CMR INSTITUTE OF TECHNOLOGY

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Internal Assesment Test - III

Sub:	Testing And Commissioning Of Power System Apparatus							Code:	15EE752/10EE756
Date:	20/11/2018	Duration:	90 mins	Max Marks:	50	Sem:	7	Branch:	EEE(A/B)
Answer Any FIVE FULL Questions									

		Marks	OBE CO	OBE RBT
1	Explain the capacitance discharge method/thumping method for locating fault in power cables.	[10]	CO5	L2
2	Explain the various tests on circuit breakers.	[10]	CO6	L2
3	Explain the procedure of installation of circuit breakers and metal clad switchgear.	[10]	CO6	L2
4	With a neat sketch Explain the procedure for laying underground cables in open trenches/direct in ground.	[10]	CO5	L2
5a	Explain the effect of open or loose neutral connections in cables.	[5]	CO5	L3
5b	What are the precautions to be taken while handling underground cable.	[5]	CO5	L2
6.	What are the factors to be considered while selecting cable for underground installations	[10]	CO5	L2
7a	Explain how to obtain i). insulation resistance to earth and ii) insulation resistance between conductors for domestic installation	[5]	CO6	L2
7b.	Explain continuity test and why it is required in domestic wiring.	[5]	CO6	L2

1. **Capacitor Discharge Method/SurgeThumper Method**

One of the oldest and most popular techniques out there is a technique called the capacitor discharge technique or thumping a cable. In application this technique is actually very straightforward and simple. In essence, a device called the thumper, or surge wave generator, creates a high voltage surge which is launched out onto the faulted cable. This surge of energy will travel along the cable conductor. If it reaches an area of dielectric breakdown or a failure in the insulating material, the transmitted energy will discharge through the gap at the fault and discharge all of the energy through the faulted insulation.

If a high voltage surge is sent into the cable, and all that energy is discharged through the gap or fault, it is going to cause a small explosion. Buried in the ground, this small explosion will cause a percussion and sound wave to travel up through the layers of earth. As a result, a thumping sound can be heard on the surface of the ground. To locate the defect in the underground cable, a repair crew has to walk along the surface of the ground listening for this thumping sound. Once the fault is pinpointed, the crew digs a hole and repairs the faulted cable.

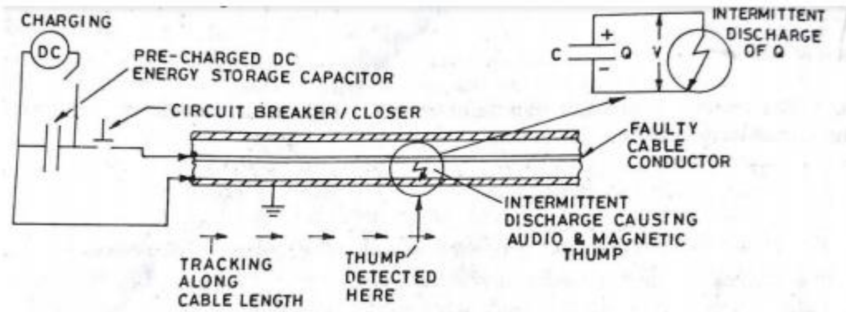


Fig. Q. 397. Capacitor Discharge Thump-Surge Tracking Method.

Advantages and Disadvantages of Thumping a Cable:

The advantages of the capacitor discharge technique are that it is very accurate to do pinpointing and is easy to learn. This technique requires fairly minimum training, in particular, some safety training on how to properly handle the instrument, how to properly make connections, and how to set the various controls.

The weak point of this technique is that it is extremely time consuming and potentially harmful if misused. In some cases it may take hours or even days to walk the cable and definitely locate the fault. During that time the cable is exposed to high voltage surges, leading to a higher rate of

repeat failures on the service age polyethylene cables. Repetitive thumping could be accelerating the channel growth of other water trees that under natural aging may have lasted several more years of service life. In essence, the cable is being set up for a future fault in the process of trying to find the current fault.

Another challenge for the capacitor discharge technique is a gap that is too large. For instance, the cable blows apart, and in the process of blowing apart the conductor had burned back into the dielectric material, or the neutral had burned back, causing a sizable distance in that gap. No matter how much voltage is applied to it, the gap is physically too large to actually arc across. The choice here may be the burn down technique, with the insulation resistance burnt away to reduce the gap size in order to get the thumper to discharge an arc across properly.

