthetic;

(b) Analytical;

(c) Conditioning; and

(d) Extractive.

Extractive industries involve the separation of one element from another, as in the case of metal from the ore. A conditioning industry involves a change in form or physical properties. Metal working industries, foundries, and leather tanning concerns condition their raw materials to have the end products. An analytical industry converts raw materials into various elements or constituent parts. An oil refinery, *For example,* yields naphtha, gasoline, paraffin, tar and kerosene. Similarly, a sugar mill gives, besides sugar, bagasse and molasses. A synthetic industry, also called the *assembling* industry, involves the production of a product by the use of various elements. In other words, various elements go into the manufacture of an end-product. The chemical industry and the paper industry are synthetic industries. Light and heavy engineering and watch-making industries, in which several components are assembled to get the final products, also fall under synthetic industries.

Each of the above types of industries may be further classified into two types, namely,

(a) Intermittent industries; and

(b) Continuous industries.

This classification is based on the method of manufacture. The former type of industries manufacture different components on different machines and assemble them to get end-products. Continuous industries uninterruptedly produce one or two products of a standardised nature. It is needless to emphasise that the layout designer should keep in mind the type of industry and the method of the manufacturing process while planning a layout.

Location : The site selected for the location of a plant influences its layout in more than one way. First, the size and the terrain of the site determine the type of building which, in turn, influences the layout. Second, the location of the plant determines the mode of transportation, depending upon the distances from the source of raw materials and market to the plant. In some cases, railroads are used, in some others trucks are pressed into service. In a few cases, water loading and unloading facilities are required. The layout plan should provide for the exact type of transportation required. Third, a plant location may be determined in part by the fuel requirements of the concern. The plant layout must provide for the storage of this fuel, whether it be coal, oil or gas. Also, the layout must consider the requirements of power generation. Fourth, the demand for future expansion influences the plant layout. If a village site is selected, expansion may be effected by adding one more wing to the existing single-storey construction. If an urban site is selected, expansion may be effected by adding more storeys to the present structures. The number of storeys determines the type of materials handling equipment which would be required and which, in turn, influences the plant layout.

Managerial Policies : Management policies significantly influence plant layout. The following are such managerial policies:

Management policies heavily influence plant layout.

(a) The volume of production and provision for expansion;

(b) The extent of automation;

(c) Making or buying a particular component;

(d) Desire for rapid delivery of goods to customers;

(e) Purchasing policy;

(f) Personnel policies.

It is obvious that many top management policies determine the plant layout objectives and the scope of the plant activities. The layout engineer must have clear and complete understanding of those top management policies that have a bearing on plant layout objectives.

PRINCIPLES OF LAYOUT

The factors discussed above influence the choice of a particular type of layout. While accepting the selected layout, the layout engineer should be guided by certain principles. The layout selected in conformity with layout principles should be an ideal one. These principles are:

The Principle of Minimum Travel : Men and materials should travel the shortest distance between operations so as to avoid waste of labour and time and minimise the cost of materials handling.

Principle of Sequence : Machinery and operations should be arranged in a sequential order. This principle is best achieved in product layout, and efforts should be made to have it adopted in the process layout.

Principle of Usage : Every foot of available space should be effectively utilised. This principle should receive top consideration in towns and cities where land is costly.

Principle of Compactness : There should be a harmonious fusion of all the relevant factors so that the final layout looks well integrated and compact.

Principle of Safety and Satisfaction : The layout should contain built in provisions for safety for the workmen. It should also be planned on the basis of the comfort and convenience of the workmen so that they feel satisfied.

Principle of Flexibility : The layout should permit revisions with the least difficulty and at minimum cost.

Principle of Minimum Investment : The layout should result in savings in fixed capital investment, not by avoiding installation of the necessary facilities but by an intensive use of available facilities.

TYPES OF LAYOUT

A layout essentially refers to the arranging and grouping of machines which are meant to produce goods. Grouping is done on different lines. The choice of a particular line depends on several factors. The methods of grouping or the types of layout are:

(i) Process layout or functional layout or job shop layout;

(ii) Product layout or line processing layout or flow-line layout;

(iii) Fixed position layout or static layout;

(iv) Cellular manufacturing (CM) layout or Group Technology layout;

(v) Combination layout or Hybrid layout.

These methods are discussed in the following paragraphs.

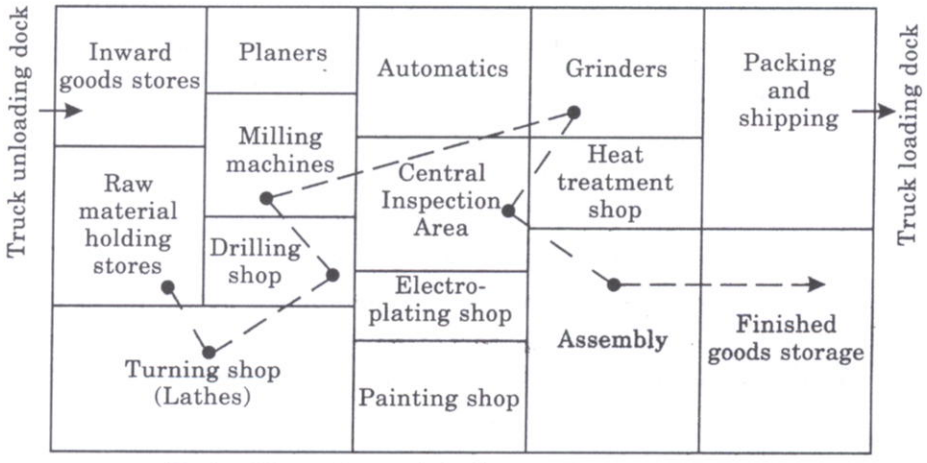
Process Layout

Process layout involves a grouping together of like machines in one department.

Also called the functional layout, layout for job lot manufacture or batch production layout, the process layout involves a grouping together of like machines in one department. *For example,* machines performing drilling operations are fixed in the drilling department; machines performing casting operations are grouped in the casting department; and so on. In this way, there would be a heating department, a painting department, a machining department and the like, where similar machines are installed in the plants which follow the process layout. The process arrangement is signified by the grouping together of like machines based upon their operational characteristics. *For example,* engine lathes will be arranged in one department, turret lathes in a second department, and milling machines in a third department.

A quantity of raw material is issued to a machine which performs first operation. This machine may be situated anywhere in the factory. For the next operation, a different machine may be required, which may be situated in another part of the factory. The material should be transported to this other machine for treatment. Thus, material would move long distances and along crisscrossing paths. At one stage, the material may be taken to a separate building, say, for heat treatment, and then brought back for grinding. If machines in one department are engaged, the partly finished product awaiting operations may be taken to the store and later reissued for production. Partly finished goods would be waiting for treatment in every department, like commuters waiting for buses in a city. *Exhibit 9.1* illustrates process layout.

Exhibit 9.1 : Process Layout or Functional Layout or Job Shop Layout



-----> Path of flow of materials for part A

Machines in each department in *Exhibit 9.1* attend to any product that is taken to them. There machines are, therefore, called general purpose machines. Work has to be allotted to each department in such a way that no machine in any department is idle. In a batch production layout, machines are chosen to do as many different jobs as possible, *i.e.*, the accent is on general purpose machines. The work which needs to be done is allocated to the machines according to loading schedules, with the objective of ensuring that each machine is fully loaded. The process layout carries out the functional idea of Taylor and from the historical point of view, process layout preceedes product layout. This type of layout is best suited for intermittent type of production.

While grouping machines according to the process type, certain principles must be kept in mind. These are:

(i) The distance between departments needs to be as short as possible with a view to avoiding long-distance movement of materials.

(ii) Though like machines are grouped in one department, the departments themselves should be located in accordance with the principle of sequence of operations. *For example,* in a steel plant, the operations are melting, casting, rolling and twisting. These different departments may be arranged in that order to avoid crossovers and backtracking of materials.

(iii) Convenience for inspection

(iv) Convenience for supervision. Process layout may be advantageously used in light and heavy engineering industries, made-to-order furniture industries and the like.

Advantages

Greater flexibility in production is the benefit of process layout.

1. Reduced investment of machines as they are general purpose machines.
2. Greater flexibility in the production.
3. Better and more efficient supervision is possible through specialisation.
4. There is greater scope for expansion as the capacities of different lines can be easily increased.
5. This type of layout results in better utilisation of men and machines.
6. It is easier to handle breakdown of equipment by transferring work to another machine or station.
7. There is full utilisation of equipment.
8. The investment of equipment would be comparatively lower.
9. There is greater incentive to individual worker to increase his performance.

Disadvantages

Process Layout requires more floor space.

1. There is difficulty in the movement of materials. Mechanical devices for handling materials cannot be conveniently used.
2. This type of layout requires more floor space.
3. There is difficulty in production control.
4. Production time is more as work-in-progress has to travel from place to place in search of machines.
5. There is accumulation of work-in-progress at different places.

