CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Paint Factory or plant is an industrial site, usually consisting of buildings and machinery, or more commonly a complex having several buildings, where workers process raw materials into paint.

Factories arose with the introduction of machinery during the industrial revolution when the capital and space requirements became too great for cottage industry and workshops.

Paint is a subdivision of surface coating. It is a relatively opaque solid coating applied as thin layer whose films are usually formed by polymerization of polyunsaturated oil. However, other subdivisions of surface coating include: varnishes (clear coating), enamels (pigmented varnishes), lacquers (film formed by evaporation only), printing inks and polishes. Paints generally have very low thermal conductivity, electrically inert and can be washed and cleaned. The various raw materials for making paints include pigments, vehicle, alkyd resins, surfactants, solvents (thinners) and colouring matters.

Paints are classified into two principal types:

Resin based paints (Gloss finishes) and Latex based paints (Emulsion paints). The major difference between the two is only in the types of vehicle used and cost.

- Resin based paints are used for exterior and interior surfaces and are dry to a lustrous or shinny finish.
- Emulsion (Latex) paint involves the emulsion of 2-phases one of which is water and any other phase.

Classically, emulsion is a suspension of one phase in another. Latex paints have as their major film forming constituent synthetic resin latex with or without other film forming constituents added in an oil-water emulsion type system. The continuous phase consists of an alkali – dispersed hydropholic colloid in water and contains two more different types of particles in suspension, styrene – butadeux (SBR) copolymer which was the original quality film former in emulsion paint. Polyvinyl acetate (PVA), acrylic and PVA acrylics copolymers have largely replaced SBR as film former.

From these, resins and latex are made objects with a wide range of colours and texture found in household wares, building materials, electrical and electronic appliances, automobile and aeronautics, clothing, building structures etc. in short it s difficult to imagine contemporary society without painting (colours).

Paints are the material employed as finishing for other materials. They are used to protect metals, timber and plastered surface from the effect of weather, heat, moisture, gases etc., thereby improving their appearance. Paints are classified into oil, water and cement and bituminom paints. There are also special paints used for special purpose e.g. heat resisting, fire proofing, chlorinated rubber paint etc.

Paint factory is regarded as an important or essential industry in many country because of it effect and function in the environment. Finally, this project (paint factory) will help in improving on the face lift of Makurdi as the capital of Benue State as well as the job opportunities which our teeming youths desire.

1.2 STATEMENT OF ARCHITECTURAL PROBLEM

In an industrial building of this nature, it is impossible to solve all architectural problems involved. However, every building has a general architectural problem that has to be solved towards the realization of the design. But, there are some specific problems that are unique to individual projects, for example a paint factory.

Subsequently, the core problem this project seek to solve is centered on its purpose; a compromise between man and machine. And this involves a careful flow in the synthesis of:

- Efficient work flow
- Making a statement to the society reflecting the mass production nature of the paint factory.
- Advertising the paint products to the society as well as creating a welcome impact.
- Expressing orderliness and aesthetic appeal.

- Creating openness in plant to give an impression of attractive working conditions, efficient production and painstaking devotion to the excellence of paint products.

1.3 OBJECTIVES

The principal objective of this project is to provide an environment capable of meeting the needs of the people of Makurdi and Nigeria as a whole by providing them with a well defined paint factory which is ultra-modern and which will meet their several needs in terms of seeking a solution for good appearance and packaging of good products.

Other objectives include:

- To create versatile, adaptable and flexible form for easy expansion with minimum damage.
- To provide a good production layout with no conflict between raw and finished goods and personnel in circulation.
- To create an ideal factory architecture and to introduce a level of automation in the proposed paint factory in Nigeria.
- Finally, to help in the state and Federal Government Programme in rural development and this could be achieved through industrial development.

1.4 MOTIVATION

Establishing a house or a commercial space does not stop at having the edifice erected on a piece of land. This is since you have to make sure that your structure preserves its excellent condition so that you can enjoy your investment for a long time. There are many industrial methods that you can do to keep your home or your workspace in good condition, but one of the most effective steps that you should take is to have your walls re-applied with the right paint.

For decades now, net and sprays have been the only effective methods for controlling the mosquitoes that causes malaria and dengue. I think by introducing the factory, it will lay more emphasize on protection by inventing a way of embedding pesticide in microcapsule stirred into house paints. And this insecticide will be realized slowly from the paint and will remain effective for two to four years, while spray will be typically re-applied at least every 6 months. The paint will act like a vaccine for houses and buildings.

The minute amount of pesticides released from the paint won't be harmful to people but will be devastating to insect.

The introduction or provision of paint factory in Makurdi will help to increase the effectiveness of other producing industries around e.g.

- Most industries producing steel and aluminum building cladding.
- For yatch, small boats and craft, fishing fleets manufacturers.
- For all furniture and plywood industries

- For most petrochemical plants-protective coating
- For all kinds of vessels that visit Nigeria port.
- For manufacturers of refrigeration, bicycles, other household articles, drums and industrial components – powder paints.
- For building industries etc

Therefore, one should realize that this material is utilized in many industries and that such service industry should be established for the propagation of other.

Finally, I intend to increase the awareness of this service industry in Nigeria, and that's what prompted my motivation towards proposing this project.

1.5 AIMS

The ultimate aim of this project is to create, functional, simple, pleasing, economical, orderly, flexible, safe and convenient industrial building – paint factory.

And to satisfy the key words of the aims, the following are inevitable:

- To achieve an effective and efficient design for a factory with a serious view to flexibility, adaptability and versatility of the building structures. Therefore, the aim is to realize a purely functional planning with a specific purpose of smooth and maximum efficient working of the different machineries, the administration of the complex and the overall production.
- To create a system that will allow personnel; operational and administrative to enjoy efficient and pleasant working environment.
- To provide efficient circulation system between the individual units of the factory and within the layout as a whole thereby facilitating easy movement and assemblage of raw materials and distribution of finished products.
- To enhance the psychology of workers towards efficiency by creating an aesthetical industrial architecture.
- To reflect the use to which the factory is to be put into which will be in form of an advertisement for the products.
- There will be a deviation from the old idea which emphasizes much on mass to a modern approach which gives emphasis on lines and planes (volume).

1.6 SCOPE OF WORK

The factory will undertake on mass production basis, the manufacture of paints and other paint products. It will also consist of four major paints of an industrial building;

- Research
- Manufacturing

- Administration and
- Welfare.

The research includes laboratory and library to investigate and recommend possible way of producing better products and raw materials.

The manufacturing section, according to the manufacturing process, include: dispersion, mixing, sieving and canning.

The administration comprises of offices, personnel and sales while

The welfare section includes the factory cline and staff canteen.

Other components include the maintenance block, staff and visitor's parking spaces, warehouse for raw materials and finished products, delivery bays and yards etc.

1.7 RESEARCH METHODOLOGY

To really collect important information towards the realization of this project and to make an important contribution to Architecture, some research activities had been carried out and data collected through;

- Visits to existing paint factories site of the projects to determine their production processes, organizational chart and determine the requirement and conditions to be fulfilled in the setting up of such factory.
- Use of libraries, research institute, books, journals and unpublished manuscript of thesis reports.
- Visits to relevant Government establishment like the ministry of commerce and industry, for collection of data, byelaws, history and other important information.
- Personal interview of some people.
- Internet.

1.8 LIMITATION OF RESEARCH

Due to the limitation of standard paint factories in Nigeria, one is limited to researching with only the small scale private paint factories.

In researching with the private factories it was discovered that the factories were over protective of their setting. They feared that their competitors might get hold of information given out for the research and have a hold over them. Some of them that co-operated discourage photographs.

Also the fact that the country is not in peace due to the Boko Haram and other threats, the factories are conscious and at the same time trying to protect their life and properties.

Materials on paint factories are not much available in libraries, research institutes, records and documents on paint factories in Nigeria.

1.9 IMPORTANCE OF THE PROJECT

The importance or the breaks through this project hope to achieve are:

- To provide a comprehensive setting for paint industry in Nigeria in order to help improve the economy attains technology and industrial independence.
- To create job opportunities for the increasing labour forces.
- It will help in saving foreign exchange by providing goods which would have been purchased abroad.

1.10 HISTORICAL DEVELOPMENT OF FACTORY

The factory began with the shop-connected residence as in Ancient Egypt, then the open air workshops and the home the home industry as in Greece. Then, some specialized craft and trades like metal smiting, carpentry, pottery, shoe making were home industry; therefore, operation were in dwelling houses.

When the need for expansion began, separate work shed from homes was realized. However, this did not survive for too long, for with the collapse of the Roman Empire, the industry reverted to its original dwelling-house status – the gradual detachment from home only started again with the emergence of the guild system between the 12th and 15th centuries.

By this period, the trades men were engaged in producing stained glass, pottery, tapestries and metal work in great quantities – all operations being carried out in small shops.

This stage was followed by the beginning of the 15th century, by the emergence of large city workshop; derived from the strong influence of the monasteries, and the basomial manors.

Then came the modern factory system during the 2nd half of the 18th century. This stage in the factory evolution was made possible by certain technological inventions like the Spinning Jenny, Samuel Cromptoris mule in 1779, Edmund Cartwrights power loom in 1785 and James Watts steam engine, also in 1785. Manufacturing at this stage developed to much a high level that the whole of Europe was ploughed into the great industrial Revolution.

The industrial Revolution with the use of capitation ushered in such keen completion among early industrialists that some old buildings and other available large spaces were acquired for loom shops and other industries. This was the period for birth of industrial architecture from the period of birth to the present day, Industrial Building Types or Industrial Designs has passed through three main stages;

- Period of construction in wood and stone with water power.
- Period of construction in bricks and metal (cast and wrought iron at first, steel later) with steam power.
- And period of modern construction in reinforced concrete with electricity as a source of power.

By 1925, this last phase experienced a new architecture creation – INTERNATIONAL STYLE – which was first noticed in the industrial designs of Peter Behrens in Germany and Auguste Perret in France between 1911 and 1924.

These works and most other modern examples revealed the design philosophy of almost all today's meritorious industrial building as an emphasis on lines and planes instead of mass. Standard design became:

- A long rectangular multi-window structure with a central cupolar or furnace itself.
- Large monitors for interior day lighting.
- A possible massing of all units of an industrial building into one imposing single structure depending, however on the sizes of the individual units of the complex

1.11 HISTORY OF PAINT MANUFACTURE

Paint is a thin protective or decorative coat or a subdivision of surface coating. Painting, the art of laying colour on a surface, therefore necessitated the development of paint.

Paint was first developed in the prehistoric times when the early men recorded most of their activities in colours on the walls of their caves. These crude paints consisted of coloured earth or clays suspended in water. However, the use of paint dated as far back as 1500 B.C. when the earliest paint works discovered in caves of Lascaux, France, Attemira and Spain were believed to have been done.

The Egyptians artist, during the early civilization was a paint formulator. He devised his paint mostly from natural pigments from resins, chalk, tale, clay etc. this could be regarded as mixture. However, by 1500 B.C. they imported such dies as indigo and madder to make blue and red pigments. By 1000 B.C. they had developed a varnish from the gum of Arcacis tree (gum Arabic) which contributed to the performance of their arts.

Coloured crayon pigments and clay binder were used in Asia, while before 600 B.C. calcined mixtures and organic pigments were developed.

Vehicles were prepared from gum Arabic, eggulute, gelatin and bees max. In our local traditional architecture, ‘Uri’, ‘Nzu’, cowdung etc. were used to prepare paints.

During the medieval and classical period more specialized form of paint was developed. This is known as oil paint. The substrate is generally canvas although other surfaces may be used. The colour consists of concentrated pure pigments ground to a thixotropic paste in refined or bleached vegetable oil, generally linseed. The pigments have an influence on the drying rate uniform. This is done by making the vehicle of a fast-drying colour more saturated oil such as popyseed, and adding a small fraction or cobalt soap to the blacks and other slow drivers.

The discovery of oil paints brought a great improvement in the art of painting. The 15th Century brought with it the knowledge of perspective in which objects could be represented in three dimensions. In this period, however, and to a more partial extent even is the earlier classical epoch, efforts were being made to widen the horizon of painting and to embrace with it the scope of its representations not only solid objects in themselves, but much objects as a whole in space, in due relation to each other and to the universe at large.

It was reserved, however, for the masters of 17th century perfectly to realize this ideal art, and in their hands painting as an art of representation is widened out of its fullest possible limits and the whole of nature in all its aspects becomes for the first time the subject of the picture. The development of painting since the 17th century gave rise to the modern and more specialized method of paint production.

CHAPTER TWO

LITERATURE REVIEW

2.1 RESEARCH PROCESS

A research survey was carried out at some existing Paint factories by way of documentation and case studies with the intention of reviewing as well as appraising the scope of the client's (Makurdi Community) developmental intentions with particular reference to their far reaching implications.

INPERICAL REVIEW OF RELATED BOOKS ON PAINT FACTORIES

European Scientific Journals (March 2013). This paper attempts to analyze the factors that affect the internal and external environmental conditions on workers of the Jordanian paints factories, in terms of the degree of satisfaction with these conditions and their impact on the case of the general satisfaction of these institutions, As well as the impact on productivity and career on the state of job rotation. The results showed that there is a strong relation between these variables and employee satisfaction and stability, especially the case of the internal conditions, with minor variations among worker categories, but the effects on productivity were not strong. The empirical findings will certainly help both

researchers and practitioners to integrate the internal and external environmental conditions on workers of the Jordanian paints factories In order to get a better understanding of the degree of satisfaction.

2.2 THE NEED AND USE OF THE BUILDING TYPE

Paint factory is a place of paint production characterized by wage labour, the use of machinery, and the division of labour. The large-scale of machinery differentiates factory production from simple manufacture, and the division of labour set it apart from even the most elaborate handicraft establishments.

In factory, standardized goods are produced and sometimes sold more cheaply by the factory system, and occasionally the goods are better than those made by Artisans.

The factory will change the face of nations, giving rise to urban centers requiring vast municipal services. It will create a specialized and interdependent economic life and make the urban worker more completely dependent on the will of the employer.

The need for industrial architecture has been a matter for major concern to professionals and it has evolved through the periods, moving in phase with the march of civilization, occupation and the advancement in technology.

MANUFACTURING PROCESS OF PAINTS

2.3 BASIC COMPONENTS OF PAINT (RAW MATERIALS)

The major raw materials for paint manufacture are: pigments, vehicles, additives and others like; dries surfactants, thinners, colouring matters of paints etc.

PIGMENTS

This may be defined as finely powdered solid substance essentially insoluble in the medium in which they are dispersed. From decorative aspect, the purpose of this material is to cover the surface over which paint is applied and provide necessary colour to the product. From protective aspect, the material has the function of protecting the vehicle from degradation by ultraviolet radiation. If the pigment highly reflects all visible wavelength of light, diffusely and non-selectively, they are said to be white in colour. The more completely they reflect the light the lighter they become. Certain pigments are used for their special chemical functions, such as rust inhibition in metal structures, and control of fouling on ship bottoms.

The most commonly used hiding pigments (the primary pigments also called primers) are Titanium dioxide (T_1 0_2), Titanium Calcium (Tica), Zinc oxide and lithopone. There are also coloured pigments which are used in making paints and they include; black pigments (carbon black , lampblack, araphite and iron black), blue pigments (ultramarine, copper, pliths locymine and iron blues), red pigments (red lead, iron

oxides, cadmium red and toners and bakes), metallic and yellow pigment, orange pigment, green pigment, brown pigment etc. These coloured pigments can either be natural or synthetic.

In addition to coloured pigments and white hiding pigments, there are also pigments called Extenders. There are used to control gloss level, suspend pigments particles in the medium in which they are dispersed, improve film strength (texture) and adjust flow (viscosity) of the paint. The most preferred extender pigment for paint manufacture is the Calcium Carbonate (Caco3).

Another class of pigment is the modifying pigments which are used in paints to control such factors as resistance to dirt collection, chalking, fading and mildew. The most commonly used is the leaded zinc oxide.

VEHICLES

This is the liquid portion of the paints. There are two types of vehicles, which include the non-volatile and volatile vehicles.

The Non Volatile Vehicle: comprises of drying oils, resins or a combination of the two. The purposes of the vehicle are to give adhesion to the surface, act as a moisture barrier and hold the pigment in place.

The Volatile Vehicle: consists of hydro carbons, solvents or water and it are usually used to lower the viscosity of the composition for ease of application.

In the manufacture of most vehicles lie alkyd resin, resin and oil are heated together to a predetermined temperature after which enough solvent is added to make the material usable. Therefore, when a paint film is applied to a surface, the solvent evaporates and the film shrinks

leaving a combination of well distributed pigments particles surrounded by the non-evaporating portion of the vehicle which is called the vehicle solid.

Two of most important vehicles used in flat wall paints are alkyd resins and latex resin. Alkyd resins are synthetic in nature and are classified based on two variables, the kind of oil and the proportion of oil.

ADDITIVES

From above it was shown that the basic components of paints are the pigments and the vehicle. In addition to these two major groups, are many items used in paint compositions in relatively small quantities for the purpose of contributing a significant benefit to the ease of manufacture, the stability of the paint in the package, ease of application or the quality of appearance of the applied film. These items are referred to as additives (problem solvers). The level of use of such materials rarely exceeds 1 or 2% of the total formulation and the total level of all additives seldom exceeds 5% of the total paint product. These additives are grouped by function, since it is the only important characteristic. The major additives classified are: driers, anti-skinning agents, anti-sag agents, anti-setting agents, bodying agents, dispersing agents, anti-fload and anti-floating agents, anti-foam of deforming agents, preservatives and mildewcides or fungicides, deodorants, ultraviolet absorbers, stabilizers etc.

A. PAINT DRIERS:

A drier could be defined as a material that promotes or accelerates the drying; curing or hardening of oxidizable coating vehicles.

The principal type of material used as a drier is metal soap of a monocarboxylic acid, dissolved to a stabilized metal content. The drier metal could be divided into active catalyst and auxiliary catalysts. The active catalysts can be subdivided into those effective under air dry condition and those effective under heat curing condition as illustrated below:

Active catalysts	Auxilliary Catalysts
Air dry	
Manganese	Lead
Cobalt	Barium
Heat cure	Calcium
Iron	Zircony (200)
Manganese	Zinc

Cobalt

Cericum or rare earth.

Most of the time, loss of drying properties of paint during storage is a common and serious commercial problem. When products are stored for three to four weeks, they may start to show loss of dryness. The major causative factor is adsorption of the drier by the pigment.

As a remedy to this problem, such of the drying power could be restored by re-dispersing the paint.

The percentage of driers usually incorporated in air-dry coating or varnishes is as follows:

Lead	-	-	-	0.20	- 100%
Cabalt	-	-	-	0.02	- 0.10%
Manganese	-	-	-	0.02	- 0.08%
Calcium		-	-	0.03	- 0.08%
Zirconium		-	-	0.10	- 0.30%

B. SURFACTANTS:

Wetting agents which may be non-ionic or anionic are used to reduce the surface tension of the water for more rapid and complete wetting of the pigments, and the dispersant function is to absorb in the pigment surface and prevent reagglomeration or flocculation of the pigment after it has been dispersed. For emulsion paint anionic type of wetting agents, like calgon PT is better.

Along with the above mentioned additives, there are several other important additives that must be incorporated into the formulation to obtain a stable and satisfactory product; there include:

THICKENERS: These are water soluble protective colloids which are necessary to control the application and flow properties of the paint.

The thickeners used for this purpose are essentially all synthetic with perhaps some small usage of natural thickeners as casein. Other usable thickeners include; Cellulose, Polyacrylates, Polyvinyl alcohols etc.

Beside the above characteristics impacted to the paint, the thickeners can also affect brush and ease of spreading during application, hold-out properties and uniformity of appearance over porous or non-uniform substrate gloss and enhance emulsion and freeze-thaw stability.

To prevent the growth of fungi and bacteria in latex paint due to its range of water content, which also manifests itself by loss of viscosity or gellation or objectionable odours, a preservative is incorporated into the paint. The preservative mostly used is dowicil 75, which is also applied in emulsion paints to prevent biological attack which, if left unchecked, could eventually lead to modification of PH, coagulation, loss of

viscosity and fouling odour. This could protect emulsion paint from microbiological spoilage in bulk storage tank for over a year. This preservation is also effective for various other sources of contamination like those from other raw materials, or raw materials picked up during manufacture. Therefore, the preservatives should be incorporated at the earliest part of the manufacturing cycle.

Defoaming and anti-foaming agents are another adjunct incorporated into emulsion paint to suppress or prevent any form that might generate during paint manufacture or in the container-filling operation. Due to the short life of the deformer, an anti-former is however, added to prevent or minimize forming during application by brush or roller. The range of use is from 0.1 – 0.4% on the wt of paint.

GLYCOLS: (ethylene and propylene)

These are added to serve as freeze-thaw stabilizers and increase the wet-edge and open time of the wet and films. However, excess of this material can cause excessive flow and sagging on vertical surface mostly under condition of high temperature and humidity. These are added in the range of 0.01% - 0.2% on wt of paint.

C. COALESCENTS

These additives are incorporated into a latex paint in order to optimize the coalescence of the latex particles. They can be a temporary type which evaporates from the film after it has dried, or they can be permanent type.

The two important coalescent agents are dalpad A and Toluene. The range of use of these coalescent agents is from 6.5 - 1% on the wt of binder.

PH ADJUSTERS

In other to neutralize the acidic effect of some materials appearing in paint, alkali or PH adjuster is required. Strong alkali like ammonia solution NH_3 is generally required in addition to the weak ones incorporated in parts like $caco_3$. In processing emulsion paints caustic soda as a PH adjuster is utilized in place of NH_3. The range of use of NH_3 or NaoH is 0.1 – 0.4% on the wt of paint.

POLYVINYL ACETATES: PVAC are the binders used for emulsion paints. They are in ready to use form and contain no solvent; therefore they are non-flammable, physiologically harmless and practically odourless.

Sodium benzoate is another chemical used in paint for preservation. It is usually referred to as in-can preservatives because of its function of preserving the paint in a storage container for say five years. This chemical is imported from overseas for use in Nigeria.

D. THINNERS

These are liquids solvents used in paints to control the viscosity of the paint. It also acts as drying agents in that when paint is applied on a surface, the thinner evaporates thereby enhancing the shrinkage of the paint film into the surface. There are two basic types of thinners used in paint manufacturing; these thinners are white spirit and water. White spirit is used for making gloss, enamel and semi-gloss paint and it is very

highly volatile, colourless, chemically inert and safe to handle. Water is used for emulsion paint and it performs the same job white spirit does in gloss.

E. COLOURING MATTER OF PAINTS

The other colours obtained in paints apart from whites originate from the primary colours which are red, blue, yellow, green and black.

The table below shows the variety of colours in which we can find paints apart from the primary colours. The specific amount of each colour for combination is not given, but the necessary colours required to achieve a third one are specified.

Table 1: COLOUR COMBINATION

Colour	Base Colour (combining colours)
Orange	Yellow
Emerald	Green + Clean yellow + black
Lime	Yellow HR + Clean yellow
Leaf Green	Yellow + Blue
Apple	Yellow + Green
Bluff Cream	Yellow + red + black
Neutral	Black + Blue

Silver grey	Yellow + Black
Dove grey	Blue + clean yellow
Dark grey	Yellow + black + red + blue
Cream	Red + Yellow + clean yellow
Sea foam	Yellow + Blue
Light cream	Yellow + blue + red
Off white	White + yellow
Sky blue	Blue + yellow HR
Rose	Yellow HR + red + blue
Pale blue	Yellow HR + red + black
Nursery Blue	Blue + Green + Yellow HR
Ice Grey	Black + Blue
Rose pink	Black + red

AVAILABILITY OF RAW MATERIALS

There are many known raw materials used for the manufacture of paints and paint productions. These raw materials could be available in different parts of the country but most of the raw materials are supplied locally to paint factories and the remaining percentage imported mostly from oversea (European Countries).

Some of these important raw materials are as follows:

PIGMENTS

The following types of pigments are required for paint manufacture; white pigment. Extend (inert) pigment, yellow pigments, blue pigments, red pigments, brown pigments, black pigments and metallic pigments. The analyses of the individual pigments have been done on the previous section on Basic Component of paint.

