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کابل فیبر نوری

Optical Fiber Cable Specifications

دفترمدیرعامل

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ابلاغ مصوبه هیأت مدیره

مدیر محترم پژوهش و فناوری و رئیس شورای استاندارد

باسلام،

به استحضار می رساند در جلسه ۱۵۳۳ مورخ ۱۳۹۱/۱۱/۸ هیأت مدیره، نامه شماره گ۹/۰۰۰/۱۵۲۹۰۶ مورخ ۱۳۹۱/۱۰/۲۷ مدیر پژوهش و فناوری و رئیس شورای استاندارد در مورد تصویب نهایی استاندارد تحت عنوان « مشخصات فنی کابل فیبر نوری به شماره تقاضای IGS-M-IT-۰۰۲(۰) » مطرح و مورد تصویب قرار گرفت.

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SCOPE

This specification specifies the minimum requirements for direct buried & duct single – mode fiber optic cable which are to be used in national Iranian gas company (here in after called NIGC). The cable (direct buried) to be installed either by trenching or by direct plowing alongside the gas pipeline to meet the telecommunication, telemetry control and operational requirements.

The cable / materials provided shall conform to the latest ITU-T, IEC, ASTM, EIA/ TIA and IEEE standards.

All cables and materials recommended by manufacturer shall be nontoxic and dermatological safe.

1. Normative References:

The following referenced documents are indispensable for the application of this document.

ITU-T-G.650.1 (06/2004): Definitions and test methods for linear, deterministic attributes of single-mode fiber and cable

ITU-T-G.650.2 (06/2002): Definitions and test methods for statistical and non-linear attributes of single-mode fiber and cable

ITU-T-G.652 (06/2005): Characteristics of a single-mode optical fiber and cable

IEC 61931(1998): Fiber Optic - Terminology First Edition

IEC 60793-1-1(2002): Optical fibers Part 1-1: Measurement methods and test procedures General and guidance Second Edition

IEC 60793-1-20 (2002): Optical Fibers - Part 1-20: Measurement Methods and Test Procedures - Fiber Geometry Partly Supersedes BS EN 188000:1994; (S)

IEC 60793-1-30(2002), Optical Fibers - Part 1-30: Measurement Methods and Test Procedures - Fiber Proof Test First Edition

IEC 60793-1-42(2002): Optical Fibers - Part 1-42: Measurement Methods and Test Procedures - Chromatic Dispersion Partly Supersedes BS EN 188000:1994; (S)

IEC 60793-1-44(2002): Optical Fibers - Part 1-44: Measurement Methods and Test Procedures - Cut-Off Wavelength Partly Supersedes BS EN 188000:1994; (S)

IEC 60793-1-45(2001): Optical Fibers - Part 1-45: Measurement Methods and Test Procedures - Mode Field Diameter First Edition; Corrigendum 1:7/2002; Together with the Other Standards

IEC 60793-1-47(2001): Optical Fibers - Part 1-47: Measurement Methods and Test Procedures - Macro bending Loss First Edition

IEC TR 61282-3(2002), Fiber Optic Communication System Design Guide - Part 3: Calculation of Polarization Mode Dispersion First Edition

IEC 60794-3(2001): Optical Fiber Cables - Part 3: Duct, Buried and Aerial Cables - Sectional Specification Third Edition

IEC 60794-3-10(2002): Optical Fiber Cables - Part 3-10: Outdoor Cables - Family Specification for Duct and Directly Buried Optical Telecommunication Cables First Edition

IEC 60794-1-1(2001): Optical Fiber Cables - Part 1-1: Generic Specification - General Second Edition

IEC 60794-1-2(2003): Optical fiber cables - Part 1-2: Generic specification - Basic optical cable test procedures

IEC 60304(1982): Standard Colors for Insulation for Low-Frequency Cables and Wires Third Edition
ASTM D 1248(2002): Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D 1765(2001): Standard Classification System for Carbon Blacks Used in Rubber Products
ASTM D 1603(2001): Test Method for Carbon Black in Olefin Plastics
ASTM D 3349(1999): Standard Test Method for Absorption Coefficient of Ethylene Polymer Material Pigmented with Carbon Black
In case of any conflict between the above standards and this technical specification, the matter shall be referred to NIGC. Supplier shall proceed with design of the cable and equipments only after obtaining clarification from NIGC in all such cases.

