Plant Design and Economics
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Lecture No-09
Site and Plant Layout

Welcome to lecture 9 of Plant Design and Economics. After you have determined the location of the plant and also you have prepared the flow sheet diagram. Then you have to decide the site, layout as well as plant layout, meaning how you will place the main processing equip processing areas; that mean state blocks, the utilities, etcetera and also how you will place different pieces of equipment, how will arrange these equipment in the main processing areas, so this will be the today's topic.

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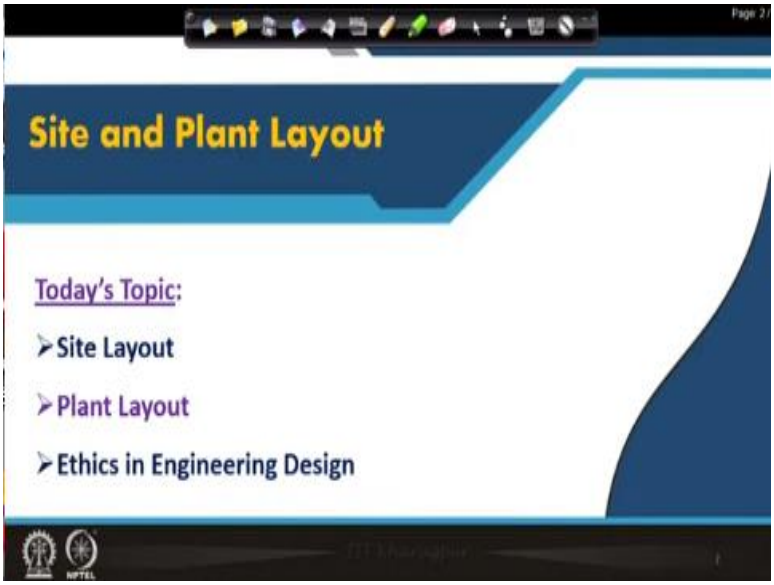

So, we will talk about Site layout, we will talk about Plant layout and then we will finish today's class with a very brief description on Ethics in Engineering Design.

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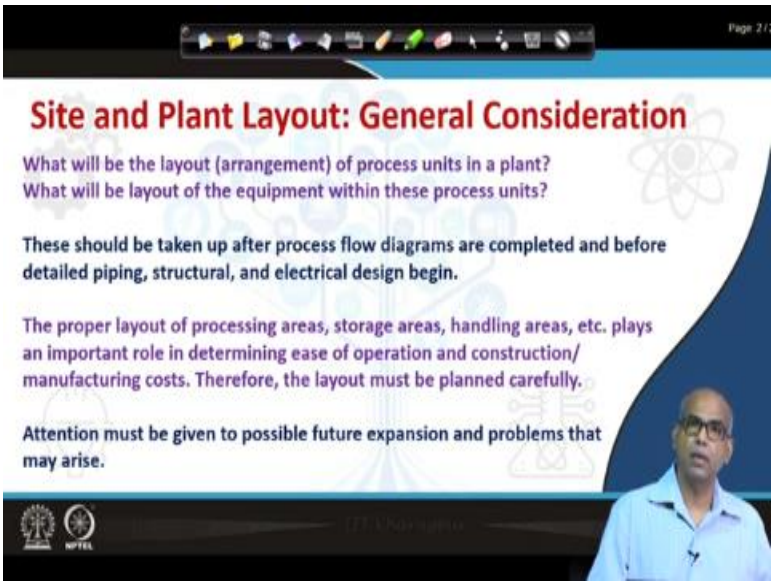

So, as I told you now you have determined the location of the plant, you have the flow sheet with you, so now you are going to decide what will be the layout or arrangement of process units in the plant, what will be the layout of the equipment within these processing units? So this should be taken up after process flow diagrams are completed and before detail piping, structural, and electrical design begin.

The proper layout of processing areas, storage areas, handling areas etcetera plays an important role in determining ease of operation and construction cost as well as manufacturing cost. Therefore, the layout must be planned very carefully. Attention must be given to possible future expansion and also problems that may arise.

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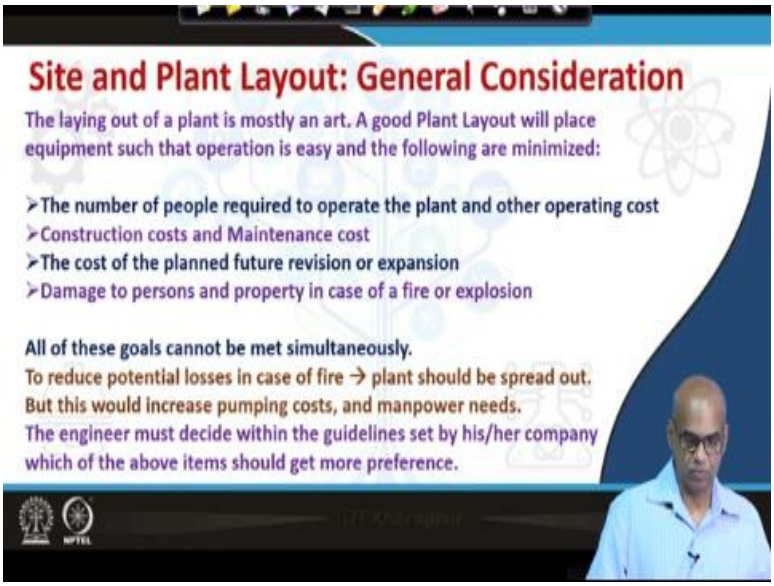

The laying out of a plan is mostly an art, a good plant layout will place equipment such that operation is easy and the following are minimized. The number of people required to operate the plan and the other operating cost. Construction cost and maintenance cost, the cost of the planned future revision or expansion, damage to persons and property in case of a fire or explosion. All of these goals cannot be made simultaneously.

