Appendix - C

GUIDELINES FOR OPGW CABLE LIVE-LINE INSTALLATION

1.General

Installation procedure for OPGW is basically similar to that for conventional overhead ground wires in overhead transmission line construction, however particular care required to be taken for protection of optical fibers in OPGW cable from damage by handling the same properly during transportation, unloading and installation at site. Live line installation to be carried out using traction machines and support rollers (hanging pully blocks) using experienced installation team comprising of minimum 30-35 persons. The installation team shall have one team leader/crew in-charge along with 15 skilled and 14 unskilled persons minimum in one installation crew.

List of Tools and Plants to be used are as per enclosed Annexure.

Following aspects are to be kept in mind before taking up live-line installation:

a)Condition of existing ground wire for its suitability for live-line OPGW installation b)Tools and Plant suitability
c)Weather Forecast for upto next 03 days to be considered before deployment/start of work in any section in consultation with POWERGRID Project Manager.

d)Working conditions, specially following:

- Strong winds more than 7 m/sec
- Rain or snow
- Foggy
- Lightening

e) These guidelines for live line installation along with checklist enclosed at Annexure-II to be provided in local language to the erection team.

f) Pep talk snapshots & photos of erection team is to be shared with POWERGRID site as a regular practice.

g) Team deployed for live line installation should have relevant experience of same or higher voltage level. Contractor to ensure the same.

2. Safety measures

All site workers must follow the Electricity Rules and Employer specified safety procedures. They must use safety belts, safety shoe, safety helmet and other safety items required.

Assign foremen/Crew In-charge for each erection crew for enforcing installation guidelines. It may be ensured that only authorized person is climbing the tower during live-line installation of OPGW. Fix the warning red flag on the tower, in order to keep the workers from encroaching into unsafe zones.

Frequent verification of healthiness of T&P and ropes shall be carried out before start of work.

2.1 **Permission to Work (PTW) :**

Permit to work to be obtained by the representative of installation agency from concerned sub-station staff in coordination with employer project manager prior to commencement of installation and the same is to be returned after completion of the work in all respect within the specified time duly following the PTW conditions.

2.2 Preparedness to tackle untoward incidents:

a) Safety Engineer <u>has</u> to make sure the availability of First Aid Box with each team.

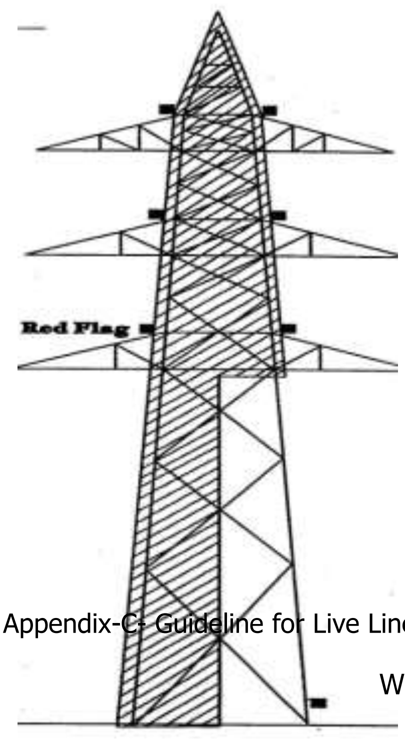
b) Maintain a record of the details of list of all nearby hospitals/clinics in each area, with contact details and Emergency contact nos. of Ambulances.

c) In case of any untoward situation, Safety engineer/crew incharge must act fast and provide the necessary first aid to the affected person(s). Ambulance to be arranged immediately from the nearby area and coordinate with hospital for immediate medical assistance as required.

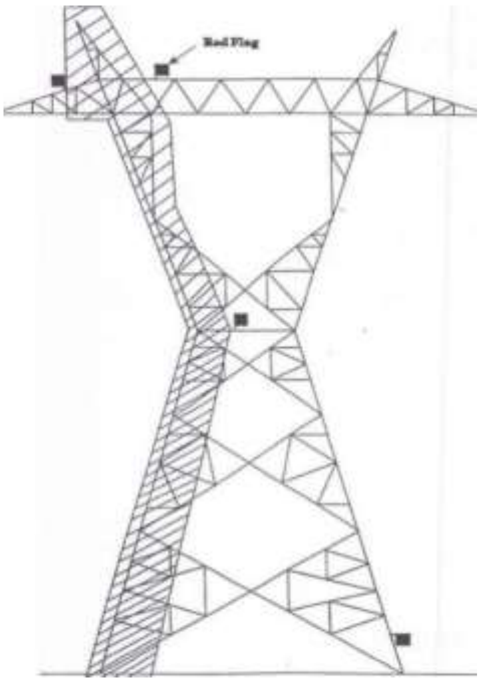
2.3 Marking of Zones during OPGW Stringing:

It is very essential for the installation agency to be aware of safe zones of the Tower while carrying out live-line installation. Generally crew members identified for preparation work on the ground, will not work on the tower and will remain within hazard-free zone.

The pictorial view of the working zone and limitation of the restricted zone are shown below for your convenience.



Working Area



Working Area

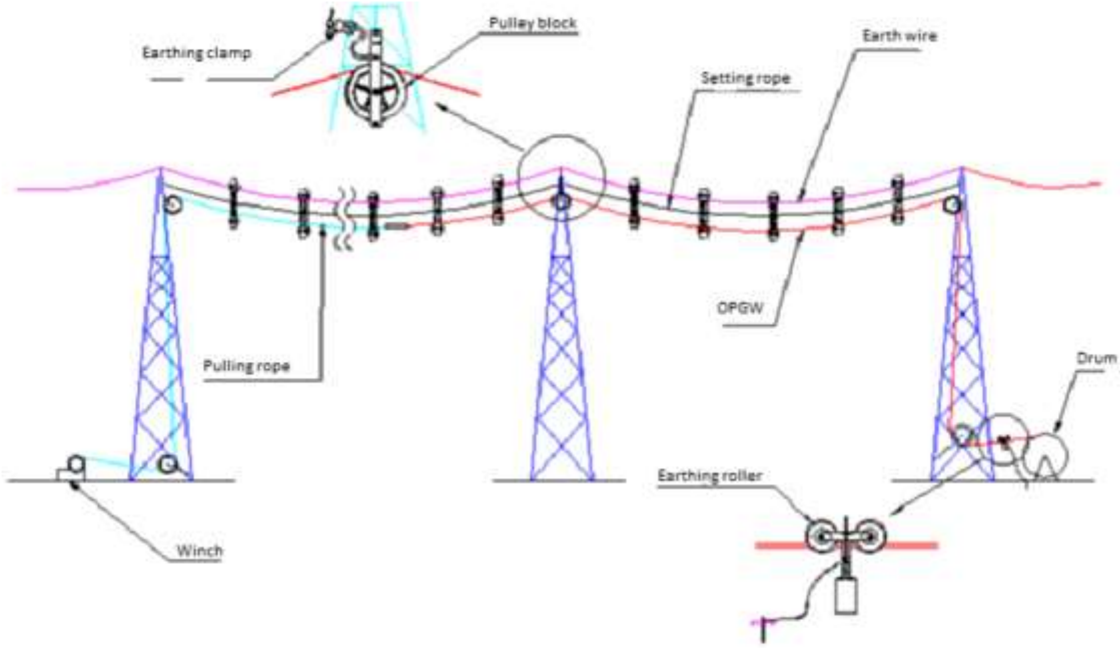
3. Grounding

Grounding of the following before starting work at site is required to be ensured. Grounding devices include the following:

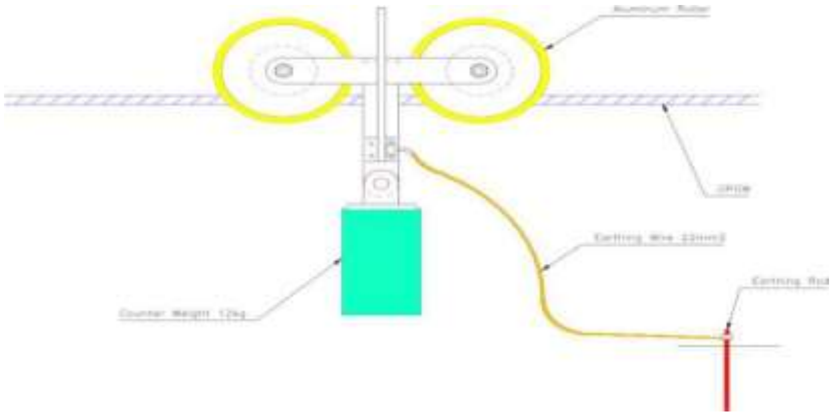
3.1 **Equipment Grounding:**

Equipment like OPGW and Existing Ground wire (GW), aerial rollers(pulley blocks) are connected with individual copper cable attached to the tower (with copper rod installed on the ground) or to the main grid if grounding system exists. Grounding clamp shall be cleaned well and ensure proper contact.

3.2 **Running Ground:**

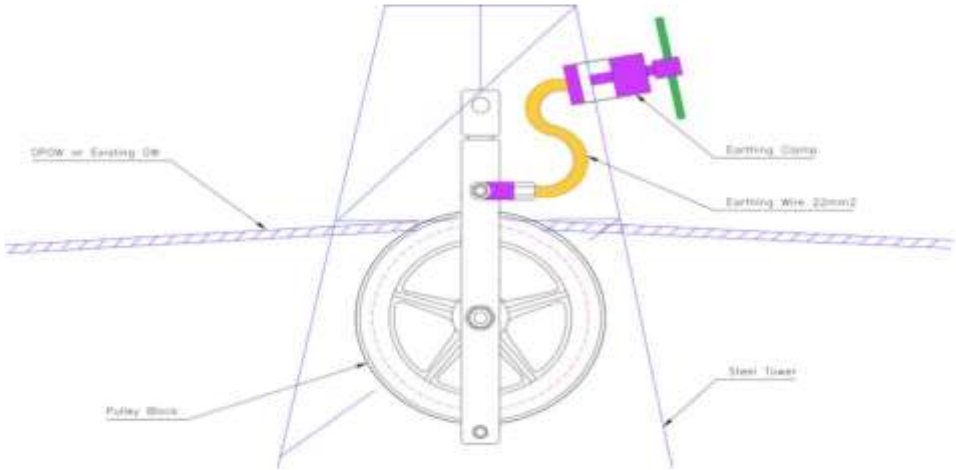


Running ground shall be installed on the OPGW at drum side during OPGW stringing time and at the Winch side on the existing GW during dismantling time for the whole stringing operation to avoid any electrical charges of induction from the line.



3.3 **Pulley Block Grounding:**

For each tower grounding type pulley block must be used.



Grounding cable must be connected to the ground source first then to the object that needed to be grounded.

When removing grounds, the ground must be removed from the grounded objects first and then remove the grounding clamp from the ground source.

In case of any problems during the installation work, the person in charge of the section will immediately contact sub-station in charge of the line and employer Project Manager immediately for required support.

Further , in order to have proper earthing, one aluminum roller (hanging pulley block) shall be used for additional safety after every ten rollers (neoprene) used in the span/section.

4. Live-line Installation Process

4.1 Installation plan:

Following measures are to be taken in advance for smooth completion of the installation.

PTW availability and coordination with employer project manager

- Erection crew mobilization along with T&Ps
- Safety aspects
- Field quality aspects
- Transportation arrangement

4.2 Materials handling:

Check the material with respect to the approved documentation. All materials shall be visually examined for any physical damage. Any material, which is not as per documentation or is damaged, shall not be used.

OPGW Drums checks:

- •Packing condition
- •Packing list (Object, Type, Length, OPGW Weight, Drum No. etc)
- •Attenuation results of OPGW

Hardware Fittings Checks:

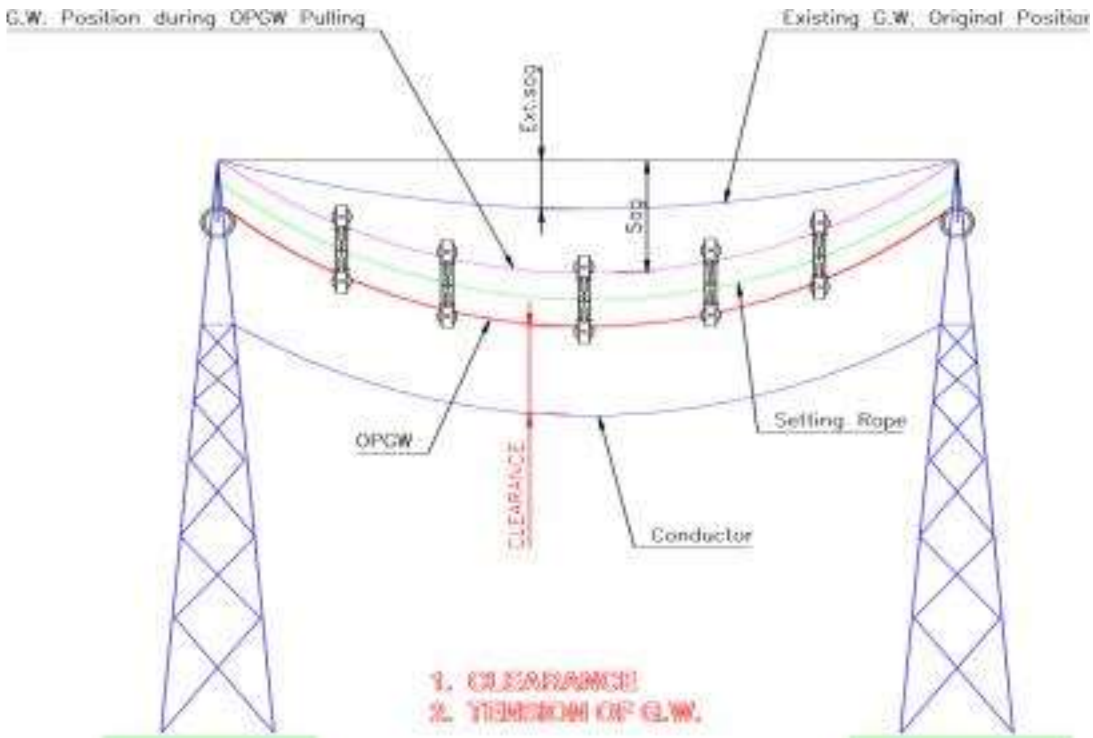
- •Bolts, Nuts Pitch
- •Type & Quantity

Handling of OPGW:

OPGW contains optical fibers which are very delicate and to be handled with due care. For the safety of optical fibers, it is very important to avoid the bending at sharp angle. Manufacturer guidelines are to be followed strictly while handling the same. In order to avoid undue tension on OPGW, it is not recommended to pay off OPGW together with phase conductors or other wires tied in parallel. The tension during stringing works should be well managed within permissible limits. Adequate length of OPGW shall be ensured as loop at each joint location after stringing so that it is possible to bring OPGW up to the ground level for carrying out jointing work.

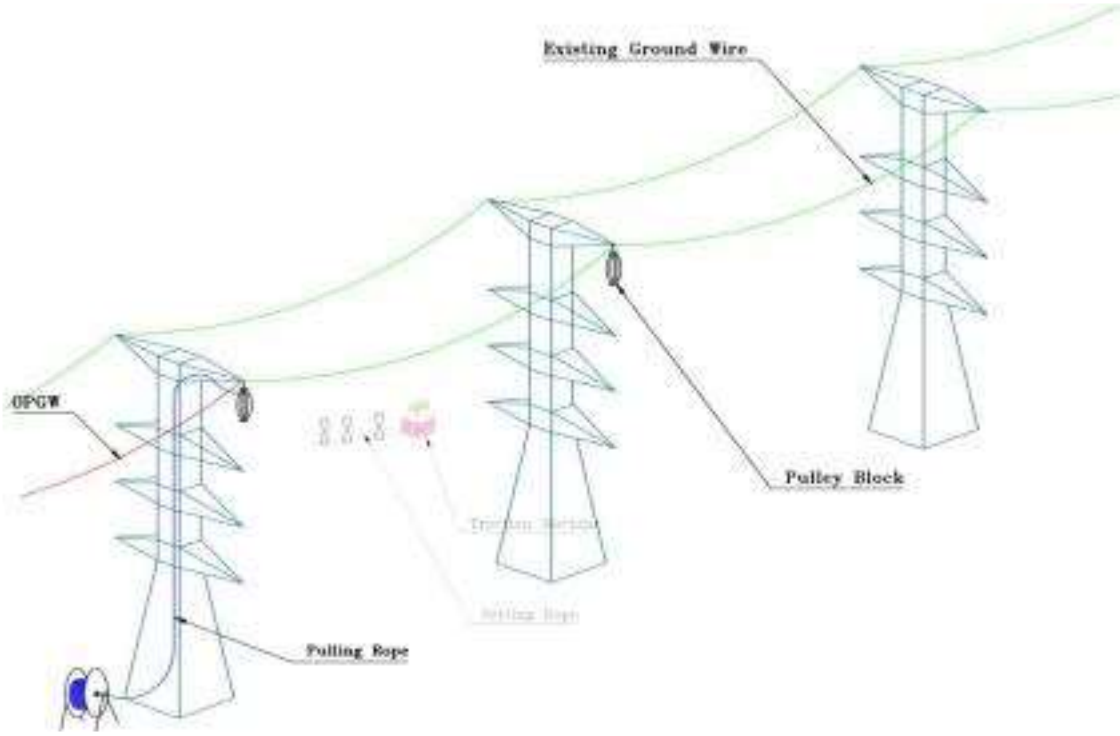
5. Clearance Checking

5.1 Check the clearance between existing ground-wire and live conductor before Stringing. Check the clearance between OPGW and live conductor. Minimum clearances as per as per pre-commissioning procedures for transmission lines is mentioned at **Annexure-III**.


G.W. Position during OPGW Pulling
Existing G.W. Original Positio
Ext.sag
Sag
OPGW
CLEARANCE
Setting Rope
Conductor
1. CLEARANCE
2. TENSION OF G.W.

6. OPGW Stringing

- Removal of Aviation globules in the spans (wherever applicable) by taking proper shutdown.
- Hang the pulley blocks on one of the earth wire peaks for the whole section (Section is a consecutive group of towers needed to support the installation of scheduled length of OPGW Drum)



- Set the Traction machine on the existing ground wire.
- Set the support rollers (hanging pulley blocks) on the existing ground wire where the OPGW is to be installed.
- Connect the Setting Rope and Pulling Rope to theTraction Machine.
- Pull the support rollers(hanging pulley blocks), Setting Rope and Pulling Rope with the use of Traction Machine. Support rollers (Hanging Pulley blocks) should be hanged at an interval depending on voltage level, which is mentioned below. (A markwith these specified interval shall be marked on setting rope)
-

Sl.no	Voltage level	Spacing
1	220kV	18-22m
2	400kV	15-18m
3	765kV	10-12m

•For every ten support rollers (hanging pulley blocks) of neoprene used in the span/section, one aluminum roller (hanging pulley block) shall be used.

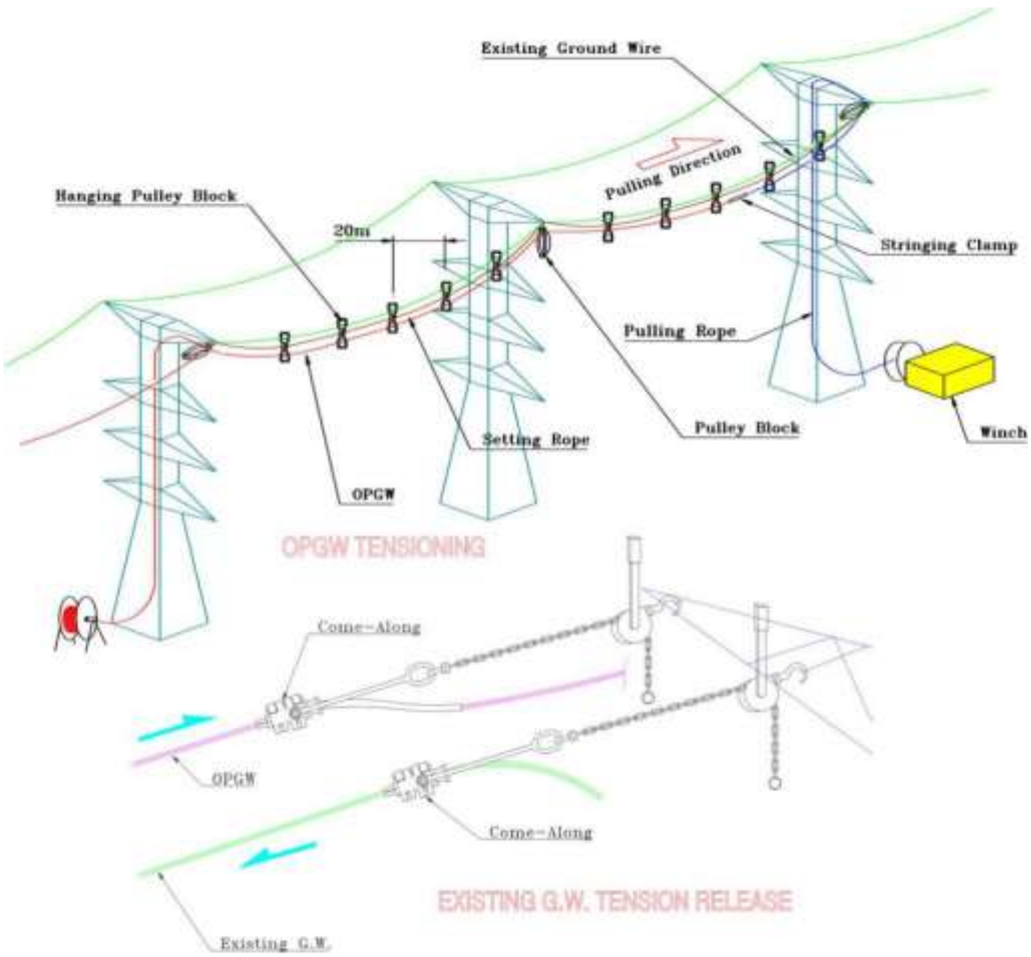
•Securing the pulling & setting rope at end towers of the stringing section.

•Connect the OPGW to the Pulling Rope with Stringing Clamp.

•Pull the Pulling Rope with the use of winch machine to pay out the OPGW.

•Set the Come-along and Lever Block to the existing ground wire.

•Release the tension of existing ground wire. At the same time, with a fixed come-along and Lever Block, give more tension to the OPGW.



• Position of OPGW and existing ground wire will interchange with above action. The OPGW will be in upper position and existing ground wire in lower position in support rollers (hanging pulley blocks).

•With this OPGW paying for a section gets completed.

•Finally after successful stringing of OPGW and dismantling of Earthwire alongwith all ropes, support rollers etc., proper shutdown may be taken to install aviation globules back in the respective spans. The installing agency to ensure healthiness of all ropes and T&Ps used for the stringing work.

Additional suggestive measures:

(a) Loosening of earth wire to be avoided.

(b) Cradle blocks of Aluminum type to be preferably used in 765kV lines as per placement recommended in the guidelines.

