Catalog

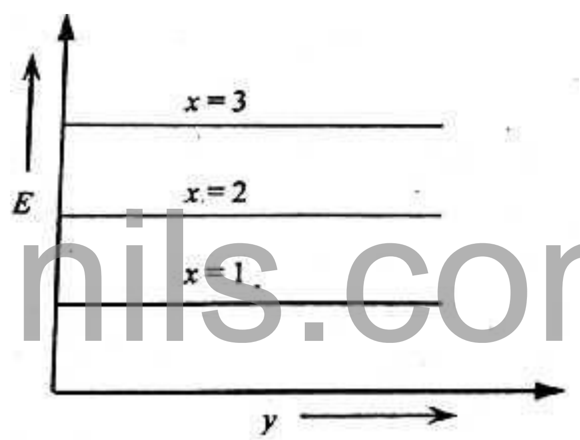
POWER TRAIFF TYPES

Energy Rates or Power Tariffs are the different methods of charging the consumers for the consumption of electricity. It is desirable to charge the consumer according to his maximum demand (kW) and the energy consumed (kWh).

1. Flat demand rate

In this type of charging, the charging depends only on the connected load and fixed number of hours of use per month or year.

This can be given by the following equation E = Ax



Flat demand rate

Here no metering equipments and manpower are required for charging. In this system, the consumer can theoretically use any amount of energy upto that consumed by all connected loads. The unit energy cost decreases progressively with an increased energy usage. The variation in total cost and unit cost are shown in fig.

2. Straight line meter rate

This type of charging depends upon the amount of total consumed by the consumer. The bill charge is directly proportional to the energy consumed by the consumer.

This can be represented by the following equation E = By

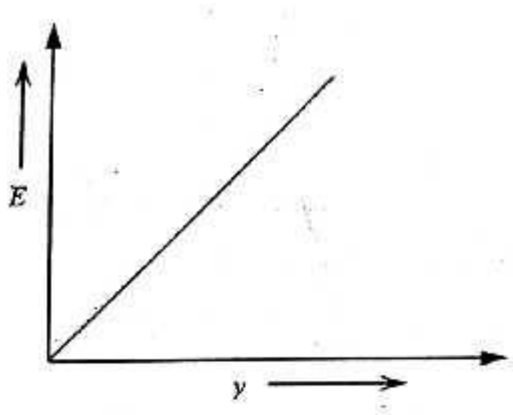
The major drawbacks of this system are:

1. In this type of system, the consumer using no energy ay any amount although he has incurred some expenses to the power station

2. The rate of energy is fixed, therefore this method of does not encourage the

consumer to use more power.

The variation in total cost and unit consumed are shown in the figure.



Straight meter rate

3. Block meter rate

In previous straight line meter rate the unit charge is same for all magnitudes of energy consumption. The increased consumption spreads the item of fixed charge over a greater number of units of energy.

Therefore, the price of energy should decrease with an increase in consumption. The block meter rate is used to overcome this difficulty.

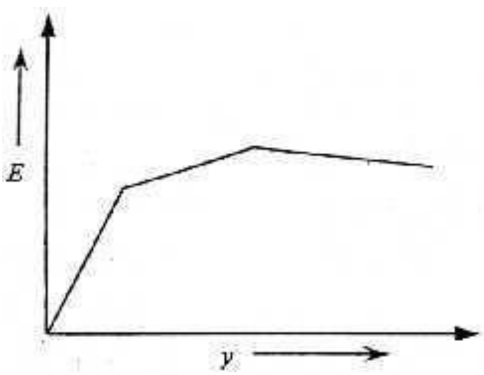
This method of charging is represented by the equation.

$E = B_1y_1 + B_2y_2 + B_3y_3 + \ldots\ldots.$

Where, $B_3 < B_2 < B_1$ and

$(y_1 + y_2 + y_3 + \ldots\ldots) = y$ (total energy consumption)

The level of $\mathbf{y_1}$ **,** $\mathbf{y_2}$ **,** $\mathbf{y_3}$ **……** is decided by the government to recover the capital cost, In this system, the rate of unit charge decrease with increase in consumption of energy as shown in fig.



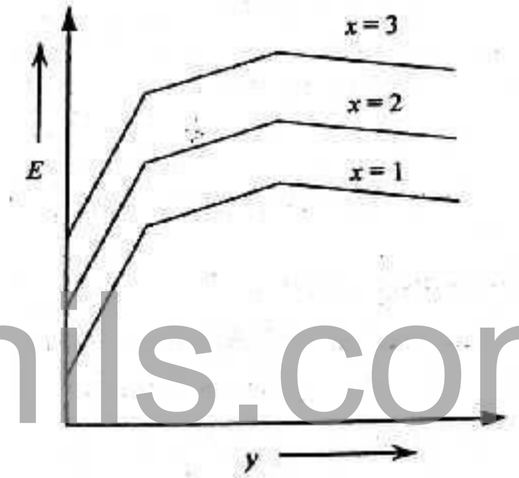
Block meter rate

4.Hopkinson demand rate or two part tariff

In this method of charging depends upon the maximum demand and energy consumption. This method is proposed by Dr.' John Hopknson in 1982.

This method of charging is represented by the equation E = A + By.

In this method two meters are required to record the maximum demand and the energy consumption of the consumer. This method is generally used for the industrial consumers. The variation in total cost with respect to the total energy consumption taking x as parameter is shown in fig.



