OPERATION & MAINTENANCE MANUAL

LV & MV CABLES

UNIVERSAL CABLES LIMITED

BIRLA VIKAS, SATNA (M.P.), 485005, INDIA

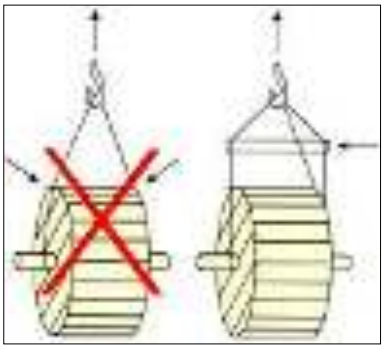
CONTENT

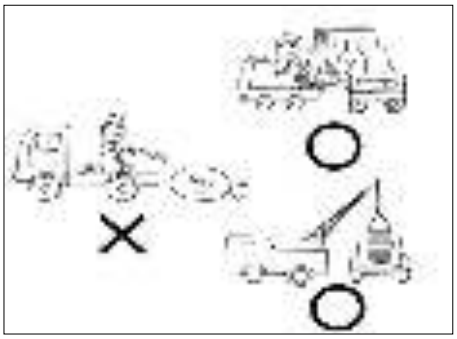
A) GENERAL

- During Installation of cable, if the temperature is below 3^0C, the cables should be warmed before the laying out, otherwise, the bending would damage the insulation and protective coverings of cables. The cable laying must be carried out swiftly, so that the cable doesn't cool down too much.
  Warming of cable may be achieved by storing the cables for adequately longer period (not less than 24 hours) in a heated chamber or in a tent with hot air provision.
- Cable is a high value commodity and is very sensitive to damage, hence must be handled with necessary care.
- It is not advisable to use cable pulling stocking when the ambient temperature is around 45^0C or more and under direct sunlight as the outer jacket might soften and get damaged.

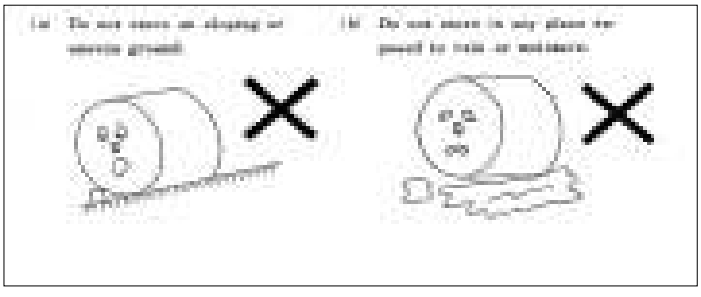
B) HANDLING AND STORAGE OF CABLE DRUMS

a) The cable drums or coils must not be dropped or thrown from railway wagons or trucks during unloading operations. A ramp or crane may be used for unloading cable drums. If neither of these is available, a temporary ramp with inclination1:3 to 1:4 approximately should be constructed. The cable drum should then be rolled over the ramp by means of ropes and winches. Additionally, a sand bed at the foot of the ramp may be made to brake the rolling of cable drum.





b) The site chosen for storage of cable drums should be well-drained and should preferably have a concert-surface/firm surface which will not cause the drums to sink and thus lead to flange rot or rust and pose extreme difficulty in moving the drums.

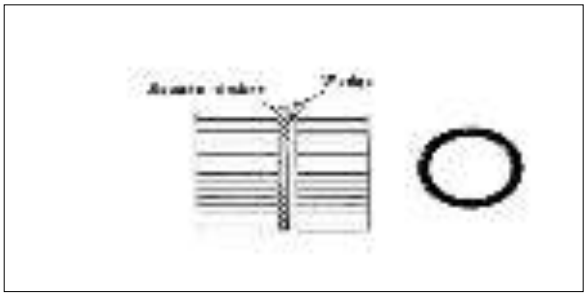


c) For outdoor storage the ground must be even and clean. Stones or bumps in the ground should be removed or smoothed out. Damage to the cable should be avoided at all costs.

