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# 1. Guide lines for plant layout optimization

## 1.1 Objective of the guide line

The main objective of this printed material is explain economic considerations of plant installation and explain systematic layout planning principle to identify basic techniques of determining space requirements of workstation, departments and supporting services areas used in plant layout planning.

**Who will benefit from guide line?**

* Plant and manufacturing managers
* Manufacturing and process engineers
* Industrial and layout planners
* Production supervisors and team leaders
* Discussion makers
* Plant layout planning consulters
* All others concerned bodies are beneficiary from this guide line

##  1.2 Plant layout and shop layout

The efficiency of production depends on how well the various machines, production facilities and employees amenities are located in a plant. Only the properly laid out plant can ensure the smooth and rapid movement of material, from the raw material stage to the end product stage. Plant layout encompasses **new layout as well as improvement in the existing layout**. It may be defined as a technique of locating machines, processes and plant services within the factory so as to achieve the right quantity and quality of output at the lowest possible cost of manufacturing. It involves a judicious arrangement of production facilities so that workflow is direct.

# 1.2 Definition

Plant layout refers to an optimum arrangement of different facilities including human resource, plant and machinery, material etc. Since a layout once implemented cannot be easily changed and costs of such a change are substantial, the plant layout is a strategic decision. A poor layout will result in continuous losses in terms of higher efforts for material handling, more waste and rework, poor space utilization etc. Hence, need to analyze and design a sound plant layout can hardly be over emphasized. It is a crucial function that has to be performed both at the time of initial design of any facility, and during its growth, development and diversification. The problem of plant layout should be seen in relation to overall plant design which includes many other functions such as product design, sales planning, selection of the production process, plant size, plant location, building, diversification etc. **The layout problem occurs because of many developments including:**

* **change in product design**
* **introduction of new product**
* **obsolescence of facilities**
* **changes in demand**
* **market changes**
* **competitive cost reduction**
* **frequent accidents**
* **adoption of new safety standards**
* decision to build a new plant

**Machine layout**: **- Showing size and general outline, location of motors, hydraulic units, fixtures, chip removal, panel access door swings, operator position, foundation requirements, pits, leveling screws, anchor bolts, and location of service connections**. For automatic machines, part entry and exit points must be indicated; direction of part flow and bottom of part elevation above floor must be shown. In addition, for plant layout purposes, a plan view shall be prepared showing size and general outline of machine, relative location of electrical panels, hydraulic units, coolant tanks, etc. Indicate as much detail from the machine layouts as practical.

# 1.3 Importance

Plant layout is an important decision as it represents long-term commitment. An ideal plant layout should provide the optimum relationship among output, floor area and manufacturing process. It facilitates the production process, minimizes material handling, time and cost, and allows flexibility of operations, easy production flow, makes economic use of the building, promotes effective utilization of manpower, and provides for employees convenience, safety, comfort at work, maximum exposure to natural light and ventilation. It is also important because it affects the flow of material and processes, labor efficiency, supervision and control, use of space and expansion possibilities etc.

#  1.4 Factors that should be considered for installation of plant

The important factors while planning for installation of plant include availability of space, power, water, raw material, good climatic conditions, good means of communication, government influences both negative and positive, infrastructure, and similar other economic considerations, marketing facilities for the planned product, space for process disposal and skilled and unskilled labor locally. One has to keep in mind the possibilities of utilization and sale of the process wastes and by-products of the planned industry. Decision of manufacturing new product, financial and other aids, facilities for expansion presence of related industries, local bylaws and securities, hospitality are also important factors which one must keep in mind for location of an enterprise. After finalizing the size and location of the plant, the next step is to design the inner layout of the plant to plan out the sequence of different shops and their locations accordingly to specifications of material and product, manufacturing processes, type of production, material handling facilities, system and facilities for storing, inter-dependability of one shop over the other, links amongfacilities for storing, inter-dependability of one shop over the other, links among various shops, service facilities and lighting and ventilation. Next, the internal arrangement of the above mentioned infrastructural facilities of different shops are identified. This identification is termed as shop layout. The main factors namely size and type of equipment, number of machines to be installed, floor area required for working on each machine, power requirements for the machines, requirements of factory services, sequence of operations to be followed, visibility to all the machines for proper supervision and control, type of drive used, safe working conditions, washrooms, drinking water, toilets, lockers restroom, first aid room cafeteria, parking area provision of stores within the shop, i.e. for tools, instruments, finished parts and consumable materials, etc. affects the layout of the plant. A good plant layout should meet the following basic requirement:

# 1.5 Essentials

An efficient plant layout is one that can be instrumental in achieving the following objectives:

a) Proper and efficient utilization of available floor space

b) To ensure that work proceeds from one point to another point without any delay

c) Provide enough production capacity.

d) Reduce material handling costs

e) Reduce hazards to personnel

f) Utilize labor efficiently

g) Increase employee morale

h) Reduce accidents

i) Provide for volume and product flexibility

j) Provide ease of supervision and control

k) Provide for employee safety and health

l) Allow ease of maintenance

m) Allow high machine or equipment utilization

n) Improve productivity

## 1.6 Types of Layout

The fulfilling the objectives of a good layout as per yearly product requirement and product

Types, the layouts are classified into four major categories namely:-

 (a) Product or line layout high volume and low variety product machines are arranged based on the sequences of operations

(b) Process or functional layout low volume and high variety product, similar machine are arranged together.

(c) Fixed position or location layout. Labor, tools and equipment come to the work site.

(d) Combined or group layout

#  2. Typical Approach to Plant Layout

##  2.1 Systematic Layout Planning

SLP is an acronym of Systematic Layout Planning which is a technique established b (Muther, 1961) It is a step-by-step planning procedure allowing users to identify, visualize, and rate the various activities, relationships, and alternatives involved in a layout project. The three fundamental areas of the technique are relationships, space and adjustment. The sub-contents of the relationship area are collection of input data, flow of materials, activity of relationships and relationship diagrams. The sub-contents of the space area are space requirements, space available and space relationship diagrams. The sub-contents of adjustment area are modifying considerations, practical limitations and evaluation and final selection. This technique combines quantitative measurement of materials movement with non-flow considerations such as noise, fumes, temperature, supervision, communications, personnel comfort and movement. Its major advantage is that it clearly documents the logic of the layout and easily allows input from all levels of staff.

