

Advantages of outdoor substations over indoor substations :

1. Fault location is easier since all the equipment is within view.
2. The time required to erect such substations is less.
3. The extension of the installation is easier.
4. The smaller amount of building material is required.
5. Switch gear installation cost is low.

Disadvantages :

1. More space required.
2. The various switching operations with the isolators, as well as supervision and maintenance of the apparatus is to be performed in the open air during all kinds of weather.
3. The influence of rapid fluctuation in ambient temperature and dust and dirt deposits upon the outdoor substation equipment makes it necessary to install apparatus specially designed for outdoor service and, therefore, more costly.

Note. Notwithstanding the disadvantages, outdoor substations are very widely used in power system.

12.13. INDIAN ELECTRICITY ACT

Some extracts of the Indian Electricity Act, 1910, are given below :

Definitions. (i) *Area of Supply.* Area of supply means the area within which alone licensee is for the time being authorised by his licence to supply energy.

(ii) *Consumer.* Consumer means any person who is supplied with energy by a licensee or the Government or by any other person engaged in the business of supplying energy to the public under this Act or any other law for the time being in force, and includes any person whose premises are for the time being connected for the purpose of receiving energy with the works of a licensee, the Government or such other person, as the case may be.

(iii) *Distributing main.* Distributing main means the portion of any main with which a service line is, or is intended to be, immediately connected.

(iv) *Electric supply line.* Electric supply line means a wire, conductor or other means used for conveying, transmitting or distributing energy, whether by overhead line or underground cable, together with any casing, coating, covering, tube, pipe or insulator enclosing, surrounding or support the same or any part thereof, or any apparatus connected therewith for the purpose of so conveying, transmitting or distributing such energy and includes any support, cross-arm, stay, strut or safety device erected or set up for that purpose.

(v) *Energy.* Energy means electrical energy—

(a) generated, transmitted or supplied for any purpose, or

(b) used for any purpose except the transmission of a message.

(vi) *Mains.* Mains means any electric supply line through which energy is, or is intended to be, supplied to the public.

(vii) *Service line.* Service line means any electric supply line through which energy is, or is intended to be, supplied :

(a) to a single consumer either from a distributing main or immediately from the supplier's premises, or

(b) from a distributing main to a group of consumers on the same premises or on adjoining premises, supplied from the same point of distributing main.

(viii) *Works.* Works includes electric supply line and any building, plant, machinery, apparatus and any other thing of whatever description required to supply energy to the public and to carry into effect the objects of a licence or sanction granted under this Act or any other law for the time being in force.

Criminal Offences and Procedure

1. Theft of energy. Whoever dishonestly abstracts, consumes or uses any energy shall be deemed to have committed theft within the meaning of theft under I.P.C. 45 and the existence of artificial means for such abstractions shall be *prime facie* evidence of such dishonest abstraction.

2. Penalty for unauthorised supply of energy by non-licensees. Whoever, in contravention of the provisions of the Act engages in the business of supplying energy, shall be punishable with fine which may extend to Rs. 30000 and in the case of a continuing contravention, with a daily fine which may extend to Rs. 300.

3. Penalty for illegal or defective supply or for non-compliance with order. Whoever— (a) being a licensee or a person who has obtained the sanction of the State Govt. to engage in the business of supplying energy to the public, save as permitted under relevant sections or by his licence or as the case may be by the conditions of sanction, supplies energy or lays down or places any electric supply line or works outside the area of supply ; or

(b) being a licensee or a person who has obtained the sanction of the State Govt. as aforesaid in contravention of the provisions of this Act or if the rules thereunder, or in breach of the conditions of licence or the sanction, as the case may be, and without reasonable excuse, the burden of proving which shall lie on him, discontinues the supply of energy or fails to supply energy ;

(c) makes default in complying with any of the provisions of an order or of any notice or requisition issued.

(d) makes default in complying with any directions issued to him shall be punishable with fine which may extend to one thousand rupees, and, in the case of continuing offence or default, with a daily fine which may extend to one hundred rupees.

4. Penalty for illegals transmission or use of energy. Whoever, in contravention of the provisions, transmits or used energy without giving the notice required thereby, shall be punishable with fine which may extend to Rs. 500 and, in the case of a continuing offence, with a daily fine which may extend to Rs. 50.

5. Penalty for interference with meters or licensees works and for improper use of energy. Whoever

(a) connects any meter or indicator or apparatus with any electric supply line through which energy is supplied by a licensee, or disconnects the same from any such electric supply line,

(b) lays, or causes to be laid, or connects up any works for the purpose of communicating with any other works belonging to a licensee : or

(c) maliciously injures any meter or any indicator or apparatus or wilfully, or fraudulently alters the index of any such meter, indicator or apparatus or prevents any such meter, indicator or apparatus, from duly registering ; or

(d) improperly uses the energy of a licensee, shall be punishable with fine which may extend to Rs. 500 and in the case of continuing offence, with a daily fine which may extend to Rs. 50 ; and if it is proved that any artificial means exists for making such connection as is referred to in clause (a) or for causing alteration or prevention as is referred to in clause (c) or for facilitating such improper use as referred to in clause (d), and that the meter, indicator or apparatus under the custody or the control of the consumer, whether it is his property or not, it shall be presumed, until the contrary is proved, that such connection, communication, alteration, prevention or improper use, as the case may be, has been knowingly or wilfully caused by such consumer.

