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Unit 1

Theory of Magnetism

To understand the **magnetic behavior** of materials, it is necessary to take a microscopic view of matter. A suitable **starting point** is the **composition** of the atom, which Bohr described as **consisting of** a heavy **nucleus** and a number of electrons **moving around** the nucleus in **specific orbits**. Closer investigation **reveals** that the atom of any **substance** experiences a **torque** when placed in a magnetic field; this is called a **magnetic moment**. The **resultant** magnetic moment of an atom depends upon three factors-the positive charge of the nucleus **spinning** on its axis, the negative charge of the electron spinning on its axis, and the effect of the electrons moving in their orbits.

magnetic behavior **starting point** **composition**
consist of **nucleus** **moving around** **specific orbit**
reveals **substance** **torque** **magnetic moment**
resultant spinning

The magnetic moment of the **spin and orbital motions** of the electron far exceeds that of the spinning proton. However, this magnetic moment can be **affected** by the presence of an **adjacent** atom. Accordingly, if two hydrogen atoms are **combined** to form a hydrogen molecule, it is found that the electron spins, the proton spins, and the orbital motions of the electrons of each atom **oppose** each other so that a resultant magnetic moment of zero should be expected.

Although this is almost the case, experiment reveals that the **relative permeability** of hydrogen is not equal to 1 but rather is very **slightly** less than unity.

spin and orbital motions	**affected**	**adjacent**	**combined**
oppose	**slightly**		

In other words, the molecular **reaction** is such that when hydrogen is the medium there is a slight decrease in the magnetic field compared with free space. This behavior **occurs** because there is a **precessional motion** of all rotating charges about the field direction, and the effect of this precession is to set up a field opposed to the **applied field** regardless of the **direction** of spin or orbital motion. Materials in which this behavior **manifests** itself are called **diamagnetic** for obvious reasons. Besides hydrogen, other materials **possessing** this characteristic are silver and copper.

Reaction	**occurs**	**precessional motion**	**applied field**
Direction	**manifests**	**diamagnetic**	**possessing**

Continuing further with the hydrogen molecule, let us assume next that it is made to lose an electron, thus **yielding** the hydrogen ion. Clearly, complete **neutralization** of the spin and orbital electron motions no longer takes place. In fact, when a magnetic field is applied, the ion is so **oriented** that its net magnetic moment aligns itself with the field, thereby causing a **slight increase** in flux density.This behavior is described as **paramagnetism** and is characteristic of such materials as aluminum and platinum. Paramagnetic materials have a relative permeability slightly in excess of unity.

So far we have considered those **elements** whose magnetic **properties** differ only very slightly from those of free space. As a matter of fact the vast majority of materials fall within this category.

Yielding **neutralization** **oriented** **slight increase**
Paramagnetism **elements** **properties**

However, there is one class of materials-principally iron and its **alloys** with nickel, cobalt, and aluminum-for which the relative permeability is very many times greater than that of **free space**. These materials are called **ferromagnetic** and are of great importance in electrical engineering. We may ask at this point why iron (and its alloys) is so very much more magnetic than other elements. Essentially,

Alloys **free space** **ferromagnetic**
domain

Like all metals, iron is crystalline in **structure** with the atoms arranged in a space lattice. However, domains are subcrystalline particles of varying sizes and shapes **containing** about 10 atoms in a volume of approximately cubic centimeters. The **distinguishing** feature of the domain is that the magnetic moments of its **constituent** atoms are all **aligned** in the same direction Thus in a ferromagnetic material, not only must there exist a magnetic moment due to a nonneutralized spin of an electron in an inner orbit, but also the **resultant spin** of all neighboring atoms in the domain must be parallel.

Structure **containing** **distinguishing** **constituent**
Aligned **resultant spin**

Large increases in the **temperature** of a magnetized piece of iron **bring about** a **decrease** in its magnetizing **capability**. The temperature increase enforces the **agitation** existing between atoms until

Temperature	**bring about**	**decrease**
Capability	**agitation**	**severe**
Destroys	**property**	

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

…….1. With his atomic theory, Bohr contributed to the understanding of the magnetic behavior of materials.

…….2. The atoms of a substance, if placed in a magnetic field, are subject to a torque.

…….3. Platinum is a diamagnetic material.

…….4. In ferromagnetic materials, the magnetic moments of large groups

…….5. In an unagnetized ferromagnetic material, the domains are aligned in different direction.

