

**REPORT ON IN-PLANT TRAINING IN (MAPS)
MADRAS ATOMIC POWER STATION (6 DAYS)**

Submitted in partial fulfilment of the requirements for the completion of

PROFESSIONAL TRAINING

By

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with grade "A++" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119

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BONAFIDE CERTIFICATE

This is to certify that this INTERNSHIP Report is the bonafide work of **SALLIANN FLORA LAURENT (41140075)** who have done the Internship in “NUCLEAR POWER CORPORATION OF INDIA LIMITED”. Who carried out the Internship entitled “MADRAS ATOMIC POWER STATION” from 10th JULY 2023 to 15th JULY 2023.

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Submitted for Viva voce Examination held on _____

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न्यूक्लियर पावर कॉर्पोरेशन ऑफ इंडिया लिमिटेड
(भारत सरकार का उद्यम)

NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

IN-PLANT TRAINING REPORT

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PREFACE

I have attended the In-plant training program conducted by Nuclear Training Centre of Madras Atomic Power Station (MAPS) located in Kalpakkam, Chengalpattu district, Tamil Nadu. The training commenced from 10-07-2023 to 15-07-2023 for a duration of week.

MAPS is an indigenous nuclear power station established by Department of Atomic Energy. The In-plant training is a part of my industry internship programme in Electrical and Electronics Engineering in Sathyabama Institute of Science and Technology Chennai – 600119.

1. COMPANY PROFILE

Madras Atomic Power Station (MAPS) located at Kalpakkam about 80 kilometres (50 mi) south of Chennai, India, is a comprehensive nuclear power production, fuel reprocessing, and waste treatment facility that includes plutonium fuel fabrication for fast breeder reactors (FBRs). It is also India's first fully indigenously constructed nuclear power station, with two units each generating 220 MW of electricity. The first and second units of the station went critical in 1983 and 1985, respectively, the station has reactors housed in a reactor building with double shell containment improving protection also in the case of a loss-of-coolant accident. An Interim Storage Facility (ISF) is also located in Kalpakkam. The facility is also home to India's first large scale fast breeder reactor of 500 MWe called the Prototype Fast Breeder Reactor operated by BHAVINI and will also be the site of first two FBR-600 commercial fast breeder reactors.

1.1 ABOUT MAPS IN BRIEF

The Madras Atomic Power Plant (MAPS) is located in Kalpakkam, Tamil Nadu, India. It is one of India's prominent nuclear power facilities and plays a crucial role in the country's nuclear energy program. Here are some key points about the Madras Atomic Power Plant:

1. Location: MAPS is situated on the Coromandel Coast of the Bay of Bengal in the town of Kalpakkam, approximately 70kilometers south of Chennai (formerly known as Madras), the capital city of Tamil Nadu.

2. Commissioning: The plant was commissioned in 1984 and is operated by the Nuclear Power Corporation of India Limited (NPCIL).

3. Type of Reactors: MAPS consists of two pressurized heavy water reactors (PHWRs)

MAPS Unit 1: It has a capacity of 220 MWe and uses natural uranium as fuel.



Fig: 1.1

MAPS Unit 2: Similar to Unit 1, it also has a capacity of 220 MWe.



Fig:1.2

4. Safety: Safety is of utmost importance in nuclear power plants, and MAPS is equipped with modern safety features and protocols to ensure the safe operation of its reactors.

5. Research Facilities: In addition to power generation, MAPS houses various research and development facilities related to nuclear science and technology. These facilities contribute to the advancement of nuclear technology and research in India.

6. Community: The Kalpakkam township houses employees and their families associated with the plant. It has infrastructure, schools, and other amenities to support the needs of the plant's workforce.

7. Contributions to Energy: Madras Atomic Power Plant, along with other nuclear power plants in India, plays a significant role in the nation's energy generation. Nuclear power is considered a clean and efficient source of electricity in India's energy mix.

8. Expansion Plans: India has plans for expanding its nuclear power capacity, and there have been discussions about adding more reactors to the Madras Atomic Power Plant complex to meet the growing energy demands of the region.

9. Environmental Impact: Nuclear power plants like MAPS produce electricity with minimal greenhouse gas emissions, making them an environmentally friendly option for electricity generation.

10. International Collaboration: India has collaborated with various countries and international organizations in the field of nuclear energy, and MAPS has been a part of such collaborative efforts. It's important to note that safety, security, and environmental protection are paramount concerns at nuclear power plants like MAPS, and they operate under strict regulations and guidelines to ensure the safe generation of electricity while minimizing the environmental impact.

1.2 INTRODUCTION TO MAPS

DAE stated that based on the experience gained in construction of Rajasthan units, the Department decided that the two units of Kalpakkam (Madras) would be set up without any external assistance. The responsibility for detailed design, safety review, construction and commissioning was taken up departmentally with maximum participation from Indian industry. Indian consulting agencies were also involved in some of the conventional areas of work. Madras Atomic Power Project (MAPP) was approved in 1965 as the third nuclear power project and sanction for construction of MAPP-I was given in December 1967.

1.3 NPCIL

Nuclear Power Corporation of India Limited (NPCIL) is a Public Sector Enterprise under the administrative control of the Department of Atomic Energy (DAE), Government of India. The Company was registered as a Public Limited Company under the Companies Act, 1956 in September 1987 with the objectives of operating atomic power plants and implementing atomic power projects for generation of electricity in pursuance of the schemes and programs of the Government of India under the Atomic Energy Act, 1962.