Product Layout

A product layout involves the arrangement of machines in one line depending on the sequence of operations.

Also called the straight-line layout or layout for serialised manufacture,* the *product layout* involves the arrangement of machines in one line, depending upon the sequence of operations. Material are fed into the first machine and finished products come out of the last machine. In between, partly finished goods travel automatically, from machine to machine, the output of one machine becoming the input for the next. It is a feast for the eyes to watch the way sugarcane, fed at one and of the mill, comes out as sugar the other end. Similarly, in paper mill, bamboos are fed into the machine at one end and paper comes out at the other end.

In product layout, if there are more than one line of production, there are as many lines of machines. The emphasis here, therefore, is on special purpose machines in contrast to general purpose machines, which are installed in the process layout. Consequently, the investment on machines in a straight line layout is higher than the investment on machines in a functional layout. *Exhibit 9.2* illustrates the product layout.

The grouping of machines should be done, on product line, keeping in mind the following principles :

(i) All the machine tools or other items of equipment must be placed at the point demanded by the sequence of operations.

(ii) There should be no points where one line crosses another line;

(iii) Materials may be fed where they are required for assembly, but, not necessarily all at one point; and

(iv) All the operations, including assembly, testing and packing should be included in the line.

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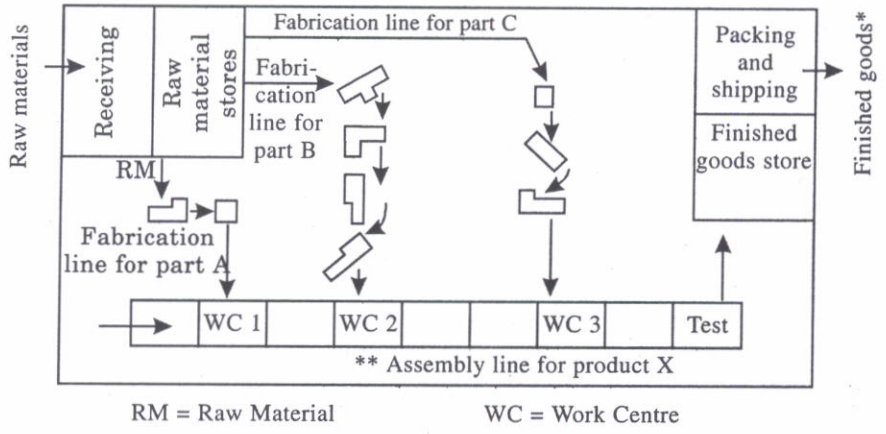
* Product X is made up of 3 parts *viz.*, A, B and C.

The product layout may be advantageously followed in plants manufacturing standardised products on a mass scale such as chemical, paper, sugar, rubber, refineries and cement industries.

Exhibit 9.2 : Line Layout or Product Layout



Advantages

Product layout avoids production bottlenecks.

1. There is mechanisation of materials handling and consequently reduction in materials handling cost.
2. This type of layout avoids production bottlenecks.
3. There is economy in manufacturing time.
4. This type of layout facilitates better production control.
5. This type of layout requires less floor area per unit of production.
6. Work-in-progress is reduced and investment thereon is minimised.
7. Early detection of mistakes or badly produced item is possible.
8. There is greater incentive to a group of workers to raise their level of performance.

Disadvantages

Product layout is known for in-flexibility.

1. Product layout is known for its inflexibility.
2. This type of layout is also expensive.
3. There is difficulty of supervision.
4. Expansion is also difficult.
5. Any breakdown of equipment along a production line can disrupt the whole system.

Table 9.1 presents relative merits of the product and the process layouts.

** The term straight-line, as applied to production, refers to the movements which do not involve backtracking, or crossing of the line of movement of the product.

Table 9.1 : Relative Merits of

Product Layout	ayout
1. Mechanisation of materials handling and consequent reduction in materials handling cost.	on machines as they es.
2. Avoidance of bottlenecks.	tion.
3. Economy in manufacturing time.	pervision possible through
4. Better production control.	
5. Less floor area required per unit of production.	machines.
6. Minimum investment in work-in-progress.	s of equipment her machine or station.
7. Early detection of mistakes or badly produced items.	
8. Greater incentive to a group of workers to raise their performance.	al workers to raise the

A comparison between product

n in *Table 9.2.*

Table 9.2 : Comparison of Product

Characteristics	Process Layout
1. Mechanisation of materials handling	
2. Avoidance of bottlenecks	
3. Economy in manufacturing time	
4. Minimisation of investment in work-in-process	
5. Better production control	
6. Early detection of bad workmanship	
7. Greater incentive to a group of workers to raise the level of their performance	
8. Reduced investment in machines	✓
9. Flexibility in production	✓
10. Scope for expansion	✓
11. Handling of breakdowns is easy	✓
12. Greater incentive to individual workers to raise the level of their performance	✓
13. Better utilisation of workers and equipment	✓
14. Specialisation in supervision	✓

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Table 9.1 : Relative Merits of Product and Process Layouts

Product Layout	Process Layout
1. Mechanisation of materials handling and consequent reduction in materials handling cost	Reduction in the investment on machines as they are general purpose machines.
2. Avoidance of bottlenecks.	Greater flexibility in production.
3. Economy in manufacturing time.	Better and more efficient supervision possible through specialisation.
4. Better production control.	Better scope for expansion.
5. Less floor area required per unit of production.	Better utilisation of men and machines.
6. Minimum investment in work-in-progress.	Easier to handle breakdowns of equipment by transferring work to another machine or station.
7. Early detection of mistakes or badly produced items.	Full utilisation of the plant.
8. Greater incentive to a group of workers to raise their performance.	Greater incentive to individual workers to raise the level of their performance.

A comparison between product and process layouts is shown in *Table 9.2.*

Table 9.2 : Comparison of Product and Process Layouts

Characteristics	Product Layout	Process Layout
1. Mechanisation of materials handling	✓	
2. Avoidance of bottlenecks	✓	
3. Economy in manufacturing time	✓	
4. Minimisation of investment in work-in-process	✓	
5. Better production control	✓	
6. Early detection of bad workmanship	✓	
7. Greater incentive to a group of workers to raise the level of their performance	✓	
8. Reduced investment in machines		✓
9. Flexibility in production		✓
10. Scope for expansion		✓
11. Handling of breakdowns is easy		✓
12. Greater incentive to individual workers to raise the level of their performance		✓
13. Better utilisation of workers and equipment		✓
14. Specialisation in supervision		✓

In fixed position layout major components remain in a fixed location.

Fixed Position Layout

As the term itself implies, the fixed position layout involves the movement of men and machines to the product which remains stationary. In this type of layout, the material or

major component remains in a fixed location, and tools, machinery and men as well as other pieces of material are brought to this location. The movement of men and machines to the product is advisable because the cost of moving them would be less than the cost of moving the product which is very bulky. (See *Exhibit 9.3*)

Table 9.3 : Circumstances When Product and Process Layouts Can Be Used

Product Layout	Process Layout
1. One or few standard products.	Many types or kinds of products, or emphasis on special orders.
2. Large volume of production of each item over a considerable period of time	Relatively low volume of production of individual items.
3. Minimum inspection required during the sequence of operations.	Many inspections required during a sequence of operations.
4. Materials and products permit bulk or continuous handling by mechanical means.	Materials or products too bulky to permit bulk or continuous handling by mechanical means.
5. Little or no occasion to use the same machine or work station for more than one operation. (minimum number of set-ups required	Frequent need for using the same machine or work station for two or more different operations.

When should a particular layout be used? *Table 9.3* presents the answer.

Exhibit 9.3 : Fixed Position Layout or Static Layout

Also called the fixed location layout, this type is followed in the manufacture of bulky and heavy products, such as locomotives, ships, boilers, air craft and generators. The construction of a building requires a fixed location layout because men, cement, sand, bricks, steel, wood and others, are taken to the site of the construction. This is equally true of a brick kiln. Another example is that of a hospital, where doctors and nurses (workers) and medicines and other paraphernalia (materials) are taken to the patient (product).

The advantages of a fixed position layout are:

(i) Men and machines can be used for a wide variety of operations producing different products.

(ii) The investment on layout is very small.

(iii) The worker identifies himself with the product and takes pride in it when the work is complete.

(iv) The high cost of, and difficulty in transporting a bulky product are avoided.