…….6. The magnetic properties of iron increase with an increase in temperature.

B. Choose a, b, c, or d which best completes each item.

1. Permeability of silver is less than unity ..... .

a. because of its atoms setting up a field against the applied field

b. because of its molecules rotating about the applied field

c. due to the precessional spin of its positive charges

d. due to the orbital motions of its negative charges

2. It is true that ..... .

a. paramagnetic materials provide a small penetration of the magnetic field

b. paramagnetic materials provide a great penetration of the magnetic field

c. the resultant magnetic moment of an atom depends on its spinning axis

d. the resultant magnetic moment o f an atom depends on the nucleus spinning on its axis

3. According to the text, ...

a. two atoms of hydrogen, if combined, pronounce a permeability greater than 1

b. two atoms of hydrogen, if combined, give rise to a high magnetic moment

c. diamagnetic materials have magnetic properties more than those of free space

d. diamagnetic materials have magnetic properties less than those of free space

4. Paramagnetism is based on the fact that the magnetic moment of a paramagnetic material, when placed in a magnetic field, ...

a. results in a decrease in flux density b. lines up with the field

c. is equal to 1 d. is low compared with free space

5. The magnetic properties of diamagnetic and paramagnetic materials ..... those of free space.

a. are greater than b. are smaller than c. differ slightly from d. differ greatly from

6. The abnormal magnetic properties of iron may be caused by ,..... .

a. the magnetic moment resulting from an inner orbital spin of a nonneutralized electron

b. the parallelism of the resultant spin of all neighboring atoms in the domain

c. the domains oriented at random with their axes pointing in various directions

d. both a and b

Part I Language Practice

A. Choose a, b, c, or d which best completes each item.

1. Copper is ..... material, therefore, it exhibits a relative permeability slightly less than unity.

a. a paramagnetic b. a diamagnetic c. a permeable d. a neutral

2. Iron provides a great penetration of the magnetic field, that is ,its ..... is many times greater than that of free space.

a. magnetic flux b. atomic composition c. relative permeability d . magnetic moment

3. Elements and metals which have slight magnetic properties are called..... materials.

a. magnetic b. metallic c. diamagnetic d. paramagnetic

4. Iron and some of its alloys have an appreciable magnetic permeability. These materials are called ..... .

a. ferromagnetic b. diamagnetic c. paramagnetic d. magnetic

5. The state of ..... is reached when all the magnetic domains are aligned in one direction.

a. magnetization b. saturation c. flux density d. neutralization

B. Fill in the blanks with the appropriate form of the words given.

1. Magnet

a. Maxwell showed that some of the properties of ..... may be compared to a flow.

b. Lines of flux are conventionally said to leave a ..... material at the north pole and re-enter at the south pole.

3. Move

a. When a conductor is ..... through a magnetic field in such a way as to cut the magnetic lines.

b. A moving - conductor microphone is a microphone the electric output of which results from the ..... of a conductor in a magnetic field.

Unit 2

Power Stations

There are five **sources** of energy which together **account for** nearly all the world's electricity. They are coal, oil, natural gas, hydroelectric power and nuclear energy. Coal, oil and nuclear plants use the **steam cycle** to turn heat into electrical energy, in the following way. The steam power station uses very **pure water** in a closed cycle. First it is heated in the **boilers** to **produce** steam at high **pressure** and high temperature, typically 150 atmospheres and 550°C in a modern station.

Sources	**account for**	**steam cycle**	**pure water**
boilers	**produce**	**pressure**	

This high-pressure steam **drives** the turbines which in turn drive the electric generators, to which they are directly **coupled**. The maximum amount of energy will be **transferre**d from the steam to the turbines only if the latter are allowed to **exhaust** at a very low pressure, ideally a vacuum. This can be achieved by **condensing** the outlet steam into water. The water is then pumped back into the boilers and the cycle begins again. At the condensing stage a large **quantity** of heat has to be **extracted** from the system.

drives	**coupled**	**transferred**	**exhaust**
condensing	**quantity**	**extracted**	

This heat is **removed** in the **condenser** which is a form of **heat exchanger**. A much larger quantity of cold impure water enters one side of the condenser and leaves as warm water, having extracted enough

heat from the exhaust steam to condense it back into water. At no point must the two water systems mix. At a **coastal site** the warmed impure water is simply returned to the sea at a point a short distance away. A 2 GW station needs about 60 tons of sea water each second. This is no problem on the coast, but inland very few sites could **supply** so much water all the year round. The **alternative** is to **recirculate** the impure water. Cooling towers are used to cool the impure water so that it can be returned to the condensers, the same water being cycled **continuously.**