2. **Various tests on circuit breaker**

4.4 Tests on Circuit Breakers

Type tests: These tests are conducted on the first circuit breaker manufactured to prove the capabilities and to confirm the specified characteristics of the circuit breaker of that design in a specially built testing laboratory.

Routine test: Routine tests are performed on each and every circuit breaker as per the recommendation of the standards to verify the performance.

Commissioning tests: These tests are conducted on the circuit breaker after installation at site to verify the readiness and proper functioning.

Development tests: These tests are carried on components, sub assemblies and complete circuit breakers during and after the development of the circuit breaker. The designers and research scientists verify the effect of various parameters.

Types of test:

1. **No load mechanical operation test:** This test is to verify speed of travel, operating time and closing time and is carried out at 85% and 110% rated voltage of shunt trip release.
2. **Mechanical performance tests (endurance):** It is to check the mechanical ability of opening and closing of the contacts by carrying out 1000 close and open operations or more.
3. **Temperature rise test:** Steady temperature of conducting part and insulating parts measured for rated continuous alternating current.
4. **Dielectric tests:**
   - 1.2/50μsec lightning impulse withstand
   - One minute power frequency voltage withstand
   - 250/2500μs switching impulse withstand
5. **Short time current test:** Rated short circuit current is passed through closed breaker for 1sec or 3secs.
6. **Short circuit breaking and making tests:** This test is conducted at 10%, 30%, 60% and 100% rated short circuit braking current with specified operating sequence and specified TRV (transient recovery voltage).
7. **Line charging current breaking test:** This test is conducted for circuit breakers 72.5KV and above.
8. **Cable charging current breaking test:** This test is applicable to circuit breakers intended for long cable network.
9. **Single capacitor bank breaking test:** This test is applicable for circuit breakers used for capacitor switching.
10. **Small inductive current breaking test:** This test is to be conducted on circuit breakers with reactors, transformers, motors etc.
11. **Out of phase switching:** This test is to be conducted on limit breaker that is used to connect two parts under out of phase.
12. **Short line test:** Applicable to circuit breakers rated above 52KV and for overhead lines.

3. Installation of circuit breker / switchgear

(a) **Preliminary Preparations.** The preliminary preparations include study of drawings, acceptance, report checking certificates and test reports of the equipment, completion of civil engineering work, arranging the tools, lifting gears etc. organising the labour, prepare the schedule of installation, preparing sequence cards for erection of major etc. Such cards indicate the sequence of operation, items involved, procedure in brief etc.

(a) **Sequence Card for Erection of Switchgear Equipment**

S. No.	*Operation*	*Tools, lifting gear etc.*	*Drawing No.*	*Technique and Procedure*

The drawing include

(1) Circuit diagrams of the plant.

(2) Civil engineering plans, foundation plans etc.

(3) Dimension drawings of equipment.

(b) **Location of switchgear.** (*i*) indoor (*ii*) outdoor.

Generally upto 11 kV, indoor switchgear is popular.

Indoor switchgear should be located in a clean, dry room free from vermins, snakes, moisture, dust etc. Floor should be dry and levelled. The floor should withstand load of about 1000 kg/m^2 (200 lb/sq. ft.). Enough space should be left in front and in the rear of the switchgear as recommended by the manufacturer. (About 1.7 metres in front and 0.7 m in the rear of 11 kV drawout switchgear).

The following points are kept in mind :

(1) Fire proof doors, roof, ceiling etc.

(2) Sealing of cable ducts.

(3) Sub-division of switchgear.

(4) Installation of fire fighting apparatus.

(c) **Unpacking.** The equipment is packed in creates and is brought to site by railway and motor-truck. Packings are lowered on the site by means of rope, hoist or crane carefully. Care is taken that they are always maintained in upright position throughout. On unpacking, the items are checked against the list. Further the items are carefully inspected visually. If any damage is found, the matter should be informed to the manufacturer and insurance company immediately, and the damaged equipment should be returned.

(d) **Foundation.** The foundation is prepared according to the foundation plan. Holes are provided for foundation bolt. Trenches and passages are provided for cables and other piping. The floor should be correctly levelled and marked according to the drawing.

