Important Terms and Definitions :-

Connected load :-

It is the Combined Continuous rating of all receiving apparatus on Consumer's premises. If a Consumer has Connections for 3 lamps of 40 W each and power point of 500 W for refrigerator and TV consuming 60 W, then the total connected load of the Consumer $= 3 \times 40 + 500 + 60 = 680$ W.

Demand :-

It is the load which is drawn from the source of supply at the receiving terminals averaged over a suitable and specified interval of time.

Maximum demand :-

It is the maximum load which is used by a Consumer at any time. It is determined by the Measurement according to specifications over a prescribed Interval of time. It Can be less than or equal to connected load. But generally, the actual maximum demand is less than the connected load because all loads never run in full load at the same time.

Demand factor :-

It is the ratio of actual maximum demand of the System to the total connected demand of the system.

$$\text{Demand factor} = \frac{\text{Actual maximum demand}}{\text{Total connect demand}}$$

Load factor :-

It is the ratio of the average load over a given time interval to the peak load during the same time interval

$$\text{Load factor} = \frac{\text{Average load over a given time interval}}{\text{peak load during the same time}}$$

... less than unity.

Capacity factor or plant capacity factor:

It is the ratio of actual energy produced in kilowatt hours (kWh) to the maximum possible energy which could have been produced during the same period.

$$\text{Capacity factor} = \frac{\text{Actual energy produced in kWhr}}{\text{Rated capacity of the plant}} = \frac{E}{C \times t}$$

$$\text{Capacity factor} = \frac{\text{Average load}}{\text{Rated capacity of the plant}}$$

where
- $E \Rightarrow$ Energy produced in kWh
- $C \Rightarrow$ Capacity of the plant in kW
- $t \Rightarrow$ Total numbers of hours in given period.

The load factor and capacity factor of the plant is will be numerically equal.

Utilization factor:-

It is the ratio of maximum load to the rated capacity of the plant

$$\text{Utilization factor} = \frac{\text{Maximum load}}{\text{Rated capacity of the plant}}.$$

Reserve factor:-

It is the ratio of load factor to the capacity factor.

$$\text{Reserve factor} = \frac{\text{Load factor}}{\text{Capacity factor}}$$

Dump power:-

This term is used in hydroelectric power plants. It shows the power in excess of the load requirements.

Prime power:-

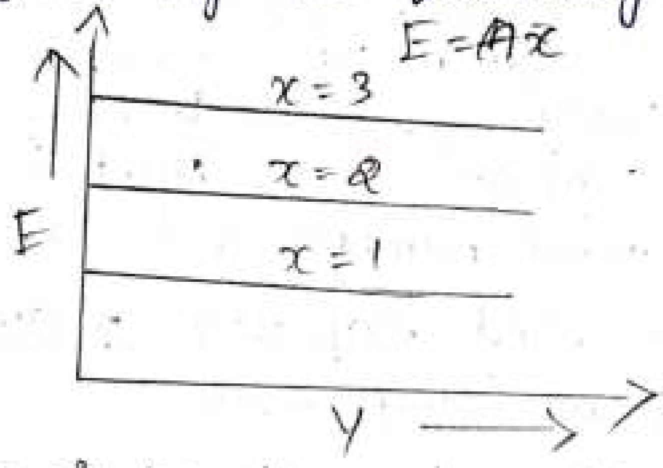
The power may be mechanical power, Hydraulic power or thermal power which is always available for the conversion into

The various forms used for charging consumers as per their energy consumed and Maximum demand are discussed below.

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. It can be given by the following equation.

$$E = Ax$$

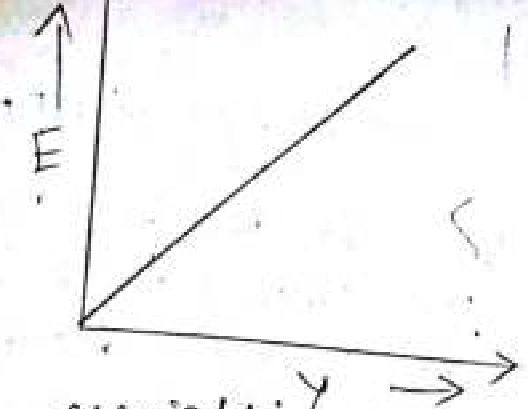


flat demand rate

As per the above discussions, the notations are taken. This rate expresses the charge per unit of demand (kW) of the consumer. Here, no metering equipment and manpower are required for charging. In this system, the consumer can theoretically use any amount of energy consumed by all connected loads. The unit energy cost decreases progressively with an increased energy usage. The variation in total cost and unit cost.