The methodology is summarized in graph format in Figure 1 which is created originally from Richard Muther. The overall procedures are consisted by three parts which are analysis, search and selection



# 2.2 Five Important Elements

The basis and entry points for the research of plant layout problems can be generalized into five important elements according to the SLP method. These five elements are the “key” to the solution. They are:

**1. P-product**

The product element includes the end product, raw materials, machining components and projects of the service. All the information is provided by the production guideline and design menu. This element is the key factor affects the composition and relationship of all the facilities, equipment categories and material handling way.

**2. Q-quantity**

The quantity element indicates the amount of production, supply, utilization or service workload. All the information is provided by production statistics and design menu, and represented by piece, weight, volume and price. This element affects the layout scale, equipment amount, handling workload and construction area.

**3. R-route**

In fact, the route element is the achievement of technological process design. It can be represented by plant layout diagram, process route diagram, process flow chart and so on. It affects the relationship among every work unit, material handling route and warehouse and store location.

**4. S-supporting service**

Support staffing services required to assist to produce product. Supporting services include: maintenance, machine repair, tool room, toilets, locker rooms, cafeteria, first aid room, parking and receiving dock, shipping dock, receiving (or "in area"), and shipping (or "out area"). It is common to include storage areas as a part of the supporting services as well. Taken all together, the supporting services often occupy more floor area than the producing departments themselves. Therefore, adequate attention must be given to them.

**5. T-time**

The time element refers to when and how long the production is, in which includes the operating time of every procedure. According to the time requirement, we can estimate the amount of the equipment, required area and the number of staff Certainly, required cycle times, shipment and delivery frequencies, besides the above five elements, the other related ones are needed to be gathered to finish the final layout design as well. But P and Q are the basis for any other characteristics, conditions and elements. To get the most optimal system layout design, it is necessary to firstly make a structured and detailed analysis and calculation according to the comprehensive and accurate original data of these five elements. Then draw a variety of forms, mathematical and graphical models based on the calculation to present the core idea in an easy, obvious and clear way.

The next phase of the SLP method involves relationship Diagram describe an interdepartmental

Material flow. In order to do this, a unit of measurement about material handling must have been decided firstly. So the products with different characteristics can be homogenized and comparisons are feasible. Then the REL chart which means the relationship diagram should be made. This chart collects the qualitative information of „proximity ratios‟ which consist of a set of letters (A, E, I, O, U, X). They reflect how necessary is for every two work units to be adjacent in the final layout (ranging from A which means „absolutely necessary‟ through to X which shows „not desirable‟). After the spaces require and space available balanced the designers have to remodel or modify the previous design to a greater or lesser extent. Therefore, certain factors which might affect the following implementation of the layout should be taken into account. These factors include various aspects like natural light in the facility, roof heights, the position of electricity points and doors, and the inclusion of aisles for staff, material and equipment movements and so on. Additionally, the practical limitations and modifications which are researched in step 7 and 8 are highly dependent on the empirical skill knowledge and the subjectivity of the person who is responsible for the layout. In the final analysis, again it is dependent on the design person’s experience and opinions to determine how the new information or sources affect the modified layout of the different sections.

|  |  |  |
| --- | --- | --- |
| **Basic element** | **Features** | **General examples** |
| **Product** | Material type | Gas, liquid ,solid, plastic, nonferrous ,glass .woods, leathers |
| Size | Large vs small |
| Weight | Heavy, light, dense vs soft or bulky  |
| Shape | Conveyable or non conveyable vs irregular |
| Condition | Clean vs dirty  |
| Quality | High vs low inspection required workman shop |
| Product design | Standard  |
| **Quantity** | Volume | High vs low volume, tones |
| Lot size | Large vs small |
| Order quantity | Large vs small |
| **Route or flow process** | Nature of process | Hot vs cold, high labor vs high capital  |
| Types of operations | Cut, form, treat, assemble, store, receive ,repair, support office |
| Sequence | Common sequence vs. different; common first, last or key operations |
| Equipment used | High technology, vs low tech, general purpose, same vs different |
| Labor skill | Normal vs. special; learning curve; level of supervision; contract or temp.  |
| **Supporting**  | Schedule | Make to stock vs. to order; pulled vs. pushed; run regularly vs. randomly, infrequently |
| Security | High security vs. normal security; restricted access |
| Supporting services | Needing central services vs. containing their own; maintenance, tooling, fixtures, testing |
| Personnel entrance | Level of personnel comfort, conveniences and amenities |
| Utility requirement | High-cost, special vs. conventional utilities and auxiliaries |
| Building requirements | High vs. low bay; floor strength, dust, temperature or humidity control; containment |
| **Timing**  | Cycle time | Short cycle work vs. long cycle |
| Urgency | Immediate rush service vs. normal; emergency vs. routine |
| Seasonality | Level throughout the year vs. peak for summer, harvest time… |
| **Other**  | Market and customer | Domestic vs. export; civilian vs. military; single vs. several or many; service level offered |
| Order go together | Frequently ordered together; belong to or form a kit |
| Inventory  | Owned vs. consigned or contract; customer-specific, active vs. service, pick vs. reserve |
| Regulation  | Segregation required; special handling or controls; bonded |

Table 1 summary of five key input data

#  3. Phase of systematic layout planning

The structure of the SLP method is divided into four stages which are shown in the following

**Phase I. Orientation determining**

The aim of this stage is determining the initial orientation. No matter the overall layout of the whole

Factory and the layout of every workshop, the appropriate location is needed to be determined first. It is very important to find a correct and suitable location and contribution direction.

**Phase II. Overall planning**

After ensuring the circumscription, an overall layout should be planned in this area. The layout should be combined with the basic logistics models and zoning arrangement. To draw a preliminary zoning map, the shape of every operating unit is needed as very important data. It is necessary to know the relationship between every operating unit as well.