Removed **condenser** **heat exchanger**
coastal site **supply** **alternativer**
ecirculate **continuously.**

A cooling tower is the familiar **concrete structure** like a very broad chimney and acts in a similar way, in that it induces a **natural draught**. A large **volume** of air is drawn in round the base and leaves through the open top. The warm, impure water is sprayed into the **interior** of the tower from a large number of fine jets, and as it falls it is cooled by the **rising air**, finally being **collected** in a pond under the tower. The cooling tower is really second heat exchanger where the heat in the impure water is passed to the atmospheric air; but unlike the first heat exchanger, the two **fluids** are allowed to come into contact and as a **consequence** some of the water is lost by **evaporation.**

concrete structure **natural draught** **volume**
interior **rising air** **collected** **fluids** **consequence**
evaporation

Coal-Fired Power Stations

Early coal-burning stations were built near the **load** they supplied. A station of 2 GW output, **consumes** about 5 million tons of coal in a year. In Britain where most power station coal **is carried** by rail, this **represents** an average of about 13 trains a day each carrying 1000 tons. This means that large coal-fired stations need a rail link unless the station is built right at the **pit head**.

Load **consumes** **is carried** **represents** **pit head**

Oil-Fired Power Stations

Power station oil can be **divided into crude oil** which is oil as it comes from the **well**, and **residual oil** which remains when the more **valuable fractions** have been extracted in the oil **refinery**. The **cost** of moving oil by **pipeline** is less than that of moving coal by rail, but even so stations burning crude oil are often sited near deep-water **berths** suitable for unloading medium-sized tankers. Stations burning residual oil need to be **sited** near to the refinery which supplies them. This is because residual oil is very **viscous** and can only be moved through pipelines **economically** if it is kept warm.

divided into **crude oil** **well** **residual oil** **valuable fractions** **refinery** **cost** **pipeline** **berths** **sited** **viscous** **economically**

Nuclear Power Stations

In contrast to coal and oil the cost of **transporting** nuclear fuel is **negligible** Because of the very small amount used . A 1 GW station needs about 4 12 tons of uranium each week. This compares very **favourably** with the 50,000 tons of fuel which would be burnt each week in a comparable coal-fired power station. Present nuclear stations use rather more cooling water than **comparable** coal-fired or oil-fired plants due to their lower **efficiency**. All nuclear stations in Britain, with one **exception**, are **situated** on the coast and use sea water for cooling.

Transporting	**negligible**	**favourably**	**comparable**
Efficiency	**exception**	**situated**	

Hydroelectric Power Stations

Hydroelectric power stations must be sited where the head of water is **available**, and as this is often in **mountainous areas**, they may need long **transmission lines** to carry the power to the nearest load center or **link up** with the **grid.** All hydroelectric **schemes** depend on two **fundamental** factors: a **flow** of water and a difference in level or head. The necessary head may be **obtained** between a lake and a nearby **valley**, or by building a small dam in a river which **divert**s the flow through the power station, or by building a **high dam** across a valley to **create** an **artificial** lake.

Available	**mountainous areas**		**transmission lines**	
link up	**grid**	**schemes**	**fundamental**	**flow**
Difference	**obtained**	**valley**	**divert**	**a high dam**
create	**artificial**			

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements . Justify your answers.

..... 1. Gas and nuclear plants use the steam cycle to turn heat into electricity.

..... 2. Condensers remove the heat from the outlet steam.

..... 3. The steam power station uses pure water in an open cycle.

..... 4. Steam pressure affects the generators directly.

..... 5. Having cooled off the exhaust steam, the warmed impure water may be recirculated.

..... 6. Natural air is forced through the cooling tower.

..... 7. Large coal-fired stations situated far from the pit head need a rail link.

..... 8. Oil-fired power stations consume certain constituents of crude oil.

..... 9. Nuclear power stations use less cooling water than comparable coal-fired or oil-fired plants.

..... 10. Hydroelectric power stations have to be built where there is enough water pressure.