Straight line Meter Rate :-

This type of charging depends on the amount of total energy consumed by the consumer. The bill charge is directly proportional to the energy consumed by the consumer. It can be represented by the following equation.



straight meter rate

The major drawbacks of this system are as follows.

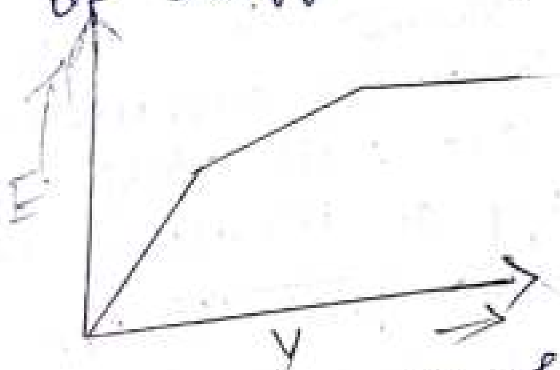
a) In this type of system, the consumer using no energy will not pay any amount although he/she incurred some expenses to the power station.

b) The rate of energy is fixed. Therefore, this method of charging does not encourage the consumer to use more power.

The variation in total cost and unit consumed.

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 reduce with increase in energy consumption. The block meter rate is used to overcome this difficulty. This method of charging is by the equation.

$E = B_1 Y_1 + B_2 Y_2 + \ldots$

where $B_3 < B_2 < B_1$ and

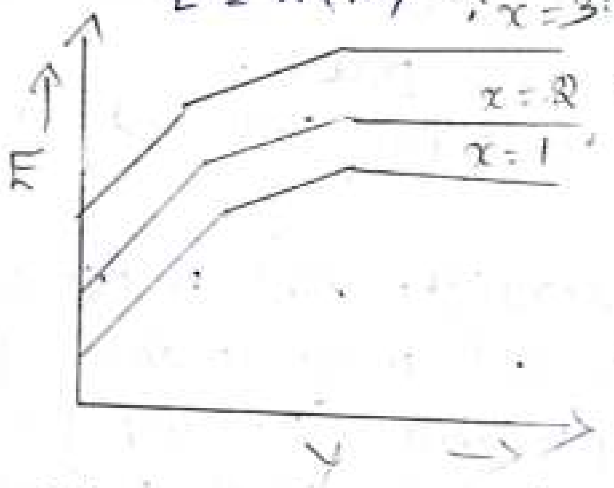
$Y_1 + Y_2 + Y_3 + \ldots = Y$ (total energy consumption)

The level of $Y_1, Y_2, Y_3 \ldots$ is decided by the government to recover the capital cost. In this system, the rate of unit charge decreases with increase in consumption of energy.

Hopkinson Demand Rate of Two-part Tariff:

This method of charging depends on the maximum demand and energy consumption. This method is proposed by Dr. John Hopkinson in 1982. This method of charging is represented by the equation

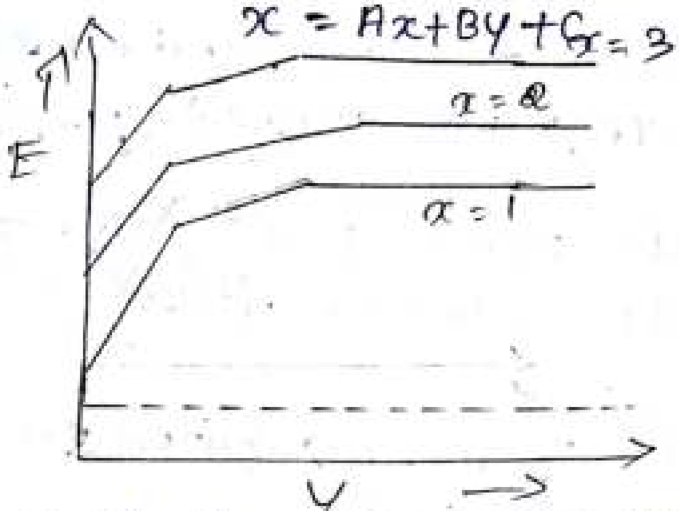
$$E = A + BY$$



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

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 charges for maximum demand and energy depends on the occasional increase in prices and wage charges of the workers etc. This method of charging is expressed by the equation