VEHICLES

For glossy paint, the major vehicle is alkyd resin manufactured by NYCIL – Nigeria Synthethic Industries Limited, Sango Ota, Ogun State. This vehicle is store at room temperature and pressure. The major vehicle for emulsion paint is water.

BINDER

The most commonly used binder in glossy paints is linseed oil. The commonly used one for latex or emulsion paint is Polyvinyl Acetate (PVA). These two raw materials are imported from overseas countries for use in Nigeria industries.

ADDITIVES

These are materials used as an integral part of paint production formula or for some corrective purposes. They include:

1. Anti-skinning Agents

Troysol is commonly used as an anti-skinning agent and it is imported from France, and Western Germany. It is usually stored at room temperature and pressure.

2. Thinning Agents

The commonly used thinning agent for paint manufacture is white spirit and it is manufactured by Petro-chemical industries, example NNPC, Warri. It is stored at room temperature and pressure in metal drums of 24 – 48 gallons.

3. Metallic driers

Some metals like, manganese (Mn), lead (Pb) Calcium (Ca) are used as driers and are imported from European Countries. They are stored at room temperature and pressure.

4. Titanium Dioxide

The material is imported from European countries and stored in paper bags at room temperature and pressure under dry condition.

5. Calcium Carbonate

This raw material is mined locally from many parts of the country and at times it is bagged by some local firms. It is stored at room temperature and pressure under dry condition.

6. Biocides

This is used to avoid the production of pollutants when bodying agents are attacked by bacteria and they manufactured locally by petro-chemical industries and imported from oversea countries. They are imported in small metal cylindrical containers or they can be paper bagged. They are stored at room temperature and pressure under dry condition.

COLOURANTS

The following colourants are employed for tinting the production of paint:

a. Alkyd Colours

These products are manufactured by NYCIL Nigeria Synthetic Industries Limited, Sango Ota, Ogun State.

b. Iron Oxide

This appears in black, yellow, red and brown colours. They can be used in its powdered form or in its paste form in which case it can be obtained directly from HOECHST (NIG) LIMITED, IKEJA, LAGOS. It is also manufactured in its paste form, in Umuoji in Anambra State. The powdered form is imported from overseas countries.

c. Extender Pigments

The materials, which can be referred to as bodying agents are mined directly from the ground and used as such or paper bagged by some local firms. They are as follows:

1. Talc. (Magnesium Silicate): This is obtained from Kwakati in Suleja, Nigeria.
2. Calcium Carbonate: This is also obtained from Ibadan, Umuahia, Awgu, Oji-River etc.

3. Caoline: This is obtained from Umuahia, Awgu, oji-River etc.
4. Clima Clay: This is locally obtained from Inyi (Oji-River Local Government Area) Enugu, Nkalagu, Awgu etc.

They are all stored at room temperature and pressure under dry condition.

CANS

These are containers for paints and they are obtained in different types as follows:

1. Metal Cans: there are produced by Metal Box Nigeria Limited, Lagos, Van Leer, Nigeria Limited, Lagos etc.
2. Plastic Cans: there are manufactured locally by Plastic Manufacturing Plants.

Processes of paint can production

2.4 MANUFACTURING PROCESS

The sequences of operation which may be employed in the manufacture of paints are in four principal stages which are as follows:

a. Dispersion stage
b. Quality Control stage
c. Scaling up stage/sieving
d. Packaging and Shipping.

However, before discussing the four stages of paint manufacture, it is necessary to discuss general principal of paint manufacture.

2.4.1 PRINCIPLES OF PAINT MANUFACTURE

Before one goes into the production of paint one has to have a good knowledge of various types of pigments, because this pigment comes in variation and modification. One should also have a good knowledge of the other classes of materials which include the Binder (oils, resins and their combination) and solvents.

The standard unit for a production formula is usually 100 gallons, with actual production batches being a multiple of this amount. Formula is obtained usually in weight units of all ingredients, or pounds of pigment and gallons of liquids. Formulation is usually done in terms

of volume relationship but the most important is the pigment volume concentration (PVC) which is the percentage of total pigment volume to total non-volatile vehicle (binder) volume plus pigment volume

DISPERSION STAGE

This stage is the most essential and in fact determines the paint quality. It should also be pointed out that pigment is the most expensive paint component and is usually introduced into a finished product system in the physical state of dispersion.

It followed quite naturally that a great deal of attention should be accorded the processing of dispersions in order to achieve maximum pigment utilization, that is optimum hiding power and colour.

Dispersion is compared primarily of a combination of pigment, binder and solvent. In addition to these three main components, dispersion contains a fourth ingredient called additives.

This dispersion process can be separated with three distinct phases. In practice, these stages overlap and occur simultaneously rather than strictly consecutively during the dispersion process. These three phases are:

1. Wetting
2. Particle separation
3. Stabilization.

Wetting involves replacement of the pigment – air and pigment – moisture interface with the pigment – vehicle interface. Wetting can be accomplished by mixing which permits intimate physical contact between the exposed pigments surface and the liquid media.

The particle separation phase involves the reduction of the pigment particle size during the dispersion process.

Although the primary pigment particle size is either equal to or more commonly below that size required to be achieved during dispersion. Therefore, during the phase of dispersion process, we are trying to accomplish reduction of agglomerate and aggregate sizes. Ideally, this phase which can be called deagglomeration or deaggregation separated the agglomerates and aggregates completely into primary pigment particle during this stage.

The third phase of dispersion process is stabilization and it involves the development and maintenance of a homogenous distribution of pigment particles in the liquid media. Subsequent to deagglomeration, particles could dump together and form floe, floccules or flocculates. Thus, this is the process of stabilization.

However, the dispersion raw materials (pigments, binder, solvents and additives) are charged into the processing equipment or better called dispenser and allowed to disperse for a minimum of 45 minutes. For high viscosity range required, 42% by wt of the total binder needed are employed at this stage with 100% by wt of the total pigment needed and 35% by wt of solvent.

A satisfactory dispersion is confirmed by the quality control department after test.

QUALITY CONTROL STAGE

This stage permits us to know when we have reached the desired end point. But before this, the paint content from the dispersion section will be transferred to the mixing machine through a rubber tube. The mixing machine or low-speed mill is fed by means of a rubber pipe from the dispersion container. Then, the binder and more bodying elements are added. This agents will make up for "adjustments" in volume and quality of paint. Where eventual mix is too thick, it will be made less viscous by adding a thinning agent.

In the quality control stage, however the quality or property, we must measure and ascertain the degree of dispersion. This is a measure of how close we have come to achieving either the real dispersion of a given pigment or more realistically to achieving the best dispersion we can on a practical basis. What we are actually measuring is the particle size distribution which is a function of the state of aggregation and flocculation of a system.

To measure degree of dispersion, we can use either a fineness or tint strength as a quality control test. Fineness method is the one extensively used by many paint factories and the procedure for determining the degree of dispersion by the fineness method is thus:

Equipments used are:

a. Grind gauge
b. Grind blade

c. Spatula knife.

A very small quantity of the dispersed paint paste is obtained with the spatula knife and deposited on the grind gauge and spread horizontally along two broad parallel lines in the grind gauge. Then if there are no small pores on the spread surface of the paint paste on the grind gauge, the grind or rather a better degree of dispersion is achieved but on the contrary, if there are small pores on the surface, the grind has not been achieved and further dispersion of the paint paste is necessary.

SEIVING AND SCALING UP STAGE

Sieving involves the filtration of unused agglomerates thereby allowing only the passage of pure paint.

The purpose of scaling up is to bring the paint to the required standard, quality and workable viscosity. This is achieved by adding the remaining 58% by wt of the vehicle, 65% by wt of the solvent and then the paint additives and driers respectively into the paint slurry system. The paint is then transferred to a reservoir inside the production hall.

PACKAGING AND SHIPPING

From the reservoir the paint is then packed and subsequently shipped. All paint packaging materials must from an effective barrier to skinning (oxidation drying of paint at the wrong place and at the wrong time) moisture, dirt and other micro-organism which might act on the paint. Hence, paint products are packed in cans made of tins or they may be packed in plastics made of P.V.C or polyethylene.

2.4.2 PROCESS DESCRIPTION OF PAINT PRODUCTION

The various operations needed to mix or produce paint are entirely physical. Chemical conversions are involved only in the manufacture of the constituents of paint as well as in the drying of the film.

The mixing process

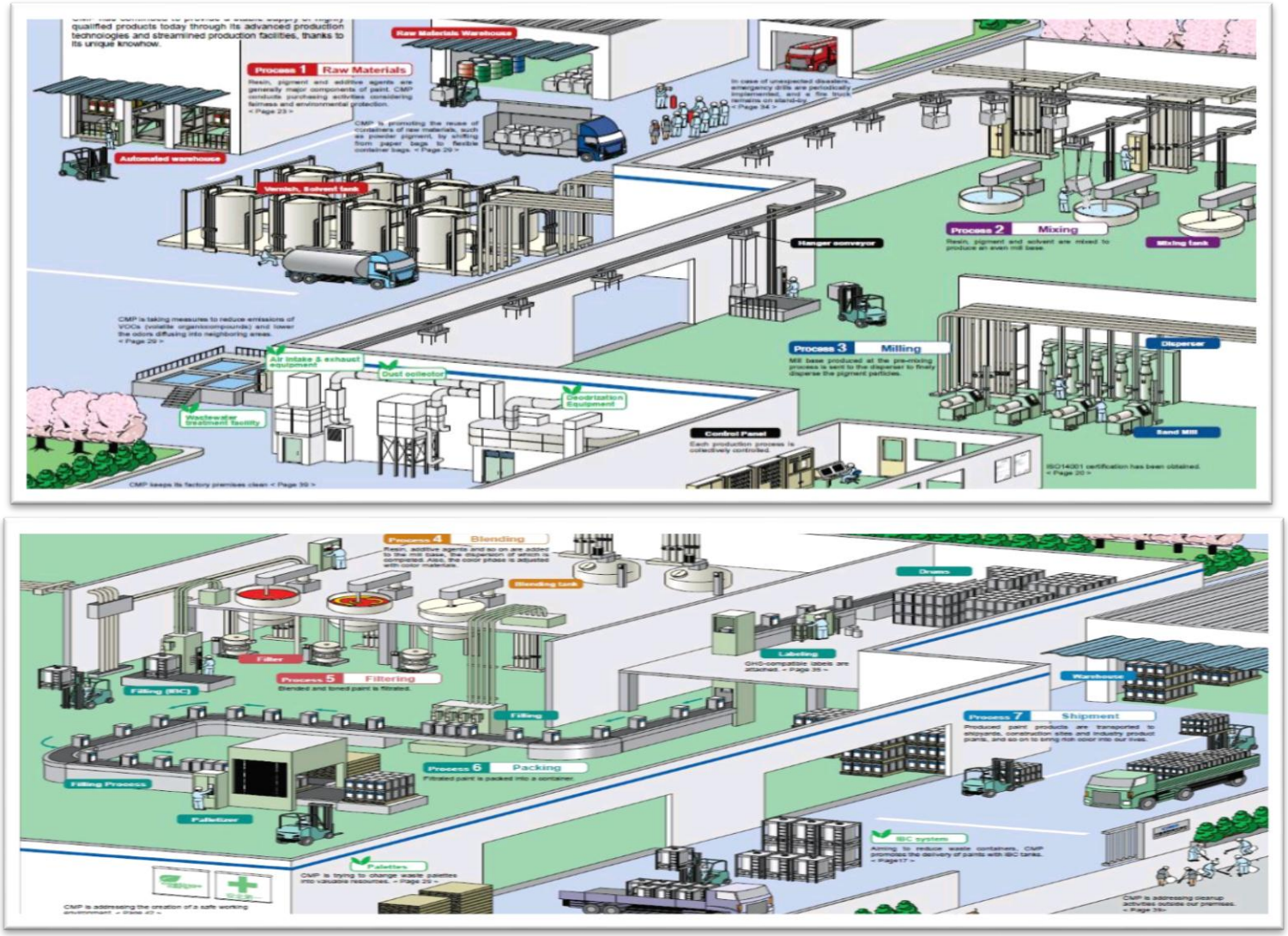
Tinting and Thinning process

The raw material from vessel B_1 is changed into the tinting and thinning tank A_6. In this tank paint pastes from dispersion equipment A_5 are thinned and possibly tinted if required.

The raw material from vessel B_2, B_3 and B_4 are changed into the feed tank A_1 from which they pass into the weighing tank A_2 where the exact amount of raw materials needed for dispersion are determined. These raw materials, however, are collected in mixer tank A_4 where they are properly mixed together, and discharged into the dispersion equipment, (which may be ball mill, high-speed disc impeller, sand mills, high-speed stone mills and pebble mills). In this equipment, dispersion or grinding of the pigment takes place. However, the operation is the principal and major operation which a paint formulator has to be careful about because it determines the quality of the paint produced.

When dispersion is complete, the dispersed phase which is the paint paste is then discharged with the thinning tank A_6 where the paint paste is then thinned to the required viscosity and possibly tinted if desired.

Then the liquid part is then strained directly into the hopper A_7 of the filling machine A_8. The paint is subsequently pured into cans and drums by the filled cans to the labeling machine A_{10} where the cans are labeled; and subsequently packed and moved to storage. Each of these operations is completely automatic.



Process of Paint Production from Stage 1 – State 7(finish and dispatching stage)

IDENTIFICATION SHEET FOR THE FLOW DIAGRAM

	EQUIPMENT		EQUIPMENT
A_1	FEED TANK	B_1	TINTS & THINNERS STORAGE VESSEL
A_2	WEIGHING TANK	B_2	RESIN STORAGE
A_3	PLATFORM SCALE	B_3	OIL STORAGE VESSEL
A_4	MIXER	B_4	PIGMENT STORAGE VESSEL
A_5	DISPERSION EQUIPMENT/MILL	B_5	CARTONING AND PACKAGING
A_6	TINTING & THINNING TANK	B_6	SHIPPING
A_7	HOPPER		
A_8	FILLING MACHINE		
A_9	BELT CONVECTOR		
A_{10}	LABELLING MACHINE		

	STREAM		STREAMS
I	TINT AND THINNERS	VII	PAINT PASTE
II	RESINS	IX	PAINT SLURRY THINNER
III	OIL	X	PAINT SLURRY FREE UNDISPERSED PIGMENT
IV	PIGMENT	XI	CANNED AND LABELLED PAINT
V	RAW MATERIAL	XII	SHIPPING
VI	WEIGHED RAW MATERIALS		
VII	MIXED RAW MATERIALS		

FORMULATION OF GLOSS PAINT

A. House paint primer (under coater)

INGREDIENTS	% BY WT
White lead	32
Rutile Titanium Dioxide	8
Extender pigment	23
Raw linseed oil	12
Heat – Bodied linseed oil	12
Resin	1
Thinner (including drier)	12

B. Ready – mixed finished coat, Exterior

INGREDIENTS	% BY WT
White lead	19
Zinc Oxide	16
Titanium Dioxide	10
Extender pigment	17
Raw linseed oil	23
Heat – bodied linseed oil	7
Thinner (including drier)	8

Gloss paints are normally formulated at a very low pigment volume concentration (PVC). This is because at high PVC, the film is more or less porous and absorbent and has poor flowing properties. In formulating gloss paints, one should try as much as possible to formulate it as 50% solids for adequate coverage.

White lead is used to promote durability and adherence, Titanium dioxide contributes whiteness, whiteness retention and opacity, zinc oxide contributes hardness to the film, the extender reduces cracking tendencies and they are used to control the pigment volume concentration (PVC).

FORMULATION OF EMULSION PAINT

FORMULATION A

INGREDIENT	LB	GAL
Dispersing Agent	15	2.0
Defoamer	2	0.2
Water	50	6.0
Titanium Dioxide	250	7.2
Extender Pigments	117	5.0
Hydroxycthy/cellulose, 2% ag. 50 C_2	50	6.0
Ethylene Glycol	25	2.6

FORMULATION B

INGREDIENTS	LB	GAL
Acrylic latex (46% non –volatile)	605	68.9
Preservative	9	1.0
Deformer	2	0.2
Water	8	1.0
Ammonium hydroxide	1	0.1

Formulation of Emulsion paint consists basically of combining pigment and latex (silky juice of certain plants). Additionally, some additives are included to achieve a desired property and these include pigment dispersing agents, preservatives, thickeners, defoamers and freeze thaw stabilizers.

In formulation A, a high-speed mill (50 H.P) is used to disperse the ingredients. After this stage, the mixture is transferred by means of a rubber tube to the next stage of production. After this 2nd stage, formulation B is added. Equipment for handling emulsion paints should be corrosion-resistant material like stainless steel. Containers have to be water resistant example, tin cans with a heat-cured resin coating on the inside surface.

FORMUATION FO INDUSTRIAL MAINTENANCE PAINTS

Navy steel-ship Maintenance Primer

INGREDIENTS	LB/100 GAL
Read lead	380
Zinc yellow	70
Mica	65
Iron Oxide red	10
Magnesium silicate	160
Aluminium stearate	6
Non-volatile vehicle	292
Volatile	348

Any kind of paint can prevent or protect metals against rust for a limited period but for durability corrosion inhibitive primers are used. The property of inhibition is a function of the pigments which are chromates, and red lead, $pb_3 04$ and zinc oxide and metallic zinc dust.

From the above table, the vehicle oil-alkyd resin and at times once can include raw linseed oil as a binder. The red lead and zinc yellow are corrosion inhibitors, iron oxide is opaque to ultraviolet and the siliceous pigments control the pigment volume somehow below PVC.

2.5 THE PRODUCTS

The major products required to be produced include;

- Exterior and interior building paint (Gloss)
- Exterior and interior latex, emulsion paint
- Industrial maintenance paints.

These products are to be produced based on previous analysis on the formulation of gloss, emulsion and industrial maintenance paints.

Additionally, there are some specialty paint products that can be produced based on special request. Such include:

Fire-Retardant Paints:

The raw materials used for the production of fire-retardant paints include, Urea and acid phosphate, esters, pentacry-thritol and others. The resulting film acts as an insulating blanket to minimize further heat transfer.

Resco:

This type of finish comes out as a design on a masonry wall (exterior and interior walls). The masonry surface is prepared by applying a specific number of coats of lime plaster. The non-reactive mineral colours, which serves as the pigment, are dispersed in the liquid water and design on the surface.

Tempera

The surface medium for this kind of paints is usually diluted with water, and it eventually becomes insoluble on drying. The raw materials required include: egg yolk, water and linseed oil, whole egg, water, linseed oil and dammar resin solution and so on.

Daylight fluorescent colours

This type of colour has a wide application in advertising and the raw materials are; hard resin with a small percentage of fluorescent dye in solution (pigment), alkyd resin or hydrocarbon-soluble acryic resin. These are widely used for safety and attention.

Water Colour:

The raw materials required for this product include; water soluble gum as a binder, glycerol which constitute a little percentage and applied to give a longer wet edge, translucent pigments such as, alizarine red, phthalocyamine green and more opaque pigment which are applied very thinly.

These kinds of colour is utilized more for staining operations and are usually applied on a special high grade of paper, the best qualities being hard-made.

2.6 PLANT AND MACHINERY

There are many types of paint making equipment. Knowledge of their size, installation and mode of operation are vital for efficient design of production hall. However, the plant and machinery which include those for processing, mixing, blinding and producing paint and paint products, to be critically analyzed based on the:

1. Mode of operation
2. Acoustic considerations
3. Dimensions – Ground coverage (m^2) and height (m)
4. Smoke generations
5. Rate of energy dissipation which is an index of vibration effects.

2.6.1 METHODS AND CONDITIONS OF INSTALLATIONS

All plants and machinery for the production should be installed at the ground floor, but any equipment installed at ground floor. These machines are installed in basement due to some factors like acoustic considerations.

The following plant and machinery are to be analyzed in this section:

i. High-speed dispenser

ii. Low-speed mill

iii. Sand grinder

iv. Roller mill

v. Sieving machine

vi. Canning machine

vii. Compressor

viii. Pumps

HIGH SPEED DISPENSER

This consists of four cylindrical tanks at the centre of which is mounted a vertical shaft with an impeller at its bottom driven by a variable speed overhead motor. The impeller is rotated at speeds up to 1200 r.p.m. as the high-speed dispenser has a power rating of 50 H.P. This impeller is a flat disc type blade with a varied periphery, which resembles a circular saw blade. This machine is suitable for pigments that have low viscosity and are easy to grind and dispersion is achieved by shear and attrition.

High Speed Dispenser

Group of High Speed Dispenser

The following variables affect the dispersion by high speed dispenser:

a. Physical dimensions and impeller position.

b. Impeller rotational speed

c. Temperature

d. Formulation.

a. Physical dimension and impeller position:

The overall dispersing efficiency of high-speed dispenser are affected individually and collectively by tank diameter, batch height, impeller height and diameter. However, adherence to the following operating ranges is recommended to minimize dead spots along the tank periphery and minimize circulation (Federation series on coating technology Unit 16).

	Minimum	Maximum
Tank diameter	2.0 D	4.0 D
Batch height	1.0 D	2.0 D
Distance from tank bottom to impeller	0.5 D	1.0 D

Where D is the blade diameter

b. Impeller rotational speed

The higher the speed, the faster the dispersive action but there is a critical speed above which grinding efficiency will drastically decrease. The peripheral speed of disc impellers are in the range of 3,000 to 6,000 Feet/Minute depending on the formation being processed and operation above any critical speed results in cavitations and little or no grinding is accomplished.

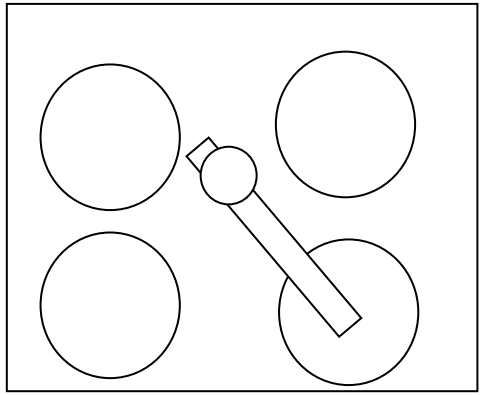
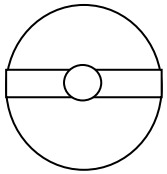
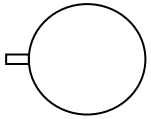
c. Temperature

Processing by high-speed dispenser is accomplished by significant increases in temperature. Therefore, heat sensitive materials are not applicable. As temperature increases during processing, viscous resistance decreases.

Since viscous resistance is important to dispersing efficiency, the efficiency at the beginning of the processing cycle when the temperature is low and the viscosity is high, is higher than at the end when the temperature is high and the viscosity is low. However, water cooled vessels can be cured to control temperature.

d. Formulation

Usually, viscous resistance is required for high grinding efficiency. The most effective formulations are usually high in pigment content and low in binder content. The high pigment loading develop the high viscosity while the low binder content permits maximum particle interaction and attrition without interference from resilient resin barrier or coating.

MACHINE	CAPACITY (H.P)	PLAN	GROUND COVERAGE	HEIGHT
HIGH-SPEED DISPENSER	50 H.P		12.53m^2	3.10m
LOW- SPEED MILL	5 H.P		1.27m^2	2.80m
SEIVING MACHINE	2 H.P		0.50m^2	1.35m

Installation:

Each of the four cylindrical tanks is mounted on four steel-stands that are supported by pad foundations. To reduce the effect of vibration on the floor the giant mixer is mounted on resilient pads supported by pad foundations.

Acoustic Consideration:

During operation, this machine produces much noise and vibration. Therefore, the following acoustic considerations are recommended; the noise generated by the mill must have a good barrier, which should act as a shield and absorb a greater part of it to avoid echo. Therefore, this machine is installed in basement, with basement wall, with sound absorbing materials, acting as the shield. Other machines like the low-speed dispenser and the compressor that produce similar noise and vibration should be treated like the high-speed dispenser.

