The Shirpur Education Society's

R. C. Patel College of Engineering and Polytechnic, Shirpur

Department of Mechanical Engineering

NAME OF COURSE: - POWER PLANT ENGINEERING

CODE OF COURSE: - 315374

SEMESTER: - TYME-5K

SUBJECT TEACHER: - Mr. ANUP PRALHAD PATIL

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Department of Mechanical Engineering

NAME OF COURSE & CODE: - POWER PLANT ENGINEERING -315374	**Academic Year:** 2026-27
Program Code, Semester & Scheme: ME-5K	

CHAPTER:- 04:- Nuclear Power Plant

COURSE LEVEL LEARNING OUTCOMES (COS):- Use suitable strategies to run nuclear power plants safely.

Learning Hours	R-Level	U-Level	A-Level	Total Marks
6	4	4	4	12

Subject Teacher

Mr.Anup P.Patil

HOD ME 24/06/26

Mr.A.D.Patil

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R. C. Patel College of Engineering and Polytechnic, Shirpur

Program Name: Mechanical Engineering **Program Code:** ME5k

Name of Subject & Code : Power Plant Engineering (315374) **Semester :** Fifth **Date:-** 18/06/2026

QUESTION BANK

Unit - IV Nuclear Power Plant

Sr.NO	QUESTION	MSBTE QUE. NO	MARKS	EXAMINATION		BLOOSMS LEVEL
1	Name the regulating agencies for Nuclear Power Plant.	QUE-01	2M	W-2025	S-2026	CO-04,TLO-4.5,R
2	List different types of Nuclear fuel.	QUE-01	2M		S-2026	CO-04,TLO-4.1,R
3	Name any four Nuclear Power Plant situated in India with their capacity.	QUE-03	4M		W-2025	CO-04,TLO-4.4,R
4	Explain with neat sketch operating principle of nuclear power plant.	QUE-03	4M		S-2026	CO-04,TLO-4.1,U
5	State four advantages and disadvantages of Nuclear Power Plant.	QUE-04	4M		W-2025	CO-04,TLO-4.1,U
6	State the four functions of Atomic Energy Regulatory Board (AERB).	QUE-04	4M		W-2025	CO-04,TLO-4.5,R
7	Compare between Boiler Water Reactor (BWR) and Pressurised Water Reactor (PWR).	QUE-04	4M		S-2026	CO-04,TLO-4.2,A
8	State different types of Nuclear reactors. Explain the working of Boiling Water Reactor (BWR) with neat sketch.	QUE-05	6M		W-2025	CO-04,TLO-4.2,U

Subject Teacher
Mr.Anup P.Patil

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Unit-4 - Nuclear Power Plant

T20-4.1- Introduction to Nuclear Power Plant:-

The nuclear rector produces and Controls the release of Nuclear energy from splitting of heavier unstable atom of certain element such as U_{235} & Th_{232} and artificial element Pu_{239} by bombarding the nucleus with neutrons.

In an nuclear power energy released from continuous fission of the atoms of the fuel is used as heat the gas or water to produced steam.

The worlds first nuclear reactor operated naturally in a uranium deposit about two billion year ago. There were in rich Uranium ore bodies and moderate by percolating rainwater

The OKlO in west africa, each less than 100 KW thermal, together Consumed about six ton of the uranium.

The main design is the pressurized water reactor (PWR) which has water at over 300°C under pressure in its primary cooling or heat transfer Circuit and generates steam in secondary circuit.

The less numerous boiling water reactor (BWR) makes steam in the Primary circuit above the reactor Core, at similar temp. and Pressure.

* Site selection Criteria of Nuclear Power Plant:-

① Availability of Water:-
- Large quantity of water is required for cooling.
- must be located near a river, sea or lake.

② Distance from Populated Area:-
- To minimize the impact of radiation leakage.
- site should be at a safe distance from cite & town.

③ Geothermal stability:-
- Area should be free from earthquakes, land sliding & floods.
- soil should be strong enough to support heavy structure.

④ Accessiability:-
- site should be easily accessible for transporation of heavy equipment & fuel.
- Good Road, Rail & sometimes port facility are required.

⑤ Waste disposal facility:-
- Proper facility should be available for disposal of radioactive waste.
- site should be allow for safe & along terms waste storage.