**Phase III. Detailed Planning**

This planning task should be very detailed for every workshop, work unit and equipment. To obtain the detailed layout, exact facility locations, aisle structures, input/output (I/O) point locations, and the layout with each department should be specified.

**Phase IV. Planning implementation**

As the name implies, the main job for this stage is making a construction plan, preparing for the

Construction, implementing the construction and installation. In addition, the planning and design department should be responsible for stages II and III. There is crossover among the sequences of these four stages. For example, for the small scale factories which need only one or two workshops, it is feasible to implement the construction accompanies with the planning or modification. Sometimes this crossover can be even more economic and efficient. Anyway, the results of each stage should be approved by higher authorities. The sources and information needed for every stage will become deeper and more complicated along with the stage progress. Furthermore, before stage I, there is a pre-planning period which is used to determine the objectives, forecast the requirements of facilities and estimate the production capacity and demand. After stage IV, there is the actual final stage which will present the test running of the whole layout after all the implementation. The main task during this period is making the conclusion and management summary for the construction, installation and commissioning of the whole project.

# 4. Basic approaches to determine Space requirements

Perhaps the most difficult determination in facilities planning is the amount of space required in the facility. The design year for a facility is typically 5 to 10 years in the future. Considerable uncertainty generally exists concerning the impact of technology, changing product mix, changing demand levels, and organizational designs for the future. The facilities planner then has the difficult task of projecting true space requirements for the uncertain future.

In determining space requirements for storage warehousing activities, inventory levels, storage units, storage methods and strategies, equipment requirements, building constraints, and personnel requirements must be considered. In manufacturing and office environments, space requirements should be determined first for individual workstations; next, departmental requirements should be determined based on the collection of workstation in the department. Richard Muther mentions five basic ways to determine space requirements each of the methods has its place and sometimes it is necessary to use all methods for the same project. Before the calculation method can be used, **it is required to identify all machines and equipment that are needed in the project**. To calculate the number of machines needed for a project is it according to several factors that need to be taken into calculation. These are; the capacity of the machine, available working hours, number of machines per operator or number of operator per machine, time and frequency of set-ups, peak quantity needs, yield or quality losses and store policies. Then the number of machines can be calculated with the following formula.

Number of machine required= $\frac{pices per hour to meet requirment}{pices per hour per machine}$

# 4.1 Calculation method

 Workstation Specification

Workstations are places where specific operations are performed. Productivity of a firm is definitely related to the productivity of the workstation. A workstation includes space for equipment, materials, and personnel. The equipment space for a workstation consists of space for:

1. The equipment

2. Machine travel

3. Machine maintenance

4. Plant services.

Floor area requirements for each machine, including machine travel, can be determined by formula multiplying total width (static width plus maximum travel to the left and right) by total depth (static depth plus maximum travel toward and away from the operator). To the floor area requirement of the machine add the maintenance and plant service area requirements. The resulting sum represents the total machinery area for a machine. The materials areas for a workstation consist of space for:

1. Receiving and storing materials

2. In-process materials

3. Storing and shipping materials

4. Storing and shipping waste and scrap

5. Tools- fixtures, jigs, dies, and maintenance materials. The personnel area for a workstation consists of space for:

1. The operator

2. Material handling

3. Operator ingress and egress (enter-exit).

When planning the space requirements for the operator and the material handling, should the operation in question be analyzed, using a so-called **motion study**?

# 4.2 Converting method

 The present space requirements are converted to those required for proposed layout. It is important to establish valid assumptions. It does not to calculate space requirements for manufacturing areas. The use of converting method for establishing **supporting service and storage areas**.

# 4.3 Space Standards

The use of pre-established space standards is a practical way to determine requirements for many projects. Basically, once the area requirements for a given machine or space element are established, the planner should be able to use that over and over again. In actual practice, however, this does not always work. In fact, there is great danger in using standards established by someone else unless the planner understands what is involved in the space element, what the working conditions are anticipated to be– and how to refer to and get access to the back-up data supporting the standards.

# 4.4 Roughed out layout method

If a scale-plan over the available space and models over the equipment that are going to be used is available and it is not wanted to calculate or convert and there is no space standards available then one can rough out a detail layout of the areas involved and use them as space requirements. However, this technique is adequate for establishing the space requirements for use in planning phase II general overall layout stage.

# 4.5 Ratio trend and projection method

This method establishes a ratio of m2 to some other factor e.g. m2 per worker, m2 per man-hour per year, m2 per produced product, Figures from previous years are used to establish a trend for the ratio the next step is to look into the future what the ratio is likely to be. From this and a projection of the companion portion of the ration, the space to meet those projections can be derived. It includes space for packaging, storage, maintenance, office, inspection, receiving and shipping, tool rooms, lab rooms, parking, cafeteria. It is limited to total or general space requirements and cannot be applied to individual activity-areas. Ratio trend and projection is perhaps the least accurate of any of the five methods. Space per unit produced is perhaps the best ratio to use.

# 5. Space available verses space requirement

When the space requirements for the new layout designs are decided it is required to look at how much space that is available. It might be the case that what has been established as required in not in accordance with what is available. If that is the case it means that is required to adjusted or compromise the space that was determined to be required means that the problem with balancing, space requirements against space available consist of three sub problems.

* Will the total space that is available be sufficient?
* Will the division of available space (building, floor, room) match in area, with the different areas needed (departments, activities, organizational groups)?
* Is the available space of such nature or in such condition that it is suitable for the work that is contemplated to take place there?

To balance total amounts of space is often a question of adding and comparing. If the area requirements do not fit to the available space it is needed to squeeze or reduce the requirements. All concerned areas should not be trimmed with an equal amount, instead should some kind of ranking system be used to find the areas that will cause the company least problem when reduced. Next is the difficult task to match the various divisions of space with the individual areas available, these must correspond in both area and condition.

#  6. Department Specification

Once the space requirements for individual workstations have been determined, the space requirements for each department can be established. To do this, we need to establish the departmental service requirements. Departmental area requirements are not simply the sum of the areas of the individual workstations included with the department. It is quite possible tools, dies, equipment maintenance, plant services, housekeeping items, storage areas, operators, spare parts boards, information-communication-recognition boards, and Additional space is required within each department for material handling within the department. Aisle space requirements can be approximated, since relative sizes of the loads to be handled are known .Aisle allowance estimates for departments is 13% of calculated size of departments.