Special Provisions in case of inclement weather:

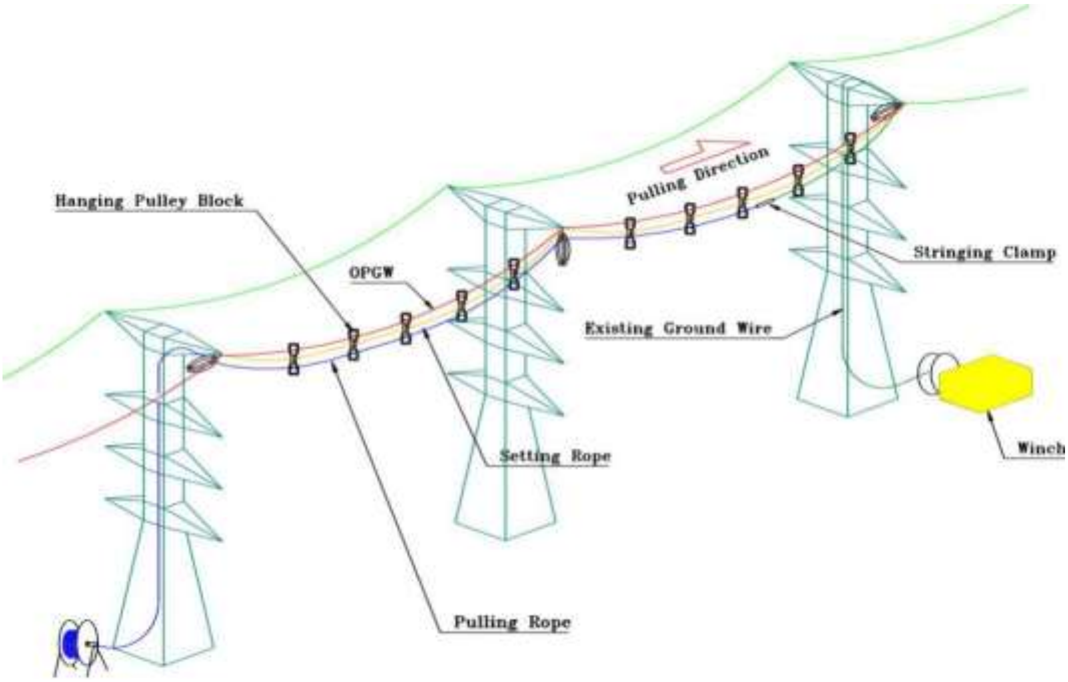
In case of sudden change in weather/possibility of rain, fog, storm etc coming to notice during stringing, the contractor may explore feasibility of pulling OPGW in possible sections and removal of pulleys/ropes etc from balance sections of drum. Use of approved Tension fitting (pass through) for Suspension tower (Yoke plate) for tension clamping of OPGW as an interim arrangement may be explored. This aspect may be used to facilitate removal of pulleys and ropes from all sections to avoid tripping of lines occurring in bad weather. This provision may be explored to limit the exposure of T&Ps/ropes/pulleys used in Live Line OPGW stringing during such bad weather to live line. This is to be done in consultation with Project Manager. This does not limits the contracting agencies from taking measures to avoid trippings of line and ensuring safety of their personnel.

7. Dismantling process

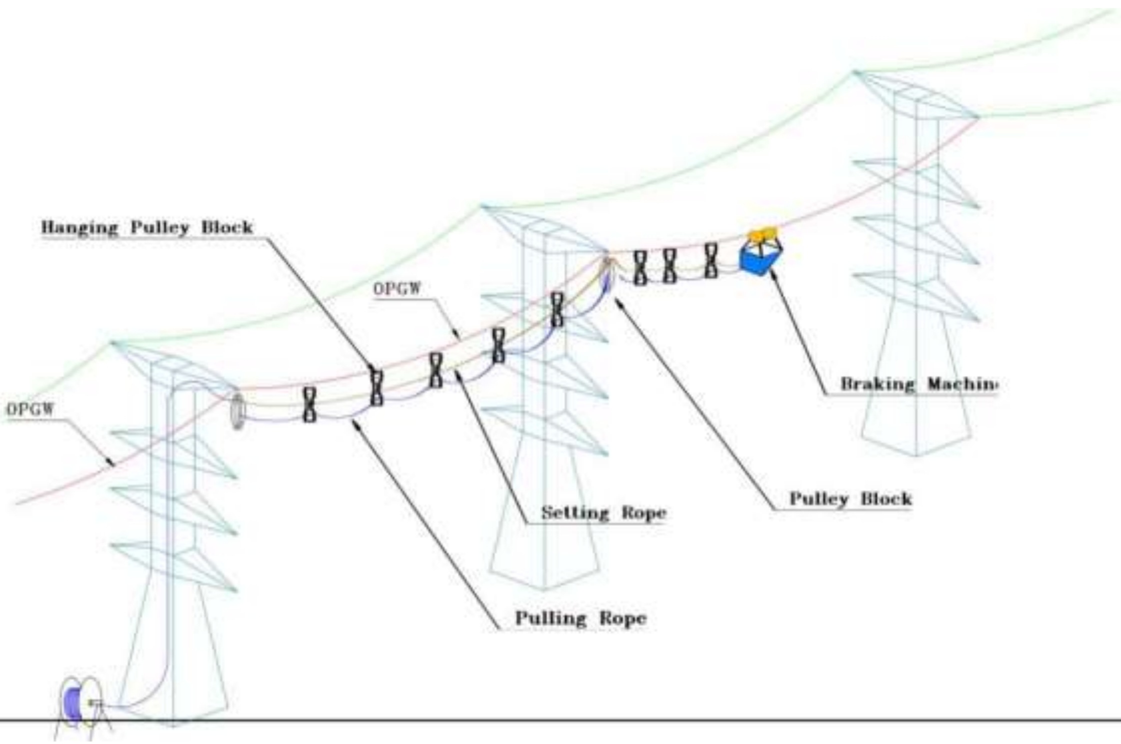
7.1 Existing ground wire:

•Connect the existing ground wire with the Pulling Rope.

•Pull the Pulling Rope with winch to dismantle the ground wire.



7.2 Hanging Pulley Block, Setting Rope and Pulling Rope:



- Set the Breaking Machine on the OPGW of the span required for dismantling.
- Connect the Pulling Rope and Setting Rope to the Braking Machine.
- Pull the Setting Rope and Pulling Rope to dismantle.

Collect and dismantle the support rollers (hanging pulley blocks) upon reaching the succeeding tower.

8. OPGW sagging

- Use the pre-calculated Sag & Tension Table as sag reference.
- Avoid fixing the sag if the wind is strong.

8.1 Sagging:

1) Methods and procedures for sagging of OPGW are the same as those of normal overhead ground wire.

2) After stringing the OPGW shall be sagged using information furnished on the sag and tension chart. The sag of the OPGW should not exceed the existing ground-wire sag.

3) Sagging thermometers shall be used to determine accurate temperature and OPGW sag of each sag section. Sagging thermometer shall be used sufficiently prior to the actual sagging operation to represent the temperature of the OPGW.

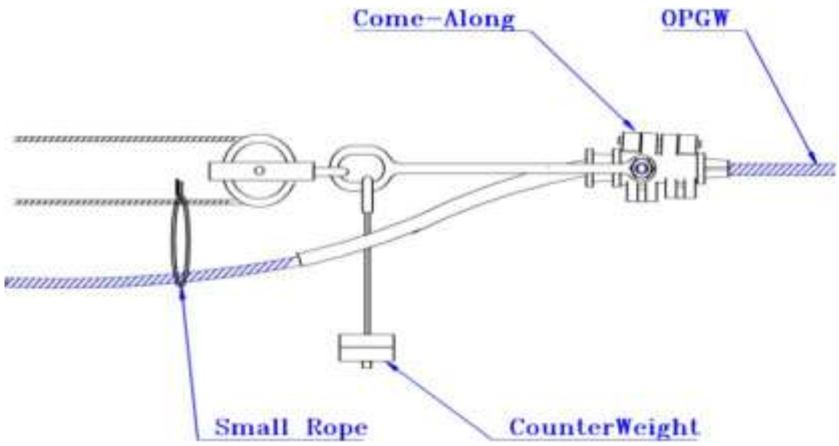
5) At the time of sagging OPGW, the sag should be within 6 inches of the theoretical value for existing temperature condition.

7) OPGW tension between each sag section shall be equalized and this shall be determined by the vertical position of the suspension clamps on the last clipped structure of the preceding sag section.

8) For pulling the OPGW with tension, the device of come-along is to be recommended.

9) Personnel should be specifically deployed for keeping watch on sag at a different section of the line during live line stringing.

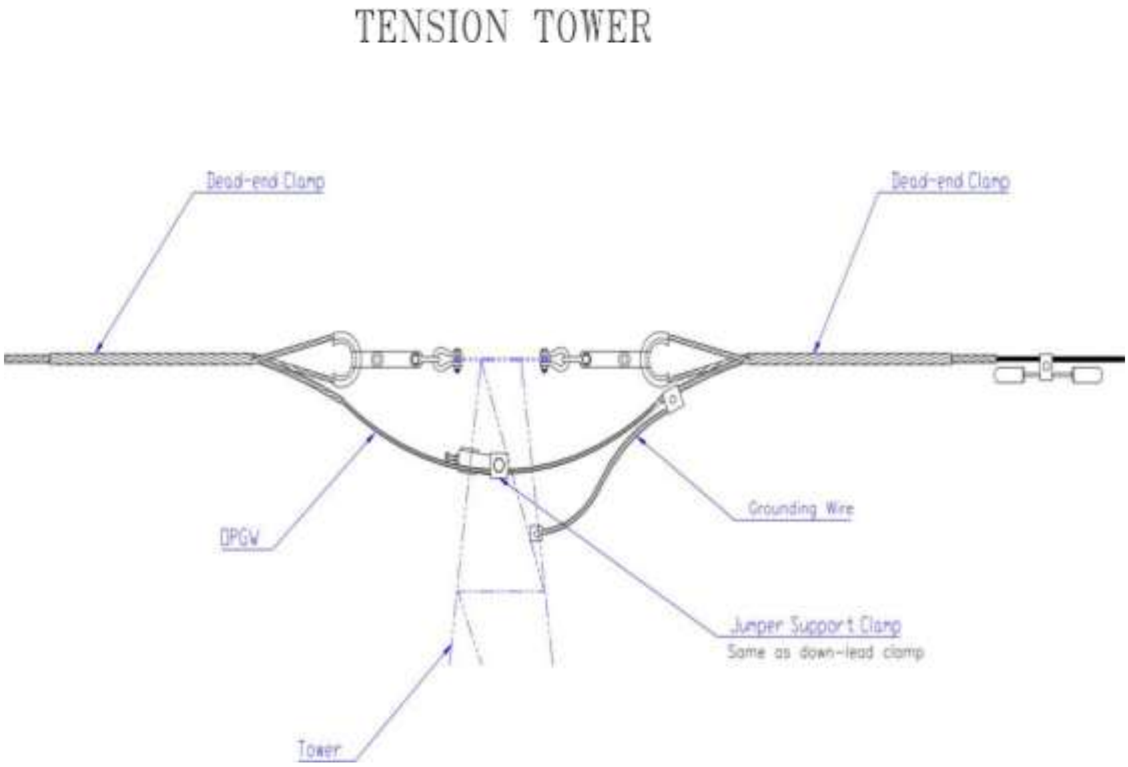
10) Waterproof caps shall be fixed at both ends of the OPGW cable after installation.



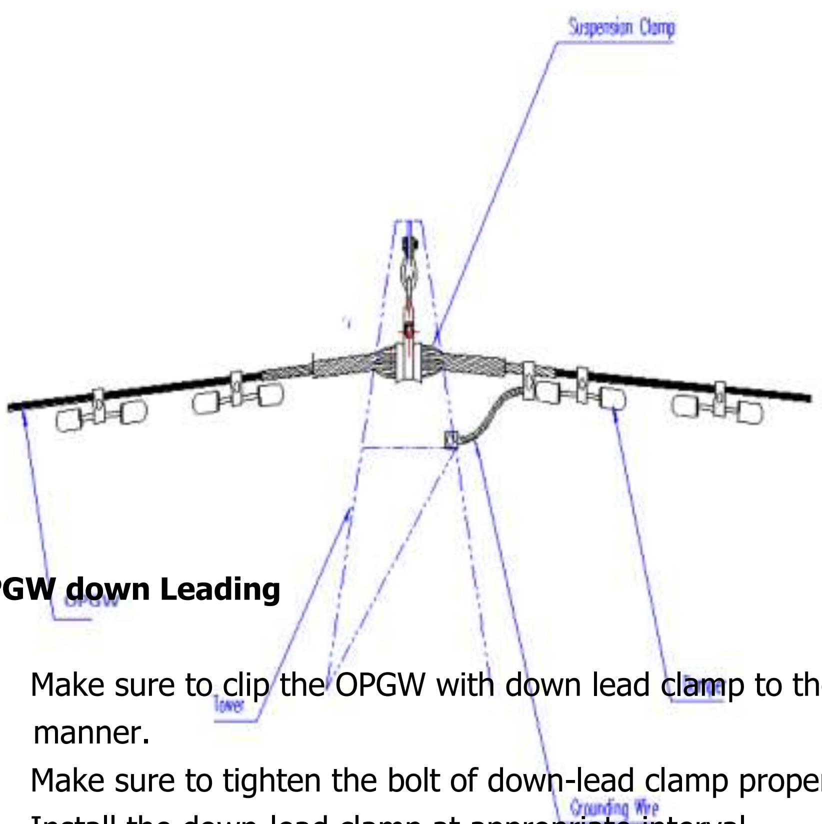
9. OPGW Clamping

9.1 Make sure to install and tighten the bolt of clamp properly.

9.2 Tightening must be made sequentially from the support point.



SUSPENSION TOWER



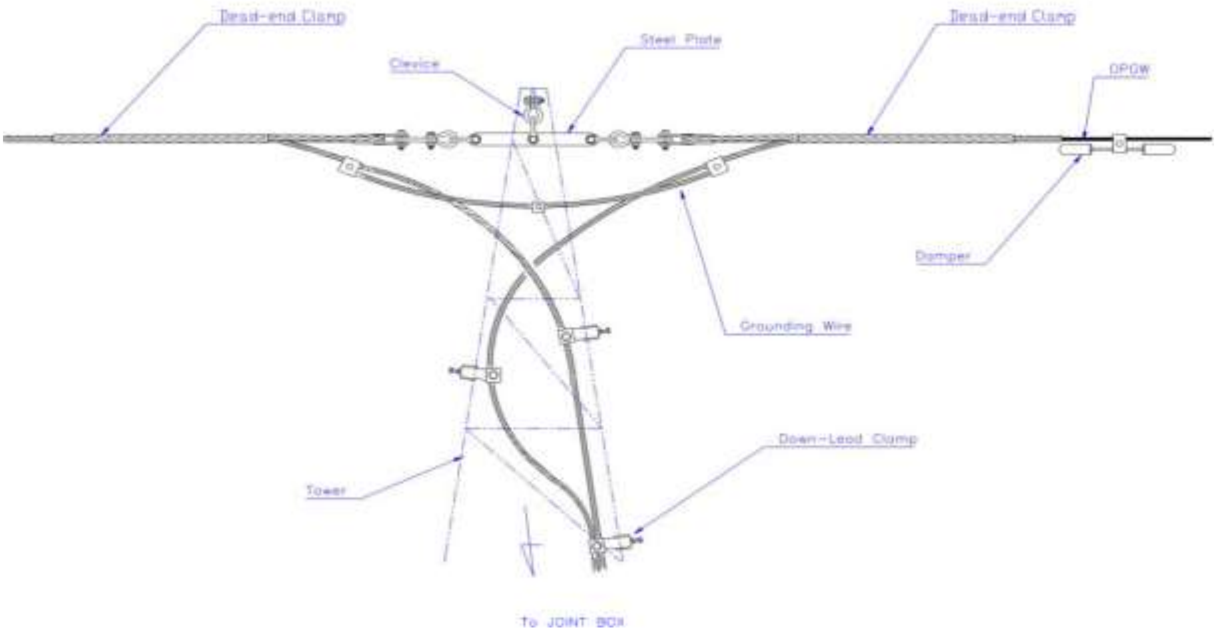
10. OPGW down Leading

10.1 Make sure to clip the OPGW with down lead clamp to the tower in a careful manner.

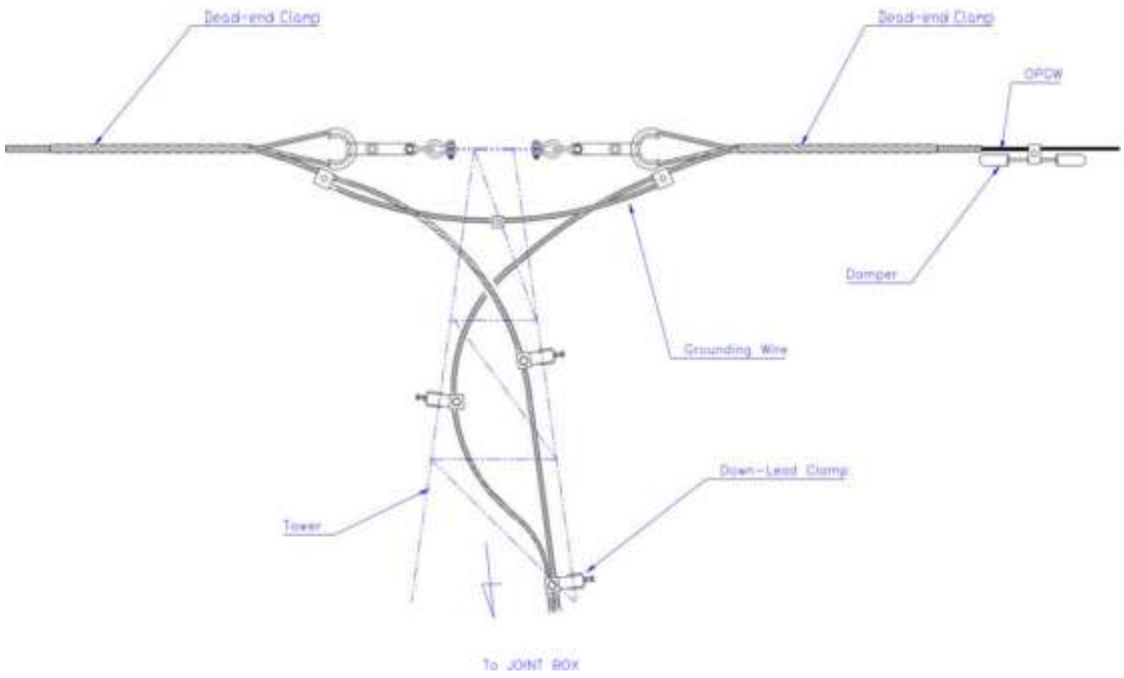
10.2 Make sure to tighten the bolt of down-lead clamp properly.

10.3 Install the down-lead clamp at appropriate interval .

SUSPENSION TOWER FOR JOINTING TOWER



TENSION TOWER OF JOINTING TOWER



Annexure-1

List of Tools:

S. No	Description	Specifications
01	Aerial Roller/Pulley Block (Aluminum)	300 mm
02	Aerial Roller/Pulley Block (Aluminum)	450 mm
03	Aerial Roller/Pulley Block (Aluminum)	600 mm
04	Setting rope	12 mm PP rope Rope
05	Pulling Rope	(i)For Preparation: a) 12mm PP Rope Rope (for 400kv and above); b) 12mm Nylon rope(for 220kV & below) (ii)For OPGW Pulling: 14mm Nylon rope
06	Lifting/Supporting Rope	12mm PP rope
07	Earthing roller	3-way roller
08	Traction machine	35 kgf
09	Winch machine	3 tons
10	Drum stand	
11	Wheel winder	
12	Come along clamp	
13	Kitto clamp	
14	D-shackle	
15	Sag-scope	
16	Support Rollers (Hanging Pulley block)	
17	Aluminium Roller (Aluminium Hanging Pulley Block)	
18	Earthing Lead	
19	Braking Machine	

Annexure-II Check List for OPGW stringing work (Frequency-Daily)

SL No	Check Point	Remarks
Before Start of Work		
1.	PTW is available	Yes/No
2.	Awareness among working gang on live-line installation procedure	Yes/No
3.	All Tool and plants are duly tested and certificates are available including healthiness of ropes.	Yes/No
4.	Weather condition is good i.e. No heavy wind/Lightning/Fog/rain/snow etc.	Yes/No
5.	First aid box is available	Yes/No
6.	Contact details of nearby Hospital is available	Yes/No
7.	Pep talk about OPGW stringing and safety requirement given	Yes/No
8.	Tower climbing persons certified for height work	Yes/No
9.	There is no aviation globule in the EW *(Note: aviation globule exist shutdown to be taken for its removal before hotline stringing. Similarly, after installation OPGW shutdown need to be taken for installation of aviation globule)*	Yes/No
10.	OPGW drum schedule is available	Yes/No
11.	There shouldn't be any uneven joint/twist/broken strands in the earth wire between stringing span.	Ensured/Not ensured
12.	Tower Footing Resistance(TFR) check as per Asset Management norms of POWERGRID. (In case of poor TFR, to be intimated to POWERGRID)	Ensure/Not Ensured
During Work		
1.	Clearance of EW to Top conductor is adequate i.e. 9 meters (for 400kV and 765 kV system),8.5 meter for 220kV system	Ok/Not OK
2.	Running ground is installed on the OPGW at drum side during stringing (To neutralize the induction effect during stringing)	Yes/No
3.	Tension during stringing is within limit to avoid breakage of OPGW/PP rope	Ensured/Not ensured
4.	Support rollers (hanging pulley blocks) should be hanged at an interval of 18-22 meter for 220kV level,15-18 meter in 400kV level and 10-12 meter for 765kV Level	Ensured/Not ensured
5.	For every ten support rollers of neoprene one aluminum roller shall be used	Yes/No
6.	Pulling and setting rope is secured at the end of Tower of stringing section.	Ensured/Not ensured
7.	Sag of OPGW is equal to existing EW sag (it shouldn't be more than that)	Ensured/Not ensured
8.	Proper clamping of down lead clamp at appropriate interval is done at the jointing Tower (either Suspension/tension)	Ensured/Not ensured
9.	Healthiness of ropes	Ensured/Not ensured
After completion of stringing work/each day target		
1.	There should not be any loose PP rope in the stringing span after completion of each day work. It should be tightened properly.	Ensured/Not ensured

2.	After final stringing Mid span clearance is adequate i.e. 9 meters (for 400kV and 765 kV system),8.5 meter for 220kV system (Actual value needs to be recorded for future purpose)	Ensured/Not ensured

Annexure-III MINIMUM CLEARANCES AS PER PRE-COMMISSIONING PROCEDURES FOR TRANSMISSION LINES

Electrical Clearance

All statutory electrical clearance of transmission lines w.r.t. ground, building, Structures, Power line crossings, River crossing, Railway & Road crossings etc. as stipulated under latest version of Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations & POWERGRID specification shall be ensured.

Minimum Ground clearance shall be as per clause 58.0 of Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010.

The ground profile at the time of commissioning shall be checked with the profile approved at the time of check survey.

Sag in one of the span in each section shall be measured and it should be ensured that sag & tension of the section is in line with specification and sag & tension calculation chart approved by Engg.

Ground clearance of lowest conductors at critical points shall be checked in the field from any of the prevalent method and the values of ground clearance at these critical points including all power line, railway line and road crossings shall be recorded in the prescribed format.

In case of hilly Terrain and for building clearance, the side clearance from conductors and jumpers at critical points shall also be checked and recorded for all phases of conductor/ earth wire/ OPGW towards hill building side.

Transmission voltage (in kV)	**66**	**132**	**220**	**± 320 HVDC**	**400**	**765**	**± 500 HVDC**	**± 800 HVDC**	**1200**
Minimum Ground Clearance (in meter)	5.5	6.1	7.015	8.5	8.84	18	12.5	18	24

Clearance of earth wire/OPGW with Top conductor at mid span to Top conductor

Availability of required vertical clearances (as per design & POWERGRID Specification) between conductor and earth wire/OPGW shall be ensured through random checking. Minimum clearances between conductor and earth wire/OPGW at mid-span shall be as indicated:

Voltage (kV)	66	132	220	+/- 320 HVDC	40 0	+/- 500 HVDC	765	+/- 800 HVDC	1200
Minimum mid span clearance (in meter)	3	6.1	8.5	8.5	9	9	9	12(pole) 6.1(DMR)	18

Record of such random checks shall be the part of pre-commissioning records.