Cellular Manufacturing (CM) Layout

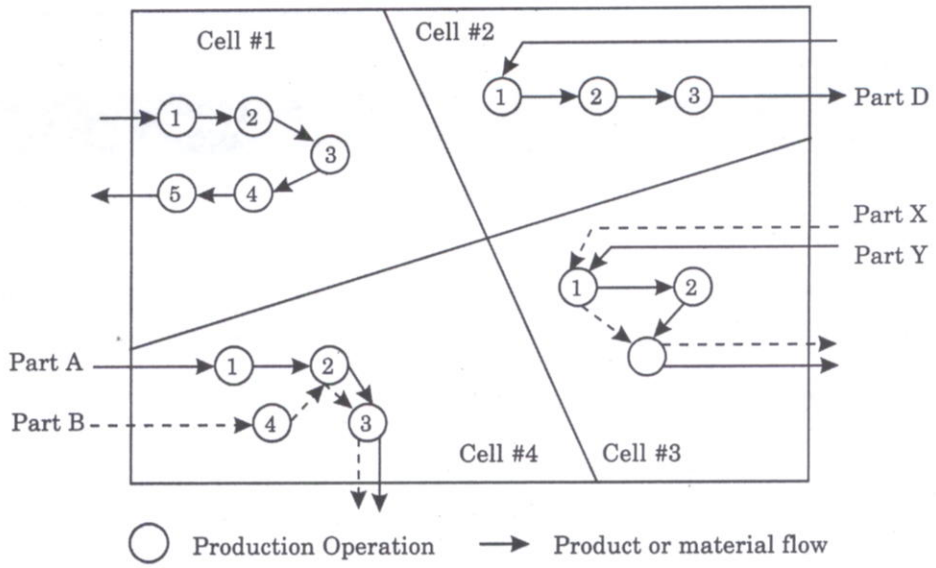
CM Layout groups all machineries into cells, which function some what like a produce layout.

In cellular manufacturing (CM), machines are grouped into cells, and the cells function somewhat like a product layout within a larger shop or process layout. *Exhibit 9.3* is an illustration of CM layout. Each cell in the CM layout is formed to produce a single parts family – a few parts, all with common characteristics, which usually means that they require the same machines and have similar machine settings.

The flow of parts with in cells, as shown in *Exhibit 9.4*, can take many forms. *For example,* in cells #1 and #2, the parts in the part family flow through the same machines in a product focused, line flow fashion. But in the cells #3 and #4, parts take different routes through the cells because of the differences between the designs of the two parts.

Among the advantages of cellular layouts are lower work-in-process inventories, reduced materials handling costs, shorter flow times in production, simplified production planning (materials and labour), increased operator responsibilities, improved visual control, and fewer tooling changes therefore facilitating quicker setups. Overall performance often increases by lowering production costs and improving on time delivery. Quality also tends to improve.

Exhibit 9.4 : Cellular Manufacturing Layout or Group Technology Layout



Disadvantages include reduced manufacturing flexibility and potentially increased machine-down time (since machines are contained to cells and may not be used all the time) and finally duplicate pieces of equipment may be needed so that parts need not be transported between cells.

Combined Layout (or Group Technology Layout or Hybrid Layout)

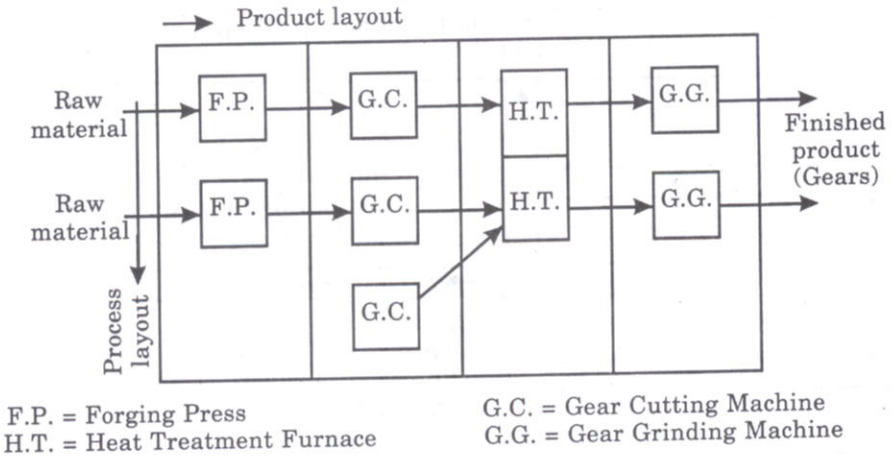
The application of the principles of product layout, process layout or fixed location layout in their strict meanings is difficult to come across. A combination of the product and process layouts, with an emphasis on either, is noticed in most industrial establishments. Plants are never laid out in either pure form. It is possible to have both types of layout in an efficiently combined form if the products manufactured are somewhat similar and not complex.

In plants involving the fabrication of parts and assembly, fabrication tends to employ the process layout, while the assembly areas often employ the product layout. In soap manufacturing plants, the machinery manufacturing soap is arranged on the product-line principle; but ancillary services, such as heating, the manufacturing of glycerine, the power-house, the water treatment plant are arranged on a functional basis.

Exhibit 9.5 illustrates the combined layout. The departments in *Exhibit* 9.5 are arranged according to the types of processes but the products flow through on a product layout.

To extend the logic of the combined layout, we may refer to the application of the fixed location principle in every industrial establishment. Is it not true that workers are brought from different places in buses to the factory every day? Will not materials and tools be carried to the place of manufacture every time?

Exhibit 9.5 : Combination Layout or Hybrid Layout for Gear Manufacturing



To sum up : In the final analysis, the combination that produces the desired volume of products at the least total cost is preferred. Marketing is concerned with maximising income, industrial engineering is concerned with minimising cost, and management is gambling that there is a sufficient difference in its favour.

SERVICE FACILITY LAYOUT

Service facility layout should provide easy entrance to service facilities from free ways and busy thoroughfares.

The fundamental difference between service facility and manufacturing facility layouts is that, many service facilities exist to bring together customers and services. Service facility layouts should provide for easy entrance to these facilities from freeways and busy thoroughfares. Large, well organized and amply lighted parking areas and well designed walkways to and from parking areas are some of the requirements of service facility layouts.

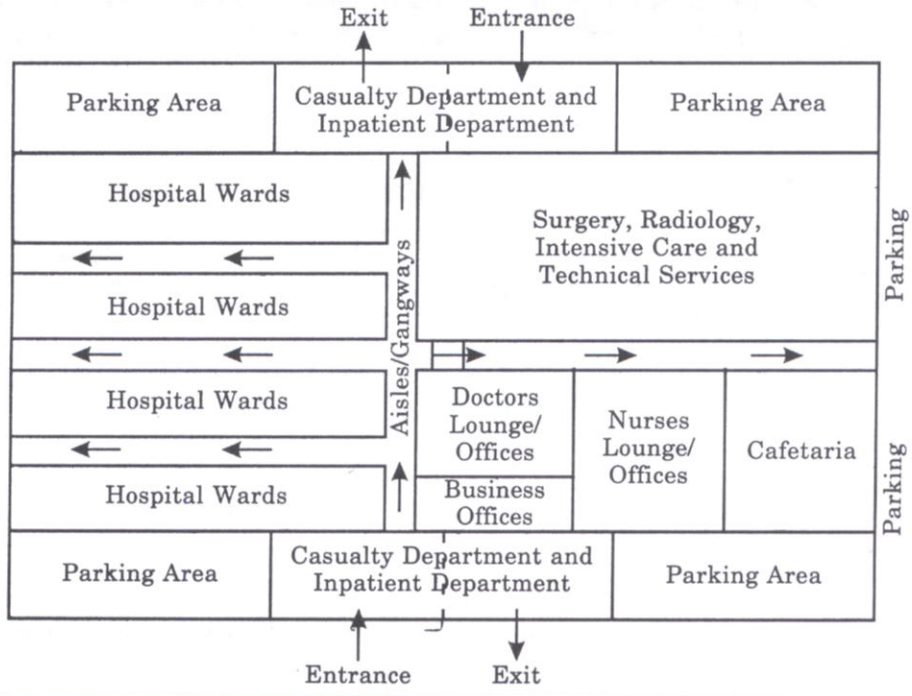
Because of different degree of customer contact, two types of service facility layouts emerge, viz; those that are almost totally designed around the customer receiving and servicing function (such as banks) and those that are designed around the technologies, processing of physical materials and production efficiency (such as hospitals).

Exhibit 9.6 depicts a layout of a small hospital. Although some area of the layout is devoted for receiving patients, settling accounts and discharging patients, the dominant consideration is the application of medical technology such as surgery, radiology, laboratory tests, patients rest and recovery, patient feeding and the like.

SPECIAL ARRANGEMENTS FOR PARTICULAR TYPES OF PLANTS

Certain plants require special arrangements which, when incorporated, make the layout look distinct from the types discussed above. The manufacture of detergent powder, *For example,* requires special arrangements. A huge boiler, with a height exceeding 80 ft., is erected vertically. A multistorey building is specially constructed to house the boiler. Materials are stored and poured into the boiler at different stages on different floors. Other facilities are also provided around the boiler at different stages. The finished product comes out of the boiler on the ground floor. It looks as though the boiler is the whole plant, and nothing else matters.

Exhibit 9.6 : Service Facility Layout (Hospital Layout)



Another example is the manufacture of talcum powder. Machinery is arranged vertically. Materials are poured into the first machine at the top and powder comes out at the bottom of the machinery located on the ground floor. The powder is then shifted to some other place in the building to be filled in tins.