(e) **Erection.** The equipment is installed according to the procedure mentioned in the instruction manual. Some types of lifting devices. Special tools etc. may be necessary. The assembly is erected vertically. The verticality is checked by means of spirit level. If necessary, packing pieces are added in the base plate for obtained proper level. After doing necessary adjustments and checking the level, the concrete mixture is poured into holes around foundation bolts and the nuts are tightened. It should be remembered that porcelain insulator columns are weak in tension. During erection, they should not be lifted under assembled state. The assembled is carried out on site and the assembled units are not shifted.

(f) **Bus-bars Earthing Connections.** The bus-bar contacts and making surfaces of connectors should be cleaned with emery paper or smooth file. The bus-bars are assembled as soon as they are cleaned. Special grease is applied.

(g) **Connections of main cable.** The cable terminal box should be clean and moisture should be removed by blow-lamps. The cable filling compound should be warmed to about 157 to 168°C and allowed to cool to pouring temperature of about 135-140°C. The buckets used for filling should be pre-heated to about 80° before use. The compound is poured slowly down in the cable box to avoid splashing and inclusion of air bubbles, and should be topped periodically to ensure good bond between the body at the compound and the topping layer. The level of the compound should be about 45 mm below the top cover to allow expansion during service conditions. The cable cover is bolted when the compound gets cold. No moisture or dirt should enter while filling the compound. The P.V.C. hose is sleeved on the cable conductor which is protected by varnish cambric tape. The terminal lug is soldered to the cable conductor.

(h) **Earthing.** The earthing bar of the switchgear, the metallic non-current carrying parts are connected to station earthing system.

The earthing bar is run through various units and the frames of each unit are connected to earthing bar. Earthing bar is connected to station earth by two GI flats.

4. Underground cable laying procedure

1. Laying direct in ground /Cable Laying in open trenches

This method shall be adopted where the cable route is through open ground, along roads/lanes, etc. and where no frequent excavations are likely to be encountered and where re-excavation is easily possible without affecting other services. Different steps to be followed are

- Trenching
- Bedding
- Laying of cables
- Tiling
- Refilling/Backfilling
- Cable warning tape
- Refilling back to normal

Trenching:

Trench is dug in the soil approximately about 1 meter deep along the planned rout as per the specification given below.

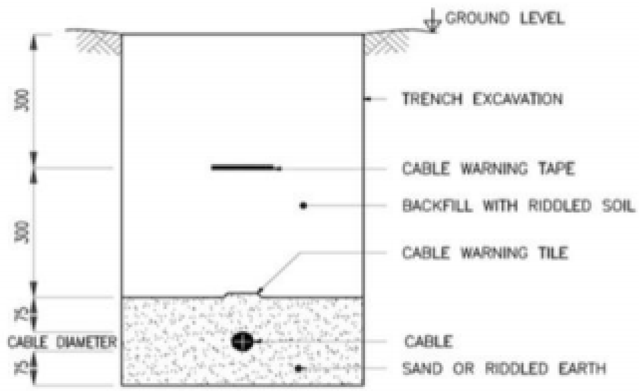
Width of trench

- The minimum width of the trench for laying a single cable shall be 35cm

Depth of trench

The desired minimum depth of laying from ground surface to the top of cable is as follows:

- High voltage cables, 3.3 kV to 11 kV rating =0.9 m
- High voltage cables, 22 kV, 33 kV rating= 1.05 m



- The trench shall then be provided with a layer of clean, dry sand cushionof not less than 75mm in depth, before laying the cables therein.
- The cables shall be tested for continuity and insulation resistance before laying.
- The cable drum shall be properly mounted on jacks, or on a cable wheel, making sure that the spindle, jack etc. are strong enough to carry theweight of the drum without failure.
- The cable shall be pulled over on rollers in the trench steadily and uniformlywithout jerks and strain.
- The cables shall again be tested for continuity of cores and insulation resistance before closing the trench.
- Cables laid in trenches in a single tier formation shall have a covering of dry sand of not less than 75mm
- The cables shall be protected by second class brick ofnominal size locally available size, placed on top of the sand /soil as the case may be. The bricks shall be placed breadth-wise for the full length of thecable
- The trenches shall be then back-filled with excavated earth, free fromstones or other sharp ended debris and shall be rammed and watered, if necessary insuccessive layers not exceeding 30cm depth.

5. A. Effect of loose neutral wire

A loose NEUTRAL WIRE is the cause of the majority of electrical fires in your house.