# 7. Aisle Arrangement

Aisles should be located in a facility to promote effective flow. Aisles may be classified as departmental aisles and main aisles. Planning aisles that are too narrow may result in congested facilities having high levels of damage and safety problems. Conversely, planning aisles that are too wide may result in wasted space and poor housekeeping practices. Aisles widths should be determined by considering the type and volume of flow to be handled by the aisle. The type of flow may be specified by considering the people and equipment types using the aisle. Industrial standards on departmental space requirements recommended aisle width for tractor 3.6m and for forklift from 2.7- 3.4m.

# 8. Supporting services space requirement

 Office space determination

It is calculated based on number of employees; international standard for individual office size is 18.58 m2 perperson. For general director 43m2, and for deputy director, 35m2. According muthar simplified plant layout system individual workshop no longer than 465m2. Simplified Systematic Layout Planning is an abbreviated version of Systematic Layout Planning (SLP). This simplified version of SLP is best suited to office areas up to about 279m2, and in storage areas up to 745 to 929 square meters.

Personnel requirements

The planning of personnel requirements includes planning for:

* Employee parking,
* Locker rooms,
* Restrooms,
* cafeteria,
* Health services.

 Employee Parking

The number of parking spaces to be provided must be specifically determined for each facility and must be in accordance with local zoning regulations.

The size of parking space for an automobile can vary from 9.76m2 to 16.77m2, depending on the type of automobile and the amount of clearance to be provided.

Storage of Employees Personal Belongings

A location for storage of employee personal belongings should be provided between the employee entrance and work area. Employees typically store lunches, cafeteria, and purses at their place of work. The lockers may be located in a corridor or adjacent to the employee entrance. For planning purposes, 0.67m2 should be allocated for each person using the locker room. Locker rooms are often located along an outside wall adjacent to the employee entrance. This provides excellent ventilation and employee convenience while not interfering with the flow of work within the facility.

 Restrooms

 Restrooms are designed for single occupancy, separate restrooms should be provided for each sex. For each space planning purposes, 1.4m2 should be allowed for each toilet and 0.56m2 for each urinal. A space allowance of 1.4m2 should be used for the entrance.

 Space requirements for cafeteria

It is based on number of employees; recommended factor ratio is 0.929m2 per person.

**Calculating warehouse space in food processing industries**

 The size of warehouse required for an operation is determined by the maximum quantity, in tonnage and volume, of supplies to be stored there at any one time. This quantity is determined by the number of beneficiaries, the lead-time needed to replenish the warehouse, the type of distribution system and the frequency of the distributions (e.g., monthly, weekly, etc.).

* Grain (rice, maize), flour, sugar 2m3 per tone
* Medicines (average for bulk shipments and medical kits) 3m3
* Vegetable oil in drums or tins 1.5-2m3

 When calculating storage requirements, only 70 per cent of the total warehouse’s surface capacity should be considered as available for actual storage space. The remaining 30 per cent is used to ensure proper ventilation, passageways, handling space and repackaging areas.

Sample area calculation

For 100 tones flour with a storage height equal to two meters

1 tone flour = 2m3

100 tone = 200m3

Maximum stacking height from grains 2m height

Required surface area = 100m2

Total warehouse space needed = 100m2 + (100m2 x30%) =130m2

**Warehouse calculation formula**

**Length x Width x (Height -1m) x70% = approximate storage capacity of warehouse**

Table 2 Summary of Space requirement for non productions areas

|  |  |  |
| --- | --- | --- |
| Basic element | Sub element | Recommended standard size |
|   Office | General director | 43m2 |
| Deputy director | 35m2 |
| Individual office | 18.58m2  per person but the total office size is no larger than 279m2  for higher industries |
| Personnel requirements | Cafeteria  | It is based on number of employees, recommended factor ratio is 0.929m2 per person |
| Lockers  | For planning purposes, 0.67m2 should be allocated for each person using the locker room |
| Rest rooms | 1.4m2 should be allowed for each toilet and 0.56m2 for each urinal. 1.4m2 should be used for the space allowance for bed. Maximum size rest room up 85m2 for large industries. |
| Parking area  | The size of parking space for an automobile can vary from 9.76m2 to 16.77m2, depending on the type of automobile and the amount of clearance to be provided |
| First aid room |  First aid room 9m2. If one nurse is provided 23m2 |
| Storage area | Raw material storage | This simplified version of SLP is best suited in storage areas up to 745 to 929 m2 for both storage and finished product for large industries. The range is maximum size.  |
| Finished product storage |
| Docking area | 36m2 minimum size max size based numbers of martial handling  |
|  | Heat treatment  | 15.96m2 for higher industries |
|  | Maintenance room | 6mx10m plus aisle allowance plus numbers of material handing width |
|  | Assembling area | 150m2 for higher metal industries max size |
|  | Painting area | 60m2 for higher industries |
|  | Packing area | 66m2 |
|  | Inspection room | 30m2 |
|  | Aisle width | 3.6m for forklift Aisle space requirements thus depend upon the volumes, size and nature of the items being moved |

# 9. Using land to building ratio for appraisal of land requirement

 Land to building ratio is the ratio of the size of building to land on which its site, the land and building ratio are used to guide building construction and other land improvements, in appraisal process. Appraiser can tell if the land is underutilized by looking at land to building ratio. The higher land to building ratio, the higher probability underutilized of land, low land to building ratio means that land is being used to its capacity. Typical land to building ratio roughly between 1.57 to 4.78. If land to building ratio is 3.0 implies that land is being used medium capacity. Please remember that the company requires that future expansion should be taken in to account at all times, meaning that the less space the workshop takes up, the more space will be left for future expansion. Therefore, the design team often intentionally overestimates the required physical area, in order to ensure there is adequate room for future expansion.