Clearance between line crossings each other, the minimum clearances between the Power line crossing each other shall be as per clause no 69.0, part-III, Sec-4 of CEA's Regulations 2010 (Measures relating to Safety and Electric Supply)

Where an overhead line crosses another overhead line, clearances shall be as under:

(Minimum clearances in meters between AC lines crossing each other)

Sl. No.	**Nominal System Voltage (kV)**	**11-66**	**110-132**	**220**	**400**	**765**	**1200**
1.	**Low and Medium**	2.44	3.05	4.58	5.49	7.94	10.44
2.	**11-66**	2.44	3.05	4.58	5.49	7.94	10.44
3.	**110-132**	3.05	3.05	4.58	5.49	7.94	10.44
4.	**220**	4.58	4.58	4.58	5.49	7.94	10.44
5.	**400**	5.49	5.49	5.49	5.49	7.94	10.44
6.	**765**	7.94	7.94	7.94	7.94	7.94	10.44
7.	**1200**	10.44	10.44	10.44	10.44	10.44	10.44

Where an overhead direct current (DC) line crosses another overhead line, clearances shall be as under: -

Minimum clearances in meters between AC and DC lines crossing each other

Sl. No.	**System Voltage (AC/DC)**	**100 kV DC**	**200 kV DC**	**300 kV DC**	**400 kV DC**	**500 kV DC**	**600 kV DC**	**800 kV DC**
1	**Low and Medium AC**	3.05	4.71	5.32	6.04	6.79	7.54	9.04
2	**11-66 kV AC**	3.05	4.71	5.32	6.04	6.79	7.54	9.04
3	**110-132 kV AC**	3.05	4.71	5.32	6.04	6.79	7.54	9.04
4	**220 kV AC**	4.58	4.71	5.32	6.04	6.79	7.54	9.04
5	**200 kV DC**	4.71	4.71	5.32	6.04	6.79	7.54	9.04
6	**300 kV AC**	5.32	5.32	5.32	6.04	6.79	7.54	9.04
7	**400 kV AC**	5.49	5.49	5.49	6.04	6.79	7.54	9.04
8	**400 kV DC**	6.04	6.04	6.04	6.04	6.79	7.54	9.04
9	**500 kV DC**	6.79	6.79	6.79	6.79	6.79	7.54	9.04
10	**600 kV DC**	7.54	7.54	7.54	7.54	7.54	7.54	9.04
11	**765 kV AC**	7.94	7.94	7.94	7.94	7.94	7.94	9.04
12	**800 kV DC**	9.04	9.04	9.04	9.04	9.04	9.04	9.04
13	**1200 kV AC**	10.44	10.44	10.44	10.44	10.44	10.44	10.44

Provided that no guarding are required when line of voltage exceeding 33 kV crosses over another line of 250 V and above voltage or a road or a tram subject to the condition that adequate clearances are provided between the lowest conductor of the line of voltage exceeding 33 kV and the top most conductor of the overhead line crossing underneath the line of voltage exceeding 33 kV and the clearances as stipulated in regulation 58 from the topmost surface of the road maintained

Type Test procedures on optical fibre are listed in the below table:

No	Item	Acceptance Criteria	Test procedure	Test result (pass/fail)
1	Attenuation	Max.: ≤0.35dB/km at 1310nm Max.: ≤0.21dB/km at 1550nm	IEC 60793-1-40 EIA/TIA 455-78A	
2	Attenuation Variation with Wavelength	0.05dB/km (1525nm to 1575nm) 0.05dB/km (1285nm to 1330nm)	IEC 60793-1-40 EIA/TIA 455-78A	
3	Attenuation at water peak	Max.: ≤0.35dB/km at 1383nm	IEC 60793-1-40 EIA/TIA 455-78A	
4	Temperature Cycling (Temperature Dependence of Attenuation)	≤0.05 dB (-60° C to +85° C), 2 Cycles	IEC 60793-1-52 EIA/TIA 455-3A	
5	Attenuation with Bending (Bend Performance) a)75mm dia±2mm., 100 turns @ 1310nm b)60mm dia±2mm., 100 turns @ 1550nm c)32mm dia±2mm.,1turn @ 1550	≤0.05dB ≤0.05dB ≤0.5dB	IEC 60793-1-47 EIA/TIA 455-62A	
6	Point Discontinuities of Attenuation	≤0.1dB	IEC 60793-1-40 EIA/TIA 455-59	
7	Mode Field Diameter	9.2 ± 0.4µm at 1310nm	IEC 60793-1-45 EIA/TIA 455-164A/167A/174A	
8	Core-Clad Concentricity Error	≤0.5 µm	IEC 60793-1-20 EIA/TIA 455-176	
9	Cladding Diameter	125 ± 1.0 µm	IEC 60793-1-20 EIA/TIA 455-176	
10	Chromatic Dispersion	≤3.5 ps/ (nm·km) from 1280nm to 1339nm ≤5.3 ps/ (nm·km) from 1271nm to 1360nm ≤18 ps/(nm·km) at 1550nm	IEC60793-1-42 EIA/TIA 455 168A/169A/175A	
	Zero Dispersion wavelength Zero Dispersion slope:	1312 nm±12nm ≤ 0.092 ps/nm^2.km		
11	Fiber Tensile Proof Testing	≥ 0.69 Gpa	IEC 60793-1-31 EIA/TIA 455-31B	
-End of Table-				

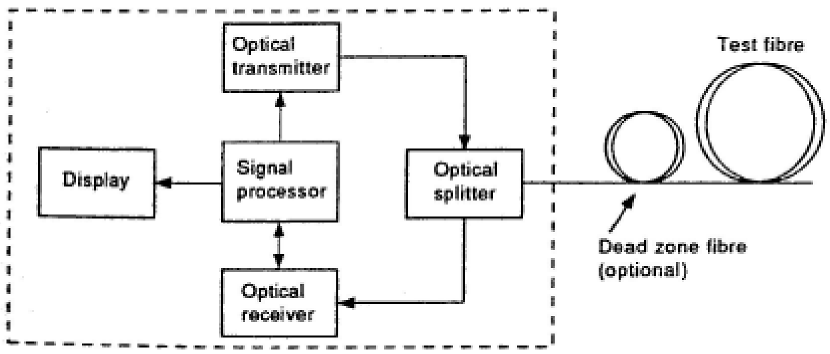
TYPE TEST PROCEDURE FOR OPTICAL FIBER

Attenuation

Test Name : Attenuation.
Final Customer : Power Grid Corporation of India Limited :
Project Name
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1- 40, EIA/TIA 455-78A.

Test Set-up

An optical time-domain reflectometer (OTDR) is prepared and used for Transmission performance testing, which consists of the following minimum list of components and block diagram is show below.



Test Procedure

Used an OTDR for indirect measurement of attenuation or fiber attenuation coefficient of the optical fiber by performing this measurement at multiple wave lengths; connected the specimen either to the instrument or to one end of the dead-zone fiber. Connected the other end of the dead-zone fiber to the instrument. The attenuation coefficient and accurate distance were recorded with the effective group-delay index of the specimen determined in advance.

Acceptance Criteria

A) Any permanent increases in optical attenuation greater than 0.35 dB/km at nominally 1310nm shall constitute failure.

B) Any permanent increases in optical attenuation greater than 0.21 dB/km at nominally 1550nm shall constitute failure.

Conclusion

The fiber meets the acceptance criteria of fiber attenuation test.

Tested by: Witnessed by: (Sign with date)
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER

Attenuation Variation with wave length Test

Test Name : Attenuation Variation with wave length Test .
Final Customer : Power Grid Corporation of India Limited :
Project Name
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-40,EIA/TIA 455-78A.

Test Set-up

The cut-back technique is the only method directly derived from the definition of fibre attenuation, in which the power levels, P1 (λ) and P2 (λ)， are measured at two points of the fibre without change of input conditions. P2 (λ) is the power emerging from the end of the fibre, and P1 (λ) is the power emerging from a point nears the input after cutting the fibre.

Test Procedure

First cleared the optical fiber and cut the end of the optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

Second choose the attenuation test key and checked the display on computer. The spectrum value should be recorded with different wavelength.

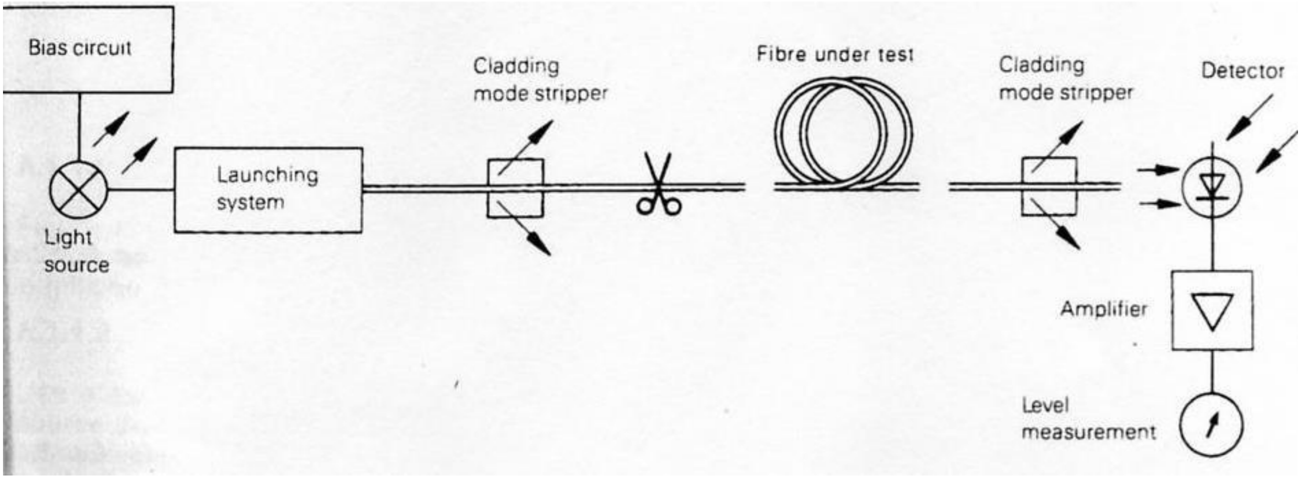
Acceptance Test

A) Any permanent increases in optical attenuation greater than 0.05 dB at nominally 1525nm to 1575nm shall constitute failure.

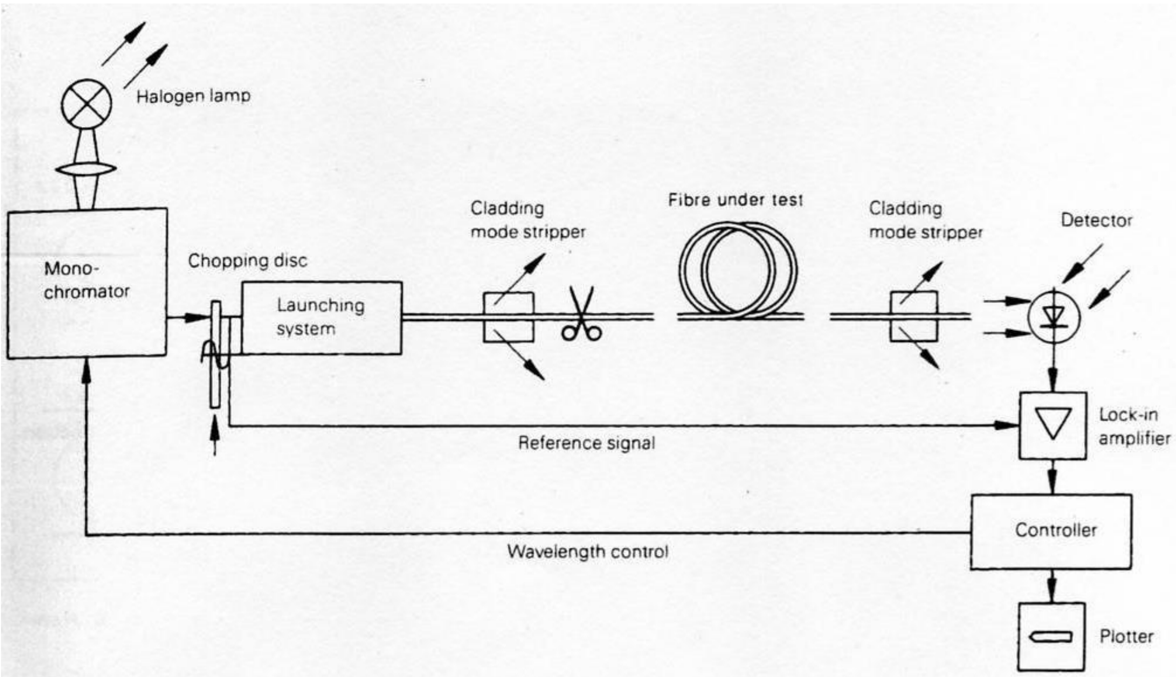
B) Any permanent increases in optical attenuation greater than 0.05 dB at nominally 1285nm to 1330nm shall constitute failure.

Conclusion

The fiber meets the acceptance criteria of fiber attenuation variation with wavelength test.



A.1- Arrangement of equipment to make loss measurement at one specified wavelength.



A.2- Arrangement of equipment used to obtain loss spectrum

Tested by:
(Sign with date)

Witnessed by:
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER
Attenuation at Water Peak

Test Name	: Attenuation at Water Peak.
Final Customer	:Power Grid Corporation of India Limited
Project Name	:
Optical fiber Manufacturer	:
Fibre Type	:
Standard	: IEC 60793-1- 40, EIA/TIA 455-78A.

Test Set-up

Any optical fiber multi-parameter analysis is to be prepared and used for attenuation at water peaking testing

Test Procedure

A)First cleared the optical fiber and cut the end of the optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

B)Second choose the attenuation test key and checked the display on computer. The attenuation value recorded at 1383nm.

Acceptance criteria

A) Any optical attenuation greater than 0.35dB/km at nominally 1383nm shall constitute failure.

Conclusion

The fiber meets the acceptance criteria of fiber attenuation at water peak test.

Tested by: (Sign with date)

Witnessed by: (Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBE
Temperature Cycling

Test Name : Temperature cycling .
Final Customer :Power Grid Corporation of India Limited
Project Name :
Optical fiber Manufacturer :
: 24B1-55(58.7:40.3), 48B1-55 (58.7:40.3)
Fibre Type
Standard : IEC 60793-1-52,EIA/TIA 455-3A.

Test Set-up

An optical time-domain reflectometer (OTDR) is prepared and used for Transmission performance testing, which consists of the following minimum list of components and block diagram is show below.

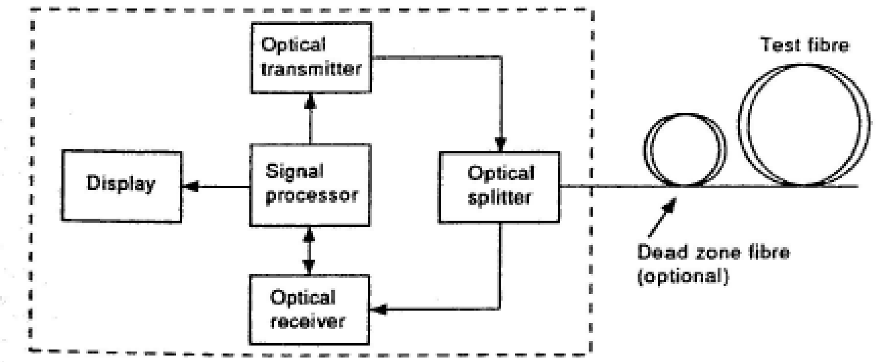


Figure.1 - Block diagram of an OTDR

Test Procedure

Use an OTDR for indirect measurement of attenuation or fiber attenuation coefficient of the optical fiber by performing these measurements at multiple wave lengths; connect the specimen either to the instrument or to one end of the dead-zone fiber. Connect the other end of the dead-zone fiber to the instrument. The attenuation coefficient and accurate distances are recorded with the effective group-delay index of the specimen determined in advance.

For Temperature Cycling (Temperature Dependence of Attenuation) test, the specimen under test i.e. optical fiber of length ≥ 2,000 meters is placed in a chamber and subjected to changes in temperature for duration & specifications as below and the attenuation is measured using OTDR.

Minimum temperature :-60₀C

Maximum temperature :+85₀C

Minimum dwell time at each temperature :2hr.

Maximum rate of change of temperature :1₀C/min

Number of consecutive cycle :2.

The length of fibre outside the chamber shall not be more than 10% of the total sample lengths.

Acceptance criteria

A) Any optical attenuation greater than 0.05dB at nominally 1310nm shall constitute failure.
B) Any optical attenuation greater than 0.05dB at nominally 1550nm shall constitute failure. .

Conclusion

The fiber meets the acceptance criteria of fiber temperature cycling test.

Tested by: (Sign with date) Witnessed by: (Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER
Attenuation with Bending (Bend Performance)

Test Name : Attenuation with Bending (Bend Performance).
Final Customer :Power Grid Corporation of India Limited Project
Name :
Optical fiber Manufacturer :
Fibre Type
: Standard : IEC 60793-1-47, EIA/TIA 455-62A.

Test Setup
Mandrel each with a diameter of 75mm, 60mm & 32mm for single-mode fibers and a loss measurement instrument is prepared. Determine the macro bending loss at 1550nm & 1310nm with optical power meter.

Test Procedure
Loosely wind the fiber on the mandrel, avoiding excessive fiber twist for 100 turns with mandrel diameter 60mm & 75mm and 1 turn with mandrel diameter 32mm to test at wavelength 1550nm & 1310nm for the fiber. In order to determine the induced attenuation due to macro bending, the value is corrected for the intrinsic attenuation of the fiber. The fiber length outside the mandrel and the reference cut-back length are free of bend. The optical power meter are monitored for test.

Acceptance criteria

A) Any permanent increase optical attenuation greater than 0.05dB at nominally 1310nm for 75mm ± 2mm dia. 100 turns shall constitute failure.

B) Any permanent increase optical attenuation greater than 0.05dB at nominally 1550nm for 60mm ± 2mm dia. 100 turns shall constitute failure.

C) Any permanent increase optical attenuation greater than 0.5dB at nominally 1550nm for 32mm ± 0.5mm dia.1 turn shall constitute failure.

Conclusion
The fiber meets the acceptance criteria of fiber attenuation with bending test.

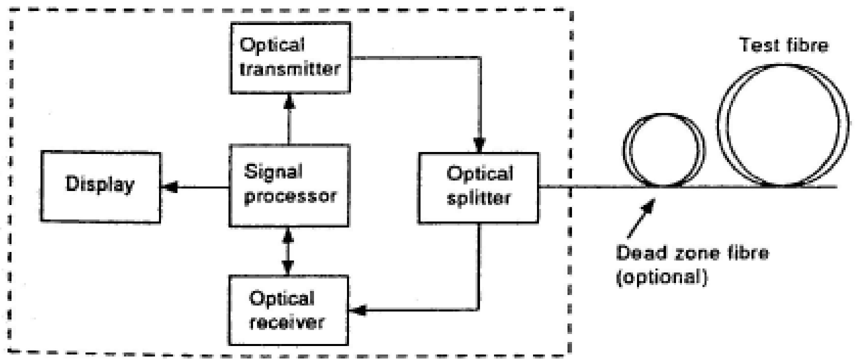
Tested by: Witnessed by: (Sign with date)
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER
Point Discontinuities of Attenuation

Test Name : Point Discontinuities of Attenuation.
Final Customer :Power Grid Corporation of India Limited, India.
Project Name :
Optical fiber Manufacturer :
: Fibre Type
Standard : IEC 60793-1-40, EIA/TIA 455-59.

Test Set-up

An optical time-domain reflectometer (OTDR) is prepared and used for Transmission performance testing, which consists of the following minimum list of components and block diagram is show below.



Test Procedure

1. Connect the test sample either to the instrument or to one end of end dead-zone fiber (if used). Connect the other end of the dead-zone fiber (if used) to the instrument.
2. If the accurate locations of point defects are to be recorded, the effective group delay index of the test sample is required. If this value is not known, use **FOTP-60** to determine it.
3. Enter OTDR parameters such as source wavelength, pulse duration, length range, and signal averaging into the instrument, along with the test sample effective group index. The values of some of these parameters may be present in the instrument.
4. Adjust the instrument to display a backscatter signal from the test sample. It may be advantageous to begin with coarse vertical and horizontal scaling to maximize the length displayed. An example is given in Figure 1. 5. Examine the OTDR signal along the test sample for point defects. If increased resolution is need, adjust the graphical display, if possible, to expand the section of interest to large scale (exercising care to assure that proper reading of the true signal can still be distinguished from the noise points); an example is given in Figure.2.
6. To determine that a point defect (rather than an attenuation non-uniformity situation) exist observe the area in question using two different pulse durations. The shape of the loss or gain changes with the pulse duration, the anomaly is a point defect. If the shape does not change, the anomaly shall be considered to be attenuation non-uniformity to be measured by **FOTP-61**.

7. Report any point defect deviations which exceed the value specified in the detail specification. Describe the nature of these faults (e.g. apparent loss or gain, reflection, duration, etc) as required by the Detail Specification.

7.1. Determine the defect location, if required, by placing a cursor at the beginning (or at another point specified by the OTDR manufacturer) of a power rise or drop, this may be difficult to do at a drop. Obtained the distance coordinate via the alphanumeric display.

7.2. Obtain the apparent loss or gain of the defect, if required, by the method described by the OTDR manufacturer. Some instruments required placement of a pair of cursors on each side of the defect. The two best-fit straight lines (from a two-point or least-squares fit for each) are extrapolated to the defect location. If available, the linear fir method should be chosen. The vertical separations of the lines give the apparent loss or gain. Note any reflection peak.

7.3. When possible, repeat the test for single launched into the test sample in the opposite direction. A more accurate loss estimate (and the elimination of apparent gain) is made by averaging readings taken directionally at the same wavelenght.This eliminates the effect of any backscatter different for the fiber sections on both side of the defect.

7.4. If required by the Detail specification, repeat the test at another wavelength.

Acceptance Criteria

A) Any permanent increases in optical attenuation greater than 0.1 dB/km at nominally 1310nm shall constitute failure.

B) Any permanent increases in optical attenuation greater than 0.1 dB/km at nominally 1550nm shall constitute failure.

Conclusion

The fiber met the acceptance criteria of fiber point discontinuities of attenuation test.

Tested by: (Sign with date) Witnessed by: (Sign with date)

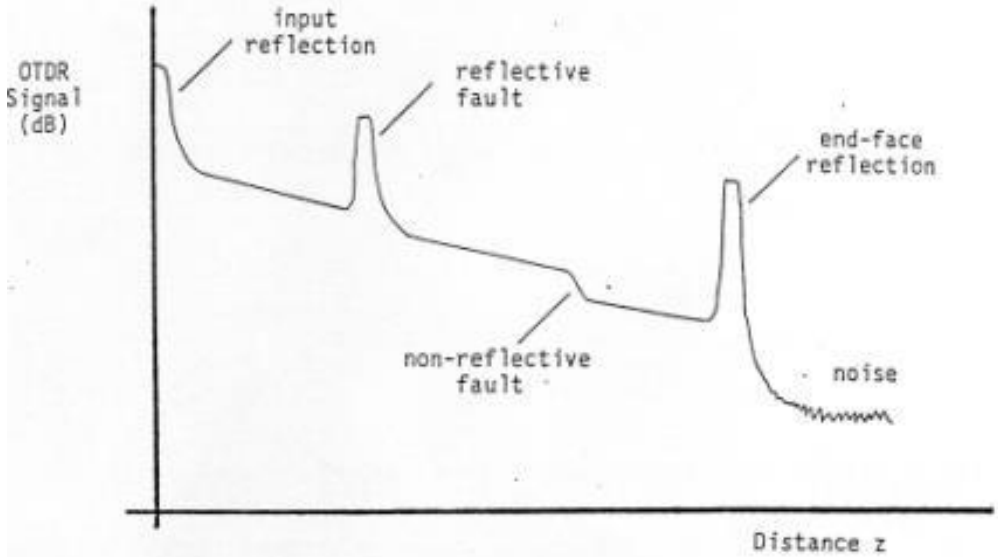


Figure 1. Schematic of an OTDR Trace. Point defects with apparent loss are shown, one reflective and one non-reflective.

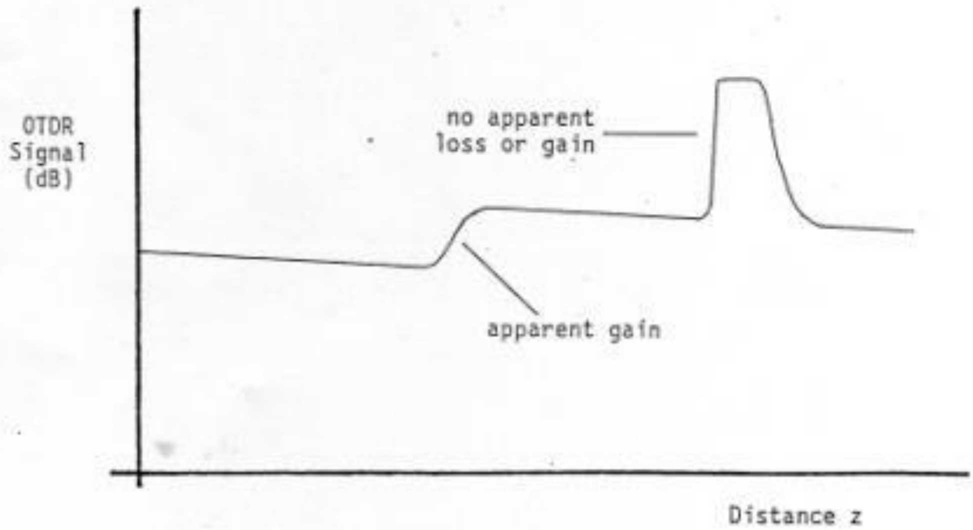


Figure 2. Schematic of an expanded OTDR trace. Two point defects are shown, one with apparent gain, and another with no apparent loss or gain.