Yet another example is the newspaper plant where the time element is of supreme importance, the accomplishment being gauged in seconds. The reliability and certainty of function must likewise be assured. To this end, working arrangements must be simple and direct, so as to eliminate distance, delay, and confusion; there must be a prefect co-ordination of all the departments, and machinery, equipment, or materials must never fail.

The layout of a five-star hotel poses peculiar problems. Lodging, bar, restaurant, kitchen, stores, swimming pool, laundry, shaving saloons, shopping arcades, conference hall, parking areas, should all find an appropriate place in the layout. The accent everywhere is on cleanliness, elegant appearance, convenience and compact looks, factors which attract customers.

Similarly, the layout of a cinema lays emphasis on the comfort and convenience of cinegoers. The projector, screen, sound-box and fire fighting equipment, should be located in appropriate places. The layout will be ideal when every individual, irrespective of the place he occupies in the big hall, is able to see the screen and listen to the music clearly.

I ARRANGEMENT OF OTHER FACILITIES

As noted earlier, a plant layout involves, besides the grouping of machinery, an arrangement for other facilities as well. Such facilities include receiving and shipping points, inspection facilities, employee facilities and storage. Not all the facilities are required in every plant. The requirements depend on the nature of the product which is manufactured in a particular plant. *For example,* the requirements of the plant manufacturing bread are certainly different from those manufacturing electric motors. Some of the industrial facilities which are needed are discussed in the paragraphs that follow.

I LOCATION OF RECEIVING AND SHIPPING DEPARTMENTS

Receiving and shipping departments represent the starting and finishing points respectively in every manufacturing concern. The receiving department is the place where raw materials and other supplies are received, and the shipping department is the place where finished goods are delivered to customers. The former represents vendor-oriented services and the latter customer-oriented services.

Raw materials enter the plant through the receiving department, undergo the manufacturing process inside the plant and reach the customers through the shipping department. This movement of materials is the core of the plant layout. It is essential that the materials should move without crossovers, backtracking and rehandling. The location of the receiving and shipping departments influences the movement of materials.

The best location of the receiving and shipping departments is at either end of the plant. But the actual location depends on a number of factors, prominent among them being the nature of the materials, the terrain and size of the site, the mode of transportation, and the nature of the industry.

Storage

A *store room* is a place where raw materials, components, partly finished goods, supplies and finished goods are stored. A store room should be so located as to be close to the production, receiving and shipping centres in order to minimise handling costs.

Storage room is a place where inventory is stored.

Inspection

The layout plan must provide for inspection at various points in the plant and at varying stages of manufacture. There are three types of inspection:

Inspection may involve checking purchased items, work in process and finished goods.

(i) Inspection of purchased items comprising raw materials, parts and supplies;

(ii) Inspection of work-in-process; and

(iii) Inspection of finished goods.

An inspection of incoming items is necessary to ensure that the quality of materials which are received is the same as the quality of the materials that were ordered. This may be done near the receiving area or storage area. Work-in-process needs inspection for the detection of defects, if any, before it becomes the finished product. Work-in- process is normally inspected at four points:

(i) At the close of departmental responsibility (more typical of the process layout);

(ii) After those operations during which there is a high probability of defects, especially if these defects can be isolated;

(iii) Before those operations during which defective items would be sequentially involved in costly operations;

(iv) At those places in the process where succeeding operations would conceal the defect and where it would not be cured without great difficulty.

Irrespective of the stage of inspection, the work-in-process is generally inspected near the work station or at a centralised place. The latter involves the transportation of the work to the place of inspection, which means high handling costs and delays.

The inspection of the finished product is essential for the purpose of ensuring that the quality obtained is the quality intended. The extent of inspection varies from a visual check to a thorough inspection employing numerous instruments and devices. The final inspection is normally conducted close to the shipping area.

Maintenance

Efficiency of machinery depends upon how well they are maintained.

The efficiency of machinery and equipment depends upon how well they are maintained. Maintenance checks should be carried out regularly. In the large establishments, a separate department is constituted for the purpose, though in small establishments workers themselves attend to the function when the work load is not heavy.

Where constituted separately, the maintenance department is entrusted with a wide range of functions, such as building, construction and maintenance, heating, ventilation and air-conditioning, machine and equipment installation and maintenance, maintenance of materials handling equipment, lighting, safety devices, fire protection, and collection and disposal of garbage, scrap and refuse. The maintenance department should be located in a place which is easily accessible to all the other departments in the plant.

Employee Facilities

Location of employee facilities in proper place helps improve workers efficiency.

Employee facilities should find a proper place in any layout because they add to the comfort and efficiency of workers. An absence of these facilities would land the management in trouble because an employee dissatisfied with a layout arrangement that affects him can, and does, object through the channels provided by his labour union.

The employee facilities to be provided are: time clocks, locker rooms, toilet facilities, drinking water facilities, first aid rooms, cafeteria, and safety measures. The location of locker rooms may be centralised for the plant as a whole or may be separately provided for each department; and the deciding factors for this should be the number of employees, convenience and avoidance of congestion. Locker rooms must be located close to the work place or at the entrance and their number should be decided by the strength of the workers. Lavatories may be located close to the work place lest workers find excuses to idle away their time. Wash rooms should be located close to the toilets. To avoid wastage of space, the locker rooms, wash rooms and toilets may be located on mezzanine floors or along elevators and stairway. In multi-storey buildings, lavatories and wash rooms must be provided on every floor; but common pipes may be used to reduce the cost of installation. Medical aid services should be so located as to be easily available to all the employees. Such places should be easily accessible to ambulance vans from outside. A centralised canteen for the whole plant or a separate canteen for each department should be provided. The centralised canteen should be located at a place which is within easy reach of all the employees at lunch time, while decentralised canteens may be attached to the various departments. Employee safety should receive due consideration by the layout engineer. Such causes of accidents as inadequate aisles, floor obstructions, slippery floors, inadequate exits and objects protruding into aisles or work places, should be avoided in a layout.

Other Facilities

Power generators are installed to keep the machines running when the supply of power from outside fails. These power generators should be located far from the production centres and should be accessible to trucks which carry coal or diesel to the generators.

Water filters, oil tankers, chilling plant and fermentation plant, are some other facilities which are peculiar to certain industrial establishments and should therefore find their place in layouts drawn for such concerns. Water filters are essential in the chemical industry *for example,* the soap factory – and in testing laboratories where stream is increasingly used. Water filters are used to clean and cool the hot and dirty water released from boilers, and manufacturing processes. They are located far from the production centres. Oil tankers are needed to store huge quantities of oil which is used. Such tankers are located far away from the centre of main activities, preferably somewhere near the compound. The chilling plant supplies chilled water, which is allowed to pass over hot coils in boilers to keep them cool. This plant is located close to the boilers, with a view to shortening the pipe length. Cleaning and fermentation plants are needed in bakeries; the former is meant for cleaning bread containers and the latter to keep the bread at a particular temperature. Both the centres should be located close to the manufacturing process.

IMPORTANCE OF FACILITY LAYOUT

Good layout helps to manufacture quality goods at less manufacturing cost.

The importance of a layout would be better appreciated if one understands the influence of an efficient layout on the manufacturing function: it makes it smooth and efficient. Operating efficiencies, such as economies in the cost of handling materials, minimisation of production delays and avoidance of bottlenecks – all these depend on a proper layout.

An ideally laid out plant reduces manufacturing costs through reduced materials handling, reduced personnel and equipment requirements and reduced in – process inventory.

The objectives or advantages of an ideal layout are outlined in the paragraphs that follow. The advantages are common to all the plants, irrespective of age; and whether a plant employs 50 workers or 50,000 makes no difference in so far as the applicability of plant layout advantages is concerned. Some of these advantages are:

Economies in Handling : Nearly 30 per cent to 40 per cent of the manufacturing costs is accounted for by materials handling. Every effort should, therefore, be made to cut down on this cost. Long distance movements should be avoided and specific handling operations must be eliminated. A cynic may say that the cheapest way to handle materials is not to handle them at all. But, in a factory, materials have to be handled; and therefore. The answer to the question how best to avoid handling depends on layout.

Effective Use of Available Area : Every inch of the plant area is valuable, specially in urban areas. Efforts should therefore be made to make use of the available area by planning the layout properly. Some steps for achieving this end are: location of equipment and services in order that they may perform multiple functions; developments of up-to-date work areas; and operator job assignments for a full utilisation of the labour force.

Minimisation of Production Delays : Repeat orders and new customers will be the result of prompt execution of orders. Every management should try to keep to the delivery schedules. Often, the deadline dates for delivery of production orders are a *bug-a-boo* to the management.

Plant layout is a significant factor in the timely execution of orders. An ideal layout eliminates such causes of delays as shortage of space, long-distance movements of materials, spoiled work and contributes to the speedy execution of orders.