NPCIL also has equity participation in BHAVINI, another PSU of Department of Atomic Energy (DAE) which implements Fast Breeder Reactors programme in the country. NPCIL is responsible for design, construction, commissioning and operation of nuclear power reactors. NPCIL is a MoU signing, profit making and dividend paying company with the highest level of credit rating (AAA rating by CRISIL and CARE), NPCIL is presently operating 22 commercial nuclear power reactor with an installed capacity of 6780 MW. The reactor fleet comprises two **Boiling Water Reactors** (BWRS) and 18 **Pressurized Heavy Water Reactors** (PHWRs) including one 100 MW PHWR at Rajasthan which is owned by DAE, Government of India and two 1000 MW VVER reactor KKNPS-1&2, in this, latest addition to the fleet.

2. PLANTS UNDER OPERATION

As of my last knowledge update in September 2021, India had several nuclear power plants in operation. These nuclear power plants contribute significantly to the country's electricity generation. Please note that the operational status of nuclear power plants can change over time due to various factors, including maintenance, upgrades, and regulatory decisions. Here is a list of some of the operational nuclear power plants in India as of my last update:

2.1 Tarapur Atomic Power Station (TAPS), Maharashtra:

- TAPS has two pressurized heavy water reactors (PHWRs),
- Units 1 and 2, each with a capacity of 160 MWe.
- TAPS also has two larger PHWRs, Units 3 and 4, each with a capacity of 540 MWe.

2.2 Kaiga Atomic Power Station, Karnataka:

- Kaiga has four PHWRs, each with a capacity of 220 MWe.
- Kaiga Units 1 and 2 use natural uranium as fuel, while Units 3 and 4 use slightly enriched uranium.

2.3 Kudankulam Nuclear Power Plant, Tamil Nadu:

- Kudankulam Nuclear Power Plant is one of India's newest nuclear power facilities.
- It has two VVER-1000 pressurized water reactors (PWRs), each with a capacity of 1,000 MWe. These reactors are of Russian design and technology.

2.4 Madras Atomic Power Plant (MAPS), Tamil Nadu:

- MAPS has two PHWRs, Unit 1 and Unit 2, each with a capacity of 220 MWe.
- MAPS is located in Kalpakkam, Tamil Nadu.

2.5 Rajasthan Atomic Power Station (RAPS), Rajasthan:

- RAPS has several reactors, including PHWRs and a fast breeder reactor.
- Units 1 and 2 are PHWRs with a capacity of 100 MWe each.
- Units 3, 4, 5, and 6 are also PHWRs with higher capacities.
- The Fast Breeder Test Reactor (FBTR) is used for research and development in fast breeder technology.

2.6 Narora Atomic Power Station (NAPS), Uttar Pradesh:

- NAPS has two PHWRs, Unit 1 and Unit 2, each with a capacity of 220 MWe.

2.7 Kakrapar Atomic Power Station (KAPS), Gujarat:

- KAPS has two PHWRs, Unit 1 and Unit 2, each with a capacity of 220 MWe.

3. PLANTS IN TAMIL NADU

3.1 Kudankulam



Fig: 3.1

Kudankulam Nuclear Power Plant (or Kudankulam NPP or KKNPP) is the largest nuclear power station in India, situated in Kudankulam in the Tirunelveli district of the southern Indian state of Tamil Nadu. Construction on the plant began on 31 March 2002,[3] but faced several delays due to opposition from local fishermen.[4][5] KKNPP is scheduled to have six VVER-1000 reactors built in collaboration with Atomstroy export, the Russian state company and Nuclear Power Corporation of India Limited (NPCIL), with an installed capacity of 6,000 MW of electricity.

3.2 Kalpakkam



Fig: 3.2

Madras Atomic Power Station (MAPS) located at Kalpakkam about 80 kilometres (50 mi) south of Chennai, India, is a comprehensive nuclear power production, fuel reprocessing, and waste treatment facility that includes plutonium fuel fabrication for fast breeder reactors (FBRs). It is also India's first fully indigenously constructed nuclear power station, with two units each generating 220 MW of electricity. The first and second units of the station went critical in 1983 and 1985, respectively. The station has reactors housed in a reactor building with double shell containment improving protection also in the case of a loss-of-coolant accident. An Interim Storage Facility (ISF) is also located in Kalpakkam.