Hopkinson method of charging

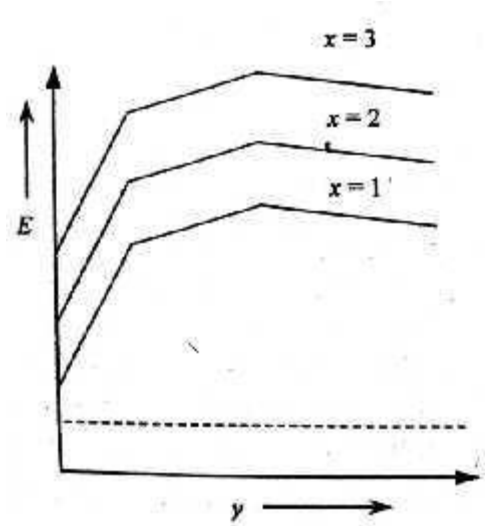
5. Doherty rate or three part tariff

This method is proposed by Henry L. Doherty. In this method of charging, the consumer has to pay some fixed amount in addition to the charges for maximum demand and energy consumed. The fixed amount to be charged depends upon the occasional increase in prices and wage charges of the workers etc.

This method of charging is expressed by the equation E = Ax + By + C.

This Doherty method of charging is most commonly used in Tamilnadu and all over India. In this method the customers are discouraged to use more power when the generating capacity is less than the actual demand.

For example, for the first 50kW-hr units the charging rate is fixed as, say, Rs. 2.5/Kw-hr and if it exceeds than this charge is rapidly increased as Rs. 3.5/kW-hr for next 100 kW-hr units (i.e from 51Kw-hr to 150kW-hr). This method is unfair to the customer, but very common in India and many developing nations.



Doherty method of charging

The variation in total cost with respect to the total energy consumption taking x as parameter is shown in fig.

LOAD CURVE AND LOAD DURATION CURVE

A power station is designed to meet the load requirements of the consumers. An ideal load on the station, from the stand point of equipment needed and operating routine, would be one of constant magnitude and steady duration. However, such a steady load on the station is never realized in actual practice.

The consumers require their small or large block of power in accordance with the demands of their activities. Thus the load demand of one consumer at any time may be different from that of the other consumer. The result is that load on the power station varies from time to time.

(i) Need of additional equipment:

The variable load on a power station necessitates having additional equipment. By way of illustration, consider a steam power station. Air, coal and water are the raw materials for this plant. In order to produce variable power, the supply of these materials will be required to be varied correspondingly.

For instance, if the power demand on the plant increases, it must be followed by the increased flow of coal, air and water to the boiler in order to meet the increased demand. Therefore, additional equipment has to be installed to accomplish this job. As a matter of fact, in a modern power plant, there is much equipment devoted entirely to adjust the rates of supply of raw materials in accordance with the power demand made on the plant.

(ii) Increase in production cost: The variable load on the plant increases the cost of the production of electrical energy. An alternator operates at maximum efficiency near its rated capacity. If a single alternator is used, it will have poor efficiency during periods of light loads on the plant. Therefore, in actual practice, a number of alternators of different capacities are installed so that most of the alternators can be operated at nearly full load capacity. However, the use of a number of generating units increases the initial cost per kW of the plant capacity as well as floor area required. This leads to the increase in production cost of energy.

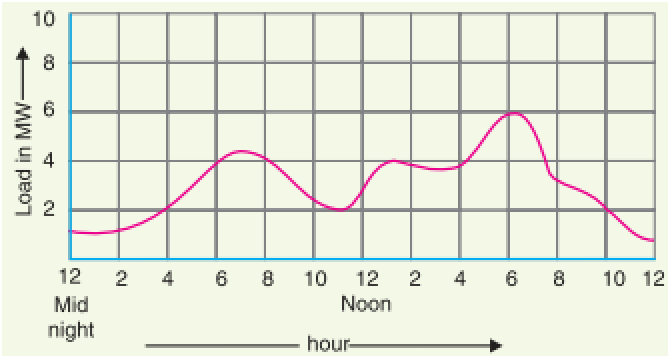
Load Curves:

The curve showing the variation of load on the power station with respect to with respect to time is known as a load curve.

The load on a power station is never constant; it varies from time to time. These load variations during the whole day (i.e., 24 hours) are recorded half-hourly or hourly and are plotted against time on the graph. The curve thus obtained is known as daily load curve as it shows the variations of load w.r.t. the time during the day. The figure below shows a typical daily load curve of a power station. It is clear that load on the power station is varying, being maximum at 6 P.M. in this case. It may be seen that load curve indicates at a glance the general character of the load that is being imposed on the plant. Such a clear representation cannot be obtained from tabulated figures.

The *monthly load curve* can be obtained from the *daily load curves* of that month. For this purpose, average values of power over a month at different times of the day are calculated and then plotted on the graph. The monthly load curve is generally used to fix the rates of energy. The yearly load curve is obtained by considering the monthly load curves of that particular year.

The yearly load curve is generally used to determine the annual load factor.



Importantterms

The **variable load** problem has introduced the following terms and factors in power plant engineering:

(i) Connected load: It is the sum of continuous ratings of all the equipment connected to supply system. A power station supplies load to thousands of consumers. Each consumer has certain equipment installed in his premises. The sum of the continuous ratings of all the equipment in the consumer's premises is the "connected load" of the consumer.