Improved Quality Control : Timely execution of orders will be meaningful when the quality of the output is not below expectations. To ensure quality, inspection should be conducted at different stages of manufacture. An ideal layout provides for inspection to ensure better quality control.

Minimum Equipment Investment : Investment on equipment can be minimised by planned machine balance and location, minimum handling distances, by the installation of general purpose machines and by planned machine loading. A good plant layout provides all these advantages.

Avoidance of Bottlenecks : Bottlenecks refer to any place in a production process where materials tend to pile up or produced at rates of speed less rapid than the previous or subsequent operations. Bottlenecks are caused by inadequate machine capacity, inadequate storage space or low speed on the part of the operators. The results of bottlenecks are delays in production schedules, congestion, accidents and wastage of floor area. All these may be overcome with an efficient layout.

Better Production Control : Production control is concerned with the production of a product of the right type at the right time and at reasonable cost. A good plant layout is a requisite of good production control and provides the plant control officers with a systematic basis upon which to build organisation and procedures.

Better Supervision : A good plant layout ensures better supervision in two ways:

(a) Determining the number of workers to be handled by a supervisor and

(b) Enabling the supervisor to get a full view of the entire plant at one glance.

A good plant layout is, therefore, the first step in good supervision.

Improved Utilisation of Labour : Labour is paid for every hour it spends in the factory. The efficiency of a management lies in utilising the time for productive purpose. A good plant layout is one of the factors in effective utilisation of labour. It makes possible individual operations, the process and flow of materials handling in such a way that the time of each worker is effectively spent on productive operations.

Improved Employee Morale : Employee morale is achieved when workers are cheerful and confident. This state of mental condition is vital to the success of any organisation. Morale depends on:

(a) Better working conditions;

(b) Better employee facilities;

(c) Reduced number of accidents;

(d) Increased earnings.

Plant layout has a bearing on all these.

Avoidance of Unnecessary and Costly Changes : A planned layout avoids frequent changes which are difficult and costly. The incorporation of flexibility elements in the layout would help in the avoidance of revisions.

REVISION OF LAYOUT

As pointed out earlier, a good plant layout involves not only the designing and installing of the layout for the first time but also encompasses revision of the existing layout as well. The best layout becomes obsolete over a period of time. When a plant has remained unchanged for a number of years, it can be assumed that the layout is obsolete in some way. Revisions, ranging from minor alterations to a complete dismantling of the existing structure and installation of a new layout, become necessary from time to time in order to increase and maintain the operating efficiency of the plant.

Reasons for Revision

Generally speaking, the following developments necessitate a revision of the existing layout:

(i) Expansion;

(ii) Technological advancements; and

(iii) Improvement in the layout.

The reasons for revision are elaborated in the paragraphs that follow:

Expansion : Expansion is a natural feature of any industrial establishment. A plant may expand in any one of the following ways:

(a) Increase in the output of the existing product;

(b) Introduction of a new product in the same line; and

(c) Diversification of the lines of activity.

In order to cater to the ever-increasing demand for its product, a plant may increase its capacity by installing a few more machines of the type already in operation or by adding machines of new designs and higher capacity. In such cases, the installation of new machinery will pose the same problems to the layout engineer as the designing and installation of a new layout for the first time. If the expansion in the capacity is sought to be achieved by adding a few more machines of the type already in operation, the problem is simple for the layout man. There is no need to disturb the existing structure; new machines are installed only to increase the capacity. The problem would have been further simplified if expansion had been foreseen and the provision for it had been made in the original layout plan. But indiscriminate installation of new machines wherever space permits would result in overcrowding and chaotic conditions.

Expansion may also be achieved by introducing a new product in the same line. The sales of the existing product might decline because of keen competition. A new product, of a better quality and bigger size, may be introduced to offset the loss, the line of production being the same. The production of a new one may be carried out with the existing plant facilities; but such an arrangement should be temporary. The permanent solution is to add a new wing to the present plant or set up a new plant at different place. The layout has to be freshly designed and installed.

Expansion may also be achieved through diversification. Diversification involves production of a product or products which are totally different from the existing ones. New lines are added by constructing new plants, generally at different places. There is no dearth of instances of diversification, because diversification, like expansion and foreign collaboration, is a symbol of progress and prestige for many managers of industrial establishments. Naturally, many managers try and succeed in effecting diversification. The layout problem for diversification would be the same as for a new plant.

Technological Advances : Thanks to industrial research, new products, new uses of existing products and materials, new machinery and new sources of energy have been, and are being, discovered. Industrial research is an insurance against obsolescence of products, processes and plant layouts. Some of the technological advances are :

Technological advances affect plant and equipment directly or indirectly.

(a) Replacement of labour by machines;

(b) Developments in fuel and energy;

(c) Developments in process;

(d) Developments in materials;

(e) Improvements in product design and

(f) Advancement in information technology

Technological advances affect plant and equipment directly or indirectly. The layout of the plant must be revised to accommodate such improvements.

Improving the Layout : Layout needs constant attention from management. It has to be reviewed and revised to correct any deficiencies which may have crept into the plant and which were originally unnoticed by the layout engineer. Even if the plant was perfectly laid initially, subsequent developments in materials, machines and methods might render the layout deficient. Generally speaking, the limitations in a layout go unchecked for two reasons:

(a) The evils of a poor layout are a hidden cost not revealed even by the best accounting method; and

(b) Even if the limitations are revealed, the management may be unwilling to initiate remedial steps because there is a built-in adjustability to any circumstance in all human beings; and the management is no exception.

What is needed is a progressive outlook and courage on the part of the management to rectify defects. Once noticed, they should be set right. These defects may be:

(a) Materials and work-in-process move at a lower rate than expected, with backtrackings and cross-overs.

(b) Materials handling costs are high.

(c) Aisles and individual work places are congested.

(d) Service departments are given inadequate space and are inconveniently located.

(e) Materials in process are frequently damaged.

(f) Frequent accidents happen to workers.

(g) There are delays in production schedule.

(h) There are no plans for future expansion.

(i) There is increased cost of production and reduced operational efficiency.

A revision of the layout to rectify these defects poses no serious problems because minor alterations in the existing plant would suffice.

LAYOUT PLANNING

Layout procedure starts with an analysis of the product to be manufactured and its expected volume of production.

Designing and installing a layout for the first time and its subsequent revision may be looked after by the Engineering or Planning Department. Not infrequently, the services of outside consultants are engaged for the purpose. Large establishments, with branches, subsidiaries and associate companies, may have a construction company as one of their subsidiaries, which discharges the responsibility of planning and constructing the plants of its family concerns, apart from accepting orders from outside.

Whoever designs and installs a layout, there is no ready-made method for preparing it. The process of preparing a layout is an art as well as a science, in spite of the advances made in the use of layouts. Naturally, the final layout will be a consummation of many trials, errors, and compromises. The final layout, which emerges out of trials and errors, may not be the best.

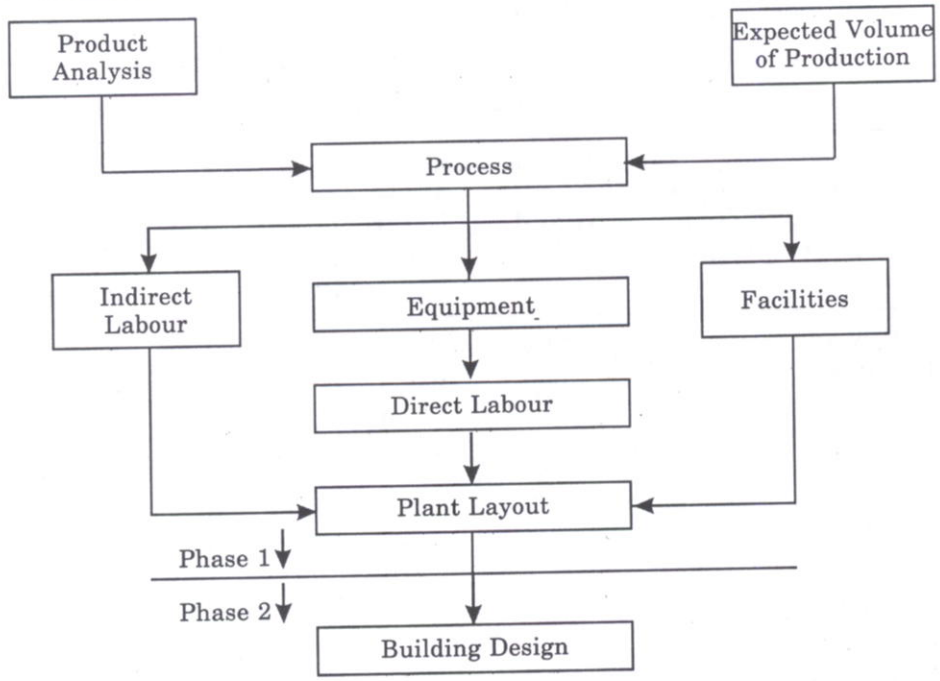
To make the final layout as perfect as possible, the layout personnel would do well to proceed step by step in the process of layout planning. These steps are shown in *Exhibit 9.7*.

