VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the following:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well-designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual For

Electrical Power Generation, Transmission and Distribution

(313333)

Semester – III

(EE/EP)

“K-SCHEME”

Maharashtra State

Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

4th Floor, Government Polytechnic Building, 49, Kherwadi, Bandra (East), Mumbai- 400051.

(Printed on July, 2024)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION, MUMBAI

Certificate

This is to certify that Mr. /Ms ……………………………………………………..........

Roll No. ………………………….., of Third Semester of Diploma in …..………………………..………………………………………………. of Institute, ………………………………………………………………………………………. (Code : ……………………) has completed the term work satisfactorily in course **Electrical Power Generation, Transmission and Distribution (313333)** for the academic year 20…….to 20…….. as prescribed in the curriculum.

Place: …………….. **Enrollment No: ………………..**

Date: ………………. **Exam Seat No: …………………**

Subject Teacher **Head of department** **Principal**

Seal of Institution

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher, instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a 'vehicle' to develop this industry identified competency in every student. The practical skills are difficult to develop through "chalk and duster" activity in the classroom situation. Accordingly, the ‘K’ scheme laboratory manual development team designed the practicals to focus on the outcomes, rather than the traditional age-old practice of conducting practicals to 'verify the theory" (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the industry/employer expected outcome, course level learning outcome, laboratory learning outcome, which serve key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centred lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

The electrical diploma holder has to work in industry as technical person in middle level management. He has to work as production, maintenance, testing engineer in various industries like power generation, transmission, distribution, traction etc. and has to deal with Urban, Rural, Industries and Agriculture sector. While performing above task he has to identify different component of the electrical power system. Therefore he/she must require the skills to maintain the proper functioning of the power system..

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Program Outcomes (POs) to be achieved through this Course Learning

- **PO 1. Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, sciences and engineering fundamentals with electrical engineering specialization to solve the engineering problems.
- **PO 2. Problem analysis:** Identify and analyze well-defined engineering problems using codified standard methods.
- **PO 3. Design/ development of solutions:** Design solutions for well-defined technical problems and assist with the design of system components or processes to meet specified needs.
- **PO 4. Engineering tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.
- **PO 5. Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.
- **PO 6. Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.
- **PO 7. Life-long learning:** Ability to analyse individual needs and engage in updating in the context of technological changes.

List of relevant expected psychomotor domain skills

This Lab manual intends to develop expected psychomotor domain skills of students. The skills mentioned below will be developed through the experiments performed in this Laboratory**.**

1. To use the vocabulary of electrical power system.
2. To identify various components of power system.
3. Ability to draw and sketch.
4. Ability to operate and handle components of electrical power system.

Practical Course Outcome matrix

Course level learning outcomes (COs)

CO1 - Maintain the optimised working of the thermal power plant and hydro power plant.
CO2 - Select the relevant power generation technology based on economic operation.
CO3 - Interpret the normal operation and parameters of the electric transmission system.
CO4 - Interpret the parameters of the extra high voltage transmission system.
CO5 - Maintain the functioning and operation of electric power distribution system.

Sr. No.	Title of the Practical	CO1	CO2	CO3	CO4	CO5
1	*Demonstration of a Thermal Power Plant using Visit/Animations/ Video programme.	✓	-	-	-	-
2	Process of Heat Recovery System in Thermal Power Plant.	✓	-	-	-	-
3	*Demonstration of a Hydro Power Plant using Visit/Animations/ Video programme.	✓	-	-	-	-
4	Demonstration of a Pumped storage Hydro Power Plant using Visit/Animations/ Video programme.	✓	-	-	-	-
5	*Demonstration of Different types of Hydro Power Plant using Animations/ Video Programme.	✓	-	-	-	-
6	*Load curve of Campus/ Institute building(s) and calculation of following economical factors: Maximum demand, Average load, Load Factor, Reserve capacity, Plant capacity factor, utilization factor, Plant use factor and Diversity factor.	✓	✓	-	-	-
7	*Selection of power generation technology as per variation in load demand of a given load curve	✓	✓	-	-	-
8	Load Duration curve and Integrated load curve.	-	✓	-	-	-
9	*Single line diagram of the Electric supply system.	-	-	✓	-	✓
10	*Layout of 400kV transmission line substation.	-	-	✓	-	-
11	Layout of 132 kV transmission line substation.	-	-	✓	-	-
12	*Demonstration of an Ultra High Voltage (UHV) Transmission lines using Animations/ Video Programme.	-	-	-	✓	-

13	Demonstration of Extra High Voltage (EHV) Transmission lines using Visit/Animations/ Video Programme.	-	-	-	✓	-
14	*Layout of HVDC transmission line.	-	-	-	✓	-
15	*Components of Distribution Substation.	-	-	-	-	✓
16	*Distribution scheme for Commercial and Residential Consumers.	-	-	-	-	✓
17	Distribution scheme for Industrial Consumer.	-	-	-	-	✓

Guidelines to Teachers

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain prior concepts to the students before starting of each experiment
3. Involve students in performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in. the students after the completion of the practical exercise.
5. Teachers should give opportunity to students for hands on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
8. Finally give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions.

Instructions for Students

1. Listen carefully the lecture given by teacher about subject, curriculum, learning structure, skills to be developed.
2. Organize the work in the group and make record all programs.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and gain confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual.
6. Student shall refer technical magazines.
7. Student should develop habit to submit the practicals on date and time.
8. Student should well prepare while submitting write-up of exercise.
9. Attach/paste separate papers wherever necessary.

Content Page

List of Practical's and Progressive Assessment Sheet

Sr. No.	Title of the Practical	Page no.	Date of Performance	Date of Submission	Assess ment Marks (25)	Dated sign. of Teacher	Remark s (If any)
1.	*Demonstration of a Thermal Power Plant using Visit/Animations/ Video programme.	1					
2.	Process of Heat Recovery System in Thermal Power Plant.	8					
3.	*Demonstration of a Hydro Power Plant using Visit/Animations/ Video programme.	16					
4.	Demonstration of a Pumped storage Hydro Power Plant using Visit/Animations/ Video programme.	23					
5.	*Demonstration of Different types of Hydro Power Plant using Animations/ Video Programme.	29					
6.	*Load curve of Campus/ Institute building(s) and calculation of following economical factors:	39					

	Maximum demand, Average load, Load Factor, Reserve capacity, Plant capacity factor, utilization factor, Plant use factor and Diversity factor.							
7.	*Selection of power generation technology as per variation in load demand of a given load curve	48						
8.	Load Duration curve and Integrated load curve.	53						
9.	*Single line diagram of the Electric supply system.	59						
10.	*Layout of 400kV transmission line substation.	64						
11.	Layout of 132 kV transmission line substation.	68						
12.	*Demonstration of an Ultra High Voltage (UHV) Transmission lines using Animations/ Video Programme.	72						

13.	Demonstration of Extra High Voltage (EHV) Transmission lines using Visit/Animations/ Video Programme.	76						
14.	*Layout of HVDC transmission line.	81						
15.	*Components of Distribution Substation.	86						
16.	*Distribution scheme for Commercial and Residential Consumers.	92						
17.	Distribution scheme for Industrial Consumer.	97						
Total								

Note: Out of above suggestive LLOs -
'*' Marked Practicals (LLOs) Are mandatory.
Minimum 80% of above list of lab experiment are to be performed.
Judicial mix of LLOs are to be performed to achieve desired outcomes.

Practical No. 1: Demonstration of a Thermal Power Plant using Visit / Animations/ Video programme

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to identify different components/equipment/apparatus and their location in a typical Thermal Power Plant and understanding the operation of various components. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Maintain the optimized working of the thermal power plant and hydro power plant.

IV Laboratory Learning Outcome(s)

1. Draw layout of the typical Thermal Power Plant
2. Identify the different components of typical Thermal Power Plant
3. Observe the operation of Thermal Power Plant

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.

b. Maintain tools and equipment.

c. Maintain tools and measuring instruments.

VI Relevant Theoretical Background

Depending upon the type of energy source which is used to generate electrical energy, the generating stations are classified as

- Thermal power stations
- Hydroelectric power stations
- Diesel power stations
- Nuclear Power stations

In a Thermal generating station where heat energy from coal combustion is used to produce steam which again used to rotate steam turbine coupled to alternator and now alternator converts mechanical energy into electrical energy. This energy is further transmitted by transmission line.

VII Practical set-up / Circuit diagram / Work Situation

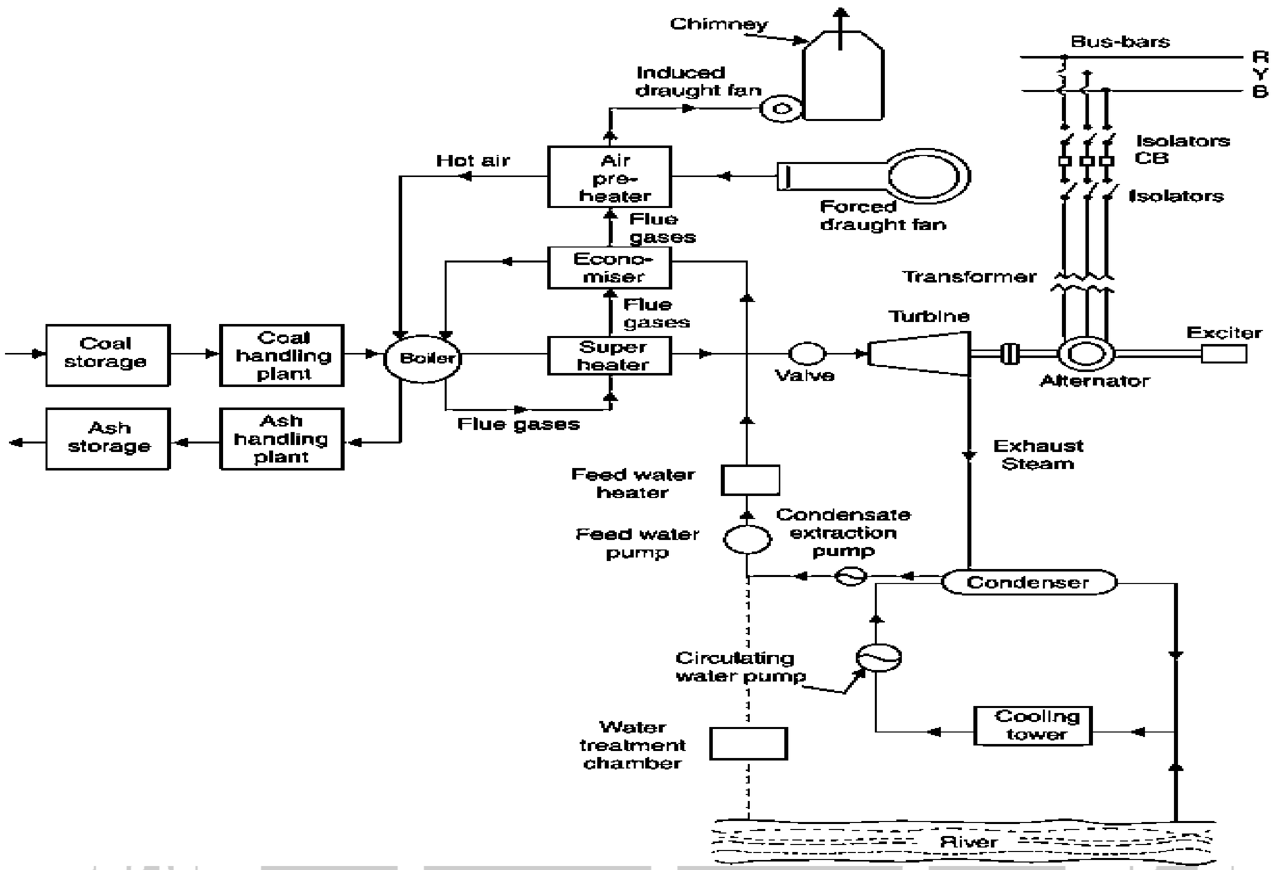

Fig: 1.1 Layout of a typical Thermal Power Plant

VIII Required Resources/apparatus/equipment with specification

1. Drawing tools
2. Half Imperial drawing sheet
3. Videos on Thermal power station

IX Precautions to be followed

1. Watch authentic videos
2. Use proper symbols while drawing the layout of Thermal power station

X Procedure

1. Watch videos of thermal power station/ visit thermal power station.
2. Observe the operation of various components of thermal power station and collect information.

XI Collect the following information about Thermal Power plant

Name of power station: ______________________________

Specifications (Technical Parameters):

Sr. No.	**Parameter**	**Specification**
1	Capacity in MW	
2	Type	
3	No. of Units.	
4	Type of turbine	
5	Location	

XII Observation table (use blank sheet provided if space not sufficient)

Sr. No.	**List of component**	**Function**	**Specification**
1	Boiler		
2	Economiser		
3	Alternator		
4	Air-preheater		
5	Steam turbine		
6			

7			
8			
9			
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11			
12			
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14			
15			
16			

XIII Conclusion

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XIV Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. Write the operation of Thermal Power Station.
2. Enlist the different types of the boilers used in TPS.
3. Enlist different types of the condensers.
4. Prepare list of TPS in Maharashtra.
5. List out the measuring and protective equipment used in control room of Thermal power station.
6. The overall efficiency of a steam power station is low, give reason.

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XV References/Suggestions for further reading

1. **https://ntpc.co.in/power-generation/coal-stations**
2. **https://youtu.be/IdPTuwKEfmA?si=jnwkIIxLCDxFrSIa**
3. **https://youtu.be/m4CwaKTQikw?si=S6Z7UcpQH1OZopc9**
4. **www.powergrid.in**
5. **https://www.electrical4u.com/thermal-power-generation-plant-or-thermal-power-station/**

XVI Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 2: Process of Heat Recovery System in Thermal Power Plant

I Practical Significance

This practical will help in acquiring necessary skills to identify the components of heat recovery and their functioning in thermal power plant.

II Industry/Employer Expected Outcome(s)

In the industry Electrical Engineering diploma graduate are expected to handle with maintenance of heat recovery systems components in thermal power plant. These components play an important role in increasing the efficiency of thermal power plant. At the time of failure of component, in some situation it becomes necessary to identify the faulty components, immediate maintenance or replacement action to be taken. This practical will help in developing these skills.

III Course Level Learning Outcome(s)

Maintain the optimised working of the thermal power plant and hydro power plant.

IV Laboratory Learning Outcome(s)

1. Identify the components of the Heat Recovery System.
2. Describe the function of Components of the Heat recovery System.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Maintain tools and measuring instruments.