4. NUCLEAR POWER PLANT

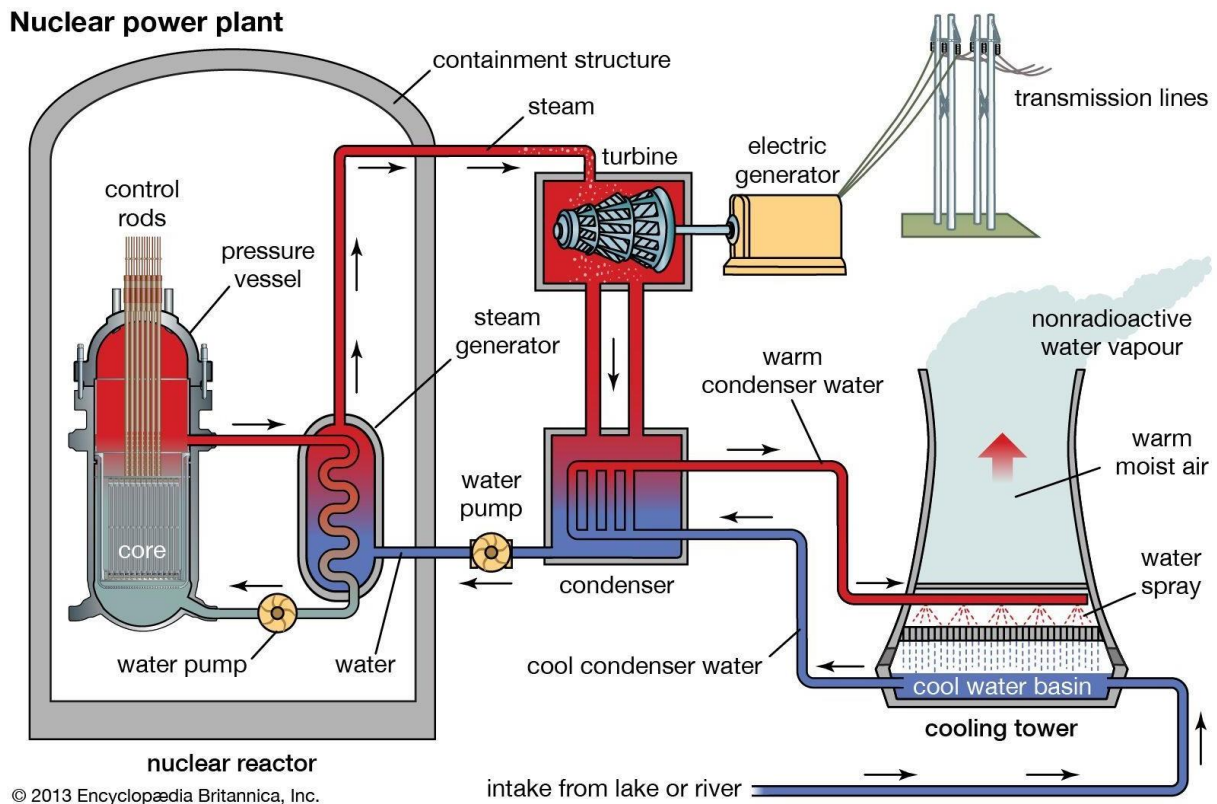


Fig: 4.0

Nuclear reactors operate on the principle of nuclear fission, the process in which a heavy atomic nucleus splits into two smaller fragments. The nuclear fission causes the water to boil, generating steam. This steam flows through pipes into turbines, the turbines are driven by the steam, and this process generates electricity. During normal operation, pressure is controlled by the amount of steam flowing from the reactor pressure vessel to the turbine. The nuclear fragments are in very excited states and emit neutrons, other subatomic particles, and photons. The emitted neutrons may then cause new fissions, which in turn yield more neutrons, and so forth. Such a continuous self-sustaining series.

PARTS OF NUCLEAR POWER PLANT

4.1. Nuclear Reactor:



Fig: 4.1

At the core of the nuclear power plant is the nuclear reactor. This is where nuclear fission reactions occur. Nuclear fuel rods (usually uranium or plutonium) are placed in the reactor vessel. Control rods are inserted or withdrawn to regulate the nuclear reaction.

4.2. Steam Generator:



Fig: 4.2

Heat produced by the nuclear reaction is transferred to a coolant (typically pressurized water) in the reactor core. The hot coolant flows through the primary loop and into the steam generator. In the steam generator, the hot coolant transfers its heat to a secondary loop of water, turning it into steam.

4.3. Turbine:

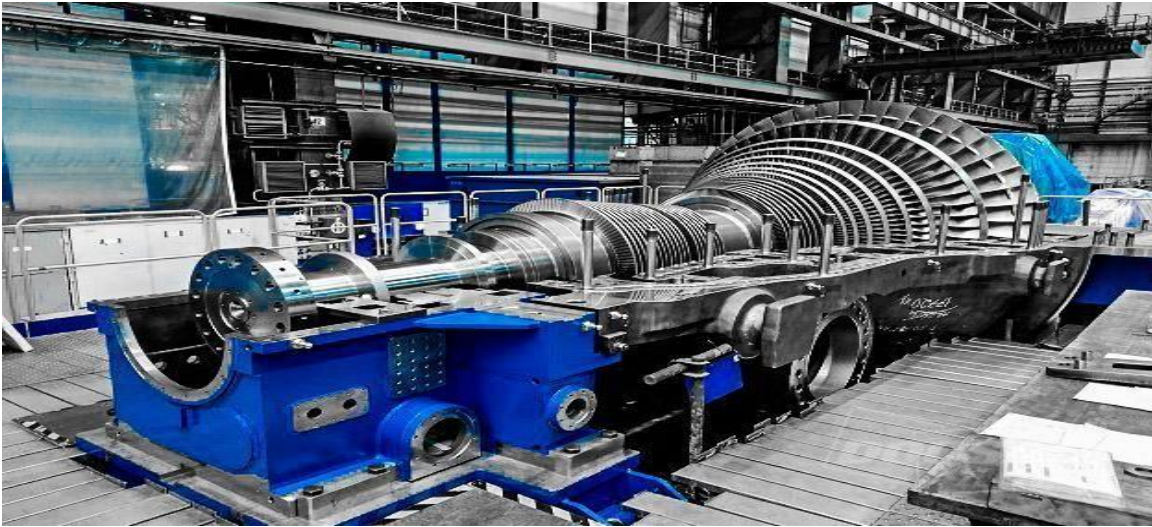


Fig: 4.3

The high-pressure steam generated in the secondary loop flows into a turbine. the steam's energy causes the turbine blades to spin.

