

Communication Specification

for

**Composite Overhead Ground Wire
with Optical Fiber (OPGW)**

OD. 13.5 mm.

Bid No. TIEC-L-06

EGAT TELECOMMUNICATIONS EQUIPMENT
(FOR OPGW diameter 10.5 and 13.5 mm)

Section A - Overview

A-1 GENERAL

A-1.1 Description

The Electricity Generating Authority of Thailand (EGAT) requires a digital fiber optic transmission system which can support the transmission of Voice, Data, Teleprotection, Telecontrol, Supervisory Control and Data Acquisition (SCADA), and other communication services for the operation and maintenance of both the power and communications systems.

This specification details the general requirements for design, manufacture, test, supply, and installation of composite overhead ground wire with optical fiber (OPGW), optical fiber cables, and accessories.

A-2 System Overview

The composite overhead ground wire with optical fibers detailed in this specification represents the sections required to develop high capacities route as specified in the Contract. These sections shall be installed along with 115 kV, 230 kV and/or 500 kV power transmission line covered in this specification.

The digital Fiber Optic Transmission System (FOTS) shall operate at 2.048, 8.192, 34.368, 139.264, 155.52 , 622.08 Mbit/s and 2.5 Gbit/s.

The Bidder is invited to quote each alternative optical fiber as an Alternate Technical Proposal. All alternative optical fiber shall include a detailed description of all aspects of this specification which have been modified, and shall describe in quantitative terms (wherever possible) the advantages of making the proposed changes.

A-2.1 Repeater Locations

All repeater locations shown on the drawing have road access and access to power. Any alternative repeater location proposed by the contractor shall be provided with similar access by EGAT.

A-2.2 Installation and Field Testing

All installation and field testing shall be performed under the direct supervision of an experienced supervisor recommended by the manufacturer. The Contractor shall provide a copy of the letter of recommendation, detailing the experience of the recommended supervisor with the proposal.

A-3 BID REQUIREMENTS SUMMARY

This specification is made up of three (3) major sections as follows:

- A. Overview
- B. General Requirements
- F. Optical Fiber

Sections B and F are EGAT general specifications which have not been specifically altered to suit this specification. Each section contains numerous sub-sections, some of which are designated as "Option". At the discretion of EGAT, these optional sections may or may not be purchased as part of the project.

The Bid Requirement table summarizes the sections which may or may not apply to this specification. Any section or sub-section listed as "Required" must be complied with. Items listed on the table not marked "Required" do not apply to this specification. Failure to comply with any "Required" section may disqualify the bid.

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BID REQUIREMENTS TABLE

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Section	Section Title	Page	Required
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Noted: “*” shall be required only for 500 kV transmission line system or anywhere specified.
“**” shall be required if specified in the price schedule.

TELECOMMUNICATIONS EQUIPMENT

Section B - General Requirements

B-1 Codes and Standards

All equipment, materials, fabrication and testing shall conform to the latest applicable standard specifications and codes contained in the following list, or equivalent applicable standard specifications and codes established and approved in the country of manufacture of the equipment. Where standards are mentioned by name equivalent applicable standards may be used. The following common abbreviations for standard documents may be used throughout the Telecommunications Equipment Specifications :

AISC	American Institute of Steel Construction
ASA	American Standards Association
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
ITU	International Telecommunication Union
CEPT	Conference Europeene des Postes et Telecommunications
CFRF	Conference Internationale des Grande Reseaux Electriques a Houte Tension
EIA	Electronic Industries Association
FCC	Federal Communications Commission (USA)
ICAO	International Civil Aviation Organization
IEC	International Electro-technical Commission
ISO	International Standards Organization
NEMA	National Electrical Manufacturers' Association
NTT	Nippon Telegraph and Telephone Corporation

All threaded parts requiring connection to any external equipment shall conform to the American National Standard for threads. All internal parts may have threads in accordance with the established specifications in the country of manufacture.

B-1.1 Units

All units of measurement shall be in the metric system, except for cables, shaped steel, pipe and threaded parts, for which inch sizes may be used. The interpretation of abbreviations and symbols used in this specification shall be determined by EGAT.

B-1.2 Proposal Data and Price Proposal

1. The Bidder shall provide a detailed compliance statement indicating compliance/non-compliance with every item of this specification. For all items where the Bidder is not able to comply, a detailed description of the specifications which can be met shall be provided.
2. The Bidder's response shall include all optical fiber descriptions and drawings necessary to support the Bidder's compliance statement.
3. The Bidder shall provide all additional documentation specifically requested throughout this specification. Failure to provide required documentation may disqualify bid. Where specific information requested is not available, alternate information providing as much as possible of the requested information may be

provided; EGAT shall notify the Bidder if the alternate information is not sufficient to qualify the bid for consideration.

4. The Bidder's proposal shall include a comprehensive Tentative Work Schedule, clearly identifying start and end dates for every phase of the telecommunications related portions of the project.

B-2 Special Climatic Treatment

All optical fiber shall be designed and manufactured for satisfactory operation under the following conditions of ambient temperature and relative humidity.