TYPE TEST PROCEDURE FOR OPTICAL FIBER

Mode Field Diameter :

Test Name Mode field Diameter.
Final Customer : Power Grid Corporation of India Limited, India.
Project Name :
Optical fiber Manufacturer :
Fibre Type :
Standard : IEC 60793-1-45, EIA/TIA455-164A/167A/174A.

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Test Set-up (Geometric Parameters)

An optical fiber multi-parameters analysis system is prepared and used for attenuation at mode field diameter testing.

Test Procedure

First cleared optical fiber and cut the end of optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

Second choose the attenuation test key and checked the display on computer. The model field diameter was recorded.

Acceptance Criteria

The mode field diameter greater than 9.2±0.4µm at nominally 1310nm shall constitute failure.

Conclusion

The fiber met the acceptance criteria of fiber mode field diameter test.

Tested by: Witnessed by: (Sign with date)
(Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER
Core-Clad Concentricity Error

Test Name : Core-clad Concentricity Error.
Final Customer : Power Grid Corporation of India Limited, India.
Project Name :
Optical fiber Manufacturer :
: Fibre Type
Standard :IEC 60793-1- 20, EIA/TIA 455-176.

Test Set-up
Suitable incoherent light sources was used for the illumination of the core and the cladding. Adjustable in intensity and stable n intensity over a time period sufficient to perform the measurement.

For the grey-scale method a CCD video camera was used to detect the magnified output near-field Image and transmit it to a video monitor. The video digitizer performance the digitization of the image for further computer analysis. This video system was sufficiently linear such that,after calibration, the measurement uncertainty was not great than required.

For single near-field scan method a means was provided to scan the focused image of the fiber near-field pattern which provides knowledge of the distance scanned. An example was a single detector (such as a PIN-hole) placed on a stepper-motor driven translator with position feedback device, or a video array detector of know element size and spacing. The detector was linear over the range of intensities encountered.

Test Procedure
First cleared optical fiber and cut the end of optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

Second choose the attenuation test key and checked the display on computer. The mode field diameter was recorded.

Acceptance Criteria
The core-clad concentricity error greater than 0.5μm shall constitute failure.

Conclusion
The fiber meet the acceptance criteria of fiber core-clad connectivity error test.

Tested by: Witnessed by: (Sign with date)
(Sign with date)

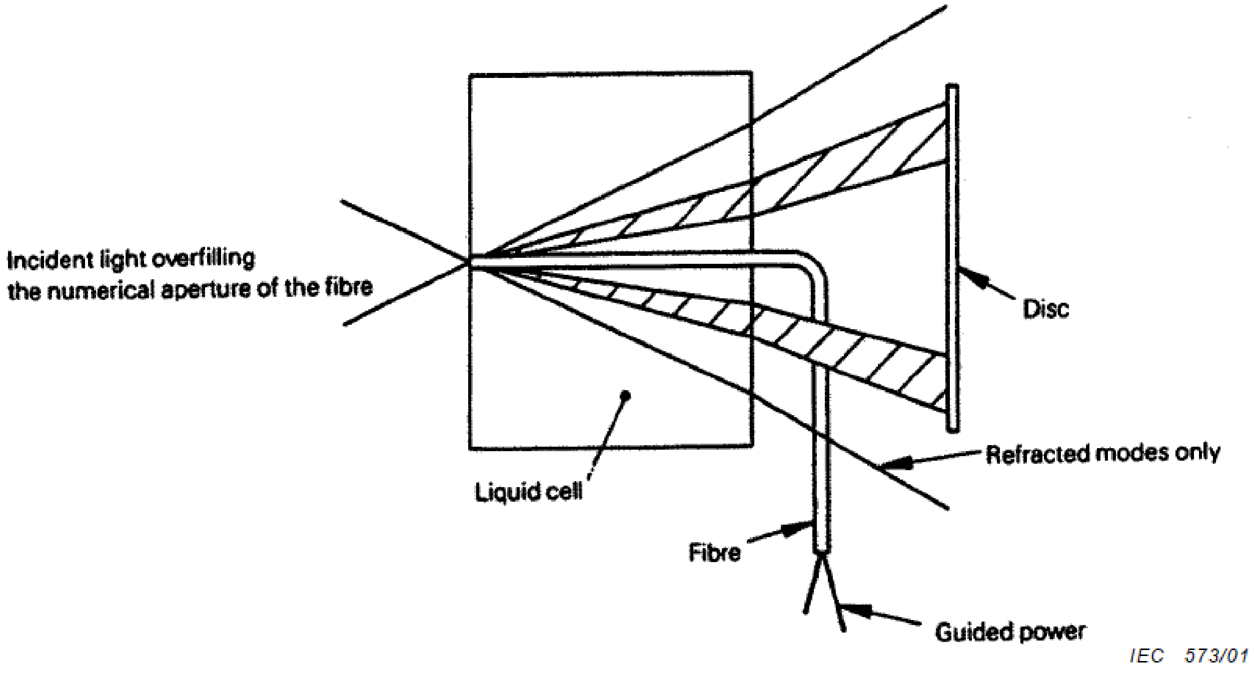


Figure2: Refracted near-field method-Schematic diagram

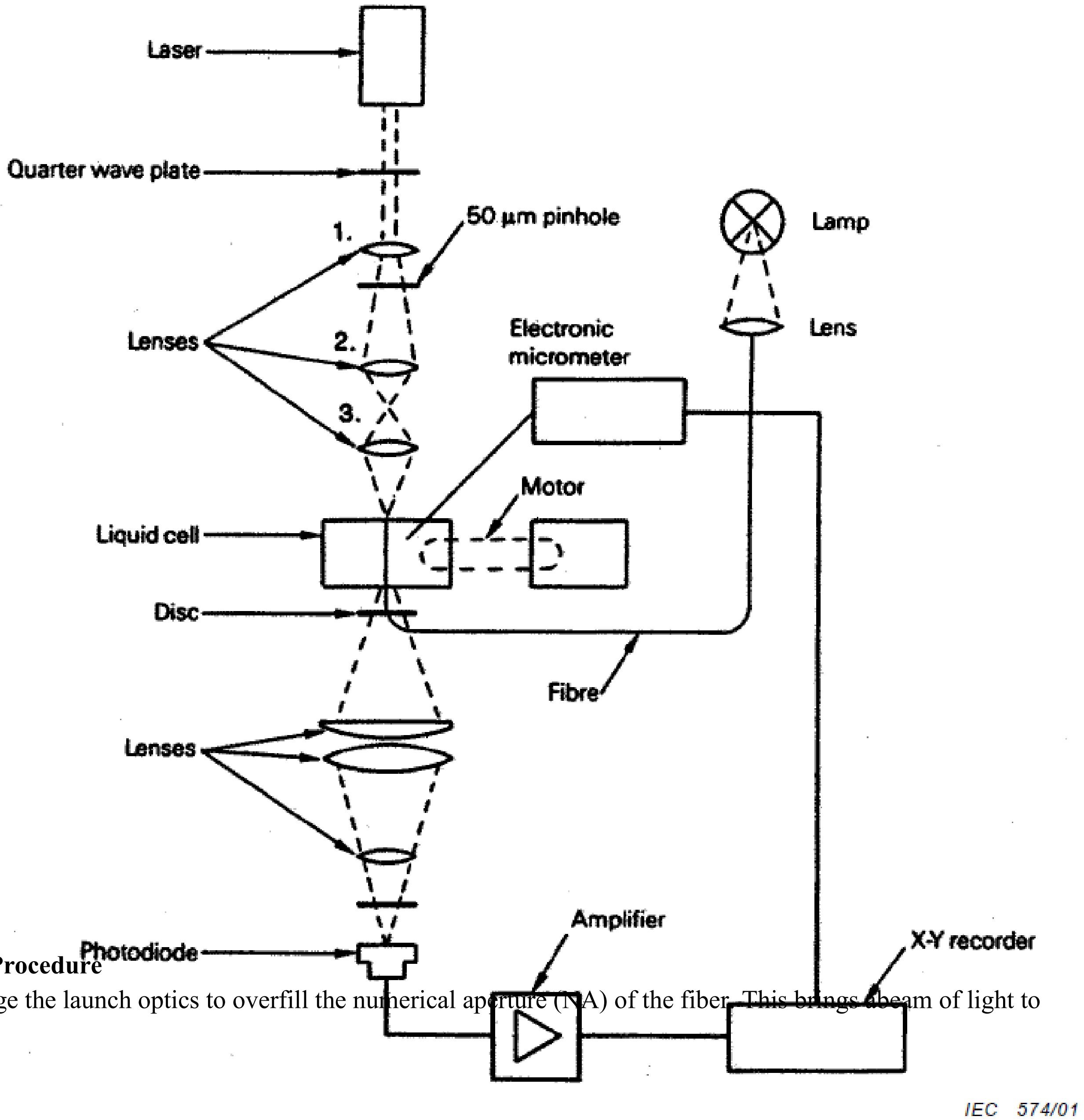


Figure3: Typical arrangement of the refracted near-field test set

Test Procedure

Arrange the launch optics to overfill the numerical aperture (NA) of the fiber. This brings abeam of light to

TYPE TEST PROCEDURE FOR OPTICAL FIBER

Cladding Diameter :

Test Name	Cladding Diameter.
Final Customer	: Power Grid Corporation of India Limited, India.
Project Name	:
Optical fiber Manufacturer	:
Fibre Type	:
Standard	: IEC 60793-1-20, EIA/TIA 455-176.

Test Set-up

Suitable incoherent light sources was used for the illumination of the core and the cladding. Adjustable in intensity and stable n intensity over a time period sufficient to perform the measurment.

For the grey-scale method a CCD video camera was used to detect the magnified output near-field Image and transmit it to a video monitor. The video digitizer performance the digitization of the image for the futher computer analysis. This video system was sufficiently linear such that,after calibration,the measurement uncertainty was not great than required.

For single near-field scan method a means was provided to scan the focused image of the fiber near-field patteren which provides knowledge of the distance scanned. An example was a single detector (such as a oin-hole) placed on a stepper-motor driven translator with position feedback device,or a video array detector of know element size and spacing.The detector was linear over the range of intensities encountered.

Test Procedure

First cleared optical fiber and cut the end of optical fiber smoothly, then put the processed optical fiber to V notch. It must be ensured that processed optical fiber connect the end of preset pigtail.

Second choose the attenuation test key and checked the display on computer. The mode field diameter was recorded.

Acceptance Criteria

The cladding diameter shall be less than 124.0μm or greater than 126.0 μm shall constitute failure.

Conclusion

The fiber meet the acceptance criteria of fiber Cladding diamter test.

Tested by: Witnessed by: (Sign with date)

(Sign with date)

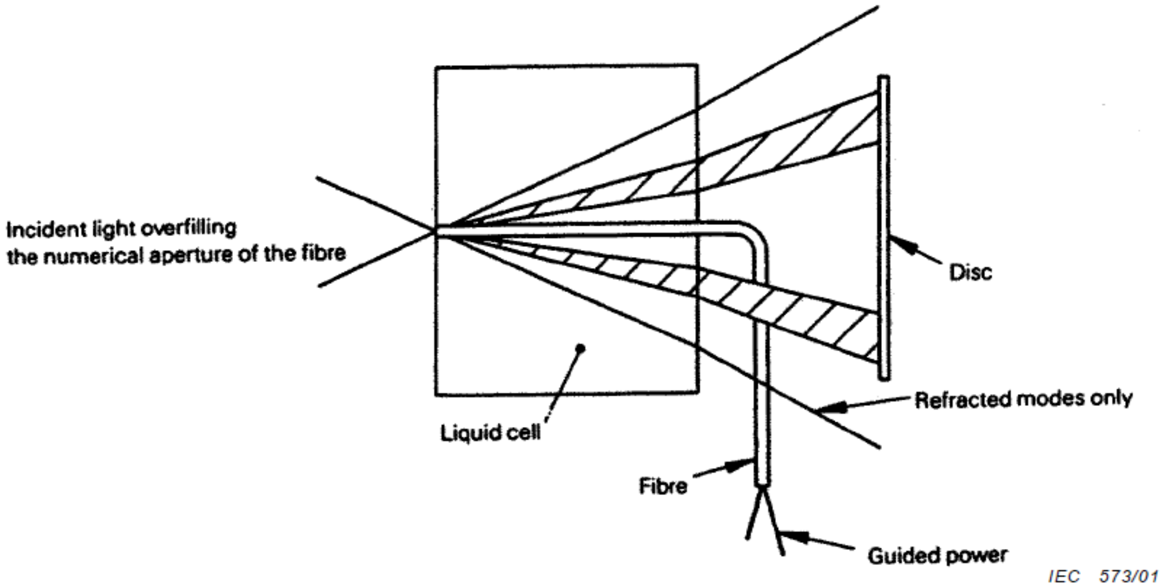


Figure2: Refracted near-field method-Schematic diagram

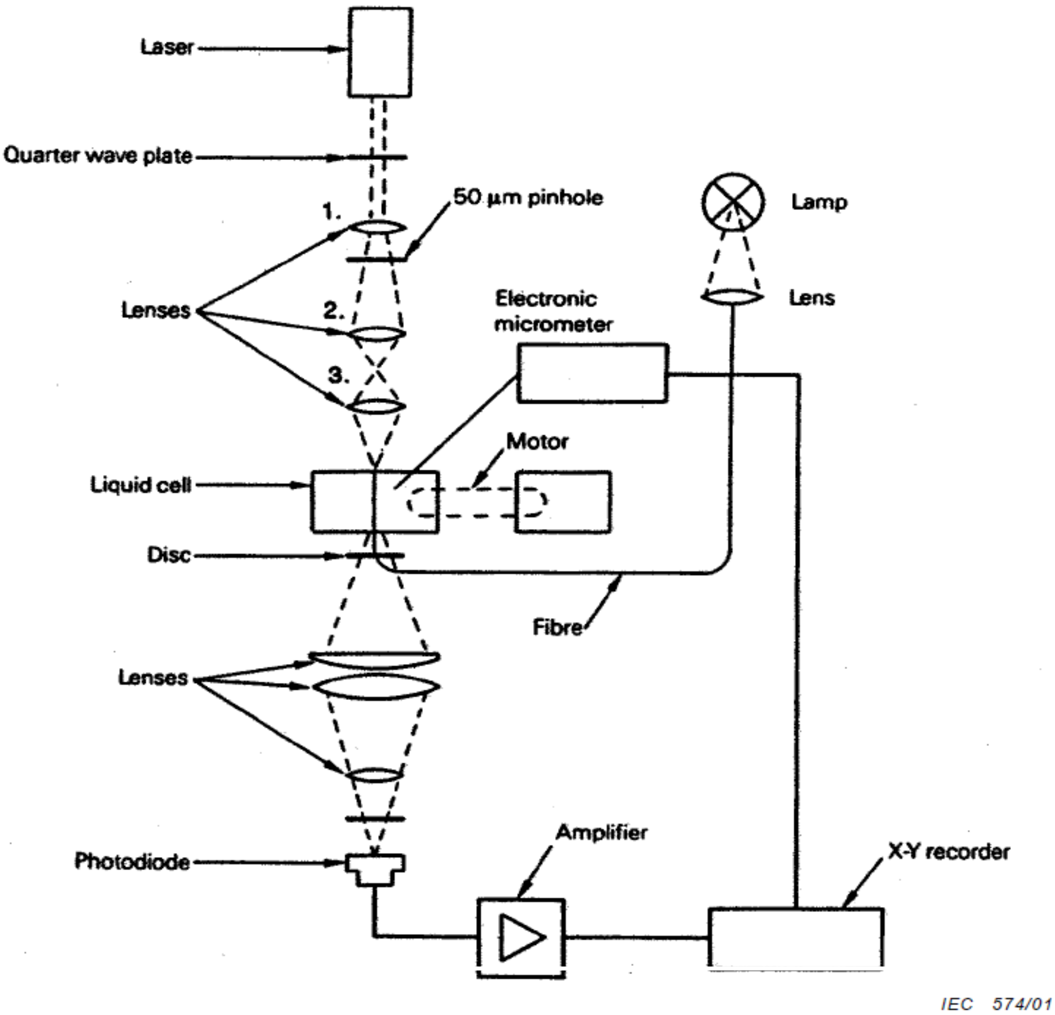


Figure3: Typical arrangement of the refracted near-field test set

TYPE TEST PROCEDURE FOR OPTICAL FIBER
Chromatic Dispersion Test

Test Name	: Chromatic Dispersion Test.
Final Customer	: Power Grid Corporation of India Limited, India.
Project Name	:
Optical fiber Manufacturer :	
	: Fibre Type
Standard	: IEC 60793-1-42, EIA/TIA 455 168A/169A/175A.

Test Set-up (Chromatic Dispersion)

The test sample shall be on fiber or cable as specified in the detail specification, of know length greater than 1 km long to produce adequate phase measurement accuracy. For a 3-wavelength system, the minimum length can be estimated from equation.

A phase calibration fiber of the same fiber class as the test sample shall be used to facilitate input phase measurement or input phase equalization. The length of this fiber shall be less than or equal to 0.2% of the test fiber length.

Test Procedure

The phase calibration fiber shall be connected to the measurement apparatus; a reference signal shall also be established. The phase, for each signal source shall be measured and recorded.

Alternately to above, if the signal sources are phase adjustable, then with the phase calibration fiber in place, the phases of all signal sources shall be equalized. Test sample measurements shall then be performed as describe in below.

The test fiber shall be connected to the measurement apparatus; a reference signal shall be also be established.

Acceptance Criteria:

a)The Chromatic dispersion greater than 3.5 ps/(nm.km) at nominally 1280nm to 1339nm shall constitute failure.

b)The Chromatic dispersion greater than 5.3 ps/(nm.km) at nominally 1271nm to 1360nm shall constitute failure.

c)The Chromatic dispersion greater than 18 ps/(nm.km) at nominally 1550nm shall constitute failure.

d)The Zero dispersion wavelength less than 1300nm or greater than 1324nm shall constitute failure

e)The Zero dispersion slope greater than 0.092 ps/nm2.km shall constitute failure.

Conclusion:
The fiber meets the acceptance criteria of fiber attenuation with bending test .

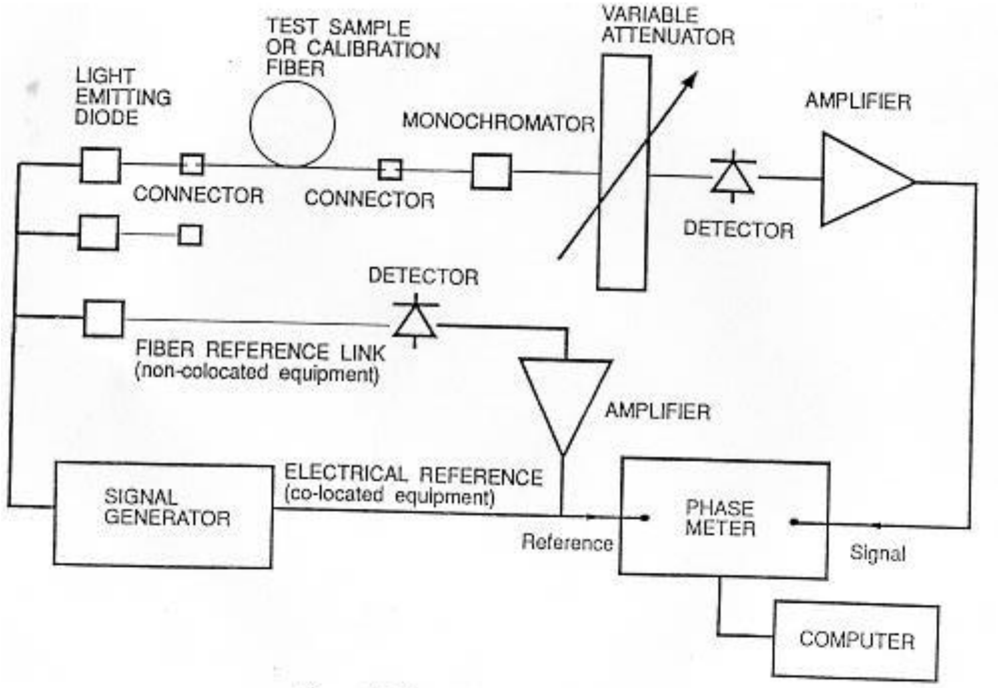


Figure 2: Chromatic Dispersion Test Set
LED System

Figure : Chromatic Dispersion Test set-LED System

Tested by: (Sign with date)

Witnessed by: (Sign with date)

TYPE TEST PROCEDURE FOR OPTICAL FIBER

Fiber Tensile Proof Test

Test Name	: Fiber Tensile Proof Test.
Final Customer	: Power Grid Corporation of India Limited, India.
Project Name	:
Optical fiber Manufacturer :	
	: Fibre Type
Standard	: IEC 60793-1-31, EIA/TIA 455-31B.

Test Set-up (Fiber Tensile Proof)

To measure fiber proof with the indicated general operating requirements, the braked capstan type machine is used. Care should be used in the design so as to prevent coating damage.

Test Procedure

The test specimen is fed into the machine according to the operating instructions for the machine. Set the tension load on the machine according to the provision in the sub procedure given in the following form. The procedure allows easy detection by the operator of any failure in the fiber, if or when it occurs. The test specimen is run through the proof test machine with 1sec.

The tension value shall be recorded by Newton.

Acceptance Criteria:

a)Fibre breakage during the test shall constitute failure

b)The stress σ on the test fiber was 0.69 GPa

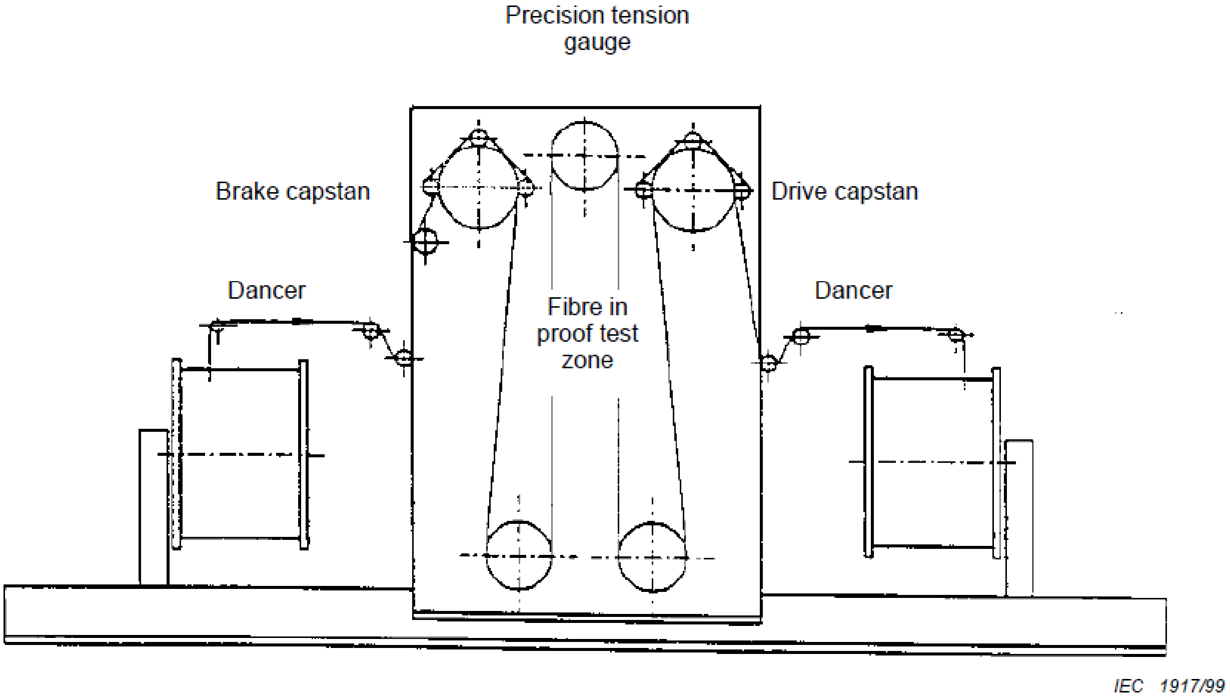
c)The strain Ɛ on fibre was greater than 1.0%

Conclusion:

The fiber met the acceptance criteria of fibre tensile proof test.