For instance, if a consumer has connections of five 100-watt lamps and a power point of 500 watts, then connected load of the consumer is 5 × 100 + 500 = 1000 watts. The sum of the connected loads of all the consumers is the connected load to the power station.

(ii) Maximum demand: It is the greatest demand of load on the power station during a given period. The load on the power station varies from time to time. The maximum of all the demands that have occurred during a given period (say a day) is the maximum demand. Thus referring back to the load curve of Figure below the maximum demand on the power station during the day is 6 MW and it occurs at 6 P.M. Maximum demand is generally less than the connected load because all the consumers do not switch on their connected load to the system at a time. The knowledge of maximum demand is very important as it helps in determining the installed capacity of the station. The station must be capable of meeting the maximum demand.

The value of demand factor is usually less than 1.It is expected because maximum demand on the power station is generally less than the connected load. If the maximum demand on the power station is 80 MW and the connected load is 100 MW, then demand factor = 80/100 = 0·8.

(iv) Average load: The average of loads occurring on the power station in a given period (day or month or year) is known as average load or average demand.

$$\text{Daily average load} = \frac{\text{No. of units (kWh) generated in a day}}{24 \text{ hours}}$$

$$\text{Monthly average load} = \frac{\text{No. of units (kWh) generated in a month}}{\text{Number of hours in a month}}$$

$$\text{Yearly average load} = \frac{\text{No. of units (kWh) generated in a year}}{8760 \text{ hours}}$$

(v) Load factor: The ratio of average load to the maximum demand during a given period is known as load factor.

$$\text{Load factor} = \frac{\text{Average load}}{\text{Max. demand}}$$

If the plant is in operation for T hours,

$$\text{Load factor} = \frac{\text{Average load} \times T}{\text{Max. demand} \times T} = \frac{\text{Units generated in T hours}}{\text{Max. demand} \times \text{T hours}}$$

The load factor may be daily load factor, monthly load factor or annual load factor if the time period considered is a day or month or year. Load factor is always less than 1 because the average load is smaller than the maximum demand. The load factor plays a key role in determining the overall cost per unit generated.

(vi) Diversity factor: The ratio of the sum of individual maximum demands to the maximum demand on power station is known as diversity factor

$$\text{Diversity factor} = \frac{\text{Sum of individual max. demands}}{\text{Max. demand on power station}}$$

A power station supplies load to various types of consumers whose maximum demands generally do not occur at the same time. Therefore, the maximum demand on the power station is always less than the sum of individual maximum demands of the consumers. Obviously, diversity factor will always be greater than 1.

(vii) Plant capacity factor: It is the ratio of actual energy produced to the maximum possible energy that could have been produced during a given period

$$\text{Plant capacity factor} = \frac{\text{Actual energy produced}}{\text{Max. energy that could have been produced}}$$
$$= \frac{\text{Average demand} \times T^{**}}{\text{Plant capacity} \times T}$$
$$= \frac{\text{Average demand}}{\text{Plant capacity}}$$

$$\text{Annual plant capacity factor} = \frac{\text{Annual kWh output}}{\text{Plant capacity} \times 8760}$$

The plant capacity factor is an indication of the reserve capacity of the plant. A power station is so designed that it has some reserve capacity for meeting the increased load demand in future. Therefore, the installed capacity of the plant is always somewhat greater than the maximum demandontheplant. It is interesting to note that difference between load factor and plant capacity factor is an indication of reserve capacity. If the maximum demand on the plant is equal to the plant capacity, then load factor and plant capacity factor will have the same value..

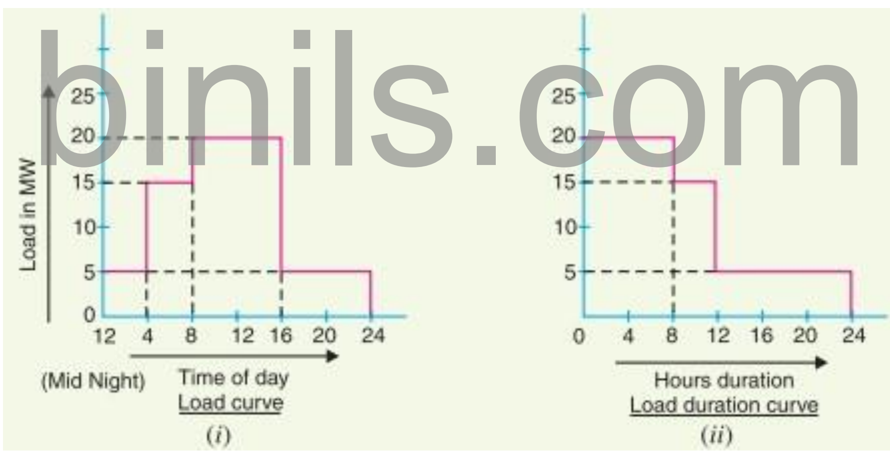
(viii) Plant use factor: It is ratio of kWh generated to the product of plant capacity and the number of hours for which the plant was in operation i.e.

$$\text{Plant use factor} = \frac{\text{Station output in kWh}}{\text{Plant capacity} \times \text{Hours of use}}$$

Load duration curve:

When the load elements of a load curve are arranged in the order of descending magnitudes, the curve thus obtained is called a load duration curve.The load duration curve is obtained from the same data as the load curve but the ordinates are arranged in the order of descending magnitudes. In other words, the maximum load is represented to the left and decreasing loads are represented to the right in the descending order.