4.4. Generator:



Fig: 4.4

The spinning turbine is connected to a generator. As the turbine turns, it drives the generator, which converts mechanical energy into electrical energy.

4.5. Condenser:

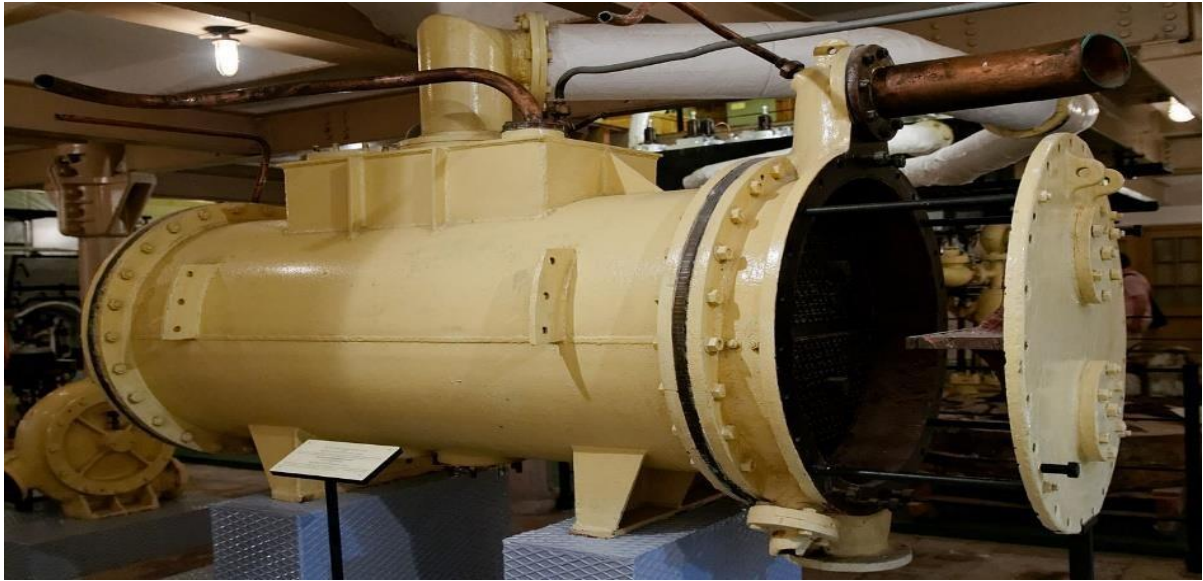


Fig: 4.5

After passing through the turbine, the steam is condensed back into water in the condenser. This process involves cooling the steam using cold water from a nearby source (e.g., a river or cooling towers) The condensed water is then returned to the steam generator to begin the cycle again.

4.6.Cooling System:

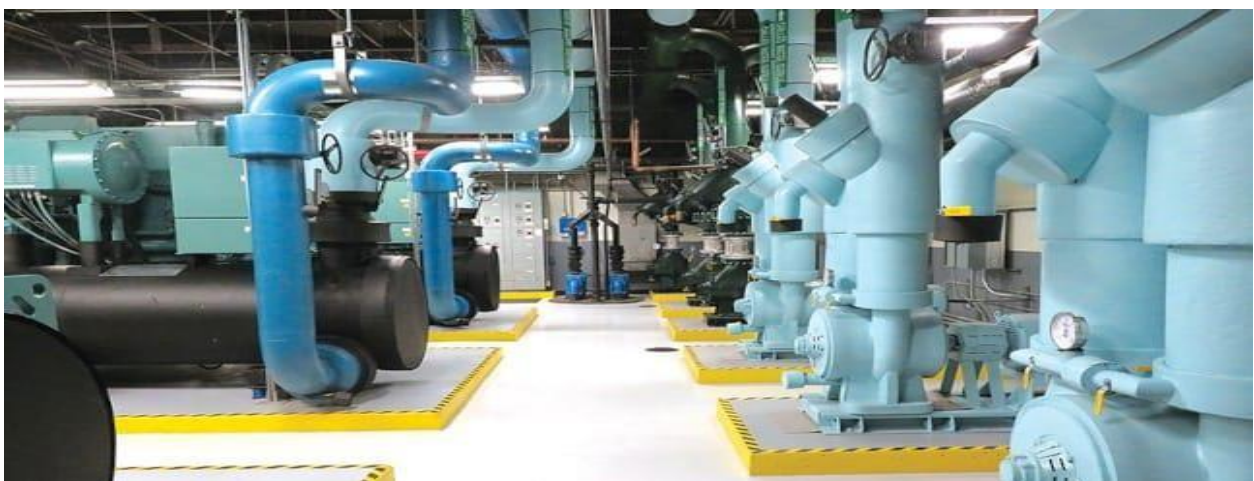


Fig: 4.6

Nuclear power plants require a cooling system to dissipate excess heat generated during the nuclear reaction and in other components. This may involve cooling towers, cooling ponds, or direct use of a natural water source.