This 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 actual demand. For examples, for the first 50 KWh units, the charging rate is fixed, says Rs 2.5/KWh and if it exceeds this charge it is rapidly increased as Rs 3.5/KWh for next 100 KWh unit (ie) from 51 KWh to 150 KWh) this method is unfair to the customer but it is very common in India and many developing nations.

LOAD DISTRIBUTION PARAMETERS

The loads are distributed in many ways. The various type of loads are described below.

Residential load :-

This type of load includes domestic lights and power needed for domestic appliances such as radios, television, electric cookers, water heaters, refrigerators, grinders etc.

Commercial load

It includes lighting for shops, advertisements and electric appliances used in shops, hotels restaurant etc

Industrial load :-

It consists of load demand of various Industry

Municipal load :-

It consists of power required for street lights, water supply and drainage purposes.

Irridation load :-

It includes electrical power required for pumps to supply water to fields.

Traction load :-

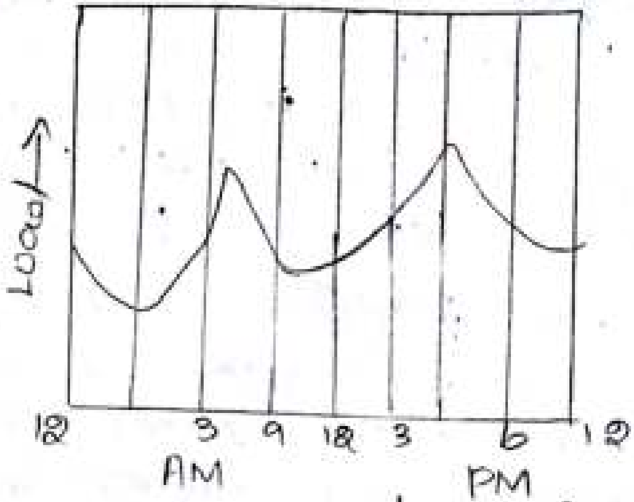
It consists of power required for tram cars, trolley, buses and railways.

LOAD CURVE :-

It is a graphical representation which shows power demands for every instant during a certain time period. It is drawn between load in KW and time in hours. If it is plotted for 1 hour it is called hourly load curve and if the time is considered is of 24 hours, then it is called daily load curve. When it is plotted for one year (8760 hours) then it is called animal load curve.

The area under the load curve represents the energy generated in the period considered. If the area under the curve is divided by the total number of hours, then it will give the average load on the power station. The peak load indicated by the load curve represents the maximum demand of the power station.

This curve gives full information about the incoming loads and it helps to decide the installed capacity of the power station. It is also useful to decide the economical size of various generating units

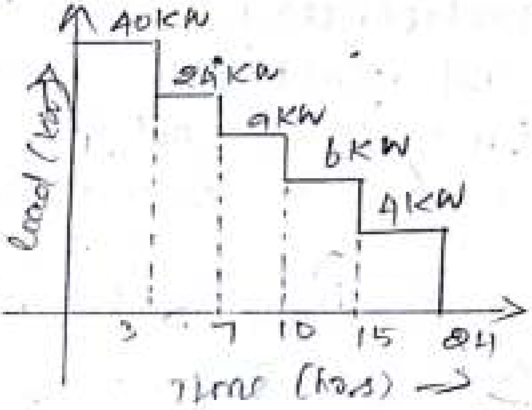


Load curve

LOAD DURATION CURVE :-

This curve represents the re-arrangement of all load elements of load curve in order to decreases its magnitude. This curve is derived from the load curve.

Load curve



Load duration curve

A typical daily load curve for a power station. The maximum load on power station is 40 KW from 6p.M to 9 P.M. Similarly, other loads of the load curve are plotted in decreasing order. This curve is called, load duration curve.