Hence the area under the load duration curve and the area under the load curve are equal. The figure below shows the daily load curve. The daily load duration curve can be readily obtained from it. It is clear from *daily load curve*, those load elements in order of descending magnitude are 20 MW for 8 hours; 15 MW for 4 hours and 5 MW for 12 hours. Plotting these loads in order of descending magnitude, we get the *daily load duration curve* as shown in Figure below.



The following points may be noted about load duration curve:

(i) The load duration curve gives the data in a more presentable form. In other words, it readily shows the number of hours during which the given load has prevailed.

(ii)The area under the load duration curve is equal to that of the corresponding load curve. Obviously, the area under *daily load duration curve* (in kWh) will give the units generated on that day.

(iii) The load duration curve can be extended to include any period of time. By laying out the abscissa from 0 hours to 8760 hours, the variation and distribution of demand for an entire year can be summarized in one curve. The curve thus obtained is called the *annual load duration curve*.

Types of loads:

A device which taps electrical energy from the electric power system is called a load on the system. The load may be resistive (e.g., electric lamp), inductive (e.g., induction motor), capacitive or some combination of them. The various types of loads on the power system are :

(i) Domestic load: *Domestic load* consists of lights, fans, refrigerators, heaters, television, small motors for pumping water etc. Most of the residential load occurs only for some hours during the day (i.e., 24 hours) e.g., lighting load occurs during night time and domestic appliance load occurs for only a few hours. For this reason, the load factor is low (10% to 12%).

(ii) Commercial load: This type of load consists of lighting for shops, fans and electric appliances used in restaurants etc. This class of load occurs for more hours during the day as compared to the domestic load. The commercial load has seasonal variations due to the extensive use of air conditioners and space heaters.

(iii) Industrial load: Industrial load consists of load demand by industries. The magnitude of industrial load depends upon the type of industry. Thus small scale industry requires load up to 25 kW, medium scale industry between 25kW and 100 kW and large-scale industry requires load above 500 kW. Industrial loads are generally not weather dependent.

(iv) Municipal load: Municipal load consists of street lighting, power required for water supply and drainage purposes. Street lighting load is practically constant throughout the hours of the night. For water supply, water is pumped to overhead tanks by pumps driven by electric motors. Pumping is carried out during the off-peak period, usually occurring during the night. This helps to improve the load factor of the power system.

(v) Irrigation load: This *type of load* is the electric power needed for pumps driven by motors to supply water to fields. Generally this type of load is supplied for 12 hours during night.

(vi) Traction load: This type of load includes tram cars, trolley buses, railways etc. This class of load has wide variation. During the morning hour, it reaches peak value because people have to go to their work place. After morning hours, the load starts decreasing and again rises during evening since the people start coming to their homes.

SELECTION OF SITE FOR HYDRO ELECTRIC POWER PLANT

1. **Water Available**. To know the available energy from a given stream or river, the discharge flowing and its variation with time over a number of years must be known. Preferably, the estimates of the average quantity of water available should be prepared on the basis of actual measurements of stream or river flow. The recorded observation should be taken over a number of years to know within reasonable, limits the maximum and minimum variations from the average discharge. The river flow data should be based on daily, weekly, monthly and yearly flow ever a number of years. Then the curves or graphs can be plotted between tile river flow and time. These are known as hygrographs and flow duration curves.

The plant capacity and the estimated output as well as the need for storage will be governed by the average flow. The primary or dependable power which is available at all times when energy is needed will depend upon the minimum flow. Such conditions may also fix the capacity of the standby plant. The, maximum of flood flow governs the size of the headwords and dam to be built with adequate spillway.

2. **Water-Storage**. As already discussed, the output of a hydropower plant is not uniform due to wide variations of rain fall. To have a uniform power output, a water storage is needed so that excess flow at certain times may be stored to make it available at the times of low flow. To select the site of the dam ; careful study should be made of the geology and topography of the catchment area to see if the natural foundations could be found and put to the best use.

3. **Head of Water.** The level of water in the reservoir for a proposed plant should always be within limits throughout the year.

4. **Distance from Load Center**. Most of the time the electric power generated in a hydro-electric power plant has to be used some considerable distance from the site of plant. For this reason, to be economical on transmission of electric power, the routes and the distances should be carefully considered since the cost of erection of transmission lines and their maintenance will depend upon the route selected.

5. Access to Site. It is always a desirable factor to have a good access to the site of the plant. This factor is very important if the electric power generated is to be utilized at or near the plant site. The transport facilities must also be given due consideration.

SELECTION OF SITE FOR NUCLEAR POWER PLANT

The various factors to be considered while selecting the site for nuclear plant are as follows :

1. Availability of water. At the power plant site an ample quantity of water should be available for condenser cooling and made up water required for steam generation. Therefore the site should be nearer to a river, reservoir or sea.

2. Distance from load center. The plant should be located near the load center. This will minimise the power losses in transmission lines.

3. Distance from populated area. The power plant should be located far away from populated area to avoid the radioactive hazard.

4. Accessibility to site. The power plant should have rail and road transportation facilities.

5. Waste disposal. The wastes of a nuclear power plant are radioactive and there should be sufficient space near the plant site for the disposal of wastes.