6. Penalty for negligently wasting energy or injuring works. Whoever negligently causes energy to be wasted or diverted, or negligently breaks, throws down or damages any electric supply line, post, pole or lamp or other apparatus connected with the supply of energy connected shall be punishable with fine which may extend to Rs. 200.

7. Penalties for offences not otherwise provided for. Whoever, in any case, not provided for by above sections makes default in complying with any of the above provisions of the Act, or with any order issued under it, or, in the case of a licensee, with any of the conditions of the licence, shall be punishable with fine which may extend to Rs. 100 and, in the case of a continuing default, with a daily fine which may extend to Rs. 20.

8. Offences by companies. (i) If any person committing an offence under this Act is a company, every person who at the time the offence was committed was in charge of, and was responsible to the company for the conduct of the business of the company, as well as the company, shall be deemed to the guilty of the offence and shall be liable to be proceeded against and punished accordingly :

Provided that nothing contained in this sub-section shall render any such person liable to any punishment, if he proves that the offence was committed without his knowledge or that he exercised all due diligence to prevent the commission of such offence.

(ii) Notwithstanding anything contained in sub-section (1), where an offence under this Act has been committed with the consent or connivance of, or is attributable to, any neglect on the part of any director or manager, secretary or other officer of the company, such directors, manager, secretary or officer of the company shall also be deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

Explanation. For the section :

(a) company means anybody corporate and includes a firm or other association of individuals ; and

(b) "director" in relation to a firm, means a partner in the firm.

9. Institution of prosecutions. No prosecution shall be instituted against any person for any offence against this Act, or any rule, licence order, thereunder, except at the instance of the Government, or an electrical Inspector or a person aggrieved by the same.

HIGHLIGHTS

1. Some of the important equipments available in a power plant are :

(i) Generators	(ii) Exciters
(iii) Transformers	(iv) Reactors
(v) Circuit breakers	(vi) Switchgear and protective equipment
(vii) Control board and equipment	(viii) Busbars
(ix) Stand by generators.	
2. An electrical generator is a machine which converts mechanical energy (or power) in electrical energy (or power). The basic essential parts of an electrical generator are :
 - (i) Magnetic field
 - (ii) A conductor/conductors which can so move to cut the flux.
3. The three important characteristics of D.C. generators are :
 1. No load saturation characteristics (E_g/I_f)
 2. Internal or total characteristics (E/I_a)
 3. External characteristics (V/I).
4. A machine for generating alternating currents is referred to an *alternator*. Alternators, according to their construction, are divided into the following two classifications :
 1. Revolving armature type
 2. Revolving field type.
5. The following methods are used to cool the alternators :
 1. Open system using air
 2. Closed system using air
 3. Hydrogen cooling.

6. The function of a *transformer* is to transform alternating current energy from one voltage into another voltage. The transformer has no rotating parts, hence it is often called a static transformer.
7. Kinds of transformers :
- (i) Power transformers
 - (ii) Auto-transformers
 - (iii) Transformer for feed installations with static converters.
 - (iv) Testing transformers
 - (v) Power transformers for special applications
 - (vi) Radio-transformers.
8. Three phase transformer connections :
- (i) Primary Y—secondary Y
 - (ii) Primary Δ —secondary Δ
 - (iii) Primary Δ —secondary Y, or vice versa
 - (iv) Primary and secondary open Δ
 - (v) Primary T—secondary T (Scott connection).
9. The *switch gear* constitutes all parts or equipments of the power plant whose function is to receive and distribute electric power. It comprises of the following :
- (i) Assemblies of switching apparatus
 - (ii) Protective and indicating metering devices
 - (iii) Interconnecting busbar systems and relevant accessories.
10. Types of Switches :
- (i) Knife switches
 - (ii) Disconnecting switches
 - (iii) Air-break switches
 - (iv) Control switches
 - (v) Auxiliary switches
 - (vi) Oil switches
 - (vii) Magnet impulse switches.
11. *Fuses* are used to protect circuits of small capacity against abnormal currents such as overloads or short circuits.
The most important types of fuses that are used for power purposes are :
- (i) Cartridge fuses
 - (ii) Transformer fuse blocks
 - (iii) Expulsion fuses.
12. The function of a *circuit breaker* is to break a circuit when various abnormal conditions arise and create a danger for the electrical equipment in any installation. The circuit breakers are classified as follows :
1. Low voltage circuit breakers
 2. High voltage circuit breakers
 - (a) Oil circuit breakers
 - (i) Bulk oil circuit breakers
 - (ii) Low oil contact circuit breakers.
 - (b) Oil-less circuit breakers
 - (i) Air blast circuit breakers
 - (ii) Water circuit breakers
 - (iii) Hard gas circuit breakers.
13. Types of switch gears :
- (i) Cellular
 - (ii) Cubicle
 - (iii) Truck
 - (iv) Metal clad
 - (v) Outdoor switch gear.
14. The function of the *relay system* is to recognize the fault and to initiate the operation of devices or circuit breakers to isolate the defective element with the minimum disturbance to the service.
Relays may be classified as follows :
1. According to their time action
 - (i) Instantaneous
 - (ii) Definite time limit
 - (iii) Inverse time.
 2. According to their mechanical details or principle of action
 - (i) Plunger type
 - (ii) Induction type.

