NUCLEAR POWER PLANT

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Nuclear Power Plant

- A nuclear power plant abbreviated as NPP. It is a thermal power station in which the heat source is a nuclear reactor.
- This thermal heat is used to generate steam that drives a steam turbine connected to a generator that produces electricity.
- As on 2018, the International Atomic Energy Agency reported there were 450 nuclear power reactors in operation in 30 countries around the world.
- Nuclear plants are usually considered to be base load stations since fuel is a small part of the cost of production and because they cannot be easily or quickly dispatched.
- The cost of proper long term radioactive waste storage is uncertain.

Nuclear Power Plant

- As of November 2020, India has 22 nuclear reactors in operation in 7 nuclear power plants, with a total installed capacity of 6,780 MW

Sl.No	Name of the Power Plant	State	Total Capacity in MW
1	Kudankulam Nuclear Power Plant	Tamil Nadu	2,000
2	Narora Atomic Power Station	Uttar Pradesh	440
3	Madras Atomic Power Station	Tamil Nadu	440
4	Rajasthan Atomic Power Station	Rajasthan	1,180
5	Tarapur Atomic Power Station	Maharashtra	1,400
6	Kaiga Nuclear Power Plant	Karnataka	880
7	Kakrapar Atomic Power Station	Gujarat	440

The Economics of Nuclear Power

The economics of nuclear power involves several aspects:

- Nuclear power plants are expensive to build but relatively cheap to run. In many places, nuclear energy is competitive with fossil fuels as a means of electricity generation.
- Waste disposal and decommissioning costs are usually fully included in the operating costs. If the social, health and environmental costs of fossil fuels are also taken into account, the competitiveness of nuclear power is improved.

➢ Capital Cost

➢ Plant Operating Cost

➢ External Cost

➢ Additional Costs

The Economics of Nuclear Power

Capital Cost:

- which include the cost of site preparation, construction, manufacture, commissioning and financing a nuclear power plant. Building a large-scale nuclear reactor takes thousands of workers, huge amounts of steel and concrete, thousands of components, and numerous other systems to provide electricity, cooling, ventilation, information, control and communication.
- To compare different power generation technologies the capital costs must be expressed in terms of the generating capacity of the plant. Capital costs may be calculated with the financing costs included or excluded.
- If financing costs are included then the capital costs change materially in relation to construction time of the plant and with the interest rate and/or mode of financing employed.

The Economics of Nuclear Power

Plant Operating Cost:

- Which include the costs of fuel, operation and maintenance (O&M), and a provision for funding the costs of decommissioning the plant and treating and disposing of used fuel and wastes.
- Operating costs may be divided into 'fixed costs' that are incurred whether or not the plant is generating electricity and 'variable costs', which vary in relation to the output.
- Normally these costs are expressed relative to a unit of electricity for example, Rupees per kilowatt hour to allow a consistent comparison with other energy technologies.
- To calculate the operating cost of a plant over its whole lifetime, we must estimate the 'levelised'(levelised cost of Electricity- LOCE) cost at present value.
- LCOE: It is the total cost to build and operate a power plant over its lifetime divided by the total electricity output dispatched from the plant over that period, hence typically cost per megawatt hour.)

The Economics of Nuclear Power

External Cost:

- The costs of dealing with a serious accident that are beyond the insurance limit and in practice need to be picked up by the government.
- The regulations that control nuclear power typically require the plant operator to make a provision for disposing of any waste, thus these costs are 'internalised' as part of operating costs (and are not external).

Additional Costs:

- Other costs such as system costs and nuclear-specific taxes.

3. **ADVANTAGES OF NUCLEAR POWER PLANT**

1. A nuclear power plant needs less space as compared to other conventional power plants of same capacity.
2. Nuclear fuel is charged to a power plant infrequently, because it has a relatively long life (usually measured in months and years).
3. The weight of nuclear fuel required is negligible in comparison to the coal required for thermal power plant of same capacity. This totally eliminates the cost and problem of transportation and storage of fuel.
4. Nuclear power plant produces valuable isotopes, which are used for different purposes
5. Nuclear power plants are not affected by adverse weather conditions.
6. The operation of a nuclear power plant is more reliable.
7. The use of nuclear fuel does not require combustion air, thus minimizing thermal stack losses and other related problems.

DISADVANTAGES OF NUCLEAR POWER PLANT

1. The capital cost of a nuclear power station is always high.
2. The burnt fuel is highly radioactive. Therefore, it requires remote handling and special processing before disposal as waste to the atmosphere.
3. The danger of radioactivity always persists in the nuclear stations. Therefore, specially designed systems are required to prevent radioactivity release during normal operation
4. These plants cannot be operated at varying load efficiently.
5. The maintenance cost is always high.
6. The disposal of fission products is a big problem.

4.Selection of Site for Nuclear Power Station

1. Water availability

The site must be equipped with ample quantity of water as the plants require substantially greater quantity of cooling water, because of its higher turbine heat rate and feed water required for steam generation. Therefore, the site must be nearer to a river, reservoir, sea or ocean.

2. Distance from load centre

The power plant should be located near the load centre as this will reduce the cost of transmission line and also reduces transmission loss.

Note: The power plant is located near the load centre while meeting other requirements like reasonable land cost, adequate cooling water, away from population distribution, local zone restriction, accessibility for fuel shipment, etc.

3. Distance from populated area

The plant should be away from the population in order to avoid the radioactive hazard.

4. Transportation facilities

The site should be accessible by rail and road as heavy machinery are to be brought to the site during the installation and fuel during its operation.

5. Waste disposal

The waste of a nuclear power plant are very radioactive therefore sufficient space must be there to dispose the radioactive waste.

6. Cost of the land

Large area is required to built a nuclear power plant, therefore the land price should be reasonable.

7. Nature of land

The land should have good bearing capacity of about 1 MN/m^2 and must not come under earthquake prone zone. The land is studied for its past history of tremors and earthquake in order to design the plant that can withstand the severest earthquake.

8. Future extension

A choice for future extension of the plant should be made in order to meet the energy demand in future.

9. Availability of workforce

During construction of the plant enough labour is required. The labour should be available at the proposed site at cheap rate.

10. Size of the plant

The capacity of the plant decides the size of the plant, large plants require large area. Therefore the capacity of the plant also plays a vital role in the selection of site.

NUCLEAR REACTIONS

- Nuclear fission and fusion are processes that involve extremely large amount of energy.