The area under both curves is equal and it represents the total energy delivered by generation station. Load duration curve gives a clear analysis about generating power economically.

Load distribution parameters :-

comparison of site selection criteria :-

Changing the site and variability still increases the cost of power plants. It is due to different locations needed ... for the use of Union or non-Union labor. Over all productivity and labor cost vary in different regions. Sales tax rates vary and local market conditions also vary. Even profit margins and perceived risk can vary.

Site-specific scope is also an issue. Access roads, lay down areas, transportation distances to the site and availability of utilities, Indoor Vs. outdoor buildings, ambient temperatures and many other site-specific issues can effect the scope and specific equipment need choices.

The site selection criteria of various plants such as thermal or steam, nuclear, gas turbine, diesel, hydroelectric, solar, geothermal, tidal, wind, biogas and fuel cell are already discussed in from Unit 1 to Unit 4

RELATIVE MERITS AND DEMERITS OF VARIOUS POWER PLANTS :-

Relative merits and demerits of various plants are already discussed in from unit 1 to unit 4

CAPITAL COST AND OPERATING COST OF VARIOUS POWER PLANTS :-

Both capital cost and operating cost are always based on the technique and availability of resources used for energy generation. Based on above-mentioned procedure for the calculation of energy generation cost, various energy research laboratories release the report about the cost of energy generation such as National Renewable energy laboratory (NREL), Energy and Environmental Energy Policy Resources (EEPR), science, and Industry Division (SID) by congressional research service, US energy information administration and World energy council, some examples.

Capital cost and Operating cost of Nuclear and Gas Turbine power plants :-

The cost of nuclear power plants are given for producing 1125 MW but it is 211 MW for gas turbine power plant. Even cost is estimated for future energy generation also. The report describes the cost for the year up to 2050. In tables below, CC refers the Capital cost and OC refers the operating cost.

Year	Nuclear power plant		Gas turbine power plant	
	CC (Dollar/KW)	OC (Dollar/KW year)	CC (Dollar/KW)	OC (Dollar/kWh)
2008	6,230	----	671	---
2010	6,100	127	651	29.9
2015	6,100	127	651	29.9
2020	6,100	127	651	29.9
2025	6,100	127	651	29.9
2030	6,100	127	651	29.9
2035	6,100	127	651	29.9
2040	6,100	127	651	29.9
2045	6,100	127	651	29.9
2050	6,100	127	651	29.9

POLLUTION CONTROL TECHNOLOGIES INCLUDING WASTE DISPOSAL OPTIONS FOR COAL

Analysis of pollution from Thermal power plants :-

The demand for electric power is continuously increasing. The power plants are simultaneously facing the problem of impurities and pollution in atmosphere. The main pollutants from the thermal plants are dust and objectionable gases CO_2, SO_2, NO_2 and ash

The pollution from the thermal plant is the
discharge of large quantity of heat to the
atmospheric air and the water is used for
Condensing the steam.

Air and water pollution by Thermal power plants:

Air pollution in the environment causes
lung cancer. The environmental pollution by thermal
power plants using fuels causes a serious
health hazard. A 350MW Coal fired thermal power
station emits about 75 tons of SO_2, 16 tons of
nitrogen oxide and 500 tons of ash per day. All
steam plants discharge 60%. of heat to the
atmosphere.