⑥ Environmental Impact:-
- Must Comply with environmental regulation.
- Impact on local flora, fauna & climate. should be minimal.

⑦ Government Regulation:-
- site should Comply with the ruler of Nuclear Regulatory Authorities (AERB in India)
- Requires detailed site Analysis, Approvals and Environmental clearances.

* Nuclear fuel:-

Naturally occuring uranium is composed almost totally of two uranium isotopes. It contain more than 99% uranium (U_{238}) and less than 1% Uranium (U_{235}).

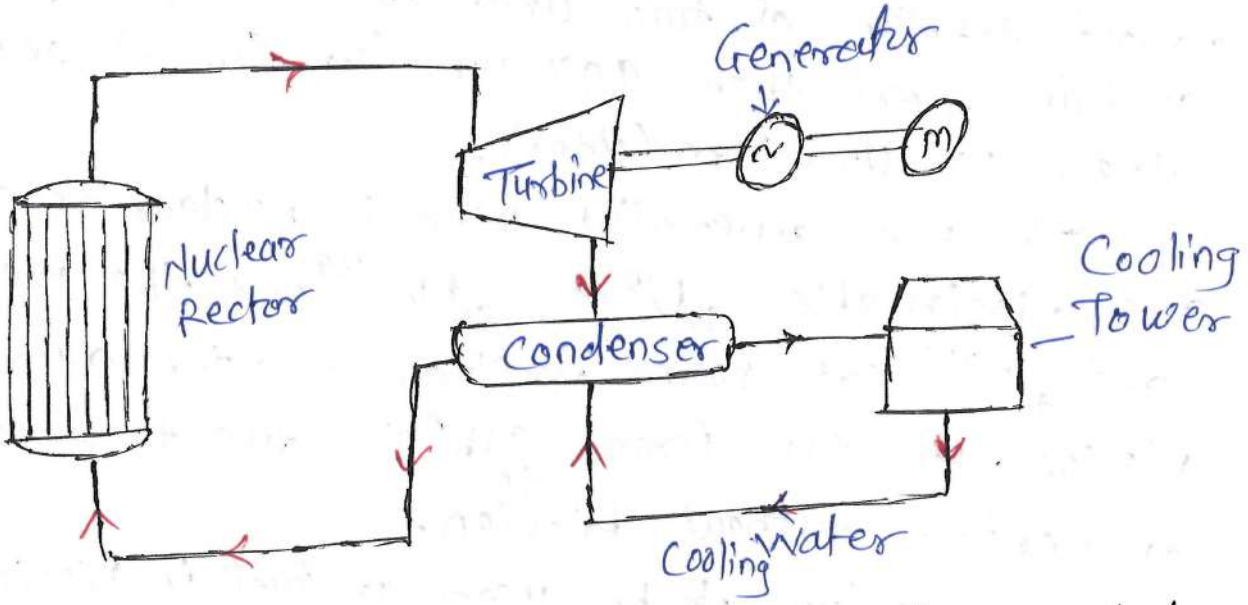
The fuel generally used in nuclear reactor are fissionable $_{92}U^{235}$, $_{94}Pu^{239}$ and the fuel $_{94}Pu^{239}$ and $_{92}U^{233}$ are form nuclear reactor during fission process from $_{90}Th^{232}$ due to absorption of neutron without fission.

For uranium to be used as fuel in fission reactor, the percentage of uranium (U_{235}) must be increased usually to about 3% of uranium in which the U_{235} content is more than 1% is used called enriched uranium.

The enriched Uranium UF_6 gas is collected, cooled until it solidified and then token to fabrication facility where it is made into fuel assemblies each fuel assembly consistant of fuel rod that contain many thimble sized, ceramic encased enriched uranium fuel pellets.

Modern nuclear reactor may contain as many as 10 million fuel pellets. The amount of energy ineach of there pellets is equal to that in almost a ton of coal or 150 gallons of oil.

* General Layout of Nuclear Power Plant:-



The location of fuel, moderator, control rods and coolant in typical power reactor. These Component are enclosed in pressure vessel.

The coolant heated in passing by the fuel element. Flow through a heat exchanger where it turn water in a secondary circuit into steam. The steam is then used to drive a turbine generator.