1. fission => the splitting of nuclei
2. fusion => the joining of nuclei

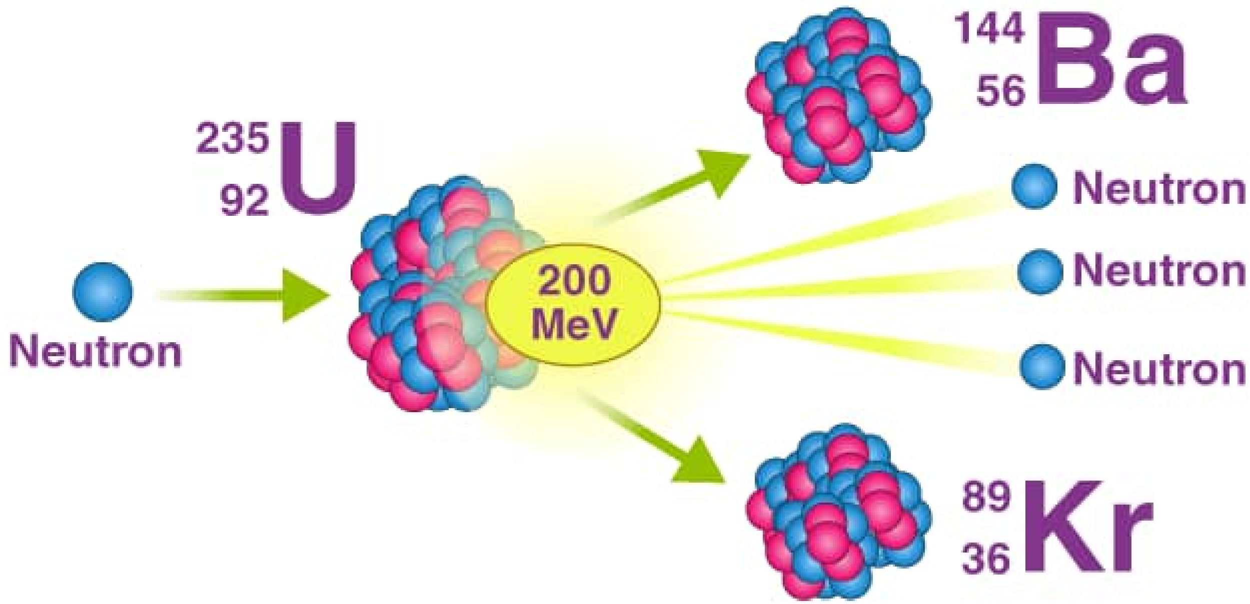
- Nuclear power plants can generate large amount of electricity.

1. Ontario, Quebec and new Brunswick currently generate nuclear power.
2. Canadian-made nuclear reactions are called CANDU reactors.

Nuclear Reaction

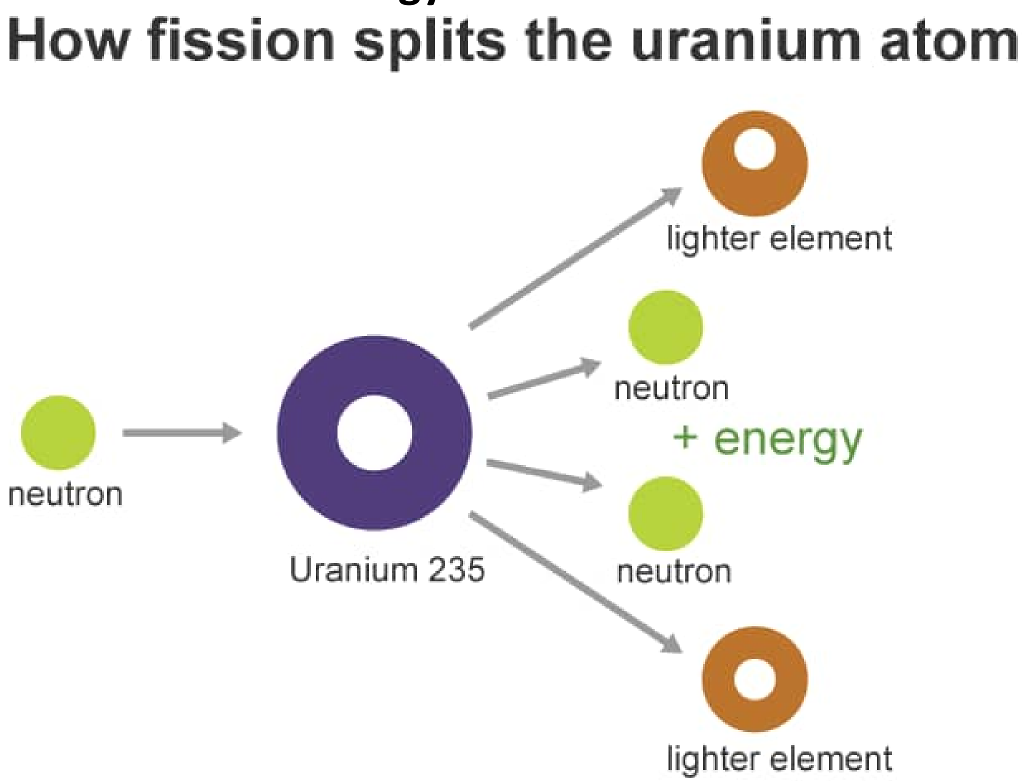
- A Nuclear reaction refers to a processes where one or more nuclides get produced from the collusion of atomic nuclei or one atomic nucleus and a subatomic particle. The nuclides obtained from nuclear reactions are not the same as of reacting nuclei or parent nuclei. Popularly these to two reactions named as Nuclear fission and Nuclear Fusion reaction.
- In nuclear fission, a heavy nucleus tend to absorb neutrons or relatively lighter particles. And further it splits into two lighter nuclei.
- Where as Nuclear fusion refers to a process where two light nuclei collide to form a single heavy Nucleus.

Nuclear fission is the process where the nucleus of a heavy atom splits into fragments of lighter nuclei. This process gives out energy. One of the ways to achieve this is to bombard the nucleus of heavy atoms with neutrinos. Along with producing energy (in terms of the ‘missing mass’), the reaction also produces neutrons. These neutrons can be used to split other atoms further in the reaction.