Application	Temperature	Relative Humidity
Indoor installation	0 - 45°C	30 - 90%
Outdoor installation	0 - 50°C	30 - 95%

B-3 Factory Testing

B-3.1 Conditions

1. The optical fiber shall be considered ready for testing at the factory when the conditions of all Performance Guarantees have been met.
2. The Contractor shall supply all necessary test equipment which shall be of high quality and shall be kept calibrated throughout the duration of factory testing. If requested by EGAT's representative, the Contractor shall demonstrate the test equipment calibration. All test equipment shall conform to that specified in the test procedures.
3. The Contractor shall be prepared to prove, to the satisfaction of EGAT's representative, the validity of any of its published specifications on the optical fiber if during the course of the factory testing these specifications appear (in the opinion of the EGAT representative) to be in doubt. Further, if it becomes necessary to change any specifications, this change must be made with the consent of EGAT, and the Contractor shall confirm the change in writing.
4. All costs incurred during the factory testing process shall be borne by the Contractor, except that EGAT shall bear the costs for any representatives witnessing factory tests.
5. Four (4) certified copies of the results of the testing shall be submitted to EGAT within fifteen (15) days of factory testing end date.

B-3.2 Tests

The Contractor shall perform complete equipment line-up tests on optical fiber. The Contractor shall test and verify all guaranteed parameters for the optical fiber purchased. In addition, the Contractor shall, upon the EGAT representative's request, test any of these parameters to the full extent of the Contractor's specifications, whether guaranteed or not. The units to be tested shall be selected by EGAT's representative from the optical fiber being supplied for the Contract. EGAT also reserves the right to request the Contractor to perform any additional test to confirm the performance of any unit(s) if, in the opinion of EGAT's representative, the performance of the unit(s) appears to be doubtful.

B-3.3 Schedule

1. The Contractor shall allow a minimum of two (2) weeks in the schedule for factory testing which may be witnessed by EGAT's representative(s).
2. The Contractor shall notify EGAT of the factory testing schedule at least thirty (30) days prior to the factory testing start date.
3. The testing schedule shall be so arranged that normally there is not more than a one (1) day break in testing. Breaks greater than one (1) day must have the consent of EGAT.
4. The Contractor shall reimburse EGAT for any and all additional expenses incurred by EGAT as a result of the testing schedule being delayed, unless the failure to meet the schedule is directly caused by EGAT or its representative.

B-4 Field Testing

The Contractor shall notify EGAT regarding the field testing schedule at least thirty (30) days prior to the field testing start date. The Contractor shall submit a field test report consisting of the results obtained by the Contractor from the various tests conducted during the field testing phase of the project. The Contractor shall submit four (4) copies of the report to EGAT within fifteen (15) days of the field testing end date.

B-5 Nameplates and Marking

Nameplates, instruction plates, warning signs, and any other markings on the optical fiber or on the parts and accessories thereof, shall be in the English language, unless otherwise specified.

B-6 Packing

In addition to the general requirements for preparation for shipment specified elsewhere, the following special requirements shall be applied:

1. The optical fiber shall be carefully packed so as to withstand shipment of long duration.
2. Cables shall be wound on strong wooden or metal drums for transportation and storage. Drum diameter shall be sufficient to prevent any detrimental effect to the electrical, optical, or mechanical characteristics of the cable. Cable ends shall be firmly secured, and the cable shall be covered with a thick canvas wrapper to provide protection against grit, dirt, etc. Drums shall be lagged stoutly with close fitting battens to effectively prevent damage during storage and transportation.
3. Cable drums shall be clearly marked on both sides with the length and type of cable, rolling mark, and the instructions "Stow away from boilers", "Do not lay flat", "Do not sling except by bar through center".
4. Wooden boxes shall be marked with the shipment number, weight, handling instructions, and contents. Small parts such as clip angles, brackets, etc. shall be packed in wooden boxes. Bolts, nuts, and washers shall be packed in burlap bags and then packed in wooden boxes for shipment.

B-7 Repair

Both REPAIR and REPLACEMENT services shall be available to EGAT at no charge during the warranty period. The Contractor shall clearly identify the costs, terms, and conditions for ongoing repair services once the warranty period has ended.

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TELECOMMUNICATIONS EQUIPMENT SPECIFICATION

Section F - Optical Fiber

F-1

GENERAL

This specification covers the provision of optical fiber cable to be supplied to the Electricity Generating Authority of Thailand (EGAT). This optical fiber cable will be connected to suitable optical line terminal and multiplex equipment to form part of EGAT's overall communications transmission system.

This specification covers two types of fiber optic cable: Overhead Ground Wire with Optical Fibers (OPGW) and Optical Fiber Cable (OFC) details on the deployment of the various fiber types can be found in the drawings. While the physical construction of the OPGW differs from that of the Optical Fiber Cable, and their operating environments vary considerably, it is expected that the optical characteristics of both types of fiber are, and will remain, identical wherever possible. Any expected variation shall be clearly identified in the Bidder's proposal.

F-2

OPTICAL FIBER CHARACTERISTICS

Optical fiber shall be supplied in accordance with ITU-T Recommendation G. 652C or G.652D with the following requirements in Table 1.