B. Choose a, b, c, or d which best completes each item.

1. In steam power stations, the turbine efficiency will increase if ..... .

a. the steam pressure is kept constant b. the outlet steam is condensed into water

c. the steam temperature is not varied d. the outlet water is pumped back into the boilers

2. The steam power station uses pure water ..... .

a. to produce the steam required to drive the turbines

b. to produce the steam required to activate the generators

c. to create the vacuum space necessary for the system

d. to create the pressure and temperature needed

3. The heat of the steam is removed by ..... the condenser.

a. the recirculation of cold pure water in b. the flow of natural air in one side of

c. the recirculation of the steam in d. the flow of cold water through one side of

4. Prior to recirculation, impure water must be cooled ..... .

a. in broad concrete structures b. in broad metal chimneys

c. at the bottom of the tower d. at the top of the tower

5. The cooling factor in a cooling tower is ..... the tower.

a. the pond under b. the interior of c. the water inside d. the air passing through

6. Systems recirculating impure water, compared with those on the coast,…… .

a. decrease the efficiency of the station b. increase the capital cost of building the station

c. reduce the impure water temperature to the required level d. both a and b

7. The first paragraph mainly discusses ..... .

a. the structure of a condenser compared with that of a cooling tower

b. the mechanism of the steam power station

c. the main sources of energy which account for electricity

d. the cooling water as a deciding factor in the choice of sites for coal, oil, and nuclear plants

Part I. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. The energy of water may be converted to work by hydraulic ..... .

a. turbines b. generator c. boilers d. towers

2. Gas oil must be ..... and then used.

a. isolated b. heated c. refined d. vapourized

3. In the condenser, the outlet steam is ..... and recirculated.

a. exchanged b. condensed c. depressurized d. purified

4. Cooling towers cause water to be ..... .

a. condensed b. exhausted c. evaporated d. recycled

5. Air pump suction must be applied to the lowest pressure point or points within a condenser which are normally at the inlet tube plate where ..... rate and hence steam side pressure drop are greatest.

a. the condensation b. the temperature c. the cooling d. the evaporation

B. Fill in the blanks with the appropriate form of the words given.

1. Exchange

a. Coupling forces, similar to the ..... forces of the atom, exist between the molecules of a compound.

b. Cooling towers and condensers are two kinds of heat ..... .

4. Condense

a. Steam can be ..... into water.

b. A ..... is a form of heat exchanger.

درس ۳

Unit3 Electrical Insulation

Insulation is required to keep electrical **conductor**s **separated from** each other and from other nearby objects. Ideally, insulation should be totally **nonconducting**, for then **currents** are totally **restrict**ed to the intended conductors. However, insulation does **conduct** some current and so must be regarded as a material of very high **resistivity**.

Conductor		**separated from**	**nonconducting**
Currents	**restrict**	**conduct**	**resistivity**

In many **applications**, the current flow due to conduction through the insulation is so small that it may be entirely **neglect**ed. In some instances the conduction currents, **measur**ed by very sensitive i**nstrument**s, serve as a test to **determine** the **suitability** of the insulation for use in service.

Applications	**neglect**ed	**measure**	i**nstrument**s
determine	**suitability**		

Although insulating materials are very **stable** under **ordinary circumstances**, they may change radically in **characteristics** under extreme **conditions** of voltage stress or temperature or under the action of certain **chemicals**. Such changes may, in local regions, **result in** the insulating material becoming highly conductive. Unwanted current flow brings about intense heating and the **rapid**

destruction of the insulating material. These insulation **failures** account for a high percentage of the **equipment troubles** on electric-power systems.

Stable **ordinary circumstances** **characteristics**
Conditions **chemicals** **result in** **rapid destruction**
Failures **equipment troubles**

The **selection** of proper materials, the choice of **proper shapes** and **dimensions**, and the control of **destructive agencies** are some of the problems of the insulation-system **designer**.

Selection **proper shapes** **dimensions**
destructive agencies **designer**

Many different materials are used as insulation on electric-power systems. The **choice** of material is dictated by the **requirements** of the particular application and by **cost**. In residences, the conductors used in branch circuits and in the cords to appliances may be insulated with **rubber** or plastics of several different kinds. Such materials can **withstand** necessary **bending**, are relatively stable in characteristics, and are inexpensive.

choice **requirements** **cost** **rubber** **withstand**
bending

They **are subjected** to relatively low electrical stress. High-voltage cables are subjected to extreme voltage stress; in some cases several hundred kilovolts **are impressed across** a few centimeters of insulation. They must be **manufactur**ed in long sections, and must be sufficiently **flexible** as to permit

pulling into ducts of small cross section. The insulation may be **oil-impregnated** paper, varnished cambric, or **synthetic** materials such as polyethylene.

are subjected	**are impressed across**	**manufacture**
flexible	**oil-impregnated**	

The coils of generators and motors may be insulated with tapes of **various kinds**. Some of these are made of **thin sheets of mica** held together by a **binder**, and other are of fiber glass impregnated with insulating varnish.