Uranium exists in different isotopes of U^{238}, U^{234} , and U^{235}. Out of these, U^{235} is the most unstable. When unstable heavy nucleus is bombarded with high energy neutrons, it splits up roughly into two equal fragments and about 2.5 neutrons are released and a large amount of energy is produced (nearly 200 million electron volts). This process is called **Nuclear fission.**

8.Nuclear Energy



Nuclear fission is a reaction in which the nucleus of an atom splits into two or more smaller nuclei. The fission process often produces gamma photons, and releases a very large amount of energy even by the energetic standards of radioactive decay.

10. Nuclear Power Plant & Layout

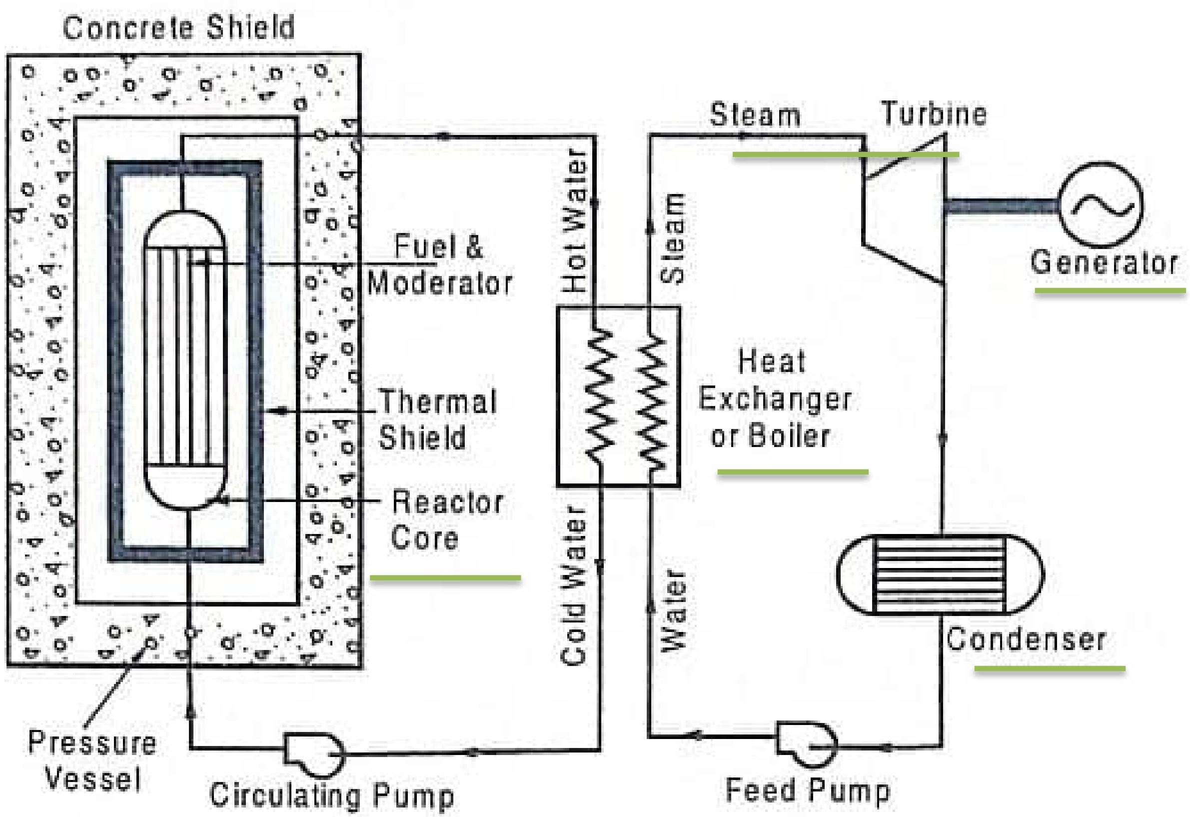


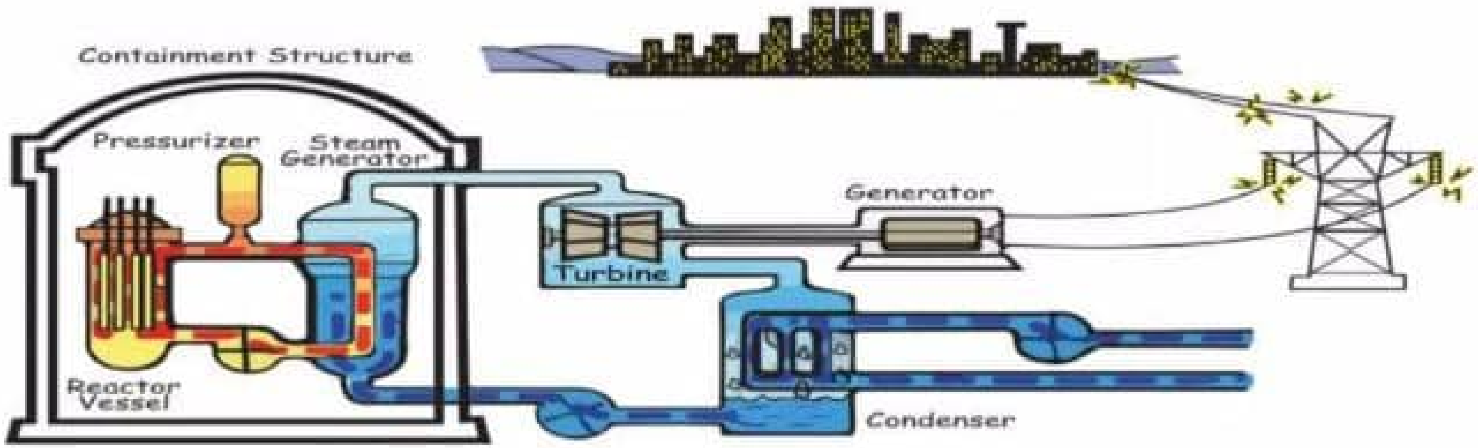
Fig:3.4 Layout of Nuclear Power Plant

OPERATING PRINCIPLE OF NUCLEAR POWER PLANT

The working of a nuclear power plant is exactly similar to that of steam power plant, except steam is generated in nuclear reactor instead of boiler. The heat energy is produced by nuclear fission

Fission of atom takes place. This process liberates large amount of heat. This heat is taken up by the coolant circulating through the rector core.

The Pressurized-Water Reactor (PWR)



GENERAL ARRANGEMENT OF NUCLEAR POWER PLANT

1. Nuclear reactor:

Reactor is the heart of the nuclear plant. In nuclear reactor, nuclear fission of radioactive material takes place. This liberates large amount of heat energy. This heat is taken up by the coolant circulating through the reactor core. After absorbing the heat, the coolant becomes hot.

