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MAINTENANCE OF CONNECTORS AND DISCONNECTORS IN THE EHV SYSTEM

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ABSTRACT*:* Connectors and Disconnectors play a major role in the performance of extra high voltage (EHV) system. Failure due to the connectors and disconnectors leads to the shutdown of the whole system. Also this leads to heavy losses and inconvenience to the users. Hence the maintenance of the connectors and disconnectors is an important activity in the EHV system. Among the three types of maintenance such as Preventive maintenance, Predictive maintenance and Shutdown maintenance , Preventive maintenance improves reliability, reduces downtime and improves availability of plant and equipment. If we do not plan and perform the scheduled maintenance, it leads to forced outage due to fault or equipment failure. As far as EHV system is concerned, preventive maintenance plays a vital role, for which a thorough knowledge on the major parts of EHV components is mandatory. This article deals specifically with the EHV Power connectors and disconnectors in Major Power systems, right from design upto maintenance aspects. The modern trends using computers enable us to achieve better maintenance results.

Keywords*:* EHV Connectors, Disconnectors

I.INTRODUCTION

Power connector is one of the most important parts which connects all the current carrying equipments in the Switch yard. They are commonly known as Aluminium clamps Whereas Disconnector provides isolation of a circuit mainly for the purpose of maintenance in the Switchyard. It is commonly known as isolator.

II. EHV POWER CONNECTORS

Power connector is primarily intended to establish connection between switchgear equipments, between conductors, rigid buses and disconnectors in the substation. As per IS norms, normal rating of the power connectors shall be selected based on the system requirement from one of the values 200, 400, 630, 800, 1600, 2000, 2600 and 3000 Amps. In our switchyard, we are using 1200 & 2000Amps rating power connectors. Upto a voltage level of 765kV and current rating 4000 Amps, Power connectors are available in the global market. The connectors are generally bolted type. Welded/Compression type are also used.

The connector materials shall be aluminium alloy 4600-(A6) to IS 617:1975 having 0.1%Copper, for Aluminium bus bar station. Whereas for Copper Bus bar station, Copper alloy with either brass grade to IS: 292 having 64 to 70% copper, 1.5% Silicon, 0.75% Iron, 24 to 35% Zinc, 1 to 3% Lead, 0.01% aluminium or special Bronze grade AB2 to IS 305 having 75 to 83% copper, 0.1% silicon, 0.5%Zinc, 0.05% Lead, 8.5 to 10% Aluminium, 4 to 6% Nickel, 3to5% Iron, 1.5% manganese. The connectors are designed as per IS 5561-1975 & B.S.159, NEMA CCI standards. Construction of good connectors are:

- Terminal connectors shall be manufactured and tested as per IS: 5561.
- In flexible connectors, braids or laminated straps shall be made from tinned copper, are used up to 132 kV or aluminium conductor welded to connectors are used for 220 kV and above. For bimetallic connectors, copper alloy liner of minimum thickness of 2mm / 4mm shall be cast integral with aluminum body.
- All castings shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners should be blurred and rounded off.
- All current carrying parts shall be designed and manufactured to have a minimum contact resistance.

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- All the Connectors shall be designed to be corona free in accordance with the requirements stipulated in IS: 5561.
- Bolts and Nuts shall have hexagonal heads and threads as per Indian Standards. All ferrous parts like bolts, nuts, plain washers and spring washers shall be hot dip galvanized confirming to IS 2633.
- Size of the terminal / conductor for which the connector is suitable shall be embossed / punched on the connector.
- Connectors shall be designed to carry the same current as the conductor. The rated current for which connector is designed with respect to the specified reference ambient temperature, shall be indelibly marked on the connector. The connectors shall have low effective power loss.
- No part of a connector shall be less than 10mm thick. The clamps shall be light in weight and easy to handle.
- Suspension connectors shall have ease of oscillation around horizontal axis and small moment of inertia enabling it to follow freely the movement of the conductor.
- Connectors shall be designed to withstand stresses in service due to wind, ice, vibrations, fluctuations in temperature and short circuit without suffering permanent deformation or breakages
- Connectors design shall be such that tensile, bending and wrenching stresses transmitted to the equipment terminal are minimum.
- Parts of current carrying connectors which are in direct contact with the conductor shall be designed so that dangerous galvanic corrosion in the contact surface does not occur.
- The shape of current carrying connectors shall be designed such that water collection is eliminated. If this is not possible, the connector shall be supplied with drainage hole of at least 6mm.
- The short time rating of the power connectors shall not be less than the corresponding rating of the circuit breakers and disconnectors in the system.