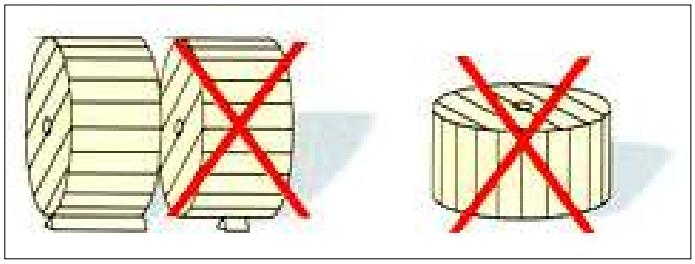
d) The arrows painted on the flange of the drum indicate the direction in which the drum should be rolled. The cable will unwind and become loose if the drum is rolled in the opposite direction.

e) Cables should be secured against accidental rolling away, by suitable wedges.

f) All drums should be stored in such a manner as to leave sufficient space between them for air circulation. It is desirable for the drums to stand on battens placed directly under the flanges. During storage, the drums should be rolled to an angle of 90^0preferably once every three months. Under no circumstances should the flange of neighbouring drums touch any cable of other drum.



g) In no case should the drums be stored 'on the flat that is, with flange horizontal. Cable drum should always be stored and transported standing on both flanges. They should not be pushed along the ground standing on the flanges. It is possible that the strength of the cable drum would then no longer be guaranteed.



h) Overhead covering is not essential unless the storage is for a very long period. The cable should, however, be protected from direct rays of the sun by leaving the battens on or by providing some form of sun shielding.

i) When for any reason, it is necessary to rewind the cable on to another drum, the barrel of the drum should have a diameter not less than that of the original drum.

j) Always uncoil the cable at a tangent, never over the flange, since torsion thus resulting would damage the cable and laying would not be possible.

k) Unloading the drum should be by forklift or crane, rolling should be avoided.

C) CABLE INSTALLATION PLAN

- On completion of laying, terminating and jointing of the cables, a plan should be prepared, which should contain the following details of the installation.
  a) Type of cables, cross-section area, rated voltage. Details of construction, cable number and drum number;
  b) Year and month of laying;
  c) Actual length between joint-to-joint or ends;
  d) Location of cables and joints in relation to certain fixed reference points, for example, buildings, hydrant, boundary stones, etc.;
  e) Name of the jointer who carried the jointing work;
  f) Date of making joint; and
  g) Results of original electrical measurements and testing on cable installation.

- **Recommended minimum bending radius of cables for fixed installations:**

a) Up to 1.1 kV grade cable:

Single core	- 15D
Multi core	- 12D

b) Above 1.1 kV to 11 kV grade cable:

Single core	- 15D
Multi core	- 15D

c) Above 11 kV to 33 kV grade cable

Single core - 20D
Multi core - 15D

Where D = overall diameter of cable.

❖ **Maximum permissible tensile Strength for cables:**

a) For cables pulled with stocking:

Armoured Cables $P = 9D^2$
Un-armoured cables $P = 5D^2$

Where, P = Pulling force in Newton
D = Outer diameter of cables in mm.

b) For cables pulled by pulling eye:

If the cables are pulled by gripping the conductor directly with pulling eye, the maximum permissible tensile stress depends on the material of the conductor and on their cross section as given below:

For Aluminium conductors : 30 N/mm^2 (approx. 3 kg/mm^2)
For Copper conductors : 50 N/mm^2 (approx. 5 kg/mm^2)

D) PRE-COMMISSIONING TESTS (TESTS AFTER INSTALLATION)

❖ Tests after installation are carried out when the installation of the cables and accessories has been completed.