(1) Core:-

Fuel are reactor have a central core in which fission occurs and most of the fission energy appers as heat. The core contain the nuclear fuel consisting of a fissile species (U^{233}, U^{235}, Pu^{239}) and usually a fertile material (Th^{232}, U_r^{238}).

The fuel elements are made of plates or rod of uranium metal or ceramic. The plates or rod are generally clad a thin sheet of stainless steel, zirconium or aluminium to provide corrosion resistance, retention of radioactivity.

② Core moderator:-

The moderator commonly water or graphite is dispersed between the fuel assemblies. It server to slow down or moderate the fast neutron produced in fission.

In this way slow nutron can maintain the fission chain. The actual energy distribution of the neutron causing most of the fission is determined by the nature and proportion of the fuel and moderators as by the step.

The best moderator are material consist of element of low mass number, preferbly with little or no ~~the~~ tendency to capture neutrons, ordinary water (H_2O) for exams is a common moderator two of its three atoms are Hydrogen with a mass number of unity.

③ Control Rod:-

The control rod are made of a neutron absorbing material and upon movement in or out of the core, vary the number of neutron available to maintain the chain reaction.

The material employed are these with high absorption cross-section, such as boron, cadmium, silver and indium.

④ Reflector:-

The main purpose of the reactor which surround the core is to decrease the loss of neutrons.

It is another method of lowering the neutron leakage and improving the neutron economy by providing a reflector around the reactor core.

A reflector material is one with a high neutron scattering across section, a ~~low absorption~~ good slowing down motion for a speed of escaping

neutron is likely to be slightly higer than thermal speed. In fact most of the material that make good moderator such as graphite, light water and beryllium also make good refractor material.

(5) Coolant:-

The heat generated in the fuel by fission is removed by circulation of the coolant through the reactor core. The coolant transfer heat out of the reactor core is circulated either directly or indirectly as the thermo-dynamic medium for conversion of the heat energy to electrical energy.

(6) Radiation shielding or Biological shielding:-

shileding is necessary in order to protect the wall of the reactor vessel from radiation damage, and also to protect operating personnal from exposure to radiation.

The first known as the internal or thermal shield is provided through steel lining, while is ~~provided through~~ the other called external is generally made of thick concrete (1.8 to 2.0 m) surrounding the reactor installation.

The particles can be travel several meter in air but is unable to penetrate thick material being easily stopped by a thin sheet of aluminium lead bricks.

TLO-4.2- Nuclear Reactor:-

Nuclear reactor technology science of the inception of the nuclear power industry several reactor technology have been developed across the world.

① The type of fissile material used as nuclear fuel e.g. Natural Uranium, enriched uranium.

② The coolant used to recover the heat produced in the core & to transport. eg. ordinary pressumied or boiling water heavy water, Carbon dioxide, sodium, Helium.

In a nuclear reactor, the energy released from Contineous fission of the atoms in the fuel as heat is used to make steam.

* Classification of Nuclear Reactor:-

① According to of neutron Energy:-

(a) Fast Reactor:-

The fission is effected by fast neutrons without use of moderate.

(b) Thermal Reactor:-

Fast neutron are slow down by use of moderate chain reaction of fissionable fuel in control

② According to fuel used:-

① Natural fuel:-

In this natural uranium is used as fuel and heavy water or Graphite are used as moderator.

② Enriched Uranium fuel:-

In this uranium used contain 5 to 10 %. of U^{235} and water is used as moderator.

(3) According to use of moderator used:-
   (a) Water moderator
   (b) Heavy water moderator
   (c) Graphite moderator
   (d) Beryllium Moderator.