4.7.Control Room:



Fig: 4.7

Highly trained operators in the control room monitor and control the reactor and various systems to ensure safe and efficient operation.

4.8.Safety Systems:

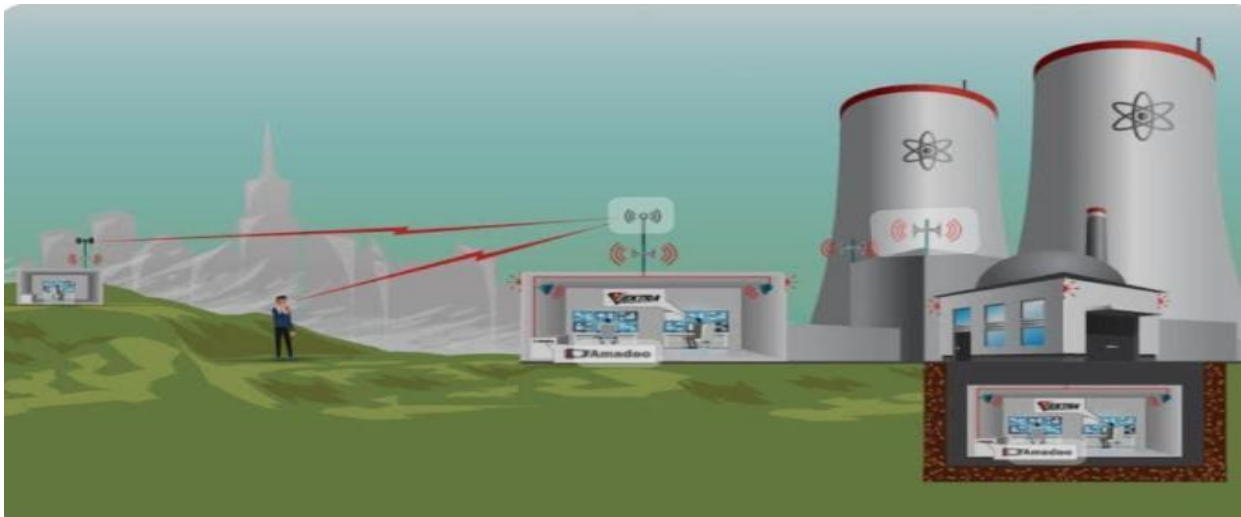


Fig: 4.8

Nuclear power plants are equipped with multiple safety systems, including emergency cooling systems, backup power supplies, and containment structures to prevent the release of radioactive materials.

4.9.Electrical Grid:



Fig: 4.9

The electricity generated by the generator is transmitted to the electrical grid, where it can be distributed to homes and businesses.

5. PARTS OF NUCLEAR POWER PLANT

5.1 TURBO GENERATOR



Fig: 5.1

Steam generators are heat exchangers used to convert water into steam from Produced in a nuclear reactor core They are used in pressurized water (PWR) between the primary and secondary coolant loops.

5.2 CALNDRIA



PHWR Fuel Assembly



PHWR Calandria

Fig: 5.2

Calandria tube (CT) made from annealed Zircaloy-2 has been installed in MWe Indian PHWRS, as well as in CANDU units. CTs of 540 MWe PHWR At Tarapur are made from annealed Zircaloy-4 material, During service, Subjected to a high neutron flux and consequently undergo irradiation Strengthening/hardening and some loss of ductility. It consists of 306 tubes.

5.3 IND00R SWITCH YARD



Fig:5.3

In an electric power transmission grid system, switchyard reactors are installed Substations to help stabilize the power system. For transmission lines, the Between overhead line and ground

forms a capacitor parallel to transmission Which causes an increase in voltage as the distance increases. To offset Capacitive effect of the transmission line and to regulate the voltage and power system, reactors are connected either at line terminals The middle, thereby improving the voltage profile of transmission line. The exhaust stacks are divided into two types depending on the facilities nuclear power plant; one is the type that ventilates by the system of each, Other is the type that ventilates all together.

5.4 STACKS



Fig: 5.4

The exhaust stacks are divided into two types depending on the facilities of the nuclear power plant; one is the type that ventilates by the system of each, and the other is the type that ventilates all together.