3. According to their application
- (i) Current relays
 - (ii) Directional relays
 - (iii) Voltage relays
 - (iv) Auxiliary relays
 - (v) Differential relays
 - (vi) Distance or impedance relays.
15. Methods of earthing system neutral :
- (i) Solid earthing
 - (ii) Resistance earthing
 - (iii) Reactance earthing
 - (iv) Resonant earthing.
16. In a power station the layout of electrical equipment consists of the following :
- (i) Busbars' arrangement (at generator voltage).
 - (ii) Circuit breakers and switches' arrangement
 - (iii) Transformers' location
 - (iv) Controlling switch board arrangement.
- The following systems are used for layout of electrical equipment :
1. Single busbar system.
 2. Double busbar system.
 3. Ring busbar system.
17. Transmission lines may be classified as follows :
- (i) Single line
 - (ii) Parallel lines
 - (iii) Radial lines
 - (iv) Ring system
 - (v) Network.
18. The substations serve as sources of energy supply for local areas of distribution in which these are located.
- Outdoor substations are very widely used in power system.

THEORETICAL QUESTIONS

1. Give the classification of generating equipment.
2. Explain the working principle of a 'generator'.
3. Enumerate and explain briefly the characteristics of D.C. generators.
4. State the application of D.C. generators.
5. Explain the working principle of an 'alternator'.
6. What is an exciter ?
7. Write short note on A.C. exciters.
8. Explain the alternator synchronising procedure.
9. Enumerate and explain briefly different methods of cooling of alternators.
10. What is a transformer ? How are transformers classified ?
11. What are the advantages and disadvantages of the following three-phase transformer connections :
 - (i) The Y—Y connection
 - (ii) The Y— Δ connection
 - (iii) V—V connection.
12. How are three-phase transformers classified ?
13. What do you mean by a 'switch gear' ?
14. What are the functions of a switch gear ?
15. Enumerate important types of switches.
16. What is a fuse ? How are fuses classified ?
17. Explain with the help of a neat sketch the construction and working of a high rupturing capacity cartridge (H.R.C.) fuse.
18. What is a circuit breaker ?
19. How are circuit breakers classified ?

20. Explain briefly any one of the circuit breakers :
 - (i) Oil circuit breaker
 - (ii) Air circuit breaker
 - (iii) Water circuit breaker.
21. State the function of a relay system.
22. How are relays classified ?
23. Explain briefly any two of the following relays :
 - (i) Plunger type relay
 - (ii) Over-current relay
 - (iii) Differential relay.
24. Explain briefly the methods of protecting alternators against damage due to excess current due to short circuit.
25. Explain briefly how the following is materialised.
 - (i) Transformer protection
 - (ii) Bus protection
 - (iii) Protection of transmission lines.
26. What is a short circuit ? What are the effects of short circuits ?
27. What are the functions of a reactor ?
28. Give the layout of a control room.
29. Enumerate the methods of earthing system neutral. Explain with a neat sketch the 'solid earthing' system.
30. Write a short note on transmission and distribution of electric power.
31. Explain briefly the following in regard to overhead transmission lines :
 - (i) Line supports
 - (ii) Conductor material
 - (iii) Insulators.
32. How are cables (for underground service) classified ?
33. What are the advantages of underground power transmission systems ?
34. What are the advantages of over-head power transmission systems ?

COMPETITIVE EXAMINATION QUESTIONS
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1. (a) What is the function of circuit breaker ? Name the different types of circuit breakers. Explain in detail with the help of neat diagrams oil circuit breakers.
(b) Explain the various methods of controlling the voltage at the consumer terminal used in power supply system.
2. (a) What is the necessity of generator cooling ? What methods are used for generator cooling ?
(b) What is the function of circuit breakers in a power supply system ? Explain the different types of circuit breakers.
3. (a) Write criteria for optimum loading of a power plant and economic loading of combined thermal and hydro-plants.
(b) Write the factors which affect economies of generation and distribution of power.
4. Write briefly on the following :
 - (a) Earthing of a power station ;
 - (b) Protective equipments ;
 - (c) Control board equipments.
5. (a) What are the different methods of earthing a power system ? Explain in detail.
(b) What are the different methods used for generator cooling ? Explain in detail.
6. (a) What type of dust collector is used in super thermal power plant ? Why is it preferred to other types ?
(b) How would you justify the combined working of power plants ?
(c) Define 'Hydrograph' and explain its importance in the design of storage of hydroelectric power project.
(d) Draw a neat sketch showing essential parts of a power transformer.
7. (a) Define rating of a transformer.
(b) Show the most commonly used connections for three-phase voltage transformation with schematic diagrams. State the merits and demerits of each.
(c) Explain parallel operation of transformers.