SELECTION OF SITE FOR THERMAL POWER PLANT

1. Land Availability. Power plant needs a wide range of land requirements. For example, coal plants tend to need larger areas to support rail lines, coal piles, and landfills. Natural gas-fired power plants may only need area for the generation facilities and support equipment. Needed information includes the site size (acres), and the portion of the site (acres) that would be occupied by plant buildings and systems.

2. Water Availability. Many power plant technologies use water from lakes, rivers, municipal water utilities, or groundwater. Surface water is used for plant cooling and groundwater is used for plant processes. Generally, the presence of adequate and usable water resources at or near a site is preferred over sites with remote, inadequate, or low-quality water resources.

3. **Fuel Availability.** Fuel availability influences choices positively; its marginal utility is diminishing with supply. Without a higher level of availability, alternative fuels are unlikely to be adopted.

4. **Skilled Manpower**. Availability A power plant requires labor for construction and operation. Local communities can benefit from these employment opportunities. Generally, sites that can make use of local labor are more desirable. These sites would have a larger skilled work force within a short distance from the plant site.

5. **Land Acquisition Cost**. Each site will have unique land acquisition requirements and effects. Generally, sites that have lower land acquisition costs and require shorter acquisition times are more desirable.

6. **Future Development Limitations**. The construction of a plant at a particular site may create limitations on future development in the local area through its effect on land use or through its consumption of local PSD air increments, water resources, or water discharge capacity. Generally, sites that impose fewer limitations on future development may be more desirable.

7. **Possibility of Site Expansion**. A site might be able to support more generating capacity than proposed. It's usually more economical and environmentally acceptable to add generating capacity at an existing site than to build at a new site.. Often, an expandable site may be more desirable. But, a potential concern of local property owners is the effect of plant siting on nearby property values. Generally, sites that enhance property values or minimize the decrease in property values may be more desirable.

WASTE DISPOSAL OPTIONS FOR THERMAL POWER PLANT

The disposal of the increasing amounts of solid waste from coal-fired thermal power plants is becoming a serious concern to the environmentalists. Coal ash, 80% of which is very fine in nature and is thus known as fly ash is collected by electrostatic precipitators in stacks. A 400 *MW* thermal power plant emits 500 *tons* of fly ash per day and the ash content of coal in India varies from 3 to 42%. In India, nearly 85 million tonnes per year of flyash is generated per annum at present and is largely responsible for environmental pollution. Although the scope for use of ash in concrete, brick making, soil-stabilization treatment and other applications has been well recognized, only a small quantity of the total ash produced in India is currently utilized in such applications. Most of the ash generated from the power plants is disposed off in the vicinity of the plant as a waste material covering several hectares of valuable land. The bulk utilization of ash is possible in two areas, namely, ash dyke construction and filling of low-lying areas.

(i) Flyash disposal in ash ponds:

Primarily, the flyash is disposed off using either dry or wet disposal scheme. In *dry disposal*, the flyash is transported by truck, chute or conveyor at the site and disposed off by constructing a dry embankment (dyke). In *wet disposal*, the flyash is transported as slurry through pipe and disposed off in impoundment called "ash pond". Most of the power plants in India use wet disposal system, and when the lagoons are full, four basic options are available:

(a) Constructing new lagoons using conventional constructional material,

(b) Hauling of flyash from the existing lagoons to another disposal site,

(c) Raising the existing dyke using conventional constructional material, and

(d) Raising the dyke using flyash excavated from the lagoon ("ash dyke").

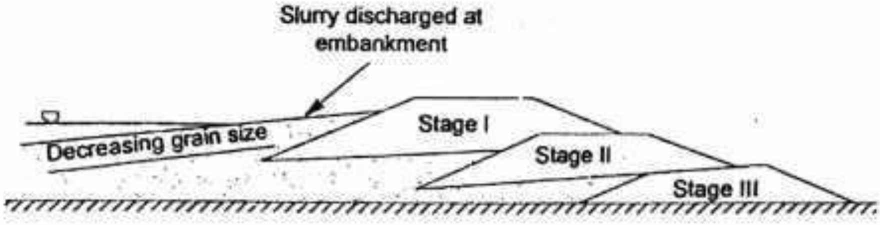
The option of raising the existing dyke is very cost effective because any fly ash used for constructing dyke would, in addition to saving the earth filling cost, enhance disposal capacity of the lagoon. The constructional methods for an ash dyke can be grouped into three broad categories:

(a) Upstream method,

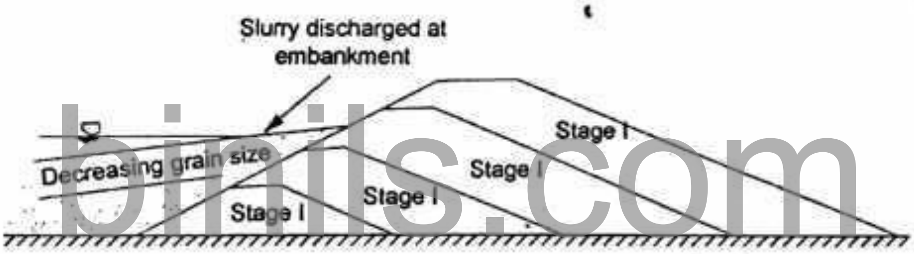
(b) Downstream method and

(c) Centerline method.