5.5 ADMINISTRATIVE BUILDING

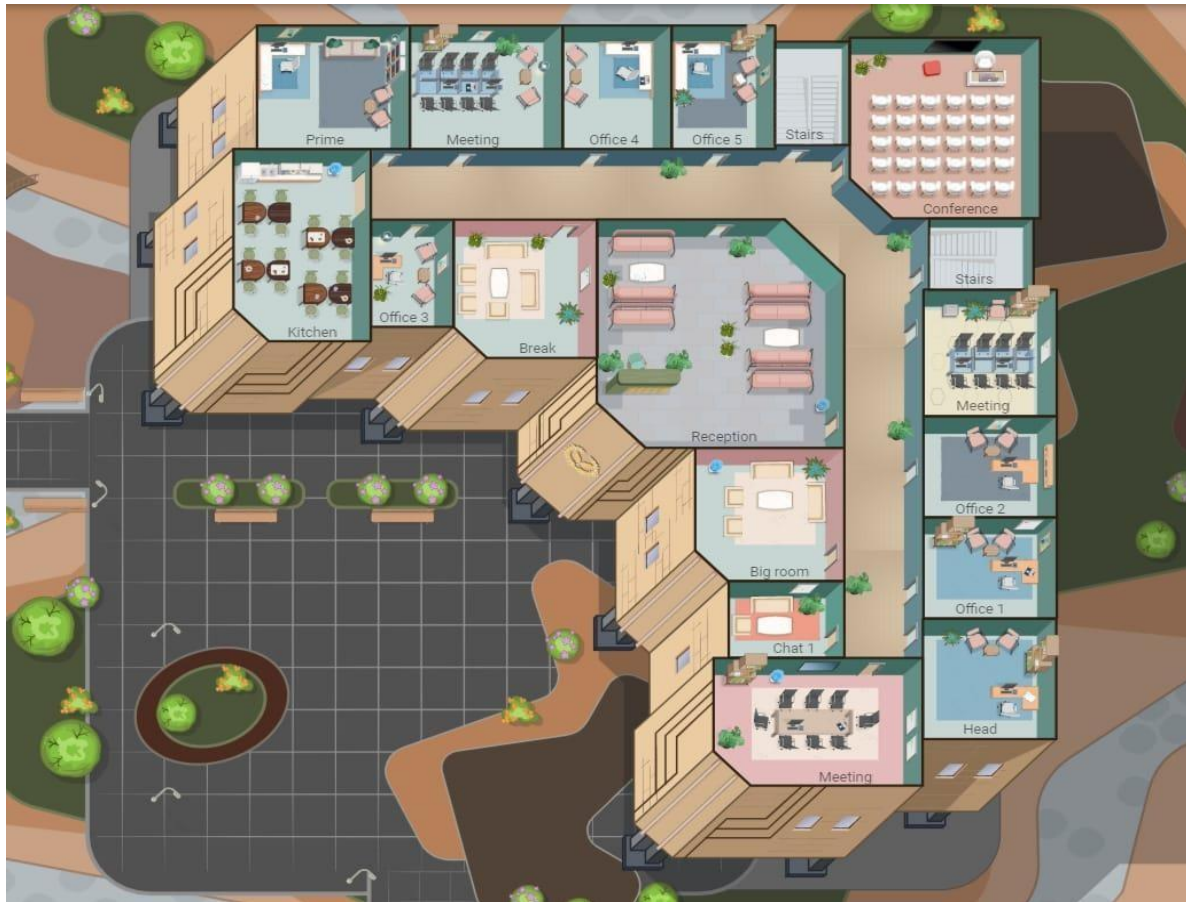


Fig: 5.5

The Administration Building at a nuclear plant often houses the following Management and supervision covering operations, maintenance, engineering. Radiation protection, chemistry, security, support, quality assurance/nuclear Performance monitoring -Engineering- nuclear, systems – mechanical, electrical, Instrumentation, programs and testing, design and modification, maintenance

Support -Operations and maintenance support, including procedures development And maintenance groups -Quality assurance and control (nuclear performance Monitoring) - Purchasing -Documentation, microfilm, typing support -Licensing -Maintenance office and shops for mechanical, electrical, instrumentation, Computers may be located in the plant or in separate facilities Than silver, U-235 is relatively rare at just over 0.7% of natural uranium. Fueling method is undergone in nuclear plants.

6. VARIOUS TRANSPORT SYSTEMS IN PLANT

1.FEED WATER SYSTEM

The system that stores and pump water directly into steam boilers.

2.MODERATOR SYSTEM

The Moderator System consists of a closed recirculating heavy water circuit. The moderator system circulates the heavy water moderator through the calandria to remove moderator heat during reactor operation; moderator heat is rejected to the Recirculated Cooling Water System.

3.PRIMARY HEAT TRANSPORT SYSTEM

PHTS transports heat generated in the reactor core to the secondary system or to the ultimate heat sink. This includes the primary side of the steam generators, the primary coolant pumps, the coolant channels, end fittings, pressuriser, piping and piping components.

4.SEA WATER COOLING SYSTEM

Sea water system is the internal energy-transfer function, water is circulated continuously in a closed-loop cycle. The primary heat source turns water to steam to drive the turbine, and the water is then condensed and returned to the heat source. In this internal circuit, hardly any water is lost, so only a very small amount of make-up water is required.

7. NUCLEAR SAEFTY MEASURES

NPPs in India are not only safe but are also well regulated, have proper radiological protection of workers and the public, regular surveillance, dosimetry, approved standard operating and maintenance procedures, a well-defined waste management methodology, proper well documented and periodically rehearsed emergency preparedness and disaster management plans.

1. Proper design, plant layout and adequate shielding.
2. Limits of air contamination levels in different zones of the plant.
3. Source control by proper selection of materials/components.

7.1 ATOMIC REGULATORY BOARD

The AERB has prescribed the following dose limits for exposures to ionizing radiations for occupational workers:

7.1.1 Effective dose (whole body)

Twenty Milli- Sievert (mSv/year averaged over five consecutive years, Calculated on a sliding scale of 5 years. (The cumulative effective dose in the same 5-year period shall not exceed 100 mSv.) A maximum of 30 mSv in a year.