2. Terms and Definitions

Single mode dispersion optical fiber unshifted: Single mode optical fiber witch has zero dispersion wavelengths around 1310 nm; this has originally optimized for use in the 1310nm wavelength region but can also be used in 1550nm region, (this specification prepared according to TUT-T G.625 table B and D)
Dispersion unshifted fiber optic Single-mode optical fiber which has zero-dispersion wavelength around 1310 nm, this fiber was originally optimized for use in the 1310 nm wavelength region, but can also be used in the 1550 nm region. (This specification prepared according to ITU-T G.652 'tables B and D)
Mode field diameter: The Mode Field Diameter (MFD) $2w$ represents a measure of the transverse extent of the electromagnetic field intensity of the mode in a fiber cross-section and it is defined from the far-field intensity distribution $F^2(\theta)$, θ being the far-field angle, through the following equation:

$$2w = \frac{\lambda}{\pi}\left[\frac{2\int_0^{\frac{\pi}{2}} F^2(\theta)\sin\theta\cos\theta d\theta}{\int_0^{\frac{\pi}{2}} F^2(\theta)\sin^3\theta\cos\theta d\theta}\right]^{\frac{1}{2}}$$

Cladding: The outermost region of constant refractive index in the fiber cross-section.
Cladding diameter: The diameter of the circle defining the cladding center.
Core concentricity error: The distance between the core centre and the cladding centre.
Cladding non-circularity: The difference between the diameters of the two circles defined by the cladding tolerance field, divided by the cladding diameter.
Cut-off wavelength: The cut-off wavelength is the wavelength greater than which the ratio between the total power, including launched higher order modes, and the fundamental mode power has decreased to less than a specified value, the modes being substantially uniformly excited.
Chromatic dispersion: The spreading of a light pulse per unit source spectrum width in an optical fiber caused by different group velocities of the different wavelengths composing the source spectrum.
Note: The chromatic dispersion may be due to the following contributions: material dispersion, waveguide Dispersion, profile dispersion.

3. Abbreviation

- NIGC National Iranian Gas Company
- GPa Giga Pascals
- FRP Fiberglass Reinforced Plastic
- PMD Polarization Mode Dispersion
- PMDQ Statistical parameter for link PMD

4. Environmental Condition

- Operation temperature: -40°C to 70°C
- Installation -29°C to 60°C
- Storage/ shipping temperature: -40°C to 75°C
- Relative humidity: 95% at 50°C
- Elevation 60 to 4000 meter ASMAL
- Wind speed up to 180 km/h

5. General Conditions and guidelines

5.1 -The offered cable and equipments shall be field proven at least for twelve (12) months. NIGC reserves the right to verify the field proven of the offered cable, at any time during the execution of the project.

5.2- NIGC reserves the right to modify/ revise/ alter this specification prior to acceptance of any offer.

5.3- The supplier shall provide a complete "Bill of Material" necessary to meet all requirements mentioned in this technical specification, in case of any discrepancy between different parts of the technical specification, the supplier shall inform NIGC in writing about the discrepancies, before submitting technical proposal to the NIGC.

5.4- The supplier shall provide the details necessary information and test results to demonstrate that the proposal meets the requirements of these specifications.

5.5- The factory test schedule and test procedures shall be submitted with technical proposal.

5.6- The manufacturer shall submit the procedures and quality test plan for routine and type test with technical proposal.

5.7- The fiber optic cable shall have a minimum design life of 40 years.

6. Optical Fiber & cable

6.1-General

6.1.1-This section covers the general design requirements, constructional, optical, mechanical properties and performance standards for the direct buried and duct fiber optic cable.

6.1.2-The purpose of this specification is to provide the essential requirements for raw material, optical fibers, core/jacket construction and transmission performance, by which the outside plant fiber optic cable can be evaluated and specified.

6.1.3-The single mode fiber optic cable to be provided shall be a loose, flexible gel-filled buffer tubes designed, suitable for outside plant.

6.1.4-The cable and equipments shall be new, unused and of current design and manufacturer and shall meet all requirements stated in this specification.

6.1.5-All fibers in the cable shall be from one manufacturer.

6.1.6-The high quality optical fibers must be made from pure silica-based glass have very low loss and can be used to carry large amounts of information for long distances in optical communication networks.

6.1.7-All fibers, coating, core, tubes, fillers dielectric members, jackets, aramid yarn and armor will be continuous, and shall be free of roughness, porosity, bubbles, splits, blister, voids and inclusions, consistent with good manufacturing practice.

6.1.8-The raw and prefabricated materials used in the manufacture of outside plant fiber optic cables must be from high quality and standard materials.

6.2- Optical Fiber Specifications

6.2.1-The fiber shall fulfill latest ITU-T Recommendation G.652 and annexes for single mode optical fibers.

a) type of fibers	dispertion-unshifted single mode
b) design	matched cladding

6.2.2-Transmission characteristics (optical specification)

attribute	***Detail***	***value***	***Test method***
attenuation	Max. at 1310 nm	0.34 dB/ km	IEC 793-1-40
	Max. at 1550 nm	0.20 dB/ km	
	Max. at 1383 nm	0.4 dB/ km	
Cut Off Wavelength(λc)	Min.	1170nm	IEC 793-1-44
	Max.	1280 nm	
Choromatic dispersion Coefficient	Max. at 1285 - 1330nm	3.5 ps / (nm .km)	IEC 791-1-42
	Max. at 1270 - 1340nm	5.3 ps /(nm . km)	
	Max. at 1550	18 ps /(nm.km)	
Polarization mode dispersion	Max.	0.2 ps/√ km	IEC 793-1-48
Zero dispersion wavelength(λ0)	Min.	1300nm	IEC 793-1-C5C
	Max.	1324 nm	
Zero dispersion slope	Maximum	0.090 ps /(nm^2. km)	IEC 793-1-C5C
Point discontinues	at 1310/ 1550 nm	≤ 0.10 dB	————
attenuation due to temperature variation from- 40°c to 85°c	Max. at 1310/1550 nm	0. 05 dB	IEC 793-1-52