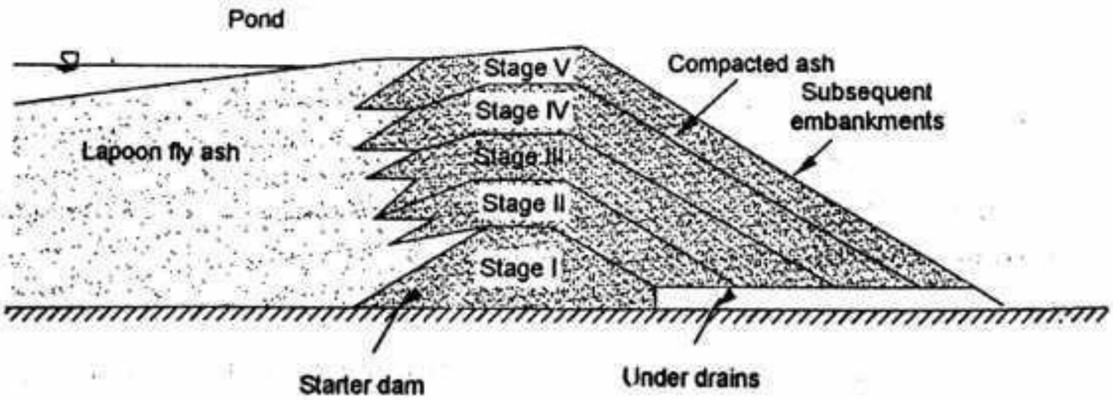
Figure shows typical configurations of embankments constructed using the different methods. The construction procedure of an ash dyke includes surface treatment of lagoon ash, spreading and compaction, benching and soil cover.



(a) Upstream Method



(b) Downstream Method



(c) Centreline Method

Typical ash dyke raising configurations

According to the hazardous waste management and handling rule of 1989, flyash is considered as non-hazardous. With the present practice of fly-ash disposal in ash ponds (generally in the form of slurry), the total land required for ash disposal would be about 82,200 hectare by the year 2020 at an estimated 0.6 hectare per MW. Flyash can be treated as a by-product rather than waste.

(ii) Treatment of wastewater of steam power plant:

If the waste water from the power plant is not properly handled, it will pollute the water basin. Various types of waste water collected from the steam power plant are given below.

(i) Waste water from water treatment plants.

(ii) Water from hydraulic ash disposal system.

(iii) Rainwater collected on the territory of power plant.

(iv) Cooling waters used in power plants.

The waste water from water treatment plants contains various metal salts, acids and alkalis which may affect the water basin. It ensures the waste water of hydraulic ash disposal system not having any contaminations before it goes to the water basin. The cooling water of plant carries an enormous amount of heat. This heat will affect the water basin. So, the heat is to be reduced before it goes to the basin. The water purification is done by the following methods.

1. Filtering
2. Flotation
3. Centrifuging
4. Coagulation
5. Setting and clarifying
6. Bio-chemical methods.

POLLUTION CONTROL TECHNOLOGIES INCLUDING WASTE DISPOSAL OPTIONS FOR NUCLEAR POWER PLANTS

Nuclear power is classified as a clean energy source because of absence of noxious combustion products and the supply of fuel which will last for centuries when breeder reactors become operational. The nuclear power generation poses mainly two problems as follows.

(i) The management of radioactive waste, and

(ii) The danger passed in case of accident is very high and long standing.

The radioactive emission during the operation of the power plant is negligible but the emission intensity is very high which comes out from wastes. They emit large quantities of γ-rays which are very danger for living matters.

The radioactive waste coming out of 400 *MW* power plant would be equal to 100 *tons* of radium daily. This much of radioactive waste disposed to the atmosphere would kill all living organisms within the area of about 100 *square kilometers*. Therefore, safe disposal of nuclear waste is a major problem and it is very much essential. Many numbers of methods are developed for the last 25*years* to dispose off various types of nuclear waste safely.

The nuclear wastes are classified as follows.

(i) On the basis of half-life time

(a) Fission products

(b) Actirides

(c) The neutron activation products.

(ii) On the basis of the intensity of radiation

(a) Low level waste

(b) Medium level waste

(c) High level waste.

1. Fission products:

The wastes produced from reactor operations include fission products and Plutonium. The half-lives of most of the fission products are 30 *years* or less. Their toxic lifetime is in the order of 500 *years* to 1000 *years*. Most of the fission products are initially radioactive and decay with the emission of β and γ-rays.

2. Actinides:

Actinides are produced in nuclear reactors as a result of neutron capture by Uranium. The most important is Plutonium. The other actinides are neptunium, americium and curium. The actinides decay mainly by emission of α-particles until a stable isotope of load is formed.

TYPES OF NUCLEAR WASTES

α-particles can be easily stopped. Therefore, actinides do not require thick shieling. However, α-particles are very energetic and toxic if inhaled as dusts.

3. Neutron activation products:

These are produced when fast neutrons are absorbed by structural materials in reactors as coolant, fuel cladding etc. These products decay with the emissions of β and γ radiations.

4. Low level wastes:

Low level wastes contain less than 10 *nanocuries per gram* of trans uranium contaminants. They have low but potentially hazardous concentration of radioactive materials. Low level wastes are produced in almost all activities such as power generation, medical, Industrial etc. They involve with radioactive materials. They require little or no shielding and they are usually disposed off in liquid form through shallow land burial.