7.1.2 Equivalent dose (individual organs)

Eye lens 150 mSv/year, Skin 500 mSv/year, Extremities 500 mSv/year (hands and feet)

7.1.3 Pregnant Woman

Equivalent dose limit to the surface of the woman's lower abdomen (for the Remaining period of pregnancy) Annual Limit on Intake (ALI) for radionuclides -0.05 ALI. (For the remaining Period of pregnancy)

7.2 Safety Culture: Fostering a strong safety culture within the organization is fundamental. This involves a commitment to safety at all levels of management and among all personnel. Safety culture encourages open communication, reporting of safety concerns, and continuous improvement.

7.3 Regulation and Oversight: Nuclear facilities are subject to strict regulatory oversight by government agencies. These agencies establish and enforce safety standards, conduct inspections, and ensure compliance with safety regulations.

7.4 Design Safety: Nuclear power plants are designed with multiple layers of safety features. These include redundant safety systems, physical barriers to contain radioactive materials, and fail-safe mechanisms to shut down the reactor in emergencies.

7.5 Operator Training and Qualification: Operators of nuclear facilities undergo extensive training and must meet stringent qualification requirements. They are trained to respond to normal operations, as well as to identify and address abnormal or emergency situations.

7.6 Radiation Protection: Stringent measures are in place to protect workers and the public from exposure to radiation. These measures include the use of shielding materials, the monitoring of radiation levels, and the enforcement of dose limits for workers.

7.7 Security Measures: Nuclear facilities have robust security measures to protect against unauthorized access, theft, sabotage, and terrorism. These include physical security measures, access controls, and surveillance systems.

8. Why nuclear energy?

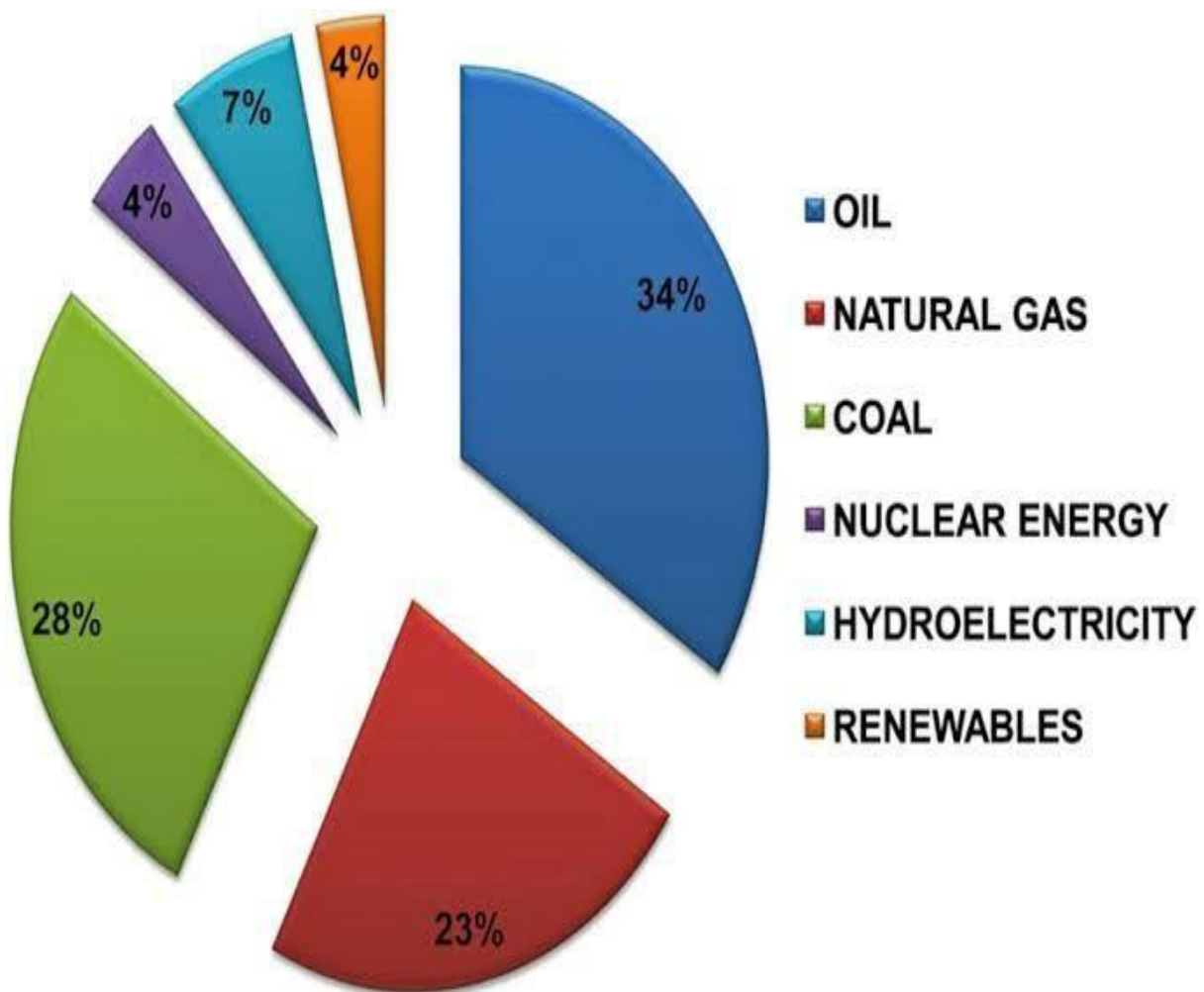


Fig:8.1

8.1 Nuclear energy protect air quality.

Nuclear is a zero-emission clean energy source. It generates power through fission, which is the process of splitting uranium atoms to produce energy. The heat released by fission is used to create steam that spins a turbine to generate electricity without the harmful byproducts emitted by fossil fuels. It also keeps the air clean by removing thousands of tons of harmful air pollutants each year that contribute to acid rain, smog, lung cancer and cardiovascular disease.