❖ To check the healthiness of the cable system, following test are carried out:

a) Insulation Resistance test by megger
b) Conductor resistance test
c) Capacitance Measurement
d) **DC Voltage test of the outer sheath:**

- This test is applicable only on the cable having conductive layer over outer sheath.
- DC Voltage shall be applied between each metal sheath or metal screen and the ground. For the test to be effective, it is necessary that the ground makes good contact with the entire outer surface of the outer sheath. A conductive layer on the outer sheath can assist in this respect.
- The DC Voltage of 4 kV per millimetre of specified thickness of extruded outer sheath, maximum 10 kV, for the period of 1 minute.

e) **High Voltage test (Insulation test) :**

❖ **AC Testing (for MV cable):**

By agreement between the purchaser and the contractor, an a.c. voltage test in accordance with item i), ii) or iii) as below may be carried out-

i) Test for 15 minutes with phase-to-phase voltage U, at a frequency between 20 Hz to 300 Hz applied between the conductor and the metal screen/sheath.

ii) Test for 24 hours with the normal rated voltage U_o of the system applied between the conductor and the metal screen/sheath.

iii) Test for 15 minutes with the RMS rated voltage value of 3 U_o at a frequency of 0.1 Hz applied between the conductor and the metal screen/sheath.

❖ **DC Testing (For MV &LV cables):**

i. For MV cables, as an alternative to the a.c. test, a d.c. test voltage equal to 4 Uo may be applied for 15 minutes.

Note: A d.c. test may endanger the insulation system under test. Where possible an a.c. test as described above should be used.

ii. For LV cables, a d.c. test voltage equal to 4 Uo applied for 15 minutes.

E) MAINTENANCE OF CABLE INSTALLATION

The maintenance of cable installation includes inspection, routine checking of current loading, and maintenance of cables, joints and end terminations to be carried out-

- ❖ To avoid failure.
- ❖ To avoid environmental damage.
- ❖ To avoid more expensive maintenance later.
- ❖ To extend the life of the cable & related accessories.
- ❖ To avoid risk.
- ❖ To repair failed cables/components of accessories, if any.

Inspection

a. Whenever the cables or joints are accessible as in manholes, ducts, distribution pillars, etc., periodical inspection should be made so that timely repairs can be made before the cables or joints actually cause by interruption to service. The frequency of inspection should be determined by customer from its own experience.

Important: heavily loaded lines will require more frequent attention than less loaded lines.

b. Cables laid direct in the ground are not accessible for routine inspection, but such cables are often exposed when the ground is excavated by other public utilities for installing or repairing their own properties. Preventive maintenance in the form of regular inspection of all digging operations by other utilities or persons, carried out in areas where electric cables exist is of utmost importance.

c. In a city where the roads are congested with services of other utilities, the likelihood of damage to electric cables is very high. Cable inspectors should patrol the various sections of the city and where it is found that cables are exposed, these should be examined thoroughly for any signs of damage; such as deformation or dents in the cable or damage to earthenware troughs or ducts.

Checking of Current Loading

- The life of cables is considerably reduced through overloading. It is, therefore, essential to check the loads as frequently as possible to ensure that the cables are not loaded beyond the safe current-carrying capacities. The de-rating factors due to grouping of several cables, higher ambient ground temperature and higher thermal resistivity of soil, should not be neglected.

- In the case of HV feeder cables emanating from generating station, receiving station; or sub-station, panel-mounted ammeters which are usually provided, should be read daily. In the case of medium voltage distribution cables emanating from distribution pillars, the loads are conveniently checked by 'clip-on' type portable ammeters. Distributor loads should be checked at intervals not exceeding three months.

Maintenance of cables

- Repairs of cables generally involve replacement of a section of the defective cable by a length of new cable and insertion of two straight joints. All repairs and new joints in connection with repairs should be made in the same manner as joints on new cables. In some cases where the insulation has not been damaged severely, or where moisture has not ingress into the insulation, it may only be necessary to install a joint at the point of cable failure.