LOW-SPEED MILL

This has a very low speed (5 H.P.) and it is used for the second stage of production process unlike high-speed dispenser which is used for first stage production process. It is made up of a cylindrical tank at the centre of which is mounted a medium size mixer. The capacity of the cylindrical tank can be 700 gallons.

Low Speed Mill Machine

Installation

The method of installation is the same as the high-speed dispenser.

Acoustic Consideration

As was mentioned earlier, this machine serves a routine purpose in paint production; therefore, it should have the same acoustic treatment as the high-speed dispenser.

SAND GRINDER

This machine is used for most of the production process and most types of paint products particularly those paints that utilized easily dispersed pigments. It has a low speed of rotation and a flat impeller with power rating of about 30 H.P.

Sand Grinder Machine

Installation

This is installed in the ground floor because it does not produce so much noise like the high-speed dispenser and the low-speed mill and it is not used for every day production.

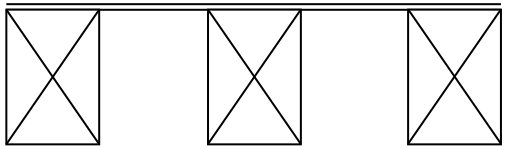
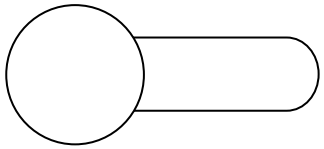
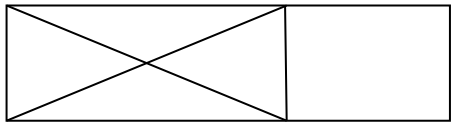
The machine is mounted on resilient pads or special coil springs to reduce the effect of vibration on the floor of the production hall. The tank should not be permanently installed just like any other machine installed on ground floor of the production hall.

ROLLER MILL

The most widely used roller mills, are the three roll mill, and consists of three highly polished steel rolls which rotate horizontally at different speeds and in opposite directions with a typical speed ratio of 1:3:9. Most of the times, the roller mill is not used to disperse abrasive pigment but are used effectively for high viscosity coatings that are not adaptable to other methods.

During the process, the premixed pigment paste is charged on to the slowest rolls and is carried to the nip between the first and second rolls from which most of the aggregates are squeezed out. From the second roll, the paste continues to the nip between the second and third and it is discharged from the last roll by a steel blade into a thinning tank.

Roller Mill Machine

MACHINE	CAPACITY (H.P)	PLAN	GROUND COVERAGE	HEIGHT
ROLLER MILLS (3 Sets)	2 H.P		4.42m^2	2.40m^2
SAND GRINDER	30 H.P		2.40m^2	2.40m^2
FORKLIFT			2.51m^2	1.20m^2

Installation

This is installed in the ground floor of the production hall because it does not produce much noise like other machines. This machine should be mounted on a special coil spring or on resilient pads to reduce the effect of vibration on the floor. Therefore, as was mentioned before, this roller mill should have a mobile tank.

SIEVING MACHINE

This comes into use during the third stage of production process and it has a motor of 2 H.P.

Sieving Machine

Installation

This machine, similarly, should be installed at the ground floor of the production hall because it produces less noise. However, relative to its vibration, the machine should be mounted on resilient pads or special coil spring.

CANNING MACHINE

This comprises of a storage tank of about 750 gallons and a cocking machine. It is used at the last stage of the production process.

Canning Machine

Installation

The installation of this machine is similar to that of the sieving machine as explained above.

COMPRESSOR

This is a pressure machine which makes use of fuel, gas or petrol. The pressure generated is used for the following:

a. To lift and transfer the mixing shaft of the high-speed dispenser from one tank to another.
b. It is used to lift the shaft of the sand grinder
c. It is also used by the cocking machine.

Installation

This compressor should be installed in the basement because it generates much noise and vibration and it is used as a routine production machine. However, provision should be made for smoke discharge since it generates a lot of smoke. Finally, the machine should be installed on resilient pads or special coil spring to reduce vibration effects on basement floor.

PUMPS

These are utilized to transfer liquid from one stage of the production process to another. It has a power rating of 3 H.P.

Installation

These machines do not generate much noise; therefore they can be installed at the ground floor or basement, depending on where they are needed. The pumps should be mounted on resilient pads or special coil springs.

There are some other equipment which are being returned after use to the storage unit. These equipment are not usually installed in the production hall but are made available when necessary. They include the following:

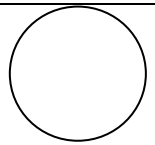
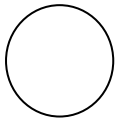
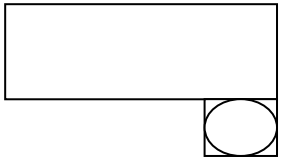
Forklift: this is used for transporting raw materials and finished goods from the storage units to the production hall and vice versa.

Forklift

Mobile tank: mobile tanks could be used in the Roller mills and grinder and can as well serve as a washing vessels. It has a capacity of 720-800 litres and can be pushed and pulled around on its four wheels.

Palette: this is a board with a hole for the thumb on which an artist mixes his colours and it can also be a wood construction with rectangular openings for packaging of cans of paint.

Pail Loader: this is used for loading or off-loading paint cans into or out of vehicle.

MACHINE	CAPACITY (H.P)	PLAN	GROUND COVERAGE	HEIGHT
STATIONARY TANK	700 GALLONS (2800 LTRS)		$1.27m^2$	1.4m
	500 GALLONS (2000 LTRS)		$1.13m^2$	1.4m
MOBILE TANK	200 GALLONS (800 LTRS)		$0.66m^2$	1.25m
CANNING MACHINE			$4.50m^2$	2.38m

2.7 PLANNING PRINCIPLES OF FACTORIES

In the past years there have been an amazing activity in the construction of smaller industrial buildings, factories ware in the form of specialized craft shop like metal smiting, carpentry, pottery shoe making etc. they were not therefore extensively planned.

In this rapid expansion, there has been a definite trend towards decentralization and has been a changing concept and use of industrial building. These factors spread the work of the design professionals, produced changes in programming and design, and in construction technique. The need for organized arrangement arose in modern factory design due to the following developments:

- Improved mechanized equipment
- Labour specialization
- Need for neatness and orderliness in the production areas.
- Improved and efficient material handling techniques.

2.8 FACTORY ACT

There are general rules and regulations applicable to all types of buildings, but there exists special, specific acts and legislation which are applicable to industrial buildings. These regulations exist for the following purposes:

1. Controlling the location of industries and their auxiliary services.
2. Guarding against poor working conditions or atmosphere for the factory workers.
3. Control of pollution from industries.

These regulations are listed in the NIGERIAN FACORIES ACT 1958 and the BRITISH FACTORIES ACT 1937, 1948 and 1961.

The following are also factories acts on some other aspects of industrial design:

A. Over crowding

Allowing space per worker shall not be less than 400 cubic feet or 11 cubic water. In calculating the space, no space more than 14 ft (4.2m) from the floor shall be taken into consideration. Any gallery shall be treated as a portion and so forms a separate room.

B. Lighting

Effective provision shall be made for securing and maintaining sufficient and suitable lighting, whether artificial or natural in every part of a factory in which persons are working or passing. All glazed windows and skylights used for the lighting of work rooms shall as far as practicable, be kept clean on both the inner and outer surfaces and from obstructions.

C. Ventilation

Effective and suitable provision shall be made for securing and maintaining the circulation of fresh air in each work-room and for rendering harmless as far as practicable all much fumes, dust and other impurities and generated in the course of any process of work carried on in the factory as may be injurious to health.

D. Removal of dust of fumes

In every factory in which, in connection with any process carried in, there is given off any dust or fume or other impurities of such a character and to such extent as to be likely injurious or offensive to the persons employed or any substantial dust of any kind, all practicable measures shall be taken to protect the persons employed against exhalation of the dust, fume or other impurities and to prevent its accumulation in any room.

No stationary combustible engine shall be used unless provision is made for conducting the exhaust gases from the engine into the open air.

E. Dangerous Substances

Every fixed vessel, structure, sump or pit of which the edge is less than 2 metres above the highest ground or platform from which a person might fell into shall, if it contains any scaling, corrosive or poisonous liquid either be securely covered or fenced to at least a height of 1 meter above the ground or platform.

F. Drainage of floors

Where any process is carried on which renders the floor liable to be wet to such an extent that the wet is capable of being removed by drainage, effective means shall be provided and maintained for drainage off the wet (floor slope should be 1:20).

G. Floors, passages and stairs

All floors, steps, stairs, passages and gang ways shall be of sound construction and properly maintained and shall as far as reasonably practicable, be kept free from any obstruction and from any substance likely to cause a person to slip.

For every staircase in a building or affording means of exist from a building, a substantial handrail shall be provided and maintained, and any open side of a staircase shall also be guarded by the provision and maintenance of a lower rail or other effective means.

All openings in floors shall be securely fenced except in so far as the nature of the work renders such fencing impracticable and all ladders shall be soundly constructed and properly maintained.

H. Safety provisions in case of fire

Any door opening on to any staircase or corridor from any room in which more than ten persons are employed, and all other doors for persons employed therein, shall except in case of sliding doors be constructed to open outwards, and every hoistway or liftway inside a building shall be completely enclosed with fire-resisting materials including all access doors.

I. Fire fighting

In every factory, there shall be provided and maintained appropriate means of fighting fire, which shall be so placed as to be readily available for use.

J. Welfare

a. Supply of drinking water:

There shall be provided and maintained at suitable points, conveniently accessible to all persons employed an adequate supply of wholesome drinking water from a public main or from some other source approved in writing by the district council. Such supply of drinking water shall be clearly marked "DRINKING WATER".

b. Washing facilities.

There shall be provided and maintained for the use of employed persons adequate and suitable facilities for washing which shall include a supply of clean running water and in addition, soap and clean towels or other suitable means of cleaning or drying, and the facilities shall be kept in a clean and orderly condition.

K. Sanitary Accommodation

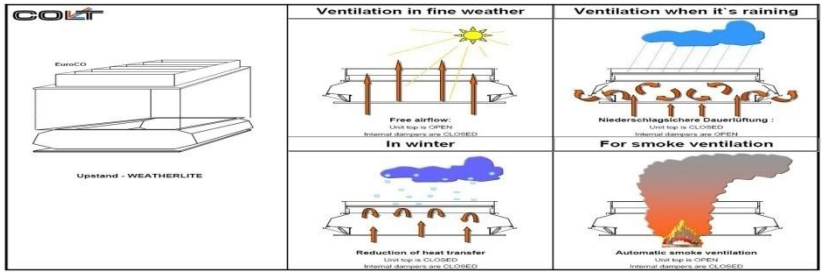
a. Provision of Conveniences:

Where females are employed in any factory there shall be provided at least one sanitary convenience for every 20 females, and where males are employed, there shall be at least one suitable sanitary convenience (not being a convenience suitable merely as a urinal) for every 25 males up to the first 100 and for every 40 thereafter.

In calculating the number of conveniences required by these regulations any number of persons less than 20, 25, or shall be reckoned as 20, 25 or 40 respectively.

b. Lighting, Ventilation and Siting:

Every sanitary convenience shall be adequately lit and ventilated and shall not communicate with any work-room except through the open air or through an intervening ventilated space, and shall be maintained in a clean condition.



Ventilation in raining & fine weather

c. Construction:

Every sanitary convenience shall be under cover and so partitioned off as to secure privacy and shall have a proper door fastening.

Urinals shall be so placed or screened as not to be visible from other parts of the factory where persons work or pass.

d. Accessibility

Sanitary convenience shall be so arranged as to be conveniently accessible to the person employed all times while they are at the factory.

2.9 EFFICIENT AND FLEXIBLE FCTORY LAYOUT

Paint design refers to the overall design of an enterprise. In addition to covering the problem of plant layout it also takes in such problems as process planning, plant location, plant size determination, product, design, building type selection etc.

An efficient and flexible factory layout entails the planning of the physical arrangements for the various industrial facilities. These arrangements are always obtained in spaces needed for the following purposes:

Operating equipment and machinery

Indirect labour

Storage

Personnel

Material Movement

Other supporting activities and service plant layout, which is another aspect of efficient factory layout, is the planning of an adequate arrangement of industrial facilities including personnel, working machinery and other subsidiary services with a consideration on the best structure to house the facilities.

There are several objectives of plant layout, and the following are considered:

- To provide convenience between separate buildings and special testing storage facilities; this means minimizing travel distance between facilities that interact frequently.
- To make work flow through the plan in a sequence of operation.
- To provide convenience between internal and external features (employee parking and working station, delivery vehicle access and shipping and receiving, storage, customer parking and administrative station.
    - ❖ Plan should be simple, efficient flexible and versatile.
    - ❖ Landscaping should be encouraged by means of planting, paving and others
    - ❖ Lighting (natural and artificial ventilation should satisfy the specific working condition.
    - ❖ Control of noise should be paramount to avoid its disadvantages.
    - ❖ Adequate clear span should be achieved in roof, ceiling and supports to eliminate excessive obstructions.
    - ❖ Provision should be made for future expansion of the factory.
    - ❖ To utilize all existing spaces adequately and effectively.
- Provide appropriate separation between facilities where serious noise or safety hazards may compromise worker's efficiency or safety.

- To achieve flexible and easily adjustable arrangement of function at minimum cost and inconvenience.
- Arrange for internal functions and all factors of production that are related and interact frequently to be located close together.
- Provide adequate conveniently located employee support services to minimize travel time. These services include rest rooms, cafeteria, employee personal services, etc.
- Provide signs, distinctive architectural features and other codes to serve as a recognizable visual reference. This will help workers to know where they are and where they are going.

Besides the above objectives of plant layout, there are three basic classification of layout based on the interactions and behavior of the three elements of production: Men, machine and material.

1. Layout by fixed position.

In this kind of layout machinery and men move while the major component of production remains static until the final product is gotten, eg. Ship building industry.

2. Layout by process

In this kind of layout machinery and man move while materials move in their different processing functions. This is applicable where various products are to be produced along the line of the major production, eg. Ceramics, pottery, paint etc.

3. Layout by product.

Here the materials move while men and machinery remain static in a sequence of operation. This means that material from one section of production is picked up by adjacent section of production, eg. Pulp and paper mill, bottling plants, oil refinery etc.

2.10 FACTORS OF THE ELEMENT OF PRODUCTION

The following factors of production are relevant for effective, flexible and efficient planning of any factory layout:

- Material factor
- Machinery factor
- Men factor
- Movement factors
- Service factor
- Building factor
- Change factor.

However, adequate compromise has to be sought for among these factors, because one at times influence and conflicts with another, for the desired efficiency to be obtained. These factors will be considered based on the way they influence the entire planning of factory layout.

THE MATERIAL FACTOR

The objective of any industrial establishment is to utilize materials to achieve a final product. Hence, material factor stands the most important factor to be considered in any plant layout design.

The features of material factor are as follows:

i. Basic raw material(s)

ii. Other incoming material(s)

iii. Materials – in – process

iv. Finished products

v. Outgoing packaged material

vi. Supplies, repairs or rework

vii. Scrap, trim, cuttings and waste

viii. Packaging materials

ix. Materials for maintenance, tool shop and other services.

Additionally, the major considerations which affect material factor include:

(a) The design and specification of the product

An adequate and efficient design and specification of the products will obviously reduce the cost of production in terms of the size, shapes, bulk, weight and condition of the products.

(b) Sequence of operation and component parts of materials.

This consideration gives the necessary and required arrangement of the machinery and its work area and interrelationship between depths and location of service areas.

(c) The chemical and physical characteristics of both raw materials and finished goods

This has an influence on other design factors like floor loads, floor treatment handling equipment, machinery, storage methods etc. and the temperature of the surroundings.

THE MAN FACTOR

The following are the features of the man factor:

- Direct labour operation
- Supervisors and forement
- Indirect or supporting personnel:

1. Set up men
2. Material handler or stockment
3. Maintenance men
4. Repair workers
5. General office personnel
6. Employment and welfare office personnel
7. Trainees and instructors
8. First aid attendants, sisters,
9. Food distributing personnel-cooks stewards etc.
10. Time keepers
11. Inspectors or quality control checkers
12. Engineers or process technicians
13. Factory protection personnel, guards and firemen
14. Receiving and dispatching clerk.

- Group leaders and stewards.

The considerations under man factor are based on safety and working conditions and psychological or personnel considerations:

- Psychological or personnel considerations. Fear of eventual injury causes uneasiness in workers and this arises due to:-

a. Reckless driving of push truck or fork lift

b. Orientation of operating machines or work benches.

c. Pieces of broken material on work areas.

d. Claustrophobic, crowding or loneliness.

- Safety and working conditions:

a. Closeness and accessibility of fire and first aid facilities

b. Adequate exits and clear escape ways.

c. Unobstructed and non-slippery floor

d. Provide a situation whereby special safety devices and guards are unnecessary.

e. Locate workers work area far from moving parts of equipment and other hazards.

MACHINERY FACTOR

The following are the features of the machinery factor:-

- Production machines

- Tools
- Process equipment
- Hand operated tools
- Maintenance machinery
- Gauges and measuring equipment
- Control equipment and panels.

The following considerations of the machine factor are necessary for efficient plant layout design:

(1) Choice of method and process

(2) Choice of number of machines, number of each allowed for future change.

(3) Adequate utilization of machine which eliminates or reduces under production or over production.

(4) Various individual machine requirements and other processes that need a special conditions or requirements.

Other important considerations are: shape and dimension of various machines, ceiling heights and over head installations; machine weights which influences location, floor load and subfloor service ducts, and machinery processes which influences ventilation procedures and the provision of special features like chiming where processes involve smoke and fumes.

THE MOVEMENT FACTOR

The handling of materials represents most of the physical activity in a plant. Raw materials, materials in process and finished products are the basis of its existence. From the receiving dock materials are unloaded, moved, stored, removed and stored and moved into manufacturing. During manufacturing process they move, wait in process and move through numerous operations and surge storages, through inspections and packaging to final storage. Therefore, it becomes obvious that in most factory designs, the material, out of the other elements of production, moves. The physical features of the movement factor are as follow:

- Chutes, tubes, pipes, guide rails
- Industrial vehicles truck, lift truck transporters, tractors, tippers etc.
- Cranes and monorails
- Stocking, tiering and positioning equipment
- Highway motor vehicle
- Water carriers – ships barges, cornel flures
- Conveyors – roller, wheel, belt, bucket, tray, apron etc.
- Elevators, lifts, hoists
- Animals

- Air transportations
- Equipment used to hold material in process – boxes, pens, trays, bags, drums etc.

The following are the considerations under movement factor:

(a) Flow pattern: consider the flow of materials from the raw materials section to the finished product, movement of machinery, men and services, supply of equipment materials to and fro the production hall.

(b) Reduction of unwanted and uneconomical handling by moving materials; towards completion, on the same device without transfer, easily and over shortest distances, safely without damages to men or materials, in co-ordination with production, and other handling equipments.

(c) Handling equipment: probably, the more conventional material handling equipments is the mechanical equipment, and movements should be under, over or through such permanent machines.

(d) Creating adequate aisle to eliminate traffic jam and crowding. Aisles should be kept straight and clear, aisles should be made two sided and located at minimum distance and aisles should he made with proper and convenient width based on, users, speed of travel, frequency of use, volume of traffic at peak load and the possible future condition of the above.

From recommendation, aisles width should be 90cm for personnel to about 4 meters for heavy 600 pound fork truck.

THE SERVICE FACTOR

In industrial establishments the services are those facilities, activities and personnel that keep labour, material and machinery in the production in operation.

The following are the features of the service factor which are based on services related to men, material and machinery:

(1) Service relating to men:

- Employee facilities
- Short distance and special access provision
- Heating, ventilation and lighting
- Offices
- Fire protection

(2) Service relating to materials:

- Quality control
- Production control
- Waste control

(3) Services relating to machinery:

- Maintenance – with access and room.
- Distribution of anxiliary service lines

Considerations under the service factor are analysed based on the service relating to men and materials:

SERVICE RELATING TO MEN

Employee facilities should include:

- Parking lot
- Toilet and washrooms
- Shower
- Locker rooms
- Resting areas
- Germicidal or decontamination room
- Waiting lounge
- Time clock and time-card racks
- First aids equipment and room

- Medical facilities
- Cafeteria/lunch room
- Janitor, clean up and trash collecting facilities
- Personnel offices
- Library and record room.

Offices for the entire system include:

- General manager
- Production manager
- Supervisor's offices
- Production engineers
- Quality control
- Accounting payroll
- Security office
- General/receptionist office
- Personnel and employment

- Conference/board rooms
- Training centre
- Purchasing and supply offices

SERVICES RELATING TO MATERIALS.

- Quality control: this is item centralized to take care of small items but when items become large, this is located at each item to take adequate care of their needs
- Production control:
  - Controls the time between different operations
  - Controls the space – allocation for raw materials and finished products
  - Controls storage spaces and delay points
- Waste controls:

Industrial waste should be handled efficiently by creating spaces for reclaiming, recycling or total destruction equipment to eliminate their hazards. The distribution of the service line should satisfy the function of the layout, economical operation, unobstruction, accessibility to equipment and out of danger to personnel equipment or materials.

THE CHANGE FACTOR

This factor is the eventual change in the industrial layout which could be either internal or external resulting to future expansion.

The considerations under change factor are as follows:

(a) Men – working hours, organization or supervision skill may change

(b) Machinery – changes in its method or process products, demand and variety.

(c) Other – handling, storage, servicing of building structures.

One of the principles of good factory design is to make the system internally and externally flexible, adaptable, expandable and versatile. It is always better, in this circumstance, to utilize movable machinery and equipment and detachable materials for the factory buildings. However, some other factors that enhance flexibility are; self contained equipment, standardized equipment, building structure with large unonstructed floor areas, etc.

Expansion entails the overall change in the whole system especially the capacity of different operating facilities. Therefore, there should be adequate considerations to avoid unnecessary and uneconomical rearrangement in future. There are different types of expansion possibilities as follows:

a. An addition of extra floor above or below to the building

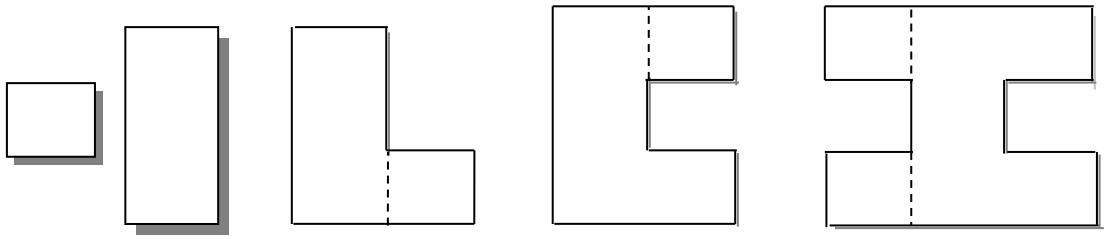
b. An addition of extra space to the ends or sides of building.

c. Addition of mezzanine floors

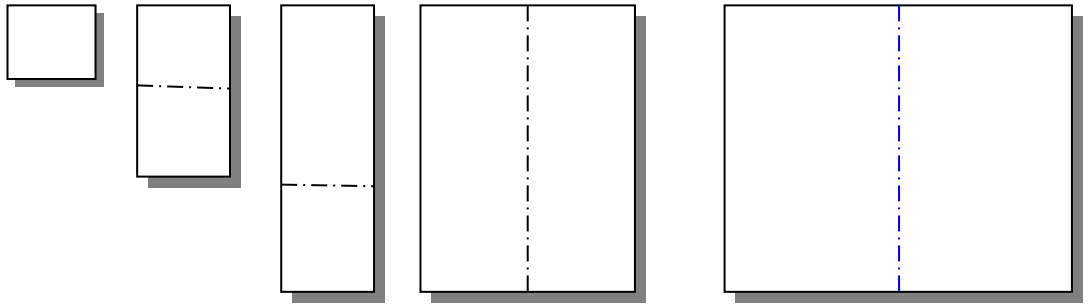
d. Addition toward storage or/and service areas

e. Utilization of buildings with easily removable ends or side walls.