VI Relevant Theoretical Background

A heat recovery unit is effectively a multi-faceted ventilation system. Mechanical heat recovery ventilation (MHRV system), works by recovering heat from extract air that would otherwise be expelled to the atmosphere and transfers this heat to fresh air being drawn into the property via a heat exchanger.

Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then “dumped” into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its “value”. The strategy of how to recover this heat depends in part on the temperature of the waste heat gases and the economics involved. Large quantity of hot flue gases is generated from Boilers, Kilns, Ovens and Furnaces. If some of this waste heat could be recovered, a considerable amount of primary fuel could be saved. The energy lost in waste gases cannot be fully recovered. However, much of the heat could be recovered.

Heat Losses – Quality

Depending upon the type of process, waste heat can be rejected at virtually any temperature from that of chilled cooling water to high temperature waste gases from an industrial furnace or kiln. Usually higher the temperature, higher the quality and more cost effective is the heat recovery. In any study of waste heat recovery, it is absolutely necessary that there should be some use for the recovered heat. Typical examples of use would be **preheating of combustion air, space heating, or pre-heating boiler feed water or process water**. With high temperature heat recovery, a cascade system of waste heat recovery may be practiced to ensure that the maximum amount of heat is recovered at the highest potential.

An example of this technique of waste heat recovery would be where the high temperature stage was used for air pre-heating and the low temperature stage used for process feed water heating or steam raising.

Heat Losses – Quantity

In any heat recovery situation it is essential to know the amount of heat recoverable and also how it can be used. An example of the availability of waste heat is given below:

• Heat recovery from heat treatment furnace:

In a heat treatment furnace, the exhaust gases are leaving the furnace at 900 °C at the rate of 2100 m^3 /hour.

The total heat recoverable at 180^0 C

Final exhaust can be calculated as $Q = V \times \rho \times Cp \times \Delta T$

Q is the heat content in KCal

V is the flow rate of the substance in m3 /hr

List of Waste Heat Recovery equipment:

Regenerative Burners	High	Saving fuel by preheating the combustion air and improving the efficiency of combustion.
Recuperative Burners	High	Both the exhaust gas and waste heat from the body of the burner nozzle are capture and more heat from the nozzle is generated.
Economisers	Low – Medium	The system maximises the thermal efficiency of a system by recovering low-medium temperature heat from the waste flue gas for heating/preheating liquids entering a system.

Waste Heat Boilers	Medium – High	The system is suitable to recover heat from medium – high temperature exhaust gases and is used to generate steam as an output.
Recuperators	Low – High	The technology is used for applications with low – high temperatures and is used to decrease energy demand by preheating the inlet air into a system.
Regenerators	Medium – High	The technology is suitable to recover waste heat from high temperature applications such as furnaces and coke ovens and for applications with dirty exhausts.
Rotary Regenerators	Low – Medium	Rotary regenerators are used for low – medium temperature applications and could potentially offer a very high overall heat transfer efficiency.
Run around coil (RAC)	Medium – High	This unit is used when the sources of heat are too far from each other to use a direct recuperator and when cross contamination between the two flow sources needs to be prevented
Heat Recovery Steam Generator (HRSG)	High	The system can be used to recover the waste heat from the exhaust of a power generation or manufacturing plant to significantly improve overall efficiencies by generating steam that can be used for process heating in the factory or power generation.
Plate Heat Exchanger	Medium – High	Plate heat exchangers have high temperature and pressure operating limits and are used to transfer heat from one fluid to another when cross contamination needs to be avoided.
Heat Pipe Systems	Medium – High	Heat pipes have very high effective thermal conductivities, which results in a minimal temperature drop for transferring heat over long distances and long life that requires no maintenance, as they incorporate passive operation. They have lower operation costs when compared to the other types of heat exchangers.
Thermoelectric Generation	Medium – High	The system produces electricity directly from waste heat and eliminate the need for converting heat to mechanical energy to produce electrical energy.
Piezoelectric Power Generation	Low	The system can be used for low-temperature waste heat recovery and works by converting ambient vibration such as oscillatory gas expansion directly into electricity.
Thermionic Generator	High	The device is used for high temperature waste heat recovery and works by producing electric current through temperature difference between two media without the use of any moving objects

Thermo Photo Voltaic (TPV) Generator	Low – High	These devices are used to directly convert radiant energy into electricity and offer a better efficiency when compared to other direct electrical conversion devices.
Heat Pump	Low – Medium	Heat pumps transfers heat from a heat source to a heat sink using a small amount of energy and can be used to offer economical and efficient alternative of recovering heat from various sources to improve overall energy efficiency. Heat pumps in particular are good for low-temperature WHR, as they give the capability to upgrade waste heat to a higher temperature and quality.
Direct Contact Condensation Recovery	Medium – High	the system uses a direct mixture heat exchanger without a separating wall and can be used to transfer heat from immiscible liquid – liquid and solid – liquid or solid-gas.
Indirect Contact Condensation Recovery	Medium – High	The system provides the advantage of eliminating cross contamination of the flue gas and water and can be designed to work as a filter of a process.
Transport Membrane Condenser	Medium – High	The system works by extracting and delivering the hot water back into the system feed water directly from the exhaust gas through a capillary condensation channel. This way, the water is extracted through a membrane channel rather than directly from the flue gas and so the recovered water is not contaminated and does not require filtering.
Thermoelectric Generation	Medium – High	The system produces electricity directly from waste heat and eliminate the need for converting heat to mechanical energy to produce electrical energy.

VII Practical set-up / Circuit diagram / Work Situation:

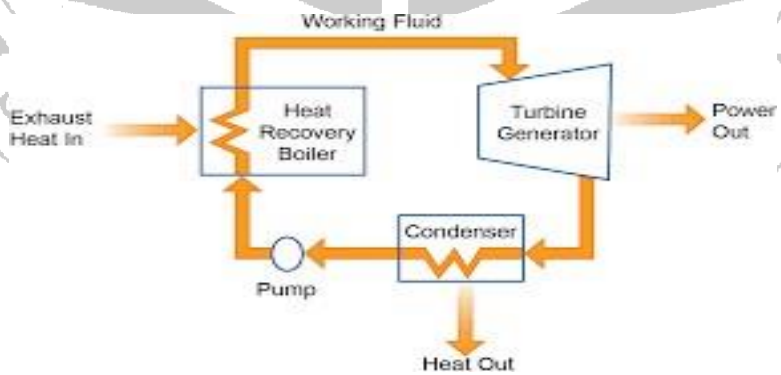

Fig. 2.1 Heat recovery cycle in thermal power station

VIII Precautions to be followed

1. See the video carefully of heat recovery system and note identify the components and their function.
2. Learn the function of heat recovery devices very well and their significance in increasing the efficiency of thermal power plant.

IX Observation table (use blank sheet provided if space not sufficient/use drawing sheet)

(Note: Students will identify and note down the components and will draw the diagram of any 5 components on half-imperial sheet under the guidance of the teacher

Sr. No.	Heat recovery equipment	Function
1	Economiser	
2	Air- preheater	
3		
4		
5		
6		
7		
8		
9		
10		

X Conclusion

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XI Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. Explain the operation of an economizer.
2. What do you understand by the term waste heat?
3. What are the direct and indirect benefits of waste heat recovery?
4. How will you go about developing a waste heat recovery system?
5. Explain the operating principle of a waste heat recovery boiler with examples.

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XII References/Suggestions for further reading

1. https://www.beeindia.gov.in/sites/default/files/2Ch8.pdf
2. https://en.wikipedia.org/wiki/Heat_recovery_steam_generator
3. https://www.pmu.edu.sa/attachments/academics/pdf/udp/coe/dept/me/waste-heat-recovery-system.pdf

XIII Suggested Assessment Scheme

	Performance Indicators	Weightage
Process Related : 15 Marks		**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

<table>
<tr><th colspan="3">Marks Obtained</th><th>Dated signature of teacher</th></tr>
<tr><td>Process Related (15)</td><td>Product Related (10)</td><td>Total (25)</td><td rowspan="2"></td></tr>
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</table>

Practical No. 3: Demonstration of Hydro Power Plant using Visit/Animations/ Video Programme.

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to maintain the functioning and operation of hydro power plant and troubleshoot the components of hydro power station. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Maintain the optimised working of the thermal power plant and hydro power plant.

IV Laboratory Learning Outcome(s)

1. Draw layout of the typical Hydro Power Plant.
2. Identify the different components of typical Hydro Power Plant.
3. Observe the operation of Hydro Power Plant.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Maintain tools and measuring instruments.

VI Relevant Theoretical Background

A generating station which uses the potential energy of water stored at high level for generation of electrical energy is called as “Hydro Power Plant”. In a Hydro power station the bulk quantity of water is stored at high level, which is made to flow through penstocks where the potential energy of water is converted into kinetic energy. These penstocks are connected to water turbine where kinetic energy is converted into mechanical energy. The alternator which is coupled to the turbine converts mechanical energy into electrical energy.

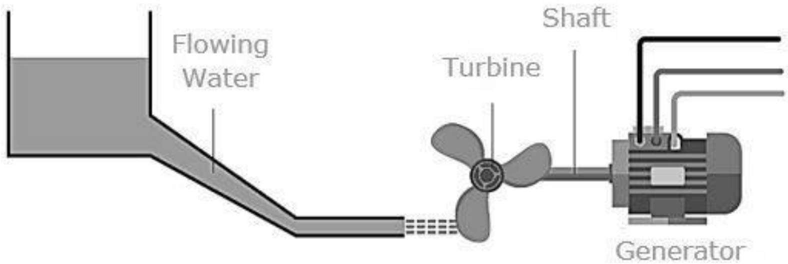

Fig. 3.1 Alternator coupled to water turbine in Hydro power plant

Block diagram given below gives the interconnection of water body (intake or reservoir), penstock, water turbine, alternator and transformer at power house. The capacity of Hydro power plant depends upon the availability of water in that region. It may be a river, big pond or a reservoir with dam.

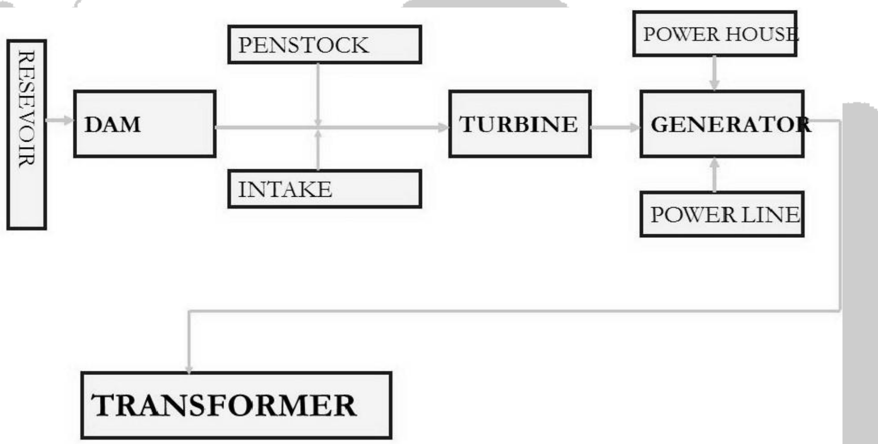

Fig.3.2 Block diagram of Hydro power

VII Practical set-up / Circuit diagram / Work Situation

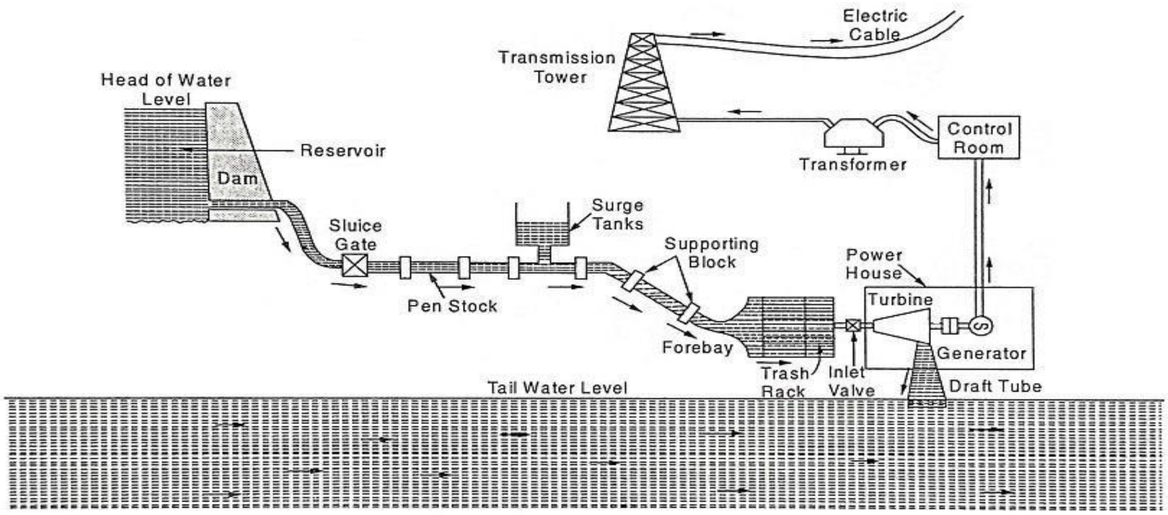

Fig. 3.3 Layout of Hydro Power Plant

VIII Required Resources/apparatus/equipment with specification

1. Drawing tools
2. Half Imperial drawing sheet
3. Videos on Hydro Power station

IX Precautions to be followed

1. Watch authentic videos and learn layout of Hydro power plant.
2. Use proper symbols while drawing the layout on the imperial half-sheet.

X Procedure

1. Watch videos of Hydro power plant/ visit hydro power station.
2. Students will draw this layout on the drawing sheet under the guidance of the teacher.
3. Observe the operation of various components of Hydro power station.

XI Collect the following information about Hydro Power plant :

1. Name of the power station: ____
2. Specifications: ____
3. No. of Units : ____
4. Capacity of each unit: ____
5. Total installed capacity: ____
6. Type of turbine: ____
7. Type of cooling system: ____
8. No. of penstock: ____

9. Type of power station: ____________________
10. Base/Peak load power station: ____________________
11. Low/Medium/high water head: ____________________
12. Rate of discharge of water: ____________________
13. Rating of generator: ____________________

XII Observation table (use blank sheet provided if space not sufficient)

Sr. No.	List of component	Function	Specification
1	Reservoir		
2	Penstock		
3	Trash-rack		
4	Surge tank		
5	Turbine		
6			
7			

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XIII Conclusion

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XIV Practical related questions (Note:- Teacher should provide various questions related to practical-sample given):

1. Write the operation of Hydro power station in brief.
2. Name the factors on which the generating capacity of Hydro power station depends.
3. Compared to the speed of steam turbine, the speed of water turbine is very low. Give reason.
4. List the Hydro power station (with capacity) in Maharashtra.
5. State the advantages of hydro power stations compared to Thermal power stations.
6. Write the difference between steam turbine and water turbine.