8.2 Nuclear energy's land foot print is small.

Despite producing massive amounts of carbon-free power, nuclear energy produces more electricity on less land than any other clean-air source. A typical 1,000-megawatt nuclear facility in the United States needs a little more than 1 square mile to operate. NEI says wind farms require 360 times more land area to produce the same amount of electricity and solar photovoltaic plants require 75 times more space. To put that in perspective, you would need more than 3 million solar panels to produce the same amount of power as a typical commercial reactor or more than 430 wind turbines (capacity factor not included).

8.3 Nuclear energy produces minimal waste.

Nuclear fuel is extremely dense. It's about 1 million times greater than that of other traditional energy sources and because of this, the amount of used nuclear fuel is not as big as you might think. All of the used nuclear fuel produced by the U.S. nuclear energy industry over the last 60 years could fit on a football field at a depth of less than 10 yards, that waste can also be reprocessed and recycled, although the United States does not currently do this. However, some advanced reactors designs being developed could operate on used fuel.

9. APPLICATION OF NUCLEAR POWER PLANT

Nuclear power plants have various applications, primarily focused on the generation of electricity. Here are the main applications of nuclear power plants:



Fig: 9.1

9.1 Electricity Generation: The primary and most well-known application of nuclear power plants is the generation of electricity. Nuclear reactors use nuclear fission reactions to produce heat, which is then converted into electrical energy through turbines and generators. Nuclear power plants are a reliable and consistent source of baseload electricity, meaning they can operate continuously to meet the demand for electricity.

9.2 Baseload Power: Nuclear power plants are ideal for providing baseload power, which is a constant, non-fluctuating supply of electricity. They can run continuously for extended periods, making them well-suited to meet the minimum level of electricity demand.

9.3 Carbon-Free Energy: Nuclear power is considered a low-carbon or carbon-free energy source. Unlike fossil fuel power plants, nuclear reactors do not emit greenhouse gases such as carbon dioxide (CO₂) during electricity generation. This makes nuclear power an important contributor to reducing air pollution and combating climate change.

9.4 Reliable Power Supply: Nuclear power plants provide a reliable source of electricity, reducing the dependence on weather-dependent energy sources like wind and solar. They can operate regardless of weather conditions or time of day.

9.5 Large-Scale Electricity Production: Nuclear power plants are capable of producing large amounts of electricity, making them suitable for meeting the energy needs of densely populated areas or entire regions.

9.6 Diverse Applications in Industry: Beyond electricity generation, nuclear reactors have applications in various industrial processes, such as desalination of seawater, hydrogen production, and the synthesis of isotopes for medical, industrial, and scientific purposes.

9.7 Space Exploration: Nuclear power sources, such as radioisotope thermoelectric generators (RTGs), have been used in space exploration missions to provide electricity to spacecraft and rovers on distant planets where solar power is not feasible.

9.8 Research and Development: Nuclear power plants serve as important research and development facilities for advancing nuclear science and technology. They contribute to the development of new reactor designs, safety protocols, and materials science.

9.9 Medical Isotope Production: Some nuclear reactors are used for the production of medical isotopes, which are crucial for diagnostic imaging, cancer treatment, and various medical procedures.

9.10 National Security: Nuclear reactors also have applications in the production of fissile materials for nuclear weapons, although this aspect is highly regulated and controlled under international treaties and agreements aimed at preventing the proliferation of nuclear weapons.

10.CONCLUSION

The nuclear power has come of age with comprehensive capabilities in all aspects of nuclear power and is poised for a large expansion program. The challenge is to pursue the three-stage program, develop and commercially deploy Technologies for utilization of thorium and ensure the country's long term energy Security. At present nuclear reactors has an increasingly important role to play in the generation of electricity and in the other areas such as defence (Plutonium Based atomic weapons) where radio nuclides are required. Needless to say, when pursuing such a program, it is paramount importance that health and safety of the Plant personnel and member of the public are fully ensured. The pressurized heavy Water reactor, which will be the main source of the nuclear power in India for Present as well as future, have several safety features. This Design provides Redundancy in protective and safety system and adopts the concept of defence in Depth. The double containment feature provides an added level safety level. Operation of nuclear power station is characterized by the strict adherence to a Set of prescribed limits and guidelines. the operation personnel are carefully Selected, trained and qualified. Environmental releases and exposure of personnel Are routinely monitored so as to ensure that they are within stipulated limits. The Regulation authorities critically review the design and procedure for manufacture, Construction and operation, prior to issue of appropriate licenses. Experience with Madras atomic power station has demonstrated that the pressurized heavy water Reactor system capable of operation with high reliability while ensuring safety Of plant personal and the surrounding population, and with the minimal impact On environment.



Thank
You!