2.11 PLANNED EXPANSION OF CONTEMPRARY FACTORIES.



PLANNED EXPANSION (EARLY FACTORIES)



PLANNED EXPENSION (MODERN RECTANGULAR PLAN)

2.12 MATERIAL HANDLING

Industrial design usually commences with plant layout, at which the general outlines of the plant and departments and choices of equipment are established. However, the fundamental emphasis is on plant layout, which is the backbone of all good industrial facilities. In turn, plant layout is fundamentally an arrangement to meet the proper flow or materials.

The handling of materials represents most of the physical activity in a plant. Raw materials, materials in process and the finished products are the basis of its existence. Materials are usually received, loaded, moved, stored, removed and stored, and move into manufacturing. During manufacturing, materials move, wait in process and move through many operations and storages, through inspection and packaging to final storage and then to final storage and then to final handling. The basic material in all industrial plants, whether processing or warehousing, is a major part of the activity.

Material handling is a top consideration of all management and its problems are major design consideration. Therefore, it is necessary for all modern industrial structures to house materials handling devices and to provide for the proper flow of materials, vehicles and personnel.

HUMAN FCTOR CONSIDERATION IN MATERIAL HANDLING SYSTEMS.

Many handling materials come into, or are moved from the industrial complex, as well as the actual handling within the facility. This may be accomplished by machines of one kind or another, humans interface with machine controls and displays. The primary human factor considerations are as follow:

1. **Prevention of material damage**.

Waste of materials due to damage is of considerable economic consequence. Therefore, it is extremely important to examine the material – handling concept in terms of the potential errors the human element could make with respect to movement of all materials in the delivery, manufacturing and dispatching phases of the proposed operation. Human errors often exist at the following points during material handling.

(a) Dock transfer to and fro. a transportation system truck, ship etc.

(b) Shipping and storage – area transfer, that is, to and from the loading bay and area designated for temporary storage of either the preprocessed materials or the finished and packaged products.

(c) Transfer within the plant, that is, between processing, assembly, test and packaging stations.

2. **Prevention of personal injuries.**

Personal injuries also have a considerable economic impact on an industrial operation. It is therefore important to create as safe a place to work as possible. Typical areas in material handling where personal injury often occurs include the following:

(a) Direct interface with raw materials that are heavy, sharp, rough, breakable or explosive.

(b) Storage and staking, where materials fall on people.

(c) Automatic material movement, where workers may be struck by materials or machine

(d) Toxic liquids or chemicals which may spill onto workers during transfer.

MATERIALS HANDLING EQUIPMENT/DEVICES.

There are different types of industrial material handling devices as described below.

1. Cranes: simplest lifting device for vertical elevation is the hoist having a 0.5 –5.0 ton capacity. Additional horizontal movement by wheel carriage (1 and 2) wheel carriages controlled from shop floor or from driver's seat (or from remote control cabin). Bracket job Cranes make load lifting above any part of an area possible. Exact positioning of load difficult, however, due to sloping extension device.

   Outside crane require enclosed or rain-protected motors. Design of structure depends on height of lift and crane capacities.

2. Other handling devices:

Other types include roller, curved roller, spiral roller, screw, wire mesh and belt, slat, portable belt conveyors, bucket conveyors.

Fork-lift truck: This device has facilitated the modern concept of the unit load. This concept is that material in any phase of production – raw, storage, in process or finished form – should be handled in as large a load of individual units as is possible this is achieved by packaging the materials into a several thousand pound load that can be readily lifted, transported and stacked by lift truck.

CHAPTER THREE

CASE STUDY

INTRODUCTION

In the previous chapters discussions have been on the production process for the manufacture of different paint products, and the factory design criteria.

All these are channeled towards the eventual realization of the project; a paint factory, Makurdi. However, still with the same purpose, this chapter will analyze the various existing paint factories based on the following:

- Background information/location
- Products
- The factory layout
- Analysis of various components
- Factory processes/production processes
- Raw materials
- Plants and machinery

- Lighting
- Services
- Materials of construction
- Landscape
- Appraisal/Assessment.

Based on these, the following care studies were analysed;

- International paints West African Limited, Ikeja, Lagos.
- Mater – Piece Chemical Company limited, Oji River.
- Haymes Paint Factory, Ballarat, Victoria Australia

3.1 CASE-STUDY 1: INTERNATIONAL PAINTS WEST AFRICA LIMITED, IKEJA LAGOS.

3.1.1 BACKGROUND INFORMATION/LOCATION

The factory is located at Oba Akran Avenue Ikeja, Lagos State. At this same avenue, there are other existing paint factories of the same standard which include; Bergar paints and Dulux paints. One can also find the following other companies; Guinness bottling company and many others.

3.1.2. PRODUCTS

International Paint West Africa Limited manufactures the following vast products;

- Nigerlux gloss paint
- Niger wood, finishes and ancillary products for furniture and plywood factories.
- Glamour Emulsion paint
- Leader gloss
- Packaging coating for most of the large food and drinking canning and bottling industries is Nigeria.
- Industrial coating for automotive, aviation agriculture, etc.
- Protective coating for steel, concrete structures etc.
- Nigertex (textured coating)
- Marine coating for small vessels for above and below the waterline.

Different types of Finished and canned Products

3.1.3 FACTORY LAYOUT

The factory is planned on separate building blocks, which means that separate blocks are utilized for different functions. The factory layout includes the following building blocks:

1. Administrative block
2. Personnel department
3. Sales department
4. Maintenance Unit
5. Welfare blocks; (Clinic, Senior staff cafeteria, Junior staff cafeteria etc).
6. Warehouse

7. Production Hall; (Tinting (colour matching) Emulsion plant, wood finish plant etc)
8. Cash and carry department
9. Research Unit (laboratory, library, Training centre).
10. Security department.

The Factory Layout

1. ADMINISTRATIVE BLOCK

This block is located nearer the main entrance gate and staff parking spaces. It contains offices for; Administrative General Manager, Confidential Secretary. General Manager, Confidential secretary, Reception and waiting area, communication, Accounts/Auditing department, Boardroom etc. Additionally, there are offices for Clerks, Attendants, Welfare officer, General office etc. This block has a double loaded corridor office planning, which virtually allows adequate cross ventilation. All the above office spaces are contained in the ground and first floors of the administrative block

2. PERSONNEL DEPARTMENT

While approaching the factory via the main entrance gate, the personnel department is at the right hand side and opposite the administrative block. It is located at the first floor with the following offices for; Assistant General Manager (Personnel), Staff offices, Training Officers, Personnel Officers, Personnel clerks, General Manager Technical and lavatories.

This unit has a single loaded corridor office planning which allows cross ventilation.

3. SALES DEPARTMENT

The department deals with the entire factory transactions with its customers and distributors and is located beside and after the administrative block. The block contains the following offices at the ground floor; General Manager Marketing, Assistant General Manager

decorative, Assistant General Manager Industrial coating, Sales development Manager (Project); Market Manager development etc. additionally, the following offices are contained at the upper floor; Market analyst, Sales office Manager, Architect sales Executive, Publicity Manager, Internal auditor, Purchasing Manager, Commercial department, planning analyst, Assistant General manager commercial, purchasing office, shipping and clearing. Similar to the administrative block, this department has a double loaded corridor office planning.

4. MAINTENANCE UNIT

The maintenance unit is attached beside the ground floor facilities of the personnel department. It is in the form of an attached bungalow with a separate decked roof. It shares the same court with the junior staff cafeteria and the Security department. This unit houses the following offices for; Technical officer, Senior electrical Engineer, Mechanical Engineer, Chief Engineer etc. It has a single loaded corridor office planning and utilizes the common court for maintenance works.

5. WELFARE BLOCKS

The facilities in the welfare block includes; the senior and junior staff cafeteria, clinic etc. all located at different areas.

- **Cafeteria/Restaurant**

The senior staff restaurant is in the form of a caravan located behind the administrative and sales department. It contains a kitchen, store, dinning and a bar.

The junior staff restaurant is located behind the personnel department, and beside the raw material warehouse. It has a larger kitchen and store, changing room, dinning etc. The roofing is made of corrugated aluninium sheets.

- **Clinic**

The following functions are contained in this unit; industrial medical consultant, Reception (card room and booking), storage space for drugs and general goods and lavatories. This unit is at the same building with the wood finish plant and cash and carry.

6. WAREHOUSE

The giant warehouse for raw materials is located beside the junior staff restaurant and behind the production hall. It has a service access from the service entrance to the factory. This unit, from where raw materials are transferred into the production hall, is joined to it with a high level canopy.

Additionally, the finished goods warehouse is at the same line and after the sales department. It is contained in the same block with the wood finish plant, clinic and cash and carry sections. The products in this warehouse are usually transferred to the cash and carry department for sales and the other products are dispatched to different depot after manufacture.

Finish Product Store

7. PRODUCTION HALLS

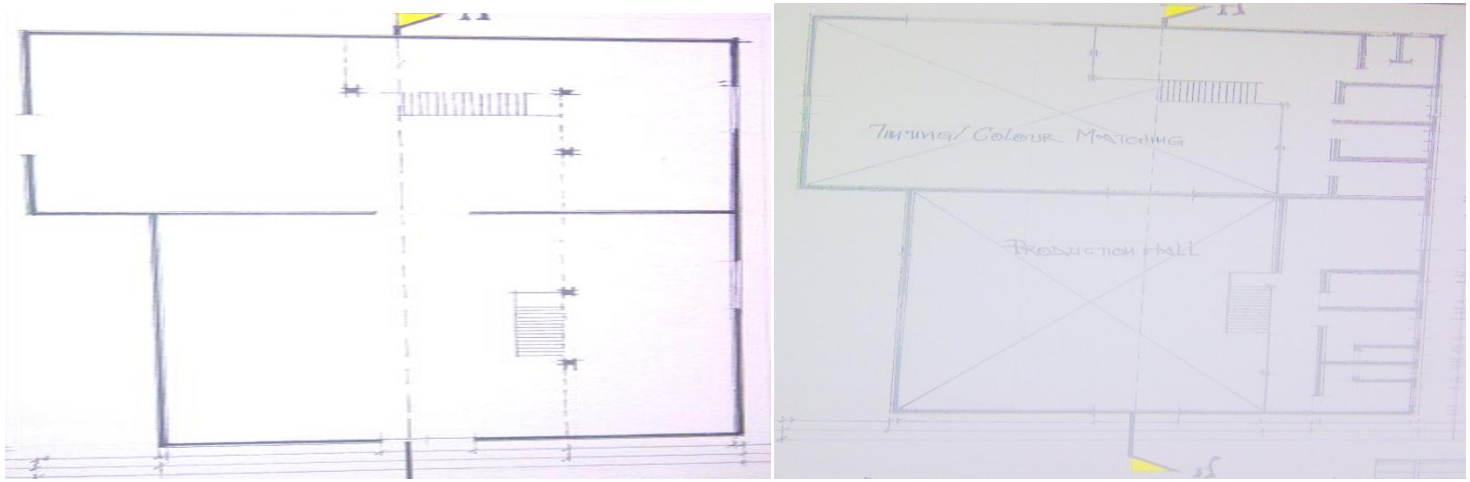
The first production hall is located beside the personnel department, and attached at this end is the high voltage generator which serves the factory.

It contains the following section: Ball mill section, weighing section, Bead mill section and cow mill section. At the mezzanine level are office space for; Production Manager, Production General Office, Production Officer and a quality control laboratory.

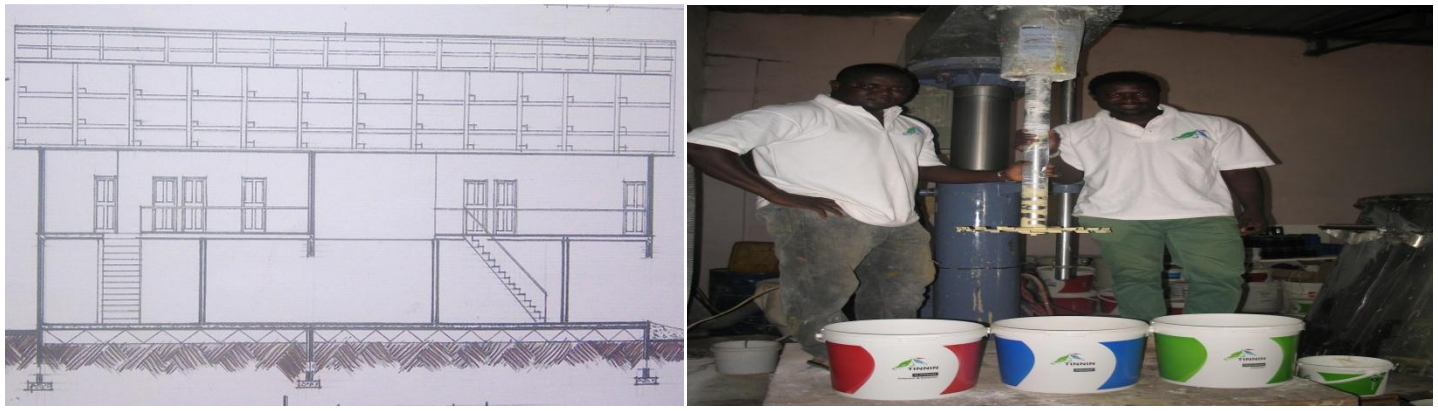
This production hall is directly linked with the next production space called the Tinting or colour matching section. Here, necessary colours are added to liquid paint based on the recommended quality and standard. In this hall there is a mezzanine floor where the mixing tanks are installed and from where the paint is transferred to the canning machine for the final stage of paint manufacture. After canning the products, they are transferred to the finished good warehouse or dispatched immediately.

The next production hall is the emulsion paint where emulsion paints are manufactured. Similarly, the machines are installed at the mezzanine floor with various sections necessary for such production. The products are later transferred to the finished goods warehouse.

The last production hall similar to the emulsion plant is the wood finish paint. Here, international paint nigerwood is produced, canned and carried into the warehouse.



Floor Plan of Production hall



Section of the production hall

Production hall

8. CASH AND CARRY DEPARTMENT

This department is carved out from the finished product warehouse. It faces the R-side view of the sales department and it deals with the direct sales of paint products, at small quantities customers.

9. RESEARCH UNIT

These include the training centre, the development laboratory and library. The laboratory occupies the ground floor of the personnel department and it houses the following office for; Chief Chemist and Senior Laboratory Technician and two adequate furnished laboratory spaces. This section usually describes the quality and type of raw materials to be purchased.

The training centre has the following facilities; staff induction room, offices for training supervisors, training Manager, General office and a library. It is located at the space between the sales department and the first production hall.

10. SECURITY DEPARTMENT

This is located at the main entrance to the factory. It monitors and moderates the movement of visitors, and it houses a reception/waiting space for visitors, Security office, offices for security officers, and security attendant.

A. FACTORY PROCESS

The factory process comes in the following phases;

- Dispersion stage (Ball mill section)
- Weighing section.

- Mixing and Tinting (Bead mill section)
- Sieving (cowls mill section).

3.1.4 PRODUCTION PROCESS

Raw materials are brought into the production hall from the warehouse and later charged into a high speed (high quality) dispersion machine – Ball mill. This machine reduces the raw materials into smaller, fine aggregates and they are weighed and their qualities determined before they are moved into the third stage. This stage entails the mixing and addition of some additives. When the raw materials are mixed and thinned at the bead mill machine until a reasonable level is achieved, the quality control laboratory tests the quality, viscousity, mix and fineness of the present paint paste. When the quality and the physical properties of the paint are confirmed, it is transferred to the cowls mill machine. Obviously, the machine sieves out the unused agglomerates and pure paint paste is transferred to the tinting section for colour matching.

The tinting section takes care of the various final colours of the paint products. However, at the Tinting machine, the quality control laboratory checks and tests the various colours that is to be applied. After this, the paint is charged into the canning machines where they are canned in gallons and transferred into the final storage area for packaging, dispatching and sales.

3.1.5 PLANT AND MACHINERY

The plant and machinery for processing, mixing, blending and production of paint include; Ball mill machine, weighing machine, Bead mill machine, cowls mill machine, tinting machine/tanks, canning machine.

3.1.6 LIGHTING

Natural lighting is admitted into the production halls and warehouse through roof lighting and high level glazing. In the offices adequate daylight is encouraged by the use and installation of wide range of Louvre windows.

3.1.7 SERVICES

Sufficient water from the Municipal water supply can be provided and stored at the overhead tank for use in the factory.

Electricity supply is from the Power Holding Company supplemented with a high voltage supply from the factory generator.

3.1.8 MATERIALS OF CONSTRUCTION

- **Walls**: Sandcrete bocks are utilized at the offices, restaurants (Jnr), Maintenance block, Security department etc. and Aluminium Cladding materials on sandcrete blocks at the warehouses, production halls etc.
- **Roofing:** Aluminium roofing sheet over simple wooden and steel roofing structures.

- **Floors:** Reinforced concrete mezzanine and upper floors and reinforced concretes ground floor for production spaces and normal mass concrete ground floor and reinforced concrete upper floors for Administrative, Sales, Personnel and Maintenance Units.

LANDSCAPE

The entire factory is fairly landscaped due to over utilization of the available space and little set-back from the main road. However, almost all external spaces are paved except the parking and entrance areas which are finished with chipping.

External layout of the factory

APPRAISAL/ASSESSMENT

The factory is planned on a separate building planning layout and based on some considerations. The assessments are as follows:

- The factory has a standard scope with the following components: administration, production, warehousing, welfare, and research, etc.
- The separate buildings help in isolating the noisy zones from the quiet zones, but the functional relationship of these various units is weak. However, the relationship between the production areas is direct and efficient.
- There is no defined, strong, covered connection between the various separate blocks.
- The overall planning of the layout has no expansion possibility due to over utilization of the spaces and poor external planning of the different blocks.
- Due to the incorporation of double loaded corridor in office planning, there is poor cross ventilation, however, this is supplemented with adequate artificial ventilation system (air condition). But, adequate natural ventilation is obtained in personnel department and other units with single loaded corridor.
- Lighting in both the production areas and offices is relatively adequate. In the production areas, it is admitted through roof lighting and high level glazing. But in the mezzanine floors maximum artificial lighting is utilized.
- There is a good control of noise and vibration generated in the production hall.
- The production line of the factory is good in terms of the in-flow and out-flows of raw materials and finished products respectively.

3.2 CASE-STUDY II: MASTER-PIECE CHEMICAL COMPANY LIMITED, OJI RIVER.

3.2.1 BACKGROUND INFORMATIONS/LOCATION

The factory is located at Mile 2 Oji-River, off the old road from Enugu to Awka. The actual place is the masterpiece village, after the police college.

3.2.2 PRODUCTS

Master-piece Company with full production capacity of 7500 gallons per week manufactures the following products;

- Decorative paints (Galaxy paints)
- Allied paint products (glue)

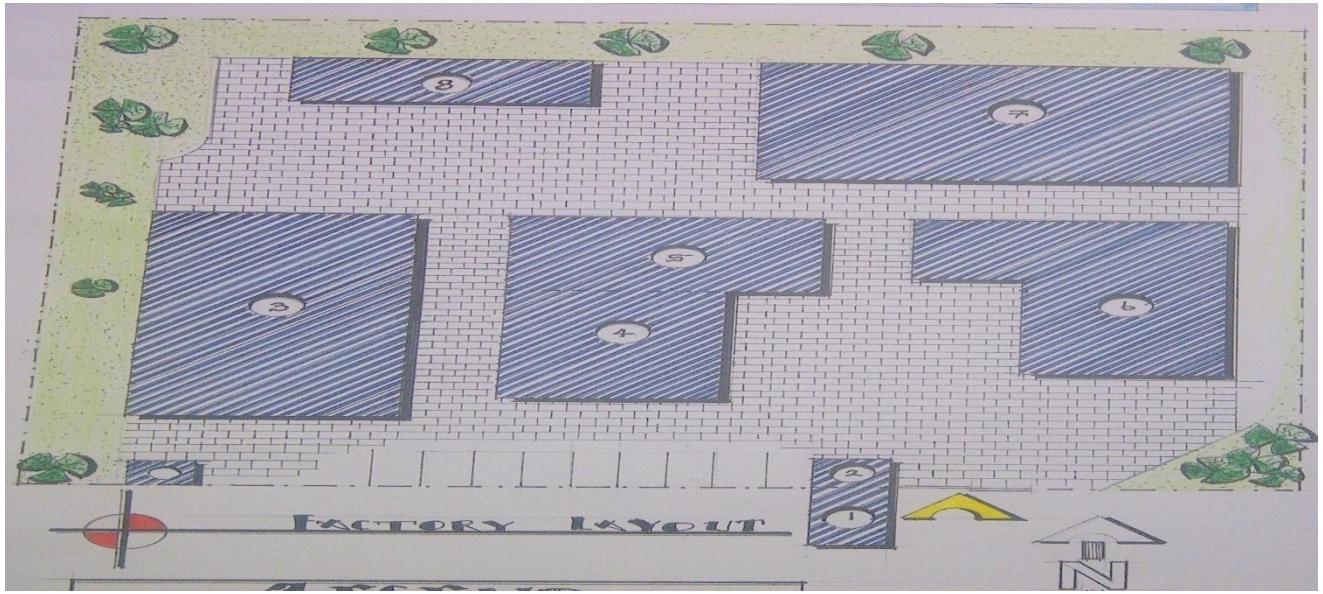
3.2.3 THE FACTORY LAYOUT

The factory layout consists of the following;

- Offices (administrative Units)
- Welfare (Canteen, Clinic)

- Showroom
- Raw Materials and finished good storage Unites
- Production Hall
- Security House.

N.B. all these are contained in separate buildings.



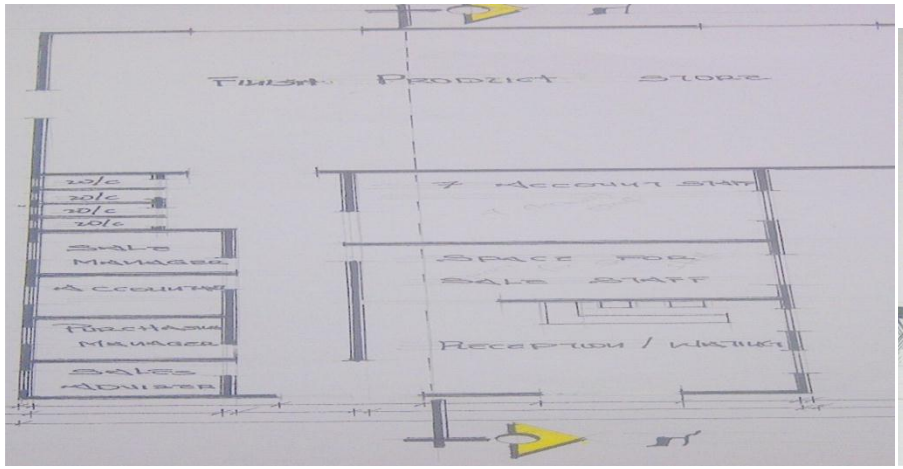
The factory layout

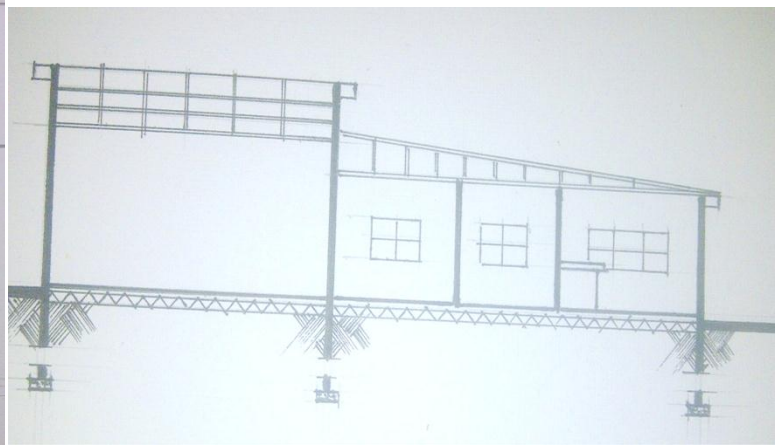
1. OFFICES

This block is easily seen while approaching form the main gate. It contains offices for; Board of directors (Chairman/Managing Director), Assistant to General Manager and office spaces for Accounts department, Marketing and Commercial departments, Store, Transport division etc.