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XV References/Suggestions for further reading

1. https://www.electrical4u.com/hydro-power-plant-construction-working-and-history-of-hydro-power-plant/
2. https://www.britannica.com/science/hydroelectric-power
3. https://www.energy.gov/eere/water/types-hydropower-plants

XVI Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 4: Demonstration of Pumped storage Hydro Power Plant using Visit /Animations/ Video programme.

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to maintain the functioning and operation of pumped storage Hydro Power Plant and troubleshoot the components such as turbine, generator etc. of pumped storage hydro power station. Therefore this practical will help students to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Maintain the optimised working of the thermal power plant and hydro power plant.

IV Laboratory Learning Outcome(s)

Draw layout of typical Hydro Power Plant.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.

b. Maintain tools and equipment.

c. Follow ethical Practices.

VI Relevant Theoretical Background

PSH (Pumped storage Hydro) plants operate much like conventional hydropower plants, except PSH has the ability to use the same water over and over again. To generate electricity when power from the plant is needed, water flows from the upper reservoir, because of gravity, through turbine(s) that rotate generator(s) to produce electricity. So it is a configuration of two water reservoirs at different elevation that can generate power as water moves down from one to the other (discharge), passing through a turbine. The system also requires power as it pumps water back into the upper reservoir (recharge). PSH acts similarly to a giant battery, because it can store power and then release it when needed.

Such type of plants is shown in the Fig:4.1 . These are used when the available quantity of water for generation is in-sufficient. Generally, a storage pond s built to store water at head race and tail race. The water passing through the turbine is stored in tail race pond and it is pumped back by the generating system working as motor and stored in the head –race pond again , during the off –peak load hours of the system. Water is drawn from the pond through the penstock to operate the turbine. This type of plants can be operated only in interconnected systems.

VII Practical set-up / Circuit diagram / Work Situation

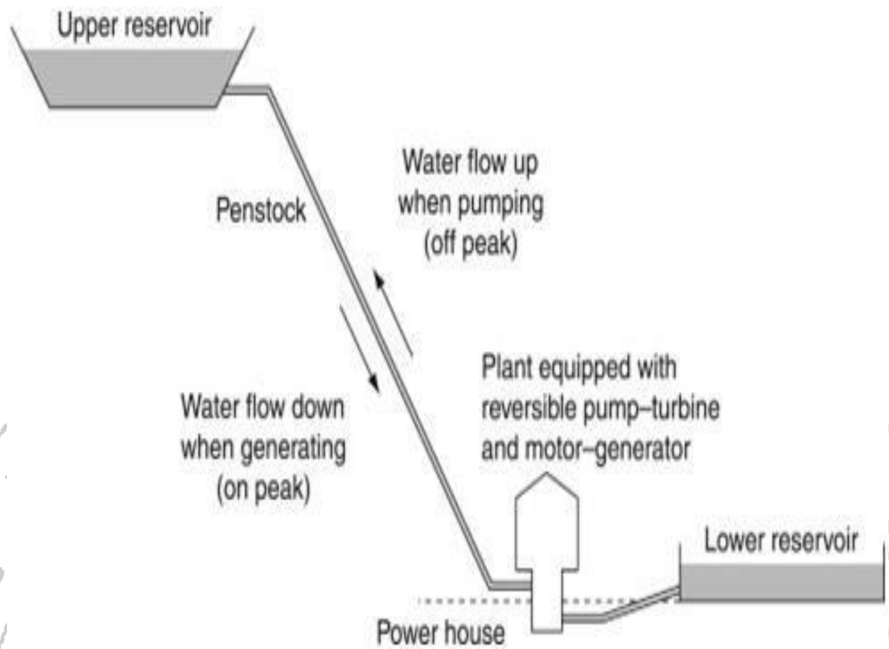

Fig. 4.1 Pumped storage Hydro power plant

VIII Required Resources/apparatus/equipment

1. Drawing tools
2. Half Imperial drawing sheet
3. Videos on Hydro Power station

IX Precautions to be followed

1. Watch authentic videos of pumped storage hydro power station.
2. Use proper symbols while making drawing

X Procedure

1. Watch videos of Pumped Hydro power plant/ visit Pumped hydro power station.
2. Observe the operation of various components of Pumped Hydro power station and understand it.
3. Students will practice the layout on imperial half drawing sheet under the guidance of the teacher.

XI Collect the following information about Pumped Hydro Power plant

1. Name of the power station: ____
2. Specifications: ____
3. No. of Units : ____
4. Capacity of each unit: ____

5. Total installed capacity: ______________________________
6. Type of turbine: ______________________________
7. Type of cooling system: ______________________________
8. No. of penstock: ______________________________
9. Type of power station: ______________________________
10. Base/Peak load power station: ______________________________
11. Low/Medium/high water head: ______________________________
12. Rate of discharge of water: ______________________________
13. Rating of generator: ______________________________

XII Observation table (use blank sheet provided if space not sufficient)

Sr. No.	List of component	Function	Specification
1	Upper Reservoir		
2	Lower reservoir		
3	Penstock		
4	Generator		
5	Turbine		
6			
7			

XIII Conclusion

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XIV Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. Write the principle of pumped storage hydro power station.
2. Write the limitations of pumped storage hydro power plant.
3. Write the efficiency of pumped storage Hydro power plant.
4. Write the lifetime of Pumped Hydro power plant.
5. Write the main advantage of pumped storage hydro power plant.
6. Write the cost per kilowatt for pumped hydro storage.
7. Enlist the hydro power station in India .

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XV References/Suggestions for further reading

1. https://www.energy.gov/eere/water/pumped-storage-
2. https://youtu.be/E-m7Psbuup0?si=mNIXs6jW222jJAYe
3. https://youtu.be/_PH0IJ-_qOI?si=Pqf_vTy1ggNHsnIW
4. https://youtu.be/lsSUPpwtqhQ?si=3-m-vL-CIe_81W5e
5. https://en.wikipedia.org/wiki/Category:Pumpedstorage_hydroelectric_power_stations_in_India
6. https://youtu.be/TdrqcbxrJgI?si=WSDY55Zi2mh0cpXV

XVI Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 5: Demonstration of Different types of Hydro power plant using Animations/Video Programme.

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to maintain the functioning and operation of Different types of Hydro Power Plant and troubleshoot the components of Hydro power station. Therefore this practical will help students to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Maintain the optimized working of the thermal power plant and hydro power plant.

IV Laboratory Learning Outcome(s)

Draw the layout of the typical Hydro Power Plant.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.

b. Maintain tools and equipment.

c. Follow ethical Practices.

VI Relevant Theoretical Background

The classification of Hydro power station can be categorized below:

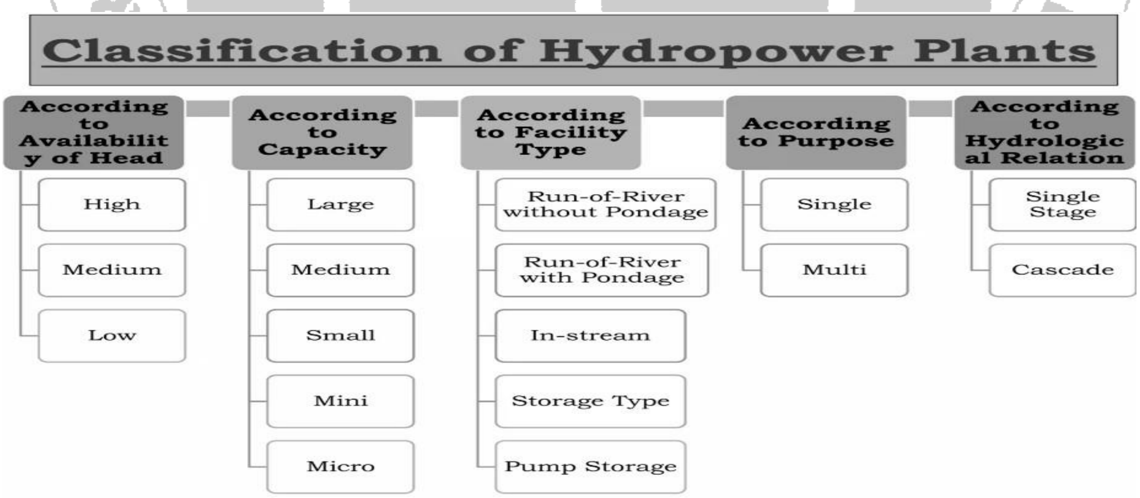

Fig. 5.1 Classification of Hydro power station

1. According to the availability of head:

High Head Plants:

Head: 100m to 2000m

- Mainly in these plants pressure tunnel is provided before the surge tank, which in turn connected to Penstock.
- A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstocks.
- The penstocks are huge steel pipes which take large quantity of water from the valve house to the power house.

Medium head plants:

Head: 30 to 100m

- Mainly forebay provided before the Penstock, acts as water reservoir for medium head plants.
- In this plants mainly water is carried through main reservoir to forebay and then to the penstock.
- The forebay acts as surge tank for these plants.
- The turbines used will be Francis type of the steel encased variety.

Low Head Plant:

Head < 30 m

- This case small dam is built across the river to provide the necessary head.
- In such plants Francis or Kaplan type of turbines are used.

2 According to Capacity:
LARGE: >100 MW

MEDIUM: 25 - 100 MW

SMALL: 1-25 MW

MINI: 100 KW - 1MW

MICRO: 5- 100 KW

Mini and Micro hydel plants:

Mini - 5m to 20m head

Micro - below 5 m head

- These plants are scattered in our country and estimated potential is 20,000MW.
- Each plant can generate about 100 to 1000kW power.

3 According to Load :

Base Load Plants:

- They cater to the base load of the system; they need to supply constant power when connected to the grid.
- These Plants are mainly depending on the nature of load.
- If demand is more, these plants are used regularly and load factor of this plants are high.

Peak load Plants:

- These plants are mainly used during the peak load.
- Run-off river plants with poundage can be used as peak-load plants.

*Note :Reservoir plants with enough storage behind the dam can be used either as base load or as peak load plants as required.

4 According to Facility Type:

Run-off-river Type without Pondage:

- These are hydro power plants that utilize the stream flow as it comes, without any storage bein

Run of river plants with pondage:

- May work as base load or peak load plants.
- Storage for a day to day fluctuation or even for a week.
- Poundage permits storage of water during the off-peak period and use of this water during peak Periods.

IN-STREAM:

When the velocity of water i.e kinetic energy flowing in the stream is used for conversion into electrical power, then the system is known as In-stream.

Storage Type Plant

- Hydropower plants with storage are supplied with water from large storage reservoir that have been developed by constructing dams across rivers.
- Assured flow for hydro power generation is more certain for the storage schemes than the run-of-river schemes.
- Flow is controlled.

Pumped storage plants

- Pumped storage type hydropower plants are those which utilize the flow of water from a reservoir at higher potential to one at lower potential.

- During off-peak hours, the reversible units are supplied with the excess electricity available in the power grid which then pumps part of the water of the tail-water pond back into the head-water pond.

5 According to Purpose

- **SINGLE PURPOSE**
- When the whole soul purpose of a project is to produce electricity then such a project is known as a Single Purpose Hydro Power Project.
- **MULTIPURPOSE**
- When the water used in hydropower project is to be used for other purposes like irrigation, flood control or fisheries then such a project is known as Multi-Purpose Hydro Power Project

6 According to the hydrological relation

SINGLE STAGE

- When the runoff from a single hydropower plant is diverted back into river or for any other purpose other than power generation, the setup is known as Single Stage.

CASCADE SYSTEM

- When two or more hydropower plants are used in series such that the runoff discharge of one hydro power plant is used as the is a intake discharge of the second hydro power plant such a system is known as CASCADE hydropower plant.

VII Practical set-up / Circuit diagram / Work Situation:

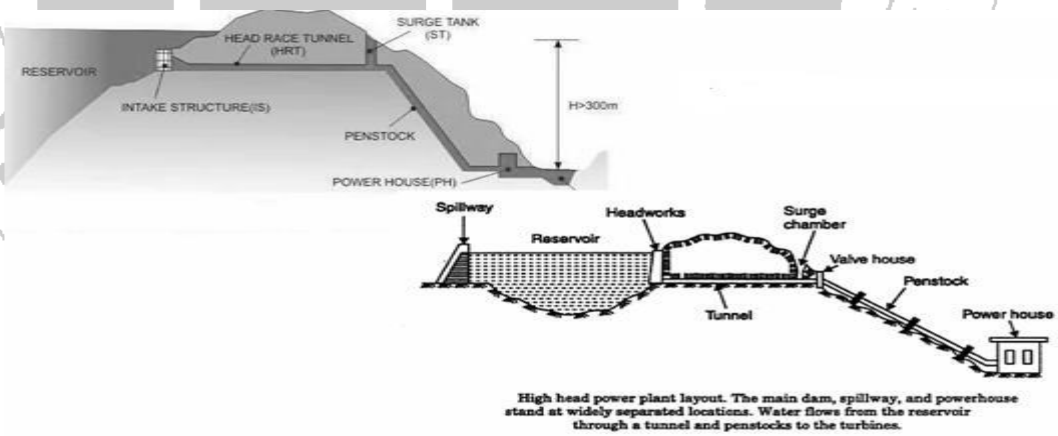

Fig. 5.2 High head plant

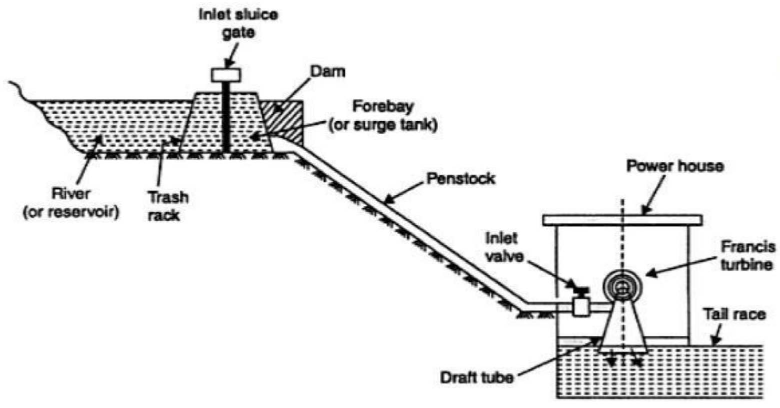

Fig. 5.3 Medium head plant

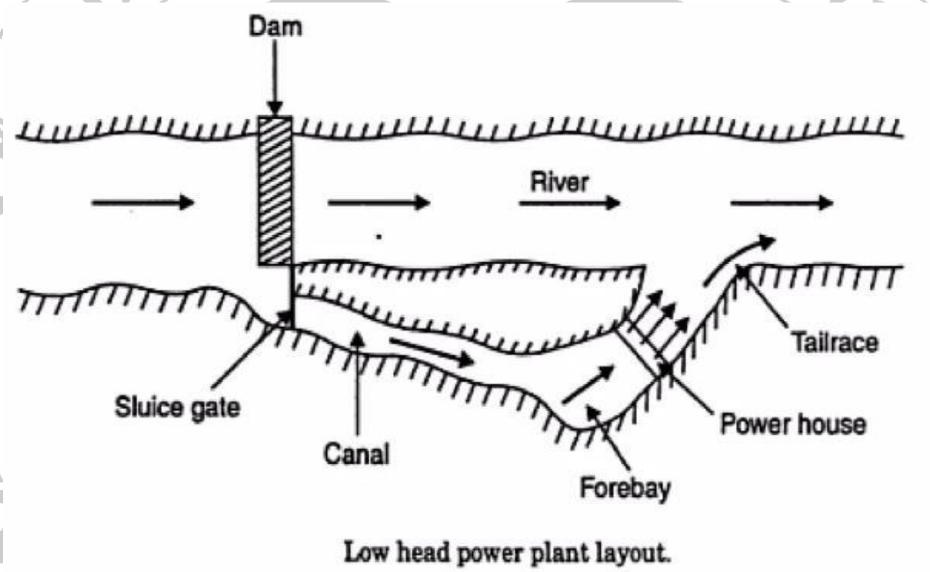

Fig. 5.4 low head plant

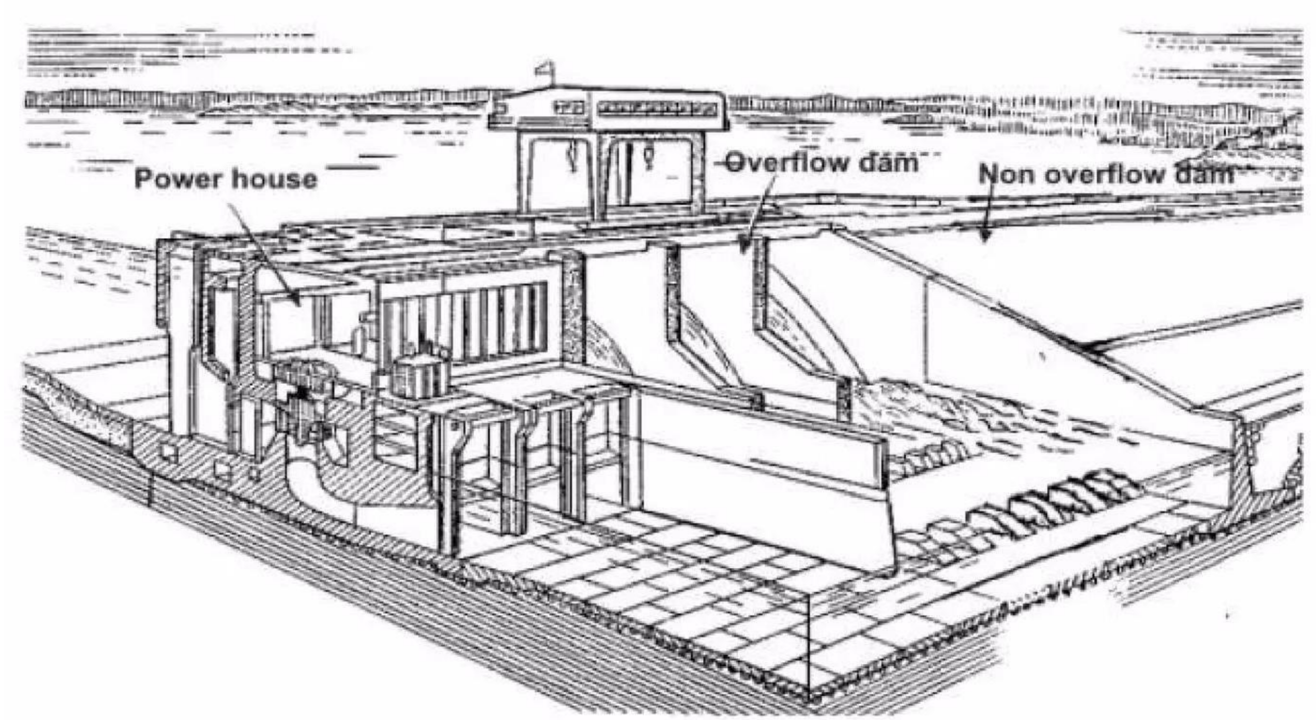

Fig 5.5 Run off river type without pondage

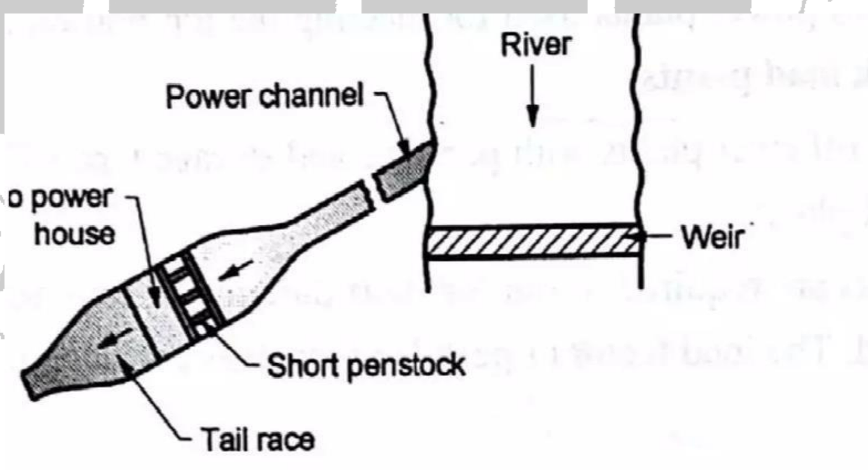

Fig 5.6 Run off river plant with pondage

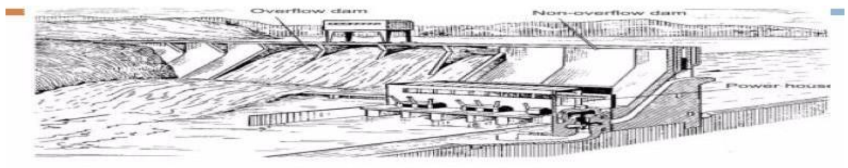

Fig. 5.7 Storage type of plant

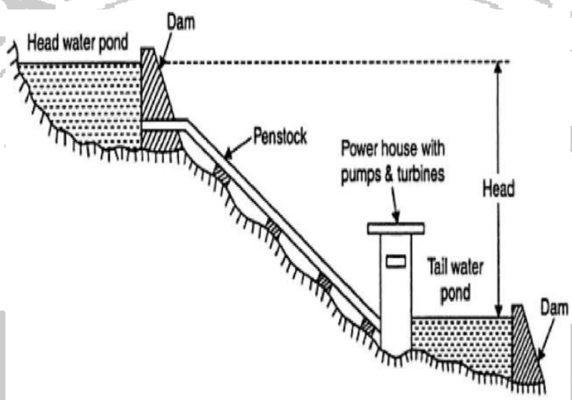

Fig. 5.8 Pumped storage plant

VIII Precautions to be followed

1. Watch authentic videos.
2. Use proper symbols while preparing the layouts of various hydro power stations

IX Procedure

Practice all important Hydro power stations drawing on imperial half drawing sheet as recommended by your teacher .

X Conclusion

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XI Practical related questions(Note:- Teacher should provide various questions related to practical-sample given)

1. List the turbine used in hydro power station.
2. Compare the impulse and reaction turbine.
3. Draw the high head Pelton wheel turbine and give the name of various parts.
4. Draw the complete diagram of Francis reaction turbine.

XII References/Suggestions for further reading

1. https://www.energy.gov/eere/water/types-hydropower-plants
2. https://powermin.gov.in/en/content/faqs-hydropower
3. https://indiawris.gov.in/wiki/doku.php?id=hydro_electric_projects_in_maharashtra
4. https://www.ireda.in/hydro-energy
5. https://www.energy.gov/energysaver/articles/energy-101-video-hydroelectric-power
6. https://youtu.be/q8HmRLCgDAI?si=8TFUIzkpsg56Ykfu
7. https://youtu.be/ztM6tL6LtFs?si=IZa1wdFFcG6ULXrK

XIII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 6: load curve of Campus/ institute building(s) and calculation of following economical factors : Maximum Demand , Average load, Load Factors, Reserve capacity, Plant capacity factor, Utilization Factor, Plant use Factor and Diversity factor.

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to deal with the above mentioned economical factors. This practical will develop the ability of the students for understanding the calculation for Maximum Demand , Average load, Load Factors, Reserve capacity, Plant capacity factor, Utilization Factor, Plant use Factor and Diversity factor for the institute. Students will be able to understand the various Load curve in the industry.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Select the relevant power generation technology based on economic operation.

IV Laboratory Learning Outcome(s)

1. Draw load curve of Campus/Institute building(s) .
2. Calculate various economic factors from the above load curve

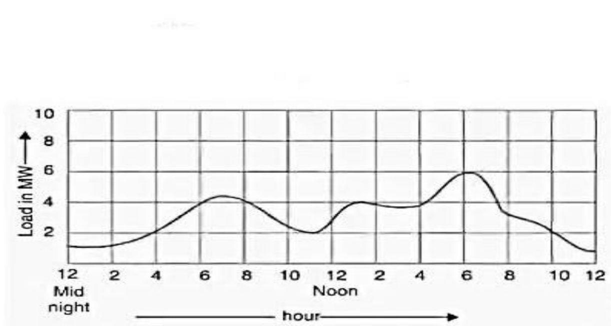
V Relevant Affective Domain related outcome(s)

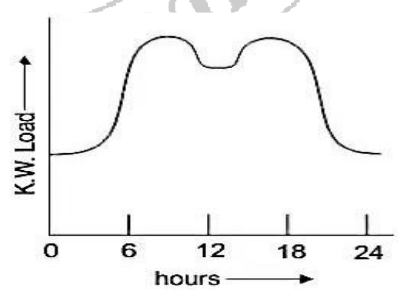
1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

Definition of load curve: the curve showing the load demand (variation of load demand) of a consumer with respect to time is called as **load curve.**

For plotting the load curve time is taken on X-axis and load on Y-axis.





Industrial Load

Fig. 6.1 Load curve

Shapes of load curves are different for different consumers like residential load, commercial toad, load, industrial load.

Daily load curve - Time is taken in hours (for 24 hours)

Monthly load curve - Time is taken in days (for a month)

Annual load curve - Time is taken in months (for 12 months)

Following important information is obtained from the load curve

(i) Variation of load during different hours of a day

(ii) Area under the curve (kWh X Hrs.) i.e. units gives the total No. of units generated in a day.

(iii) The maximum value of Load on the curve shows maximum demand (M.D.) on the station on the particular day.

iv) Average load can be computed = (Area under load curve Number of hours / No. of hours)

(v) Load factor can be computed = (Area under load curve /Total area of rectangle in which it is contained)

From the study of load curve in such a way we arrive to conclusion we can obtain

- The cost/unit supplied.
- Rating of plant required to meet the load demand.
- Number of energy units generated.
- Operation schedule of the station can be prepared

2 **Maximum Demand:** Maximum Demand or Peak demand on an electrical grid is the highest electrical power demand that has occurred over a specified time period. Peak demand is typically characterized as annual, daily or seasonal and has the unit of power.

1 **Average Load: T**he average load on a power station is defined as the average of loads occurring on the power station in a given period (either day or month or year).

The daily average load on the power station is given by,

$$\text{Daily average Load} = \frac{\text{Number of units generated in aday(inkWh)}}{\text{24Hours}}$$

The monthly average load on the power station is given by,

$$\text{Monthly average Load} = \frac{\text{Number of the units generated in a month(inkWh)}}{\text{(30 X24)Hour}}$$

The yearly average load on the power station is given by,

$$\text{Yearly average Load} = \frac{\text{Number of the units generated in a year(inkWh)}}{(365\ \text{X24})\text{Hours}}$$

4 **Load Factor**: In Electrical Engineering **load factor** is defined as the average load divided by the peak load in a specified time period It is a measure of the utilization rate, or efficiency of electrical energy usage; a high load factor indicates that load is using the electric system more efficiently, whereas consumers or generators that underutilize the electric distribution will have a low load factor.

$$\text{Load factor} = \frac{\text{Average Load}}{\text{Maximum Load in a given time}}$$

5 **Reserve capacity:** Reserve capacity is a backup energy generation capacity that is used by the electric grid in the occurrence of unexpected fault such as the unavailability of a power plant. Energy storage systems have the ability to provide this service and are used to offset or reduce costs incurred for generation of reserve capacity.

6 **Plant capacity factor**: At the time of deciding capacity of power plant, we take into account the present Maximum Demand in that area and consider a fixed rate of growth so that future demand in a particular period of time can be decided. The plant capacity factor is the ratio of average demand on that station divided by the installed capacity.

$$\textbf{Plant capacity factor} = \frac{\textbf{Actual energy generated}}{\textbf{Maximum energy that could be produced}} \quad \textbf{or}$$

$$\boldsymbol{Plant\ capacity\ factor} = \frac{\boldsymbol{Actual\ demand\ on\ the\ station}}{\boldsymbol{Max.installed\ capacity\ of\ station}}$$

7 **Utilization Factor:** it is the ratio of Maximum Demand on the station to the plant capacity. Higher the M.D. on the station great will be utilization factor.

$$\boldsymbol{Utilisation\ factor} = \frac{\boldsymbol{Maximum\ demand\ on\ the\ station}}{\boldsymbol{Max.installed\ capacity\ of\ station}}$$

8 **Plant use factor :** The plant use factor is the ratio of average demand to the rate capacity, i.e.

$$\textbf{Plant use factor} = \frac{\boldsymbol{Station\ output\ in\ KWH}}{\Sigma(\text{KW1})\text{H1}+(\text{KW2})\text{H2}+(\text{KW3})\text{H3}}$$

Where, KW1 , KW2 ,KW3…. etc. are the kilowatt ratings of each generator and H1 , H2 , H3 …. etc are the number of hours for which they have been worked.

$$\textbf{Plant use factor} = \frac{\textbf{Average demand}}{\textbf{Rated capacity}}$$ or in other way

$$\textbf{Plant use factor} = \frac{\textit{Actual Energy produced}}{\textit{plant capacity X Time (Hours)}}$$

9 **Diversity Factor Definition**: Diversity factor is defined as the ratio of the sum of maximum demands of individual loads to the simultaneous maximum demand of the system.

$$\textbf{Diversity factor} = \frac{\textbf{sum of individual maximum demands of eacg category}}{\textbf{Maximum Demand of the station}}$$

in this case its value is more than 1 . Sometimes it is defined as follows

$$\textbf{Diversity factor} = \frac{\textbf{Maximum Demand of the station}}{\textbf{sum of individual maximum demands of each category}}$$

In this case its value is less than 1.