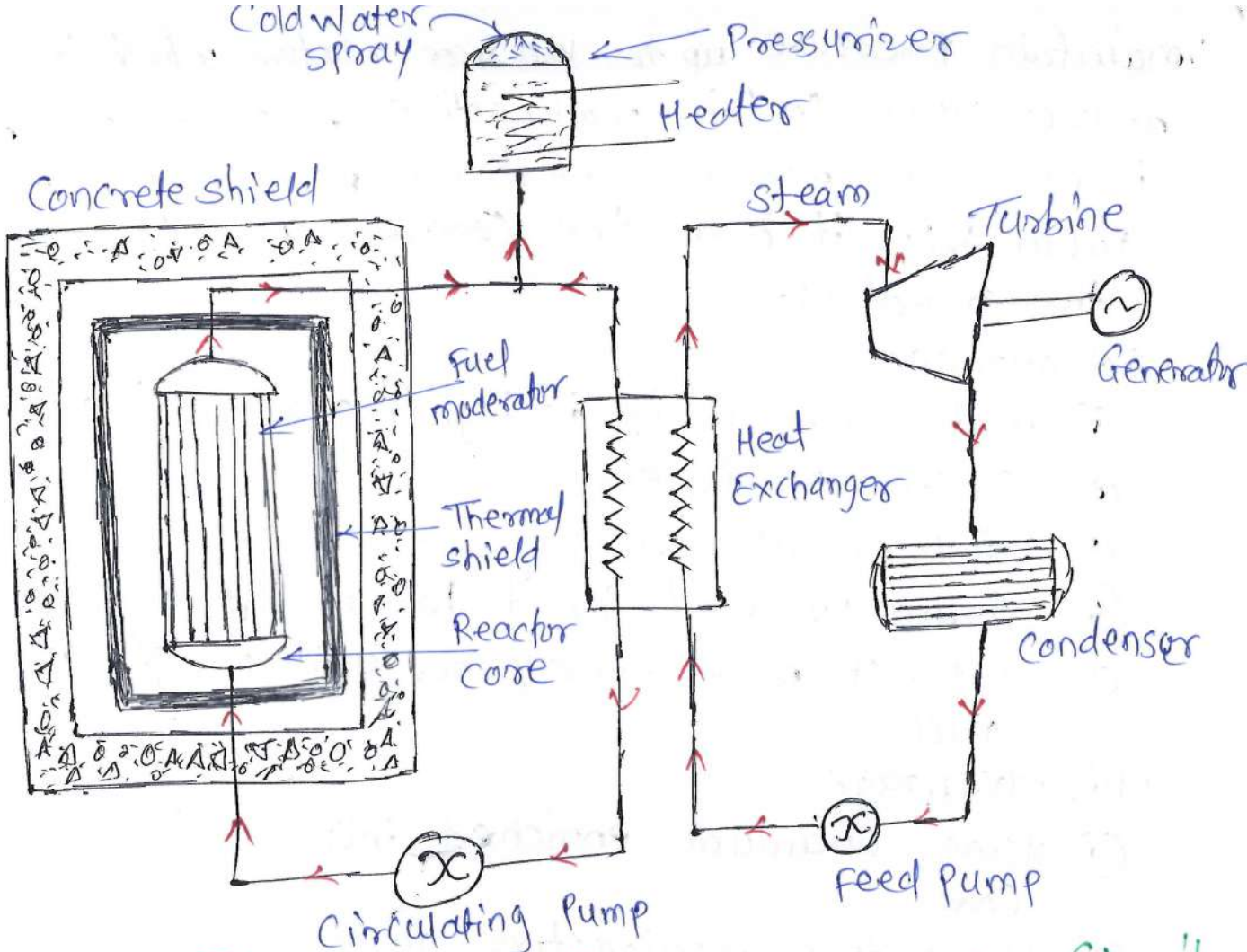
(4) According to use of coolant:-
   (a) water cooled reactor
   (b) Liquid cooled reactor
   (c) Gas cooled reactor
   (d) organic liquid cooled reactor.

(5) According to Core used:-

a) Homogeneous Reactor:-
Both moderator and fuel used represent uniform mixture in fluid form. These have better heat transfer characteristics and its control but repair and maintenance have problem due to highly radioactive mixture.

b) Heterogeneous Reactor:-
Solid fuel is used and coolant is in liquid form and fuel rod are inserted in moderator arranged in some regular order to generate uniform heat energy.

* Types of Reactor:-
* Pressurized Water Reactor:- (PWR):-
This process is used to develope to steam with help of liquid water and moderated reactor it is used enriched ~~Uniform~~ Uranium clad with zirconium alloy as fuel in it.



Pressurized water Reactor (PWR).

*working:-

This is the most common type with about 300 operable reactor for power generation and several hundred more employed for naval propulsion.