For example to reduce potential losses in case of fire your plant must be spread out, but if you spread out your plants the pumping cost will increase and possibly also you will require more manpower for operation. The engineer must decide within the guidelines set by his or her company which of the above items should get higher preference. So it is a multi-objective problem.

There is no single objective on which you can decide what should be the best plant and site layout. You have to consider various factors.

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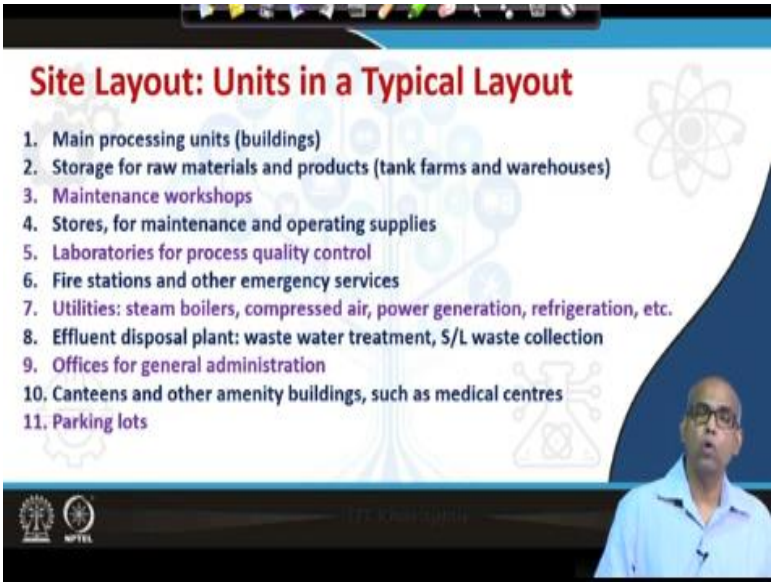

So, these are the typical units that you will be placing in a layout. Main processing units, storage for raw materials and products; this will be tank farms and warehouses, maintenance workshop, stores, for maintenance and operating supplies, Laboratories for process quality control, Fire stations and other emergencies services, Utilities: such as steam boilers, compressed air, power generation, refrigeration, etcetera.

Effluent disposal plant: waste water treatment, solid liquid waste collection, offices for general administration, Canteens and other amenities buildings such as medical centres and also parking lots.

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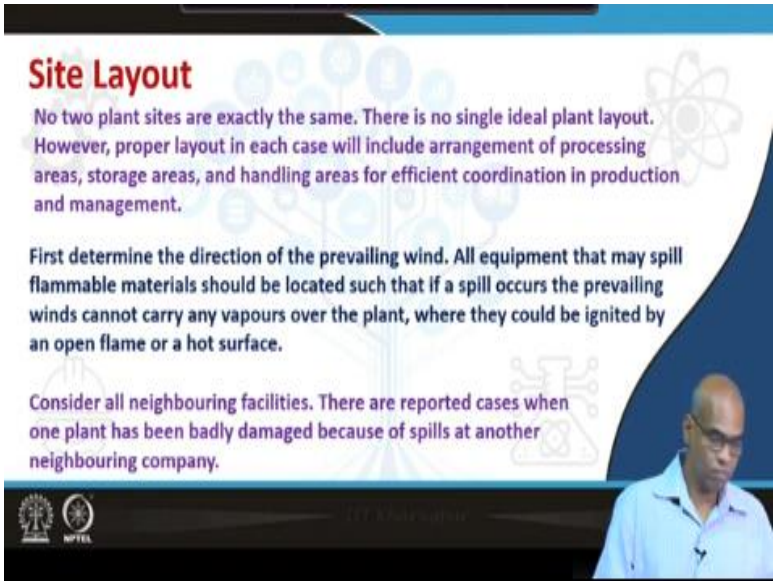

No two plants are exactly the same. Because most probably no two plants will be exactly same and no two plants sites will also never be exactly the same. So, there is no single ideal plant layout. However, proper layout in each case will include arrangement of processing areas, storage areas and handling areas for efficient coordination in production as well as management. First determine the direction of the prevailing wind.

All equipment that may spill flammable materials should be located such that if a spill occurs the prevailing winds cannot carry any vapours over the plant where they could be ignited by an open flame or a hot surface. Consider all neighbouring facilities not only consider your own facilities, but also consider neighbouring plants and facilities. It has happened in the past when one plant has been badly damaged because of spills at another neighbouring plant.

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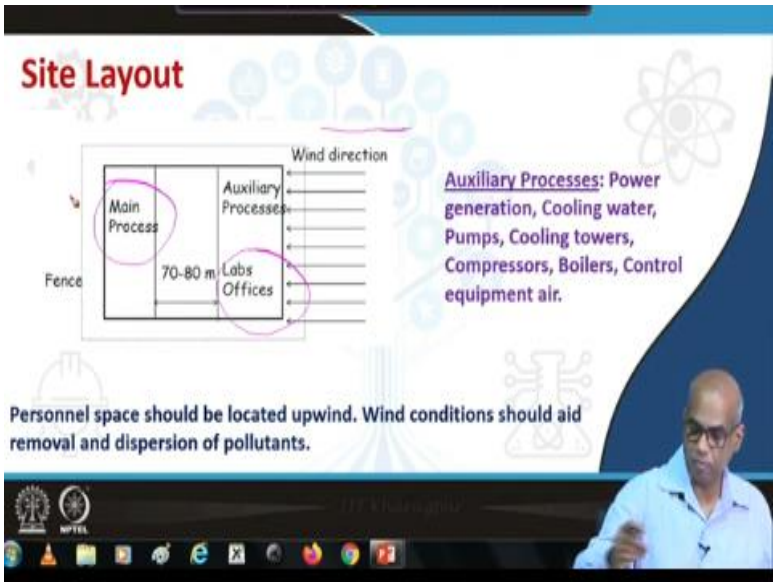

What you see is a very simple schematic of a site layout. Look at the wind direction so, the occupied buildings such as labs offices, these are occupied by human. So, occupied buildings are located such that, the wind conditions will aid removal and dispersion of pollutants. So this is the main process and there is about 70 to 80 meters distance between these occupied buildings and the main process.