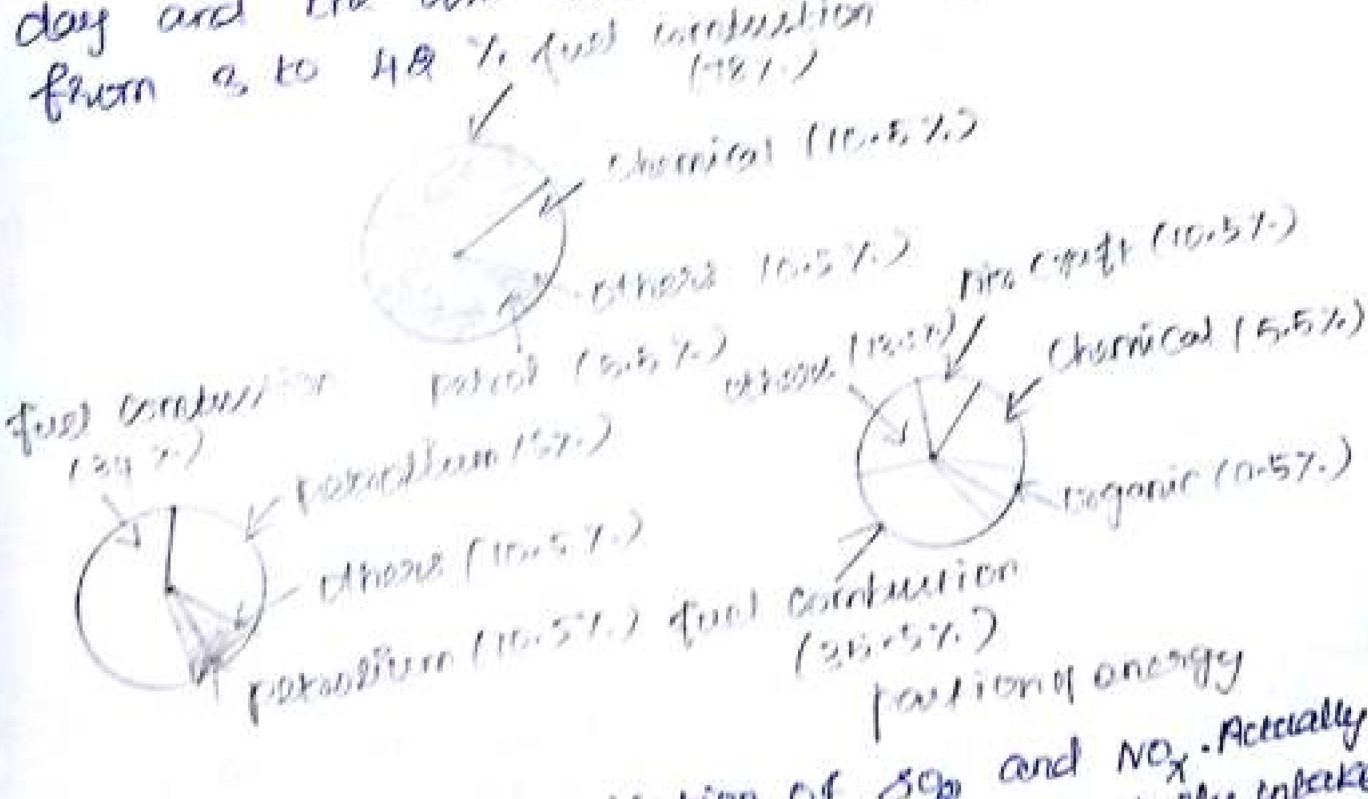
Co emission due to incomplete combustion of
fuel in furnaces causes human health and it
Combines with homoglobin in red blood corpuscles.

CO_2 emission due to combustion of fuel will
affect atmospheric climate which could turn
fertile land into deserts. SO_2 emission in the
steam power plant will cause the toxic effect
vegetables are most sensitive to the contact of
SO_2 gas in the atmosphere. It is the main
pollutant from steam power plants.

Another emission of nitric oxide will not
affect the atmosphere. But, NO_2 is a result of
series of chain reactions highly irritant to
the lung. The maximum permissible limit of
nitrogen oxide is 0.05 to 0.1 ppm. Exposing 2 to 3
ppm of nitrogen oxide for a couple of hours
causes fibrotic changes in pulmonary tissues.
The table describes the pollutants emitted by
400 MW plant for different fossil fuels.

	Annual emission in kg from plant using pollution control equipment of 99.5%		
	Coal	Oil	Natural gas
fuel used annually	2.0 × 10^6 tons (3.5% sulphur and 9% ash)	1.44 × 10^9 litres (1.6% sulphur content)	4.7 × 10^9 litres
pollutants Aldehydes	1.6×10^4	$1.03 \times 10^{[illegible]}$	8.18×10^4
oxides of nitrogen	1.84×10^7	1.91×10^7	1.66×10^7
oxides of sulphur	1.38×10^8	1.61×10^8	$1.02 \times 10^{[illegible]}$
carbon monoxide	4.6×10^5	7.36×10^3	negligible
Hydrocarbons	1.84×10^5	5.88×10^5	negligible
particulates	3.96×10^6	6.4×10^5	1.02×10^6