Every time the connection is made or broken, an arc forms. Usually this arc is very brief, but it is very hot and so it causes some damage every time. Thus the condition of the connection gets worse over time. At some time that can't be predicted, a large long-lasting arc may occur. This can cause damage to the surroundings, and it can start a fire.

A resistive neutral is closely related to a loose neutral. A resistive neutral occurs when the neutral is connected, but it's not a very good connection. Good connections have extremely low electrical resistance, but a resistive neutral condition has an intermediate resistance — its resistance is low enough to conduct some electricity, but too high to conduct as well as it's supposed to. This poor connection has several damaging and dangerous effects.

One effect is that a loose or resistive neutral can cause abnormally high and low voltages to occur in the house wiring. For example, a cardinal sign of a resistive neutral is that lights will get brighter than normal at odd times, such as when another circuit is turned on, or when an appliance cycles on. A resistive neutral won't always cause the lights to get abnormally bright, but when it happens, it's a pretty reliable indication that you have a resistive neutral. If you are aware of a situation in which the lights get abnormally bright when other circuits are used, you should call in-house technician or wireman to take a look and rectify that you believe that there is a problem with the neutral connection. They know this can be very dangerous, so they will likely treat it as a high-priority situation.

Another effect of a resistive neutral connection is that the connection becomes hot. As a result, it can overheat its surroundings and even start a fire. Even if it doesn't do either of these right away, it will tend to get worse over time because heat accelerates the aging of the wire, its insulation, and surrounding materials.

Another very dangerous effect of a loose or resistive neutral is that it can lead to electrical shocks and even electrocution. The ways this can happen are extremely unpredictable and depend on exactly how your house is wired and the exact condition of the wiring.

5 b. Handling underground cables

Transportation and handling of cables

- Cables are generally received wound on wooden drums , both ends of the cable being accessible for inspection and testing.
- Cables drums are transported on rails/trucks/ships to the location for installation
- Cable drums not to be dropped/thrown from railway wagons or trucks during unloading.
- When the cable drums have to be moved over short distances, they shouldbe rolled in the direction of the arrow marked on the drum.

- For manual transportation over long distances, the drum should bemounted on cable drum wheels, strong enough to carry the weight of the drum and pulledby means of ropes. Alternatively, they may be mounted on a trailer or on a suitablemechanical transport.
- For loading into and unloading from vehicles, a crane or a suitable liftingequipment should be used. Support should be given only on the drum flange and never on the cable as it might create mechanical damage to the cable.

- While lifting on a crane, make sure that axile spreader rod is used to equally balance the drum weight. Otherwise, the cable drum may collapse

6. SELECTION OF CABLE

Q. 379. State the factors to be considered while selecting a cable.

1. Type of Cable Installation
2. Type of Cable based on Site Requirements and Techno-Economy.
3. Main Operating Ratings (Voltage, Current other Ratings)
4. Core Arrangement Cable size, Termination Space Available
5. Shielding Requirements

Cable Installation.

— Outdoor or Indoor installation ?

— For transmission/Distribution/Utilization ?

— Length and route

— Type of installation buried/in pipe/in soil/in trenches/on racks, overground

— At ground level/raised and taken over structured racks, heat dissipation, protection from injury environmental impact. Special considerations of exposure (water, chemicals, flames, ambient temperature).

Type of Insulation is based on Temperature Permissible. Method of heat dissipation, Ease of handling, Weight per m, Flexibility desired, Cost, Rated Voltage.

— **Cable Type and Specifications.** Selection and application of cable involves the type of cable construction needed for a particular installation, cable arrangement, single core or three core, armoured and type of armour, shielded or unshielded, serving, type of insulation, type of cooling and finish and covering.

— **Conductors** Copper or Aluminium ? Class of stranding required for a particular installation.

— **Core Arrangement. Power Cables are either** single core type or three core type. Control cables are multicore type.

Voltage Stresses. Three core shielded cables have balanced and uniform internal field distribution and therefore lower voltage stress and corona/partial discharges.

Ground Wire. The availability of ground wire in three core cable or a separate ground wire with single core cable Requires special consideration.

The ground conductor in a three core cable provide lowest impedance path and therefore. It offers a good system ground. Similarly a separate ground conductor in the same conduit of power cable provides a better ground return path than a ground path *via* the equipment or building steel reinforcement.