Item no	Description	EGAT's Requirement
1	Profile of Optical Fiber	Single mode stepped index
2	Optical Fiber Attenuation	
	at wavelength 1310 nm	≤ 0.38 dB/km
	at wavelength 1383 nm	≤ 0.38 dB/km
	at wavelength 1550 nm	≤ 0.23 dB/km
3	Splicing loss	≤ 0.07 dB/Joint
4	Number of Fiber	as specified in price schedule
5	Mode field diameter	10 ± 1 μ m
6	Cladding diameter	125 ± 3 μ m
7	Core/cladding mode field concentricity error (MFCE)	≤ 1 μ m
8	Chromatic Dispersion coefficient	
	at wavelength 1310 nm	≤ 3.5 ps/(nm.km)
	at wavelength 1550 nm	≤ 20 ps/(nm.km)
9	- Polarization mode dispersion coefficient	≤ 0.5 ps/ $\sqrt{\text{km}}$ (for G.652C)
	- Polarization mode dispersion coefficient	≤ 0.2 ps/ $\sqrt{\text{km}}$ (for G.652D)
10	operating temperature	0-80°C continuously
11	Maximum Allowable Temperature	
	- For optical fiber in loose tube type OPGW @ 1 sec.	$\leq 160^{\circ}\text{C}$
	- For optical fiber in rigid or tight buffer type OPGW @ 1 sec.	$\leq 250^{\circ}\text{C}$
	- For grounding application @ 1 sec.	$\leq 250^{\circ}\text{C}$
12	Maximum transmission loss change-temperature range 0°C to 150°C	≤ 0.1 dB/km

Table 1 : Optical Fiber Characteristics Required by EGAT

F-3

PACKING AND SHIPPING

The cable shall be furnished on reels of sufficiently sturdy construction to withstand normal shipping, hauling, and field erection. The size, length, weight, manufacturer's name or trade mark, date of manufacture, direction of rolling for each drum, and contract number shall be clearly marked on the outside of each drum. The cable shall be packed to protect it from moisture, salt, or any other impurities which may cause rust or other harmful effects.

F-4**F-4.1****OVERHEAD GROUND WIRE WITH OPTICAL FIBER****General**

The composite overhead ground wire with optical fibers (OPGW) shall be used as a transmission medium for communications signals and as a conventional overhead shield wire along the length of the power transmission line. Since the OPGW forms an integral part of the power transmission system, its electrical and mechanical performance characteristics shall be as close as possible to those of conventional overhead ground wire with respect to: sag, tension, dimension, short circuit capacity, life span, etc. The Bidder's quotation shall include the OPGW and all necessary accessories, including connectors, joint boxes, clamps, mounting hardware, etc.

F-4.2**Construction**

The OPGW shall be composed of an optical fiber unit with the fiber cores embedded inside the optical tube or spacer, completely surrounded by a cluster of aluminum-clad steel ground wire conductor strands or combination of aluminum-clad steel wires and aluminum alloy wires. The optical tube shall be an aluminum tube or an aluminum covered stainless steel tube or two-layer tube with aluminum outside layer tube. Each reel of OPGW shall have all finished strand wire with no joint or splice and the lay direction of outer layer shall be the opposite direction of the reinforcing rods of the vibration damper, the suspension assembly and the tension assembly. The ground wire shall protect the optical fiber unit from adverse effects by external forces, and from effects of hydrogen contamination by using an adequate hydrogen-absorbing filling compound. In order to give the optical fiber adequate heat resistance, it shall be reasonably proved to illustrate that the optical fiber meets the requirement in item no 10 in Table 1. The optical fiber itself shall be manufactured using high grade silica for the cladding, and doped high grade silica for the core, to provide the required performance.

F-4.3**OPGW Characteristics**

Item no	Description	EGAT's Requirement
1	Ultimate Tensile Strength (kg)	≥ 6000
2	Outside diameter (mm)	13.5 ± 0.1
3	Nominal Cross sectional area of Conductor (mm^2)	≥ 99
4	Number of strands	≥ 11
5	Outer layer direction	Left hand lay
6	Nominal Weight kg/m	0.55
7	D.C. Resistance @20°C (ohm/km)	≤ 0.45
8	Length per reel (m.)	≥ 3000
9	Nominal Modulus of elasticity (kg/mm^2)	11,000
10	Nominal Coefficient of linear expansion ($^{\circ}\text{C}$)	15.0×10^{-6}
11	Capacity fault current (KA) ² sec	≥ 100

Table 2 : OPGW Characteristics Required by EGAT

The Bidder shall design the OPGW requirements to suit each span in the system, based on the applicable drawings and field surveys. The Bidder's proposal shall stipulate the characteristics of the OPGW required for each span in the system.

F-4.4 Assemblies and Line Accessories

F-4.4.1 General

The overhead ground wire assemblies and line accessories shall consist of the hardware indicated below. All hardware and accessories shall be made of aluminum, aluminum alloy, malleable iron, steel (metal mold or drop forging process), stainless steel, or non-ferrous metal, unless otherwise specified. In addition, all hardware and accessories shall have an ultimate tensile strength equal to or exceeding the rated ultimate tensile strength of the overhead ground wire. All metal shall be free from burrs, sharp edges, lumps and dross, and shall be smooth, so that interconnecting parts will fit properly, and so that the parts may be assembled and disassembled readily.

Unless otherwise specified, all ferrous metal shall be galvanized in accordance with ASTM A153. Bolts and nuts shall be galvanized after being threaded, and excessive zinc shall be removed; they shall run freely (hand fit) for the entire length of the thread. Re-tapping of nuts after galvanizing is permitted. Each piece of hardware shall be permanently marked by casting or die-forging.

All bolts and other fasteners shall be installed according to manufacturer's recommendations. Materials not specifically covered herein by detailed specifications shall be of standard commercial quality suitable for the intended use.