So, there labs, offices, etcetera are located around one end of the side and wind direction, so wind conditions is such that, it should aid removal and dispersion of pollutants. Here auxiliary

processes include power generation, cooling water pumps, cooling towers, compressors boilers, control equipment, air etcetera.

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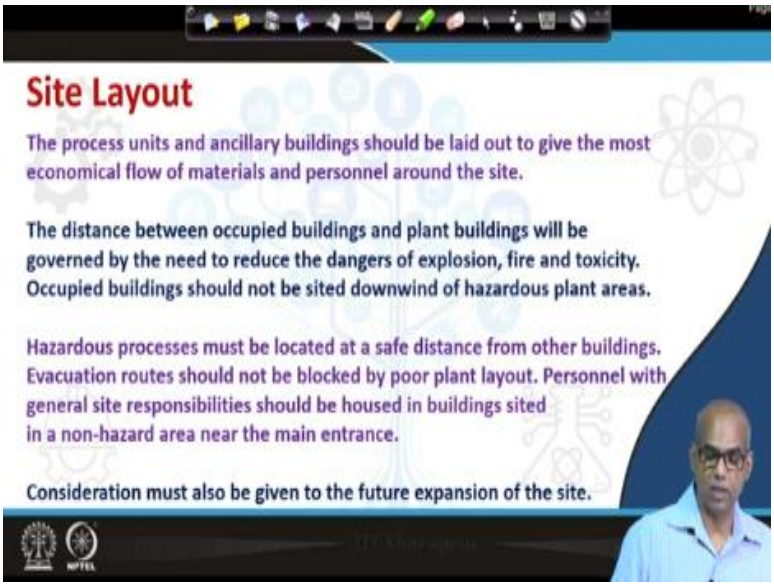

The process units and ancillary buildings should be laid out to give the most economical flow of materials and personnel around the site. The distance between occupied buildings and plant buildings will be governed by the need to reduce the dangers of explosion fire and toxicity. Occupied buildings should not be cited downwind of hazardous plant areas. I repeat occupied buildings should not be cited downwind of hazardous plant areas, there should be cited upwind.

Hazardous processes must be located at a safe distance from other buildings. Evacuation routes should not be blocked by poor plant layout. Personnel with general side responsibilities should be housed in buildings cited in a non-hazard area near the main entrance. Consideration must also be given to the future expansion of the site.

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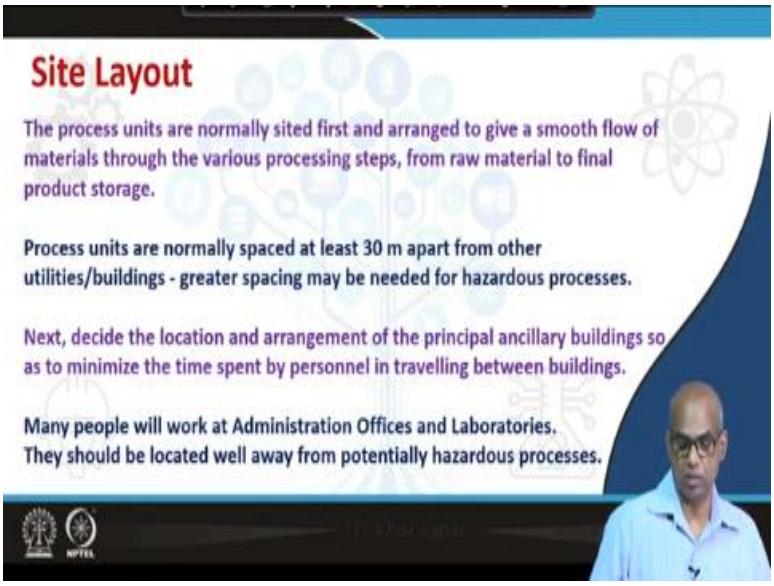

The process units are normally cited past and arrange to give a smooth flow of materials through the various processing steps from raw material to final finish product storage. Process units are normally spaced at least 30 meter effort from other utilities or buildings, greater spacing must be needed for hazardous processes. Next decide the location and arrangement of the principle ancillary buildings, so as to minimize the time span by personnel in travelling between the buildings.

Many people will work at administration offices and laboratories; they should be located well away from potentially hazardous processes.