2. Heat exchanger or Steam generator:

The hot coolant coming from nuclear reactor flows through the tubes of heat exchanger (or steam generator). In the heat exchanger, hot coolant gives up the heat to feed water, so that it can be converted in to steam.

3. Steam turbine:

The steam produced in the heat exchanger is sent to steam turbine. The steam undergoes expansion in steam turbine and produces useful work in the steam turbine.

4. Steam condenser:

In condenser, the steam is cooled and condensed with the help of cooling water coming from cooling tower. exhaust steam is converted to water, which can be used as feed After cooling and condensation.

5. Cooling tower:

After absorbing the heat from exhaust steam, temperature of cooling heat from exhaust steam, temperature of cooling water increases, making it warm or hot water. This hot water is sent to cooling tower, where it is cooled.

6. Alternator or Generator:

Output shaft of steam turbine is coupled to generator which converts mechanical energy into electrical energy.

Comparative point	Steam Power Plant	Nuclear Power plant
Site	Located near load center.	Location depends upon availability Site of water & away from load center and populated area.
Capital cost	Low.	Very high
Operating Cost	More	Less
Maintenance cost	Moderate	Higher
Supervisory staff required	More	Less
Space required	More	Less
Fuel consumption	Huge	Less
Reliability of plant operation	Low	High
Qty water required	Huge	Comparatively Less

11.Nuclear reactor & its control

Main parts & their functions

1. Nuclear reactor:

It consists of the following components.

(a) Core: This contains the nuclear fuel and space for coolant. The fuels used are U^{233}, U^{235}, Pu^{239}

To have uniform release of heat, the fuel is shaped and located in the core.

(b) Moderator: The moderator is used to reduce the speed of the fast moving neutrons. For natural uranium, the following are used as moderators-graphite, heavy water or beryllium. For enriched uranium, the ordinary water is used as moderator.

(c) Control rods: The control rods are used to start the chain reaction, maintain the chain reaction at required level and to shut down during emergency. The control rods are made of cadmium, boron and hafnium.

(d) Coolant: Coolant is used to transfer the heat which is produced in the reactor to steam generator for rising the steam. The generally used coolants are ordinary & heavy water, air, carbon dioxide, helium and hydrogen and liquid metals like sodium and potassium.

(e) Reflector: Reflector is used to reflect the escaping neutrons back into the core. This improves the neutron economy of the reactor. The generally used reflectors are heavy water, graphite and beryllium.

(f) Radiation shield: Radiation shield is a concrete shield to absorb dangerous radiations like alpha, beta, gamma rays tend to escape to the atmosphere.

(g) Reactor vessel: This is a housing for all the equipment's and it is designed in such a way that it can withstand high pressures safely. The reactor is positioned at the bottom of the vessel.

2. Steam generator:

In this, the steam is generated from the feed water by absorbing heat from the hot coolant from the reactor.

3. Turbine:

The generated steam is made to expand in the turbine to produce work. This work is converted into electricity by generator which is coupled with turbines.

4. Coolant pump & Feed pump:

The coolant pump is used to maintain the flow of coolant and the feed pump is to pump the feed water to the steam generator.

5. Generator:

The generator is used to convert the mechanical energy into electrical energy. The generator is directly coupled to the turbine.

Control of Nuclear Reactor

It is very very important to control the heat produced by nuclear reactor. This is achieved by controlling the neutron flux by

(i) Control rods. (ii) Control through flow of coolant.

(i) Control rods:

For normal operation, the multiplication constant must be maintained at unity. This will ensure the neutron flux is held at constant value. Neutrons may be absorbed by inserting some material having high absorption cross-section. Such materials are boron, hafnium and cadmium. They are generally alloyed with steel and made into control rods which can be moved in and out of channels in the core. To ensure even distribution of neutron flux it is necessary to employ large number of rods(hundred or even more). When rods are fully inserted, the neutron absorption will be maximum.

Control of Nuclear Reactor

(ii) Control through flow of coolant:

In addition to control by using control rods, it is necessary to maintain an appropriate relation between mass flow of coolant and power. At constant temperature the power output is proportional to the rate of flow of coolant. Coolant temperature recorders and coolant flow indicators recorders and coolant flow indicators and operating switches are necessary for this purpose.

CLASSIFICATION OF NUCLEAR REACTORS

1. On the basis of Neutron Energy

I) Fast reactors (II) Slow or thermal reactors III) Intermediate reactor

2. On the basis of Type of Fuel Used

i)Natural Uranium 0.7% U^{235} , ii) Enriched Uranium 2.5% to 10% U^{235}

3. On the basis of Type of Coolant Used

i) Water cooled reactors , ii) Heavy water-cooled reactor

iii) Liquid metal (sodium) cooled reactors, iv) Gas cooled reactors.

4. On the basis of Type of Moderators Used:

i) Water (H2O), ii) Heavy water reactors (D20),

iii) Graphite reactors, iv) Beryllium reactors.

5. On the basis of Type of fuel - Moderator Assembly

i) Homogenous reactors, ii) Heterogeneous Reactor.