All suspension and strain clamps shall be installed with insulators in quantities and strengths required for use in the assemblies. The insulator assemblies shall be assembled and attached in accordance with the drawings found in this specification. The contractor shall determine the most suitable type of clamp to be used at each and every transmission tower location.

F-4.4.2 Suspension Clamps

The suspension clamps for the OPGW shall be of bolt or preformed type. The bolt type suspension clamps shall be complete with bolts, keeper pieces, and other required parts. Each clamp shall be capable of holding the OPGW without slipping under an unbalanced tension of 25% of the ultimate tensile strength of the OPGW.

F-4.4.3 Dead End/Tension Clamps

The dead end clamps shall be of bolt or preformed type, and capable of holding the OPGW without slipping or damaging the OPGW under a tension of 70% of the OPGW ultimate tensile strength. A suitable extension link shall be installed, when required, to protect the OPGW from damaging bends. Strain clamp assemblies shall have a steel oval eye or clevis eye with bolts and cotter pin. The keeper piece shall be of the same material as the clamp body. Bolts, nuts, and washers shall be hot-dipped galvanized malleable iron or steel.

F-4.4.4 Grounding clamp, Parallel Groove clamp

Each clamp shall be capable of holding the OPGW using bolts and nuts.

F-4.4.5 Vibration dampers

Stockbridge type vibration dampers, suitable for use on the OPGW shall be supplied. The dampers shall have an aluminum clamping bolt, or other suitable device, on the galvanized wire between the weights, and be suitable for attachment to the OPGW. The damper clamp shall be designed to permit installation and removal using hot line tools. Each damper weight, subject to the accumulation of moisture, shall be provided with one drain hole positioned at the bottom of the weight when the damper is installed in the vertical plane. Damper weights shall be made of hot dip galvanized cast iron or steel.

F-4.4.6**Armor Rods**

The armor rods for the OPGW shall be of the preformed type. They shall be smooth and free from corrosion, splitting, cracking, or any other defects. They shall be designed to effectively protect the OPGW from fatigue caused by vibration.

Armor rods may or may not be employed, as per OPGW manufacturer recommendations, however the contractor shall provide the confirmation letter and any necessary supporting document from the OPGW manufacturer on whether the use of armor rods is required or not.

F-4.5**Joint Boxes**

The joint box shall be dome type designed with air-tight, water-proof, and weather-proof qualification. The cover shall be securely fastened to the case by non-loosening fasteners. Both the case and the cover including mounting bracket and its accessories shall be made of metallic material with sufficient galvanized or equivalent substance coating in order to prevent any chemical reactions, such as rusting, on the surface of the equipment. The life time of joint box shall not be less than 20 years. The joint box shall be sufficiently rugged and sturdy to withstand outdoor climatic and environmental conditions. The joint box shall accommodate sheath protected arc-fusion splices and up to 1.5 m of additional fiber on each side of the splice; guides shall be provided at the back of the tray stack to keep the extra fiber well above the allowable bending radius of the fiber. Contractor shall provide at least three splice trays for each joint box. The spliced parts of the optical fiber within the joint box shall be reinforced and free from tension after completion of the splicing. The protective sleeve for each fiber connection shall be at least 60 mm long. The joint box shall be installed without drilling the tower structure, and shall not be removed manually. The fixing part and the joint box base shall be mounted by using nuts and bolts or equivalent mounting accessories. Each OPGW cable shall be installed and removed individually. In addition, the joint box itself shall be able to hold entry cables without using external equipment such as cleat(s) and clamp(s).

The Contractor shall provide one set of terminating materials with every joint box for optical fiber connection

1. 2-Way Joint Box for OPGW

This type of joint box shall be used to straight joint OPGW to OPGW, or OPGW to OFC. It shall be used at all locations requiring such a device except those specified otherwise in the text or drawings elsewhere in this specification.

2. 3-Way Joint Box for OPGW and approach cable

This type of joint box shall be used to spur joint all fibers contained in two OPGW cables to one multi-core optical fiber cable at each terminal station, repeater station, or other location, as detailed in the text or drawings elsewhere in this specification.

F-4.6**Fiber Terminal Box**

The fiber terminal box at each station shall be suitable and large enough to accommodate the connection of all optical fiber cable and fiber cord leading to optical line terminating equipment. The fiber terminal box shall have at least two splicing trays and shall be a secure and versatile wall mounted unit for terminating and patching of optical fiber cable.

The contractor shall provide pigtailed of at least 10 meters long or otherwise specified with FC connector for splicing to all fibers in each of optical fiber cable cores and terminating to through adapter (D-format) of the fiber distribution panel.

F-4.7**Rack Cabinet**

The rack cabinet shall be designed by taking into flexibility, softly and durability in its operation, and capability to meet all types of EGAT's demands. The rack shall made of

steel sheet with the typical thickness of 1.5 mm molded to be durable and 100% rust-proof. The mounting support shall be designed to be durable and capable of adjustment as required. Panels shall be constructed in 1 mm steel sheet and all corners shall be welded and dressed prior to finishing.

The rack cabinet shall be 19" rack unit Telecom Standard format which complied with standard DIN 41494, EIA RS-310C1977, IEC 297-2 and the dimension of 2200 mm high, 600 mm wide and 800 mm deep. Flush doors at front and rear shall be mounted on lift-off type hinges. The doors shall have a full 180° swing and shall be fitted with central key lock or magnetic catches. The front door shall be made of plastic acrylic with transparency brown color having the thickness of 5 mm, dust-proof rubber edge and right-hand hinged.