The water in the primary circuit get heated by the help of heat energy created through fission reactor in the reactor the heated water is supplied through the heat exchanger to heat the water and produce steam which is entering from another side ~~steam~~ of heat exchanger. by this heat is supplied to develope steam and used for the process.

The water inside the heat exchanger used to recirculate with the help of a pump and

maintain Pressure up to 120 bar, water which is recirculating contain radioactive material which is not safe who are working near to it, from this it uses the concrete wall to protect the operators.

Advantages:-

① Water used in it is highly available in nature.
② Construction is easy.
③ Investment is loco
④ steam produced by it has no effect.
⑤ Extract more energy per unit weight of fuel.

Disadvantages:-

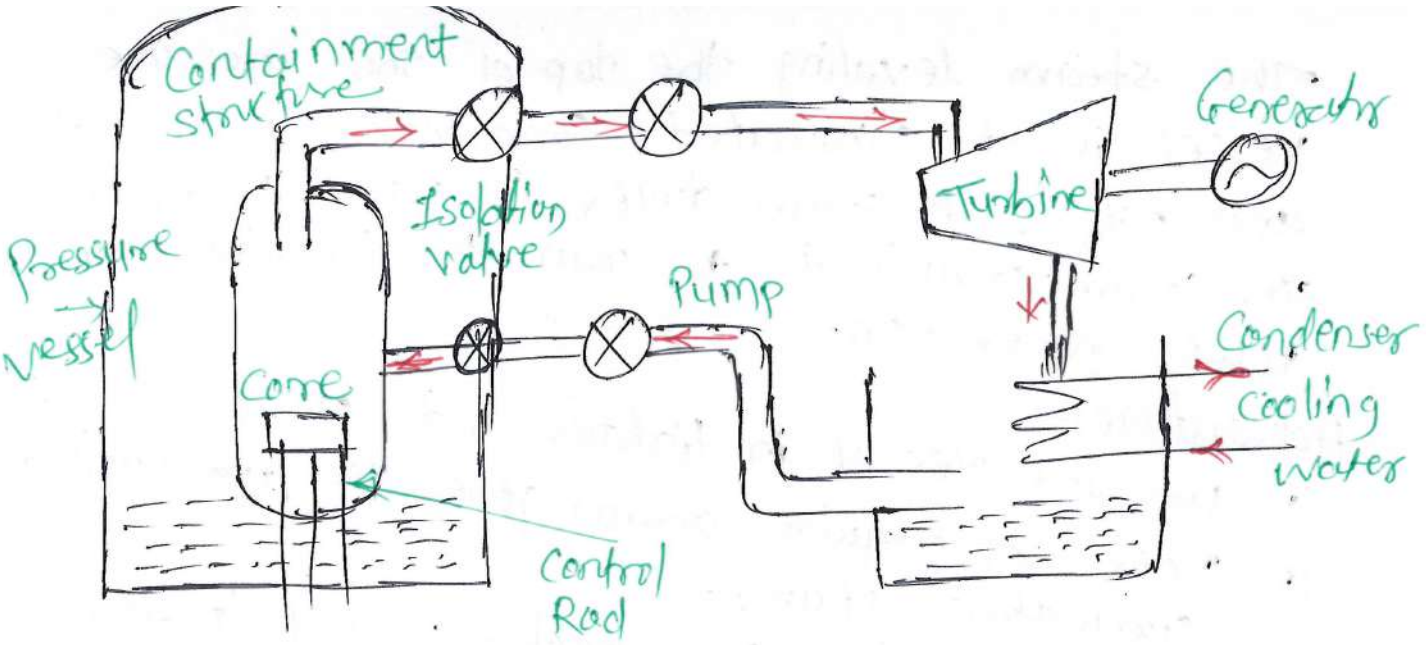
① Using Uranium enriched increase the fuel cost.
② It produce radioactive gases which are harmfull
③ Final efficiency obtained is less
④ It may cause corrosion effect.

② Boiling Water Reactor:- (BWR)

This reactor the coolant boils in the reactor pressure vessel itself.

The boiling water reactor utlizes enriched uranium as the fuel and light water as both moderator and coolant.

It operates at a relatively lower Pressure of about 76 bar in such way that water boils in the core at about 285°C.