6. On the basis of Type of Application or Principal Product:

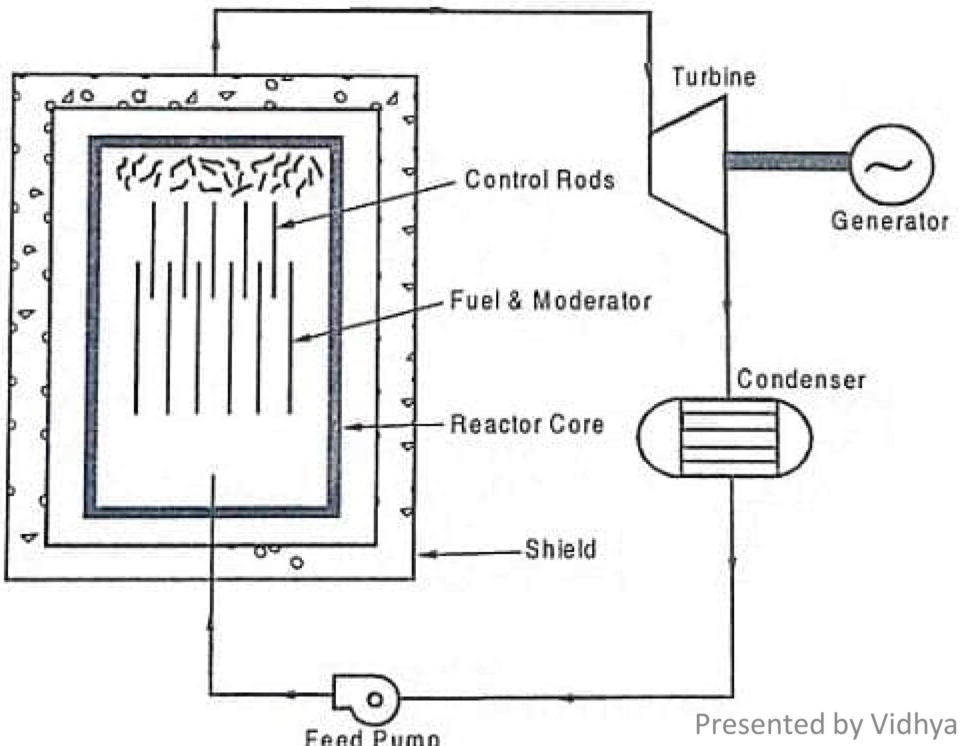
i) Power reactors: to produce heat, ii) Breeder reactors :to produce fissionable materials, iii) Production reactor: To produce isotopes.

iv) Research reactors: to produce neutrons

13. Power Reactors in use

i)Boiling Water reactor

In this Boiling Water reactor, enriched Uranium is used as fuel. Enriched uranium contains **more fissionable isotope U^{235}**. Water is used as coolant, moderator and reflector like in PWR except the steam is generated in the reactor itself instead of separate steam boiler. **Water enters the reactor at the bottom**. It takes up the heat generated due to fission of fuel and **gets converted into steam**. Steam leaves the reactor at the top and flows into the turbine.



Coolant used: Ordinary water

Moderator used : Ordinary water

Fuel used: Enriched Uranium

e.g. Tarapur power station.

Advantages

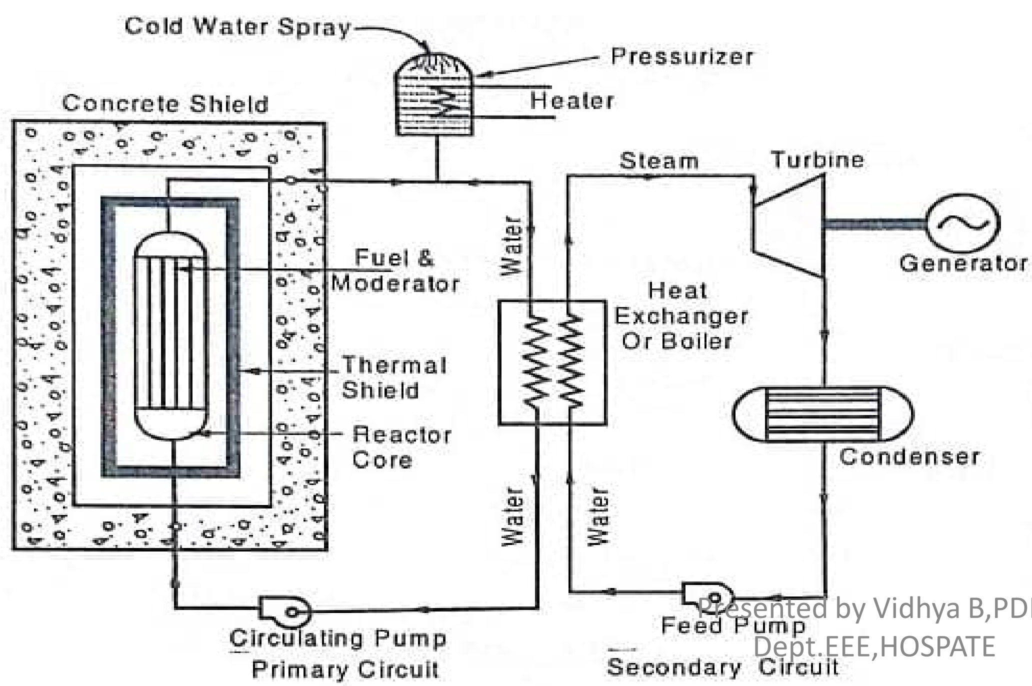
- The pressure inside the reactor vessel is much lower than PWR as water is allowed to boil inside the reactor. Hence, the reactor vessel is much lighter than PWR and reduces the cost of pressure vessel considerably.
- Since the reactor does not require steam generator, pressurizer, circulating pump and piping's, the cost is further reduced.
- Boiling water reactor is more stable than PWR.
- Thermal efficiency of BWR plant is more than PWR plant.

Disadvantages

- The BWR has negative power demand coefficient. i.e., when more power is demanded from the reactor, it may produce less.
- The steam leaving the reactor is slightly radioactive and hence the turbine and the pipings should be properly shielded.
- Since the boiling of water on the surface of the fuel is allowed, the 'burn out' of fuel is more.

ii). PRESSURIZED WATER REACTOR (PWR)

Pressurized Water Reactor uses enriched U as fuel. In this reactor, water is used as coolant and moderator. The water passes through the reactor core and becomes hot water. The hot water flows to a heat exchanger (steam generator) where its heat is transferred to the feed water to generate steam. The top of the pressurizer is filled with steam at primary circuit pressure. If the primary circuit pressure drops, the heater is operated which generates steam and increases the steam content in the vessel. This results in the increase of pressure in the primary circuit.
And if the primary circuit pressure becomes too high, the cold water is sprayed in the pressurizer. This condenses the steam and reduces the primary circuit pressure.