The layout procedure might start with an analysis of the product to be manufactured and the expected volume of its production. An analysis of the product includes a study of the parts to be manufactured and/or bought, and the stages at which they should be assembled to obtain the end product. The volume of production is estimated in terms of market and management policies.

For a given product at a stated volume of production, a process most appropriate must be determined. The process that is determined, like any other factor, may not be permanent

because it will be influenced by changes in the volume of production, changes in the product and changes in equipment. The process which is decided upon determines the type of equipment that would be needed to manufacture a given product at a given volume. The equipment requirements of a company vary with its methods of grouping machines or the type of layout, the main consideration being an increasing use of machines and not of labour. The equipment which is selected determines the number of workers who will be required. The trend nowadays is to replace labour by machines because that results in increased production, reduced cost, better quality and fewer labour troubles. But labour cannot be completely dispensed with; it would always be needed to switch on and switch off the machines, even if the whole plant is mechanised.

Exhibit 9.7 : Steps in Layout Planning and Design



At the fourth stage, product and volume have led to a process which dictates the type of equipment which would be acquired and which, in turn, would require operators. But the operators require the services of indirect labour - of material handlers, janitors, maintenance staff, quality control staff and production supervisors. The arrangement of all these facilities and personnel constitutes plant layout. Once the plant layout is designed, the layout engineer often engages the services of an architect or the construction division of the company to design the system.

I LAYOUT TOOLS AND TECHNIQUES

Various techniques are available for lanning the layout. The most commonly used technique is the use of two-dimensional templates. Other techniques depend upon the method of layout. For example, to design the process layout operations, sequence analysis is mainly used, whereas line balancing is used to design the product layout.

Plant layout template is a scaled representation of a physical object in a layout.

Templates : Templates are patterns which consist of a thin plate of wood or metal, which serves as a gauge or a guide in mechanical work. A plant layout template is a scaled representation of a physical object in a layout. This object may be a machine, materials

handling equipment, a worker or even materials. The templates are fixed to plan drawing and are moved around the drawing to explore the various layout possibilities until a layout, which eliminates unnecessary handling and back-tracking of materials and offers flexibility to admit revisions at the least cost, emerges. The template method is particularly useful in developing a layout-for an existing department or building or when the configuration of the building is already established through other layout techniques.

Where a layout is to be developed with no building around, other techniques, as explained below, will be useful.

Operations sequence analysis helps arrange departments graphically analysing the layout problem.

Operations Sequence Analysis : Being an early approach to process layouts, operations sequence analysis develops a good scheme for arrangement of departments graphically analysing the layout problem. *Exhibits 9.8* and *9.9* illustrates the technique. The exhibits are drawn using the following data:

Number of departments - 10.

Number of products travelling among the departments - 6.

During one month, the products travel among departments as shown in the *Table 9.4.*

Table 9.4 : Department and Code

Department Code	Department Description	Grind 5	Paint 6	Drill 7	Rework 8	Glaze 9	Ship & Receive 10
1	Blow and mould	1,000	–	5,000	–	3,000	3,000
2	Heat treat	2,000	2,000	–	–	–	3,000
3	Neck	–	2,000	–	–	2,000	–
4	Package	1,000	–	4,000	–	–	5,000
5	Grind	–	2,000	–	–	–	–
6	Paint	–	–	–	–	2,000	–
7	Drill	–	–	–	1,000	–	–
8	Rework	–	–	–	–	–	1,000
9	Glaze	–	–	–	–	–	–
10	Ship & receive	–	–	–	–	–	–

Exhibit 9.8 shows an initial solution with circles representing departments and lines representing product travels among departments. The number of products that travel during the month among departments in written on the lines.

Exhibit 9.8 : Initial Solution for Layout

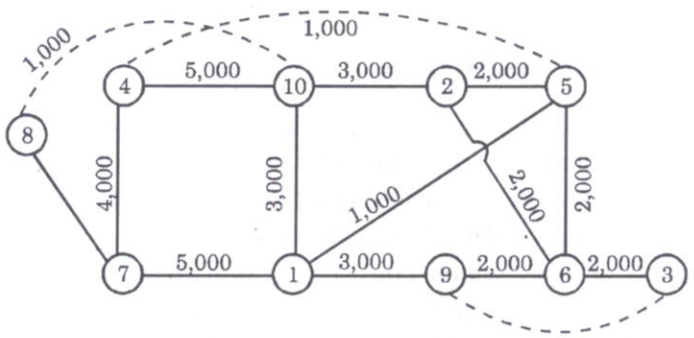
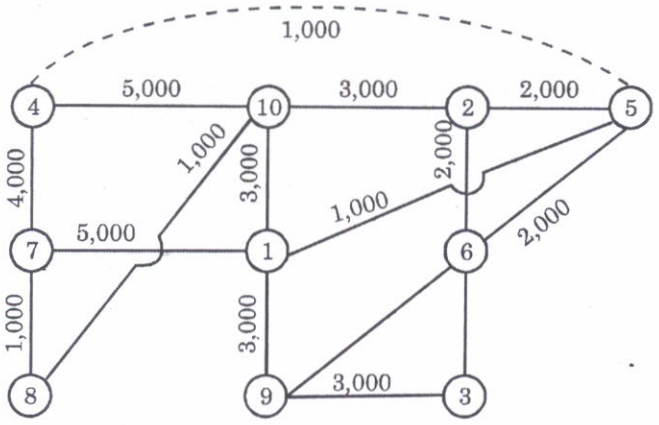


Exhibit 9.9 shows the restructured layout with certain departments moving closer to others. For example, Department 3 has been shifted closer to Department 9, and Departments 8, 9 and 6 have been shifted to form a rectangular shape.

Exhibit 9.9 : Restructured Layout



Thus, *operations sequence analysis* helps determine locations of operating departments relative to one another.

Line balancing is the study that nearly equally divides the work to be done among the workers and minimises the number of employees required to complete a project.

Line Balancing : Line balancing is the phase of assembly line study that nearly equally divides the work to be done among the workers so that the total number of employees required on the assembly line is minimised. Line balancing is not simple; in fact, there are usually many alternative ways that the work can be divided among the workers. Operation researchers have used linear programming dynamic programming and other optimal methods to study line balancing problems. Explanation of all these is beyond the scope of this text.

ANALYSING LAYOUTS WITH COMPUTERS

As in other fields, computers have entered the field of layout engineering in a big way. Various techniques have been developed and used in layout planning. For example, in designing process layout, the analyses used are - ALDEP (automated layout design programs), CORELAP (computerised relationship layout planning) and CRAFT (computerised relative allocation of facilities technique).

These and other computer programmes can save time and effort in large and complex layout problems, but the plans they offer are only the beginning of a final layout. The layouts given by computers must be fine-tuned by hand and checked for logic, and machines and other elements of the layout must usually be hand-fitted with templates.

LAYOUT OR BUILDING?

Which comes first, the chicken or the egg? This ancient puzzle can be used to illustrate the relationship between the layout and the industrial building. Should the building be built first and the layout planned to fit it? Or should the layout be planned first and the building built around it?

The ideal procedure would be to plan the layout first and construct the building around it. But the ideal situation is not always available because of certain reasons. In the case of

going concerns, some, if not all, the buildings may be in existence. To demolish the existing building to plan the layout would be very difficult and expensive. Moreover, the site selected may impose restrictions and make it difficult for one to plan the layout first and construct the building around it. In such circumstances, the building comes first, and then the layout. Plant layout will be generally a compromise between the ideal layout and the limitations of a plant site and building.

Whichever comes first, care should be taken to make the building and the layout as ideal as possible within the available facilities, for both are vital to the success of any industrial establishment. If the building is compared to the skin and bones of a human body, the layout is naturally the arrangement of heart, liver, muscles, etc., inside the skin and bones; the difference between the two is that, in the case of a factory, one comes after the other; but the human body emerges from the womb ready-made.

I CRITERIA FOR SELECTION AND DESIGN OF LAYOUTS

Material handling cost and worker effectiveness are the two criteria used for selecting layout design.

Facility layouts must integrate work centre location, office, computer facilities, tool room, storage space and washrooms etc. Two of the major criteria for selecting and designing and layout are:

1. Material handling cost and
2. Worker effectiveness

Materials handling costs are minimized by using mechanised material handling equipments such as belts, cranes and conveyors to automate product flows and keeping the flow distances as short as possible by locating the work centres for sequential processing activities in adjacent areas.

Worker effectiveness is another important criteria in the layout of facilities. Good layout provides workers with a 'satisfying' job and permit them to work effectively at the highest skill level for which they are being paid. Good communication systems and well-placed supporting activity locations are critical to the success of any facility.