Tested by: Witnessed by:

(Sign with date) (Sign with date)



Fibre pay-off region
Stage 1 : constant pay-off

Proof testing region
Stage 2 : Proof testing with master braking capstan and precision tension gauge

Fibre take-up region
Stage 3 : Constant tension take-up spooling

Figure 5 - Braked capstan machine

APPROACH CABLE INSTALLATION AND HANDLING DOCUMENT

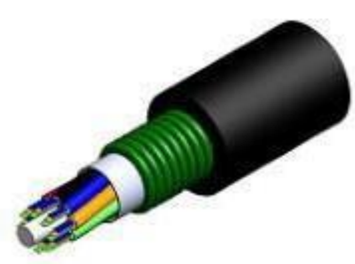
Introduction: -

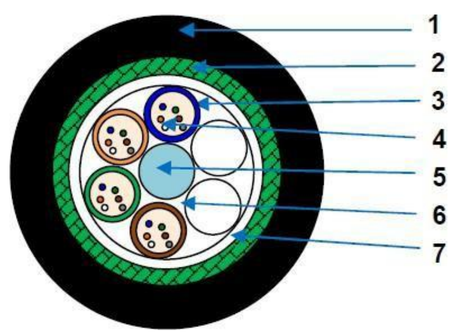
A fiber optic approach cable is defined as the Armored Underground fiber optic cable required to connect Overhead Fiber Optic Cable (OPGW) between the final in line splice enclosure on the gantry/ tower forming the termination of the fiber cable on the power lines and the fiber Optic Distribution Panel (FODP) installed within the building. The Supply and installation of optical fiber approach cable as required based on detailed site survey. The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. The approach cable shall be laid in the PLB HDPE duct in all conditions.

Overview: -

Optical fibers require special care during installation to ensure reliable operation. Installation guidelines regarding minimum bend radius, tensile loads, twisting, squeezing, or pinching of cable must be followed. Cable ends should be protected from contamination and scratching at all times. Violation of any of these parameters causes increased attenuation or permanent damage to the cable. Make sure you check the installation instructions of the module for the appropriate cable lengths to ensure proper operation.

Approach Cable Structure





Construction :

1. Outer sheath (PE, Anti-rodent)
2. Armor tape
3. Loose tube
4. Fiber and jelly
5. Center strength member (FRP)
6. Cable jelly
7. Water blocking tape

Technical Characteristics

The unique extruding technology provides the fibers in the tube with good flexibility and bending endurance. The unique fiber excess length control method provides the cable with excellent mechanical and environmental properties multiple water blocking material filling provides dual water blocking function provides good crush resistance.

Dimensions and Properties

Physical	Fibre Count	24 G652D	48 G652D
	No. of Fibre Per Tube	4	8
	Cable OD	11.5 mm	
	Cross Sectional Area	100 mm	
	Cable Weight	Approx. 130 kg/Km	
	Operation Temperature Range	-30° C to + 70° C	
	Installation Temperature Range	-30° C to + 70° C	
	Transport and Storage Temperature Range	-30° C to + 70° C	
Mechanical	Max. Tensile Load	4.5 KN	
	Crush Resistance	3000 N/10 Cm	
	Minimal Installation Bending Radius	20 X OD	
	Minimal Operation Bending Radius	10 X OD	

HANDLING AND LAYING OF PLB HDPE DUCT:

1. The coil of PLB HDPE duct shall be unloaded from either a crane or by any other suitable means very carefully so as not to cause any damage to the duct. The coils at site shall be protected until they are laid. The duct shall be given the same care in handling as that given to the cable. The coils shall be kept as per the guidelines issued by the manufacturer. The coil shall not be set by jerks but shall be handled slowly and care. The walls of the ducts shall not be damaged while moving the coils, if required for unloading.

2. The coil shall normally be unrolled at the same place and the PLB HDPE duct carried by workmen near the trench. The coils shall not be dragged in any case. But where the drums/coils of duct have to be moved should always be rolled in the direction of the arrow, otherwise the coils tend to unwind and the same may get battered. In case no such direction of arrow is given see the direction of winding of the coil and the coil should be rolled pointing in the opposite direction in which the upper end is coiled.

3. All care should be taken in handling the coils with a view to ensure safety of the coils but also of the working party handling them. The coil should not be broken by standing in front of the coil but only from side.

INSTALLATION PROCEDURE OF PLB HDPE DUCT LAYING :

It is advisable to employ the people before commencement of the laying, inspection of the trench and inspection of protection works should be carried out so as to ensure their conformity with the specification. The trench bottom should be clean, smooth and free of small stone. When the soil contains stone or pieces or rock and therefore cannot be raddled, sieved earth about 10 cm. thick should be used both for the bedding on which the duct is being laid. The duct coil should be brought as close to the trench as possible. It should be lifted carefully with the aid of jacks

1. Supervisor in charge should stand in a commanding position where he can view the entire trenches and shout evenly and call his men to pull. If there is proper synchronization between the mates call in the pulling by the men the duct will leave the coil without difficulty. It is important that the duct shall be pulled with steady and even pulls and there should not be unnecessary twists. Care should be taken to avoid twist as this is likely to damage the PLB HDPE duct. When pulling around bends one or two men should be stationed to give the duct the correct bent when it passes.

2. While laying the duct employ adequate number of men so that the duct can be conveniently carried by them in both hands without stretched arms. The distance between any two persons carrying the duct shall be two to ten meters depending upon the weight such that the maximum sag of the PLB HDPE duct between any two persons is not more than 0.5 meters.

3. While laying work is in progress one man has to continuously observe the PLB HDPE duct along its line in order to determine indentations poles or other damaged parts are apparent. Such damaged parts have to be protected immediately.

4. The conditions of the PLB HDPE duct shall be visually inspected throughout its line and in case damage or defect is noticed, the trench shall be filled up only after ensuring that the damage is not likely to affect the cable.

5. The end of the duct should be sealed with flex to prevent entry of soil before filling back. Adjoining ducts shall be joined by couplers. Duct integrity testing shall be carried out when laying is completed in a block section (1 kms). In case the continuity is not achieved the fault shall be localized and rectified by providing PLB HDPE DUCT couplers/Compression couplers.

6. Tools necessary for laying PLB HDPE Duct is to be checked as physically available before starting the Duct laying. For efficient and safe laying, communication may be provided between following points using portable VHF Walkie talkie sets.

7. The Supervisor In charge of the duct laying. During PLB HDPE duct laying care must be taken not to twist duct in any direction. For this purpose, the survival (rotating hook) shall be attached between pulling line and pulling eye at the end of duct so as to avoid any possible twist during pulling and laying of the cable.

8. During duct laying care must be taken not to twist duct in any direction. For this purpose, the rotating hook shall be attached between pulling line and pulling eye at the end of duct so as to avoid any possible twist during pulling and laying of the cable. In case it is planned to lay the cable in duct by pulling the cable by using a winch; the duct should be provided with a nylon rope for pulling

PREPARATION FOR CABLE PULLING GRIP

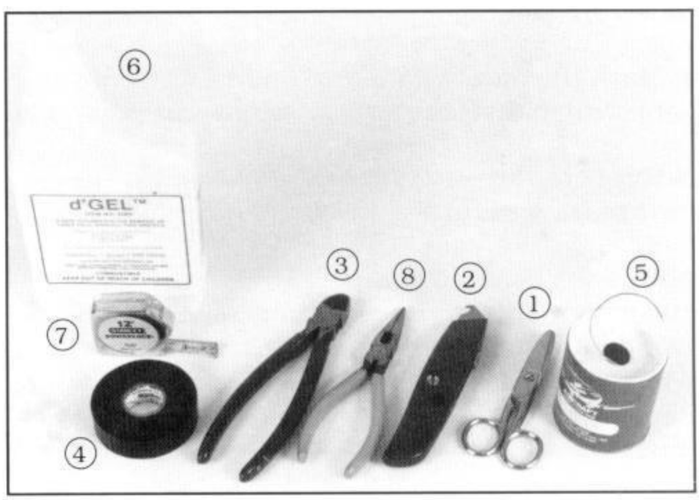
1. Methods used for placing fiber optic cables in ducts are essentially. However, fiber optic cable is a high capacity data transmission medium which can have its communication characteristics degraded when subjected to excessive pulling force, sharp bends, and crushing forces. These losses may not be

revealed until long after installation is complete. For these reasons extra care must be taken during the entire installation procedure.

2. Cable manufacturers install special strength members, usually aramid yarn, to absorb the stress of pulling the cable. Fiber optic approach cable should only be pulled by these strength members unless the cable design allows pulling by a grip on the jacket. Any other method may put stress on the fibers and harm them. Swivel pulling eyes should be used to attach the pulling rope or tape to the cable to prevent cable twisting during the pull.

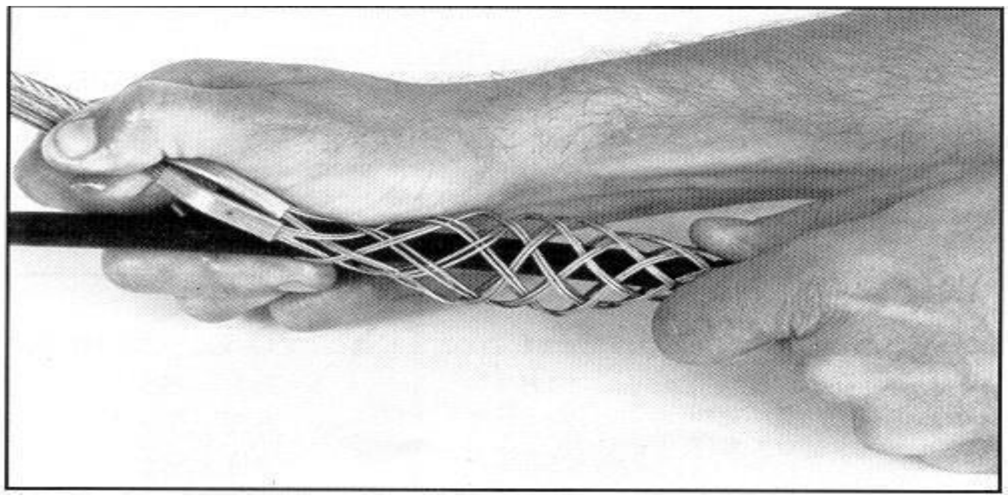
3. A Cable pulling grip is installed on fiber optic cable to provide optimum load distribution during cable pulling. When correctly installed, the cable-pulling grip distributes the pulling force equally along the cable strength members. To prevent dangerous cable twisting during the pulling operation.

4. Tools and Materials Required
    - Scissors
    - Utility Knife/Hook Blade
    - Diagonal Pliers/Wire Cutters
    - Vinyl Tape
    - Stainless Steel Wire
    - Cable Cleaner or Approved Solvent
    - Tape Measure
    - Needle Nose Pliers



5. Prior to installation, the proper size grip must be chosen for the cable to be pulled. Grip selection is based on cable inner-outer jacket diameter. Generally, use the smallest grip that will fit over the inner jacket without excessive difficulty. Measure the cable inner jacket diameter and determine the proper grip.

- Remove 1.25 meters (48 inches) or outer sheath exposing the polyethylene jacketed cable core. The length removed depends on pulling grip and should be roughly the length of the grip plus 12-16 inches.
- Mark the outer sheath 48 inches from the cable end with a piece of PVC tape or marking pen.
- Ring cut the outer jacket and armor at the tape mark with utility knife or hook blade.
- Flex the cable to completely server the jacket and armor sheath. Remove the cable sheath carefully.



- Slide the grip over the end of the cable core and push the cable out through the tape of the mesh leaving about 12 inches of core exposed. (Figure 4)

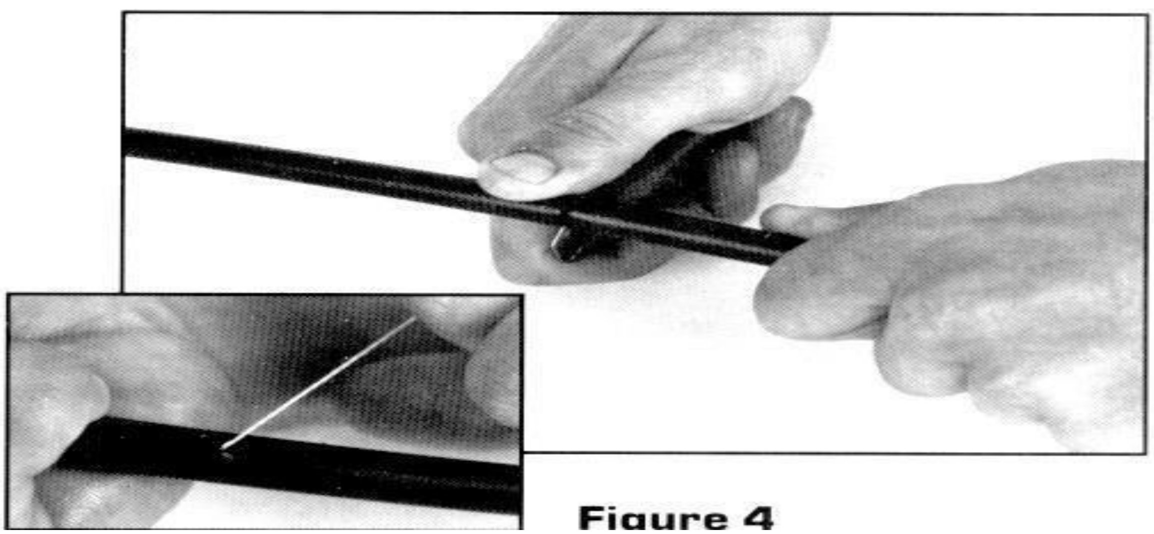


Figure 4

- Remove approximately 12 inches of cable inner sheath from the cable end Cut away all cable Components except the yellow aramid yarn. (Figure 5)

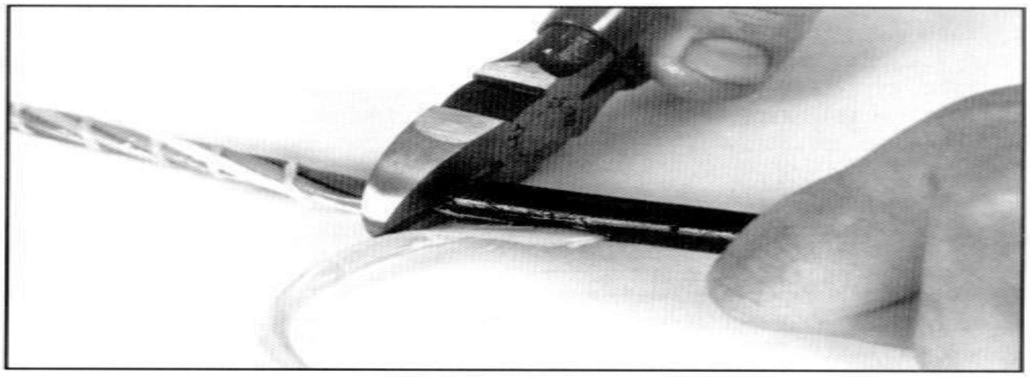


Figure 5

- Secure the yarns to the inner loop of the pulling grip using a square or bowknot. The yarn should be the same length as the pulling grip to insure that pulling forces are equally distributed. (Figure 6)

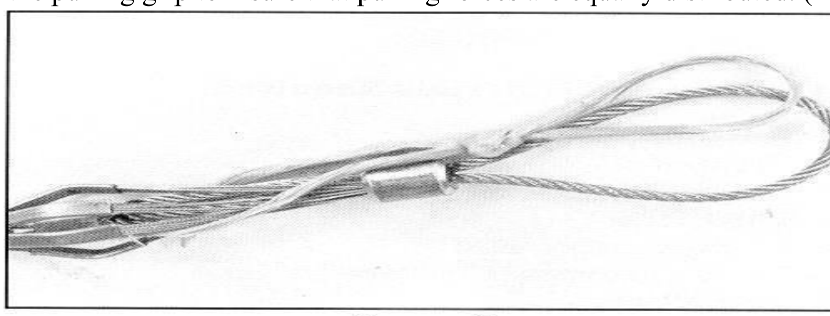


Figure 6

- Adjust the grip position on the inner sheath such that the wire mess section is completely over the cable. Anchor the grip into position by binding with stainless steel wire. (figure 7)

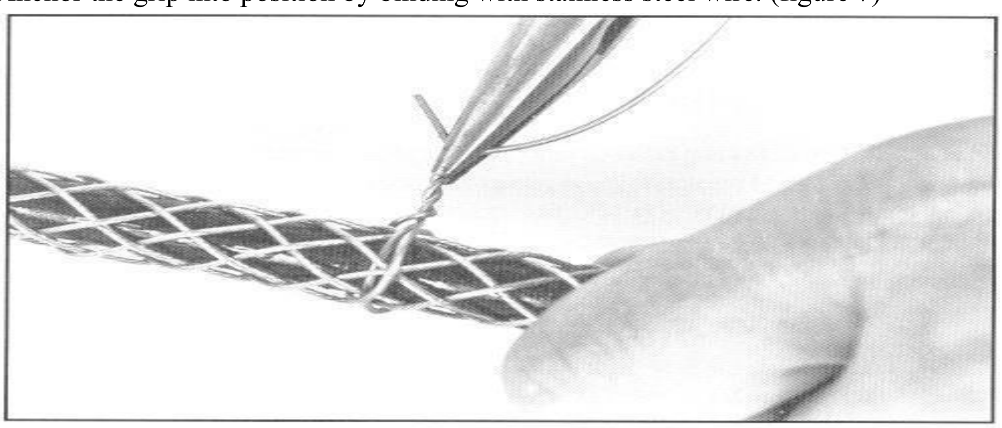
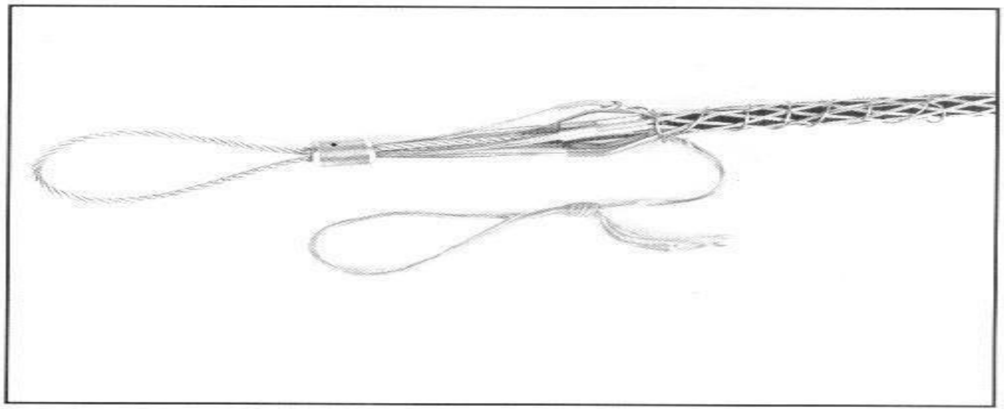
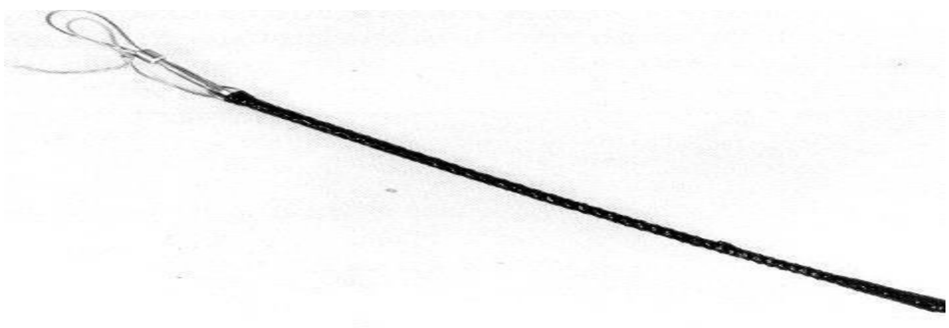


Figure 7

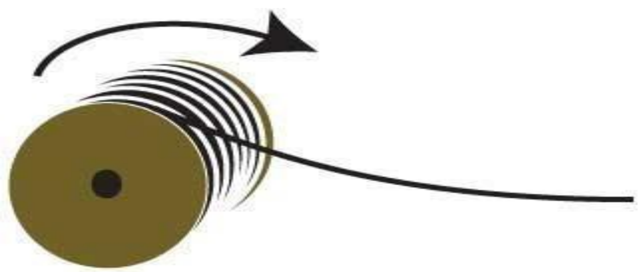
- Place PVC tape over the entire grip and over the junction of the outer sheath to inner sheath. The transition from inner to outer sheath should be smooth. Additionally, the grip ribbing and wire should not be exposed below the tape. The spiral wrap tape should lay from the pulling grip toward the cable to insure smooth pulling. (figure 8)



- Place PVC tape over the entire grip and over the junction of the outer sheath to inner sheath. The tape should lay from the top of the pulling grip toward the cable to insure smooth pulling without snags.
- If applicable, secure the aramid yarns to the inner loop of the pulling grip using a square or bowknot. The yarn should be the same length as the pulling grip to insure that pulling forces are equally distributed.



6. Cables should not be pulled by the jacket unless it is specifically approved by the cable manufacturers. These grips are usually tied to the strength members also. Tight buffer cable can be pulled by the jacket in premises applications if a large (~40 cm, 8 in.) spool is used as a pulling mandrel. Wrap the cable around the spool 5 times and hold gently when pulling. Do not exceed the maximum pulling tension rating. Consult the cable manufacturer and suppliers of conduit, innerduct, and cable lubricants for guidelines on tension ratings and lubricant use. If possible, use an automated puller with tension control and/or a breakaway pulling eye. When laying loops of fiber on a surface during a pull, use "figure-8" loops to prevent twisting the cable.
7. Twisting Cable :- Do not twist the cable. Twisting the cable can stress the fibers. Tension on the cable and pulling ropes can cause twisting. Use a swivel pulling eye to connect the pull rope to the cable to prevent pulling tension causing twisting forces on the cable.