VII Practical set-up / Circuit diagram / Work Situation

Students may get the energy consumption data from the institute. Incase data is not available students will practice the calculations from the given data below or teacher can give the data to calculate all the factors with different data.

Case 1: Draw the daily load curve for a 210 MW generating station from the following recorded data during 24 hours of a day and find the M. D. Graph is provided at the back of this practical .

Time Load in MW	6am 100	7am 110	8am 120	9am 120	10am 120	11am 125
Time Load in MW	12noon 125	1pm 130	2pm 130	3pm 130	4pm 125	5pm 125
Time Load in MW	6pm 120	7pm 110	8pm 140	9pm 145	10pm 130	11pm 120
Time Load in MW	12pm 110	1am 100	2am 40	3am 45	4am 50	5am 55

(Teacher may provide more other data to calculate **all the factors** for better understanding)

VIII Precautions to be followed

1. Learn all the definition well.
2. Learn all the formulae very well.
3. Practice on more numerical to understand the concept.
4. Implement the formula correctly after understanding the concept.

IX Result(s)

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X Interpretation of results

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XI Conclusion and recommendation

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XII Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. A generating station has a connected load of 43 MW and maximum demand of 20 MW. The units generated are 61.5X 10^6 per year. Calculate Load factor.

2. A generating station supplies the following loads:

(i) Domestic load: 2000KW,maximum demand
(ii) Industrial load : 1000KW ,maximum demand
(iii) Commercial load : 6000 KW, maximum demand
(iv) Irrigation load : 3000 KW, maximum demand

The diversity factor of these loads at the generating station is 1.5 and the average annual load factor is 55%. Calculate the maximum demand on the station and total energy supplied by the plant in a year. Suggest the installed capacity and number of units considering all aspects.

3. The peak load on a power station is 30 MW. Loads having maximum of 25 MW,10 MW , 5MW, 7MW are connected to the power station. Capacity of the power station is 40 MW and annual load factor is 50%. Find the following factors;

(i) Average load on power station
(ii) Energy supplied per year
(iii) Demand Factor
(iv) Diversity factor

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XIII References/Suggestions for further reading

1. **https://www.electrical4u.com/load-curve-load-duration-curve-daily-load-curve/**
2. **https://testbook.com/question-answer/what-is-the-reserve-capacity-if-the-maximum-deman--5dd401e0f60d5d4aeb58e54c**
3. **https://www.electrical4u.com/diversity-factor/**
4. **https://www.electrical4u.com/load-curve-load-duration-curve-daily-load-curve/#google_vignette**

XIV Suggested Assessment Scheme:

Performance Indicators		**Weightage**
Process Related : 15 Marks		**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale

X-axis -

Y-axis -

Scale

X-axis -

Y-axis -

Practical No. 7: Selection of power generation technology as per variation in load demand of a given load curve.

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to identify different situation of fluctuation of load on the generating station. He must be able to understand that in particular situation how many generating units are to be kept on. Therefore this practical will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s):

Industry/Employer Expected Outcome(s): Maintain the functioning and operation of electric power distribution.

III Course Level Learning Outcome(s):

Course Level Learning Outcome(s): Select the relevant power generation technology based on economic operation.

IV Laboratory Learning Outcome(s)

Select appropriate power generation technology as per variation in load demand.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

Electrical power is being generated in large generating stations, which are either hydro, thermal, nuclear power stations. These generating stations are mostly far away from the load centres, (i.e. where the load is required). Hence, it is required to erect large and long transmission network to feed the electricity from the generating end (i.e. sending end) to place of load centre, (i.e. receiving end) of electrical supply. It needs several electrical equipment to be connected for proper transmission of generating power.

In an interconnected power system, which consists of number of power stations of different types of operating in parallel. It is required to direct different stations to operate for their best possible economic operation. That, is to decide which type of plant is to be used for which plant factor depending upon the availability of fuel and other resources at the site of plant and in the vast scence availability of fuel etc. in the country.

The types of generating stations that are usually available in India are: Hydro-electric, steam thermal power, gas plants. Diesel plants and nuclear plants, these have to be used either as base load plants or peak load plants or sometimes both for coordinated operation to supply load demand.

Important Points in the Selection of Units:

While making the selection of number and sizes of the generating units, the following points should be kept in view:

(i) The number and sizes of the units should be so selected that they approximately fit the annual load curve of the station.

(ii) The units should be preferably of different capacities to meet the load requirements. Although use of identical units (i.e., having same capacity) ensures saving (Due to duplication of sizes and dimensions of pipes, foundations etc.)

(iii) The capacity of the plant should be made 15% to 20% more than the maximum demand to meet the future load requirements.

(iv) There should be a spare generating unit so that repairs and overhauling of the working units can be carried out.

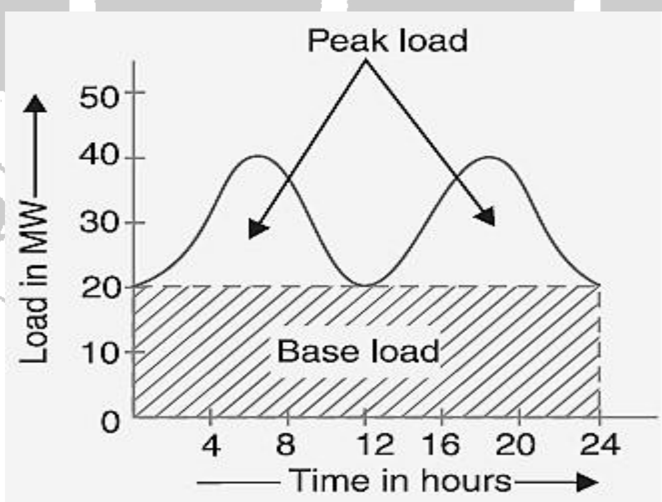
(v) The tendency to select a large number of units of smaller capacity in order to fit the load curve very accurately should be avoided. It is because the investment cost per kW of capacity increases as the size of the units decreases.

Base Load and Peak Load on Power Station:

A close look at the load curve reveals that load on the power station can be considered in two parts, namely; **(*i*)** Base load **(*ii*)** Peak load

***(i)* Base load.** *The unvarying load which occurs almost the whole day on the station is known as* base load. Referring to the load curve of Fig. 3.13, it is clear that 20 MW of load has to be supplied by the station throughout 24 hours. Therefore, 20 MW is the base load of the station.

***(ii)* Peak load.** *The various peak demands of load over and above the base load of the station is known as* peak load.



VII Practical set-up / Circuit diagram / Work Situation (Not applicable for this practical)

VIII Precautions to be followed

1. Calculation and formula are to be understood carefully.
2. Concept must be understand carefully for type and choice of generating units .

IX Procedure

(Note: under the guidance of Teacher student should solve any TWO case studies and must recommend the type of generating station and number of units with rating)

X Conclusion

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XI Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. A generating station is to supply 4 regions of load whose peak load are 10 Megawatt, 5 Megawatt ,8 Megawatt and 7 Megawatt. The diversity factor at the station is 1.5 and the average annual load factor is 60% calculate ;
   A. The maximum demand on the station
   B. Annual energy supply by the station
   C. Suggest the installed capacity and the number of units

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XII References/Suggestions for further reading

1. https://www.slideshare.net/slideshow/load-curve-notespdf/257875616
2. https://testbook.com/question-answer/determine-the-average-load-from-the-load-curve--600ec8d42ed300aa7df4dd8c
3. https://aec.edu.in/aec/Instruction_Material/PS-I%20UNIT-5.pdf
4. https://www.scribd.com/presentation/370483287/loadcurve-120427075031-phpapp01

XIII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8: Load duration curve and Integrated load curve.

I Practical Significance

In Electrical Engineering Industry Load curves are the best way to show how electricity is being used and play an important role in long-term planning and daily production scheduling for power systems. For residential customers, long-term load curves can be used to understand the household's electricity consumption and habits. This practical will develop the ability of the students for understanding the importance of correct no. of units of generation, planning and economic dispatch by study the load duration and load integration curve.

II **Industry/Employer Expected Outcome(s):** Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s):

Select the relevant power generation technology based on economic operation.

IV Laboratory Learning Outcome(s):

Draw the load duration curve and integrated load curve from a given load curve.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background (With diagrams if required)

A load curve shows the variation of load on a power station over time, with daily, monthly, and yearly curves. It is important for generation planning and economic dispatch. A load duration curve arranges all load levels in descending order, with area under the curve representing total energy demanded.

A load duration curve (LDC) is used in electric power generation to illustrate the relationship between generating capacity requirements and capacity utilization. Typical Load Duration Curve. A LDC is similar to a load curve but the demand data is ordered in descending order of magnitude, rather than chronologically

The Fig: below shows the daily load curve. The daily load duration curve can be readily obtained from it.

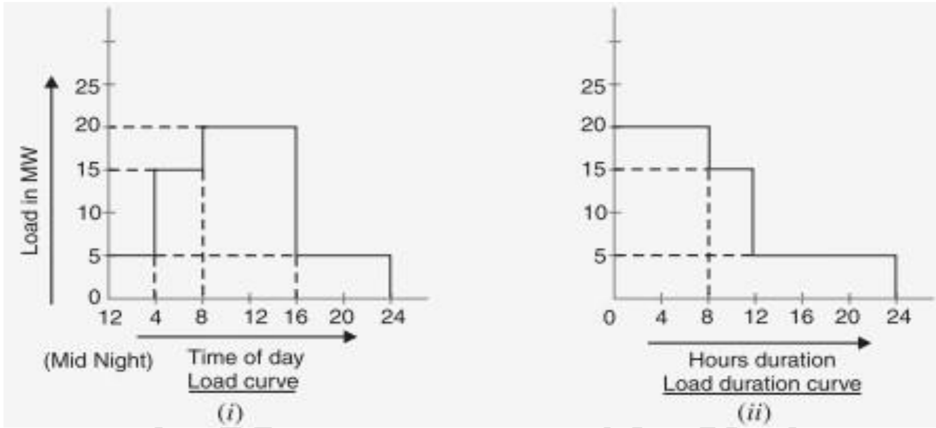

Fig:8.1. Load Curve and Load Duration Curve

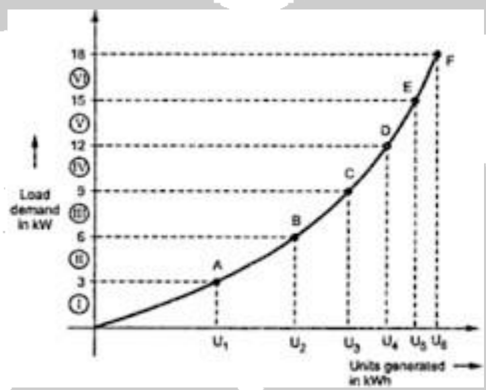

Fig:8.2 load Integration curve

VII Practical set-up / Circuit diagram / Work Situation (Not applicable for this practical)

VIII Precautions to be followed

1. Calculation and formula are to be understood carefully.

IX Procedure

(Note: under the guidance of Teacher student should solve any one case study to draw load duration curve and integration curve)(Attach blank pages if space is not sufficient)

Case Study:

X Conclusion

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XI Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. Write the significance of load integration curve.
2. Write the importance of load duration curve.
3. Write the procedure to draw the load duration and load integration curve.

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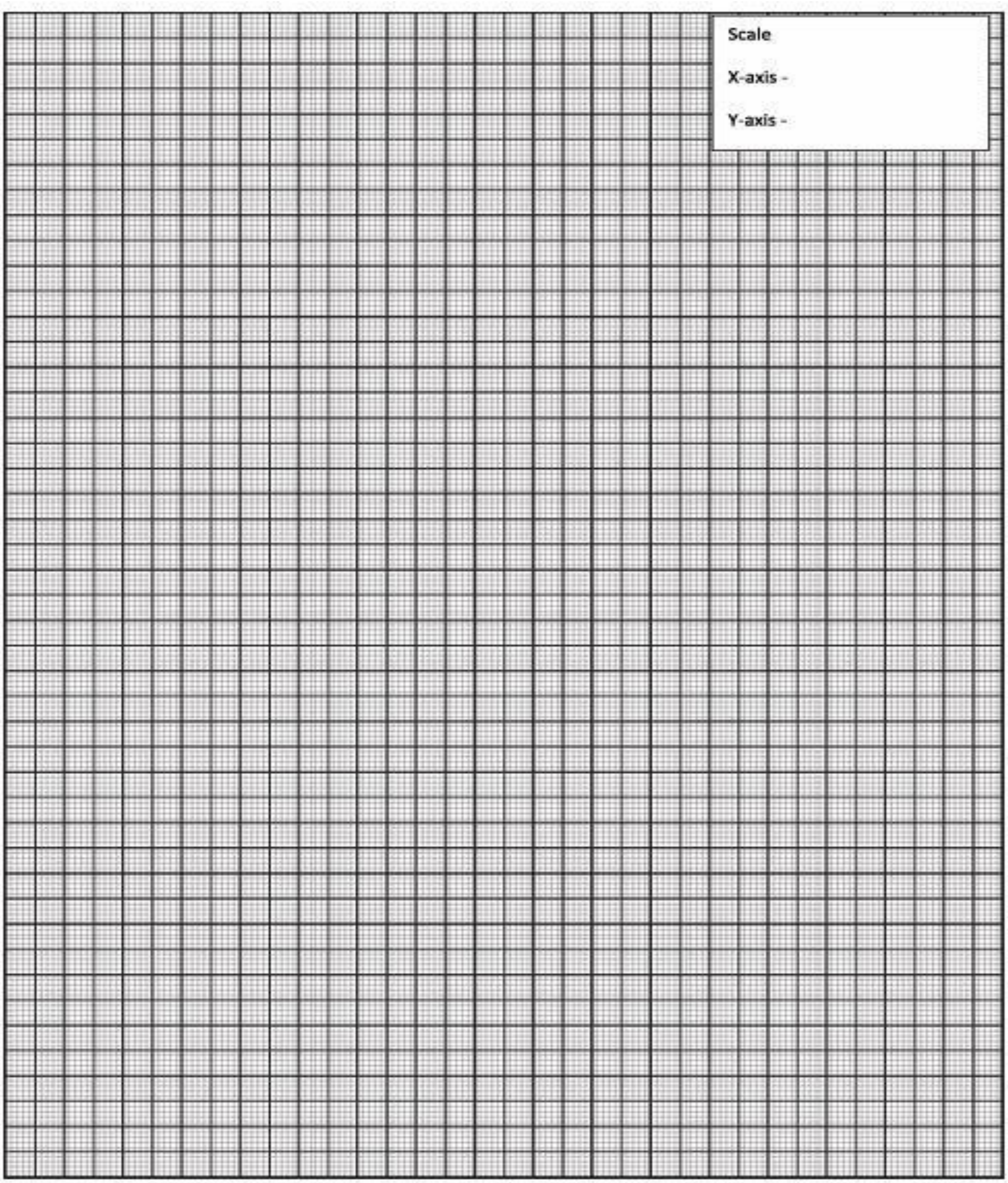
XII References/Suggestions for further reading

1. https://www.electrical4u.com/load-curve-load-duration-curve-daily-load-curve/
2. Power Plant Engineering Nag P K McGraw Hill,New Delhi,2017 ISBN:978-9339204044

XIII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	


Scale
X-axis -
Y-axis -

Practical No. 9: Single line diagram of the electric supply system.