2. SHOWROOM

This is at the opposite side of the office units and could be easily seen while approaching from the main gate. In this space, the products are exhibited are displayed and even sold to interested visitors.





Showroom and Finish Product Store Section H-H

3. WELFARE

The staff welfare comprises of the staff canteen and medicare.

- Canteen: this is at the rear of the factory buildings, nearer to the Giant warehouse and the production hall. It shares the same open court with these units.
- Medicare: this is off the factory premises, outside and close to the security house. The factory hospital delivers the required drugs to this unit for onward utilization by workers.

4. WAREHOUSE

There are different types of storage spaces, the general storage area, the finished goods storage area, the raw material storage area and the giant warehouse.

The general storage area is located at the same building with the showroom, divided by a partition wall. It is used for the storage of stationaries, or general goods. The raw material storage area is beside the showroom and it has its delivery yard at the entrance to the factory (the open court). This court is common to the offices and the showroom.

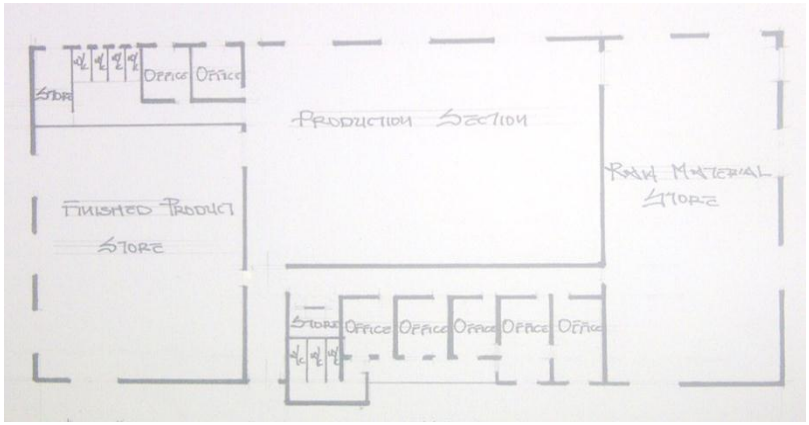
The giant warehouse for the storage of finished products, maintenance equipment and repair of vehicles, is located at the rear and close to the staff canteen.

As previously mentioned, it shares a common open court with the production hall and staff canteen, and this usually serves as the service yard.

Finish Product Store

5. PRODUCTION HALL

This is where the production process takes place and it is located behind the general storage and showroom and has an open court as mentioned above.



Production Section

Production hall

6. SECURITY HOUSE

This is at the main entrance gate to the factory and has an area for 3 security men and a waiting space.

3.2.4 FACTORY PROCESS

This include: Weighing

Mixing

Sieving

Packaging/Canning.

3.2.5 PRODUCTION PROCESS

From the storage area, raw materials are weighed and transferred to the mixing machine in the production hall. Different raw materials are thoroughly mixed to a reasonable level and quality. The physical properties are usually tested and controlled during this stage.

The paint paste eventually goes to the sieving machine from where they are charged into the storage tank for the final stage of the manufacturing process – Canning. The finished products are packaged, stored and dispatched to various depots

3.2.6 RAW MATERIALS

The basic raw materials are:

- High grade pigment
- Solvents and vehicles
- Water
- Synthetic resins.

3.2.7 PLANT AND MACHINERY

- Weighing machine
- Medium size mixing machine
- Mixing and storage tanks
- Canning Machine.

3.2.8 LIGHTING

The introduction of daylighting into the production hall, storage spaces, giant warehouse, etc. is through high level (600mm) window opening, vertically protected with metal rods. However, the interiors of the above spaces are daily lit, due to the amount of light admitted and the lack of rooflighting.

Natural lighting is introduced into the office and staff welfare blocks through a wide Louvre window opening.

SERVICES

Obviously, the supply of electricity is not a problem due to the location of the Oji River Power generating station close to the factory village. Water supply comes from the water Board, while as River water supply comes from Dodo River and Oji River.

MATERIALS OF CONSTRUCTION

FLOORS: Reinforced mass concrete floor with reinforced strip foundation at production areas and normal mass concrete floor at other spaces.

WALLS: Sandcrete block walls.

ROOFING: The roofing system is the normal pitch roof with wooden roof structures and zinc roofing sheets.

LANDSCAPE

The entire factory and open courts are still bare without grasses, trees or shrubs. There are no defined walkways, driveways and the parking spaces are not sufficiently landscaped.


External layout of the factory

APPRAISALS/ASSESSMENTS

- The facilities are not adequate for a standard paint factory but, the existing ones are enough for smooth and effective functioning of the factory. However, there is no research unit, standard sales, accounts, administrative or commercial department.
- The adoption of separate building blocks is not well articulated and it is not efficient in terms of the smooth and direct functional relationship between various facilities. However, this concept really separates the noisy zones from the quite or private zones.

- From the concept of separate building, there is a high expansion possibilities. All the facilities can expand as much as necessary. However, this idea was not considered thoroughly during the initial design and layout.
- The separate buildings encouraged adequate cross ventilation except in the administrative offices due to the use of double loaded corridor.
- The lighting of production spaces through high level windows is not sufficient and effective at work places and worktops.
- The entire landscape of the factory needs to be redesign and improved based on the existing facilities.
- The factory does not reflect itself and it does not exhibit a good aesthetic façade.
- The production line of the factory is not direct and it conflicts with other facilities.

3.3 CASE STUDY THREE: HAYMES PAINT FACTORY

3.3.1 LOCATION: BALLARAT, VICTORIA AUSTRAILIA

3.3.2 BRIEF HISTORY

The Haymes Paint complex sited outside Ballarat on an industrial estate was designed in response to the brief of a local private paint production company to provide a socially aware environment that balanced the needs of staff and community groups with normal business aspirations.

The intrinsic nature of paint and its potential to affect environments was a strong element in the shaping of buildings and their surrounding spaces. The expressed structure and planar elements of the buildings celebrate the notion of as a persuasive pscho-responsive medium that embellish elements in a colour field experiences.

Haymes Paint has built an enviable reputation for one thing, a single-minded dedication to quality. A fourth generation family company Haymes now supplies premium quality products around Australia through the paint specialist network.

When David Haymes says “Paint runs in my veins”, he really means it. Haymes Paint, started by his father Henry. It isn’t just a business to David, it’s an obsession.

Haymes Paints is also a signature to the Australian Packaging conevant and understand the fragility of our environment and climate. Therefore, Haymes Paints is working towards a goal of zero waste. Reducing out water usage, energy consumption and emissions are examples of areas Haymes are targeting to improve sustainability and protect our environment for future generation.

3.3.3 PRODUCTS

- **Haymes Interior Expression**

Haymes Interior Expression is quite simply the first interior paint, offering the most advanced way to bring colour and style into life. Using Haymes enables passion to craft the best paint, the interior Expression range brings you discernibly richer, true colours to impress.

- **Haymes Ultra Premium Prepcoats**

Haymes Ultra Premium Preparation coats offers a complete range of primers, sealers and the best possible results. Preparation is vital in achieving the best possible finish which is why Haymes have an extensive range of specialist preparation products to cater for every substrate to ensure the right foundation for every finishing coat.

➢ The Haymes Newlife interior wall finish range offers a premium quality finish that is easy to achieve. Available in a wide variety of finishes suitable for every area of the home the new life wall finish range is an acrylic formulation making it a washable and durable finish. It provides great coverage and is easy to apply.

➢ **Haymes Designer finishes Suede**

It is a rich, ultra premium paint that dries to a soft matt finish, delivering a textured, sophisticated look. This water-based is suitable for use on both exterior and interior surface.

- Easy to apply
- Wash up in water
- Interior and exterior durable.

➢ **Haymes Solashield**

Self-priming with superior UV protection and durability, Haymes solashield is reinforced with a 15 year protection guarantee. It resists cracking, fading and is easy to apply.

➢ **Haymes Ultratrium**

Is the next generation water based enamel ideal for doors, windows and trims. It advanced low odour formulation goes beyond the Green building requirements which mean that now you have a green alternative and can say no to those smelly solvent based enamels.

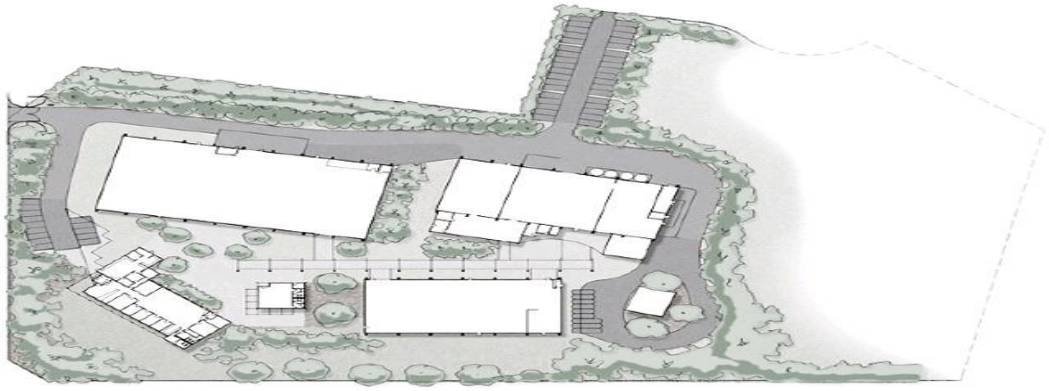
Factory External Layout

Tinting Tank

Production hall

An Internal Layout of one of the Production halls

Internal Layout of other Porduction hall



Entire Factory layout

External Factory Layout

Finish and Package Products

3.3.4 APPRAISALS

- The elevtions of the Administration building is very impressive
- The planning of the site is wonderful according to the information given by the website – it falls in concordance with the nature of the Ballarat Town.

3.4 GENERAL DEDUCTIONS/LESSON FROM CASE STUDY

❖ LOCATION:

All the factories are sited in the industrial district of the town in which they are located.

❖ SITTING FACTORS:

Proximity of supply to raw materials and market transport access, availability of labour and the general topography have all been given attention in all the case studies made.

❖ WATER SOURCES:

Water availability is given some measures of prominence in all the industries visited and should therefore consititute a vital element of any plastic industry. A borehole is a necessity.

❖ PLANNING:

The layout of independent units did not observe the zoning principle as the administration units is almost glued to the factory building. Major prominent areas identified include:

- Administrative block
- Production hall
- Technical area
- Staff welfare.

❖ ORIENTATION:

East-West oriented sites do not have problems with ventilation and cross ventilation for the production is well disposed.

CHAPTER FOUR

SITE ANALYSIS, SUMMARY OF PLANNING & DESIGN CONSIDERATION

LOCATION: SITE ANALYSIS

To a large degree the site has a direct influence on the ultimate efficiency and performance of the plant through the effects of site factors on plant design and construction. Subsequently, the selection of a site is necessary to understand the kind of plant to be built. Therefore, for the paint factory to be efficient there must be considerations towards suitable site selection.

4.1 SITE SELECTION CRITERIA

Industrial location decisions involve the determination of all factors that will afford the establishment, the greatest advantage to be obtained by virtue of location. The determination will be whether the site will be away from congested city areas, away from any industrial slums or whether the site will tend to be in a country area. Subsequently, there will be determination towards the size of the site, immediate community and other general conditions. Perhaps the most important reason for a large site is flexibility for expansion. The design must be such that the plant can be extended on any of its four sides, so that extension is feasible without reshuffling the entire layouts.

Additionally, there is nothing quite conducive to contented working as a pleasant, landscaped, park-like setting. Then there will be other considerations like market, utilities, transport, labour and perhaps publicity value if the site is near a main highway. To a great extent, the site has a direct influence on the ultimate performance of the plant.

4.1.1 GENERAL INDUSTRIAL LOCATION FACTORS

Some of the general determinations of a site's value are:

1. Geographical location
2. Market location
3. Proximity of competitors
4. Relation to suppliers of components, accessories etc.
5. Local climate (prevailing winds, sun heat load, humidity – does the process required dust-free atmosphere? High or low operating temperature.
6. Sources and availability of raw materials -
   (a) Locate plant at raw material source or at market or between them when materials used are without weight loss.
   (b) Locate plant at raw material source when weight losing materials are used.
   (c) Locate plant close to market, when materials are universally available.

(d) Locate plant at the market, when material increases in weight alter operation.

7. Local power and fuel sources.
8. Industrial and fire protection water.
9. Sewage and waste disposal possibilities.
10. Tax rates
11. Labour force and cost of skilled and unskilled labour.
12. Transport facilities.
13. Land contours (existing or easily modified contours may actually simplify solution of traffic, loading dock, multi-level processing problems).
14. Site size, available land and comparative cost.
15. Possible residential facilities for employees.
16. Soil strength
17. Spring or potential flood conditions, and natural disaster.
18. Laws and working condition.

4.2 PROJECT SITE LOCATION

There are about 40 different types of raw materials used in a paint factory, and about 45% of the raw materials are generated locally and the remaining percentage are imported from European countries. In this circumstance, therefore, source of raw material should not be a prime influence on the location.

However, there have been new trend towards the building of modern factory and there have been a rapid decentralization of the industries. Subsequently, a good distribution system has led to a wide dispersion of industries and transportation factors have always determined the location and design of industrial building, and as transportation changes, so do the building and its location.

The dispersal of industry is a central if obvious fact. Though, this has been a stated objective of government, as a safety measure in case of bombing attack. Congestion of industries is both expensive and unpleasant. Considering the various programmes by the Federal and state government on rural industrial development and the social implication of sitting industries in developed towns and the problems of urban congestion, dispersal or deantralization of industries becomes an obvious statement.

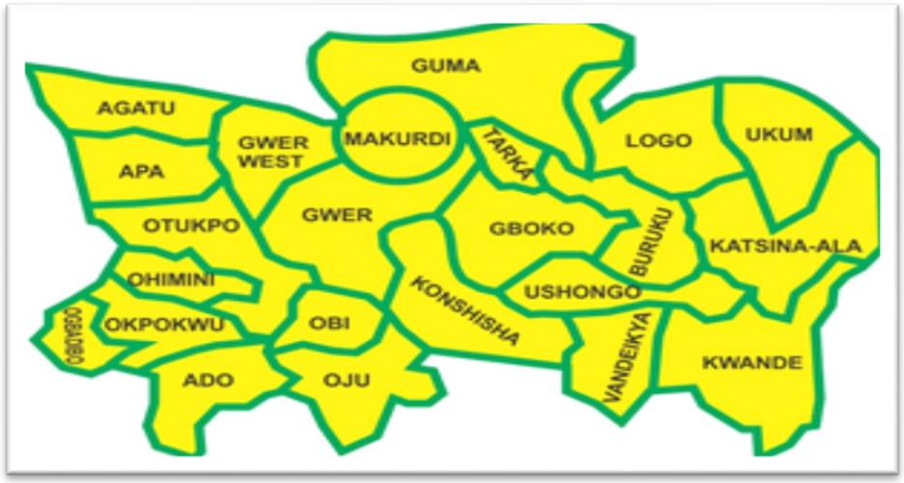
Today, adequate parking spaces for employee and visitor's cars are more important than mass transportation for workers. Additionally, city taxes drive industries outwards, so do labour consideration, land cost etc.

More important than this common inducement is the distribution system. Markets today are not confined to city concentrations; markets are everywhere. As once under-developed areas become increasingly important marker places, industry move out to serve them.

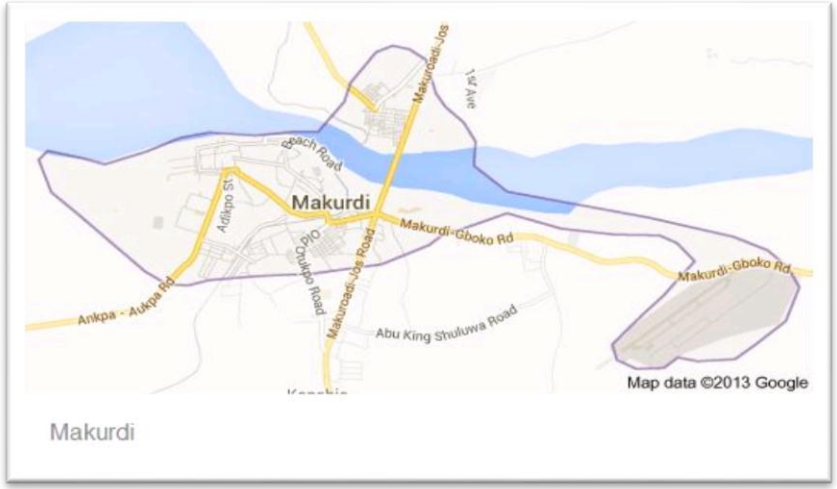
Therefore, from the above analysis, the location of this industry would best be in semi-urban area that will guarantee good roads, good power-supply, ready market, an expanse of land etc. However, the issue of nearness to raw material cannot be overlooked especially the bulky ones like the extender pigments. This pigment consist of about 40% of the entire weight of paint, and such pigments like caoline clay and calcium carbonate can all be gotten from Benue State.

Map of Africa showing Nigeria

Map of Nigeria Showing Benue State



Map of Benue State showing Makurdi



Map of Makurdi Showing the Site

Satellite view of Site Location

Apart from the above factors, Makurdi has good water supply. Fresh water supply comes from the water board, while the river water supply comes from the Benue River located at Makurdi industrial layout (the project site).

The supply of raw materials and the dispatch of finished product to and from the site to other areas should not be a problem by virtue of the site location. The site is located close to Makurdi to Abuja express road (dual carriage way). Hence, there is the existence of good roads for the supply and dispatch of goods.

The market for the proposed factory products shall mainly be Benue State, Enugu State, Anambra State, Nasarawa state and other states of the Federation.

Makurdi is the capital of the State Benue in Nigeria. Makurdi is located on the banks of Benue River, a major tributary of the Niger River. It is also located on the main narrow gauge railway line running north from port Harcourt, although this is not currently working. It is geographically located on latitude 7º 43' 32" N and longitude 8º 33' 51"E

Makurdi is bordered on the North by Guma, on the East by Tarka, on the South by Gwer and on the West by Gwer West Local Government area.

Project Site viewed from Makurdi – Abuja Road

Project Site showing the Electricity supply and Access Road.

Project Site showing Existing Features like the town major Roundabout and Wurukum Market.

CLIMATIC ANALYSIS

Benue State has a tropical subhumid climate, with two distinct seasons, namely a wet season and a dry season. The wet season which at lasts for seven months, starts from April and ends in October. There is, however, usually one or more is heavy outofseason rains in January, February and March from EastWest line squails. It is this early rainstorm that enables farmers to hoe their farms in preparation for the planting season that starts in March. The annual rainfall total ranges from 1,200mm1, 500mm.

Sometimes the location of a place can influence its micro-climate. For instance, if a building is located near a river, hill etc. one of this season can be shortened. Subsequently in Southern Nigeria, the climate fluctuates with the rainy season being shortened and the dry season being stretched.

SOIL AND SOIL EROSION

The soils are mainly oxisols and ultisols (tropical ferruginous) which vary over space with respect to texture, drainage, gravel content, etc. A typical profile is highly weathered with a sandy surface layer overlying a clay mottled subsoil. In the southern part of the state, around Vandeikya, Oju, Obi, Oturkpo, Ogbadibo LGAs, well developed lateritic profiles with pallid zones exist. Deep seated lateritic crusts over extensive areas on the plains.

The agronomic significance of this subsoil crust is that it often produces a perched water table which is an important source of capillary water, which keeps the surface moist long after the end of the rainy season. Entisols and inceptisols also occur associated with young soils on hill slopes and recent alluvium on flood plains.

Sheet erosion is the dominant form of water erosion in the state. Deep gullies occur in Ogbadibo LGA and represent a northern extension of the eastern Nigerian, metasedimentary deepgully system. Other gulled areas in the state include Makurdi North Bank area, TseMker and Gbem in Vandeikya LGA, Gbajimba town, stream bank erosion in Gboko town.

VEGETATION

Benue State lies in the southern Guinea Savannah. Persistent clearance of the vegetation has led to the development of regrowth vegetation at various levels of serai development, but more importantly, parklands with grasses ideal for animal grazing during their early growth. These succulent grasses can be cut with machinery, dried and baled for dry season livestock feeding.

The grasses however grow very tall, coarse and tough on maturity. The scatted tress are mainly those of economic value and include locus bean, shear butter, mango, silk cotton, African iron, Isoberlinia, cashew, oil palm, Daniellia Oliveri, gmelina, et cetera. These trees produce valuable fruits, wood and fibre which can be utilized for small-scale cottage industries.

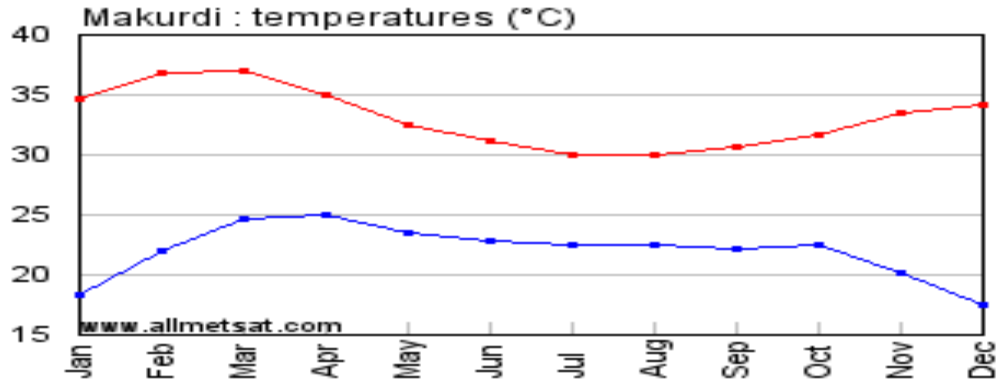
RAINFALL

Rainfall increases Southwards as the coast is approached. The Southern part of the country has double peak rainfall while the Northern part has a single peak.

Extreme Southern rainfall is 249m while that of the North is 50cm. Makurdi record an annual down-pour of (1500 – 2050mm).

TEMPERATURE

Temperature is generally very high during the day, particularly in March and April. Along the river valleys, these high temperatures plus high relative humidity produce inclement/debilitating weather conditions. Makurdi, the state capital, for example, records average maximum and minimum daily temperature of 35A^{o}C and 21A^{o}C in summer and 37A^{o}C and 16A^{o}C in winter, respectively.



Makurdi : Temperature

HUMIDITY

In January the relative humidity is considerably low when the whole country is under the influence of tropical continental air-mass, with the exception of the Southern Coast region. The South records the highest humidity because of the constant wind and evaporations from the swamp. In the middle wet season, the relative humidity is high because of the existence of the warm wet air mass. However, humidity is over 80% in South and a minimum of 60% in North. Makurdi records relative humidity averaging 60% and 85%.

WIND

There are two types of wind to be considered, the tropical continental air mass and the tropical Maritime air mass.

- The tropical continental air mass (harmattan winds) carries little or no moisture with it, therefore it is dry. This is predominantly obtained during the dry season.

- The tropical maritime air mass comes from the South and it carries moisture with it which diminishes from South to North. This wind influences the whole country during the wet season.

SOLAR RADIATION

Just like any other tropical cities, sun movement in Makurdi is from East through South to West. The early Eastern sun rays are gentle in heat intensity but gradually heats up reaching its maximum temperature in the afternoon (when the sun is overhead). The evening sun has a reduction in temperature as the sun goes over to the West. Consequently, the site is exposed to intense solar radiation.

4.3 SITE ANALYSIS

PROJECT SITE

The exact plot of land (190 and 200) is opposite abattoir, and it is alongside the Makurdi to Abuja Road close to the Benue River. It is also close to Wurukum market to ease the marketing of the products. The site is bordered by different plots and access road.