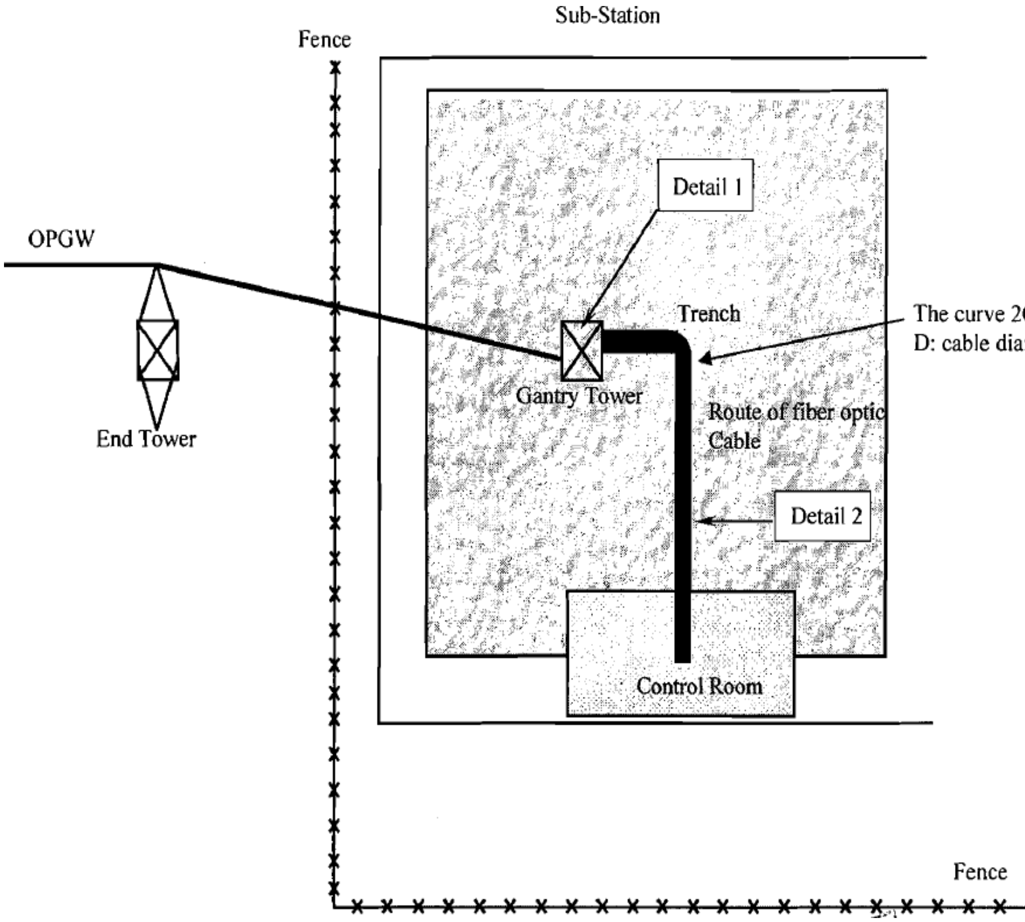


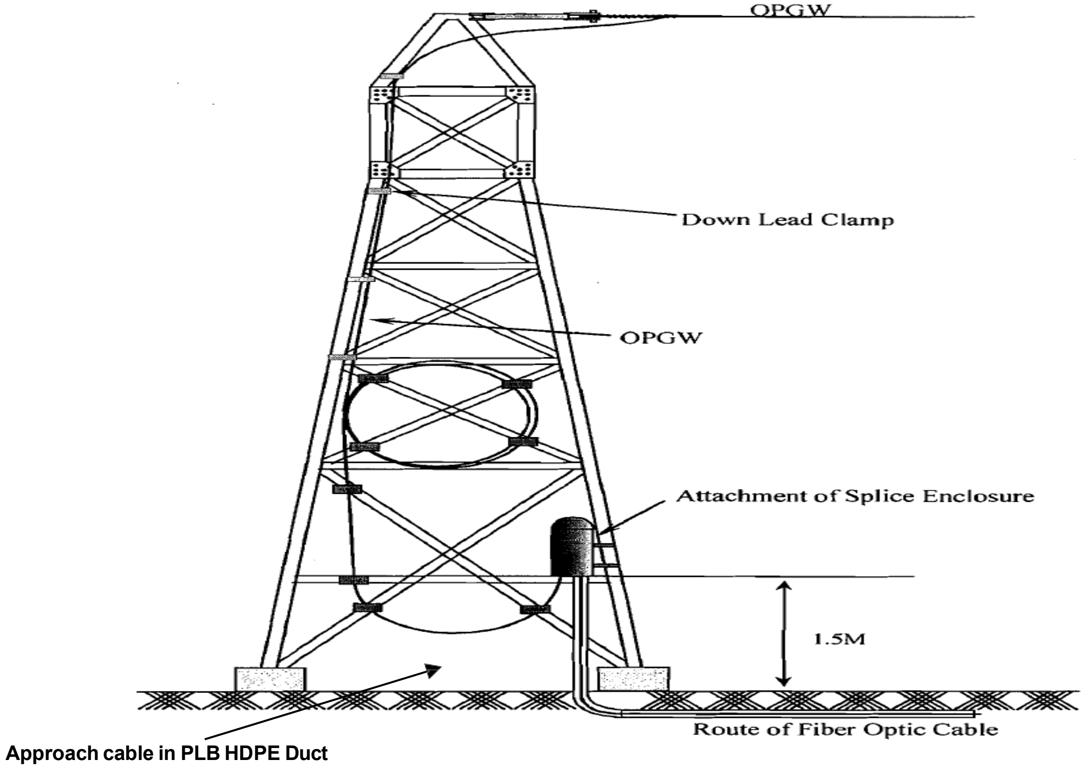
Roll the cable off the spool instead of spinning it off the spool end to prevent putting a twist in the cable for every turn on the spool. When laying cable out for a long pull, use a "figure-8" on the ground to prevent twisting. The figure 8 puts a half twist in on one side of the 8 and takes it out on the other, preventing twists.

PROCEDURE FOR PULLING OF OPTICAL FIBER CABLE:

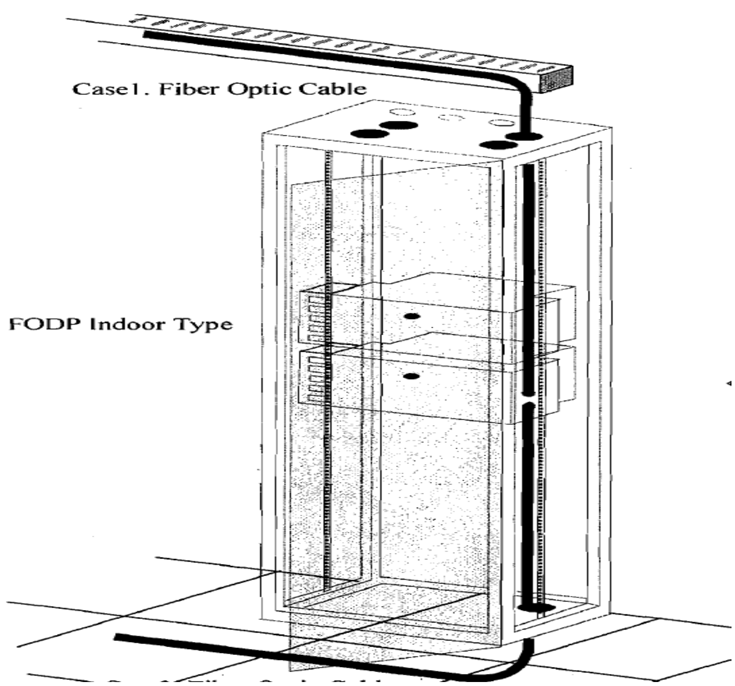
1. Use pulling grip designed for pre-connected fiber optic cables. Grips with a fixed pull ring should use a swivel to attach the pulling rope.
2. Monitor pulling tension. Do not exceed the maximum pulling load rating. On long runs, use proper lubricants and make sure they are compatible with the cable jacket. On really long runs pull from the middle out to both ends. If possible, use an automated puller with tension control or at least a breakaway-pulling eye.
3. Always use a straight pull. Use cable guides to maintain the recommended bend radius. Do not exceed the cable bending radius otherwise it will harm the optical fibers. It may not be immediate but it may even take a few years but eventually by exceeding the recommended bending radius of the cable you reduce life of the cable.
4. Do not twist the cable; putting a twist in the cable can stress the fibers.
5. Roll the cable off the spool. Use the device to aid in uncoiling long cables. Do not spin it off the spool end. This puts a twist in the cable for very turn on the spool. Figure 8 for a long pull. If you are laying cable for a long pull, use a figure 8 on the ground to prevent twisting.
6. Bend Radius: - Do not exceed the cable bend radius. Fiber optic cable can be broken when kinked or bent too tightly, especially during pulling. If no specific recommendations are available from the cable manufacturer, the cable should not be pulled over a bend radius smaller than twenty (20) times the cable diameter. After completion of the pull, the cable should not have any bend radius smaller than ten (10) times the cable diameter.
7. Vertical Cable Runs: - Drop vertical cables down rather than pulling them up whenever possible. Support cables at frequent intervals to prevent excess stress on the jacket. Support can be provided by cable ties (tightened snugly, not tightly enough to deform the cable jacket) grips. Use service loops can to assist in gripping the cable for support and provide cable for future repairs or rerouting.

The route for the fiber optic cable and FODP Lay out in control room. Planned route for approach cable at switchyard of sub-station





<u>**Gantry Tower in Sub-station**</u>



FODP (Fiber Optic Distribution Panel in Control Room

Protect cables from excessive or frequent bending. Routing on a cabinet door should be used as a resort and special care must be taken to protect the cable and avoid exceeding the bending radius of the cable.
When routing the cable proper pulling techniques should be used earlier in this manual. When attaching cables with clamps use plastic clamps with large surface areas and avoid pinching or squeezing cable. Cable should be installed manually with gentle pressure.

Cleaning Fiber Optic Connections

We recommend always keep dust caps on connectors, bulkhead splices, patch panels or anything else that is going to have a connection made with it. Not only will it prevent additional dust buildup, but it will prevent contamination from being touched or damaged from dropping.

When testing, we recommend that connectors on both the reference and tested cables be cleaned before every test, as every time the connector is exposed to air, it can accumulate dust.

Type Test Procedure for

OPGW Cable

The type test procedures to be conducted on the OPGW cable are as follows:

S.No.	TEST NAME	APPLICABLE STANDARD	TEST RESULT (PASS / FAIL)
1	Water Ingress Test	IEEE 1138-2021 Method 6.5.3.5	
2	Seepage of Filling Compound Test	IEEE 1138-2021 Method 6.5.3.6	
3	Short Circuit Test	IEEE 1138-2021 Method 6.5.3.3	
4	Aeolian Vibration Test	IEEE 1138-2021 Method 6.5.3.1	
5	Galloping Test	IEEE 1138-2021 Method 6.5.3.2	
6	Cable Bend Test	IEEE 1138-2021 Method 6.5.2.3	
7	Sheave Test	IEEE 1138-2021 Method 6.5.2.1	
8	Crush Test	IEEE 1138-2021 Method 6.5.2.2	
9	Twist Test	IEEE 1138-2021 Method 6.5.2.4	
10	Creep Test	IEEE 1138-2021 Method 6.5.1.1	
11	Strain Margin Test	IEEE 1138-2021 Method 6.5.1.3	
12	Stress Strain Test	IEEE 1138-2021 Method 6.5.1.2	
13	Temperature Cycling Test	IEEE 1138-2021 Method 6.5.3.7	
14	Corrosion (Salt Spray Test)	IEEE 1138-2021 Method 6.5.3.8	
15	Ultimate Tensile Strength Test	IEEE 1138-2021 Method 6.5.1.4	
16	Lightning Arc Test	IEEE 1138-2021 Method 6.5.3.4	
17	DC Resistance Test	IEEE 1138-2021 Method 6.5.1.5	

Note: All Hardware fittings to be used during type test shall be as per approved DRS/ drawings applicable for offered OPGW cable to be type tested.

Reference docs:

1. Approved DRS / Drawings of OPGW
2. Approved DRS / Drawings of OPGW fittings
3. Applicable standard. (IEEE 1138-2021)
4. Section -03– Technical specifications

TYPE TEST PROCEDURE FOR OPGW CABLE

（1） **Test Name: Water Ingress Test**

Final Customer: Power Grid Corporation of India Limited, India.
Project Name:
Manufacturer:
Cable Type:
Standard: IEEE 1138-2021 Method 6.5.3.5

CLASSIFICATION: Operation/environmental/ mandatory

INTENT

The intent of the Water Ingress Test is to determine if the quantity of fluid blocking compound in the OPGW cable is sufficient and uniformly distributed to inhibit water from migrating through the optical fiber unit. This test is only applicable for those cable designs that utilize a water-blocking compound inside the optical fiber unit. Water ingress into the optical fiber unit can degrade the performance of the optical fibers.

OBJECTIVE

To expose a length of fluid blocked optical fiber unit to a head of water to verify that water does not passthrough the unit.

The optical performance of the OPGW cable is not monitored during this test.

SET-UP

Water ingress test for OPGW cable that use water-blocking compound is based on the most recent revision of EIA/TIA-455-82, except that the test and retest lengths, if used, shall be 1.0 m.

A 1.0 m section of OPGW cable shall be prepared for this test. All components of the cable shall be removed from the fluid-blocked optical unit that contains the optical fibers.

The fluid-blocked optical fiber unit shall be positioned horizontally with one end attached to the bottom of a suitable tube containing a column of water that is at least 1 m in height using a watertight fitting. A clear, plastic tube is commonly used for this purpose. No part of the fluid-blocked component shall be above horizontal. The fitting shall not restrict water from entering the optical fiber unit. A collection dish, or equivalent means of detecting water, shall be placed under the open end of the optical fiber unit to collect any water that may pass through it.

Optical measurements are not required for this test.

The optical fiber unit and collection dish shall be visually checked for water. The start and completion times shall be recorded. No electronic measurements are required for this test.

PROCEDURE

The reservoir, or tube, shall be filled with water such that the head above the optical fiber unit is least 1.0m. The water shall be maintained at this level for at least one hour. During, and at the conclusion of, the one hour period, the open end of the optical fiber unit shall be visually checked for water.

ACCEPTANCE CRITERIA

No water shall leak through the open end of the 1.0m sample. If the first sample fails, one additional 1.0 m sample, taken from a section of OPGW cable immediately adjacent to the first sample, may betested for acceptance.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Water Ingress test.

(TESTED BY) (WITNESSED BY)
Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE
（2）Test Name: Seepage of Water-blocking Compound Test
Final Customer: Power Grid Corporation of India Limited, India.
Project Name:
Manufacturer)
Cable Type:
Standard: IEEE 1138-2021 Method 6.5.3.6

Classification: In-service/environmental/conditional

Intent

The intent of the Seepage of Water-blocking Compound Test is to determine if the water-blocking compound in the OPGW cable is vulnerable to flowing at elevated temperatures.

NOTE-This test is only applicable for those cable designs that utilize a fluid-blocking compound. The test is to demonstrate that the water blocking compound is not likely to seep.

Objective

a) To subject the OPGW cable to an elevated temperature that may cause the fluid-blocking compound to drip or otherwise leak from the optical fiber unit.

b) The optical performance of the OPGW cable is not monitored during this test.

Set-up

The general arrangement for the seepage of water-blocking compound test is shown in Figure2.1. The test shall be performed in accordance with TIA/EIA-455-81, except that an optional preconditioning cycle be used.

Five OPGW cable samples, each 30.0 cm ± 0.5 cm in total length shall be prepared. All metallic strandsare cut back 13.0 cm ± 0.25 cm from one end to expose the fluid-blocked optical fiber unit(s). The sample ends shall not be blocked or sealed to restrict the fluid flow. The samples are suspended vertically from a support frame. Small, lightweight collection dishes are placed directly under each sample to collect any fluid- blocking compound that may drip from the optical fiber unit. The samples shall be shielded from any aircirculation in the chamber. The temperature in the chamber shall be measured using a thermocoupleplaced near the support frame close to the samples.

Optical measurements are not required for this test.

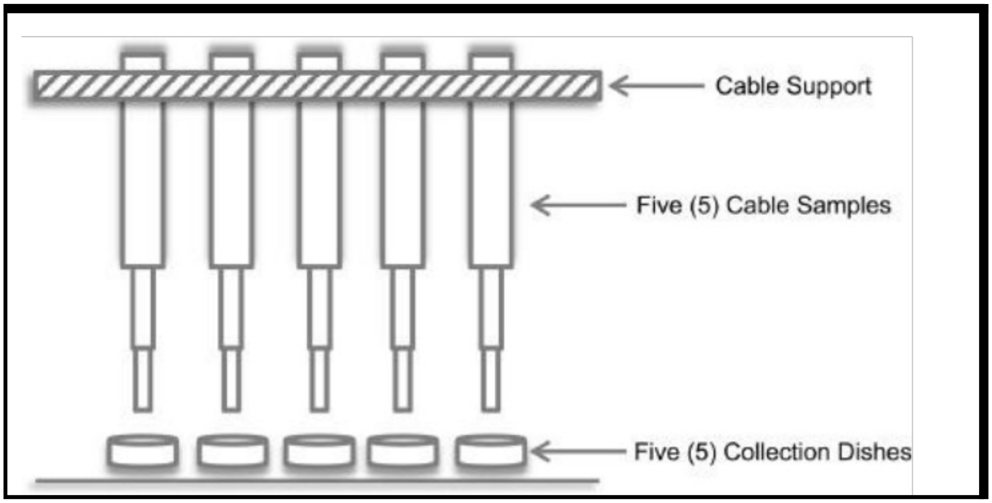


Figure 2.1—General arrangement for seepage of water-blocking compound test

Procedure

The temperature chamber shall be preheated to at least 65 °C.

The five samples and collection dishes shall be weighed and recorded using a scale having an accuracy of at least ±0.001 g. The support frame, with the covered samples, shall be placed in the chamber.

Optional preconditioning: A clean dish shall be placed directly under the test specimen. The sample shall be suspended vertically for one hour at 65 °C ±2 °C, unless otherwise specified. After preconditioning, the samples are removed from the chamber and the dishes weighed and recorded to measure the quantity of water-blocking compound that may have dripped during the preconditioning period. The preconditioning limit is the smaller of 0.5% of the total cable specimen weight or 0.5 g. Presence of a greater amount of material in the glass dish constitutes failure. If any fluid is collected in dish during preconditioning, replace it with a clean dish.

After the optional or one hour preconditioning period, clean dishes are placed under the samples and returned to the chamber. After 23 additional hours (24 h total), the samples are again removed from the chamber and the dishes weighed and recorded. Unless otherwise specified, report"NoFlow" for measured quantity changes less than or equal to 0.005 g.

Changes in weight of ±0.001 g are not considered due to leakage of water-blocking compound.

Acceptance criteria

At the end of 24 h, the water-blocking compound shall not flow (drip or leak) at 65 °C. Unless otherwise specified, the five cable samples shall be permitted a maximum flow quantity of 0.050 g.

If the flow quantity from one of the five initial cable samples exceeds 0.050 g, but is less than 0.100 g, prepare five new cable samples and retest. The test shall be considered successful if none of the second batch of samples have flow quantities greater than 0.050 g.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Seepage of Filling Compound test.

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(3) Test Name: Short Circuit Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2021 Method 6.5.3.3

Classification: In-service/electrical/mandatory

Intent

The intent of the short-circuit test is to subject the OPGW cable to a simulated short-circuit condition that represents an anticipated fault current. The intent is to determine if the resulting high temperatures adversely affected the optical signals or damages the cable strands such as permanent bird caging, loss of tensile strength through annealing of metallic components, or melting or softening of non-metallic components.

NOTE—Due to the potential loss of tensile strength of the cable when temperatures exceed 220 ºC, a tensile strength test following the Short-circuit Test is recommended on the test sample to verify it meets the vendor's specification for UTS.

Objective

a) To verify the mechanical performance of the OPGW cable when subjected to the specified short circuit conditions.

b) To verify the optical performance of the OPGW cable when subjected to the specified short- circuit conditions.

Set-up

A typical set-up for the Short-circuit Test is shown in Figure 3.1.

Apparatus

Two OPGW cable samples shall be used for this test. One sample is used to monitor the performance of the optical fibers and to observe any physical damage that might occur during the test. The second sample is used to measure the temperature at several points in the cross-section of the cable. If placed outdoors, the samples shall be positioned such that effects due to wind, solar radiation, etc., are the same on the samples.

The cables shall be electrically connected in series so that they are subjected to the same short-circuit current. Suitable means, such as low-level circulating ac current, shall be used to maintain the temperature of the cables as measured by the temperature sample to the manufacturers specified reference temperature for short-circuit capacity of the cable.

Optical sample

For optical attenuation measurements, the optical cable sample shall be prepared according to Table 3.2.

The length of cable between the current injection points shall be at least 10 m. The optical fibers shall be terminated beyond each dead-end clamp. A suitable means shall be used to tension the cable from 15% to 20% of the UTS of the OPGW cable when the cable is at the manufacturer's specified reference temperature. A suitable device such as a dynamometer or load cell shall be used to measure the tension in this sample.

Temperature sample

The temperature in this sample shall be measured at three locations or more. This is normally achieved using fast-responding thermocouples. However, other techniques that provide reliable and accurate data may be used if available. If thermocouples are used, they shall be spaced approximately 1 m apart, at the midpoint of the sample. They shall be installed in the cable to provide the temperature at the following points in the sample:

a) Located where the maximum temperature rise is expected. Depending on the design of the OPGW cable, this would normally be aluminum component(s) such as the wires, an aluminum tube, or the slotted central core, if applicable.

b) Located where the second highest temperature rise is expected. This may involve an aluminum component and a steel component or two steel components.

c) Located inside the optical unit with the intent of measuring the temperature of the optical fibers.

Thermocouples may be "pinched" between two adjacent components. It is recognized that the thermocouple will be influenced by any components making contact with the junction.

The thermocouples shall be isolated from other instrumentation to prevent electrical interference. A suitable means (e.g., turnbuckles, hydraulic cylinder) shall be used to tension this cable but it is not necessary to measure the tension.

Instrumentation and data acquisition

For each short-circuit application, or "pulse," a suitable data acquisition system shall record the short circuit current, the optical power readings from the optical sample and the thermocouple readings from the temperature sample.

The aluminum, steel, and non-metallic components of the cable will reach their respective maximum temperatures at different times. Typically, the optical fiber unit will take the longest time. For this reason,the data shall be acquired for sufficient time after each pulse in order to record the maximum temperatures of all components. The temperatures in the metallic components may reach their respective maximums in less than 1 s. For this reason, the data sampling rate shall be fast enough to capture these maximums.

Procedure

The cables shall be heated to 40 °C ±5 °C, unless otherwise agreed upon between supplier and user as indicated by the highest reading thermocouple in the temperature sample. All thermocouples shall be maintained at a constant temperature. The optical signals shall be stable for at least 15 min before proceeding.

If required, "preliminary" pulses, not to exceed about 50% of the supplier's specified short-circuit current value, may be applied in order for the test laboratory to determine the proper electrical parameters. Preliminary pulses are not considered part of the "official" test. If necessary, the optical signals shall be allowed to stabilize after the preliminary pulses before proceeding with the official test. Once stable, the difference between the power meters shall be zeroed 5 min before the first official pulse and shall be considered the start of the official test.

The cable shall then be subjected to five official pulses. For the official pulses, the minimum and maximum values for the electrical parameters are shown in Table 3.3:

Table 3.3—Electrical parameters

Parameter	Target value
Fault I^2t	Minimum kA^2s specified by supplier
Fault duration	Same as primary protection breaker operation, if known. Otherwise, maximum 0.5 s

The cable shall be allowed to cool (without the use of a water spray) to the specified reference temperature after each pulse as measured by the highest reading thermocouple. The cable will be held at the reference temperature for at least 5 min between pulses.

For each pulse, the fault current and duration may vary slightly from the target values. The objective is to achieve the I^2t level for each pulse. To recognize the practical issues of performing this test, the following allowances are made. The average of the five pulses shall equal or exceed the minimum I^2t level specified by the supplier. However, no single pulse shall be less than 95% of the minimum I^2tlevel.

The optical sample shall be visually inspected for birdcaging or other damage periodically throughout the test. Because the cable components can be disturbed when the thermocouples are installed, observations made on the temperature sample are not considered official.

After the final pulse, the optical and temperature data shall continue to be acquired for at least 15 min after the thermocouple with the highest reading has returned to the reference temperature. Final optical and temperature readings and observations of the cable shall be taken at this time. This designates the official end of the short-circuit test.

The optical cable sample shall be dissected after the test. Attention shall be paid in particular to the sections of cable closest to the terminating hardware, and at the midpoint of the span. Each separable component of the cable shall be separated and inspected for excessive wear, discoloration, deformation, or other signs of breakdown.

Acceptance criteria

a) Any cracking or breaking of any component of the optical sample shall constitute failure. This assessment is made with the naked eye.

b) There shall be no bird-caging of any of the strands of the optical sample. Bird-caging is defined as one or more cable strands that permanently protrude greater than one strand diameter from the normal cable geometry. A strand will be considered to have bird-caged if light can be seen betweenthe protruding strand and the cable. This observation will be made after the cable has cooled to the reference temperature after the last pulse. Temporary bird-caging during the pulses shall not constitute failure.

c) There shall be no permanent increase in optical attenuation greater than 0.05 dB/test fiber km at nominally1550 nm ± 20 nm for single-mode fibers.

d) If specified, the maximum temperature of any metallic component shall not exceed the manufacturers' value at any time during the test. Additionally, the temperature inside of the fiber unit shall not exceed 180 C at any time during the test. Higher temperatures may be allowed if agreed upon between manufacturer and end user.

e) Any excessive wear, discoloration of fibers, deformation, or other signs of breakdown shall constitute failure.

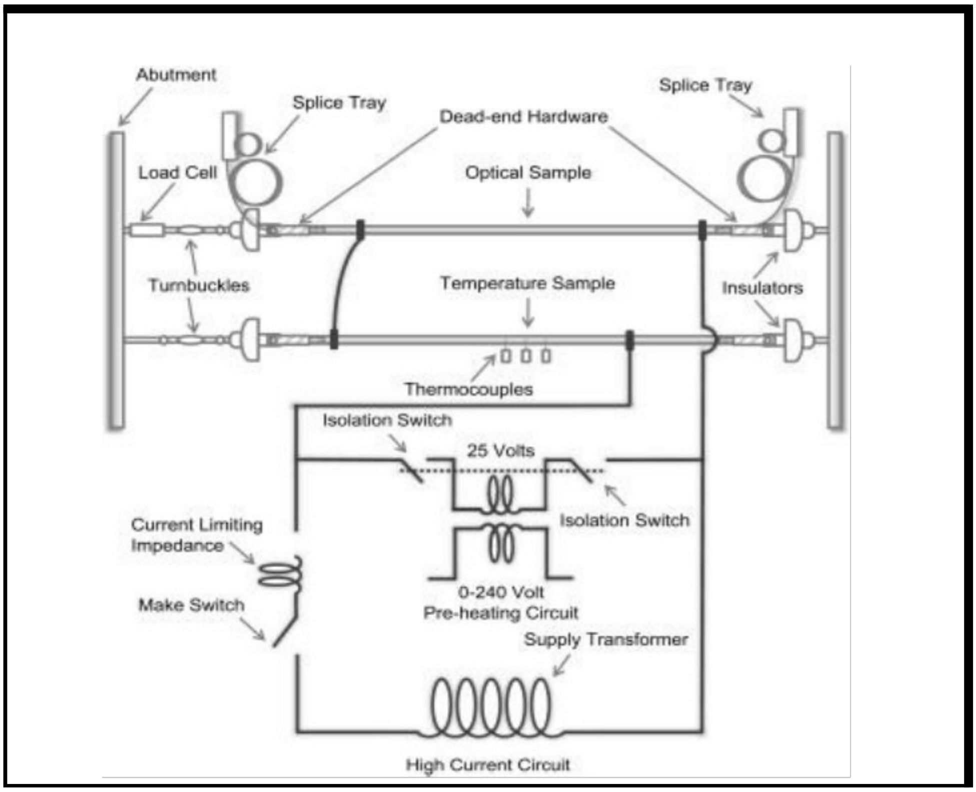


Figure 3.1—Electrical circuit for short-circuit test—Example

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Short Circuit test.