I Practical Significance

In the Industry Electrical Engineering diploma graduate are expected to deal with the Electrical power produced in generating station which is transmitted over large distance through transmission lines. This practical will develop the ability of the students for understanding complete understanding of the electric supply system.

II Industry/Employer Expected Outcome(s)

In the industry Electrical Engineering diploma graduate are expected to understand the various stages of Electric supply system.

III Course Level Learning Outcome(s)

Interpret the normal operation and parameters of the electric transmission system.

IV Laboratory Learning Outcome(s)

LLO 9.1 List the components of the electric supply system.

LLO 9.2 Prepare a single line diagram with vertical and horizontal clearance of the electric supply system.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

An electrical power system is a network of interconnected electrical devices, which are used to generate, transmit, distribute and utilize the electrical power.

A typical electrical power system has following main components −

- Generating Station
- Transmission System
- Distribution System
- Electrical Load

So the electrical energy is produced at generating stations, and through the transmission network, it is transmitted to the consumers. Between the generating stations and the distribution stations, three different levels of voltage (transmission, sub-transmission and distribution level of voltage) are used.

The high voltage is required for long distance transmission and, the low voltage is required for utility purposes. The voltage level is going on decreasing from the transmission system to the distribution system. The electrical energy is generated by the three-phase synchronous generator (alternators) as shown in the Fig: below. The generation voltage is usually 11kV and 33 KV.

This voltage is too low for transmission over long distance. It is, therefore, stepped up to 132, 220, 400 KV, or more by step-up transformers. At that voltage, the electrical energy is transmitted to the bulk power substation where energy is supplied from several power substations.

The voltage at these substations is stepped down to 66KV and fed to the sub-transmission system for onward transmission to the distribution sub-stations. These substations are located in the region of the load centres.

The voltage is further stepped down to 33KV and 11KV. The large industrial consumers are supplied at the primary distribution level of 33KV while the smaller industrial consumer is supplied at 11KV.

The voltage is stepped down further by a distribution transformer located in the residential and commercial area, where it is supplied to these consumers at the secondary distribution level of 400V three phase and 230V single phase.

Under the Section 77 in the Indian Electricity Rules, 1956
Clearance above ground of the lowest conductor:
(1) No conductor of an overhead line, including service lines, erected across a street shall at any part thereof be at a height of less than-
For low and medium voltage lines: 5.8 meters
For high voltage lines: 6.1 meters
(2) No conductor of an overhead line, including service lines, erected along any street shall at any part thereof be at a height less than-
For low and medium voltage lines: 5.5 metres
For high voltage lines: 5.8 metres
(3) No conductor of an overhead line including service lines, erected elsewhere than along or across any street shall be at a height less than-
For low, medium and high voltages lines up to and including 11,000 volts, if bare: 4.6 metres
For low, medium and high voltage lines up to and including 11,000 volts, if insulated: 4.0 metres
For high voltage lines above 11,000 volts: 5.2 meters
(4) For extra-high voltage lines, the clearance above ground shall not be less than 5.2 meters plus 0.3 metres for every 33,000 volts or part thereof by which the voltage of the line exceeds 33,000 volts:
Provided that the minimum clearance along or across any street shall not be less than 5.5 meters.

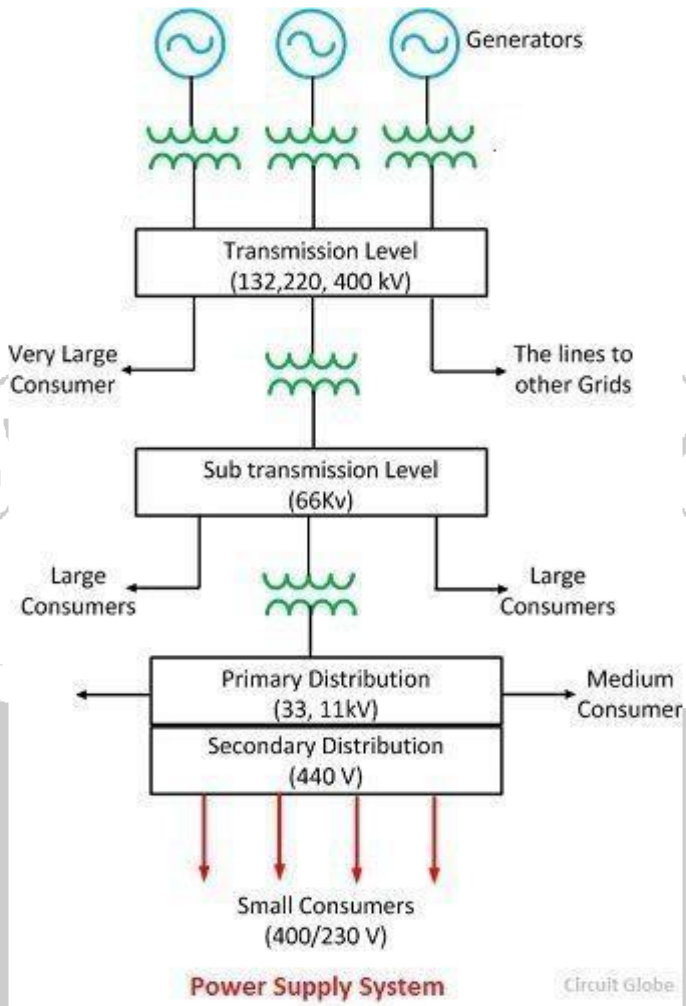


Fig:9.1 Single line diagram of Electric Supply system

Or

Any other equivalent single line diagram

VII Precautions to be followed

1. Learn and understand the single line diagram well.
2. Use correct symbols.
3. Learn the sequence of single line diagram correctly.

VIII Procedure

(Note: under the guidance of Teacher student should draw single line diagram with vertical and horizontal clearance of the electric supply system on blank imperial half drawing sheet)

IX Conclusion

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X Practical related questions (Note: Teacher should provide various questions related to practical-sample given)

1. List out all the components of a typical AC supply system.
2. Write the full name of HT and LT transformer.
3. State any two reasons for the necessity of transmission of line.

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XI References/Suggestions for further reading

1. https://www.electrical4u.com/transmission-line-in-power-system/
2. https://www.tutorialspoint.com/electric-supply-system-a-c-power-supply-scheme-and-its-single-line-diagram

XII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 10: Layout of 400 KV transmission line substation.

I Practical Significance

In the Industry Electrical Engineering diploma graduate are expected to deal with the Electrical power produced in generating station which is transmitted over large distance through transmission lines. In this practical students will learn about 400 KV transmission line substation in which in multiple incoming and outgoing transmission line connecting to other substation in the region operating at 400KV and 220KV.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Interpret the normal operation and parameters of the electric transmission system.

IV Laboratory Learning Outcome(s)

1. Prepare single line diagram of 400 KV transmission line substations.
2. Prepare plan and elevation diagram of 400 KV transmission line substation.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

A 400 kV transmission line substation is a critical component in the power transmission network, facilitating the safe and efficient transfer of electrical power from generation sources to distribution networks. The substation's design must ensure reliability, flexibility, and safety while accommodating the high voltage levels typical of such infrastructure.

Components of a 400 kV Transmission line Substation

1. Busbars
2. Circuit Breakers
3. Current Transformers (CTs) and Voltage Transformers (VTs)
4. Disconnect Switches
5. Shunt Reactors
6. Power Transformers
7. Protection and Control Equipment

8. Auxiliary Services

VII Practical set-up / Circuit diagram / Work Situation:

Fig10.1. Transmission line substation

VIII Precautions to be followed

1. Learn and understand the single line diagram well.
2. Use correct symbols.
3. Learn the sequence of single line diagram correctly.

IX Procedure

Note: under the guidance of Teacher student should

i) Draw single line diagram of 400KV transmission line substation

ii) Prepare plan and elevation diagram of 400 KV transmission line substation on blank imperial half drawing sheet

X Conclusion

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XI **Practical related questions** (Note: - Teacher should provide various questions related to practical- sample given)

1. How much power can a 400 KV LINE CARRY.
2. What is the rating of 400 KV circuit breaker.
3. What is the clearance of 400 KV substation.
4. What is the area required of a 400 KV substation.
5. What is the horizontal clearance of a 400 KV transmission line.

XII References/Suggestions for further reading

1. https://www.scribd.com/doc/38820467/Basic-of-400KV-Substation-Design
2. https://www.researchgate.net/Fig:/Floor-plan-of-the-400kV-substation-Crosses-depict-where-the-receivers-were-placed_fig4_311899093
3. https://www.balajiengineers.in/blog-electrical-substation-equipments.php
4. https://www.electrical4u.com/electrical-power-substation-engineering-and-layout/

XIII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 11: 132 KV Transmission Line

I Practical Significance

In the industry Electrical Engineering diploma graduate are expected to deal with the 132kv Station where high voltage of 132kv is received, stepped down to 11kv and then given to different feeders that feed distribution lines. This whole process is carried out by different parts and equipment. This practical will develop the skills of identify the components and their operation too.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Interpret the normal operation and parameters of the electric transmission system

IV Laboratory Learning Outcome(s)

1. Prepare the single line diagram of 132 KV transmission line.
2. Prepare plan and elevation diagram of 132 KV transmission line substation.

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

A 132 kV transmission line substation is a pivotal component in the power transmission network, facilitating the transfer of electrical power from generation sources to distribution networks efficiently and safely. The substation's design ensures reliability, flexibility, and safety while accommodating high voltage levels. This document provides an in-depth look at the various aspects of designing and laying out a 132 kV substation.

Components of a 132 kV Substation

1. Busbars
2. Circuit Breakers
3. Current Transformers (CTs) and Voltage Transformers (VTs)
4. Disconnect Switches
5. Shunt Reactors
6. Power Transformers
7. Protection and Control Equipment
8. Auxiliary Services

VII Practical set-up / Circuit diagram / Work Situation

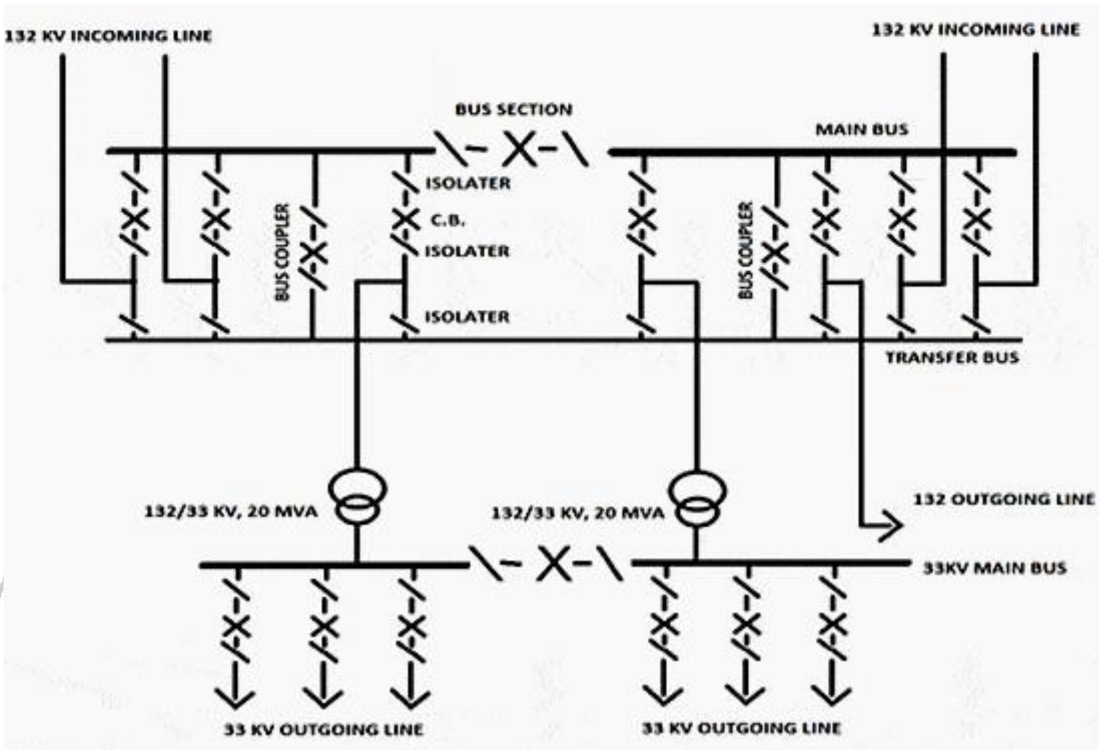

Fig:11.1. Single line diagram of 132KV transmission line substation.

VIII Precautions to be followed

1. Learn and understand the single line diagram well.
2. Use correct symbols.
3. Learn the sequence of single line diagram correctly.