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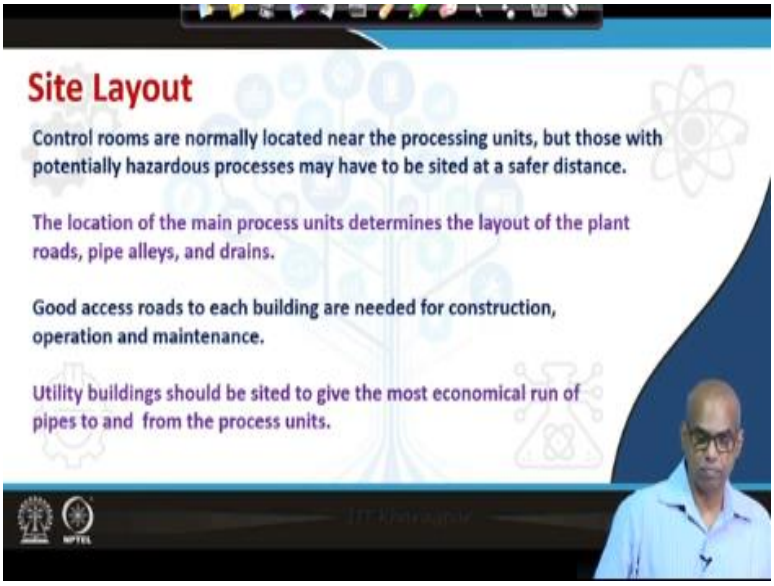

Control rooms are normally located near the processing units, but those with potentially hazardous processes may have to be cited at a safer distance. The location of the main process units determines the layout of the plant roads, pipe alleys and drains. Good access roads to each building are needed for construction operation and maintenance. Utility buildings should be cited to give the most economical run of pipes to and from the process units.

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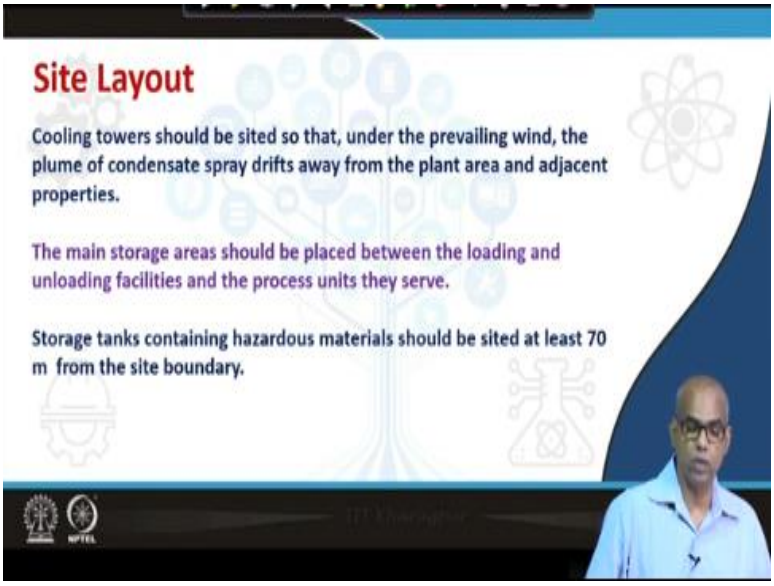

Cooling towers should be cited so that, under the prevailing wind, the plume of condensate spray drifts away from the plant area and adjacent properties. The main storage areas should be placed between the loading and unloading facilities and the process units they serve. Storage tanks containing hazardous materials should be cited, at least 70 meter from the site boundary.

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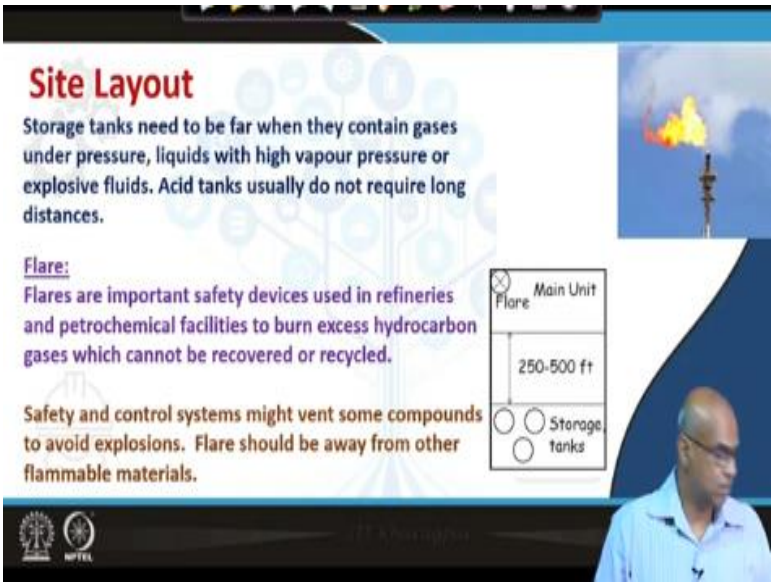

Storage tanks needed to be far when they content gases under pressure, liquids with high vapour pressure or explosive fluids. Acid tanks usually do not take long distance. What you see here, is another simple schematic of the site layout. So, these are the storage tanks on one end. Now between the storage tank and the main unit there is about 250 to 500 feet distance meaning about 70 meter to about say 170 meter distance.

Now, on one end on one corner, you see the flare this is the flare. So flare is a safety device that you see in refineries in petrochemicals, etcetera. Flares are important safety devices used in the fineries and petrochemical facilities to burn excess hydrocarbon gases, which cannot be recovered or recycled. So instead of releasing these vapours to atmosphere, these vapours are safely burned using flares.

So when you see flares, please be ensured that this is a safety device and the operations are going on safely. Safety and control systems might vent some compounds to avoid explosions. Flare should be away from other flammable materials.