(TESTED BY)

Sign & Date

(WITNESSED BY)

Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(4) Test Name: Aeolian Vibration Test
Final Customer: Power Grid Corporation of India Limited, India.
Project Name:
Manufacturer:
Cable Type:
Standard: IEEE 1138-2021 Method 6.5.3.1

Classification: In-service/mechanical/mandatory

Intent

The intent of the Aeolian Vibration Test is to subject the OPGW cable and support hardware to simulated conditions. This type of conductor vibration is caused by laminar wind as it passes over bare cable and is a common occurrence in the field. Fatigue damage can occur on the metal components of the cable or hardware at attachment locations. The optical signals may also be adversely affected by Aeolian vibration.

Objective

a) To verify the mechanical integrity of the OPGW cable and the supporting hardware when subjected to simulated vibration conditions.

b) To verify the optical performance of the OPGW cable when subjected to the specified vibration conditions.

Set-up

The set-up for the Aeolian Vibration Test is shown in Figure 4.1.

Test Apparatus

The OPGW cable shall be contained between two intermediate abutments. The active span cable length shall be at least 20 m. The passive span cable length shall be approximately half the active span length. Fixed-end abutments shall be used to load and maintain tension in the fiber optic cable.

The dead-end assemblies shall be installed between intermediate abutments. The suspension assembly shall be supported at a height such that the static sag angle of the cable to horizontal shall be 1.5°± 0.5° in the active span.

An electronically controlled shaker shall be used to excite the cable in the vertical plane. The shaker armature shall be securely fastened to the cable so that it shall be approximately perpendicular to the cable in the vertical plane. The shaker shall be located in the span to allow a minimum of five vibration loops between the suspension assembly and the shaker.

The cable shall be prepared for attenuation measurements as described in 6.3.

A laser micrometer or other suitable means shall be used to measure the free loop antinode amplitude. The free loop antinode amplitude of the cable shall be measured at the second free loop from the suspension assembly toward the shaker.

A load cell or dynamometer shall be used to measure the cable tension. A thermocouple shall be used to measure the air temperature.

The optical power signals, peak-to-peak free loop amplitude, vibration frequency, number of cycles, cable tension, and air temperature shall be recorded at periodic intervals by a suitable data logging system.

Procedure

The OPGW shall be tensioned to 25%± 2% of the cable UTS and the exit angles of the cable from the suspension clamp measured.

This tension shall be applied using a cantilever weight arm on oneof the end abutments or other suitable means.

The vibration frequency shall be approximately equivalent to that produced by a 4.5 m/s wind (i.e., frequency = 830 divided by the diameter of the OPGW in mm). The actual vibration frequency shall produce standing waves and good system stability. The target free loop peak-to-peak antinode amplitude will be approximately one-third the diameter of the cable. This amplitude shall be maintained at this level in the second free loop from the suspension assembly toward the shaker. The frequency and amplitude may vary slightly during the test; however, the average antinode peak velocity (v=pi*f*Ymax) at the completion of the test shall be a minimum of 860 mm/s where Ymax the peak-to-peak free loop antinode amplitude.

The amplitude of the span from the dead end to the shaker and the passive span shall not exceed the amplitude of the span between the shaker and the suspension.

The number of vibration loops shall be counted, and their average loop lengths calculated for each of the three sections of the OPGW. The three sections are: between the dead end and shaker ; between the shaker and suspension ; and in the passive span between the suspension and dead end.

The OPGW shall be subjected to 100 million vibration cycles.

Optical measurements shall be taken for 15 min after the completion of the vibration cycles.

Acceptance criteria

a) Any cracking or breaking of any component of the OPGW cable or the supporting hardware shall constitute failure. This assessment is made with the naked eye.

b) A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at nominally 1550 nm for single-mode fibers shall constitute failure.

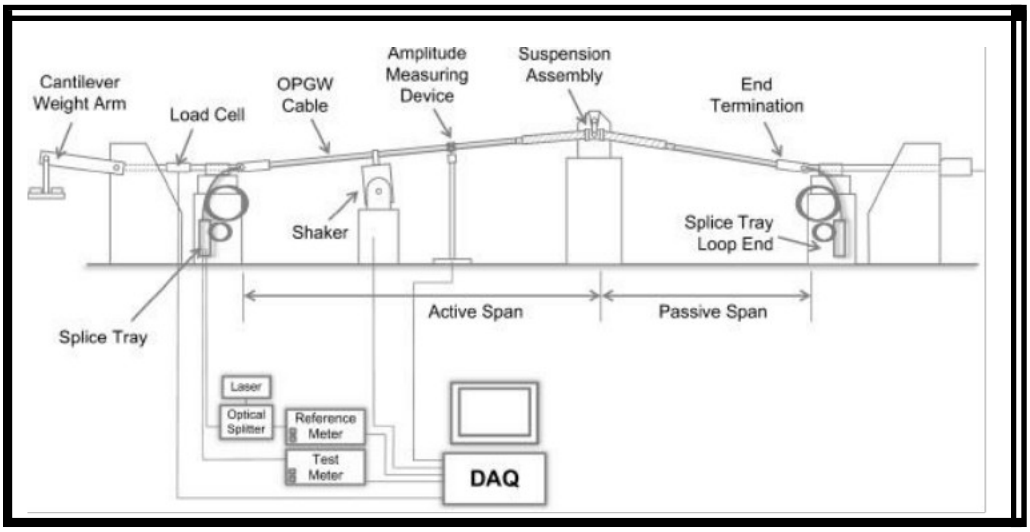


Figure 4.1 —General arrangement for Aeolian Vibration Test

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Aeolian Vibration test.

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(5) Test Name: Galloping Test
Final Customer: Power Grid Corporation of India Limited, India.
Project Name:
Manufacturer:
Cable Type
Standard: IEEE 1138-2021 Method 6.5.3.2

Classification: In-service/mechanical/conditional

Intent

The intent of the Galloping Test is to subject the OPGW cable and support hardware to galloping motions. This type of conductor motion is caused by the wind as it passes over bare or iced cables. This phenomenon typically occurs in areas that experience icing or wet snow. Fatigue or other damage can occur on the components of the cable, hardware, and/or to the structure. The optical signals may alsobe adversely affected by galloping.

Objective

a) To verify the mechanical integrity of the OPGW cable and the supporting hardware when subjected to simulated galloping conditions.

b) To verify the optical performance of the OPGW cable when subjected to the specified galloping conditions.

Set-up

The set-up for the Galloping Test is shown in Figure 5.1.

Test apparatus

The test section shall be contained between two intermediate abutments. The active span cable length shall be approximately 20 m, and the passive span cable length shall also be approximately 20 m. Fixed-end abutments are used to load and maintain tension in the cable. The initial tension shall be approximately 2% of the cable's UTS. This shall be applied using a cantilever weight arm or other suitable means.

The dead-end assemblies shall be installed between the intermediate abutments. The suspension assembly shall be supported at a height such that the static sag angle of the cable to horizontal shall be approximately than 1.5º in the active span. A calibrated load cell or dynamometer shall be used to measure the cable tension.

A suitable mechanism (e.g., hydraulically driven, motor-drive) shall be used to oscillate the cable in the vertical plane. The mechanism shall be located in the span and attached to the cable to oscillate the cable in a steady, single-loop gallop motion between the suspension assembly and the shaker.

The free loop antinode amplitude shall be measured in the active span at a point midway between the suspension assembly and the dead end. This shall be achieved by manually observing a graduated scale supported next to the cable.

The cable shall be prepared for attenuation measurements as described in 6.2.

The free loop peak-to-peak antinode amplitude, galloping frequency, optical power signals, tension, and number of cycles shall be recorded at periodic intervals. They may be recorded manually or with a data logging system.

Procedure

Reference optical measurements shall be taken while the cable is at tension and prior to starting the test. The difference between the reference and test signals for the initial measurement provides an initial base reading.

The change in this difference during the test indicates the change in the attenuation of the test fiber.

The cable shall be subjected to 100 000 galloping cycles in the single-loop mode. The frequency shall be adjusted such that the cable exhibits steady, single-loop galloping motions in the active span. The free loop peak-to-peak antinode amplitude shall be maintained at one twenty-fifth of the active span length for the duration of the test. Reasonable movements at both dead end and at the suspension are permitted in order to promote steady galloping motions in the active span. The galloping amplitude in the passive span shall not exceed the amplitude in the active span.

Acceptance criteria

a) Any cracking or breaking of any component of the OPGW cable or the supporting hardware shall constitute failure. This assessment is made with the naked eye.

b) A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at nominally 1550 nm for single-mode fibers shall constitute failure.

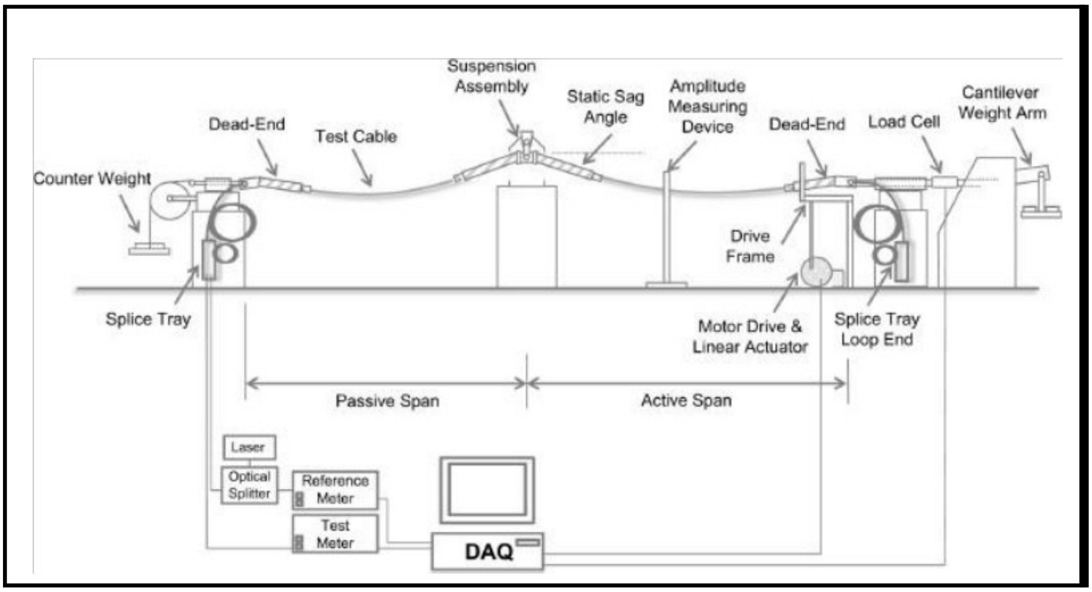


Figure 5.1: General Arrangement for Galloping Test

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Galloping test.

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(6) Test Name: Cable Bend Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE1138-2021 Method 6.5.2.3

Classification: Installation/mechanical/mandatory

Intent

The intent of the Bend Test is to subject the OPGW cable to a bending action similar to what might be experienced during installation. The cable and/or the fiber unit(s) could be damaged, and the optical performance could be adversely affected.

Objective

a) To verify the mechanical integrity of the OPGW cable when subjected to the specified minimum bend radius.

b) To verify the optical performance of the OPGW cable when subjected to the specified minimum bend radius.

Set-up

The preparation of the fibers and number of fibers to be spliced shall be according to 6.2.

Procedure

The minimum bend radius specified by the manufacturer shall be used for the maximum bend radius of the test set-up unless a larger value is agreed to between supplier and purchaser.

The cable sample shall be wrapped two complete times in a close helix around a mandrel with a radius no larger than the minimum bend radius specified by the manufacturer. Sufficient tension shall be applied to keep the sample in close contact to the mandrel. The cable shall beheld in this position for 1 min.

A reference optical measurement shall be taken prior to bending. Another measurement shall be made after the cable is bent around the mandrel and held stationary. The difference between the two signals for the initial optical measurement provides the test result. The change in this difference during the test would indicate any changes of attenuation in the test fiber. The signals shall be recorded using a digital data logging system.

Acceptance criteria

a) There shall be no cracking or breaking of any component of the OPGW cable constitutes failure.
This assessment is made with the naked eye.

b) There shall be no permanent increase in optical attenuation greater than 0.05 dB/fiber at 1550 nm± 20 nm for single-mode fibers.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Cable Bend test.

(TESTED BY)	**(WITNESSED BY)**
Sign & Date	Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(7) Test Name: Sheave Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2021 Method 6.5.2.1

Classification: Installation/mechanical/mandatory

Intent

The intent of the Sheave Test is to subject the OPGW cable to a simulated action of being pulled over a number of sheaves during installation. Installation includes stringing and sagging operations. During installation, it is possible the OPGW cable could become excessively deformed. The optical unit(s) could also be damaged, and the optic fibers adversely affected.

Objective

a) To verify the mechanical integrity of the OPGW cable when subjected to the specified installation conditions.

b) To verify the optical performance of the OPGW cable when subjected to the specified installation conditions.

Set-up

The general arrangement for the Sheave Test is shown in Figure 7.1. For optical attenuation measurements, the cable shall be prepared according to 6.3. The length of OPGW cable between loading points of the dead-end assemblies shall be a minimum of 8 m. The sheave shall be rigidly supported such that it cannot swing. For the sheave test, the nominal diameter of the sheave shall be 40 times the OPGW cable diameter unless otherwise specified. For practical reasons, considering commercially available sheave sizes, the chosen sheave shall be between 38 times and 42 times the OPGW cable diameter unless otherwise specified by the cable manufacturer.

NOTE—For installation applications, refer to IEEE Std 524 for the minimum sheave diameter and block recommendations, unless otherwise specified by the manufacturer. The sheave may be grooved or ungrooved and lined. The cable is initially tensioned to 15%± 1% of the cable UTS at a total deflection angle of 30°± 2º over the sheave. The method of attachment, while not required to be rigid, is limited to the twisting of the cable occurring near the dead ends. A suitable instrument, such as a dynamometer or load cell, is installed to measure the tension in the OPGW cable during the test.

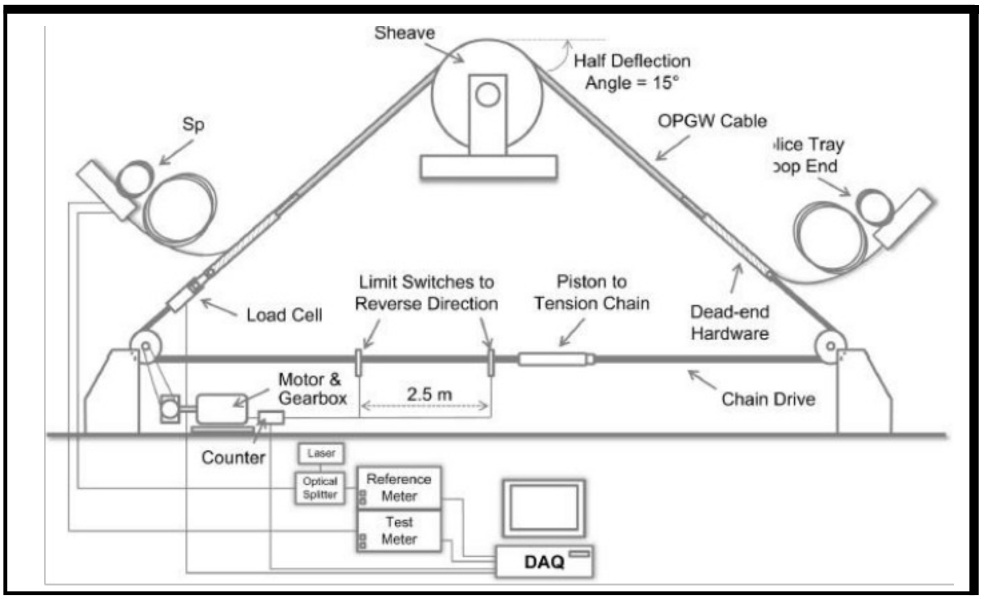


Figure 7.1—General test arrangement for sheave

Procedure

At least 2.5 m of the cable sample shall be pulled 20 cycles (i.e., 20 times in each direction) over the sheave.

Before the first pull, the midpoint and both ends of the 2.5 m length shall be located and marked. A suitable instrument (e.g., caliper, micrometer) shall be used to measure the maximum and minimum diameters at the three locations after tensioning before the first cycle and after the twentieth cycle. If necessary, the cable tension may be adjusted between cycles to maintain the level at 15% ± 1% UTS before each cycle.

The cable tension and the optical power meter signals shall be recorded at least two times every cycle using a suitable data logging system.

After the test, the cable section passing over the sheave shall be dissected and all cable components visually examined for any damage. The maximum and minimum diameters (dmax and dmin, respectively) of the unit(s) containing the fibers shall be measured at the same locations as the cable diameters were measured.

The ovality of the cable and of the metallic unit containing the fibers shall be calculated after the test using the following calculation:

$$\text{Ovality} = ((d_{max} - d_{min}) / (d_{max} + d_{min})) * 100\% \quad (1)$$

Acceptance criteria

a) The ovality of the cable and metallic units at the measured locations shall not exceed 10%.

b) Cracking or breaking of any component of the OPGW cable caused by the test shall constitute failure. This assessment is made with the naked eye.

c) A permanent increase in optical attenuation greater than 0.1 dB/test fiber km at 1550 nm ± 20 nm for single-mode fibers shall constitute failure.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Sheave test.

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(8) Test Name: Crush Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2021 Method 6.5.2.2

Classification: Installation/mechanical/conditional

Intent

The intent of the Crush Test is to subject the OPGW cable to simulated crushing or clamping forces that could occur during installation or maintenance. The cable could be crushed to the extent of adversely affecting the optical signals or reducing the tensile strength.

Objective

a) To verify the mechanical integrity of the OPGW cable and the supporting hardware when subjected to crush forces. Reference IEEE Std 1591.1.

b) To verify the optical performance of the OPGW cable when subjected to crush forces.

Set-up

The set-up for the Crush Test is shown in Figure 8.1. An untested cable section from the test sample prepared for the Sheave Test may be used for the Crush Test.

The number of fibers to be spliced shall be according to 6.3.

The cable shall be supported between two steel plates that transfer a compressive load uniformly over a 100 mm length of the sample. The edges of the plates shall be slightly rounded. The cable and plates shall be positioned in a suitable test machine. The test shall be carried out in a temperature-controlled laboratory at 22 °C ± 3 °C.

The crush load and the optical power meters shall be monitored and recorded every second by a digital data logging system.

Procedure

The test shall be performed in accordance with the most recent revision of EIA/TIA-455-41.

The cable shall be mounted between the plates with minimal load such that the cable is firmly positioned along the length of the steel plates. The load shall be then gradually increased to the value specified by the supplier within 1 min and 2 min and held for 10 min. The test shall be performed at three locations approximately 1 m apart.

The ovality of the cable and of the metallic unit(s) containing the fibers shall be calculated after the test using the following calculation:

$$\text{Ovality} = ((d_{max} - d_{min}) / (d_{max} + d_{min})) * 100\%$$

Acceptance criteria

a) Any ovality of the cable or optical fiber units at the measured locations that exceed 10% shall constitute failure.

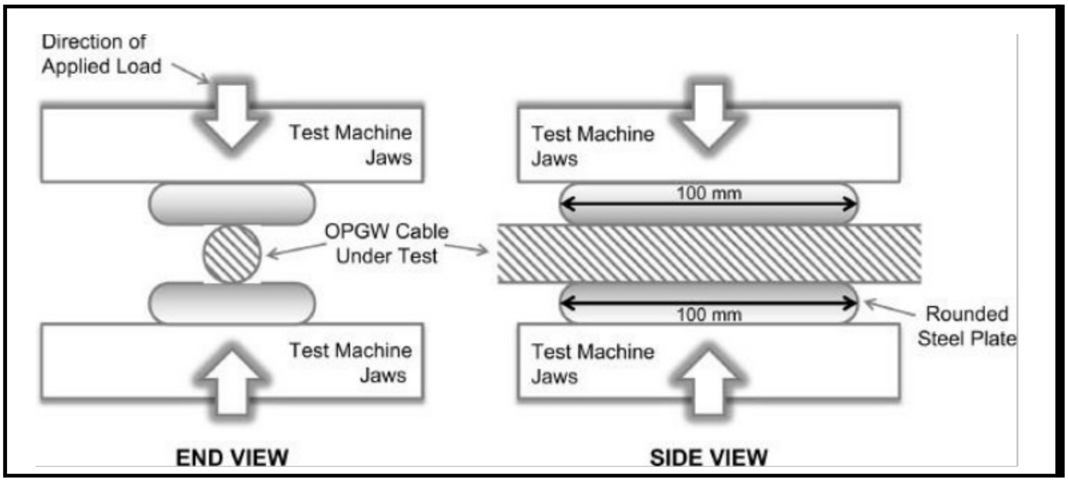
b) Any cracking or breaking of any component of the OPGW cable shall constitute failure.

This assessment is made with the naked eye.

c) A permanent increase in optical attenuation greater than 0.05 dB/fiber at 1550 nm ± 20 nm for single-mode fibers shall constitute failure.

The above criteria shall apply to all three test locations.

Figure 8.1: General Arrangement for Crush Test



OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Crush test.

(TESTED BY)	**(WITNESSED BY)**
Sign & Date	Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(9) Test Name: Twist Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2021 Method 6.5.2.4

Classification: Installation/mechanical/mandatory

Intent

The intent of the Twist Test is to subject the OPGW cable to a simulated action of being pulled during installation (i.e., stringing and sagging). During installation, the OPGW cable could become excessively deformed. The optical unit(s) could also be damaged, and the optical performance could be adversely affected.

Objective

a) To verify the mechanical integrity of the OPGW cable when subjected to the specified installation conditions.

b) To verify the optical performance of the OPGW cable when subjected to the specified installation conditions.

Set-up

The general arrangement for the twist test is shown in Figure 9.1. An OPGW cable sample shall be installed in a suitable tension test machine. The length of the cable between the dead-end assemblies shall be at least 10 m. One dead-end assembly shall be attached to the tensioning device through a load cell. The other dead-end assembly shall be attached to the stationery end of the test machine through a swivel. The OPGW cable sample shall be fixed onto itself so as to allow rotational motion without disturbing the optical splice arrangement.

The OPGW cable sample shall be terminated beyond both dead-end assemblies such that the optical fibers could not move relative to the OPGW cable. The cable and fiber terminations and the method to measure optical attenuation are described in 6.3.

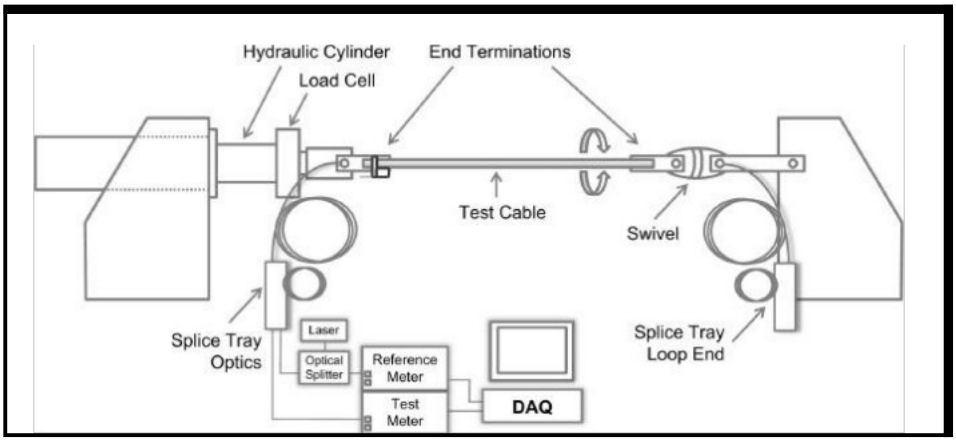


Figure 7—General arrangement for twist test

Procedure

The cable shall be tensioned to 20% of the cable UTS. The cable sample shall be rotated in the direction of the lay of the strands for two and one-half turns (i.e., “tightening” the lay of the cable). This number of turns shall be calculated from the test cable length to produce a total twist in the cable of 90º per meter. The cable sample shall be rotated back to the initial position. The cable shall be rotated in the reverse direction to the lay of the strands (i.e., “loosening” the lay of the cable). The cable sample shall be again reversed in direction to rotate the cable sample to its original position. This constitutes one torsion cycle. This cycle shall be repeated a second time. The signals from the optical power meters and the cable tension as measured by the load cell shall be monitored continuously using a data logging system.