A. TOOGRAPHY

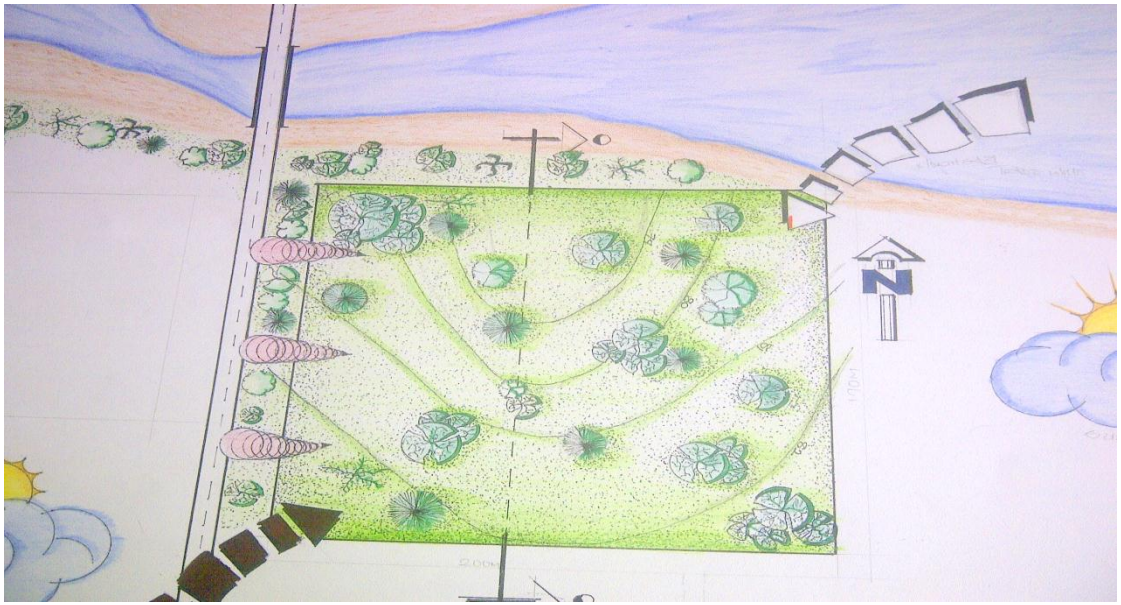
The physical landscape of Nigeria is dominated by four highlands area, one in the North, one in the West and two in the Eastern Borders. Flanking the highlands are eight lowlands which together constitute the twelve relief regions in Nigeria. Based on the above analysis, Makurdi falls into the North Central scarp land, the entire site layout slopes downwards to the existing Benue River.

B. SOIL

Nigeria is classified based on its soil into the following zones:

- Northern zone of Sandy soil
- Interior Zone of Laterite soil
- Southern Belt of forest soil
- Zone of alluvial soil.

The site consists of loam – sandy soil which is fairly compacted.



Site analysis showing: the site sun rise and sun set, the site slope, wind direction, north direction and noise direction.

C. VEGETATION

The site is overgrown by grasses, shrubs, herbs, bamboo, tall trees, etc. However, adequate landscaping will be used to enhance the natural vegetation already existing.

D. DRAINAGE

Because of the nature of slope which runs from the Southern to northern part of the site, drainage system will be introduced to restrict and direct the flow of water away from the proposed buildings on the site in general. The slope will also aid in natural drainage.

E. TRAFFIC

This will be considered based on the transportation network of the site. The site is so located that there will be less or no transportation problem. Since it is alongside the Makurdi – Abuja road therefore, this will be a major traffic route. The service rout will be through the road from the site to the Commercial area of Makurdi

F. EXISTING INFRASTRUCTURES

Various parts of Makurdi are linked up by a network of partially untarred road. And the site is also close to the commercial area which will attract people (tourist) from different parts of the country making them aware of the factory and its products. As mentioned before, pipe borne water, electricity supply etc. is steadily available and the town enjoys good post and telecommunication facilities.

G. SERVICES

The site is serviced by municipal water and Electricity lines. The town has a regional electrification services direct from the National grid. The Municipal Water Supply can be supplemented by the supply from the Benue River.

H. POLLUTION

The presence of this factory will provide hazard air pollution to the surrounding environment. Additionally, there is expected pollution from exhaust gases, dust and noise from the traffic.

I. ORIENTATION

The following factors will influence the located of the paint factory:

- **Ventilation**

For adequate ventilation, the building will be oriented based on the prevailing wind direction. However, care must be taken in the ventilation of the various components of the building.

- **Solar Radiation**

The amount of solar radiation has to be reduced but the accepted level of daylighting has to be reduced. A compromise has to be reached in such a way that fenestrations should be located so that they will receive diffuse lighting. This will definitely reduce the chances of glare and intense solar heat.

- **Daylighting**

For adequate daylighting, the various components of the entire system should be oriented to admit the sufficient daylighting needed for various internal spaces, viz, Production stall, offices, restaurant, display admit etc.

- **Access**

The access to the building will also influence the orientation. The other factors include existing infrastructures, slope etc.

J. LANDSCAPE

There will be sufficient landscaping to control the environmental pollution, increases human comfort, enhance the external facilities and increase the entire aesthetics of the whole complex. This will actually help in effective functioning of the paint factory when one considers the location of car park, access routes, pedestrian walkways etc. and the building.

K. VIEW

View from the major Makurdi – Abuja road could provide a sense of belonging to the industrial community because their industrial operations and products could be observed.

L. ZONING

The various functions of the building will be zoned according to the amount of noise generated and the level of privacy. This should be based on:

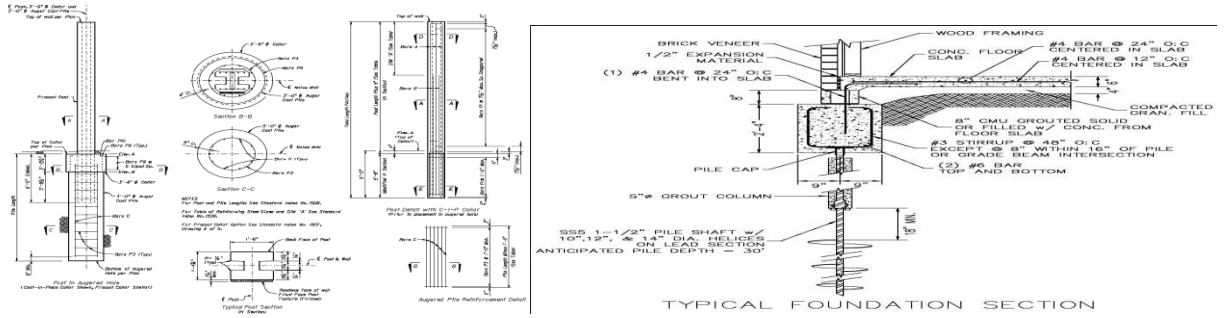
- Noisy zones: These include the car park, relaxation areas, Production Hall, Warehouse, Maintenance unit.
- Semi-noisy zones: These include lobbies, restaurant, induction room, medical units etc.
- Quiet zones: These include the display units, offices, library etc.
- Public zones: Display units, entrance hall, library (semi – public).
- Restricted zones: These include the production hall, warehouse, laboratory etc. accessible to only workers.

4.4 DESIGN CONSIDERATIONS

MATERIALS AND CONSTRUCTION

A. FOUNDATION

The recommended type of foundation for the Paint Factory is pile foundation, and it is based on ground water content of the soil. The depth of the pile foundation will vary depending on the function under consideration.



Recommended Foundation

B. FLOORS

1. **Ground floors:** for all types of ground floors supporting heavy machine, there will be the need for:

- Adequate strength to support the machines and equipment.

- Adequate resistant to shock, abrasion, vibration and heat conduction.
- An easily moved and replaced large floor section.
- A surface that does not suffer from temperature and humidity changes or sudden contact with oil, acids and other solvents.
- A noiseless, sound absorbing, non-slippery surface under any condition.
- A surface where machine and equipment can easily be fastened.

From the above analysis, reinforced concrete is recommended. For other ground floors like: administrative areas, welfare unit, ceramic floor tiles are recommended.

2. **Upper Floor:** The upper floor of some areas and the mezzanine floors of the production units are to be constructed with reinforced concrete. For spaces with exceptional span, special floor construction like waffle grid could be used as an alternative

C. WALLS AND COLUMNS

The structural systems applied to the construction of factory are:

I. Load bearing wall system; in this system adequate natural ventilation, lighting and views are sacrifice because of the existence of small openings on heavy and costly load bearing walls.

II. Frame construction system; in this system effective and maneuverable wall surface is achieved with sufficient ventilation and lighting due to wide fenestrations. This system also suffers from a high noise and heat penetration.

From the above analysis, the frame construction system will be adopted for the factory with the incorporation of plastic panels on this block walls with an insulation gap between them. The block wall prevents fire noise penetration while the panels prevent heat penetration and the insulation gap traps air and prevents the ease of heat absorption (solar radiation) and noise.

D. ROOFS AND CEILINGS

Roofs due to their large surface are the chief sources of heat inside the building from the sun through convention and radiation. Roofs should exclude unfavourable weather, have adequate height and allow sufficient daylight without glare or shadow.

Therefore, heat-reflective aluminium sheets material with adequate insulation will be adopted. Besides, the ceiling will have a good reflective property.

Some of the considerations on the types of roof structure are the ceiling height and usefulness of overhead. For example, in the production hall, warehouses etc. there will be considerations of materials handling machine, machine height stacking system, overhead service etc.

The following ceiling heights are recommended:

Administration block	- 3m
Entrance Hall	- 4m
Conference Hall	- 4m
Board room	- 4m
Staff induction room	- 4m
Staff cafeteria	- 4m
Laboratory and Library	- 3m

For the production section the following standards are adopted where necessary.

	Types of Production	Without Overhead	With Overhead
1	Small product assembly on benches, offices	3 - 5m	3.5 - 6m
2	Large product assembly on floor or floor fixtures.	Maximum height of product + 75%	Maximum height of product + 125%
3	Small product forming	Height of machine + 100%	Height of machine + 125%
4	Large product forming	Height of machine + 125%	Height of machine + 150%

For these spaces, roof light, head expellers, overhead lighting and services will be adopted.

E. DOORS AND WINDOW

Doors: for safety against fire and burglary, folding doors and recommended for the following spaces; Production Hall, warehouses, Maintenance Units, Storage etc.

For Entrance Hall, Restaurant, Induction room, Conference Hall, Boardroom, Library etc. revolving doors with heat reflective glazing are recommended. Fire escape doors will also be located at different areas.

Windows: All windows will be made of metal frame and louvre with heat absorptive glazing, free from heat, fire, noise, dust etc, effects. Windows in the production Hall and warehouse can be double glazed.

FIRE AND NOISE CONTROLS

A. FIRE CONTROL

Fire is a chemical reaction which occurs when the chemical structure of a fuel is broken by heat energy. This reaction usually occurs in the presence of oxygen with the release of heat and light. Fire control is an effective measure towards industrial safety because most of the materials found in an industrial environment are always disposed towards fire hazards. Therefore, this should be considered in the design of this paint factory.

Fire control involves the following safety measures:

- Prevention of fire by eliminating oxygen or isolating fuel from the source of heat.
- Extinguishing fire by reduction or removal of the heat by cooling below the ignition temperature, removal of fuel or by the use of dry chemical extinguishers, removal of oxygen by smothering with carbon dioxide (CO_2) and a combination of more than one method.

Therefore, for fire control in the entire system, the following devices will be used:

1. The active and passive measures include the use of fire fighting equipment, fire alarm, automatic sprinkler, water tanks etc. use of hood and stair venting to remove heat and smoke and installation of smoke and heat detectors.
2. Choice and treatment of building materials; use of enough concrete cover on reinforced concrete structures, use of plastic panels of lower class flame spread, use of adequate timber dimensions, use of flame-retardant surface coating, insulatory steel and aluminium materials, etc.
3. General Design Measures

Provision of an alternative means of escape in various components of the factory, use of fire-resisting construction in staircases, self closing doors, etc; provision of access route for firefighting department, prevention of air cavities between walls and combustible linings.

NOISE CONTROL

Control of noise pollution will be based on two sources; from outside and inside the factory. However, the following devices will be used.

- Use of landscape features to shield noise pollution from traffic and other external sources.
- Use of acoustic panels to prevent noise from production areas and warehouse.
- Use of discontinues floor units to prevent noise or vibration transmission from one floor to the other.
- Use of resilient materials as machine pads to absorb vibrations.
- Avoid transmission of vibration from floors to walls by separating both units.
- Isolate noise sources; group noisy equipment in one compartment.

ENVIRONMENTAL/CLIMATIC CONTROL

Climatic control is an important element of factory design. It influences the disposition of buildings, process layout, orientation of building, the selection of materials and the detailing of building elements. The means of control of climatic factors analyzed as follow.

RAINFALL

- Use of water resistant materials for construction and surface finishing.

- Effective water drainage by sloping roofs and floors, drains, roof gutters etc.
- External ground covers and landscaping to prevent water erosion.
- Overhanging caves and other means of countering the effects of wind drives rain.

TEMPERATURE

- Use of heat insulating material and devices.
- External ground covers and landscaping to absorb heat from the sun.
- Use of heat absorbent and heat reflective glazing.
- Adequate cross ventilation through efficient design.
- Use of building materials and structures that will tolerate large temperature variations.

SOLAR RADIATION

- Use of vegetation and landscaping to prevent glare and intensive sun rays.
- Use of sun shading devices to cut off sun rays like; deep overhangs, sun breaking horizontal and vertical fins.
- Efficient orientation of building to achieve good sun incident angle (diffuse lighting).

WINDS

- Use of good materials, construction and building structures that can withstand excessive wind effects.
- Good orientation of building relative to wind direction will ensure good ventilation and prevent wind draught.

HUMIDITY

- Utilize good ventilation for effective air changes which will reduce the level of internal humidity.
- Use of moisture-resistant building materials on walls and floors.
- Use of mechanical and chemical dehumifiers and air expellers in warehouses and production hall.

ENVIRONMENTAL CONTROL

The following solutions to different environmental problems are to be adopted; viz:

VENTILATION:

In a warm humid climate like that of Makurdi, irrespective of the quantity of fresh air required, in busy manufacturing areas, it is always essential to ensure adequate but not excessive air movement in working zones. This prevent stagnation and avoid a built up of odour or contamination. This air movement does not depend on volume of air in rooms but on the volume of air handled, the velocity and

temperature at which it is introduced and the characteristics and location of air supply ventilators, lourvres or other means of cooling the working zones.

To provide pleasant comfort condition in the entire system, natural air movement will be induced by the use of the following:

- **STACK EFFECT**

This can be achieved by the installation of heat expellers, use of roof vents or adjustable roof lights, etc. that will enhance the flow of air current. In other words, warm air generated by machines and workers is made to rise up and escape through the roof openings while cool air from outside replaces its position.

- **PRESSURE DIFFERENCES**

This could be possible by placing air outlet directly opposite air inlet as much as possible to provide cross ventilation which aids rapid air changes without any change of direction which reduces wind speed in its journey from the pressure to the suction area.

- Use of adjustable windows example louvres, landscaping, courtyard, use of single loaded corridors, use of mechanical ventilation.

TOPOGRAPHY

- Use of land covers and landscaping to check erosion.
- Use of ramps and steps to provide access from one level to another.
- Use of embankments, retaining walls to exploit height differences.

VEGETATION

- Utilize good natural vegetation to provide effective surface cover and landscape against and radiation, wind, noise pollution etc.

ORIENTATION

This involves the placement of building on site to satisfy the demand for adequate ventilation, view, reduction in amount of solar radiation, etc. In other words, this is influenced by wind, and sun directions.

However, the best orientation based on sun path, is East-West, facing this direction. Similarly, the best orientation based on wind direction is SE-NW, with the longer side of the building facing the direction. Based on the above, the best orientation is a compromise between the two and in satisfaction of visual requirement on site.

LIGHTING

The provision of lighting to work places is a valuable contribution to people's working condition. The quality and quantity of light affects people's productivity, accuracy and psychological attitude towards the work.

The basic aim of lighting is to achieve a specific high standard of visual efficiency for a task, which requires a systematic approach to the working environment. Interior lighting in this factory must fulfill two functions:

- Illuminating the interior and its contents.
- Illuminating the manufacturing processes to an extent that allows visual efficiency.

Natural and artificial lighting are the means of achieving good lighting and they have significantly different characteristics and their effects must be considered.

NATURAL LIGHTING: This can be achieved by using the following:

- Fenestration – use of window, doors glazing and void.
- Roof lighting – for this to be adequate they must be large enough to give the required daylight factor and spaced to provide an even spread of light over the work place. They should also control disability glare and make provisions for maintenance.

ARTIFICIAL LIGHTING: The availability of daylight is such that the majority of building cannot be adequately lit by daylight alone through normal working hours and mostly during the night. This is, however, supplemented with artificial light.

Different types of lamps are good solutions to the problem but, fluorescent lamps are suitable and cheap solution for the majority of all. The following table gives the types of lamps to be installed in some stated sections.

COLOURING

Use of complementary harmonious colours has an effect on performance, efficiency and productivity. It also promotes safety by identifying dangerous areas and escape routes. Coloured lighting can also be used to emphasis working and circulation zones and for identifying services and machinery.

The basic functions of colour are to aid vision, psychological effects, aesthetic effects, and to develop a pleasant and orderly appearance. The proposals for colour application are as follows:

(a) Brightness contrasts shall be greater within the confines of the work in hand.

(b) Brightness contrast shall be less between work in hand and its background.

(c) That is contrast farther away shall be permitted to interfere with the first two relationship mother words, effective illumination upon the object in work is required, slightly less upon the background against which the object is seen, and successive small contrast against the floor, walls or other surfaces within view.

FLOORS: This should be light in colour in order to minimize brightness contrast. The specification of lighter colours is based on the fact that less light falls open the floor than upon the machine. The colour of the floor will approach neutral as a concession to maintenance and as a common denominator between other coloours.

WALLS: Slight brightness contrast is required between the walls, the machine and their colour value depends on their distance, height, orientation and illumination. Upper part of walls shall be in white and lower parts in colours that will achieve the above effect.

CEILINGS: These should be handled with care because they are situated above the horizontal field of vision and usually reflects all possible light from sky or interior sources. In most cases they should be white and maintained by repainting at reasonable intervals.

MACHINES:

I.	Mechanical Equipment	-	Neutral
II.	Maintenance Equipment	-	Yellow
III.	First aid Equipment	-	Green Cross on white background

OFFICES: White ceilings, walls with colours of not less than 50% reflectance and provision of architectural light sources above and left of the officers left shoulder.

ENTRANCE LOBBBY: This space where public is admitted should obviously exemplify in colour, the quality, function, character, etc. of the paint factory it represents.

Here, different kind of painting can be used to exhibit the products, create free expansion, imagination, drama and fancy. Fortunately, the necessity of observing rules for good seeing is not present, since people spend on a few moments here.

Therefore, the visitor's first impression is important and then lobby should be designed with features that will influence him favourably towards the factory. Painting in colour will be an integral part of the attack upon his emotions.

The following colours are recommended:

- BLUE: This is definitely calming, welcoming and cool colour.
- YELLOW (LIGHT): Brings good cheer.
- RED: Excites to courageous endeavour and feels warm.
- ORANGE: Powerful stimulant of all.

CAFETARIA/RESTAURANT

This space requires, peach, yellow or light soft green on its walls, white tinted with the wall colour on its ceiling, and a deep value of the same in the floor covering.

Finally, as the visitor progresses from entrance lobby through offices to the last machine in the production line, he should encounter a coordinated series of colour impressions calculated to create comfortable seeing, good cheer, integrity and aesthetic pleasure.

ROAD AND PATHS

- The existing roads in the industrial layout close to the proposed site will be used for the service, staff and visitors routs.
- Landscaped foot paths will be used for the pedestrian walkway.
- Additionally, covered walkways will be used where necessary.
- Provision will be made for disabled circulation, if necessary, with the use of ramps etc.

4.5 SPACE REQUIREMENT

INTRODUCTION

The general design consideration will involve the analysis of the different components or spaces that make up the factory. These considerations will be based on the following design data:

Major design date:

(1) Administration:

- Reception, offices, board room, factory supervision etc.

(2) Manufacturing:

- Manufacturing process (dispersion stage, quality control stage (mixing, thinning and adjustment, scaling up/sieving stage, packaging and shipping etc.

- Warehousing (delivery and dispatching, storing – raw materials, products, stationary etc.)

- Engineering installation (external and internal).

- Services
- Maintenance (repairs and maintenance of machinery; vehicles etc.)

(3) Staff welfare:

- Catering facilities
- Medical facilities
- Changing facilities

(4) Research and training facilities

(Experiments, staff induction and improvement).

Other design data:

(1) Pedestrian traffic flow

(2) Vehicular movement and parking

(3) Gate house and security.

VEHICLE AND PEDESTRIAN TRAFFIC FLOW

The vehicular and pedestrian traffic flow would be directed through;

(a) Public entry gate:

The public entrance gate will take pedestrian, visitors and employee cars, only etc.

(b) Service entry gate:

This would be used by factory delivery and dispatching vehicles and at times for factory workers on foot etc.

PARKING SPACES (VEHICULAR PARKING)

There would be parking spaces for visitors and staff cars, trucks, tippers, forked vehicles, vans etc.

- Parking spaces for visitors and staff cars will be provided together and nearer to Security Department for supervision.
- For the above parking spaces, open air system is recommended.
- Enclosed parking spaces shall be provided for factory owned and operated vehicles.

ADMINISTRATION

The administration block will be an outstanding component of the factory. It will house the main entrance (reception), offices, conference and board room etc. The administration will be oriented to enhance good natural day light and ventilation. For adequate ventilation in the tropics, double loaded corridor in office building is not ideal and the single loaded corridor is unnecessarily expensive but, it enhance ventilation and provides deep office rooms.

Location of Administration block:

- It will be located away from the noisy zones, example, warehouse and production hall.
- It will be located in good relation with the welfare block and parking spaces for visitors and employee.
- It will also be located in good relation with the entrance gate so that there will be easy access for pedestrian.

A. Entrance Hall

The entrance hall to the complex will have the following functions and features;

- It will be prominent.
- Will face the major approach to the complex

- It will have efficient enquiry space with telephones, mail boxes etc.
- The entrance hall will be a major access for visitors and employee; it should contain notice boards, display material, waiting area etc.

B. Offices

The administrative offices will be planned on different floors based on:

(a) Offices dealing with direct factory plant matters.

(b) Those that do not deal with direct factory matters.

(c) Those that deal directly with the manufacturing section.

For category 'C', the offices will be provided on the production hall, either screened off with glazed partition or located on mezzanine floor.

The offices for category 'A and B' are grouped based on the following classification:

1. Offices for general management
2. Offices for accounts section
3. Offices for sales department
4. Offices for public and personnel department

WELFARE UNITS

The welfare block will comprise of many facilities which include; 6-bed clinic, cafeteria for employees, welfare offices, locker rooms, laundry, rest rooms, etc.

- ✓ **Staff Cafeteria:**

There will be 2-types of staff cafeteria; one will be for junior workers and the other for senior executive officers. The cafeterias will be within reach of the other sections of the factory and it will be linked directly with the rest-rooms, kitchen, medical unit and other welfare facilities. However, the environmental condition of these facilities will be totally different from that of the entire complex and they will be provided with relaxation areas with a good view of the natural surroundings.

- ✓ **Medical facilities:**

There will be provision for a 6-bed medical unit, physician and nurse offices, a general treatment and dispensary space etc. These facilities will have a complex and there will be an ambulance waiting space for emergency cases.

- ✓ **Lavatories:**

This facility will be located at each sections of the whole complex as much as required, to reduce congestion and loss of man-hour. Provision will be made for easy servicing and maintenance of these facilities.

- ✓ **Changing rooms:**

This facility which usually comprise of lockers, changing accommodation and lavatories are provided especially at the production section and the kitchen. The number of facilities that is lavatories, lockers etc. will depend on the number of staff in each area. Protective clothing will also be provided for use by production and kitchen workers, therefore these facilities will be linked directly with the laundry area.

- ✓ **Kitchen:**

This facility is placed near to staff cafeteria. There should be provisions for preparation space, storage spaces, cooking area and loading bays (close to storage space).