Coolant used:
Ordinary water
Moderator used :
Ordinary water
Fuel used:
Enriched Uranium

Advantages of PWR

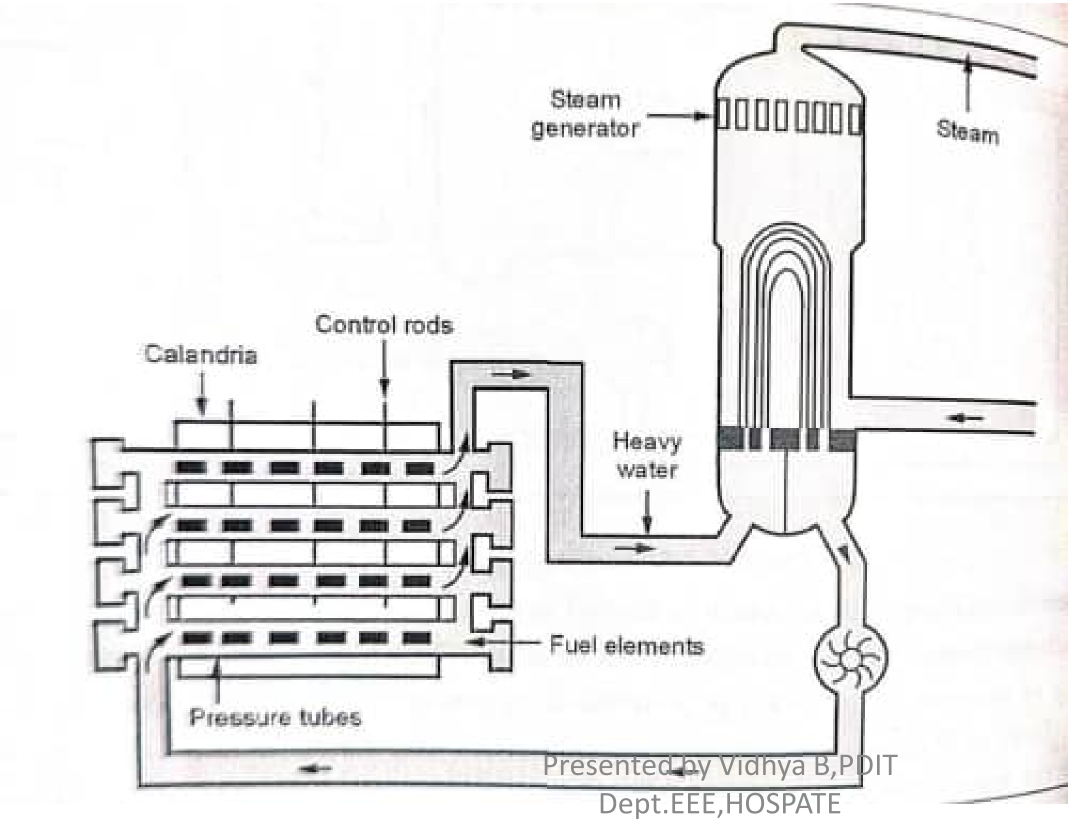
1. The ordinary water is used as a coolant and moderator, which is considerably cheap and easily available,
2. The reactor is compact and its power density is 65 kW/litre.
3. This reactor reduces fuel cost by extracting more energy per unit weight of fuel
4. Less number of control rods are required.
5. Steam is not contaminated by radioactivity.
6. Fission products remain contained in the reactor, i.e. they are not circulated

Disadvantages of PWR

1 The capital cost of reactor is high, as it requires strong pressure vessel
2. The running cost of reactor is high, as it uses enriched Uranium.
3. Thermodynamic efficiency of the cycle is low.
4. The erosion and corrosion problems are more severe.

iii). Heavy Water Cooled Or Moderated Or CANDU Type Reactor Or Canadian Deutorium Uranium Reactor

It is a Canadian invented pressurized heavy water reactor which uses 99.8 percent of Deuterium oxide D_2O (Heavy water) as moderator and coolant. The reactor uses 0.7% U^{235} (natural uranium) as its fuel. The Canada Deuterium Uranium Reactor consists of a steel cylinder with a horizontal axis containing number of pressure tube (channel) which are subjected to high internal pressure. The channels contains fuel elements and the pressurised coolant flows along the channels and fuel elements to remove the heat generated during the fission. The coolant flows in the opposite direction of its adjacent channel



Coolant used: Heavy water

Moderator used : Heavy water

Fuel used: Natural Uranium

- The fuel used in a Canada Deuterium Uranium Reactor is normal uranium oxide pellet (the uranium is unenriched or unbreeded). The pellets are packed in a corrosion resistance zirconium alloy tube, which is 0.5 cm long and its diameter is 1.3 cm called fuel rod. The short fuel rods are combined in bundles of 37 rods, there are 12 bundles placed end to end in each pressure tube. The reactor refuelling i.e. removal of spent fuel and replacement by fresh fuel is carried out while the reactor is operating.
- A number of strong neutron absorber rods of cadmium are provided for control and protection of reactor, rods of cadmium are mainly used for reactor shut down and start up. In addition to this, there are other less strongly, absorber rod to control power variation during the operation and to produce uniform heat distribution though out the core.
- The high temperature coolant leaving the reactor passes out through the outlet header to a steam generator where steam is generated at a temperature of about 265°C, the heated steam run the steam turbine, after work is done, the cold water from the turbine is pumped back into the reactor by the way of inlet header.
- There are two coolant outlets and two inlet headers – one at each end of the reactor vessel corresponding to the opposite direction of coolant flow through the core. Each inlet and outlet header is connected to a separate steam generator and pump loop. The reactor vessel and [steam generator]() system are enclosed by containment building made up of reinforced concrete.

Advantages of CANDU Reactor

1. Natural uranium can be used as fuel.
2. Only fuel tubes are designed to withstand high pressure and reactor vessel can be made of light material.
3. Easy to control. 4. Fuel consumption is low.
5. Period required for construction is shorter than for PWR and BWR.
6. The moderator can be kept at low temperature, which increases the effectiveness in slowing down neutrons.

Disadvantages of CANDU Reactor

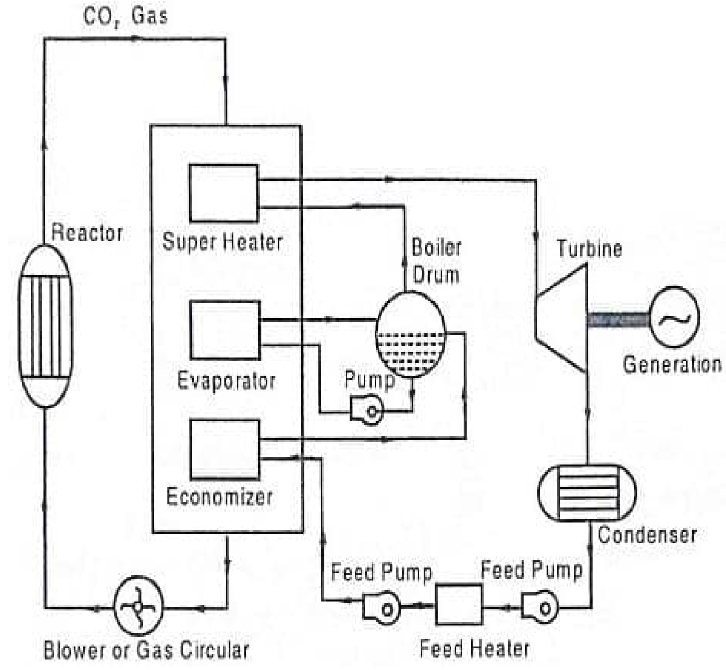
1. The cost of heavy water is very high.
2. Leakage of heavy water is one of the major problems in construction of reactor.
3. Reactor requires high standards in the areas of design, manufacturing and maintenance.
4. The power density is low. Therefore, the reactor size is considerably large as compared to DWP and BWR.