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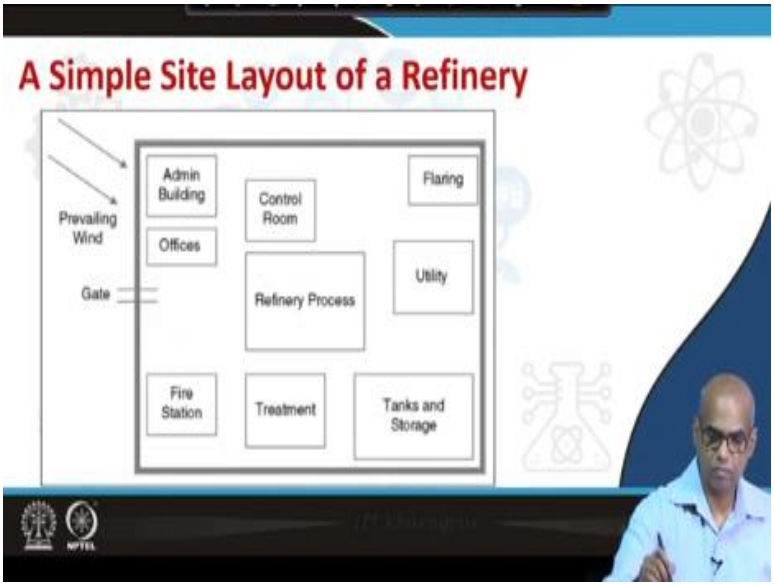

This is a simple site layout for a refinery. So look at the layout, you have the main refinery process here. These are the occupied building, administrative building as well as offices. So they are near the main entrance and prevailing wind condition is such that the pollutants will be carried away from the occupied buildings. The control room is located in a nearby place where the main refinery is located and flare is cited far away at one corner.

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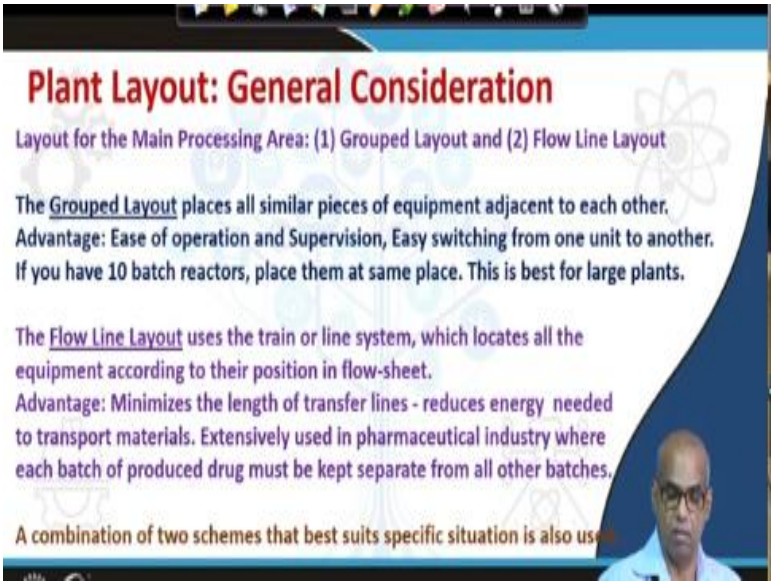

Now, we will talk about Plant Layout. There are two types of plant layouts group layout and flow line layout. The group layout places all similar pieces of equipment at one place. So, all similar pieces of equipment will be placed adjacent to each other. So, what is the advantage? This leads to ease of operation, ease of supervision also it is easy to switch from one unit to

another. Imagine there are 10 batch reactors in your plant.

So you should place them at the same place then what will happen is that you will require less number of personal to monitor this 10 batch reactors. So monitoring and supervision will be easier there will be ease in operations if you place all 10 batch reactors in one place. This is a good strategy for large plants. On the other hand the flow line layout scheme uses the train or line system, which locates all the equipment according to their position in the flows if that you have designed.

So what is the advantage here? In minimizes the length of transfer lines and thereby it reduces energy needed to transport materials. This scheme is extensively used in pharmaceutical industry where each batch of produce drug must be kept separate from all other batches. In other industries, this scheme is sometimes used for the products that you produce in small volume but has high price, so specialty chemicals similar to pharmaceutical products.

Oftentimes a combination of group layout scheme and flow line layout schemes will be used that base suits the specific situation you have in hand.

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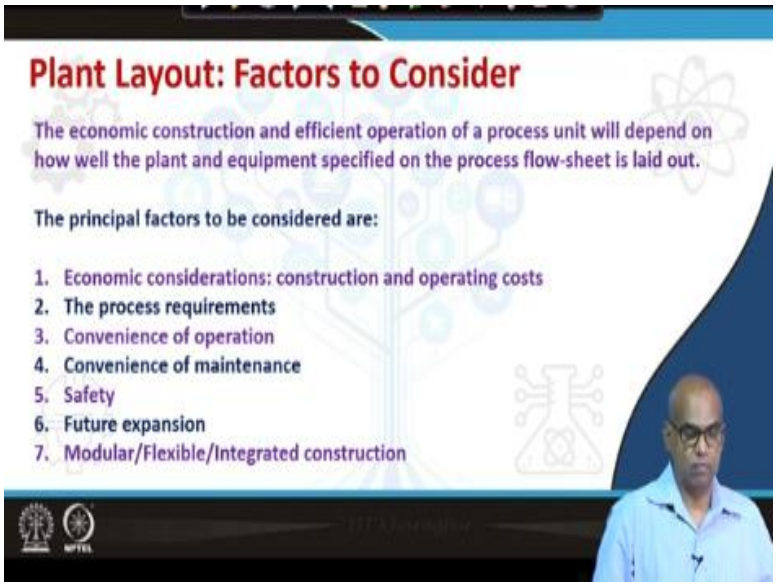

Now, there are various factors that will have to be decided, that you have to be considered. To decide plant layout economic construction and efficient operation of a process unit will depend

on how well the plant and equipment specified on the process flow series lay out. So, what are the various factors? These are the principal factors to be considered for plant layout: economic consideration, construction.