IX Procedure

Note: under the guidance of Teacher student should

i) Draw single line diagram of 132KV transmission line substation

ii) Prepare plan and elevation diagram of 132 KV transmission line substation on blank imperial half drawing sheet

X Conclusion

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XI Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. Which cables are used for 132KV line?
2. Which transformer is used in 132 KV substation?

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XII References/Suggestions for further reading

1. https://cea.nic.in/wp-content/uploads/2020/04/765_powerplants.pdf
2. https://electrical-engineering-portal.com/download-center/books-and-guides/power-substations/132-kv-ss-training
3. https://www.bsptcl.in/FINAL_SLD/KHAGAUL.pdf
4. https://www.linkedin.com/pulse/brief-overview-132kv-sub-stationgrid-station-umar-farooq-o8s1f

XIII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 12: Demonstration of an Ultra High Voltage (UHV) Transmission lines using Animations/ Video Programme.

I Practical Significance

Promotion of renewable energies, UHV transmission technology enables the transportation of renewable energy, such as wind and solar energy, from resource-reach regions to load centres. Thus driving the wide adoption of renewable energy sources.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Interpret the parameter of the Extra high voltage transmission system

IV Laboratory Learning Outcome(s)

Identify the components of Ultra High Voltage (UHV) Transmission line

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background (With diagrams if required)

The alternating current (AC) transmission voltage classes are usually classified into high voltage (HV), extra-high voltage (EHV), and ultra-high voltage (UHV). Internationally, HV usually refers to a nominal voltage from 35 kV to 220 kV, EHV from 330 kV to below 1000 kV, and UHV 1000KV and above. UHV AC transmission refers to AC transmission with a voltage level of 1000 kV and above. It has significant advantages such as large transmission capacity, long transmission distance, low line loss and space saving. This chapter introduces the development of UHV transmission systems and the construction of EHV/UHV transmission projects, as well as key technologies for UHV transmission such as voltage level, overvoltage, insulation and electromagnetic environment.

VII Precautions to be followed

1. Watch the animation/Video programme carefully.

VIII Procedure

Note: under the guidance of Teacher student should watch the animation/Video programme of Ultra High Voltage Transmission Line.

i) Identify the components of Ultra High Voltage Transmission line.

IX Observation

Sr. No.	Component	Function

X Conclusion

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XI Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. State the advantages of UHV transmission system.
2. Write the challenges of UHV transmission.
3. Write any two UHV transmissions in India.
4. Write the name of any one UHV transmission out of India.
5. Compare EHV and HT transmission conductors.

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XII References/Suggestions for further reading

1 https://youtu.be/DY2v0fQX7-8?si=iXop4rvDqaLunMD2
2 https://youtu.be/aHw932S1G_4?si=EustmNV7eoGIN1e2
3 https://youtu.be/WkLa3O3krCc?si=GPXzz-nJE7jU3NRl

XIII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 13: Demonstration of Extra High Voltage (EHV) Transmission lines using Visit/Animations/ Video Programme.

I Practical Significance

Power loss during transmission is the common problem. To reduce transmission losses, transmission of power through long distance is carried out through EHV. Specifically, when load is off large capacity and distance of transmission is long, EHV line are recommended. Hence for Electrical Diploma graduate, it becomes important to study EHV system.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Interpret the parameters of the extra high voltage transmission system.

IV Laboratory Learning Outcome(s)

Identify the components of Extra High Voltage (EHV) Transmission lines

V Relevant Affective Domain related outcome(s)

1. Follow safety practices.
2. Maintain tools and equipment.
3. Follow ethical Practices.

VI Relevant Theoretical Background

EHV lines are used to move large amounts of power across long distances. The higher the voltage, the lower the losses. In addition, by being able to move more power across one line, fewer overall lines are needed for transmission. This reduces project costs and the right of way required. EHV AC Transmission Extra High Voltage (EHV) A.C. transmission may be considered to have come of age in 1952 when the first 380–400 kV line was put into service in Sweden. Since then, industrialized countries all over the world have adopted this and higher voltage levels. Very soon it was found that the impact of such voltage levels on the environment needed careful attention because of high surface voltage gradients on conductors which brought interference problems from power frequency to TV frequencies. Thus electrostatic fields in the line vicinity, corona effects, losses, audible noise, carrier interference, radio interference and TVI became recognized as steady state problems governing the line conductor design, line height, and phase-spacing to keep the interfering fields within specified limits. The line charging current is so high that providing synchronous condensers at load end only was impractical to control voltages at the sending-end and receiving-end buses. Shunt compensating reactors for voltage control at no load and switched capacitors at load conditions became necessary.

1. Reduction of Electrical Losses, Increase in Transmission Efficiency, Improvement of Voltage Regulation and Reduction in Conductor Material Requirement:

For transmission of given amount of power over a given distance through the conductors of a given material and at a given power factor as the transmission voltage increases, (a) Line losses are reduced since line losses are inversely proportional to the transmission voltage, (b) Transmission efficiency increases because of reduction in line losses, (c) Voltage regulation is improved because of reduction of percentage line drop, and (d) Lesser conductor material is required being inversely proportional to the square of transmission voltage.

2. Economic considerations have led to the construction of power stations of large capacity and so need of transfer of bulk power over long distances arose. Transmission of bulk power from generating stations to the load centres is technically and economically feasible only at voltages in the EHV/UHV range.

3. Generating stations (Steam-, hydro- and nuclear-power stations) are located in remote areas (far away from load centres) because of the reasons of economy, feasibility and from the point of view of safety and environmental conditions. EHV transmission is, therefore, inevitable for transmission of huge blocks of power over long distances from these power plants to load centres.

VII Precautions to be followed

a. Watch the animation/Video programme carefully.

VIII Procedure

Note: under the guidance of Teacher student should watch the animation/Video programme of Extra High Voltage Transmission Line.

i) Identify the components of Extra High Voltage Transmission line.

IX Observation

Sr. No.	Component	Function

X Conclusion

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XI Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. Write the advantages and EHVAC over HVDC.
2. List any two EHVAC in India.

XII References/Suggestions for further reading

1. https://www.electricaltechnology.org/2018/07/electrical-transmission-networks-ehv-and-hv-overhead-lines.html
2. https://www.electrical4u.com/electrical-engineering-articles/transmission/
3. https://www.sciencedirect.com/topics/engineering/ehv-power-transmission
4. https://www.electricaltechnology.org/2018/07/electrical-transmission-networks-ehv-and-hv-overhead-lines.html#google_vignette

XIII Suggested Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 14: Layout of HVDC transmission line.

I Practical Significance

High voltage direct current lines are commonly used for long distance power transmission, since they require fewer conductors and incur less power loss than HVAC lines. Hence it is important for Electrical Engineering Diploma graduate to study the HVDC transmission line.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Maintain the functioning and operation of electric power distribution system.

IV Laboratory Learning Outcome(s)

LLO 1 Prepare single line diagram of HVDC transmission line.

LLO 2 Prepare plan and elevation diagram HVDC transmission line.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

HVDC transmission is the method of transmitting electricity in DC form over long distances using either submarine cables or overhead lines.

- The massive transmission of electricity in the form of DC over long distances by means of submarine cables or overhead transmission line is the high voltage direct current transmission. This type of transmission is preferred over HVAC transmission for very long distance when considering the cost, losses and many other factors. The names Electrical superhighway or Power superhighway are often used for **HVDC**.
- **HVDC Transmission System**
- We know that AC power is generated in the generating station. This should first be converted into DC. The conversion is done with the help of rectifier. The DC power will flow through the overhead lines. At the user end, this DC has to be converted into AC. For that purpose, an inverter is placed at the receiving end.
- Thus, there will be a rectifier terminal in one end of HVDC substation and an inverter terminal in the other end. The power of the sending end and user end will be always equal (Input Power = Output Power).
- **Conversion and Components**: The hvdc transmission system uses rectifiers and inverters for converting AC to DC and vice versa, with components like smoothing reactors and harmonic filters to ensure stability and reduce interference.

- **Link Types**: HVDC links can be mono-polar, bipolar, or homopolar, with configurations chosen based on the specific transmission needs and geographical conditions.
- **Efficiency Advantages**: HVDC is favored over HVAC for its lower losses, better voltage regulation, and higher reliability, especially for long-distance transmission.
- **Practical Applications**: HVDC technology is ideal for undersea and underground cables, allowing for effective interconnections between different power systems and overcoming geographical challenges.

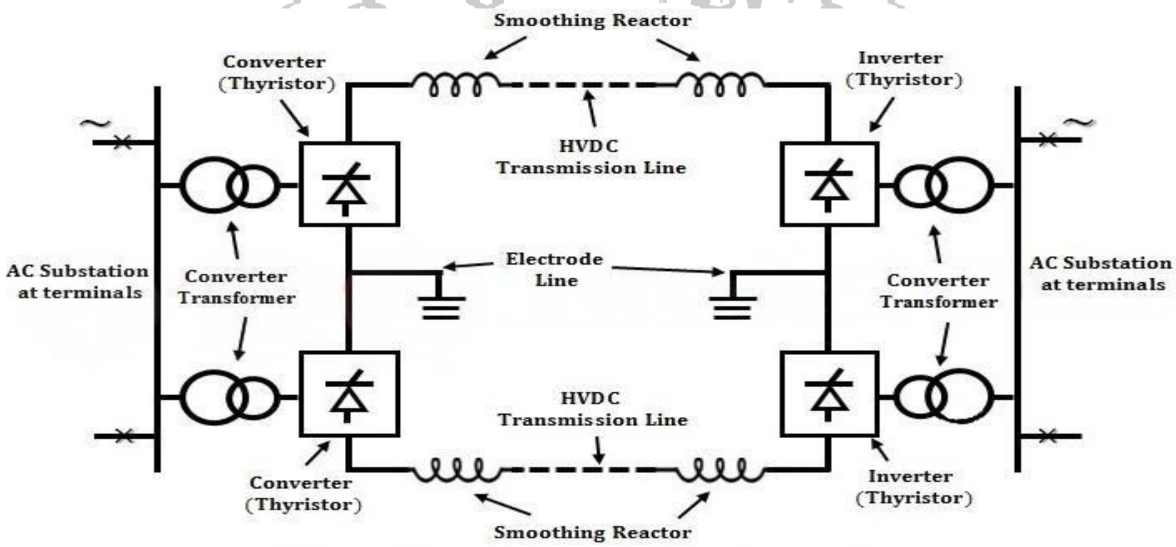

Fig:14.1 Schematic Diagram of HVDC Transmission System

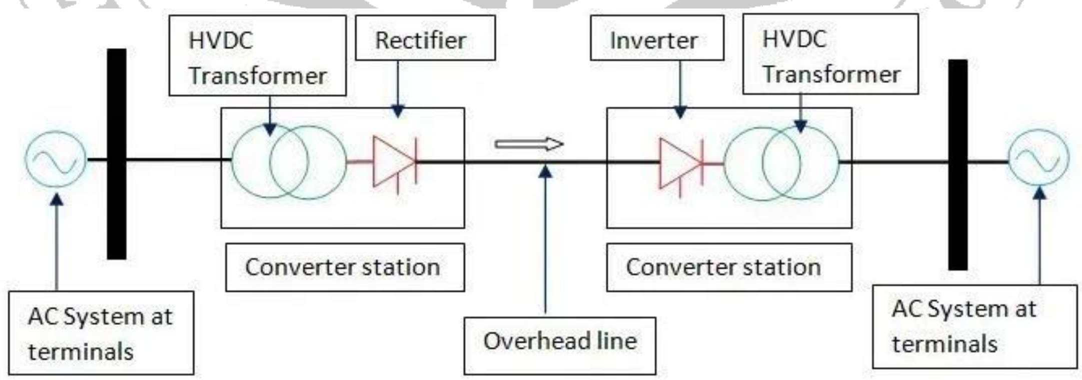

Fig:14.2.HVDC Substation layout

VII Precautions to be followed

1. Learn and understand the single line diagram well.
2. Use correct symbols.
3. Learn the sequence of single line diagram correctly.

VIII Procedure

Note: under the guidance of Teacher student should

i) Draw single line diagram of HVDC transmission line.

ii) Prepare plan and elevation diagram of HVDC transmission line substation on blank imperial half drawing sheet

IX Conclusion

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X Practical related questions (Note: - Teacher should provide various questions related to practical-sample given)

1. Enlist the advantages for HVDC transmission.
2. Enlist the Dis-advantages for HVDC transmission.
3. Write the application of HVDC and HVAC transmission.
4. Enlist the HVDC transmission line routes in India.

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XI References/Suggestions for further reading

1. https://www.electricaldeck.com/2021/08/what-is-hvdc-transmission.html
2. https://www.electrical4u.com/high-voltage-direct-current-transmission/
3. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8661892
4. https://youtu.be/DY2v0fQX7-8?si=JvQM1xH57tcUtcIl

XII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 15. Components of Distribution Substation

I Practical Significance

In Industry, Electrical Engineering student should identify different components of Distribution system. It will help you to acquire necessary skills.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Maintain the functioning and operation of electric power distribution system

IV Laboratory Learning Outcome(s)

1. Prepare list of components of the distribution substation.
2. Prepare a single line diagram of the distribution substation.
3. Prepare plan and elevation diagram with clearances of distribution substation.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

A distribution substation is a voltage regulation point that delivers electric energy from transmission systems to residential and industrial consumers. Power is transported from the distribution substation via distribution feeders to the premises of the end consumer.