Side panels shall be lifted off for easy access. Jacking feet shall be fitted inside the rack base for leveling. The rack shall have mobile base with large castors. At the bottom of the rack, there shall be a slide panel with sponge for running signal cable and electrical wire and preventing the intrusion of animals.

F-4.8

Fiberframe Termination Cabinet

The fiberframe termination cabinet at each station shall be rack mounted and suitable and large enough to accommodate the connection of all buried cables and fiber cords leading to optical line terminating equipment as shown in the drawing.

The fiberframe termination cabinet shall have at least two splicing trays with the amount of splice reinforcement tubes as same as the number of fiber core specified in the price schedule and shall be a unit for terminating and patching of up to the number of fibers as specified in price schedule in 19" rack frames. The fiberframe termination cabinet shall have a slide out termination compartment and front access patch panel which shall have the amount of single FC connector as same as the number of fiber core specified in the price schedule. The height of the fiberframe termination cabinet shall be 3U (rack unit) in order to provide easy access. The through adapter (D-Format) shall be supplied by the contractor for each fiberframe termination cabinet with the same amount as the FC connectors. The through adapter shall combine a metal housing and either Phosphorus Bronze or Copper inner alignment sleeve. The termination compartment shall have rear and side cable entry points and facilities for fusion splicing or direct termination of outdoor and indoor style cable. The fiberframe termination cabinet shall have looming facilities maintaining correct bend radii to ensure orderly arrangement of excess fiber lengths.

The contractor shall provide optical fiber patch cords of at least 10 meters long and pigtailed of 1.5 meters long or otherwise specified with FC connector for splicing to all fibers in each of optical fiber cable cores and terminating to through adapter (D-format) of the fiber distribution panel. The protective sleeve provided for each fiber connection shall be at least 60 mm long.

F-4.9

Factory Testing

Factory tests shall be performed on complete OPGW in accordance with world-wide recognized standards which are ASTM, ITU-T, IEC, IEEE and TIA/EIA. These references shall be clearly specified in the procedure and also in the report along with the criteria and detail applied during the test.

The following test items shall be required to be performed on one randomly selected reel (reel length must be more than or equal to 3,000 meters) for every 100 km of the total proposed length. However, if the total proposed length is less than 100 km, the test shall be performed on at least 3,000 meters. :

- chromatic dispersion
- mode field diameter
- cladding diameter
- core / cladding concentricity error
- cladding non-circularity
- over all diameter
- coating diameter
- coating non-circularity
- cable cutoff wavelength

The following test items shall be required to be performed once for every 200 km of the total proposed length. However, if the total proposed length is less than 200 km, the test shall be performed at least once. :

- tensile test
- crush test
- impact test
- water ingress test
- twist characteristic
- linear expansion coefficient
- temperature cycle test
- electrical resistance at 20°C
- bend response
- breaking load

For optical fiber attenuation shall be tested for all reels.

In addition, the Contractor shall provide standard test certificates from a world-wide recognized independent “third party” testing organization for each of the type tests for OPGW whose diameter is equal or close to that of EGAT’s requirement listed below. Separate certificates shall be provided for each type of OPGW proposed. Alternatively, the tests may be quoted as an option for EGAT consideration.

- water ingress test
- seepage of flooding compound
- short circuit test
- aeolian vibration test
- sheave test
- crush test
- creep test
- stress – strain test
- temperature cycle test
- galloping test

F-5
F-5.1

OPTICAL FIBER CABLE

General

The Optical Fiber Cable(OFC) shall have high mechanical strength to protect the fibers from external forces, be easily installed without requiring any special care or equipment, and shall be suitable for installation in conduits, ducts, cable trench, above or below ground or direct burial. All OFC accessories including terminations, insulating materials, markers, support grips, and OFC ties shall be furnished and installed. The proposed OFC shall be certified by TISI according to TIS 2166-2548(2005) standard and the bidder shall be required to submit the copy of certificate with proposal.

F-5.2**Cable Structure**

The OFC shall consist of:

- Multiple fiber cores, as required,
- Central strength member,
- Loose tube,
- Filling, and
- Suitable hydrogen absorbing compound.
- Marking.
- Wrapping,
- Polyethylene inner sheath,
- Strength member,
- Outer sheath.

The central strength member shall be fiber reinforced plastic, or other material of equivalent strength. The fibers shall be protected in jelly filled loose tubes stranded around a central strength member to ensure optimum performance and long life. Each fiber shall be color coded for easy identification during splicing and termination.

The interstices of the cable core shall be completely filled with water repellant (petroleum jelly compound or equivalent material) to prevent water impregnation. The inner sheath with the nominal thickness of 1.7 mm shall be extruded above the layer of central strength members. The outer sheath shall be made of abrasion resistant polyethylene with the nominal thickness of 2.0 mm. There shall be the strength member between inner sheath and outer sheath to protect any damages and to provide the tensile strength to pull OFC through the duct. The outer sheath of finished cable shall be clearly colored, i.e. black with color strip(s) to distinguish it from the power cable. The identification required to be printed on the cable sheath shall include manufacturer's name, type of the cable, year of manufacture and the cumulative length.

F-5.3**Mechanical Properties**

Allowable tension:

Shall withstand at least 150 kg force without breaking or damaging the fibers in the cable.