5. Medium level wastes:

Medium level wastes contain more than 10 nanocuries but they are less than 100 nanocuries per *gram* of trans uranium contaminants. These wastes are mainly contaminated with neutron activation product isotopes.

6. High level wastes:

The high level wastes contain more than 100 *nanocuries per gram* of trans uranium contaminants. These are generated by reprocessing of spent fuel. The spent fuel is withdrawn from the reactor and placed in a water pond. The heat is removed from the water pond. The pond wastes are continually treated to remove activity due to release of fuel from defective cladding. The spent fuel is then transferred to the reprocessing plant where the cladding contains the fuel to be removed and the fuel is dissolved in nitric acid. U^{235} and Pu^{239} are then removed around 99% non-volatile fission products behind in solution known as "***highly active liquid waste***".

Effects of High-Level Wastes

It is important to study the effects of high level wastes to biological systems. The principle effect is the destruction of body cells in the vicinity of the irradiated region due to interaction of the radiation and tissue. The interaction between radiation and tissue is manifested in three ways.

1. Ionization:

The formation of ion-pair in tissue requires $32.5eV$ of energy when a single $1Mev$ β-particle is stopped by tissue about 3100 *ion-pairs* formed. If $1cm^2$ area of tissue surface is subjected to a beam of β-particles/cm^2/s, 31×10^6 *ion-pairs* will be formed in each second. This absorption results the complete damage of tissues in the body of man or beast or bird.

2. Displacement:

If the energy of the impinging particle is sufficiently high, an atom in the tissue is displaced from its normal lattice position with possible adverse effects. Neutron and γ-radiation result the atomic displacement.

3. Absorption:

Absorption of neutron by a tissue nucleus results the formation of a radioactive nucleus and it changes the chemical nature of the nucleus. It causes malfunctioning of the tissue cell and the cell damage causes severe biological effects including genetic modifications.

NUCLEAR WASTE DISPOSAL

These wastes must be disposed off in such a manner that there is no harm to human, animal or plant lives. Solids of low and medium level wastes are buried at a depth of few meters at carefully selected sites. Gaseous wastes are discharged to the atmosphere through high stacks. Liquids having low or medium level of radioactivity are given preliminary treatment to remove the most of activity in the form of solid precipitate and then it is discharged in dry wells or deep pits. Different methods for various nuclear wastes disposed are discussed below.

Disposal of Low Level Solid Waste

Low level solid waste requires little or no shielding. It is usually disposed off by keeping it in a steel or concrete tank. These tanks are buried either few meters below the soil or kept at the bed of the Ocean shown in Figure

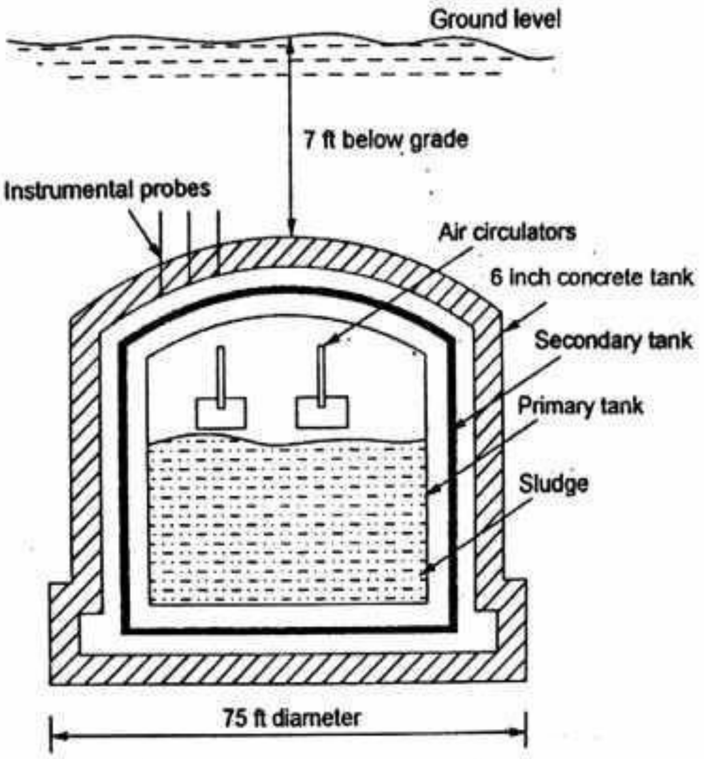


Figure ***Disposal of low level solid waste***

Disposal of Medium Level Solid Wastes

Medium level wastes are mainly contaminated with neutron activation product isotopes. They are incorporated into cement cylinders. Cement is non-combustible material and it provides shielding against the external exposure. Cement is also having the ability of resistance to reach by ground water.

Disposal of High Level Wastes

Spent fuel from the nuclear reactor can either be stored directly or reprocessed. The storage system avoids the cost and hazards associated with a reprocessing plant. The second method utilizes reprocessing of unused uranium and converted into Plutonium and other radioisotopes for the use in wide variety of services such as isotope generators, medicine, agriculture and industry.

Reprocessing of the spent fuel is done by dissolving it in nitric acid and then removing the converted Plutonium and unspent uranium by solvent extraction. The remaining solution contains more than 99.99% of the non-volatile fission products plus some constituents of the cladding of fuel elements, traces of plutonium and Uranium.