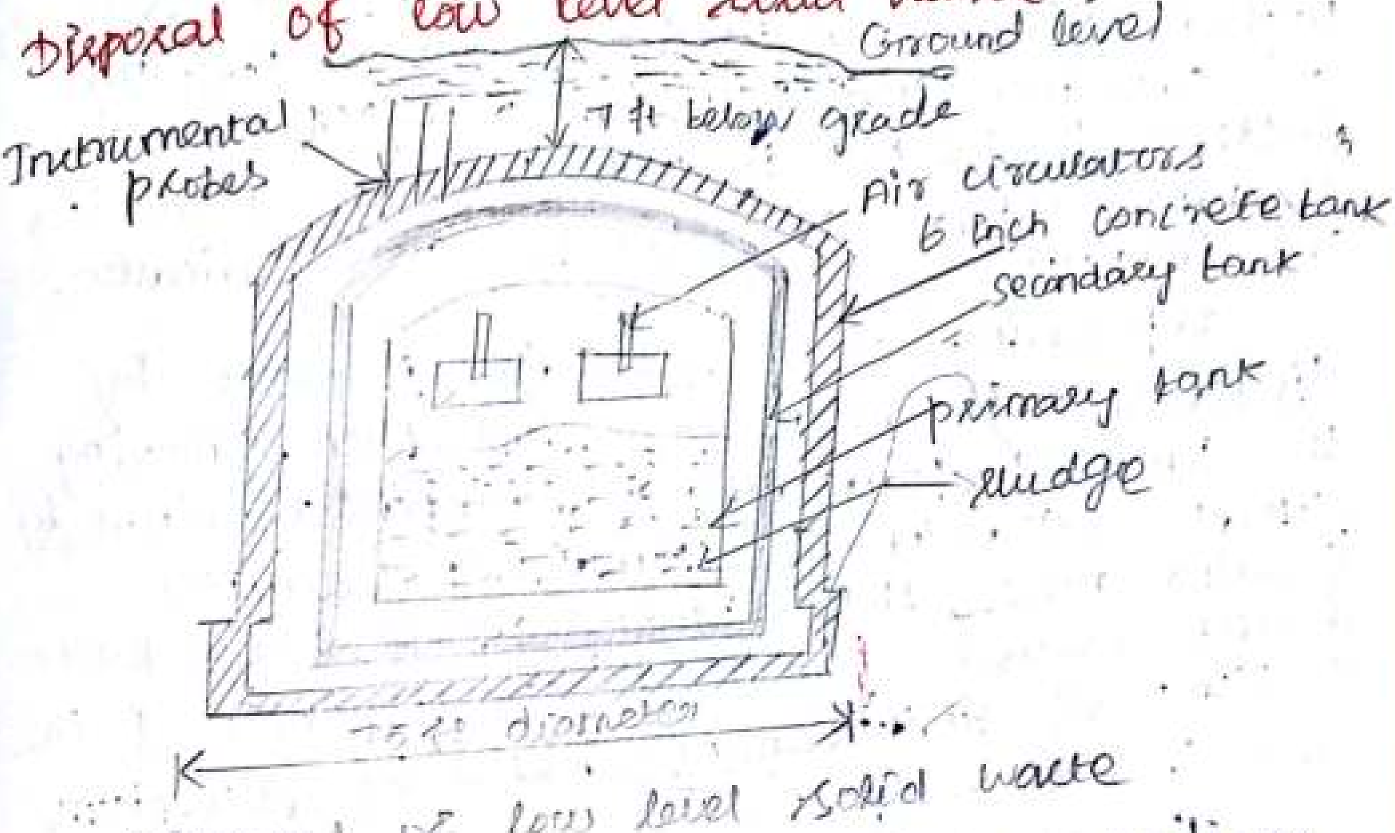
400 MW plant emits 800 tons of fly ash per day and the ash content of coal in India varies from 3 to 48 %.



The contribution of SO_2 and NO_x. Actually the air constitutes about 80% of man's daily intake by weight. We breathe about 22000 times a day inhaling about 16kg of air. The effects 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



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.

Disposal of medium level solid wastes :-

Medium level wastes are mainly contaminated with neutron activation product ... 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.