iV). GAS COOLED REACTORS

This type of reactor is cooled by the gas. The heat carried by the gas from the reactor is either used for generating steam in the secondary circuit like PWR (or) it can be directly used as the working fluid in the gas power plant. In this type, the carbon dioxide gas is used as primary coolant which in turn generates steam in the secondary circuit.

Carbon dioxide gas is used to carry away the heat produced in the reactor. The gas is circulated at a pressure of about 7 bar.

The gas flowing up through each of the channels round the elements leaves the reactor at the top. This gas flows to heat exchanger and transfers its heat to water so that it gets converted into steam. The gas is recirculated with the help of gas blowers. The steam drives the turbines which in turn drives alternator to generate electricity.



Coolant used: Helium or Carbon Dioxide
Moderator used : Graphite
Fuel used: Natural Uranium

Advantages of Gas Cooled Reactors

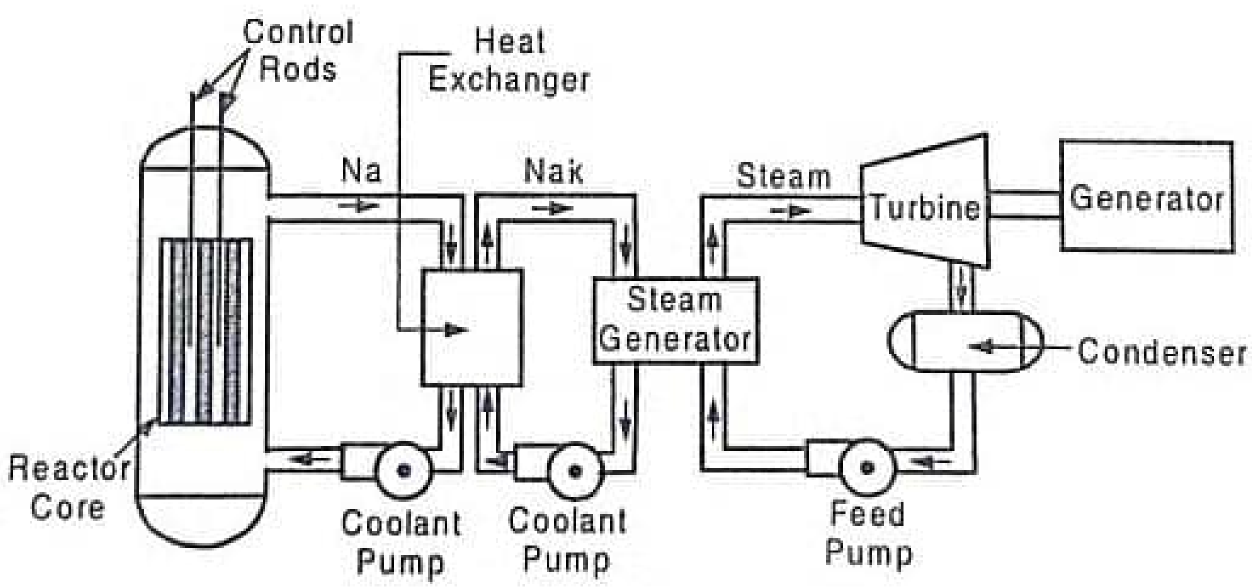
1. Processing of fuel is simpler.
2. No corrosion problem.
3. Use of carbon dioxide as coolant completely eliminates the possibility of explosion in the reactor, which is always present in case of water-cooled reactors.
4. Graphite remains stable, even at high temperatures.

Disadvantages of Gas Cooled Reactors

1. Loading of fuel is more elaborate and costly.
2. As the critical mass required is more, therefore initially large amount of fuel.
3. If helium is used instead of carbon dioxide as coolant , the leakage of gas is a major problem.
4. Coolant circulation requires more power.

V). Breeder Reactor Or Liquid Metal Cooled Reactor Or Sodium-graphite Reactor (SGR)

A liquid metal cooled reactor (LMCR) is an advanced type of nuclear reactor that uses a liquid metal as the primary coolant. The use of liquid metal has many advantages because the reactor need not to be kept under pressure and they allow high power density than the conventional coolant. The high temperature of the liquid metal is used to produce vapour at higher temperature leading to higher plant efficiency. Sodium-Graphite Reactor (SGR) is a typical liquid metal cooled reactor that uses sodium as coolant and graphite as moderator.



Coolant used: Liquid metal of sodium
Moderator used : Not required
Fuel used: Natural Uranium

- Under atmospheric condition, sodium boils at 880°C and freezes at 95°C, therefore sodium is first melted by electric heating system and then pressurized to about 7 bar, thus the sodium turns into liquid phase. The liquid sodium is then circulated by the circulation pump.
- The reactor has two coolant loop. The primary loop contains liquid sodium which is circulated through the fuel core and it absorbs the heat liberated by the fission of fuel. The liquid sodium gets cooled in the heat exchanger and goes back to the reactor vessel. The secondary loop contains an alloy of sodium and potassium in liquid form. This liquid takes heat from the heat exchanger and then passes through a boiler.
- Feed water from the condenser enters the boiler, the heated sodium potassium liquid passing through the tube gives heat to the water thus converting it into steam (superheated). Graphite is used as the moderator in this reactor.

Breeder Reactor Or Liquid Metal Cooled Reactor Or Sodium-graphite Reactor (SGR)

Advantages of Breeder Reactors

1. Breeder reactor does not require moderator.
2. Breeder reactor gives high power density.
3. The sodium as a coolant need not to be pressurized.
4. Breeder reactor gives superheated steam.
5. Size of reactor is small.