PRODUCTION SPACE

MANUFACTURING PROCESSES:

These are carried out in the production hall, which is the central part of the factory. Other activities revolve round the various production halls; which produce; gloss and emulsion paints, industrial maintenance paints and wood finish paints.

These processes comprise the productive lines, the dispersion machines, sieving machine, canning machines etc. all in direct relationship with each other.

1. **Plant buildings**

There are two different types of plant buildings which include:

- Special building type
- Multipurpose building type.

- Special building type:

This category of plant building is usually expensive and less negotiable. It usually goes out of function as soon as the facilities, products and machine grow or change with new conditions. Hence, this type of building is not usually ideal.

- Multipurpose building type:

This type usually fits into the production system of several products because of its high adaptability and resale potentials. This building type is usually chosen based on; the initial cost of project, frequency of change in production and production process, material and machinery and ease of getting the layout into use. Therefore, this type is usually ideal for most industrial buildings.

2. Single and multi-storey Plant Buildings

Single storey plant building is ideal when production is large and heavy

- Weight of machinery causes heavy floor loads.
- Large, unobstructed floor space is required
- Land cost is low and land is available for future expansion.

Multistory plant building is ideal when the above considerations are reversed. Based on the above considerations, single-storey plant building is recommended for the paint factory.

3. Shape of industrial plants

For a plant building, the need for natural lighting, ventilation and other factors will be a criteria for choice of its shape. Besides, the selected shape will provide easy expansion and unobstructed walls.

Therefore, for the proposed factory located in tropical country like Nigeria, where the use of internal stack effects, cross ventilation, natural lighting is desirable for comfort, the rectangular shaped industrial plant is ideal. This shape will permit natural ventilation and lighting coupled with artificial means and it also provides easy expansion and unobstructed walls.

The other anticipated problems like; noise, glare, heat gain etc. can be solved by design and use of ideal building materials.

However, other building shapes can be utilized where there are some restrictions like;

- Land limitations.
- Property lines being at curious angles.
- Where production process will cause dirt, noise or vibration, odour etc.
- Where production is susceptible to fire or explosion.

4. Production flow

It is necessary to design the production flow so that the production, either in product layout or process layout should make sufficiently flexible.

The design of production lines is based on the following considerations;

- Ease of material flow
- Expansion possibilities
- Ease of supervision

- Degree of flexibility
- Least initial investment.

WAREHOUSING

Warehousing simply involves deliver, storing and dispatching of raw materials, products and stationary. The material for warehousing are (delivering)

- Pigments, vehicles and additives as the basic raw materials.
- Machine, motor, electrical and mechanical parts to maintenance block.
- Foodstuff and drugs are stored in the welfare block.
- Chemical and books are stored at the research unit.

Dispatching: this involves the loading of the waiting Lorries with the finished product at the loading bay for delivery to distributors, to different warehouses and consumers. Usually, from the receiving dock, materials are delivered and stored and after manufacturing they are packaged and stored again. The delivery and storing before manufacturing are done at the warehouse.

Design of warehouse building

The design of either multi-storey or single storey warehouse is affected or influenced by:

- Flexibility
- Size and number of products
- Method of material handling.

Flexibility can be achieved by the installation of a minimum permanent storage aids.

For an efficient operation of a warehouse an effective material handling equipment is essential. This material handling represents the physical activity that take place in a plant. Some of the material handling equipment have been analysed in section (2).

The size and number of products will also determine the physical features of a warehouse.

Subsequently, the nature of the products will also determine the internal condition of the warehouse.

Warehouses are built in a multi-storey or single-storey system. But, in this project, all warehouses will be in a single-storey system.

Loading Bays: Loading bays form the link between production or storage and distribution system. An efficient loading bay enhances the workability of a warehouse.

Loading bays should not face the direction of the prevailing winds and they should be provided with canopy where dock shelter or enclosed dock is not installed. Additionally, loading bays should not be congested so that production process should not be slowed down.

ENGINEERING INSTALLATIONS

1. **Internal Engineering:**

Internal Engineering facilities are usually located towards a fixed façade where expansion is not expected and they are not centralized so as to be an obstacle to future expansion.

The internal Engineering facilities or the mechanical and electrical installations have to be provided with adequate space, however they are usually built 100% larger than initially required.

2. **External Engineering:**

The following outside utilities required for efficient operation of a plant are called the external Engineering facilities.

- Parking
- Waste disposal
- Truck ducks

- Water storage facilities
- Electrical transformer pads
- Sewage disposal plants
- Pumping stations

Based on the aforementioned facilities, care must be taken in their design and location so that it should not coincide with the direction of expansion of industrial plant or employee facilities.

SERVICES

Power and water supply

The main source of power to the factory is electricity and it is usually supplied by PHCN through a transformer located on the site. From the transformer, power lines are taken through a trench to the switch gear on the factory meter room. However, in case of power failures, a generating plant of appropriate capacity will be installed on site to supply the whole factory components.

Water supply to the factory, just as mentioned before, will be through the municipal water supply and the Obibia river after passing through the treatment plant.

Maintenance Block

This includes the mechanical and electrical units. This block consists of the following sections

- Individual storage units
- Offices for maintenance engineering and their officers.
- Large storage space for machine and motor spare parts.
- Other spaces for repairs and Lub-services pits.

The maintenance block should have a good relationship with the production hall for ease of transfer or maintenance of broken-down machineries.

Research

For the future of this factory, it is necessary that research facilities are included in its components. These will help in improving the quality of plant products, better and improved manufacturing methods and processes and modern materials handling methods and equipment. The research unit will include the following facilities:

- Research laboratory
- Library

- Exhibition and seminar hall
- Space for staff lectures and induction.

The location of the research unit will be based on; its quiet nature and relationship with other facilities. However, it will be located away or shielded from the noisy area (production hall, maintenance block, etc) with good relationship with the production, staff welfare, administration etc.

1. LIBRARY

The research library will encompass both reading desks and book stacks arranged within the library hall.

There will be also office spaces for library staff and other necessary facilities like; enquiry, conveniences, dialogue etc.

2. STAFF LECTURES AND INDUCTION

Orientation of new staff as well as instruction of older staff will be made possible by the provision of a space for staff lectures, induction and improvement. This space will also serve as the exhibition and seminar hall when necessary.

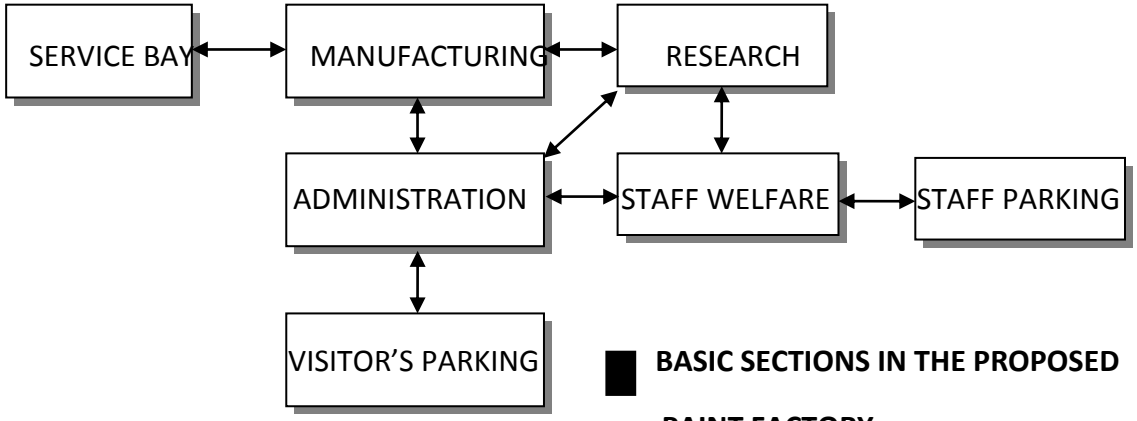
3. LABORATORY

The research laboratory will be planned on a square modular system to allow for greater flexibility in bench arrangement. Module width varies from 2600x5250; average approximate to 3000 to 3600. This will accommodate two parallel rows of benches with centre gangway to pass between 2 workers. The whole service rooms will be linked to a general service zone.

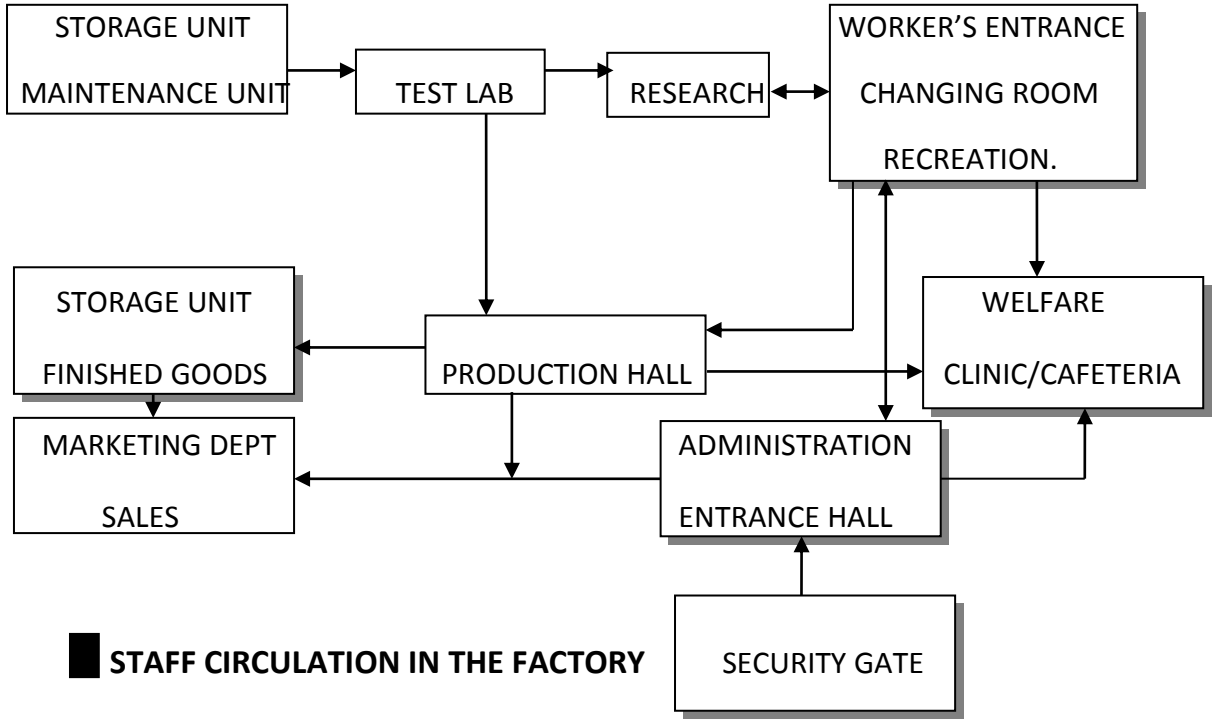
4. SECURITY AND GATE HOUSE.

This will be located in the security section, to control the entrance and exit of vehicles, goods, pedestrian, etc. The security block will have its own conveniences and offices for security personnel.

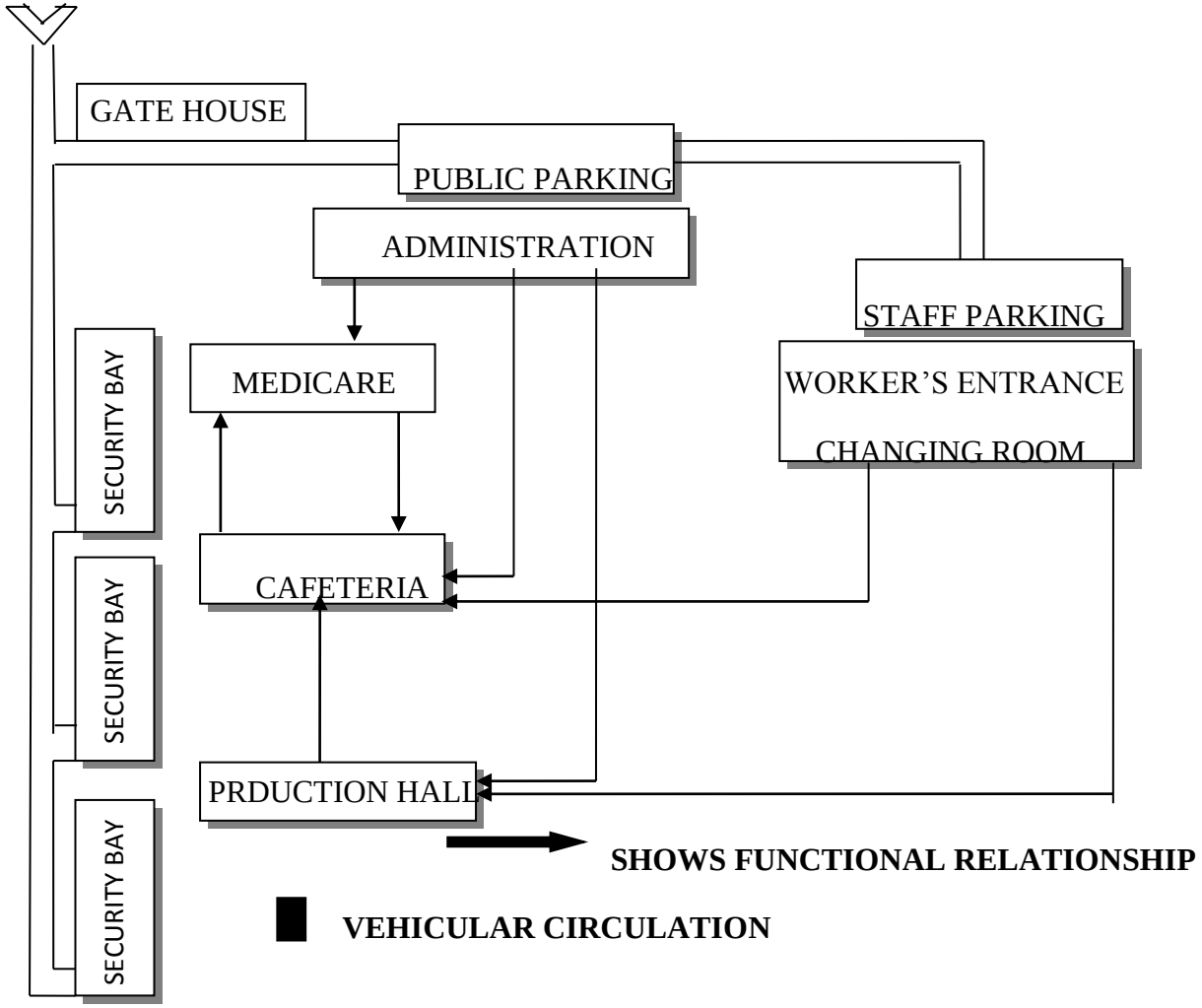
4.6 FUNCTIONAL RELATIONSHIPS OF SPACES

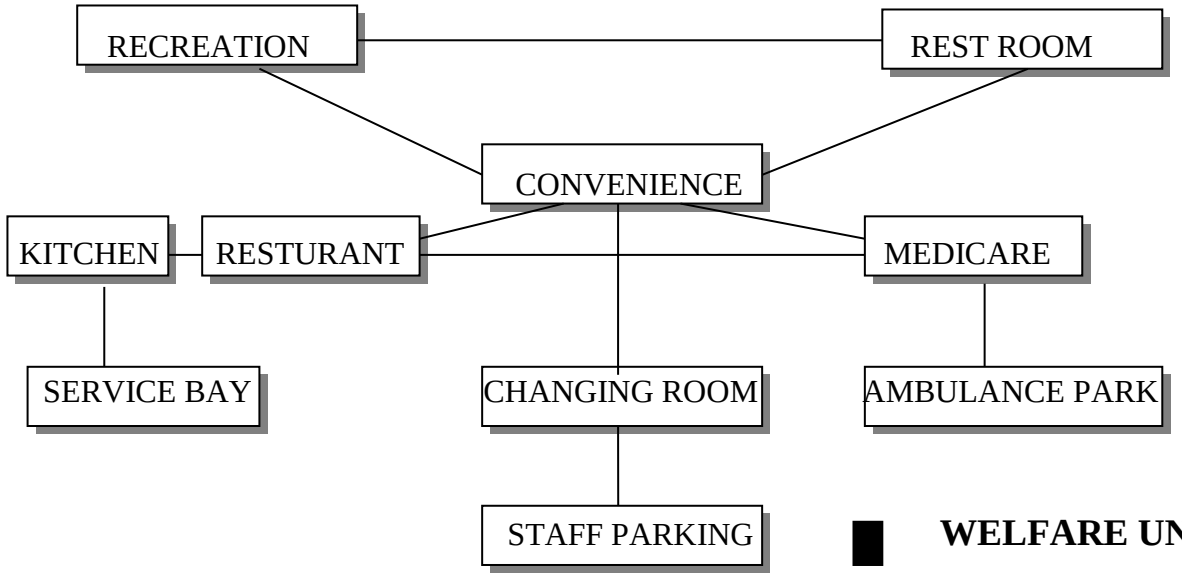


BASIC SECTIONS IN THE PROPOSED PAINT FACTORY.

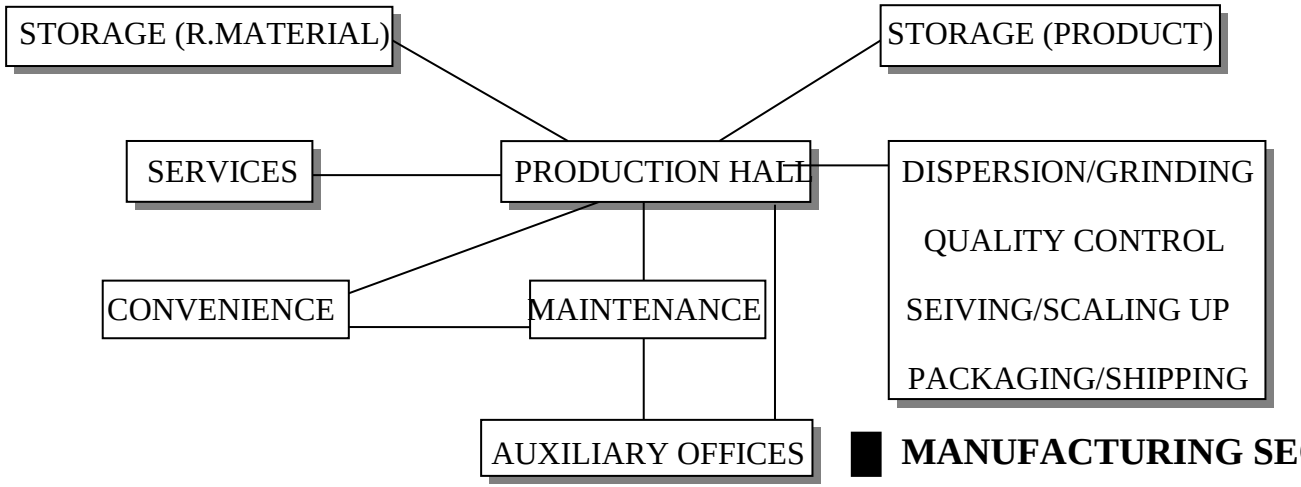


STAFF CIRCULATION IN THE FACTORY

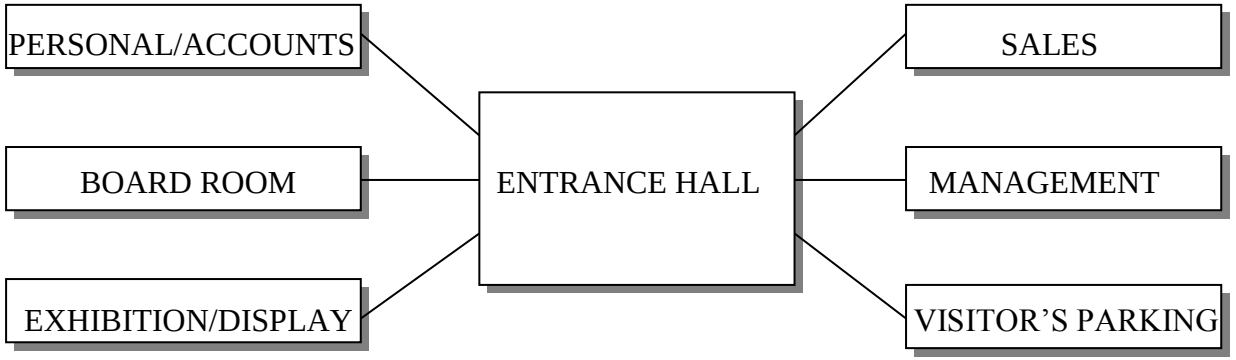

GATE HOUSE
PUBLIC PARKING
ADMINISTRATION
STAFF PARKING
MEDICARE
WORKER'S ENTRANCE
CHANGING ROOM
SECURITY BAY
SECURITY BAY
SECURITY BAY
CAFETERIA
PRDUCTION HALL
SHOWS FUNCTIONAL RELATIONSHIP
VEHICULAR CIRCULATION