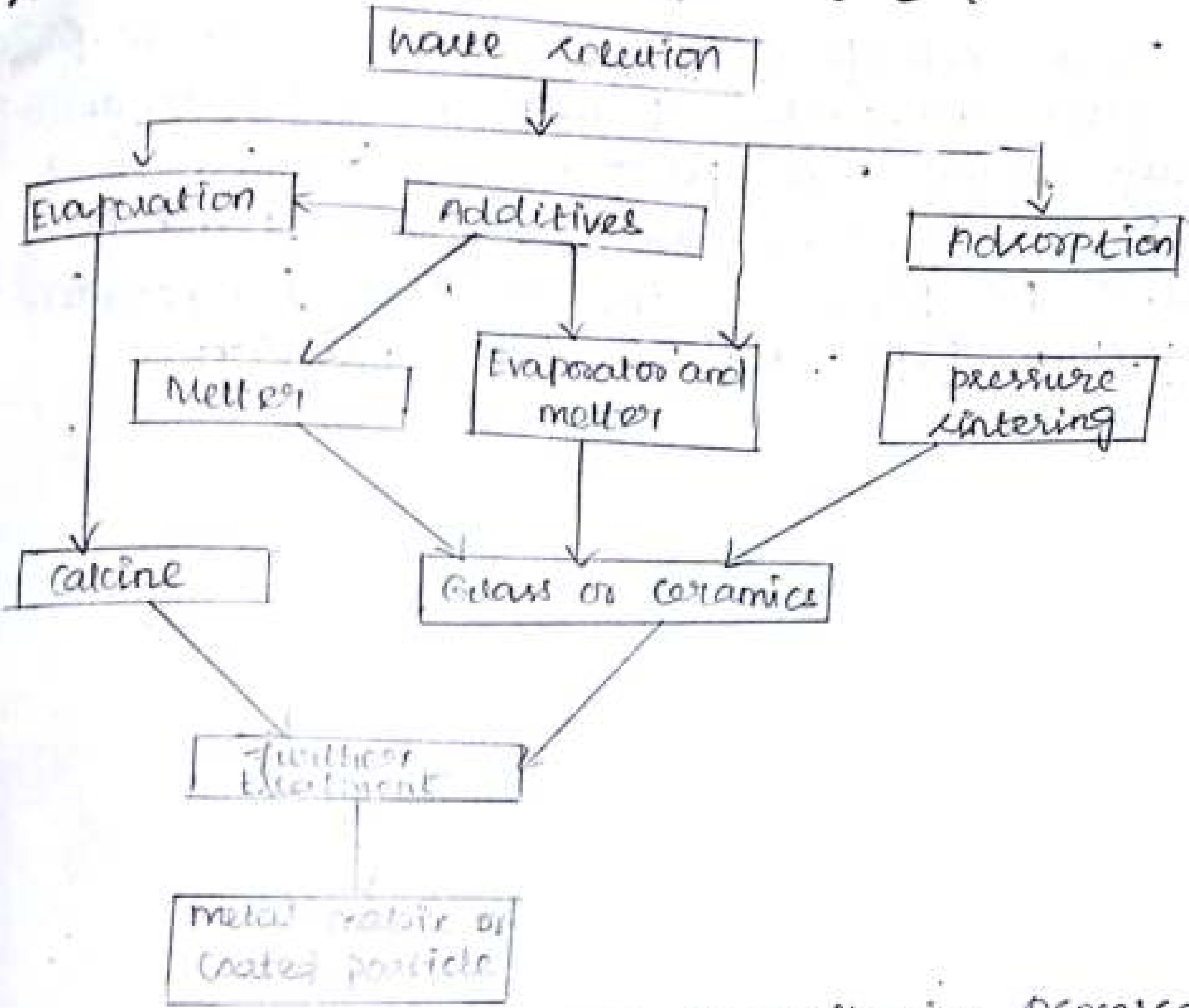
Disposal of High Level Wastes :-

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 radio isotopes 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

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.



Basic high level waste solidification process.

Glasses and Ceramics are now considered to be most suitable forms for this final disposal. The basic processes. It involves in evaporation and de-nitration 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 radio activity.

29/5/17