III . TYPES OF CONNECTORS

1. Tee connector

A connector designed for the purpose of connecting two conductors / bus bars whose axes are perpendicular to each other.

2. End connector

A connector designed for the purpose of connecting terminal pad of Disconnector / Equipment to the conductor / bus bar whose axes are in line with or at an angle to each other.

3. ‘L’ connector

A connector designed for the purpose of connecting terminal pad of disconnector / equipment to the conductor / bus bar whose axes are at right angle to each other.

4. P.G. (Parallel Groove) connector

A connector designed for the purpose of connecting two conductors of same size whose axes are parallel to each other.

5. B.M. Connector (Bi-Metallic)

A connector designed for the purpose of connecting two or more conductors of dissimilar metals.

6. Sliding support connector (Free end)

A connector designed for the purpose of supporting the bus bar with allowance for relative movement developed due to linear expansion / contraction of bus bar under temperature variation.

7. Rigid connector (Seating block)

A connector designed for the purpose of supporting the bus bar with no allowance for the relative movement developed due to linear expansion / contraction of bus bar under temperature variation.

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Fig.1.(a) Tee connector (b) End connector (c) 'L' connector (d) P.G. connector (e)B.M.connector


(f) Sliding support connector (g) Rigid connector

IV. MAINTENANCE FOR EHV POWER CONNECTORS

Connectors are often weak links in the electrical system because of hostile environment, bad design, poor installation and higher loading which may lead to premature failures of connectors and forced outage may occur. Some of the maintenance are given below to avoid such premature failures.

- Aluminum expands and contracts with temperature, so swings in the conductor temperature cause the conductor to creep with respect to the connector. This can loosen connectors and allow oxidation to develop between the connector and conductor. During periodic maintenance, visual inspections of the connectors have to be carried out without fail.
- Check the connector surface temperature in regular intervals, if exceeds the limit i.e. above atmospheric temperature, we must inspect the connectors for any pittings during the next LC period. Replace the connector if required. Non contact type thermography is the primary way utilities spot bad connectors.
- If carbonized and oxide film are found, the contact surface of connectors shall be thoroughly cleaned with smooth wire brush or steel wool or smooth emery. Proper cleaning is essential to make good contact between connector surfaces.
- Apply "No oxide grease" of approximate 1mm thick over the contact area of the connector and bus bar / conductor prior to placing the bus bar / conductor on the connector groove. Contact paste shall effectively prevent corrosion occurring on the contact surfaces throughout the service period. It shall not decay, evaporate, run away, harden or crack under the service conditions.
- Check the tightness after placing the bus bar / conductor properly on the connector grooves. The bolts shall be tightened with hand evenly. After tightening one bolt slightly diagonally opposites bolt shall be tightened by rotation using torque limiting spanners. Over tightening of bolts will result breakage of connectors and improper tightening of bolts will cause loose connection. Recommended values of torque to be applied in the bolts are M10 bolts – 277Kg.mm [27.17Nm], M12 bolts – 555Kg.mm [54.44Nm], M16 bolts – 762Kg.mm [74.75Nm].
- Check the arcing if any in the joints (i.e. bolt & Nuts). If the contact is poor enough to cause arcing, the arcing can quickly eat the connection away. Mechanical forces can also break an already weakened or corroded connector. This should be attended immediately.
- Poor quality work lead to failures. Not using joint compound, misalignments, inadequate cleaning and not fully inserting the conductor prior to compression can cause a joint to fail prematurely.
- Observed for any glow and corona discharge during odd hours, if found, the connectors should be inspected.
- Visually inspect the bimetallic sheet wherever used in the connector and replace worn out sheets.

V .DISCONNECTORS

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Disconnector is an off-load switching device which can be opened or closed only under no current condition. It has the dual function of providing physical separation in an electric circuit and restoring its continuity. It does not have any current making or breaking capability. Disconnector is installed on both the sides of a circuit breaker to provide physical and visible isolation to the circuit breaker and the part of the circuit from live circuit. They are capable of dealing with small charging currents of bus bars and connections. In some cases, disconnectors are used for breaking the charging current of transmission lines. Construction of Disconnectors are