And operating cost the process requirements, convenience of operation, convenience of maintenance, safety, scope for future expansion and modular or flexible or integrated construction. So now let us look at some of these factors in some more detail.

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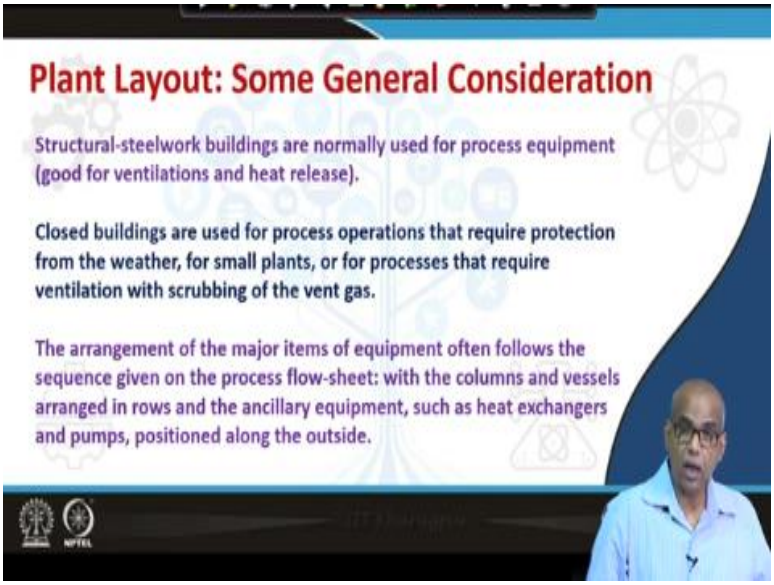

Before that let us talk about some general consideration. Structural steel work buildings are normally used for process equipment because they are good for ventilation and heat release. Close buildings are used for process operations that require protection from the weather for small plants or for processes that require ventilation with scrubbing of the vain gas. The arrangement of the measure items of equipment often follows the sequence given on the process flow sheet;

With the columns and vessel arrange in rows and the ancillary equipment's such as heat exchangers and pumps position along the outside.

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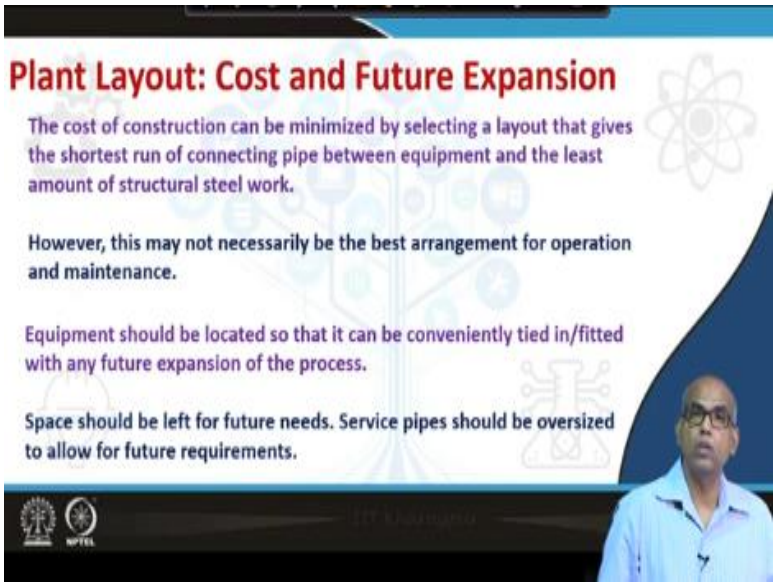

These are the factors that do not need to be considered for plant layout based on cost and scope for future expansion. The cost of construction can be minimized by selecting a layout that gives the shortest run of connecting pipe between equipment and the list amount of structural steel work. However, these may not necessarily be the best arrangement for operation and maintenance.

Equipment should be located so that it can be conveniently tied in fitted with any future expansion of the process. Space should be left for future needs service wise to be oversized to allow for future requirement.

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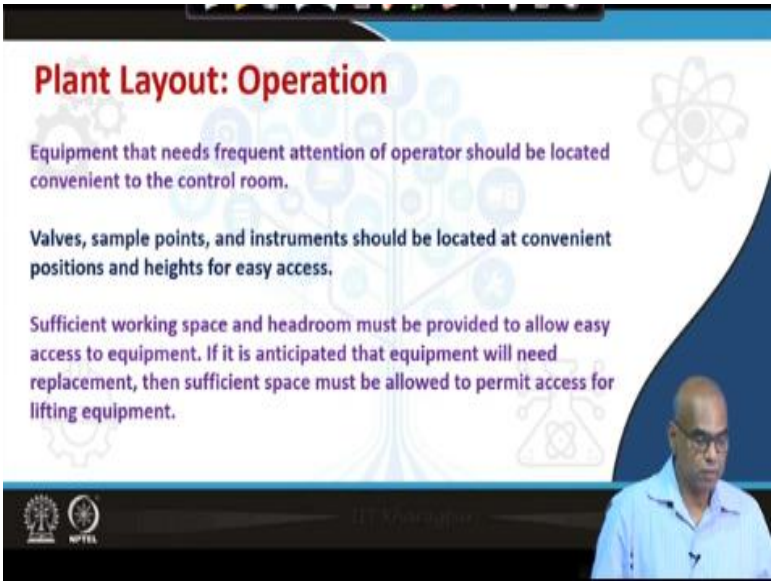

These are the factors based on ease of operation. Equipment that need frequent attention of operators should be located convenient to the control room. Valves, sample points and instruments should be located at convenient positions and heights for easy access. Sufficient working space and headroom must be provided to allow easy access to equipment. If it is anticipated that equipment will need replacement then sufficient space must be allowed to permit access to lifting equipment.