This insulation must be **capable of** withstanding quite high operating tempera-mechanical **forces**, and **vibration**.

various kinds	**thin sheets of mica**	**binder**
capable of	**forces**	**vibration**

Overhead lines are **support**ed on porcelain insulators. Between the supports air **serves** as insulation. Porcelain is chosen because of its **resistance** to **deterioration** when **exposed** to the **weather**, its high dielectric strength, and its **ability** to wash clean in rain.

Overhead lines	**support**	**serves**	**resistance**
deterioration	**exposed**	**weather**	**ability**

Part I Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answers.

..... 1. The higher the insulation the less the loss of power.

..... 2. In order to avoid insulation failures, very expensive materials are used in power systems.

..... 3. Insulation failures do not affect the electric equipment.

..... 4. Voltage and temperature variations may bring about insulation failures.

..... 5. Rubber and plastic insulating materials are preferred to other kinds because of their cost.

..... 6. Polyethylene and mica have different applications in electrical power systems.

B. Choose a, b, c, or d which best completes each item.

1. The first paragraph mainly discusses ..... .

a. electrical conductors b. nonconducting materials

c. the purpose of insulation d. the application of insulators

2. As we understand from the text, ...

a. perfect insulation is not possible b. stable insulators are not available

c. chemicals do not affect good insulators d. insulators may never change to temporary conductors

3. The second paragraph mainly discusses ..... .

a. the problems caused by the insulation-system designer b. the factors resulting in insulation failures

c. the characteristics of insulating materials d. the rapid destruction of insulating materials

4. Tapes of insulating fiber glass are commonly used to insulate .....…..

a. ordinary conductors b. the windings of power transformer

c. high-voltage cables d. the coils of generators and motors

5. Insulating tapes ..... .

a. cannot withstand high electrical stress b. can withstand high temperatures

c. are used to insulate ducts of small cross section d. are used to stop deterioration caused by the weather

Part II. Language Practice

A. Choose a, b, c, or d which best completes each item.

1. In order to keep electrical conductors separated from each other, ……. . materials must be used.

a. capacitive b. resistive c. insulating d. conducting

2. The ..... of metals increases with increase of temperature.

a. conductivity b. resistivity c. solubility d. durability

3. Voltage stress may affect ..... of insulating materials.

a. the sensitivity b. the suitability c. the stability d. the conductivity

4. Certain insulating materials are impregnated with oil; that is, they are …… oil.

a. saturated with b . covered with c. deprived of d. made of

5. Porcelain has high resistance to deterioration; in other words, it does not..... quickly.

a .deflect b.degenerate c. decrease d. decline

B. Fill in the blanks with the appropriate form of the words given.

1. insulate

a. Different …. ..... have different characteristics.

b. We should …….these wire and cords

c. An insulated joint is used to ..... adjacent pieces of conduits, pipes, rods, or bars.

d. The solid ..... generally are of the form of annular discs and truncated cones.

2 Measure

a. The gas pressure can be ..…… by means of a standard pressure gauge.

b. Most branches of science and technology rely on electrical .....…. for the control of processes and machines as well as for information.

Unit4

The Distribution System

While the energy flow is **obviously** from the **power generating plant** to the **consumer**, it may be more informative for our **purposes** to **reverse** the direction of observation and consider events from the consumer back to the generating source. Energy is consumed by **users** at a **nominal utilizati**on voltage that may range generally from 110 to 125 V, and from 220 to 250 V, the nominal figures are 277 and 480 V.

Obviously	**power generating plant**	**consumer**	**purposes**
reverse	**users**	**nominal utilization**	

It flows through a **metering device** that **determine**s the **billing** for the consumer, but which may also serve to **obtain** data useful later for **planning**, design, and **operating purposes**. The metering equipment usually includes a means of **disconnecting** the consumer from the **incoming supply** should this become necessary for any reason.

metering	**device**	**determine**	**billing**	**obtain**
planning	**operating**	**purposes**	**disconnecting**	

At the **transformer**, the voltage of the energy being **delivered** is reduced to the utilization voltage values from higher **primary line** voltages that may range from 2200 V to as high as 46,000 V. The transformer is **protect**ed from **overloads** and **faults** by fuses or so-called weak links on the high-

voltage side; the latter also usually include circuit-breaking devices on the low-voltage side. These **operate** to disconnect the transformer in the event of overloads or faults.