Bending Radius:

The permissible bending radius shall be no greater than 20 times the external diameter of the cable for operation.

F-5.4**Conduit****F-5.4.1 Rigid Steel Conduit (RSC)**

The conduit shall be made of non-corrosive material, rust-proof and weather-proof to withstand outdoor climatic and environmental condition.

F-5.4.2 High Density Polyethylene Conduit (HDPE)

The HDPE shall be made of high-density polyethylene which is non-corrosive, flexible, and suitable for installation in cable trench, above ground or direct burial.

F-5.4.3 EFLEX Corrugated Hard Polyethylene Conduit (EFLEX)

The EFLEX shall be made of high-density polyethylene with spiral corrugated pipe shape which is highly corrosion, weather resistant, flexible, mechanically strong and suitable for installation in cable trench, above ground or direct burial.

The nominal diameter of conduit shall be at least three times of optical fiber cable outside diameter or have cross-section area ten times of optical fiber area or as specified elsewhere, and shall contain minimum diameter of 4.8 mm poly propylene strand rope or equivalent for use in pulling the OFC or other pulling line.

F-5.5 Factory testing for OFC

Factory tests shall be performed on OFC in accordance with world-wide recognized standards which are ASTM, ITU-T, IEC, IEEE and TIA/EIA. These references shall be clearly specified in the procedure and also in the report along with the criteria and detail applied during the test. The test sample(s) shall be randomly selected from the ordered reels. The factory test items for OFC shall include, but not limited to, as follows:

- chromatic dispersion
- tensile test

Optical fiber attenuation test shall be performed on every core of all ordered reels.

F-6 INSTALLATION AND FIELD TESTING

The Contractor shall provide a complete description of all procedures and methods used during installation of the Optical fiber.

F-6.1 Overhead Ground Wire with Optical Fiber

The installation methods and tools required for OPGW shall be similar to those of conventional overhead shield wire. The OPGW shall be strung, sagged and clipped before phase conductors are strung. The method of stringing, sagging and clipping used by the Contractor shall be according to the manufacturer's recommendations. However the contractor shall submit the lists of installation equipment such as counter weight, tensioner, puller, accessories tools for installation and OPGW stringing block as shown in the typical drawing no. DW-FOT-D01-214-01 and the suitable of the installation equipment in the drawing shall be approved by the OPGW manufacturer. Then the contractor shall submit the drawings and detail of each installation equipment which has been approved by the OPGW manufacturer to EGAT for approval. During installation the Contractor shall take every precaution necessary to ensure that the OPGW is not damaged, and that its optical characteristics are not detrimentally affected in any way. If one part of an OPGW reel is damaged during installation, the Contractor shall replace the damaged reel with a new reel at no additional cost to EGAT.

F-6.1.1 Installation Method

F-6.1.1.1 Insulation Method

The insulation and grounding for OPGW shall be as shown on drawing no DW-FOT-D01-212-01. All joint boxes and OPGW down-leads from the insulated tension clamps shall stand from the tower at an insulation level as defined in drawing no DW-FOT-D01-212-01. The stand-off material shall be insulation material which has electrical and mechanical characteristics complying with the Insulator and Hardware section. The contractor shall submit the detailed installation drawings for hardware assembly including all clamping which has been approved by OPGW manufacturer to EGAT for approval.

F-6.1.1.2 Grounding Method

The OPGW shall be connected to the transmission tower for grounding at every location identified in drawing no DW-FOT-D01-212-01. To obtain a solid ground connection, the Contractor shall connect the OPGW to the transmission tower with Grounding clamps and 3/8" high strength galvanized steel ground wire.

F-6.1.2 Isolated Line Sections

Where the OPGW documentation requires that respective line sections be physically and electrically isolated from each other, the Contractor shall employ two (2) joint boxes connected to each other using non-metallic fiber optic cable.

F-6.1.3 OPGW Connections

The jointing of OPGW shall be performed using joint boxes located on tension towers as shown in drawing no DW-FOT-D01-233-01 contained in this specification. The OPGW shall have sufficient surplus length for coiling three (3) turns of cable with more than 1 meter diameter for each side and shall be attached with the suitable clamps above the joint box before installing into the joint box. The contractor shall have precaution in installing OPGW for insulation method by having the minimum distance between the OPGW down-leads and the member of tower to be at least 13 cm. All OPGW connections shall be of the underpass or overpass variety. However for the overpass connection there shall be attaching jumper clamp to protect the vibration of the overhead ground wire.

F-6.1.4 OPGW and Optical Fiber Cable Connections

Every OPGW and overhead ground wire (OHGW) from the deadend tower to take off structure shall be terminated with the insulator before installing to the take off structure. Every joint box at take off structure shall be insulated as shown in drawing no DW-FOT-D01-202-02. The OPGW down-leads and joint box shall be stand-off from the take off structure with the insulator and the OHGW shall be connected to the tower for grounding while the OPGW shall be connected to the tower with 3/8" high strength galvanized steel overhead ground wire for grounding as shown in typical drawing no. DW-FOT-D01-202-02. In case of replacing the OPGW for the OHGW of the existing transmission line, the installation process above shall be performed only on the replacement circuits.

F-6.1.5 Optical Fiber Connections

The jointing of optical fiber shall be performed using arc-fusion splicing. All cores shall be spliced at every location, fiber identification shall be matched and maintained for the entire length of the installation.