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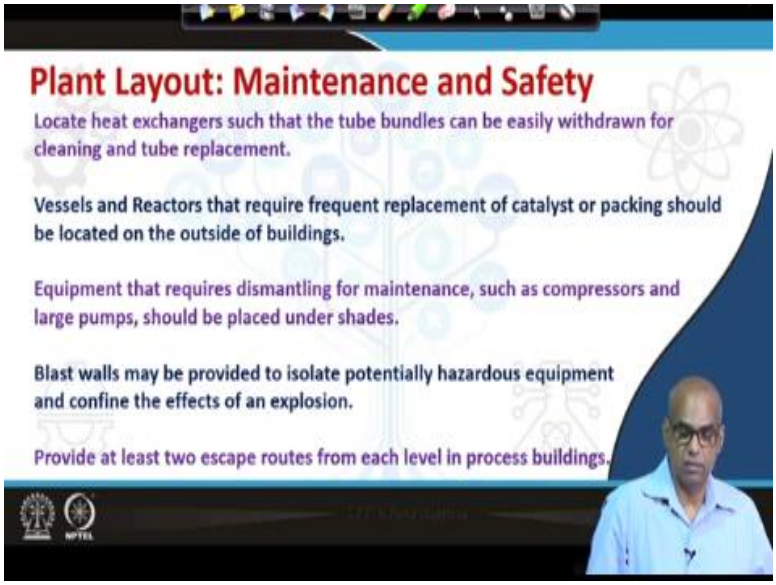

Now, let us consider some factors based on maintenance and safety. Locate heat exchangers such that the tube bundles can be easily withdrawn for cleaning and tube replacement. Vessels and reactors that require frequent replacement of catalyst or packing should be located on the outside of buildings. Equipment that requires dismantling for maintenance such as compressors and large pumps should be placed under shades.

Blast walls maybe provided to isolate potentially hazardous equipment and to confine the effects of an explosion. Provide at least two escape routes for operators from each level in process building.

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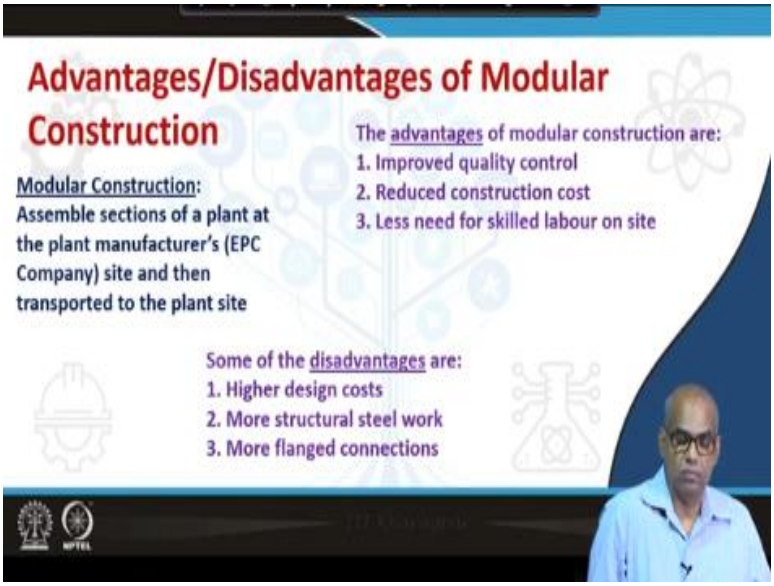

Now, let us talk about modular construction; modular construction is being popular these days you know, there are plant manufacturers we call them EPC Company, Engineering Procurement Construction Company they also do commissioning. So EPCC, Engineering Procurement Construction Commissioning Company. Modular construction means that some part or some sections of the plant is assembled at the site of the EPC Company and then that is transported to the plant site.

So instead of building everything on site EPC Company or the plant manufacturer company will assemble sections of a plant on their side and then it will be transported to the plant site. What is the advantage? Improved quality control, reduce construction cost and less requirement for skill labour on site. But there are disadvantages also higher design cost, more structural steel work, more flanged connections.

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What are the techniques used in preparing site and plant layout? So you must first prepare simple models for plant layouts and site layout. Simple physical models of plant layouts can be made using cardboard or rectangular and cylindrical blocks typically; a scale of 1 is to 30 may be used for large projects. Now models need not necessarily be physical models these days computer generated models are becoming more popular because they are more convenient and they more effectively convey information's.

So currently computer Aided design tools are being increasingly used for plant layout studies. Such models are replacing previously used physical models. Several proprietary software are available for the generation of three dimensional models of planned layout and piping. One can zoom in on a section of a plant and view it from various angles so that way it becomes very convenient also a virtual three dimensional work through the plant is now possible.