# 9.1 Machinery and equipment layout data for general metal workshop space standards

**1. Machine shop**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.N** | **Name of Machines** | **Quantity** |  **Required Area (m2)** |
| **Machine**  | **Material**  | **Personnel**  | **Total**  |
| 1 | Radial drilling machine  | 1 | 3.2 | 6 | 5 | 14.2 |
| 2 | Pedestal grinding machine | 1 | 1.5 | 6 |  3 | 10.5 |
| 3 | Power hack saw  | 1 | 1.8 | 6 | 5 | 12.8 |
| 4 | Hydraulic press machine | 1 | 4.3 | 5 | 2 | 11.3 |
| 5 | CNC lathe machine | 1 | 6.2 | 5 | 3 | 14.2 |
| 6 | Universal cylindrical grinding machine  | 1 | 5.1 | 5 | 2 | 12.1 |
| 7 | Conventional lathe machine | 1 | 4.46 | 5 | 3 | 12.46 |
| 8 | CNC universal milling machine | 1 | 11 | 5 | 3 | 18 |
| 9 | Conventional universal milling machine | 1 | 7 | 6 | 2 | 12.5 |
| 10 | Surface grinding machine | 1 | 3.7 | 3 | 3 | 9.7 |
| 11 | Universal Tool and cutter Grinder | 1 | 1.224 | 2 | 2 | 5.224 |
| 12 | CNC universal cylindrical grinding machine  | 1 | 2.8 | 4 | 3 | 9.8 |
| 13 | Workbench | 1 | 3.6 | 2 | 2 | 7.6 |
|  |  | Net area required 13% allowance Machine shop 150.384 19.549 170 |
| 1 | AC Arc Welding Machine | 1 | 0.33 | 8 | 3 | 11.33 |
| 2 | TIG invert Welding machine | 1 | 0.2 | 8 | 3 | 11.2 |
| 3 | MIG inverter welding machine | 1 | 0.43 | 8 | 2 | 10.43 |
| 4 | Oxy-Acetylene Welding Machine | 1 | 1.5 | 8 | 3 |  14.5  |
| 5 | Submerged Arc Welding Machine | 1 | 0.4 | 12 | 3 | 15.4 |
| 6 | Workbench | 1 | 3.6 | 0 | 2 | 5.6 |
| Net area required 13% allowance welding shop | 68.46+8.9= 77.3 |
| 1 |  Rolling Machine | 1 | 6.4 | 6 | 5 | 17.4 |
| 2 | Shearing Machine | 1 | 5 | 5 | 3 | 13 |
| 3 | Combination shear machine | 1 | 2 | 6 | 3 | 10 |
| 4 | Pedestal grinder | 1 | 1.5 | 6 | 3 | 10.5 |
| 5 | CNC plasma metal cutting machine | 1 | 12 | 6  | 3 | 21 |
| 6 |  pipe bender | 1 | 2.6 | 4 | 2 | 8.6 |
| 7 |  punching machine heavy duty | 1 | 19  | 6 | 3 | 28 |
| 8 | Spiral tube duct making joint machine | 1 | 3.8 | 5 | 2 | 10.8 |
| 9 |  circular shear machine | 1 | 0.4 | 4 |  3 | 7.4 |
| 10 | Seam locking machine | 1 | 0.83 | 5 | 2 |  7.83  |
| 11 | Hydraulic tank end flange making machine | 1 | 1 | 4 | 3 | 8 |
| Net area required 13% allowance sheet metal shop | **142+18.5= 160.5** |
| 1 | Portable drilling machine | 1 | 0.34 | 5 | 3 | 8.34 |
| 2 | Portable grinding machine | 1 | 0.24 | 3 | 2 | 5.24 |
| 3 | Pedestal Grinding machine | 1 | 1.5 | 2 | 1 | 4.5 |
| 4 | Floor drilling machine | 1 | 0.18 |  4  | 2 | 3.18 |
| 5 | Power polishing machine | 1 | 3 | 3 | 2 | 8 |
| 6 | Air compressor | 1 | 1.6 | 6 | 3 | 10.6 |
| 7 | Painting equipment | 1 |  0.14 | 3  |  2 |  5.14 |
| 8 | Paint booth | 1 | 25 | 3 | 2 | 30 |
| 9 | Drying area | 1 |  | 5 | 3 | 8 |
| 10 | Workbench | 1 | 3.6 | 2 | 2 | 7.6 |
|  | Net area required 13% allowance finishing and assembling shop | 90.6+11.77= 102 |

# 9.2 Garment machinery layout data example 1

 Let assume that in bahir dar city y.n.g garment factory 1milion birr initial investment capital and when the factory run create 100 operator, also having 1 general director ,2 deputy director , 3 garment engineers

 **EQUPMENT AND MATRIEAL**

|  |  |  |
| --- | --- | --- |
| **CODE** | **Description** | **Quantity** |
|  01 | Patter making software(CAD) |  2 |
|  02 | Pattern making table |  2 |
| 03 | Spreading table | 1 |
| 04 | Straight knife cutter | 1 |
| 05 | Band knife cutter | 1 |
| 06 | Cutting press | 1 |
| 07 | Single needle lock stitch machine  | 20 |
| 08 | 2 needle 5 thread interlock | 10 |
| 09 | Single needle double chain stitch machine  | 5 |
| 10 | Single needle chain button hole stitch  | 4 |
| 11 | Two Needle Four thread over lock machine | 8 |
| 12 | 5 Thread Cylinder Bed type interlock machine for hemming operation | 3 |
| 13 | 5 Thread falt Bed type interlock machine for binding operation with bimde | 2 |
| 14 | Multi needle double chain stitch machine equipped with puller for waistband operations | 2 |
| 15 | Computer controlled bar tacking machine | 3 |
| 16 | Computer controlled High speed lock stitch button sewing machine  | 3 |
| 17 | Computer controlled high speed lock stitch button holing machine  | 4 |
| 18 | Pneumatic Snaps fixing machine | 2 |
| 19 | Blind Stitching machine  | 3 |
| 20 | Electrically heated steam iron with Vacuum ironing table | 2 |
| 21 | Boiler | 1 |
| 22 | Embroidery Machine | 5 |
| 23 | Embroidery Software | 2 |
| 24 | Air compressor | 1 |
| 25 | Generator | 1 |
|  Total | 89 |