Distribution substations are comprised of several components, each serving a critical role in delivering power to homes and businesses

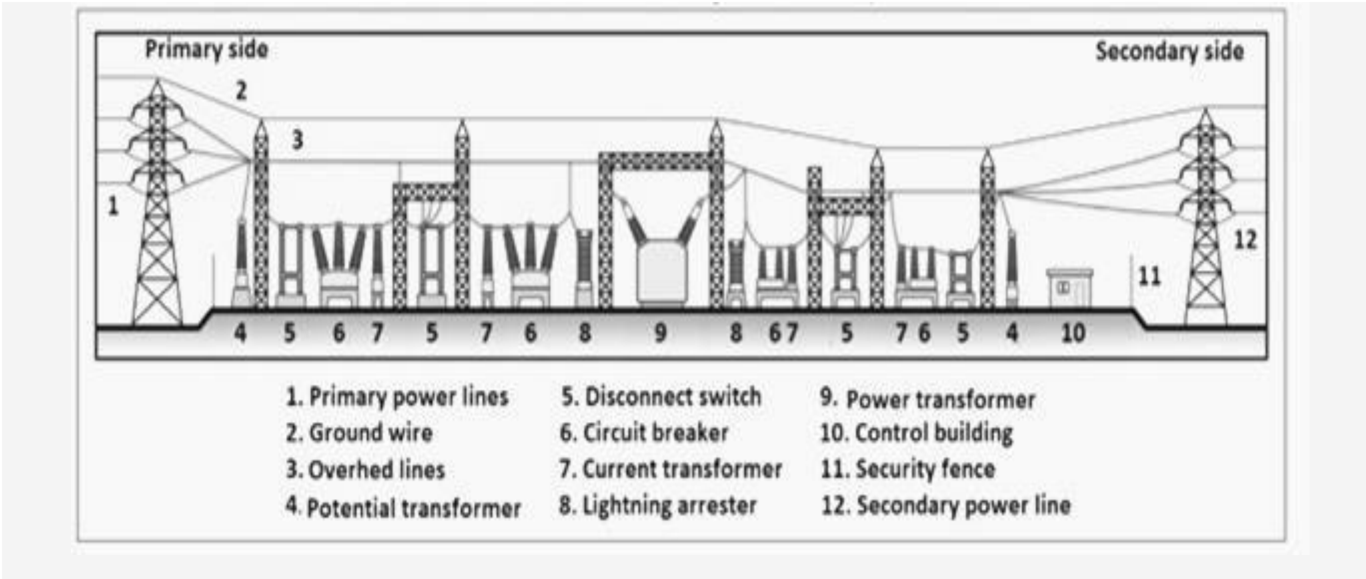

Fig:15.1 .Arrangement of Equipment in a distribution substation

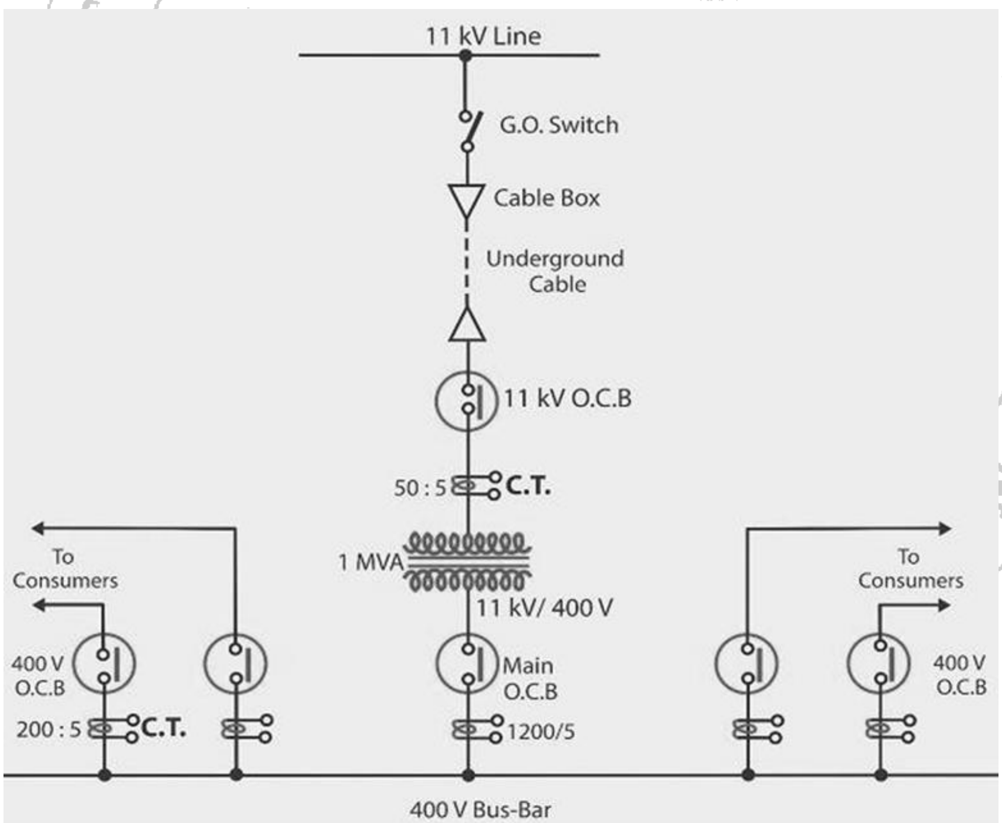

Fig:15.2.Single line diagram of 11KV/400V substation

VII Precautions to be followed

1. Learn and understand the single line diagram well.
2. Use correct symbols.
3. Learn the sequence of single line diagram correctly.

VIII Procedure

Note: under the guidance of Teacher student should

i) Draw single line diagram of the distribution substation.

ii) Prepare list of component of the distribution substation.

iii) Prepare plan and elevation diagram of HVDC transmission line substation on blank imperial half drawing sheet

IX Observation table (use blank sheet provided if space not sufficient)

(Identify the different components of distribution substation and note down their function)

Sr. No.	Equipment	Function
1	Power Lines	
2	Distribution transformer	
3	Feeder	
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X Conclusion

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XI Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. What is the basic requirement of a distribution substation?
2. Write application of distribution transformer?

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XII References/Suggestions for further reading

1. https://electrical-engineering-portal.com/distribution-substation
2. https://en.wikipedia.org/wiki/Electrical_substation

XIII Suggested Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
	Product Related: 10 Marks	**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
	Total (25 Marks)	**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 16: Distribution scheme for Commercial and Residential consumer.

I Practical Significance

Electrical Engineering Diploma graduate should understand the proper distribution scheme for different types of loads as per their requirement.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Maintain the functioning and operation of electric power distribution system

IV Laboratory Learning Outcome(s)

LLO 1 Calculate the load for Commercial and Residential consumer.

LLO 2 Prepare a feeder scheme for consumers

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

Classification of Distribution Systems

A distribution system may be classified according to

(i) Nature of current: According to nature of current, distribution system may be classified as

(a) d.c. distribution system (b) a.c. distribution system.

Now-a-days, a.c. system is universally adopted for distribution of electric power as it is simpler and more economical than direct current method.

(ii) Type of construction: According to type of construction, distribution system may be classified as

(a) overhead system

(b) underground system.

(iii) Scheme of connection:

According to scheme of connection, the distribution system may be classified as

(a) Radial system
(b) Ring main system
(c) Inter-connected system.

Each scheme has its own advantages and disadvantages A.C. DISTRIBUTION:

Now-a-days electrical energy is generated, transmitted and distributed in the form of alternating current.

- Alternating current in preferred to direct current is the fact that alternating voltage can be conveniently changed by means of a transformer.
- High distribution and distribution voltages have greatly reduced the current in the conductors and the resulting line losses.
- The a.c. distribution system is the electrical system between the step-down substation fed by the distribution system and the consumers' meters.

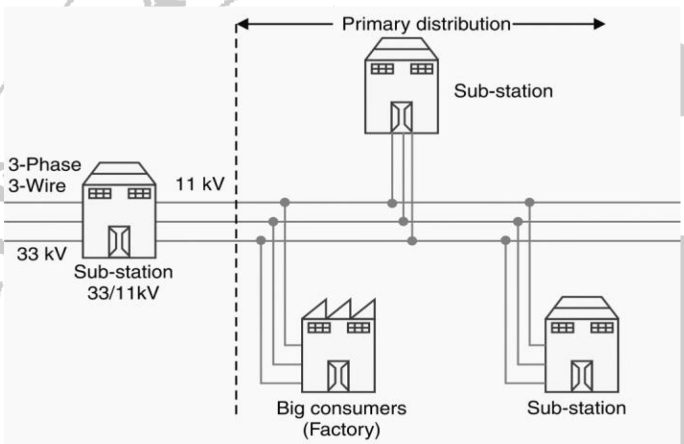

Fig: 16.1 Primary distribution to big consumer at 11KV

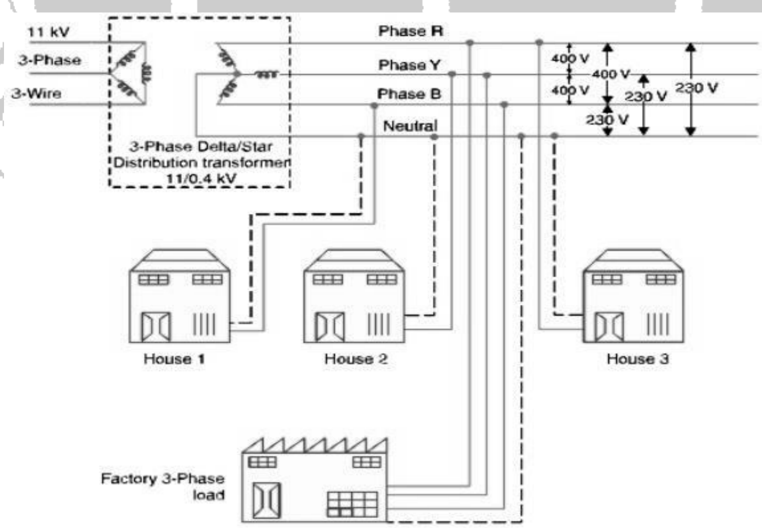

Fig: 16.2 Secondary distributions to commercial and residential consumer at 400V/230V

VII Precautions to be followed

1. Use correct symbols.
2. Do the calculation correctly.

VIII Procedure

Note: Teacher student should provide case study to

i) Calculate Load for commercial and residential consumers.

ii) Prepare a feeder scheme for commercial and residential consumers on blank imperial half drawing sheet

IX Conclusion

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X Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. Compare the distribution scheme of commercial and residential consumer.
2. Write the steps to be followed for calculation of residential and consumer load

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XI References/Suggestions for further reading

1. https://www.electrical4u.com/electrical-power-distribution-system-radial-ring-main-electrical-power-distribution-system/
2. https://www.electricaleasy.com/2018/02/radial-parallel-ring-main-interconneted-distribution.html
3. https://www.electrical4u.com/electrical-grid-system/
4. https://www.electrical4u.com/electrical-engineering-articles/distribution/

XII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 17: Distribution scheme for Industrial Consumer.

I Practical Significance

Electrical Engineering Diploma graduate should understand the proper distribution scheme for different types of loads as per their requirement. Distribution scheme for Industrial consumer comes under primary distribution.

II Industry/Employer Expected Outcome(s)

Maintain the functioning and operation of the electrical power generation, transmission and distribution systems.

III Course Level Learning Outcome(s)

Maintain the functioning and operation of electric power distribution system

IV Laboratory Learning Outcome(s)

1. Calculate the load for industrial Consumer.
2. Prepare a feeder scheme for industrial consumers.

V Relevant Affective Domain related outcome(s)

a. Follow safety practices.
b. Maintain tools and equipment.
c. Follow ethical Practices.

VI Relevant Theoretical Background

The electrical energy is produced at generating stations, and through the transmission network, it is transmitted to the consumers. Between the generating stations and the distribution stations, three different levels of voltage (transmission, sub-transmission and distribution level of voltage) are used.

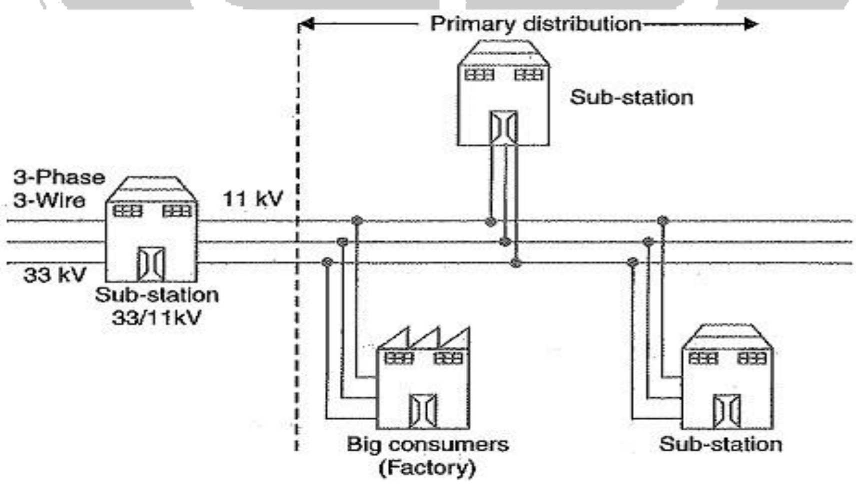

Fig:17.1 Distribution scheme for Industrial consumers

In this diagram a three phase 11 KV feeders come out from this station and go to the different points to feed industrial demands.

A primary distribution level can be 3.3 KV, 6.6 KV or 11 KV as per the requirement, line conductors are known as a feeders .Consumers are bulk consumer, big locality and industrial area. Consumer has its own distribution substation in their premises.

Feeder feeds the power from receiving station to substation. Generally these are 33KV or 11 KV feeders. On feeders no tapping points. This is also known as 3-phase, 3- wire, R, Y, B High tension line, voltage level may be 33KV, 22KV or 11 KV. Load is n directly connected to the feeder. It is a line between receiving substation to distribution substation. It is designed as per the current carrying capacity. Feeder is a high current capacity conductor, feeder forms primary distribution. Voltage drop can be compensated by the provision of voltage regulating equipment. So a Primary Distribution systems are composed of feeders that transport power from distribution substations to distribution transformers. Typically, a feeder starts with a feeder breaker located at the distribution substation. Numerous feeders exit the substation through concrete ducts and proceed to an adjacent pole. Here, the underground cable changes to an overhead three-phase main trunk.

VII Precautions to be followed

1. Use correct symbols.
2. Do the calculation correctly.

VIII Procedure

Note: Teacher student should provide case study to

i) Calculate Load for Industrial consumers.

ii) Prepare a feeder scheme for Industrial consumers on blank imperial half drawing sheet

IX Conclusion

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X Practical related questions (Note:- Teacher should provide various questions related to practical-sample given)

1. What is the purpose of a feeder?
2. Write the difference between distributor and feeder?

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XI References/Suggestions for further reading

1. https://www.electrical4u.com/electrical-power-distribution-system-radial-ring-main-electrical-power-distribution-system/
2. https://www.electricaleasy.com/2018/02/radial-parallel-ring-main-interconneted-distribution.html
3. https://www.electrical4u.com/electrical-grid-system/
4. https://www.electrical4u.com/electrical-engineering-articles/distribution/

XII Suggested Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Identification of the components of power plant/transmission system/Distribution system	10%
2	Drawing of layout/preparation of plan and elevation diagram/preparation of single line diagram	20%
3	Interpretation of normal operation of the plant/transmission system/Distribution system	20%
4	Understanding the importance of team work in various power plants & T& D systems	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Conclusions	10%
7	Practical related questions	05%
8	Submitting the journal in time	15%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	