The various methods used for selecting the best layout among several alternatives layouts are illustrated below with example:

1. Travel Chart Method

The trave chart which is also known as *from-to-chart* is helpful in analysing the overall flow of material. It shows the *number of moves* made between departments and identifies the most active departments. A typical travel chart is shown in *Exhibit 9.10.*

Exhibit 9.10 : Facility Outline Chart and Travel Chart for a Typical Facility

1	2	3
4	5	6

(a) Facility outline chart

From	Number of moves to					
	A	B	C	D	E	F
A	–	7	–	–	–	5
B	–	–	–	4	10	–
C	–	7	–	–	2	–
D	–	–	8	–	–	–
E	4	–	–	–	–3	
F	–	6	–	–	10	–

Travel chart method shows the number of moves made between departments and identifies most active department.

The solution is obtained by the trial and error method which attempts to minimise non-adjacent flows by centrally locating the *active departments* (i.e., departments which have the maximum number of links with other departments). The work centres are shown as circles and the connecting lines represent the loads transported during a given time. Departments next to each other or diagonally across from each other are regarded as adjacent departments.

Procedure

Step 1 : Determine which departments have the most frequent links with other departments. This can be done by totalling the number of entries in each row and column. The number of links between the departments are as below:

Department	A	B	C	D	E	F
Number of links	3	5	3	2	5	4

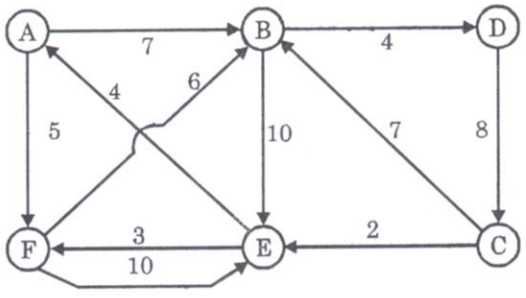
Step 2 : Try to locate the most active departments in the central positions in the facility outline.

In this example, departments B and E which have the maximum number of links with other departments are located at locations 2 and 5 of the facility outline.

Step 3 : By trial and error method, locate the other departments so that the non-adjacent flows are minimised. *Exhibit 9.11* shows one such arrangement made by the trial and error method. Next, the number of moves and the link between departments are indicated on the schematic diagram as per travel chart.

Step 4 : If all the non-adjacent moves are eliminated, the solution is complete. If non-adjacent flows still exist, try to minimise the number of units flowing to non-adjacent areas as weighted by the distances between non-adjacent departments. In this example, the trial and error solution indicated by the schematic diagram in *Exhibit 9.10* results in complete elimination of non-adjacent flows and hence gives the complete solution.

Exhibit 9.11 : Schematic Diagram for Facility Layout



2. Load-Distance Analysis Method

Load-distance analysis method is useful in comparing alternative layouts.

Load-distance analysis is useful in comparing alternative layouts to identify the one with the least product or material travel time per period. This method helps to minimise transportation costs by evaluating alternate layouts on the basis of the total of the product of actual distance moved and the load (the units moved) for each layout alternative. Alternatively, the material handling costs can be computed directly by multiplying the number of loads by the material-handling cost per load. The layout with the lowest total (load × distance) or total (load × cost) is the best choice.

The following illustration helps in understanding the load-distance analysis method to determine the best layout alternative which minimises the total (load × distance moved).

Illustration for Load-Distance Analysis

Two layout alternatives are shown below. The facility's products, their travel between departments and the distances between departments for each layout alternative are also shown below. The layout alternative that minimises the monthly product travel through the facility has to be determined.

Layout A

8	4	10	2	5
3	7	1	9	6

Layout B

7	1	9	6	3
4	10	2	5	8

Department Movement Combination	Distance between Department (feet)		Department Movement Combination	Distance between Department (feet)	
	Layout A	Layout B		Layout A	Layout B
1 - 5	30	30	3 - 9	30	20
1 - 7	10	10	4 - 5	30	30
1 - 9	10	10	4 - 7	10	10
1 - 10	10	10	4 - 10	10	10
2 - 5	10	10	5 - 6	10	10
2 - 6	20	20	6 - 9	10	10
2 - 10	10	10	7 - 8	20	50
3 - 6	40	10	8 - 10	20	30

Products	Department Processing Sequence	Number of Products Processed per month	Products	Department Processing Sequence	Number of Products Produced per month
a	1 - 5 - 4 - 10	1000	d	1 - 7 - 8 - 10	1000
b	2 - 6 - 3 - 9	2000	e	2 - 5 - 6 - 9	2000
c	2 - 10 - 1 - 9	3000	f	1 - 7 - 4 - 10	4000

Steps Involved in the Solution

Step 1 : Compute the total travel for each product through each layout alternative as given below:

Product	Department Processing Sequence	Distance Moved per Product	
		Layout A	Layout B
a	1 - 5 - 4 - 10	30 + 30 + 10 = 70	30 + 30 + 10 = 70
b	2 - 6 - 3 - 9	20 + 40 + 30 = 90	20 + 10 + 20 = 50
c	2 - 10 - 1 - 9	10 + 10 + 10 = 30	10 + 10 + 10 = 30
d	1 - 7 - 8 - 10	10 + 20 + 20 = 50	10 + 50 + 30 = 90
e	2 - 5 - 6 - 9	10 + 10 + 10 = 30	10 + 10 + 10 = 30
f	1 - 7 - 4 - 10	10 + 10 + 10 = 30	10 + 10 + 10 = 30

Step 2 : Compute the total distance travelled per month for each product through each layout alternative as below:

Product	Products per month (load/units)	Distance per product (feet)		Load × Distance per month (units × feet)	
		Layout A	Layout B	Layout A	Layout B
a	1000	70	70	70,000	70,000
b	2000	90	50	1,80,000	1,00,000
c	3000	30	30	90,000	90,000
d	1000	50	90	50,000	90,000
e	2000	30	30	60,000	60,000
f	4000	30	30	1,20,000	1,20,000
			Total	5,70,000	5,30,000

Step 3 : Determine the layout alternative to be chosen based on the minimum (load × distance) per month. Layout B results in the least total (load × distance) per month and hence the choice.

3. Systematic Layout Planning

SLP method is used where the amount of material that flows between departments may not be critical for developing a good facility layout.

Systematic layout planning (SLP) method is used in some production systems such as service systems, where the amount of material that flows between departments may not be critical for developing a good facility layout. This method develops a chart known as "relationship chart" or Richard Muther's half-matrix, which rates the relative importance of locating one department close to another department. The importance ratings are indicated by code letters a, e, i, o, u, x is known as *'nearness codes'*, which indicate the following degree of importance.

Nearness code	Degree of Importance
a	absolutely necessary
e	very important or essential
i	important
o	ok, ordinary importance
u	unimportant
x	undesirable

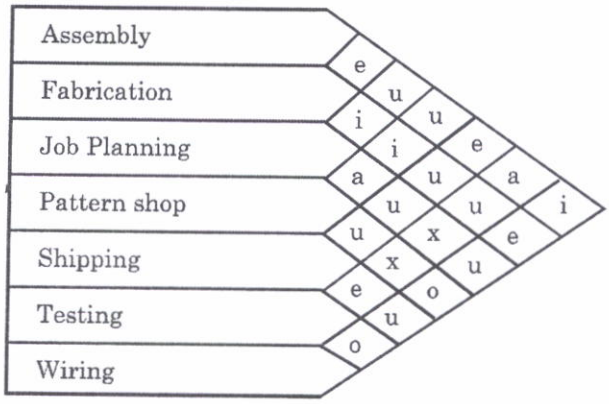
In addition to the nearness code, a reason code indicated by a number (say 1, 2 or 3) based on a variety of reasons for locating any two departments adjacent to each other, is used.

The examples of reason codes are:

Reason Code	Reason
1	use of common personnel
2	noise isolation
3	safety purposes
4	ease of supervision
5	common equipment
6	type of customer

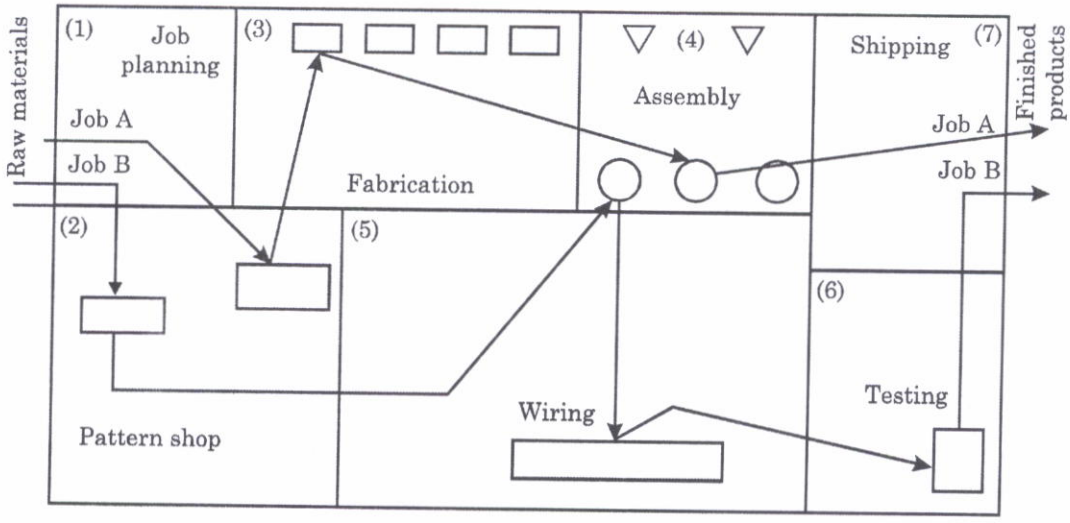
Exhibit 9.12 illustrates the half-matrix developed for a job-shop layout for producing a made-to-order product.