- Disconnectors shall be manufactured and tested as per IS 1818:1972 or IEC129.
- Live metal parts shall be of non-rusting and non-corroding metal such as copper silicon alloy. Current carrying parts shall be non-ferrous material such as aluminum or copper.
- The disconnector design should be free from visible corona discharge in both closed and open positions. Necessary stress relieving rings or shields shall be provided to meet this requirement.
- Disconnectors and earthing switches including their operating mechanism shall be such that they cannot be dislodged from their open or closed positions by gravity, wind pressure, vibrations, shocks or accidental touching or seismic forces or breaking of the connecting rods or the operating mechanism.
- The operating mechanism shall provide a quick, simple and effective operation. Maximum time of operation shall not exceed 12 seconds.
- Adjustable stops shall be provided to prevent over travel in either direction.
- The arrangement for manual operation is such that when manual operating handle is in the engaged position, the power operation shall be made inoperative.
- The disconnector or earthing switch shall be provided with high current carrying contacts on the hinge and jaw ends and all contact surfaces shall be of silver faced copper.

VI. TYPES OF DISCONNECTORS

1.Centre break

In the Centre break type, the two arms rotate and the disconnector opens in the centre. It is the most commonly used disconnetor and offers ratings from 72kV to 550kV, 4000A. Centre-break requires an increased inter-phase distance.

2. Double side break

The double break design features three insulators. The end insulators are fixed while the centre one pivots and provides two breaks in series. It requires nominal inter-phase distance and allows higher loads on HV terminals. It offers rating from 12kV to 550kV, 6000A.

3.Knee type

The Knee type has two fixed and one moving insulators and folding arm design requires a limited overhead clearance. It offers rating from 245 kV to 800kV, 4000A.

4.Pantograph type

Double-Side Break Pantograph & Center Break semi-Pantograph has one fixed and one rotating insulator. They are usually used to connect the two bus bars of double-deck substations. Placed diagonally to the axis of the bus bars and feeder, they offer a very clear arrangement and space saving solutions. It offers rating from 100kV to 800kV, 4000A.

5.Earthing switch

Earth switch is installed along with the disconnector to discharge the voltage on circuit capacitance to earth and provide safety to maintenance personnel. Earth switch provides phase to ground discharge path to capacitive charges trapped in the circuit. They can be installed in combine with any type of disconnector.

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Fig.2.(a) Centre break (b) Double side break (c) Knee type (d) Pantograph type

VII. MAINTENANCE FOR DISCONNECTORS

- Mechanisms should be adjusted to maintain full contact on the poles of a multi-pole switch as simultaneously as possible.
- Arcing horns shall be adjusted such that it should barely touch the movable switch mechanism when opened and closed.
- Main contacts and arcing horns should be cleaned for dirt, oxides and pitting and live contacts should be resilvered or replace if necessary.
- Electrical grounds should be checked for continuity and tightness. Ground sources should be checked to be sure that their resistance is sufficiently low.
- Disconnector hinges should be lubricated, but kept sufficiently stiff so that when the blades are open they will not fall back on the live stationary contacts. Other rotating parts should also be lubricated.
- All bolts and nuts, clamps, guide plates and other similar parts should be tightened and adjusted.
- Supporting insulators should be cleaned and inspected for cracks and signs of flash over or fatigue.
- The motors and electric supply and controls shall be checked periodically.
- Locking arrangements shall be checked to make sure that they are reasonably safe from being tampered by unauthorized people.
- It is good practice to open and close Disconnector switches which are not in operation for long stretches of time to make sure that they are in good mechanical operating conditions. The frequency of such checking depends on their exposure to cold, rain, salt, polluted atmosphere and other local adverse conditions.
- Check the Insulation and contact resistance of each pole of the disconnector.

VIII. MODERN TRENDS AND DEVELOPMENTS

E-commissioning system for disconnector is a user friendly and cost effective tool developed for the onsite commissioning and preventive maintenance of EHV disconnectors. It is plugged into the motor operating mechanism of the disconnector. Measurements are recorded during the opening and closing operation and saved in the computer. It can be recalled for comparison during every new test. Any deviation from the latest test result or from the originally recorded data of the particular disconnector will drive the need for preventive maintenance actions. The information measured during operation is motor voltage, operating time, motor maximum starting current, ambient temperature of substation.

IX. CONCLUSION

The requirement of maintenance of switchgear equipments vary with the environmental aspects such as dust, chemical fumes, moisture/humidity, ambient temperature variations etc,. It is not possible to obtain exact maintenance schedule, meeting local requirements of each site. Hence maintenance schedule shall be determined after initial periodic inspection at each site. For switchgear and protective equipment, preventive maintenance is recommended because failure of single switchgear cannot be permitted. Also it improves reliability, reduces downtime and improves availability of plant and equipment. The modern trends using computers enable us to achieve better maintenance results.

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