Boiling Water Reactor (BWR)

Construction:-

The BWR reactor core consist of a large number of fuel rod housed in fuel assemblies in a nearly cylindrical arrangement.

The BWR reactor core is housed in a pressure vessel that is larger than that of a PWR. A typical BWR pressure vessel which also house the reactor core, moisture separator steam dryer has a diameter of 6.4 m with height of 22m science a BWR operator at a nominal pressure of 6.9 mpa. its pressure vessel is thinner that of a PWR.

Working :-

Light water which act as the coolant and moderator passes through the core where boiling takes places in the upper part of the core.

The wet steam then passes through a bank of moisture separator and steam dryer in the upper part of the pressure vessel.

The feed water enters through the nozzle located high on the vessels but below the water level.

The steam leveling the top of the pressure vessel is at saturated condition of 7.2MPa and 278°C. A steam dryer is used to produce dry steam required to run the turbine for power generation.

Advantage:-

(1) Pressure vessel in lighter and of low cost.
(2) Does not require steam generator, pressurizer circulating pump.
(3) pressure inside the reactor vessel is low.
(4) Extract more energy per unit weight of fuel.
(5) No Heat exchanger gain in thermal efficiency.

Disadvantages:-

(1) steam leaving the reactor is slightly radioactive, therefore light shield for turbine and piping is needed.
(2) possibilities of burning of fuel in reactor is more.
(3) Power demand cannot be meet suddenly
(4) waste steam lowering the thermal efficiency on part load operation.

TLO.4.3- Nuclear Waste & Disposal:-

Nuclear waste refer to radioactive by product generated from nuclear reactor, fuel passing plants and institution that use radioactive material for research medicine power generation.

Its disposal is one of the most critical challenges in the nuclear industry due to its long lived radioactivity and potential environmental and health Hazards.

* Types of Radioactive Nuclear Waste:-

① Low level waste (LLW):-
- Items like clothing, tools, filter and medicine tubes.
- Typically short lived radioactivity
- Disposed of in near surface facilities.
- Nuclear reactor, clinics dental workplaces comparative sort of officies frequently utilize low level nuclear waste material every day.

② Intermediate level waste:- (ILW):-
- It includes resign chemical sludges and reactor components.
- Require shielding due to higher radiation level.
- may be solidified & stored underground or in engineered facilities.

③ High level waste:- (HLW):-
- Primarily spent nuclear fuel or waste From reprocessing.
- Extremly radioactive & thermally not requires deep geological disposal.

④ Mining & milling:-

Clean & mitereliged waste stone is delivered during mining exercies which must be uncovered to get to the uranium metal body.

* Disposal method:-

① Near Surface Disposal:- (For LLW).

- Buried in engineered container near the surface.
- Monitored & maintained to prevent leakage.

② Deep Geological Reposifories:- (for HLW):-

- Waste placed deep underground
- Facilities are designed to isolate waste for thousand to million of year.

③ storage:- (short to medium term):-

① Wet storage:-

spent fuel stored in a pools of water at reactor site.

② Dry Cask storage:-

used after cooling with fuel in sealed steel & concrete container.

④ Reprocessing & Recyling:-

- some countries (France, Russia) reprocess spent fuel to extract unstable Uranium and plutonium.
- Reduces the volume of HLW but create complex waste steam.

TLO-4.4- Present Nuclear power scenario in India:-

India is steady expanding its nuclear power generation capacity to meet the growing energy demands & reduce dependence on fossile fuel.

Plant Name	Location	Type of Reactor	Capacity (MW)
(1) Tarpur Automic Power station	Maharashtra	BWR + PHWR	1400
(2) Rajstan Automic power station	Rajstan	PHWR	1180
(3) Madras Automic Power station	Tamilnadu	PHWR	440
(4) Narora Automic Power station	Utter-Pradesh	PHWR	440
(5) Kakrapar Automic Power station	Gujrat	PHWR	1140
(6) Kaiga Automic Power station	Karnataka	PHWR	880
(7) Kundakulam Nuclear Power Station	Tamilnadu	VVER (Russion Tech)	2000
(8) kundakulam unit (3-6),	Tamilnadu	VVER	4000
(9) Gorakhpur Anu vidyut Pariyojana	Haryana	PHWR	1400
(10) GHAVP (phase-I)	Rajstan	PHWR	1400

TLO-4.5- Introduction to Regulatory Agencies and regulations:-

* Automic Energy Regulatory Board (AERB):-

AERB was consituted on 15 NOV. 1983 by the president of India. (Head Quarter- mumbai)

The regulatory authority of AERB is derived from the rules and notification promulgated under the Automic Energy Act 1962 and the Environmental Act 1986.