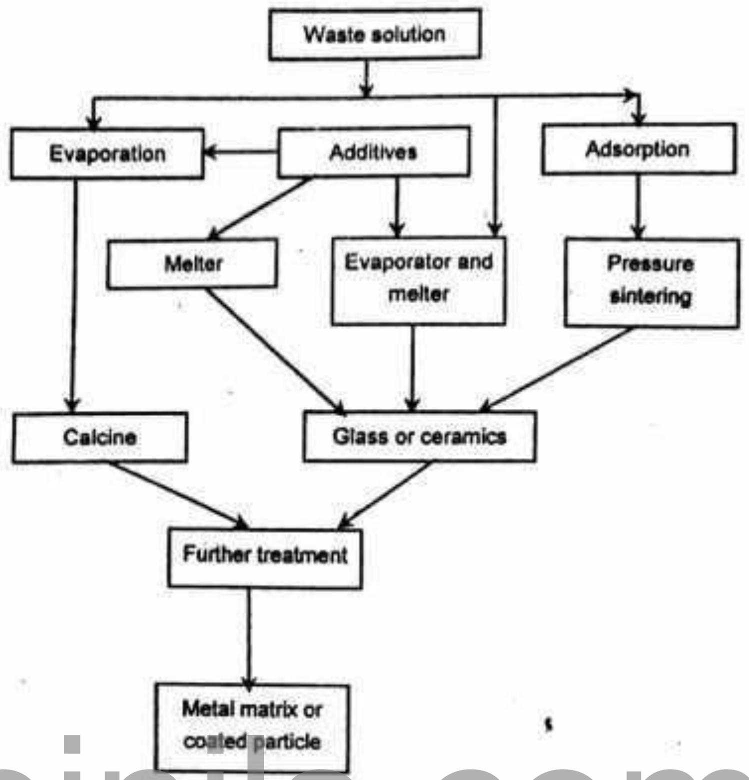


Figure 5.30 Basic high level waste solidification processes

The remaining solution consists of high level wastes. It is usually concentrated by evaporation. It is then stored as an aqueous nitric acid solution usually in high integrity stainless steel tanks. However, the permanent storage in liquid form requires continuous supervision and tank replacement over an indefinite period of time.

The conversion of the liquid wastes to a solid form is very important. It avoids leakages. It requires less supervision and it is more suitable for final disposal. Advanced processes are currently being developed. This solid product should maintain its mechanical strength. Ideally, it should have a low leak rate.

Glasses and ceramics are now considered to be most suitable forms for this final disposal. The basic processes are shown in Figure 5.30. It involves in evaporation and de-nitration (or calcinations) to form a granular or solid calcine. It is considered an interim product since it does not meet all above requirements. It is treated further by being mixed with additives and it is then melted to form glasses or ceramics.

A second process involves mixing of additives with the original waste solution, evaporating, de-nitrating and melting this mixture to form glasses or ceramics.

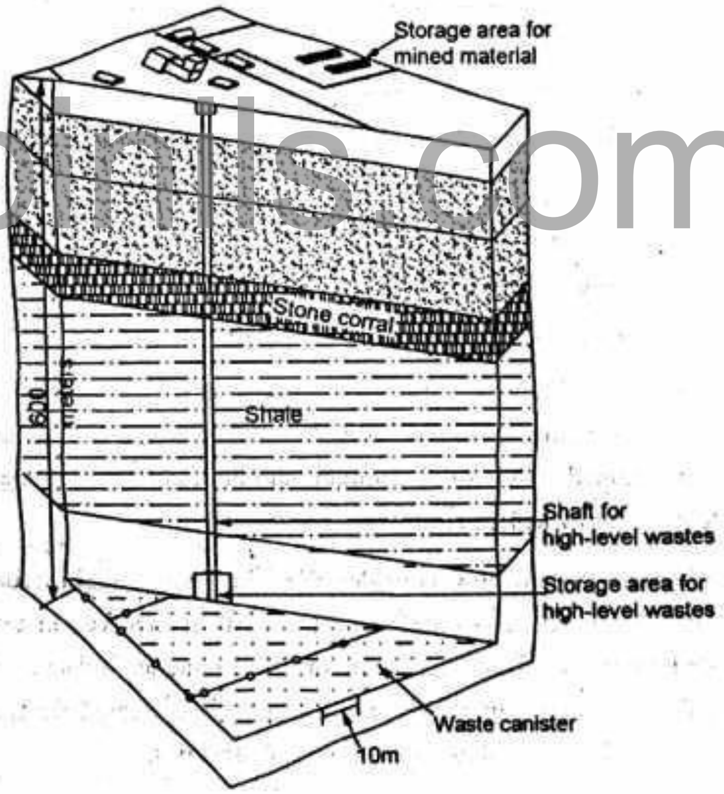
A third process uses an adsorption process and treatment at high temperature to produce ceramics.

Most solidification plants produce steam from off-gases and oxides of nitrogen that usually contain some fine particulate carryover and volatile radio-nuclides. These gases must be treated. All processes involve high temperature as well as high level of radioactivity.

Underground Disposal of High Level Waste

The final disposal of wastes with or without above treatments is also a major concern. Many countries are undertaking activities involving underground disposal in deep geological formation. These activities include the investigation of suitable sites and suitable methods of storing in these sites.

The main objectives are the protection of present and future populations from potential hazards. The suitable sites must be free of flowing ground wastes but the storage vessels must demonstrate the reliability even in flowing condition.



Underground disposal of high level nuclear waste