Transformer	**delivered**	**primary line**	**protect**
overloads	**faults**	**operate**	

The circuit breakers (where they exist) on the secondary, or low-voltage, side operate only if the condition is caused by faults or overloads in the **secondary mains**, services, or consumers' premises; the primary fuse or **weak link**, in addition, operates in the event of a failure within the transformer itself. If the transformer is **situated** on an overhead system, it is also protected from **lightning** or line voltage **surges** by a **surge arrester**, which **drains** the voltage surge to ground before it can do **damage** to the transformer.

secondary mains	**weak link**	**situated**	**lightning**	**surges**
surge arrester	**drains**	**damage**		

The transformer is connected to the primary circuit, which may be a **lateral** or spur consisting of one phase of the usual three-phase primary main. This is done usually through a line or **sectionalizing fuse**, whose **function** is to disconnect the lateral from the main in the event of fault or overload in the lateral. The lateral conductors carry the sum of the energy **components** flowing through each of the transformers, which represent not only the energy used by the consumers connected thereto, but also the energy **lost** in the lines and transformers to that point.

Lateral	**sectionalizing fuse**	**function**	**components**
lost			

The three-phase main may consist of several three-phase branches **connected together**, sometimes through other line or sectionalizing fuses, but sometimes also through switches. Each of the branches may have several single-phase laterals connected to it through line or sectionalizing fuses. Where single-phase or three-phase overhead lines run for any **considerable distance** without distribution transformer **installations** connected to them, surge arresters may be installed on the lines for protection.

connected together **considerable distance** **installations**

Some three-phase laterals may sometimes also be connected to the three-phase main through circuit **reclosers**. The recloser acts to disconnect the lateral from the main should a fault occur on the lateral, much as a line or sectionalizing fuse. However, it acts to reconnect the lateral to the main, reenergizing it one or more times after a time delay in a **predetermined sequence** before remaining open **permanently**. This is done so that a fault which may be only of a **temporary nature**, such as a tree limb falling on the line, will not cause a **prolonged interruption** of service to the consumers connected to the lateral.

Reclosers **predetermined sequence** **permanently**

temporary nature **prolonged interruption**

The three-phase mains **emanate** from a distribution substation, supplied from a bus in that station. The three-phase mains, usually referred to as a circuit or **feeder**, are connected to the bus through a **protective** circuit breaker and sometimes a voltage r**egulator**. The voltage regulator is usually a

modified form of a transformer and serves to **maintain** outgoing voltage within a predetermined band or range on the circuit or feeder as its load **varies**.

emanate **feeder** **protective** **regulator** **modified form** **maintain** **varies**

It is sometimes placed electrically in the substation circuit so that it regulates the voltage of the **entire** bus **rather than** a single outgoing circuit or feeder, and sometimes along the route of a feeder for **partial** feeder regulation. The circuit breaker in the feeder acts to disconnect that feeder from the bus **in the event of** overload or fault on the outgoing or **distribution feeder**.

Entire **rather than** **partial** **in the event of** **distribution feeder**

Part I. Comprehension Exercises

A. Put "T" for true and "F" for false statements. Justify your answer

..... 1. The text describes the distribution elements used between the power generating plant and the consumer.

..... 2. The metering device is mainly used to offer data useful for design and operating purposes.

..... 3. The three-phase main may consist of several three-phase branches which in turn may consist of several single-phase laterals.

..... 4. Any power system must have secondary mains in order to supply the consumer with energy through the services.