Exhibit 9.12 : Richard Muther's half-matrix for a Job Shop Layout (or process layout)



Based on the nearness code, the above seven departments can be arranged in the job-shop layout as shown in *Exhibit 9.13* below:

Exhibit 9.13 : Job Shop Layout as Determined by Systematic Layout Planning Method Using Richard Muther's Half-matrix Indicating Nearness Codes



I LAYOUT DESIGN PROCEDURE

Designing the layout of a plant is a specialised activity and should be carried out systematically. The various steps to be followed in the layout design are:

1. Statement of specific objectives, scope and factors to be considered.
2. Collection of basic data on sales forecasts, production volumes, production schedules, part lists, operations to be performed and their sequences, work measurement, existing layouts, building drawings.

3. Preparation of various kinds of charts such as flow process charts, flow diagram, string diagram, templates etc.
4. Designing the production process.
5. Planning the material flow pattern and developing the overall materials handling plan.
6. Calculation of requirement of work centres and equipments.
7. Planning individual work centres.
8. Selection of materials handling equipments.
9. Determining storage requirements.
10. Planning of auxiliary and service facilities.
11. Determination of routing, space requirements for each work station, service department, employee facilities etc.
12. Draw building specifications to fit the requirements of the layout.
13. Preparation of floor plan indicating location of doors, windows, stair case, lifts etc.
14. Preparation of tentative or drafts layout plans.
15. Preparation of detailed layout drawing and get approval of the top management.
16. Preparation of work schedule for the installation of layout.

QUESTIONS

1. Define the term plant layout. Discuss the factors influencing the layout.
2. Mention the types of layout. Briefly describe each.
3. Bringout the comparison between product layout and process layout.
4. "Plant layout involves, besides grouping of machinery, an arrangement of other facilities also" Discuss.
5. "An ideally laid out plant goes a long way in reducing manufacturing costs through reduced materials handling, reduced personnel and equipment requirements and reduced in-process inventory" elaborate.
6. Explain with examples, the reasons for layout revision.
7. Briefly explain the steps in layout planning. Give the meaning of :
   (a) Templates (b) Process charts (c) Process flow chart
8. Discuss the objectives of a good layout.
9. What is a manufacturing cell or cellular manufacturing?
10. Which three factors are essentially significant in determining the type of layout?
11. How do the major layout concerns vary between job shop and line processing layouts?
12. How does the systematic layout planning approach differ from the basic load-distance analysis?
13. Under what conditions is G.T. layout appropriate?
14. Explain the tools and techniques of plant layout.
15. What is fixed position layout? Give two examples.

I PROBLEMS

1. A manufacturing concern has 3 departments and to flow between departments is as follows:

From	To			
	A	B	C	D
A	–	2	–	2
B	2	–	4	–
C	–	3	–	1
D	2	–	1	–

Using the operators sequence analysis technique, how should the departments be arranged.

2. A warehouse processes six products monthly. The products are A, B, C, D, E and F. Two alternative layouts, X and Y, for the warehouse are being considered.

Layout X

1	3	5	Receiving (R)
2	4	6	Shipping (S)

Layout Y

5	1	4	Shipping (S)
6	2	3	Receiving (R)

The products, their monthly production quantities, their sequence of processing and distances between processing departments are shown in the following table:

Product	Number of Products Processed per month	Product Sequences	Sequence of Distances (Feet)	
			Layout X	Layout Y
A	1000	R-1-S	70	50
B	3000	R-2-S	70	50
C	2000	R-3-S	50	30
D	3000	R-4-S	50	30
E	2000	R-5-S	30	70
F	2000	R-6-S	30	70

Which layout alternative minimizes the monthly warehouse travel? Use load-distance analysis.

3. A company wants to add a new wing to its present manufacturing shop to manufacture certain products. The two alternative layouts being considered are as below:

Layout A

	2			6
1		4	5	
	3			7

Layout B

2		
3	5	6
1	4	7

The products manufactured, the trips that batches of these products make between departments and the distances between departments are shown below:

Trips between Departments	Distances between Departments	
	Layout A	Layout B
1-2	24	50
1-3	24	30
1-4	38	46
2-3	44	20
2-4	30	72
3-4	44	52
4-5	50	40
5-6	50	44
5-7	50	60
6-7	40	40

Sequence of processing products through departments.

Products	Department Processing Sequence	Batches of Products to be produced per year
P_1	1-2-3-4-5-6-7	1400
P_2	1-2-4-5-6-7	200
P_3	1-3-4-5-6-7	1200
P_4	1-3-4-5-7	300
P_5	1-4-5-6-7	200

Use load distance analysis to determine which layout minimizes the annual distance that the batches of products travel through the new facility.

4. Arrange six departments a, b, c, d, e and f in the facility outline chart shown below so as to meet the objectives listed below:

Facility outline chart

1	2	3
4	5	6

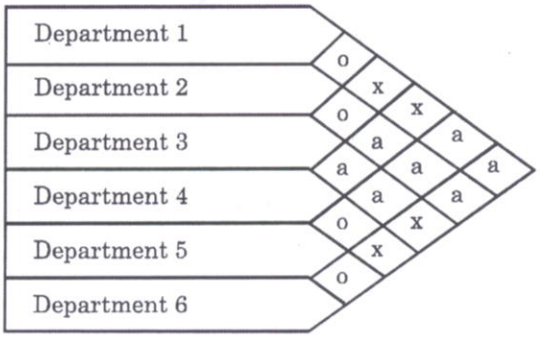
Objectives of layout

Department	
	A near E
	A near D
	A near C
	B near C
	F near D
	E near F

5. Arrange six departments 1, 2, 3, 4, 5 and 6 in the facility outline shown below so that the nearness priorities shown in the matrix are satisfied.

Facility Outline

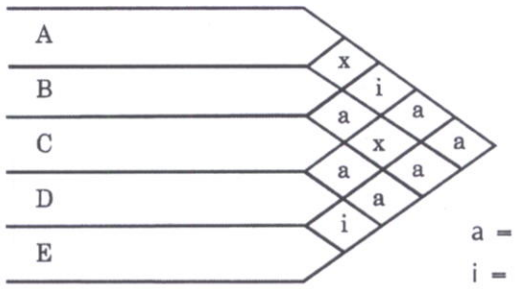
Half-matrix



0 = OK
a = absolute necessity
x = undesirable

6. Department A, C, D and E should be 40 metres × 40 metres.

Department B should be 40 × 80 metres. Arrange these five departments in an 80 × 120 metres space so that the layout meets the conditions specified in the matrix.



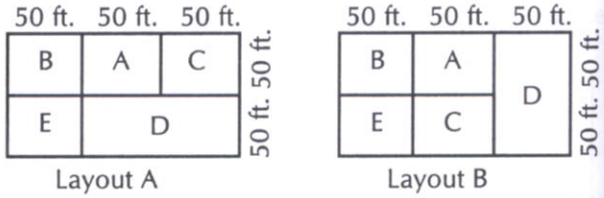
a = absolute necessary
i = important
x = undesirable

7. Determine which of the following two layouts will result in a lower product of trip times distance travelled per year. The number of trips between pairs of departments are given in the table below: The layouts are shown in the facility outline.

Table

Exchanging Department	Load per Year (units)
A-C	1,100
A-B	1,300
D-E	1,600
C-D	2,100
A-D	2,500
B-C	3,200
B-D	3,800
A-E	4,200
C-E	4,300
B-E	4,600

Facility Outline



Assume that all movements are between the centres of the specified departments and are made parallel to the walls of the building and all turns must be at right angles, since there are no diagonal aisles.

8. The flow of material between 6 departments of a manufacturing firm is shown below:

		To					
From		**A**	**B**	**C**	**D**	**E**	**F**
A	→	x	50	100	25	60	x
B	→	40	x	80	x	150	x
C	→	10	70	x	55	x	x
D	→	10	x	80	x	x	x
E	→	40	x	x	80	x	30
F	→	x	60	50	x	x	x

Design a layout on a (3 × 2) grid that will facilitate maximum collaboration among departments.

* * * * *