 **How much LAND IS GIVEN FOR THIS FACTORY????????**

 **Calculate each machine work station (working area) for Donga garment**

Machine Work station (working area) is the working area of the each machine this we get from knowing each machine width and length, material, personal in this case two alternative can be used first the machine width and length get from the machine specification, second the material and personal area get from the smart estimation and motion study for a given job worker.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CODE** | **Description** | **Quantity** |  **Workstation Area(m2)**  | **Total****(m2)** |
| **Machine** | **Material** | **Personal** |
|  01 | Pattern making software computer (CAD) |  2 |  0.8 | 0.4 | 0.62 | 2\*1.82=3.64 |
|  02 | Pattern making table |  2 |  1.5 | 0.3 | 0.7 | 2\*2.5=5 |
|  Net area required 13% aisle allowance design and pattern making room **8.64 9.7632** **1.1234**  |
| 03 | Spreading table | 1 |  40 | 4 |  3 | 1\*47=47 |
| 04 | Straight knife cutter | 1 |  0 |  | 0 |  |
| 05 | Band knife cutter | 1 |  0 |  | 0 |  |
| 06 | Cutting press | 1 |  0 |  | 0 |  |
|  Net area required 13%assile cutting and preparation room **47 53.11**  **6.11** |
| 07 | Single needle lock stitch machine  | 20 |  1 | 0.5 | 0.5 | 2\*20=40 |
| 08 | 2 needle 5 thread interlock | 10 |  1 | 0.5 | 0.5 | 2\*10=20 |
| 09 | Single needle double chain stitch machine  | 5 |  1 | 0.5 | 0.5 | 2\*5=10 |
| 10 | Single needle chain button hole stitch  | 4 |  1 | 0.5 | 0.5 | 2\*4=8 |
| 11 | Two Needle Four thread over lock machine | 8 |  1 | 0.5 | 0.5 | 2\*8=16 |
| 12 | 5 Thread Cylinder Bed type interlock machine for hemming operation | 3 |  1 | 0.5 | 0.5 | 2\*3=6 |
| 13 | 5 Thread flat Bed type interlock machine for binding operation with bimde | 2 |  1 | 0.5 | 0.5 | 2\*2=4 |
| 14 | Multi needle double chain stitch machine equipped with puller for waistband operations | 2 |  1 | 0.5 | 0.5 | 2\*2=4 |
| 15 | Computer controlled bar tacking machine | 3 |  1 | 0.5 | 0.5 | 2\*3=6 |
| 16 | Computer controlled High speed lock stitch button sewing machine  | 3 |  1 | 0.5 | 0.5 | 3\*2=6 |
|  17 | Computer controlled high speed lock stitch button holing machine  |  4 |  1 | 0.5 | 0.5 | 4\*2=8 |
|  18 | Pneumatic Snaps fixing machine |  2 |   |  | 2 |  |
|  19 | Blind Stitching machine  |  3 |  1 | 0.5 | 0.5 | 3\*2=6 |
|  Net area required 13% sewing department **134** **17.42**  | **151.42** |  |
|  20 | Electrically heated steam iron with Vacuum ironing table |  2 |  1.5 | 0.5 | 0.5 | 2\*2.5=5 |
|  21 | Boiler |  1 |  0.5 | 0.25 | 0.25 | 1\*1=1 |
|  22 | Embroidery Machine |  5 |  2.5 | 2 | 1.1 | 5\*5.6=28 |
|  23 | Embroidery Software |  2 |  0.8 | 0.4 | 0.3 | 2\*1.5=3 |
|  24 | Air compressor |  1 |  1.35 | 1.2 | 1.5 | 1\*4.05=4.0 |
| 25 | Generator |  1 |  0.37 | 1.3 | 1.2 | 1\*2.87=2.8 |
|  Net area required 13% finishing department **43.8** **5.69** | **49.49** |  |
|  For sewing Thread |
| 26 | Winding machine | 2 | 93.87 | 0.25 | 1.2 | 190.64 |
| 27 | Twisting machine | 2 | 50 | 0.12 | 0.11 | 100.46 |
| 28 | Warping | 2 | 93.87 | 0.25 | 1.2 | 190.64 |
| 29 | sizing | 1 | 13 | 0.12 | 0.2 | 13.32 |
| 30 | desizing | 1 | 11.5 | 1.5 | 1.5 | 14.5 |
| 31 | Bleaching  | 1 | 10 | 0.03 | 1.2 | 11.23 |
| 32 | Jigger machine | 2 | 5 | 0.45 | 0.35 | 2\*5.8=11.6 |
| 33 | Washing and drying machine(for yarn) | 2 | 20 | 1.25 | 1.1 | 44.7 |
| 34 | Calendaring machine(for yarn)  | 1 | 13 | 0.4 | 0.2 | 13.6 |

**Space requirement for non production area**

As mention above the non production area set a standard this standard multiplies by number of worker we get the required area

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Description** |  **Area(m2)**  | **Total** **(m2)**  |
| 01 | General director office |  1\*43=43 | 43 |
| 02 | Deputy director office | 2\*35=70 | 70 |
| 03 | Individual office  | 3\*18.5=55.5 | 55.5 |
| 04 | Cafeteria for operator | 129\*0.929=119.84 | 119.84 |
| 05 | Cafeteria for staff | 6\*0929=5.574 | 5.574 |
| 06 | Locker | 129\*0.67=86.13 | 86.43 |
| 07 | Rest room | 85 | 85 |
| 08 | Parking area | 16.77 | 16.77 |
| 09 | First aid | 50 | 50 |
| 10 | Raw material storage  | 250 | 250 |
| 11 | Finished product storage | 250 | 250 |
| 12 | Docking area | 36 | 36 |
| 13 | Heat treatment | 15.96 | 15.96 |
| 14 | Maintenance room | 81.6 | 81.6 |
| 15 | Printing area | 60 | 60 |
| 16 | Packing area | 66 | 66 |
| 17 | Inspection area and quality control | 150 | 150 |
| 18 | Water treatment plant | 100 | 100 |
| 19 | Guard house | 25 | 25 |
| 20 | Green area | 529 | 529 |
| 21 | Product display room | 50 | 50 |
| 22 | Laboratory room | 250 | 250 |
|  | Total  |  | 2395.67 |

**Total area non productions area =2395.67m2.**

Productions areas + non production areas = total required area = **1604.55 + 2395.67 = 4000m2.**

Use land –to-building ratio 3.0 to approve land that implies **4000\*3=12000 m2**

* The production workshop including both open and built-up area is expected to be **1604.55m2**
* The total built-up area including workshop building, office, cafeteria storage for raw materials and finished products, internal road, parking and green area is estimated to be **2395.67** square meters.