B. Choose a, b, c, or d which best completes each item.

1. It is true that ..... .

a. circuit breakers disconnect the high-voltage side of the transformer in the event of overloads

b. fuses and circuit breakers are identical devices

c. fuses are weak links always installed on the secondary side of the transformer

d. circuit breakers protect the high-voltage side of the transformer in the event of overloads

2. The distribution transformer ..... .

a. is connected to the primary circuit through a line or sectionalizing fuse

b. is connected to the primary main through a line or sectionalizing fuse

c. helps to disconnect the lateral from the main in the event of fault or overload

d. helps to disconnect the consumers from the services in the event of fault or overload

3. A circuit recloser is used to ..... .

a. connect a three-phase lateral to the three-phase main

b. disconnect the lateral from the main if a fault occurs on the lateral

c. reconnect the lateral to the main after a predetermined time delay

d. all of the above

Part II Language Practice

A. Choose a, b, c, or d which best completes each item.

1. The ..... deliver electric energy from the secondary distribution or street main, or other distribution feeder, or from the transformer, to the wiring system of the premises served.

a. meters b. buses c. services d. feeders

2. The function of ..... is to interrupt circuit faults.

a. a line b. a service c. a main d. a transformer

3. A ..... serves as a common connection for two or more circuits.

a. fuse b. switch c. lateral d. bus

B. Fill in the blanks with the appropriate form of the words given.

1. Connect

a. A connection diagram shows the ..... of an installation or its component devices, controllers, and equipment.

b. A network is ..... if there exists at least one path composed of branches of the network, between every pair

of nodes of the network.

c. A low voltage or secondary network is a continuous secondary main or grid fed by a number of transformers ..... to the same primary feeder.

2. Protect

a. To ensure maximum ..... , the ..... system must possess a high degree of electricity.

b. ..... equipment should be used against vibrations of voltage.

c. A differential relay responds to the difference between incoming and outgoing electrical quantities associated with the ..... apparatus.

3. Limit

a. The function of a relay is to prevent or ..... damage during faults.

b. The inrush current of the rectifier transformer is generally the .....factor.

Unit 5

Protective Devices

For the **distribution system** to **function** satisfactorily, faults on any part of it must be **isolated** or disconnected from the rest of the system as quickly as possible; indeed, if possible, they should be **prevented from** happening. The **principal devices** to accomplish this include fuses, automatic sectionalizers, reclosers, circuit breakers, and lightning or surge arresters. Success, however, depends on their **coordination** so that their operations do not **conflict** with each other.

distribution system	**function**	**isolated**	**prevented from**
principal devices	**coordination**		

Fuses

Time-Current Characteristic. A fuse consists basically of a **metallic element** that **melts** when 'excessive' current **flows through** it. The **magnitude** of the excessive current will **vary** inversely with its duration. This time-current characteristic is determined not only by the type of metal used and its dimensions (including its **configuration**), but also on the type of its enclosure and holder. The latter not only affect the melting time, but in addition, affect the arc **clearing time**. The clearing time of the fuse, then, is the sum of the melting time and the arc clearing time. Fuses are **rated** in terms of voltage, normal current-carrying ability, and **interruption characteristics** usually shown by time-current curves.

metallic element	**melts**	**flows through**	**magnitude**	**vary**
configuration	**clearing time**	**rated**	**interruption characteristics**	

Fuse Coordination. The **number**, rating, and type of the interrupting devices, **depend on** the system voltage, normal current, maximum fault current, the **sections** and equipment connected to them, and other **local conditions**. The devices are usually **located** at branch **intersections** and at other **key points**, When two or more such devices are **employed** in a circuit, they will be coordinated so that only the faulted portion will be deenergized.

Number	**depend on**	**sections**	**local conditions**
Located	**intersections**	**key points**	**employed**

Repeater Fuses

Line fuses are sometimes **installed** in groups of two or three (per phase), known as **repeater fuses**, having a time **delay** between each two fuse units. When a fault occurs, the first fuse will blow and the second fuse will be mechanically placed in the circuit by the opening of the first; if the fault **Persists**, the second fuse will blow; if There a third fuse, the process is repeated. If the fault is **permanent**, all of the fuses will **blow** and the faulted part of the circuit will be deenergized. new fuses must be installed to **restore** the line to normal.

Installed	**repeater fuses**	**delay**	**Persists**
permanent	**blow**	**restore**	

Where **capacitor**s are applied to **feeder**s for power factor **correction**, fuses chosen to **protect** the line from the bank (and vice versa) must also coordinate with **sectionalizing** and other devices in the circuit back to the source .