The optical fiber splicing loss shall not be more than 0.07 dB for any one joint. Splicing loss shall be measured immediately after the splice has been made, and if the splice does not meet minimum standards above, it shall be re-spliced or replaced.

All successful splices shall be protected using a heat shrink protection sleeve with integrated reinforcement, or some other material/process providing equivalent protection. Each sleeve shall be at least 60 mm long. An additional slack of 1 to 1.5 m shall be provided on each side of each splice, and stored securely in the joint box.

F-6.1.6 Vibration Protection Devices

The vibration protection devices, such as vibration dampers, shall be installed in accordance with the manufacturer's recommendations.

F-6.2 Optical Fiber Cable

Optical Fiber Cable (OFC) shall be installed from the joint box at each takeoff structure to the rack cabinet in the corresponding substation communication room.

The OFC shall be placed in the RSC conduit and buried from the joint box at each take off structure to the cable trench. Then the OFC shall be placed in HDPE or EFLEX and installed along the trench side for the full length of the cable trench to the rack cabinet in the communication rooms as shown in the drawings provided by EGAT.

The conduit and OFC installation shall be accordance with the conduit and OFC manufacturers' recommendation. All installation equipments and method shall be acceptable to EGAT.

F-6.2.1 OFC placement

Immediately prior to the placement of OFC in its assigned RSC , the dimensions of the OFC and RSC shall be checked to determine that the RSC is of adequate size. If the RSC size is inadequate, a new RSC of sufficient capacity shall be provided.

Immediately prior to the placement of OFC, The OFC route to be followed shall be inspected and ascertained to be complete in installation and free of all materials detrimental to the OFC

F-6.2.2 Cable pulling

The wire grip, swivels, a steel winch line if required etc. shall be used to pull the cable. The maximum pulling tension of the OFC shall be 50% of working load or recommended by the OFC manufacturer. Extreme care shall be exercised during installation of all OFC to prevent tension and bending conditions in excess of the manufacturer's recommendation. Damage to the sheath or finish of the OFC shall be sufficient cause for rejection the OFC. The OFC damage in any way during installation shall be replace by and at the expense of the contractor.

F-6.3

Field Testing

Every optical fiber cores shall be tested in the field at each applicable location. All test equipments to be used shall be kept calibrated and still within one year prior to their validity periods. EGAT reserves the right to use his own test equipments for verification of the result. The calibration report which shall conform to International Electro-technical Commission (IEC) standard shall be submitted to EGAT for approval. The bidder shall also submit the make, model and serial number of the test equipments that to be used in this field test. The field testing required by for the OPGW and OFC shall include, but not be limited to, the following:

1. Optical Fiber Loss Requirement

1.1 For OPGW-Drum Test

The Contractor shall measure the attenuation loss per drum before the stringing process and the measured values shall be recorded in the table and submitted to EGAT for approval. The resulting value shall be less than the value specified in item no 2 in Table 1.

The purpose of the test is to monitor any damage that may cause from packaging and transportation. The measured values shall be compared with the values from the factory test report. In case that the measured values of any drum are greater than the factory test values or the values specified in item no 2 in Table 1, those non-conforming drums shall be replaced with new conforming drums. The test equipment to be used in this process shall be OTDR or light source & power meter.

The results of these tests shall be tabulated by drum.

1.2 For OFC

The Contractor shall measure the attenuation loss at each FOTS terminal station, from the joint box at each takeoff structure to the terminal box located in the corresponding

sub-station communications room. These values shall be less than the value specified in item no 2 in Table 1.

In case that the measured values of any substation are greater than the factory test values or the values specified in item no 2 in Table 1, those non-conforming sections shall be replaced with new conforming sections. The test equipment to be used in this process shall be OTDR or light source & power meter.

The results of these tests shall be tabulated by substation.

2. Optical Fiber Splice Loss

2.1 OPGW-to-OPGW Splice Loss

The Contractor shall measure the splicing loss per joint for each and every splicing point. This measured value shall not be more than 0.07 dB. The test equipment to be used in this process shall be OTDR or light source & power meter.

The results of these tests shall be tabulated by transmission tower number.

2.2 OPGW-to-OFC Splice Loss

The Contractor shall measure the splicing loss per joint for each and every splicing point between OPGW and OFC in joint box at take-off structure. This measured value shall not be more than 0.07 dB. The test equipment to be used in this process shall be OTDR or light source & power meter.

The results of these tests shall be tabulated by location.

2.3 OFC-to-Pigtail Splice Loss

The Contractor shall measure the splicing loss between OFC and pigtail in the fiberframe termination cabinet for every substation. This measured value shall not be more than 0.07 dB. The test equipment to be used in this process shall be OTDR or light source & power meter.

The results of these tests shall be tabulated by location.

3. Total Transmission Loss (End-to-End Loss)

The contractor shall measure the total transmission (end-to-end) loss for every hop from fiberframe termination cabinet at one station to another station. The measured value shall be within the calculation value that is calculated as follows:

For wavelength of 1310 nm :

$$\text{Total transmission loss} = (L \times 0.38 \text{ dB/km}) + (NS \times 0.07 \text{ dB/joint}) + (NC \times 0.5 \text{ dB/connection})$$

For wavelength of 1550 nm :

$$\text{Total transmission loss} = (L \times 0.23 \text{ dB/km}) + (NS \times 0.07 \text{ dB/joint}) + (NC \times 0.5 \text{ dB/connection})$$

Where L = Length of each hop (km)

NS = Number of splice

NC = Number of connector (equal to 2 (two))

The test equipment to be used in this process shall be light source & power meter.