#

# 9.3 EXAMPLE 2 GENERAL MACHINE SHOP LAYOUT INPUT DATA FOR METAL INDUSTRIES

Let assume general metal workshop a company of Steel Industry which is situated at bahir dar city number of employee assumed to be 125

Main production shop which is situated in 8782m2.

The main production section which are used in producing steel are

1. Machine shop 2. Welding shop 3. Sheet metal shop

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CODE** | **Description** | **Quantity** |  **Workstation Area(m2)**  | **Total****(m2)** |
| **Machine** | **Material** | **Person** |
| 01 | Conventional lathe machine | 5 | 22.3 | 25 | 15 | 62.3 |
| 02 | CNC lathe machine | 2 | 12.4 | 10 | 6 | 22.4 |
| 03 | Milling machine | 3 | 21 | 18 | 4 | 43 |
| 04 | Radial drilling machine  | 1 | 3.2 | 6 | 5 | 14.2 |
| 05 | Pedestal grinding machine | 1 | 1.5 | 6 |  3 | 10.5 |
| 06 | Power hack saw  | 1 | 1.8 | 6 | 5 | 12.8 |
| 07 | Hydraulic press machine | 1 | 4.3 | 5 | 2 | 11.3 |
| 08 | Surface grinding machine | 1 | 3.7 | 3 | 3 | 9.7 |
| 09 | Universal Tool and cutter Grinder | 1 | 1.224 | 2 | 2 | 5.224 |
| 10 | CNC universal cylindrical grinding machine  | 1 | 2.8 | 4 | 3 | 9.8 |
| 11 | Workbench | 3 | 14.2 | 16 | 10 | 42.2 |
|  | Machine shop  | Net area required 13% aisle allowance 275m2 |
| 13 | AC Arc Welding Machine | 4 | 1.32 | 32 | 12 | 45.32 |
| 14 | TIG invert Welding machine | 1 | 0.2 | 8 | 3 | 11.2 |
| 15 | MIG inverter welding machine | 1 | 0.43 | 8 | 2 | 10.43 |
| 16 | Oxy-Acetylene Welding Machine | 1 | 1.5 | 8 | 3 |  14.5  |
| 17 | Submerged Arc Welding Machine | 1 | 0.4 | 12 | 3 | 15.4 |
| 18 | Workbench | 4 | 14.2 | 0 | 8 | 22.2 |
| Net area required 13% aisle allowance welding shop | **135.035** |
| 19 |  Rolling Machine | 1 | 6.4 | 6 | 5 | 17.4 |
| 20 | Shearing Machine | 1 | 5 | 5 | 3 | 13 |
| 21 | Combination shear machine | 1 | 2 | 6 | 3 | 10 |
| 22 | Pedestal grinder | 1 | 1.5 | 6 | 3 | 10.5 |
| 23 |  pipe bender | 1 | 2.6 | 4 | 2 | 8.6 |
| 24 |  punching machine heavy duty | 1 | 19  | 6 | 3 | 28 |
| 25 | Spiral tube duct making joint machine | 1 | 3.8 | 5 | 2 | 10.8 |
| 26 |  circular shear machine | 1 | 0.4 | 4 | 1  | 7.4 |
| 27 | Seam locking machine | 1 | 0.83 | 5 | 2 | 7.83  |
| 28 | Hydraulic tank end flange making machine | 1 | 1 | 4 | 3 | 8 |
| 29 | Bending machine | 1 | 4.95 | 5 | 3 | 12.95 |
| 30 | Workbench | 4 | 14.2 | 20 | 10 | 42.2 |
|  | Net area required 13% aisle allowance for sheet metal shop department | 199.64 |
| 31 | Portable drilling machine | 1 | 0.34 | 5 | 3 | 8.34 |
| 32 | Portable grinding machine | 1 | 0.24 | 3 | 2 | 5.24 |
| 33 | Pedestal Grinding machine | 1 | 1.5 | 2 | 1 | 4.5 |
| 34 | Floor drilling machine | 1 | 0.18 | 4  | 2 | 3.18 |
| 35 | Power polishing machine | 1 | 3 | 3 | 2 | 8 |
| 36 | Air compressor | 1 | 1.6 | 6 | 3 | 10.6 |
| 37 | Painting equipment | 1 | 0.14 | 3  | 2 |  5.14 |
| 38 | Paint booth | 1 | 25 | 3 | 2 | 30 |
| 39 | Drying area | 1 |  | 5 | 3 | 8 |
| 40 | Workbench | 1 | 3.6 | 2 | 2 | 7.6 |
|  | Net area required 13% allowance finishing and assembling shop | 102 |

Total productions areas 711.675m2

Non production area requirement

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Description** |  **Area(m2)**  | **Total** **(m2)**  |
| 1 |  Office  | 300 | 300 |
| 2 | Cafeteria  | 130\*0.929=92.9 | 121 |
| 3 | Locker worker for both female and male | 125\*0.67=83.75 | 83.75 |
| 4 | Rest room | 85 | 85 |
| 5 | Parking area | 16.77\*3 | 50 |
| 6 | First aid | 23 | 23 |
| 7 | Raw material storage  | 250 | 250 |
| 8 | Finished product storage | 250 | 250 |
| 9 | Docking area | 36 | 36 |
| 10 | Heat treatment | 15.96 | 15.96 |
| 11 | Maintenance room | 81.6 | 81.6 |
| 12 | Packing area | 66 | 66 |
| 13 | Inspection area and quality control | 30 | 30 |
| 14 | Scrape disposal area  | 30 | 30 |
| 15 | Guard house | 25 | 25 |
| 16 | Green area | 300 | 300 |
| 17 | Product display room | 50 | 50 |
| 18 |  |  |  |

**Total productions areas +non productions areas = total area required = 1797.31m2 + 711.675 =2508.985m2.**

Use land –to-building ratio 3.0 to approve land

* The production workshop including both open and built-up area is expected to be 7527m2
* The total built-up area including workshop building, office, cafeteria storage for raw materials and finished products, internal road, parking and green area is estimated to be 2508.985 square meters.