Capacitor	**feeder**	**correction**	**protect**	**sectionalizing**

Transformer Fuses

Fuses on the **primary side** of distribution transformers serve to disconnect the transformer from the circuit not only in the event of a fault in the transformer or on the secondary, but also when the normal load on the transformer becomes so high that **failure** is **imminent**. Fuses on the secondary side protect the transformer from faults or overloads on the secondary circuit it **serves**.

primary side **failure** **imminent** **serves**

The **characteristics** of a primary fuse are a **compromise** between **protection f**rom a fault and protection from overload, yet the fuse also has to coordinate with other fuses on the line. One attempt at a solution is the completely self-protected (CSP) transformer, in which the primary fuse, with characteristics based only on protection against fault, is situated within the transformer tank (and, to **differentiate**, is called a link) while overload protection is accomplished by low-voltage circuit breakers (instead of fuses) on the secondary side of the transformer that are also situated within the tank. The circuit breakers, once open, however, must be reclosed **manually.**

Characteristics **compromise** **protection** self-protected **differentiate** **manually**

Fuses are **provided** on the line side secondary **network**s. These are **backup** protection in the event the protector fails to open during back feed from the network into the primary when it is faulted or **deliberately** grounded.

Secondary fuses, known as **limiters**, are also provided at the **juncture** of secondary mains to isolate

faulted sections of the secondary mains and to prevent the spread of burning in **conductors** (usually in cables) where **sufficient** fault current does not exist to burn them clear in a small **portion** of the mains.

Provided	**networks**	**backup**	**deliberately**	**limiters**
juncture	**conductors**	**sufficient**	**portion**	

Part I. Comprehension Exercises

A. Put T for true and "F" for false statements. Justify your answers.

..... 1. Protective devices connected on a distribution system cause the system to function satisfactorily

…… 2. The greater the excessive current flowing through a fuse, the longer the melting time.

…… 3. Different fuses with different rates of voltage, current-carrying ability, and interruption characteristics can be produced.

…… 4. The interrupting devices may be located anywhere in a distribution system.

…… 5. Limners, employed at the juncture of the secondary mains, isolate their faulted sections.

B. Choose a, b, c, or d which best completes each item.

1. The clearing time of a fast fuse is ..... .

a. comparatively low b. comparatively high

c. equal to its arcing lime d. equal to its melting time

2. According to the passage, ...

a. the minimum and the maximum of the clearing time for a certain value of current cannot be evaluated

b. the minimum and the maximum of the clearing time of a fuse are always constant

c. protective devices in a circuit must be coordinated so that their operations do not conflict with each other

d. protective devices in a circuit must be adjusted to deficiencies resulting from manufacturing problems

3. Repeater fuses ..... .

a. are installed in groups with a time delay between each two fuse units

b. are installed in series to restore the equipment to normal

c. may act as capacitors for power factor correction

d. may all operate simultaneously to prevent deenergization

4. Fuses on the primary side of distribution transformers ..... .

a. will not protect the transformer if a fault occurs on the secondary

b. will not protect the transformer if a fault occurs in the transformer itself

c. will protect the fuses on the secondary side if a permanent fault occurs

d. will disconnect the transformer from the circuit if it is seriously overloaded

5. It is true that ……. .

a. a transformer fuse is basically designed for fault protection

b. a transformer circuit breaker is manually opened and closed

c. a self-protected transformer is equipped with links and circuit breakers

d. a self-protected transformer is fully automatic

Part IL Language Practice

A. Choose a, b, c, or d which best completes each item.

1. Devices called ..... are designed to open when a fault occurs on that part of the main in which they are connected.

a. regulators b. fuses c. reclosers d. relays

2. Some ..... are designed to open in air, with special provisions for handling the arc that follows when the contacts are opened.

a. fuses b. arresters c. line sectionalizers d. circuit breakers

3. In liquid-filled construction, ... link is enclosed in a tube that is filled with a fire-extinguishing fluid such

as carbon tetrachloride.

a. the fuse b. the switch c. the fault-counting relay d. the circuit breaker

4. Switches are installed in the main of the feeder, enabling the main to be sectionalized, isolating the fault between two switches or other …….. devices.

a. connecting b. sectionalizing c. energizing d. feeding

5. Like the secondary circuit, the design of the primary ..... is based on the maximum voltage variation permissible at the farthest consumer.

a. recloser b. limiter c. conductor d. feeder

B. Fill in the blanks with the appropriate form of the words given.

1. Energize

a. A relay is said to 'pick up' when it changes from the unenergized position to the ..... position.

b. Relay functioning time is the time between ..... and operation or between deenergization and release.

c. The elapsed time after the coil has been ..... to the time required.

3. Melt

a. Melting-speed ratio refers to the ratio of the current magnitudes required to ..... the current-responsive element at two specified melting times.

b. The time required for over current to severe the current-responsive element is known as the ..... time.