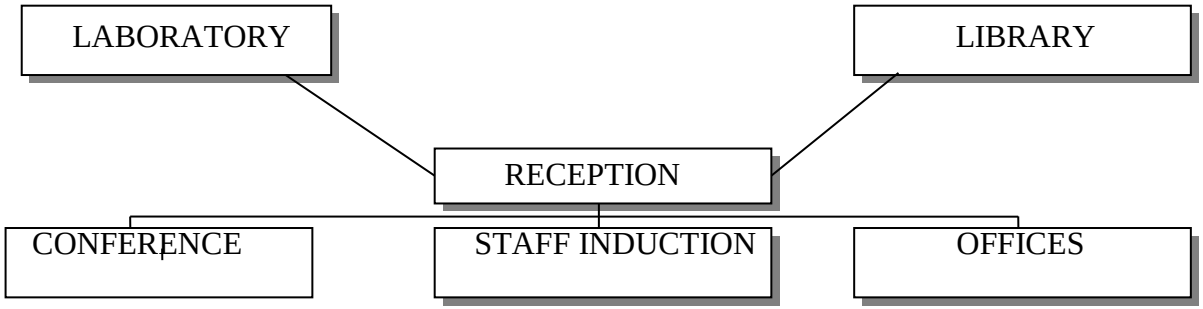
WELFARE UNIT



MANUFACTURING SECTION

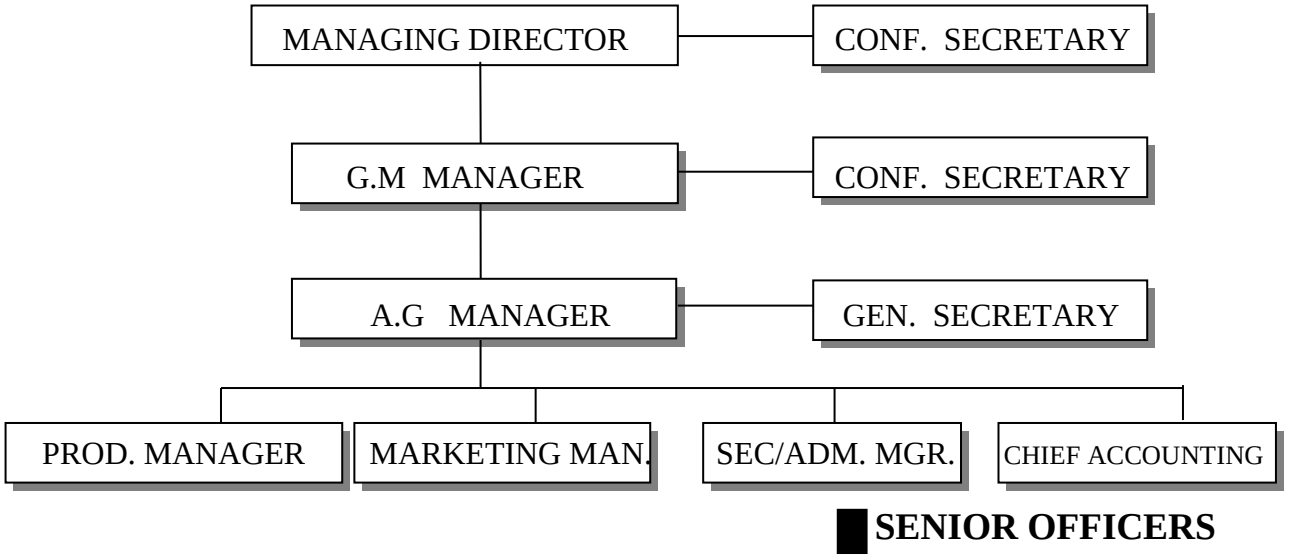


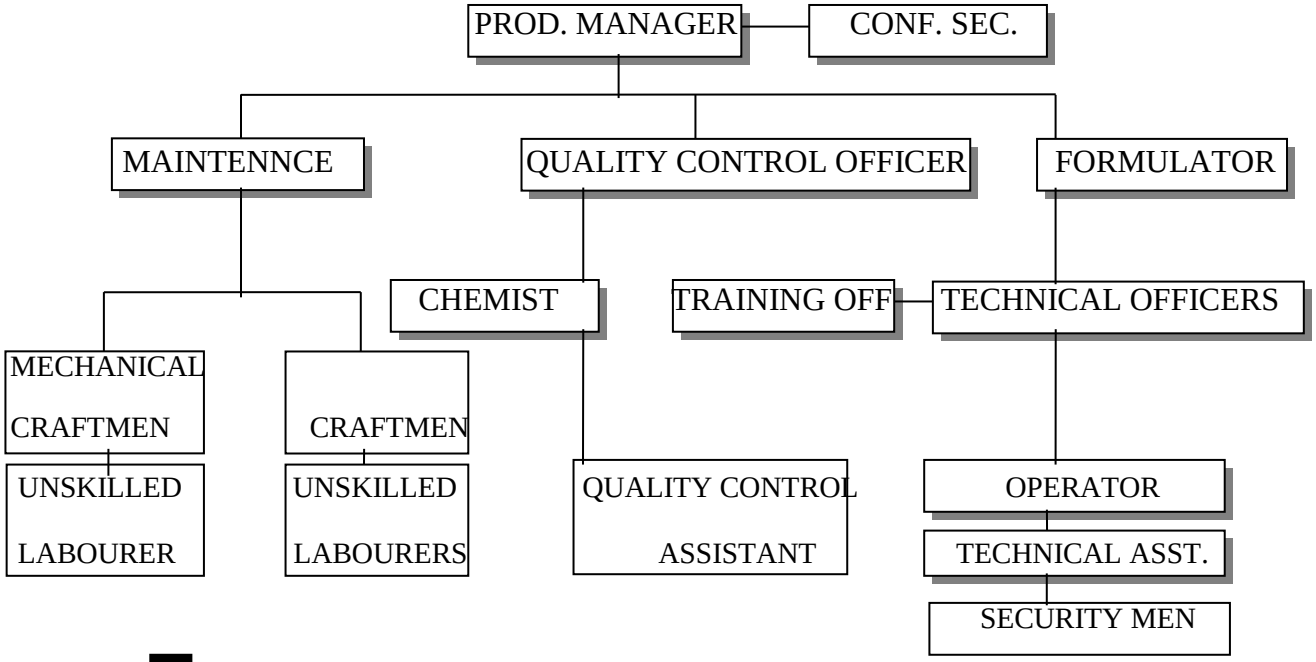
ADMINISTRATION UNIT



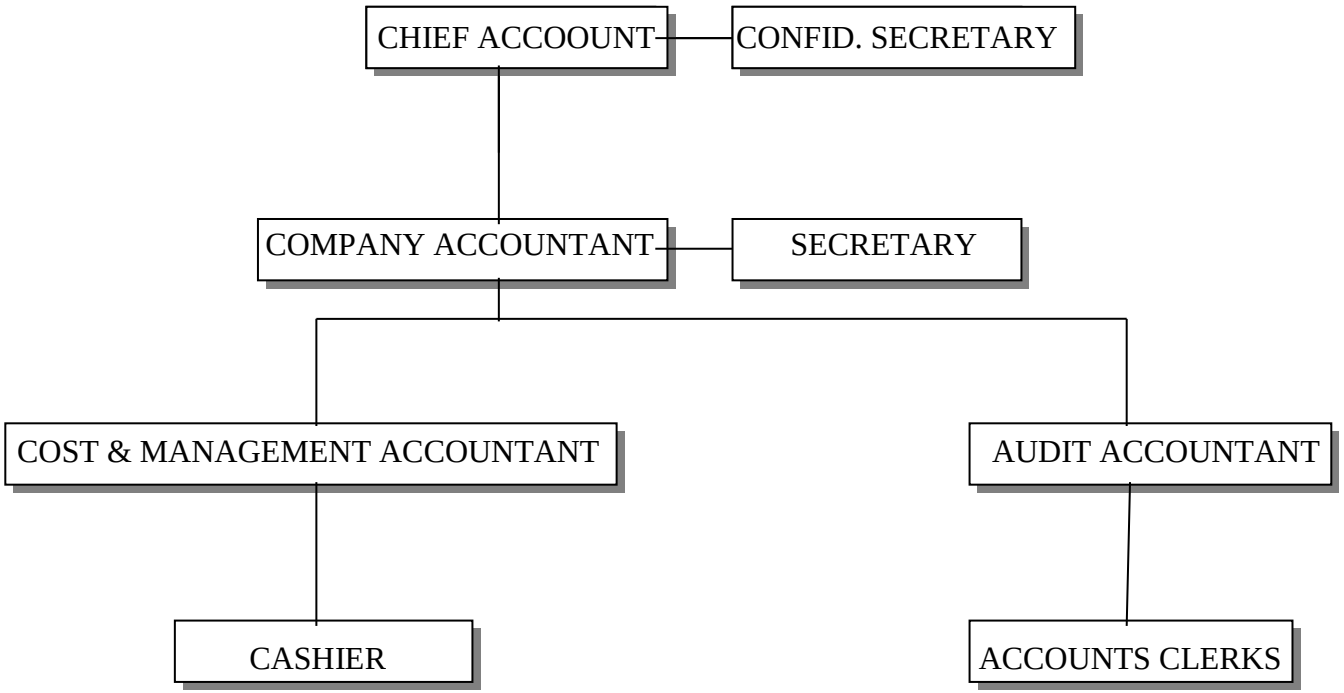
RESEARCH UNIT

4.8 ORGANISATIONAL CHART AND LABOUR STRENGHT





MANUFACTURING DEPARTMENT



ACCOUNTS DEPARTMENT

4.9 PROGRAMMING

SPACE OR DETERMINING SPACE STANDARDS

(Derived from Neufert Architect's data)

1. ADMINISTRATION: OFFICE SPACES

- People Space = Individual Space Standard X number + allowance for immediate ancillary + Factor for primary circulation (15%).
- None-people space = This space depend more on Equipment than people; it is calculated based on existing good practice + Factor for primary circulation.

Floor area for desk = 1.4m 0.7m

Operating areas; Typist = 1.7m

Clerk (General) = 2.3m^2

Filling clerk = 1.9m^2

Public clerk = 2.5m^2

A. Entrance Hall

- Receptionist/Enquiry - 12m^2
- Display area - 36m^2
- Waiting for 15 persons - 24m^2
- Circulation + stairs - 35m^2

Total = 97m^2

B. MEETING SPACES

	Space	No of Persons	Space required /person (m)
▪	Board room	15 - 25	1.5 - 2
▪	Lecture room (introduction)	50 - 100	1.5 - 2
▪	Conference room	10 - 20	1.5 - 2
▪	Assembly area for Staff	100 - 150	1.5 - 2
▪	Interview room	2 - 3	1.5 - 2

C. STORAGE SPACES

- Filling cabinet with a passage between 2 cabinets and the drawers are shut (1473 – 1574).
- Filling cabinet with a passage between 2 cabinets and drawer open (2032 – 2082)

2. STAFF WELFARE

Lockers – 1 Locker per person

Steel locker = 300 x 300 x 1730

Timber locker = 400 x 500 x 2000

Changing areas = 0.5m^2 per person

Washing – 1 wash basin person.

- **Cafeteria**

Area required per seat - 1.48 - 2.15m^2

Ratio of service area to total area - 25 - 50%

Net kitchen area - 15 - 25%

Service aisles - Not less than 900 - 1350

For both trolley and eaters.

- **Medicare**

Nurse station - 4 - 10m^2

Treatment room - 14 - 14m^2

Sister's room - 7 - 9m^2

Bathroom - 7m^2

Washing and shower - 2.7m^2

Cleaner - 5 - 8m^2

Circulation area - 25 - 40%

Toilet - 3m^2

Toilet and shower - 6m^2.

3. RESEARCH

- **Laboratory**

Length - 1500/researcher

Module width - 3 - 3600

Corridor W - 2000 – 2.500

Headroom - 3.600 – 4.200

- **Library**

Adult lending - 27 – 40% of total area

Reference - 20% of total area.

Circulation/Service/Ancilliaries – 40% of total area.

Book Stacks - 3.6m length - 7.2m

Reading/Study room - $3m^2$ per Researcher.

4. MANUFACTURING

- **Production Hall** – Circulation space required = Total area x 50%

Machine	Ground Coverage	Height	Remarks
-High – speed dispenser	12.53m2	3.10m	Total space occupied big machine.
-Low – speed mill	1.27m2	2.80m	Space occupied by one machine.
-Sand grinder	2.40m2	2.40m	Space occupied by one machine.
-Roller mills	4.42m2	2.40m	Space occupied by a set of 3 machines.
-Sewing machine	0.50m2	1.35m	Space occupied by one machine.
-Canning machine	4.50m2	2.38m	Space occupied by one machine.
-Stationary tanks (700 gals. (2800ltr)	1.27m2	1.4m	Space occupied by one tank.
-500 gals. (2000 ltrs)	1.13m2	1.4m	Space occupied by one tank.
-Mobile tanks (200 gals. 800 ltrs)	0.66m2	1.25m	Space occupied by one tank.
-forklift	2.51m2	1.20m	Space occupied by one machine.

C. WAREHOUSE

- **For forklift in block stack**

  Aisle = 3500

  Stack height = 3600

- **Forklift in pallet rack**

  Aisle = 3500

  Stack height = 7500

S/N	FUNCTION	NO OF USERS	UNIT AREA(M^2)	NO OF UNITS	NET AREA	REMARK
A	**MANAGEMENT**					
1	Managing Director	1	30	1	30	
2	Confidential secretary to M/D	1	12	1	12	
3	General Manager (GMD)	1	24	1	24	
4	Confidential Secretary to (MD)	1	12	1	12	10 Clerks/ Typist.
5	Asst. Gen. Manager (ASM)	1	18	1	18	
6	General Secretary	1	18	1	18	
7	Boardroom	25	2.5	1	60	
8	Lavatory		6	3	18	

9	General Office	10	2.3	1	23	
10	Telax/Telecom. Room	2	4.5	1	9	
11	Reception/waiting	15	1.6	1	36	
12	Records and file room		18	1	18	
13	Stationary store.	1	12	1	12	
					290	

S/N	FUNCTION	NO OF USERS	UNIT AREA(M^2)	NO OF UNITS	NET AREA	REMARK
B	**ACCOUNTS DEPARTMENT**					
1	Chief Accountant	1	20	1	20	
2	Confidential Secretary to Chief Acct.	1	12	1	12	
3	Company Accountant	1	15	1	15	
4	Secretary to Company Accountant	1	9	1	9	
5	Cost and Management Account	1	10	1	10	
6	Audit Accountant	1	10	1	10	
7	Cashier	2	5	1	10	
8	Accounts Clerk	4	2.5	1	10.0	
	TOTAL				**96**	

B	**MARKETING DEPARTMENT**					
1	Marketing Manager	1	20	1	20	
2	Confidential Sec. to marketing Mgr.	1	12	1	12	
3	Purchasing Officer	1	16	1	16	
4	Purchasing Supervisor	1	15	1	15	
5	Store Keeper	4	12	2	96	
6	Clerks	3	5	2	30	
7	Supply Officer	1	16	1	16	
8	Sales Supervisor	1	15	1	15	
9	Salesman	4	16	1	64	
10	P.R.O	1	12	1	12	
11	Secretary/Typist	1	1.7	1	1.7	
12	Advert Officer	1	16	1	16	
13	Display Artists	8	2.5	1	20.0	
14	Display Unit Attendant	3	2.3	1	6.9	
	TOTAL				**340.6**	

C.	**PERSONNEL DEPARTMENT**					
1	Personnel Manager	1	16	1	16	
2	Training Officer	1	12	1	12	
3	Staff Affairs	1	12	1	12	
4	Clerical Office	1	20	1	20	
5	Recruitment Officer	1	12	1	12	
6	Interview Room	3	3	1	9	
7	Records and file		18	1	18	
	TOTAL				**99**	

S/N	FUNCTION	NO OF USERS	UNIT AREA(M^2)	NO OF UNITS	NET AREA	REMARK
E1	Entrance Hall		90	1	90	Receptionist + 15 visitors Display area + circulation and stair.
E2	Conference Room	25	2.5	1	62.5	
2.	**<u>MAINTENNCE</u>**					Electrical workshop.
1	Maintenance Engr. (Electrical)	1	12	1	12	
2	Maintenance Engr. (Mechanical)	1	12	1	12	Mechanical workshop
3	Electrical Craftman + Unskill					

	Laborers	6	10	1	60	
4	Mechanical Craftmen +					
	Unskilled Laborers	7	10	1	70	
5	Supervisor	2	6	1	12	
6	Fire service Unit			1	30	
	TOTAL				**196**	
3.	**STAFF WELFARE**					
A	Medicare					
1	Consultation	2	5	1	10	
2	Treatment	2	7	1	14	
3	Reception/waiting	8	2	1	16	
4	Wards	3	5	2	30	
5	Office/Records	1	12	1	12	
6	Music's room	4	5	1	20	
B	Changing room	50	0.5	1	25	
1	Male changing	30	0.5	1	15	

2	Female changing	15	6	1	90	
3	WC/Shower	2	6	1	12	
4	Store			1	30	
5	Clock-in lobby					
	TOTAL				**172**	
C	Recreation					
1	Games	25	1.2	1	30	
2	Relaxation area	25	1.2	1	30	
	TOTAL				**60**	
D	Restaurant					
1	Catering manager	1	15	1	15	
2	General office	6	2.5	1	16	
3	Dining room (Jnr. Staff)	40	1.5		60	Service area 25%
4	Dining room (Snr. Staff)	25	2.0	1	50	Service area 30%
5	Total Service Area			1	30	
6	Kitchen			1		
7	Store (dry)			1	20	
8	Store (cold)			1	10	
9	Store (drink)			1	20	

10	Pantry			1	12	
11	Toilets and shower		6	8	48	
12	Changing rooms	5	2	1	10	
	TOTAL				**551**	
	Laundry Units					
1	Receiving/Issuing	1	12	2	24	
2	Sewing room	1	9	2	18	
3	Soiled linen store	1	12	2	24	
4	Clean Linen Store	1	12	2	24	
5	Washing room	2	16	2	24	
6	Ironing	4	6	1	24	
	TOTAL				**138**	
	RESEARCH					
A	Laboratory					
1	Unit		15	4	60	
2	Lab. Attendant	1	12	2	24	
3	Lab. Store		1.6	2	3.2	
	TOTAL				**87.2**	

B	Library					
1	Librarians Office	1	16	1	16	Reference= 20%
2	Reading room	25	3	1	75	
	TOTAL				**91**	
C	General					
1	Staff Induction Space		50	2	100	
2	Staff Induction Office	1	16	1	16	
3	Toilets		3	10	30	
	TOTAL				**146**	
D	Ancillaries					
A	Security Department					
1	Chief Security Officer	1	12	1	12	
2	Asst. Chief Sec. Officer	1	12	1	12	
3	Gate house	4	6	2		
4	Store		20	1	20	
5	Toilet/Bath		6	2	12	
	TOTAL				**56**	

B	Car park	30	15	30	450	
1	Customer's car park	15	32	15	480	
2	Customer's lorries	30	15	30	450	
3	Staff Cars	80	2.5	80	200	
4	Motorcycle/Bicycle	20	15	20	300	
5	Factory cars	10	32	10	320	
6	Factory Lorries					
	TOTAL				**2200**	

CHAPTER FIVE

5.1 DESIGN SYNTHESES

Architecture is normally conceived (designed) and realized (built) in response to an existing set of conditions. This condition in most cases is purely functional or may represent social, economic, political, or symbolic intentions in varying degrees. In all cases it is assumed the existing set of conditions – the problems – is less than satisfactory and that a new set of conditions – a solution – would be desirable. The proposed paint factory is seen as a response to the existing set of conditions, that is, the problems created by the present state of various paint factories, which in most cases, is unsatisfactory.

The recognition and identification of the problematic conditions and the decision to find a solution constitute the first phase of any design process. This will be done based on the statement of the major project goals and objectives, followed by the design philosophy, concept and realization.

5.2 DESIGN PHILOSOPHY AND CONCEPT

Factories can be seen as mere housing facilities for a certain layout of machines and the necessary personnel facilities. Subsequently, there is a trend toward enlarging selling or abandoning the system whenever its operation starts. We expect a little flexibility in manufacturing operation and we design for it.

Therefore, the designer takes his mind off from institutional monumentality, in favour of flexibility, expandability and even demountability.

Industrial architecture at times places a difficult decision to the designer on whether to house the machine or the man. Although the operator will be regarded as merely servicing automatic machinery, the designer will still face resistance since the operator will expect the same kind of air conditioned building to work in, that he always had. At times, weather conditions would make his maintenance and operational work difficult. However, the occurrence of bad weather and breakdown would surely be in frequent, so infrequent as to make it economically unsound to design and conventional building cover merely for machine maintenance.

At any rate, it would be healthful to think of the industrial plant more as a “shell over a mechanical process” than as the standard home of a corporation and try to design for fast-changing times.

The reception room, to which the public is admitted, should display the quality and character of the firm it represents. It should convey a cohesive impression of operation and emphasis the best point of employee’s facilities.

In some industrial architecture, the visitor's entrance has been a forgotten corner of the industrial plant. Usually, it comprises of the receptionist, display areas, waiting area and the various charts of the production operation. However, industrial architecture should thoroughly integrate the reception area with the rest of the facilities. This facility should be a bold element in an otherwise severely straight forward building and should be a starting point or otherwise a working pivot point around which other facilities exist.

Subsequently, atmospheric and environmental controls are rendered essential by the nature of the process in an industrial building. Usually the raw materials, finished products and machinery are seriously affected by temperature and humidity. These environmental factors usually affect workers psychology, performance and efficiency, although the healthy workers can adapt quite readily to a considerable variation in temperature, humidity or ventilation. However, the stress of compensating is sometimes cumulative and can lead to sudden collapse in the event of a sudden task stress. Most times there is more effect on workers performance and morale when noise, vibration and atmospheric contamination are not properly controlled.

Therefore, it is important to consider all the potential environmental hazards in terms of system design control; as opposed to discovering that such hazards exist after the system is designed. There should be an effort towards the realization of a space that people will enjoy and equally enhance the optimal performance of the plant.

Additionally, industrial architecture should consider workers to be human beings as well as a production unit. The task is primarily one of arranging the system so that Managers and Workers can meet on common ground and spend time with each other. A meeting ground which

should be ideal in its standard of working conditions, beautiful in appearance, conducive for both executive and workers. Therefore, there should be an effort towards the creating of a common ground that people will enjoy and which can be viewed from both production and office spaces, which will also serve as a relief from the production spaces and a pleasant meeting ground for all level of employees at the plant. This should be an environment that is visually connected, but atmospherically isolated or common with the climate outside.

It is the considered opinion of this project to reflect the mass production nature of this factory whose dominant role is manufacturing.

Besides, it will also satisfy the utilitarian needs of efficient work flow of the production lines and its architecture is supposed to make certain statements to the society.

In realizing, its concept the project will make some additional achievements.

- The function, a systematic and hierarchical flow of space from the public to the semi-public and then to the private zones integrated with a flow from the noisy to the semi-noisy and then to the quite zone. The factory will be arranged and subdivided into these zones based on the disposition to public contact and noise generation and accommodation (See Chapter Four for the zoning of the functions).
- This concept will rely heavily on expressing in the design the note of orderliness and the appeal of aesthetics. This factory aesthetics will definitely be improved by the use of heights and volume differences to articulate the different units of the factory.

Beside the use of paint colouring to make and architectural statement will promote its image and expose its architectural and finishing possibilities. This will be achieved by the use of either steel or aluminium building cladding whose end uses entails the application of wide ranges of coil coating.

- As a paint factory, colour will be used extensively to achieve a sense of impressions, each of which is calculated to perform an appropriate function for easy, comfortable seeing, for good cheer and even for aesthetic pleasure. Colour will also be used for other functions such as safety, cleanliness, psychology and at the same time advertise its products, their possibilities and potentials. (Refer to chapter 4 for colour recommendations). In the other hand, daylighting is desirable in working places and for their psychological reasons too. It is normal for the workers to have daylight in daylight hours and not shut away from nature. Usually windows are not relied on for ventilation in production spaces, therefore Air conditioning will be extensively used where necessary.
- To facilitate this modern material handling, single storey building will be adopted for this project. It facilitates efficient arrangement of parts and assembly lines and also provides for ease of material handling by conveyors, monorails and forklifts or lift trucks. This one level building includes mezzanine, basement and penthouse areas.

5.3 CONCLUSION

In conclusion, manufacturing process is a sound economic based for the evolution of developed economics which affects the general well being of a nation through a judicious use of proceeds from the exports of manufactured products.

In order to support the welfare and services requirements of a developing nation like Nigeria, the government should over haul the industrialization policy with a view to breaking the unfavorable economic pattern of exporting raw materials to advanced metropolitan countries, from whom the finished products of these raw materials are imported into the country at petrochemical industries in the country will be of immense economic advantage that will help sustain the nation.

Therefore, the architect's role in this matter, among the other things, is to provide a functional design that will not only observe all the important recommendations for a successful design but should also work toward the provision of factories that are economic in capital cost. The architect's role should include the following:

- Educating the industrialist on a need for future expansion
- The importance of installing modern machinery
- Diversification of production
- Ensure good working conditions for staff.

5.4 REFERENCE

FOOT NOTE

- Waldrun Faulkary F.A.I.A.; ARCHITECTURE AND COLOUR: WILEY Interscience. Pg. 62
- Bikales "SURFACE COATING". Pg.
- Painting "ENCYCLOPAEDIA BRITANNICA" 11TH Edition, Vol. XX: Newyork U.S.A. Pg.
- Anthony Standen "PAINT" Encyclopedia of Chemical Technology: 2nd Edition Vol. 14. New York, U.S.A.Pg.
- Ibid. Pg.
- Ching Francis B.K, "ARCHITECTURE, FORM AND ORDER": VAN NO strand R. Reinhold Company. New York (1975). Pg.
- A.I.A publication: FACTORIES, PLANNING, DESIGN AND MODERNISATION. Pg.
- Encarta dictionary 2009

BIBLOGRAPHY

- Chiara D. and Callender, (1973). *"Time Saver Standard for Building Types"* New York, Mcgraw-Hill.
- Le Corbusier, (1901). *"Towards A New Architecture"* London, Mcgraw-Hill.
- Lie T. (1972). *"Fire and Building"* London, Applied Science Publication Limited.
- Smith R. (1973). "*Materials and Construction"* London, Mcgraw-Hill.
- Neufert E. (1980). *"Architects Data"* London, Granade Publication limited.
- Wesley E. (1774). *"Human Factors Design Handbook"* London, Mcgraw-Hill Book Company.

ARTICLES:

- DRURY J. (1977). FACTORIES: *"Manufacturing Industries",* ARCHITECTS JOURNALS.

UNPUBLISHED ARTICLES

- NWOSU UCHENNA NNAMDI, (1989). "*Paint Factory"* UNIVERSITY OF NIGERIA, ENUGU.
- ADRIAN B. (2010), "*Plastic Factory"* CARITAS UNIVERSITY, ENUGU.