# 9.3 Machinery and equipment layout input data example

**For flour milling machine specification**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.N** | **Name of Machines** | **Quantity** |  **Required Area (m2)** |
| **Machine**  | **Material**  | **Personnel**  | **Total**  |
| 1 | Dray wheat storage | 1 | 21.4 | 7 | 5 | 33.4 |
| 2 | Dry wheat cleaner | 1 | 27.2 | 5 | 3 | 35.2 |
| 3 | Clean wheat storage | 1 | 23.6 | 3 | 5 | 31.6 |
| 4 | Filer | 1 | 3.08 | 5 | 4 | 12.08 |
| 5 | Checker | 1 | 1.87 | 3 | 5 | 9.87 |
| 6 | Milling machine | 1 | 0.96 | 5 | 5 | 10.96 |
| 7 | Elevator | 1 | 1.2 | 3 | 2 | 6.2 |
| 8 | Flour outlet(flour exiting) | 1 | 0.5 | 11 | 10 | 21.5 |
|  | **Total** |  |  |  |  | **160.81** |
|  | **Aisle(allowance)13%** |  |  |  |  | **20.9** |
|  | **Net area required** |  |  |  |  | **181.71** |

# 9.4 Machinery and equipment layout for tomato processing machine specification

|  |  |  |  |
| --- | --- | --- | --- |
| **S.N** | **Name of Machines** | **Quantity** |  **Required Area (m2)** |
| **Machine**  | **Material**  | **Personnel**  | **Total**  |
| 1 | Fruit washing machine | 1 | 5 | 7 | 5 | 17 |
| 2 | Fruit grinding machine | 1 | 3 | 3 | 4 | 10 |
| 3 | Storage tanker | 1 | 2.79 | 5 | 2 | 9.79 |
| 4 | Industrial juice mixer machine | 1 | 1.68 | 5 | 3 | 9.68 |
| 5 | Air compression | 1 | 1.9 | 3 | 1.7 | 6.6 |
| 6 | Filling and packing machine | 1 | 3 | 7 | 5 | 15 |
|  | **Total** |  |  |  |  | **68.07** |
|  | **Aisle** |  |  |  |  | **8.84** |
|  | **Net area required** |  |  |  |  | **76.9** |

 Example3 for 26 ton per day flour milling machine layout data. Assume the company has 105 employees, 1 general director, 1 deputy director

|  |  |  |  |
| --- | --- | --- | --- |
| **S.N** | **Name of Machines** | **Quantity** |  **Required Area (m2)** |
| **Machine**  | **Material**  | **Personnel**  | **Total**  |
| 1 | Dray wheat storage | 1 | 21.4 | 7 | 5 | 33.4 |
| 2 | Dry wheat cleaner | 1 | 27.2 | 5 | 3 | 35.2 |
| 3 | Clean wheat storage | 1 | 23.6 | 3 | 5 | 31.6 |
| 4 | Filter | 1 | 3.08 | 5 | 4 | 12.08 |
| 5 | Checker | 4 | 1.87\*4=7.48 | 3 | 5 | 15.48 |
| 6 | Milling machine | 6 | 0.96\*6=5.76 | 5 | 5 | 15.76 |
| 7 | Elevator | 1 | 1.2 | 3 | 2 | 6.2 |
| 8 | Flour out late(flour exiting) | 1 | 0.5 | 11 | 10 | 21.5 |
|  | **Total** |  |  |  |  | **171.22** |
|  | **Aisle(allowance)** |  |  |  |  | **22.3** |
|  | **Net area required** |  |  |  |  | **193.5** |

 **Calculating warehouse space in food processing industries**

For 100 tones flour with a storage height equal to two meters

1 tone flour = 2m3

100 tone = 200m3

Assume delivery time of company is 7 days, during the 7 days the company can be produced 182 tone

Required surface area = 236

Total warehouse space needed = 182m2 + (182m2 x30%) =236m2

**Warehouse calcula**

**tion formula**

**Length x Width x (Height -1m) x70% = approximate storage capacity of warehouse**

Non production area requirement

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Description** |  **Area(m2)**  | **Total** **(m2)**  |
| 1 |  Office  | 297 | 297 |
| 2 | Cafeteria  | 105\*0.929=92.9 | 96 |
| 3 | Locker worker for both female and male | 105\*0.67=83.75 | 70 |
| 4 | Rest room | 85 | 85 |
| 5 | Parking area | 16.77\*3 | 50 |
| 6 | First aid | 23 | 23 |
| 7 | Raw material storage  | 236 | 236 |
| 8 | Finished product storage | 236 | 236 |
| 9 | Docking area | 36 | 36 |
| 10 | Maintenance room | 81.6 | 81.6 |
| 11 | Packing area | 66 | 66 |
| 12 | Inspection area and quality control | 20 | 20 |
|  13 | Waste disposal area  | 30 | 30 |
|  14 | Guard house | 25 | 25 |
|  15 | Green area | 300 | 300 |
|  |  |  |  |

**Total productions areas + non productions areas = total area required = 193.5m2 + 1651.6 = 1845m2.**

 Use land –to-building ratio 3.0 to approve land

* The production workshop including both open and built-up area is expected to be 5535 m2
* The total built-up area including workshop building, office, cafeteria storage for raw materials and finished products, internal road, parking and green area is estimated to be 1845 square meters.

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