Disadvantages of Breeder Reactors

1. Breeder reactor requires highly enriched fuel, so the initial cost of fuel is very high.
2. Difficult to control.
3. The handling of the coolant sodium is very difficult.
4. Thermal stresses create problem.
5. Heat exchangers must be leak proof.
6. The leakage of sodium is very dangerous as compared with other coolants.

14. Effects of Nuclear Power Plants

- A nuclear reactor produces α, β and γ rays and neutrons which can disturb the normal working of human beings and animals and it enforces need of special safety measures.
- γ-rays are electromagnetic radiation of very short wavelength, have high energy and are very penetrating. They are capable of causing considerable damage to organic materials.
- Overexposure of γ-rays caused the blood disease, undesirable genetic effects, anemia etc.,
- Large exposure may cause death within hours of exposure.
- Nuclear power stations are prohibited to build close to residential buildings.
- The level of radiations of this NPP area is checked periodically.

Positive Effects:

Low Greenhouse Gas Emissions: Nuclear power generation produces very low levels of greenhouse gases (GHGs), especially compared to fossil fuel-based power plants. This makes it an attractive option for mitigating climate change.

High Energy Density: Nuclear power plants have a high energy output relative to their size and fuel input, which means they can provide large amounts of electricity consistently.

Energy Security: Nuclear power reduces dependence on imported fossil fuels, enhancing energy security for countries with significant nuclear capacity.

Long Operational Life: Nuclear reactors can operate continuously for many years, providing a stable and reliable source of electricity.

Negative Effects:

Radioactive Waste: One of the most significant concerns is the production of radioactive waste, which remains hazardous for thousands of years. Safe disposal and storage of this waste are major challenges.

Accidents: While rare, nuclear accidents can have devastating consequences for human health and the environment. Events like Chernobyl and Fukushima highlight the risks associated with nuclear power.

High Initial Costs: Building nuclear power plants is expensive due to stringent safety measures and regulatory requirements. Initial investment costs can be a barrier to adopting nuclear power.

Security Risks: Nuclear facilities and materials pose security risks, including the potential for terrorism or unauthorized access.

Environmental Impact: While emissions during operation are low, the mining and processing of uranium, construction of nuclear plants, and transportation of radioactive materials have environmental impacts.

Public Perception: Negative public perception and concerns about safety can hinder the development and expansion of nuclear power.

15.Disposal of Nuclear waste & effluent

NUCLEAR WASTE DISPOSAL

1. Solid waste:

It consists of discarded control rods, fuel cans, scrap material etc. Out of these, the combustible matter is burnt and the resulting gases are disposed to atmosphere, after dilution.

The remaining material is mixed with concrete in the form of shielded vaults and buried deep in sea or ground.

2. Liquid waste:

Liquid waste coming from treatment plant is diluted by adding water to it. Then it is released to ground (deep pits or dry wells), if the activity level is low.

In this method, there is a danger of contaminating ground water, if dilution is not adequate.

Another method is to fill the concentrated liquid in steel tanks and buried in ground. The leakage from these tanks is more dangerous for human and plant life. So, care should be taken to have leak proof tanks.

3. Gaseous Waste:

They do not require any treatment except filtration.

The gases are treated in a cleanup plant to remove radioactive iodine, which is more hazardous for human health.

The gaseous wastes are commonly diluted with air and after passing through, filter they are released to atmosphere through a high stack (chimney).

Low level radioactive waste

- cooling water pipes, radiation suits, etc.
- stored in storage facilities
- radioactivity will fall to a safe level after 10 to 50 years.

High level radioactive waste

- used nuclear fuel
- highly radioactive
- embedded in concrete and stored deep underground for several thousand years

16. # Shielding

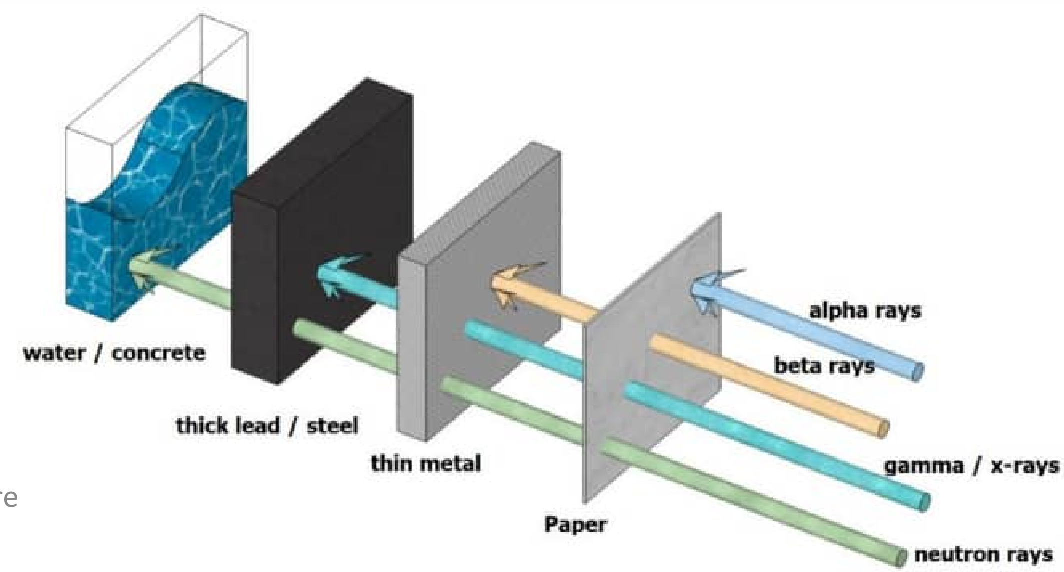
- Adequate shielding has be provided to guard personnel and delicate instruments form radioactive wastes. The various materials used for shielding are
- **Lead:** It is a common shielding material has high density 11.3 gm/cm^3 and is invariably used due to its low cost.
- **Concrete:** Its density is 2.4 gm/ cm^3 and is less efficient than lead.
- **Steel:** Its density is 7.8 gm/cm^3. It is not an efficient shielding material but has good structural properties. It is sometimes used for attenuating shield.

Shielding

- **Cadmium:** Its density is 8.65 gm/cm3. It can absorb slow neutrons by a nuclear reaction.

No single material is effective in shielding against all types of radioactive radiation.

In nuclear power reactors a thermal shielding of several cm's thick steel surrounded by about 3 meters thick concrete is used.



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