Acceptance criteria

a) Any cracking or breaking of any component of the OPGW cable shall constitute failure.This assessment is made with the naked eye.

b) A permanent increase in optical attenuation greater than 0.10 dB/test fiber km at 1550 nm ± 20 nm for single-mode fibers shall constitute failure.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Twist test.

(TESTED BY)	**(WITNESSED BY)**
Sign & Date	Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(10) Test Name: Creep Test
Final Customer: Power Grid Corporation of India Limited, India.
Project Name:
Manufacturer:
Cable Type:
Standard: IEEE 1138-2021 Method 6.5.1.1

Classification : Cable characteristic/mechanical/conditional

Intent

The intent of the Creep Test is to determine the long-term tensile creep characteristics of the OPGW cable. This information is used in the sag-tension calculations during the design layout of an optical fiber cable system.

Objective

a) To produce the long-term, room temperature tensile creep curve and equation for the OPGW cable.

b) The optical performance of the OPGW cable is not required to be monitored during this test unless specified by the cable purchaser.

Set-up

The general arrangement for the creep test is shown in Figure 10.1.

The test shall be set up in accordance with IEC 61395 [B2] unless otherwise specified by the cable purchaser and were noted in this standard.

The OPGW cable sample shall be terminated such that all the load carrying components of the cable are prevented from moving relative to each other at the loading points. A suggested method is to use epoxy resin grips to encapsulate all components of the cable at the loading points.

The OPGW cable sample shall be installed in a test facility suitable for creep testing. The length of the cable between the loading points of the dead-end assemblies shall be ~10 m. The cable shall be preloaded to a maximum of 2% of the UTS of the cable. The cable shall not remain at the preload value for more than 5 min. A suitable transducer shall be used to measure the longitudinal cable elongation over a gauge length of ~8 m. A suitable transducer such as a load cell or dynamometer shall be used to measure the tension in the cable.

A shorter cable length or gauge length may be used, provided that the accuracy of the strain measuring device satisfies the guidelines outlined in IEC 61395.

The cable temperature shall be measured at both ends of the gauge section. The test shall be carried out in a temperature-controlled environment at 22 °C ± 3 ºC.

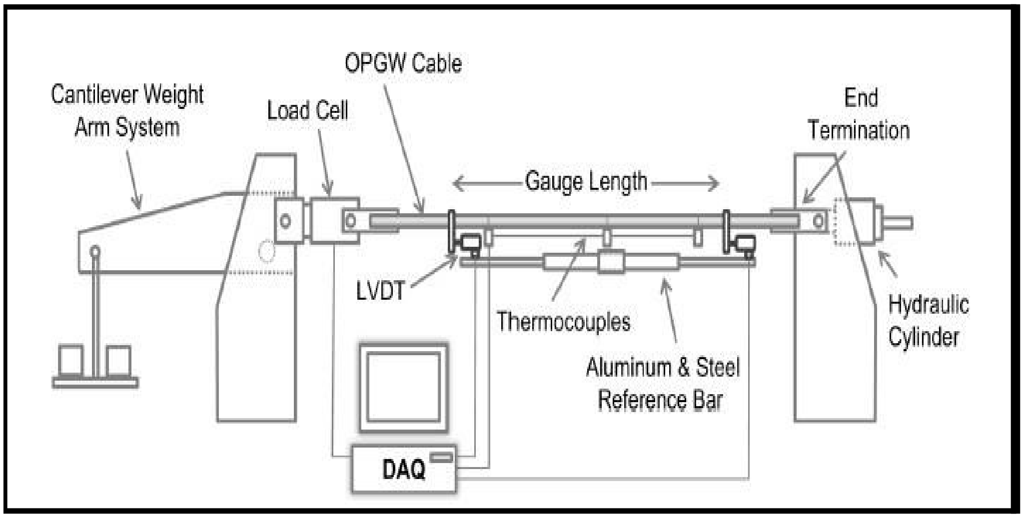


Figure 10.1-General arrangement for creep test

Procedure

The test shall be performed in accordance with IEC 61395 unless otherwise specified by the cable purchaser or noted in this standard.

The test shall comprise of the two separate tensions of 25% and 40% of the UTS of the cable unless otherwise specified by the cable purchaser and depending on laboratory capability.

The cable shall be tensioned at a rate such that the time to reach the test tension ±2% of this tension is 5 min± 10 s. Final adjustments may be made to achieve the test tension within 10 min of the start of loading. However, the load shall remain within ±2% of the test tension at all times while any final adjustments are made. Sudden loading or unloading of the cable shall be avoided at all times. For each tension, the load on the cable shall be maintained at the test tension ±1% for 500 h.

The elongation of the cable and applied load shall be monitored and recorded during the test as per IEC 61395 using a suitable data logging system.

Acceptance criteria

Unless otherwise specified by the cable purchaser, there are no acceptance criteria for this test.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for creep test.

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(11) Test Name: MRDT (Strain Margin Test) Test
Final Customer: Power Grid Corporation of India Limited, India.
Project Name:
Manufacturer:
Cable Type:
Standard: IEEE 1138-2021 Method 6.5.1.3

Classification: Cable characteristic/mechanical/mandatory

Intent

The intent of the MRDT test is to tension the cable up to the manufacturer's MRDT and observe the fiber strain and verify that acceptable optical performance is maintained.

NOTE—The MRDT is a load limit that the manufacturer recommends not be exceeded should the cable be exposed to its heavy load conditions.

Objective

a) To determine the cable tension at which the optical fibers begin to strain (0.05% strain level).

b) To verify the optical performance of the OPGW cable during the test up to the MRDT.

Set-up

The OPGW cable sample shall be terminated such that all of the load carrying components of the cable are prevented from moving relative to each other at the loading points. For optical attenuation measurements, the cable shall be prepared according to 6.3. The number of fibers to be spliced shall be according to 6.3 less the number used for fiber elongation.

For the fiber elongation measurement, at least four fibers shall be spliced together. Fiber elongation shall be measured using suitable optical equipment. If the optical equipment is able to measure fiber strain directly, then a gauge length is not required. If the equipment used measures absolute fiber elongation, such as a high resolution OTDR, then the gauge length shall be taken to be the length of fiber from dead end to dead end, plus half the length of each set of three loops beyond each dead end.

The OPGW cable sample shall be installed in a suitable tensile test machine. The length of the cable between the loading points of the dead-end assemblies shall be a minimum of 10 m. The cable shall be preloaded to a maximum of 2% of the UTS of the cable. It shall be supported over its length such that the cable will not lift by more than 10 mm at the test tension condition. A suitable transducer shall be used to measure the longitudinal cable elongation over a gauge length of at least 8 m. A suitable transducer such as a load cell or dynamometer shall be used to measure the tension in the cable.

The test shall be carried out in a temperature-controlled environment at 22 °C ± 3 ºC.

Procedure

The cable shall be tensioned to the manufacturer's MRDT at a uniform rate that is used to achieve the cable UTS in 20 min to 30 min. The load shall be held for 5 min at the MRDT. Readings of the optical attenuation, fiber, and cable elongation shall be taken at periodic intervals, at least every 5 min while loading the cable.

The load shall be reduced back to 2% UTS and permanent attenuation measured.

If fiber elongation was not reached during the first cycle, the load may be continuously increased up to 100% UTS or until the fibers begin to elongate. The data from the instruments shall be recorded simultaneously. This step is considered for information only. Refer to Fig. 11.1 for loading schedule for MRDT test.

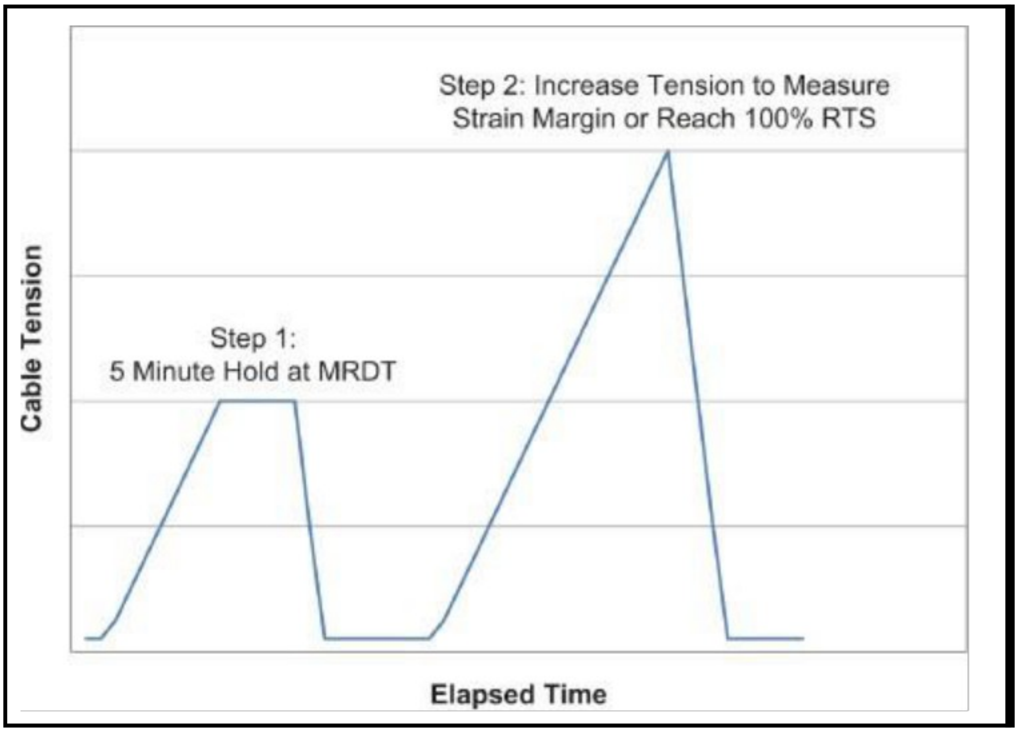


Figure 11.1—Loading schedule for MRDT test

The strain margin is assumed to be the cable strain (or cable load) at which the fibers are measurably strained in the context of sample preparation and resolution of measuring equipment (typically equal or greater than 0.05%).

From the strain margin point, it is expected that the slope of the cable strain and fiber strain should be parallel when plotted.

NOTE-If agreed between the supplier and the purchaser, the cable may be loaded to failure on completion of the MRDT test to obtain the breaking strength of the cable. If this is done, it is not considered part of the MRDT test and therefore cable strain measurements are not required. If a breaking strength test is performed, the load is to be applied at a rate such that the time to reach the UTS of the cable is at least 5 min. Premature failure of the cable during the breaking strength test does not invalidate the data obtained from the MRTD test.

Acceptance criteria

The cable shall show no permanent change in attenuation per test fiber km from preload to the maximum rated design tension (MRDT) of the cable at 1550 nm ± 20 nm for single-mode fibers.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for MRDT test.

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(12) Test Name: Stress Strain Test

Final Customer: Power Grid Corporation of India Limited, India.

Project Name:

Manufacturer:

Cable Type:

Standard: IEEE 1138-2021 Method 6.5.1.2

Classification : Cable characteristic/mechanical/mandatory

Intent

The intent of the stress-strain test is to determine the stress-strain characteristics and the final modulus of elasticity (MOE) of the OPGW cable. This information is used in the sag-tension calculations during the design layout of an overhead cable system.

Objective

a) To produce the stress-strain curve and the initial and final MOEs for the OPGW cable.

b) Monitoring the optical performance of the OPGW cable is not required during this test unless specified by the cable purchaser.

Set-up

The general arrangement for the stress-strain test is shown in fig.12.1. The test shall be set up in accordance with IEC 61089[B1] unless otherwise specified by the cable purchaser and where noted in this standard.

The OPGW cable sample shall be terminated such that all the load carrying components of the cable are prevented from moving relative to each other at the loading points. A suggested method is to use epoxy-resin grips to encapsulate all components of the cable.

The OPGW cable sample shall be installed in a suitable tensile test machine. The length of the cable between the loading points of the dead-end fittings shall be a minimum of 10 m. The cable shall be preloaded to a maximum of 2% of the UTS of the cable. It shall be supported over its length such that the cable will not lift by more than 10 mm at the maximum tension condition. A suitable transducer shall be used to measure the longitudinal cable elongation over a gauge length of at least 8 m. A suitable transducer, such as a load cell or dynamometer, shall be used to measure the tension in the cable.

The test shall be carried out in a temperature-controlled environment at 22 °C ± 3 °C.

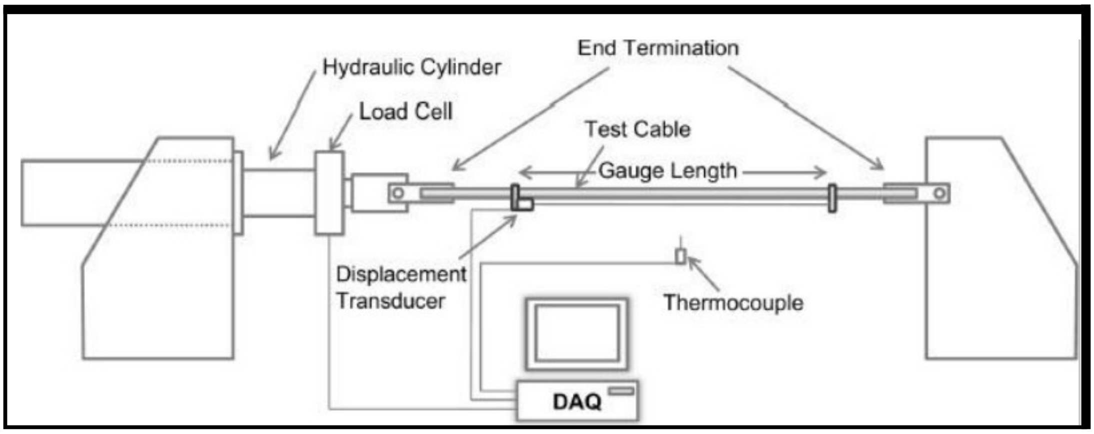


Figure 12.1-General arrangement for stress-strain test

Procedure

The test shall be performed in accordance with IEC 61089 unless otherwise specified by the cable purchaser or noted in this standard.

The cable shall be tensioned according to the loading schedule in the following table. To reduce creep during loading, all loads shall be applied based on the rate to reach 30% of UTS within one to two minutes. Higher rates may be used, if agreed between the supplier and the purchaser. The elongation of the cable and applied load shall be monitored and recorded at appropriate intervals using a suitable data logging system. Load and elongation data shall be recorded a minimum of every 5 min during each hold period and at all preloads. If possible, more frequent readings are preferred.

See Table 2.

Table 2 —Tension loading schedule

Step	**Load % UTS**	**Hold time (min)**
Preload	2	—
1	30	30
Preload	2	< 2
2	50	60
Preload	2	< 2
3	70	60
Preload	2	< 2
4	85	60
Preload	2	—

The slope of the final unloading curve from 85% UTS is the final MOE of the cable.

If agreed between the supplier and the purchaser, the cable may be loaded to failure on completion of the Stress-Strain Test to obtain the breaking strength of the cable. If this is done, it is not considered part of the Stress-Strain Test and therefore cable strain measurements are not required. If a breaking strength test is performed, the load shall be applied at a rate such that the time to reach the UTS of the cable is at least 5 min. Premature failure of the cable during the breaking strength test does not invalidate the data obtained from the Stress-Strain Test.

Acceptance criteria

Unless otherwise specified by the cable purchaser, there are no acceptance criteria for the Stress-Strain Test.

If performed the breaking strength of cable shall meet or exceed 100% of the cable UTS.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met the acceptance criteria for Stress Strain test.

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(13) Test Name: Temperature Cycling Test
Final Customer: Power Grid Corporation of India Limited, India.
Project Name:
Manufacturer:
Cable Type:
Standard: IEEE 1138-2021 Method 6.5.3.7

Classification: In-service/environmental/mandatory

Intent

To subject the OPGW cable to extreme temperatures as may be experienced in the field by the cable.

Objective

To verify the optical performance of the OPGW cable when subjected to the specified temperature conditions.

Set-up

A sample with a minimum of 500 m of cable shall be placed in a suitable thermalchamber.

For optical attenuation measurements, the optical cable sample shall be prepared according to 6.3.

Two thermocouples shall be placed in the environmental chamber to measure the temperature.

They shall be placed on a 25 cm cable sample located either side of the cable reel.

Procedure

The test shall be performed in accordance with the most recent revision of TIA/EIA-455-3.

The cable shall be subjected to two thermal cycles. A thermal cycle is based on the chamber temperature starting at 22 °C± 3 ºC, lowering to at least–40 ºC and holding for a minimum of 16 h. The temperature shallthen be increased to at least 85 ºC and held for a minimum of 16 h. To complete the cycle, the temperature shall be returned to 22 ºC. All temperature transitions shall be conducted at a rate of 20ºC to 40 ºC per hour. The chamber temperature is based on the average of the two thermocouples onthe 25 cm cable samples.

At a minimum, the thermocouples and optical data shall be at recorded at the beginning and end of the test and at the beginning and end of every hold period.

Refer to Figure 13.1 for a typical example of a temperature profile for a temperature cycling test.

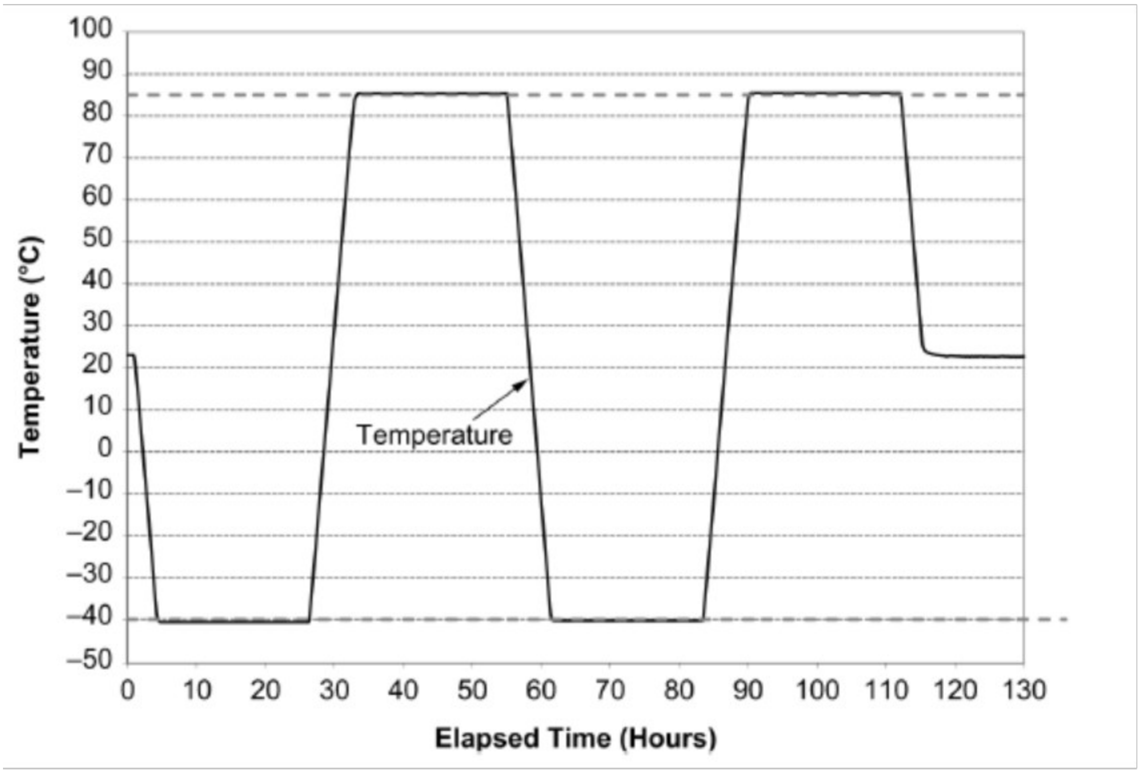


Figure 13.1-Typical temperature profile for temperature cycling test

Acceptance criteria

A permanent or temporary increase in optical attenuation greater than 0.2 dB/test fiber km at 1550 nm ± 20 nm for single-mode fibers shall constitute failure.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Temperature Cycling test.

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date

TYPE TEST PROCEDURE FOR OPGW CABLE

(14) Test Name: Corrosion (Salt Spray Test)
Final Customer: Power Grid Corporation of India Limited, India.
Project Name:
Manufacturer:
Cable Type:
Standard: IEEE 1138-2021 Method 6.5.3.8

Classification: Storage/in-service, environmental/conditional

Intent

To subject the OPGW cable to salt fog corrosion that may be experienced in the field by the cable.

Objective

The objective of this test is to determine the effects of a controlled salt atmosphere on the OPGW sample.

Set-up

This test is a 1000 h saltbox spray test. Three cable samples of 75 c m ± 5 cm shall be cut from the reel of OPGW. Heat shrink tubing or silicone seal shall be placed over both ends of the cable to a distance not to exceed 7.5 c m ± 0.5 cm from either end of the cable sample. The purpose of the tubing is to reduce or eliminate the corrosion occurring at the open ends of the test cable.

Procedure

Pre-test cleaning and handling:

= During cutting and preparation of the test samples, care shall be taken not to introduce any contamination or debris onto the surface of the cable samples.

= Samples shall not be disassembled or rinsed.

= Optionally, samples may be cleaned using forced air supply to remove any foreign particles from the surface. This may not be applicable for greased cable designs.

The test cables are placed into a standard salt spray-testing box as defined by ISO 9227 [B7] or ASTM B 117 [B1]. The cable samples are to be placed horizontal in the test chamber to simulate a standard horizontally suspended OPGW cable. The test is to run continuously for 1000 h for salt spray testing.

Post-test cleaning and handling:

- Unless otherwise specified, the cable samples shall be carefully removed from the chamber, with care not to damage or disturb the tested samples.

- As specified in ASTM B117, samples may be gently washed or dipped in clean running water not warmer than 38 °C (100 °F) to remove salt deposits from the surface, and then immediately dried.

Visual inspection:

a) Samples shall be inspected as soon as possible once removed from the chamber.

b) Samples shall be inspected with the unaided eye. A low magnification lens may be used for the suspect areas.

c) Samples with heavier salt deposits may be lightly brushed to remove the surface deposits. Care shall be taken not to disturb the underlying metallic surface.

d) In the event suspect locations are found in more than two locations, additional detailed inspections may be warranted under higher magnification. 1) For example: If wires are identified on all three samples, where the aluminum cladding appears to have corroded to expose the underlying steel member, a suitable metallographic analysis [e.g., potted cross section or energy dispersive spectroscopy (EDS)] may be used.

e) Samples sent for additional detailed inspection shall not be disturbed any way (i.e., no brushing).

Acceptance criteria

At the end of the test, the cables are to be removed and dissected for corrosion damage. The cable design has failed and is not suitable for high corrosion sites if:

a) There is more than one location (see NOTE) where the aluminum-clad steel wires have been pitted so as to expose the underlying steel strength member in any way whatsoever.

b) There is more than one location (see NOTE) where solid aluminum wires have been point pitted beyond a depth of 10% of the total individual wires diameter at the point of the pit.

c) There is damage to the optical fiber unit (e.g. material loss, point pitting beyond a depth o0f 10% of the tube thickness, deformation of the tube or any other condition that may affect the performance of the fibers).

d) In the case of aluminum coated tubing, there can be no removal of the aluminum coating that exposes the underlying stainless-steel tube.

e) In the case of“other”coated tubing or wires, there can be no removal of the coating that exposes theunderlying tubing to the elements.

NOTE—One (1) suspect location, in only one (1) wire, may not be a significant representation of the overall cable performance.

OBSERVATIONS, IF ANY:

TEST RESULT: The OPGW cable met/not met the acceptance criteria for Corrosion (Salt Spray test).

(TESTED BY) **(WITNESSED BY)**

Sign & Date Sign & Date