The AERB is responsible for regulating the use of ionizing radiation & nuclear energy in india. to ensure safety of worker the public and environment.

AERB secretaials has geotechnical division & 2 supporting division. The head directors of division constitute the executive committee which meet periodically with chairman, AERB, and executive Director, AERB to take desion on important policiles mattern related to the management of the secretaries of the Board.

OPSD - Operating plant safety Division.
NPSD - Nuclear project safety Division.
RSD - Radiological safety Division.
NSAD - Nuclear safety Analysis division.
R&DD - Resources & Documentation Division.
DRI - Directorate of Regulatory Inspection.
DRA&C - Directorate of Regulatory Affairs and communication.
DRP&E - Directorate of Radioaction Protection and Environment.
SRI - Safety Reserch Institute, Kalpkkam.

* Function of AERB:-

① Regulation & oversight:-
- Ensure safety in the operation of nuclear power plant, radiation facilites & nuclear fuel cycle facilities.
- Grant licenses & Automization.

② standard & Guidlines:-
Developer safety Codes, Guides & manual for radiation protection & nuclear safety.

③ Inspection & Enforcement:-
- Conduct safety review and Inspections.
- Can issue directive or suspend licences for non-compliance.

④ Radiation Protection:-
Ensure protection measure are in place in medical industrial and research application involving radioactive material.

⑤ Emergency preparedness:-
Oversees and support emergency response plan for nuclear emergencies.

⑥ Reserch & Development:-
support researeh on nuclear & radiation safety.

⑦ Public Awareness:-
Educates the public on radiation safety and promotes transperancy in nuclear regulation

⑧ International Collabration:-
Collabrate with Global Regularity likes.
- International Automic Energy Agency (IAEA)
- World Association of nuclear operator (WANO)
- Participate in global safety initiative and peer reviews.

* International Automic Energy Agency:- (IAEA)

IAEA is an autonomous organization with in the united Nations System. It promotes the safety, secure & peacefully use of nuclear Technology would wise.

* safety standard:-

① Nuclear Power Plant Safety:-

a) Nuclear Power Reactor:-

Establishing rules for the design, operation and decommissioning of Nuclear reactor to ensure public health and environmental protection.

b) Safety of Nuclear fuel cycle facilities:-

Cover the safety standard for all stages of the nuclear fuel cycle from mining to waste disposal.

c) Safety of Research Reactor:-

focus on safety in research reactor used for academic & scientific purpose.

② Radiation Protection:-

ⓐ Radiation Protection of workers & Public:-

Ensure the protection of people from radiation, explosion, setting doer limits and safety practices for workers & public.

ⓑ Transport of Radioactive Material:-

Governs the safe transport of radio active substances across borders following IAEA regulation to minimise risk during transit.

③ Waste Management:-

Establisher standard for managing radioactive waste including storage, treatment and disposal with a focus on environmental and human health Projection.

④ Safeguards Agreement:-

These are legal agreement between the IAEA and individual states that allow the agency to verify that nuclear material are not deviveted to weapon programs.

⑤ Nuclear security Recommendation:-

These recommendation helps Countries strengthen the physical protection of nuclear and radioactive material.

⑥ Code of Conduct on the safety & security of Radioactive sources:-

This documents provides guidliner for the protection of radioactive source to prevent their theft or misuse.

⑦ Guidline for safe use of Nuclear Technology:-

ⓐ medical use of Radiation:-

Ensure that medical use of radiation such as radiology and diagonstic imaging are Carried out safety Protecting both patients and medical Professions.

ⓑ Agricultural Uses of Radiation:-

Guidlines for the safe uses of radiation in agriculture such as in pest Control, plant breeding and food preservation.

ⓒ Industrial Application:-

Ensuring safe practices in industrial use of radiation such as the testing material sterilization & oil exploration.