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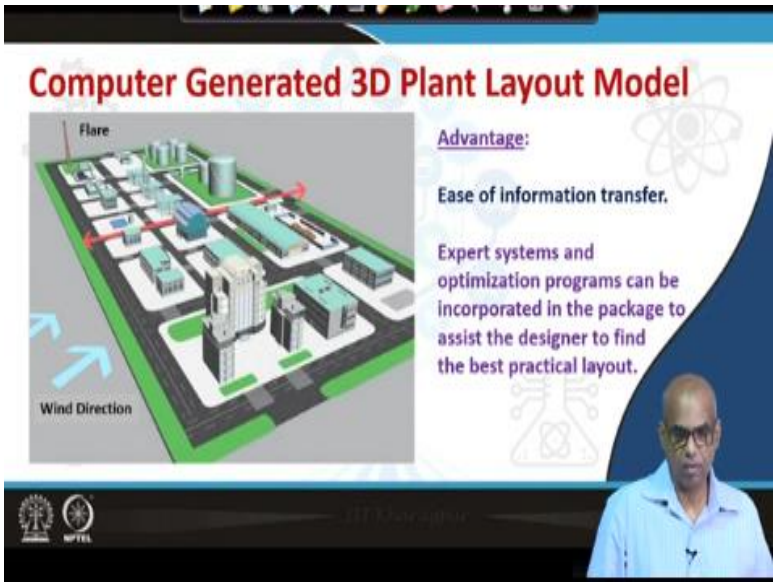

So this is a computer generated 3 D plant layout model. So look at the wind direction, you have the offices near the main entrance, you have the storage tanks, you have the flare. So the layout conforms to whatever we discussed as factors that we consider. So if you generate models for plant layout using computers software's, it becomes very easy to transfer this information say to your colleague.

So is of information transfer is an advantage for computer generated Plan layout model also expert systems and optimization algorithms can be incorporated in the package to assist the designer to find the best practical layout. So once you have developed using software a plant layout model. It should be possible to make use of optimization algorithms to come up with the best practical layout.

So you can formulate the layout optimization problem as an optimization problem, so not only you will use your past experience, but you can also make use of expert systems and optimization algorithms to find the best practical layout.

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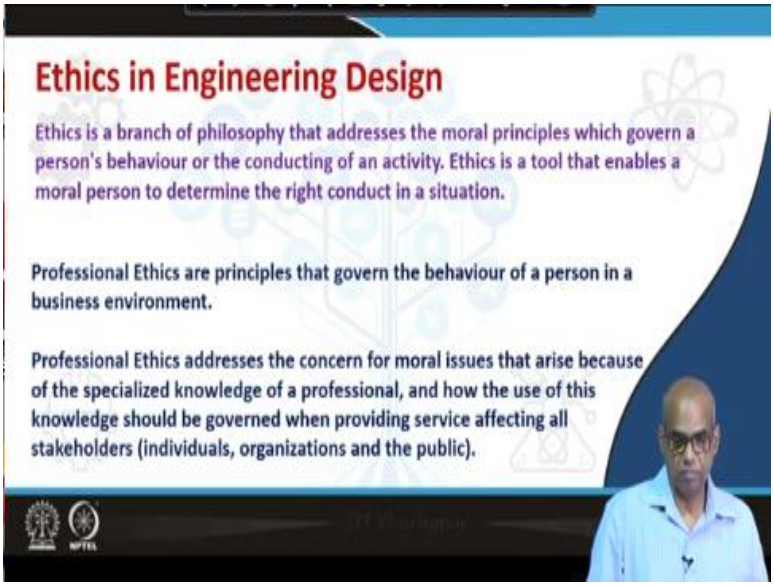

Now, we will briefly talk about ethics in engineering design. Ethics is a branch of philosophy that addresses the moral principles which govern a person's behaviour or the conducting of an activity. Ethics is a tool that enables a moral person to determine the right conduct in a situation. Professional ethics are principles that govern the behaviour of a person or a group of persons in a business environment.

Professional ethics addresses the concern for moral issues that arise because of the specialized knowledge of a professional and how the use of this knowledge should be governed when providing service affecting all stakeholders such as individuals, organizations and the public in general.

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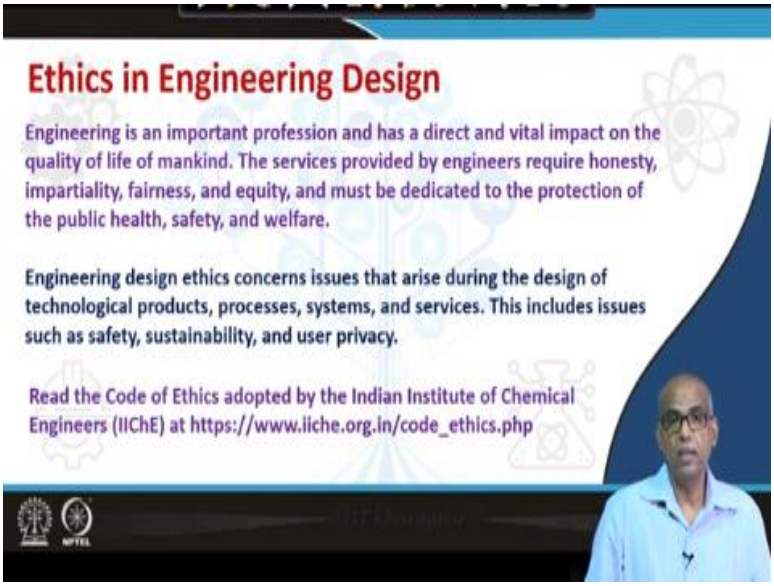

Engineering is an important profession and has a direct and vital impact on the quality of life on mankind. The services provided by the engineers require honesty, impartiality, fairness and equity and must be dedicated to the production of the public health, safety and welfare. Engineering design ethics concerns issues that arise during the design of technological products processes systems and services. This includes issues such as safety, sustainability and clients and users privacy.

You can read the code of ethics adapted by the Indian Institute of chemical engineers at the website shown on the slide. So there are various engineering bodies who have adopted various code of ethics. In India, we have Indian Institute of Chemical Engineers as a premier body professional body for the Chemical engineers and technologists. So you can log on to the website to read the code of ethics adapted by the Indian Institute of chemical engineers popularly known as IIChE, with this we stop our discussion today here, thank you for watching.