The results of these tests shall be tabulated by hop.

F-6.4 Terminal Station Equipment

The Contractor shall install the required rack cabinet as per the floor layout drawings. The contractor shall request the floor layout drawing from EGAT 30 days prior to the installation date.

F-6.5 Repeater Station Hut/Shelter

The Contractor shall design and construct the repeater station shelters (if required) as shown in the drawings contained herein. At every repeater location the Contractor shall perform a ground test on the transmission tower to ensure the resistance to ground does not exceed 10Ω . The Contractor shall make all changes necessary to meet the 10Ω objective, and shall ensure that the neutral of the commercial power, the load center ground, and the ground terminal from every electrical outlet in the repeater station is effectively grounded to the associated transmission tower.

The Contractor shall provide the optical fiber cable from the junction box to the cable entrance of the repeater station with sufficient flexibility and slack to permit at least one (1) meter of vertical movement of the repeater station with respect to the tower (allowance for differing settling rates between the repeater station building and the tower). In addition, the design and installation of sensor system, i.e. fire alarm, door alarm, temperature alarm and flood alarm, shall be carried out by contractor.

The Contractor's response to this specification shall include complete construction details, design drawings, and specifications. EGAT will approve drawings and specifications along with award of the contract.

F-6.6 Supporting Structure for Solar panel

The Contractor shall design and install the supporting structure for solar panel, if required elsewhere, at the tower nearby the repeater station as shown in the drawings contained herein.

F-6.7 Repeater Station Installation

The Contractor shall install the required rack cabinet as per the floor layout drawings contained herein.

F-7 Test Equipments

The bidder shall quote, as an option, a comprehensive list of recommended test equipment as specified in price schedule which could be used by EGAT to perform field maintenance and central repair :

F-7.1 Optical Time - Domain Reflectometer (OTDR)

The following function is a minimum requirement :

- Mode of operation Wavelength = 1310/1550 nm single mode which can be selected for continuous wave mode or modulated squarewave mode
- 10 ns to 20 μ s adjustable pulse width
- Optical connector FC-type
- Output shall be real-time backscatter signal
- Distance range 100 km minimum
- Built-in color display and floppy disk drive
- Output RS-232C and/or parallel interface

- Power supply 220 VAC \pm 10% @ 50 Hz or 12 VDC built-in battery for portable type
- Carrying case shall be included

F-7.2 Handheld Optical Time - Domain Reflectometer (HANDHELD OTDR)

The following function is a minimum requirement :

- Mode of operation Wavelength = 1310/1550 nm single mode which can be selected for continuous wave mode or modulated squarewave mode
- 10 ns to 20 μ s adjustable pulse width
- Optical connector FC-type
- Output shall be real-time backscatter signal
- Distance range 100 km minimum
- Built-in color display
- Power supply 12 VDC built-in battery at more than 2 hours in continuous operation and 220Vac adapter
- Total weight including battery pack shall be less than 3.7 kg
- Capable of data transferring from handheld OTDR to personal computer
- Software for data viewing and printing shall be included
- Carrying case shall be included

F-7.3 Power Meter

The following function is a minimum requirement :

- Wavelength range of 0.7 to 1.7 μ m
- Dynamic range of -40 to +10 dBm
- Optical connector FC-type
- Output power measurement – a minimum of 2 channels
- Memory function
- Comparator function
- Data hold function
- Set up function
- Resolution of 0.01 dB
- Power supply 220 VAC \pm 10% @ 50 Hz or 12 VDC built-in battery for portable type
- Carrying case shall be included

F-7.4 Light Source

The following function is a minimum requirement :

- Stabilized LEDs and lasers light source
- Single and dual wavelength configuration
- Dual wavelength of 1310 and 1550 nm
- Able to combine with power meters to create attenuation test sets
- Output stability of \pm 0.4 dB or less
- Single mode and multimode uses
- Optical connector FC-type
- Power supply 220 VAC \pm 10% @ 50 Hz or 12 VDC built-in battery for portable type
- Carrying case shall be included

F-7.5 Optical Talk Sets

The following function is a minimum requirement :

- 1310 / 1550 nm wavelength operation
- Bi-directional communication via an optical fiber
- Full duplex analog modulation
- Optical connector FC-type
- Output stability of \pm 0.4 dB or less

- Distance range 150 km minimum
- Headset microphone
- Carrying case shall be included
- Power supply battery at more than 12 hours in continuous operation and 220 VAC adapter

F-7.6 Optical Fiber Fusion Splicer

The following function is a minimum requirement :

- Cladding diameter : 80 to 150 μm
- Coating diameter : 100 to 1000 μm
- Average splice loss ≤ 0.05 dB
- Splicing program/mode ≥ 40 modes
- Splice memory ≥ 2000 splices
- Splice time ≤ 20 seconds
- Built-in tube heater with heating time ≤ 50 seconds
- Applicable fibers : MM (ITU-T. G651), SM (ITU-T G.652), DS (ITU-T G.653), NZDS (ITU-T G.655),
- Carrying case shall be included
- Power supply 220 VAC $\pm 10\%$ @ 50 Hz and 10 -15 VDC built-in battery