- When cables are exposed during the work of other public bodies and such cables are required to be temporarily supported until the work is completed, the overhanging length of the cable should be well supported either by means of temporary piers erected below the cable at short intervals or by lashing the cable to a wooden plank laid below it and supported by further lashings at short intervals to a wooden beam placed above the trench parallel to the cable. Particular attention should be given to joints, as the slightest tension may result in the pulling out of the conductors at the ferrules in the joints.

- If the depth of the excavation carried out by another public body below the cable is considerable, it is necessary to build a permanent masonry support below the cable before filling in the trench. This eliminates the possibility of the cable sinking due to subsidence of the backfilling as it gradually consolidates. On completion of the work, the original

protection covers should be carefully replaced over a bedding of soft earth and the trench filled in.

F) CONDITION MONITORING OF CABLE

Conditions based maintenance or predictive maintenance are to be carried out-

- Performance of conditions assessment on a cable or accessory, followed by adequate action to avoid failure in service.
- Plan is based on measuring the condition of equipment in order to assess whether it will fail subsequently, and then take appropriate action to avoid the consequences.

Plan of Action

- **Visual inspection:** Visual Inspection shall be carried out as routine or at scheduled intervals.
- **Common Test Methods:**
  - Sheath Testing
  - Inspection of cable (In cable tunnels or in Air)
  - Inspection of Terminations
  - Inspection of fire alarm systems
  - Temperature monitoring of cable circuits
  - Earth resistance Measurement
- **Electrical tests:**
  - Insulation Resistance (Volume resistivity).
  - Polarization Index test
  - Capacitance Measurement
  - Conductor resistance Measurement
  - Metallic sheath resistance measurement

Possibility of cable failure

- Damage by third party
- Damage due to brittleness of outer sheath
- Ingress of water in the insulation
- External mechanical stress, thermal stress, improper clamping / mounting
- Improper preparation of joints & terminations
- Movement of cable due to thermal cycling
- Improper laying of cables, cable damage while cable laying

G) FAULT LOCALIZATION OF CABLE

- In order to restore supply at the earliest possible movement after the occurrence of a fault, it is essential to proceed with the fault localization in a systematic manner so that no time may be wasted by using unsuitable tests or carrying out unnecessary excavation work.

- The first step is to isolate the faulty cable, as far as possible, by opening any links or section switches, and thus reducing the length on test to a maximum. The faulty length of cable having been isolated, any exposed sealing ends or other insulators should be cleaned, and insulation resistance tests and conductor resistance tests made described under analysis of fault.

- Excavation is usually carried out at the located position and also at the nearest joint to this. While excavation is proceeding, the calculations may be checked and the test may be repeated from other end of the cable. If possible, location should be checked by another independent test. If equipment is available to carry out the induction test or capacitor discharge test; the fault location can be pin-pointed in many cases.

- If the ground is opened and the cable is exposed for about 4.5 or 9 m on either side of the located position without any signs of the breakdown being seen, the most usual method is to break open the joint nearest to the located position and reset from the joint position.

- It occasionally happens that there are no external signs of failure, the sheath and armour being undamaged. If second test made after the joint has been opened indicates the same position as the first this is probably the correct position.

- The majority of failures are caused by mechanical damage, and an inspection of the route near the suspected position may often show that the ground has been opened for laying cables, pipes, etc. or that a gate post has been put up above the cable.

Preventative Fault Check:

- Regular check of proper earthing and earth connections.
- Excessive loop jumbled at one place specially in LT cables to be eliminated and dressed up properly.
- Dust/cement/chemical accumulation on terminations specially in motor terminal boxes to be cleaned regularly.
- Regular checks of cables that are installed on cable tray that are running along with other utility pipelines such as steam, gas, hot Slurries etc. for leakage from the latter that might be striking the cables.
- Thermograph of high loaded cables for hot spots.
- Ensure proper support and clamping for vertical portions of laid cables

Analysis of fault:

- The exact nature of the fault can be ascertained by taking the following tests which may be made with an insulation testing set and a Wheatstone bridge or a resistance tester of the bridge type. If none of the cores is likely to be burnt through or broken, tests (a) and (b) given below may be made and the conductor resistance tests limited to the cores actually used during the location.
  (a) Measure insulation resistance between each core and earth with the far end of the cable open and free from earth;
  (b) Measure insulation resistance between cores with the far end of the cable as given in (a); and
  (c) Measure conductor resistance of each pair of conductors with all conductors connected together and free from earth at far end of line, and compare with the calculated resistance.