Selection and application of a cable system is based on proper ground return arrangements.

Type of Serving. The selection of cable serving is normally based on the type of installation, ambient operating temperature, service conditions, type of load served, and other criteria as applicable. In many installations may have unusual conditions such as corrosive atmosphere high ambient temperature, insect and rodent hazard, presence of oil and solvents, presence of ozone and extreme cold or hot ? In certain applications two or more such unusual conditions may be present. In such case the selection of suitable cables serving becomes much more difficult.

Other factors that affect selection of cables include

- Nature of soil : Sandy ,Hard, Rocky
- Soil Conditions: Wet, Muddy, Dry , Hazardous components
- Chemical action
- Operating conditions

  1. Rated voltage / current
  2. Earthing Conditions
  3. Load Conditions
  4. Permissible Temperature Conditions
     : For conductor, insulation, sheath

- Drum length and mass
- cable jointing and terminations
- Economic considerations

7 . Continuity test & insulation resistance

Continuity Test

To check the continuity of the conductors and the protective devices like fuse, Circuit breaker etc, Continuity tester is used. It is a small handy instrument with a low voltage bulb and a cell housed in plastic casing and two outward leads.

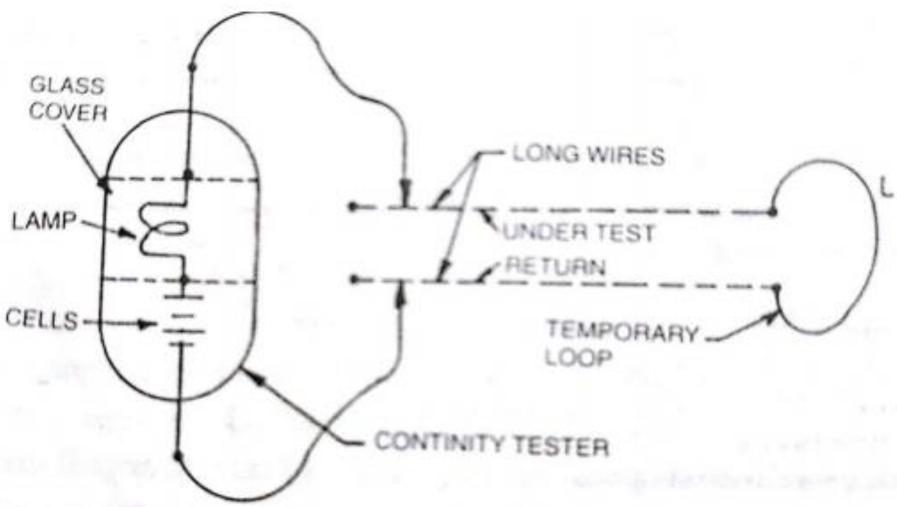


Fig. Q. 688. Continuity test.

The instrument generates a no-load voltage in the range 4 to 24 V (DC or AC) with a minimum current of 0.2 A. For checking the continuity of cable A, another healthy cable, B is also necessary. The healthy cable is connected to cable, A using a low resistance jumper. The tester checks the continuity of the cable on pressing the test button. If cable is continuous, the lamp glows else not.

The most common continuity test is measuring the resistance of protective conductors, which involves first confirming the continuity of all protective conductors in the installation, and then testing the main and supplementary equipotential bonding conductors. All circuit conductors in the final circuit are also tested. As continuity testing measures very low resistances, the resistance of the test leads must be compensated for.

Insulation resistance of electrical installation

Insulation integrity is critical to prevent electric shock. It is generally measured between live conductors; and between each live conductor and earth. To measure the insulation resistance between live conductors and earth, the complete installation must be switched off, all lamps removed and all equipment disconnected. All fuses must be left in, circuit breakers closed and final circuit switches closed.

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Measurements are carried out with direct current using an instrument capable of supplying a test voltage of 1000, 500 or 250 V depending on the nominal circuit voltage. On single phase supply systems, insulation testing is normally undertaken using a test voltage of 500 V. Before testing, it is necessary to disconnect equipment and take measures to prevent the test voltage damaging voltage-sensitive devices such as dimmer switches, delay timers, and electronic starters for fluorescent lighting.

According to IEC , the resistance values should be greater than 1 megohm for 1000 V test voltage, 0.5 megohms for 500 V, and 0.25 megohms for 250 V.