Typical Type of failure of Cables:

- Shorted conductor
- Open conductor
- Joint failure

Classification of Fault Localization tests:

The fault localization tests may be classified as follows:

- Identification of faulty cable:
  a) Continuity testing
  b) Insulation resistance Test
  c) DC Voltage test on insulation
- Fault resistance & direct loop test
- Murray loop test
- Cable fault pin pointing

Procedure of fault location tests are covered in IS: 1255-Code of Practice for Installation and maintenance of power cables up to and including 33 kV rating.

H) REFERENCES

IS: 1255
IEC 60502-1 & IEC 60502-2
IEC 60229

UNIVERSAL CABLES LIMITED
Regd. Office:
Power Cable and Capacitior Plant:
P.O. Birla Vikas,
Satna - 485 005, (Madhya Pradesh), India
P: +91 7672 257121 to 27, 414000
F: +91 7672 257129/257131
E: sales@unistar.co.in
CIN: L31300MP1945PLC001114
W: www.unistar.co.in

GOA
Optical Fiber Plant and
Light Duty Wires & Cables Plant:
Plot No. L-64A,
Verna Industrial Estate,
Verna, Salcette,
Goa – 403 722, India
T: +91 832 6696483 / 6696400
F: +91 832 2782614 / 6696414
E: goa@unistar.co.in

CHENNAI
G.R.Tower, 2nd Floor,
136, Nelson Manickam Road, Aminjikarai,
Chennai - 600 029 (Tamil Nadu)
T: +91 44 23746623, 23746624
F: +91 44 23746625
E: chennai@unistar.co.in

ALLAHABAD
B-30, Ekanki Kunj Colony,
24, Muir Road,
Allahabad - 211 001 (Uttar Pradesh)
T: +91 532 2423646, 2423132
F: +91 532 2423132
E: allahabad@unistar.co.in

HYDERABAD
603/1, 6th Floor,
Block-1,White House,
Municipal No.6-3-1192/1/603/1,
Kundanbagh, Begumpet
Hyderabad - 500 016 (Telangana)
T:+91-40-23408218
F:+91-40 23403272
E: hyderabad@unistar.co.in

BENGALURU
287,15th Main,
RMV Extension, Sadashivnagar,
Nr. Nagasena School,
Bengaluru - 560 080 (Karnataka)
T: +91 80 23612484
F: +91 80 23619981
E: bangalore@unistar.co.in

KOLKATA
27-B, Camac Street, 5th Floor,
Kolkata - 700 016 (West Bengal)
T: +91 33 22805043 - 44, 22801192, 22871302
F: +91 33 22805046
E: kolkata@unistar.co.in

BARODA
"Satyam", 1st Floor,
Opp. State Bank of India,
Fatehgunj,
Vadodara - 390 002 (Gujrat)
T: + 91 265 2791794, 2795642
F: + 91 265 2793128
E: baroda@unistar.co.in

MUMBAI
Industry House,
159, Churchgate Reclamation,
Mumbai - 400 020
T: +91 22 444 222 00
F: +91 22 22027854
E: mumbai.sales@unistar.co.in

BHOPAL
S-592, Nehru Nagar,
Bhopal - 462 003 (Madhya Pradesh)
T: + 91 755 4284170
E: bhopal@unistar.co.in

NEW DELHI
2nd Floor, Wing-B, Commercial Plaza,
Radisson Hotel, NH 8,
Mahipalpur,
New Delhi - 110 037
T: +91 11 45538800
F: +91 11 26779038
E: delhi@unistar.co.in