6.2.3-Geometrical Specification

Attribute	**Detail**	**value**		**Test Method**
Mode field diameter	Wavelength	1310	1550	IEC 60793-1-45
	Range of nominal values Tolerance	9.2 μm ± 0.4	10.4 μm ± 0.5	
Cladding diameter	Nominal	125 μm		IEC 60793-1-20,21
	Tolerance	$\pm 1.0 \mu m$		
coating diameter	Nominal	245 μm		IEC793-1-20,21
	Tolerance	$\pm 10 \mu m$		
core noncircularity error	Max.	6 %		IEC793-1-20,21
Core /cladding concentricity error	Max.	o.4 μm		IEC793-1-20,21
cladding/ coating concentricity error	Max.	12 μm		IEC793-1-21
coating noncircularity error	Max.	10%		IEC793-1-20,21
Cladding non-circularity error	Max.	1.0%		IEC 60793-1-20,21

6.2.4- The optical fiber shall be coated with UV cured double acrylate compound. It should not have any reaction with cladding or core material.

6.2.5- Simultaneous coating & inking of the optical fiber is preferred.

6.2.6-The coating shall be max. resistance to microbending, abrasion and ensure mechanical & tensile strength. The coating shall be easily stripped with mechanical tools, without damaging the fiber.

6.2.7-The coating shall be provided excellent performance over a wide range of environmental conditions and enhanced aging reliability characteristics.

6.2.8-Fiber length per reel $\geq$ 25 km

6.2.9-Mechanical Specification

attribute	***Detail***	***value***		***Test method***
Fiber macrobend	wavelength	1550 nm	1550 nm	IEC 793-1-47
	diameter	60 mm	32 mm	
	number of turns	100	1	
	Max. attenuation	≤0.5dB	≤0.5dB	
coating strip force	Min.	8.9 N		IEC 793-1-32
	Max.	1.3 N		
Dynamic Tensile Strength	----------	unaged	aged	IEC 793-1-31
		>550 kpsi	> 660kpsi	
fatigue	----------	Dynamic	static	----------
		≥ 20 years	≥ 20 years	
Fiber curl radius	----------	≥ 4m		IEC 793-1-34
Proof test	-	≥ 0.7Gpa(1 % 100 kpsi)		IEC 793-1-30

6.2.10- The full length of each fiber shall be proof and macrobend tested and recorded before the cabling operations.

6.2.11- Fiber Identification

6.2.11.1-The coating shall be in various colours in order to facilitate fiber identification. The colours shall correspond reasonably with standard colours and shall readily be identifiable and shall be homogenous and durable.

6.2.11.2-The coating and the colour shall not react with surrounding jelly.

6. 2.11.3-The colour coding for individual fibers in a loose tube shall preferably be as given below:

a) 6 fibers in loose tube:

1. white 2. Red 3. Green 4. Blue 5. Yellow 6. black

b) 4 fibers in loose tube:

1. white 2. Red 3. Green 4. Blue

6.2.11.4- The nominal outside diameter of the coloured fiber shall be $250 \pm 10 \mu m$.

6. 2.11.5-The optical, geometrical and mechanical properties of optical fibers shall be tested and measured prior to cable manufacturing and remain traceable throughout the manufacturing process and the lifetime of the cable.

6.3- Cable Construction

6.3.1-The cable construction shall be fully qualified and tested in accordance with ITU-T, EIA/TIA, IEC, IEEE and ASTM standards and shall meet all requirements stated in this specification.

6.3.2- Central Strength Member

6.3.2.1-The central anti-buckling member shall consist of a dielectric, Fiberglass Reinforced Plastic (FRP) rod. The purpose of the central member is to prevent buckling of the cable, with the following properties:

a) tensile strength ≥ 1500 N/mm^2

b) elongation at break ≥ 3 %

c) water absorption ≤ 0.1%

d) young's modulus ≥ 50,000 N/mm^2

e) outer diameter ≥ 2.5 mm

6.3.2.2-The FRP rod shall be over-coated with a layer of polyethylene conforming to ASTM D-1248 type III, class C, category 5, grade E8, when required to achieve dimensional sizing to accommodate buffer tubes/ fillers.

6.3.2.3- The FRP and filler must not contain any splices in the cable length.

6.3.3- Buffering (cable core assembly)

6.3.3.1-All coated fiber shall be placed inside a non-conductive loose buffer tubes. Each tube shall contain up to six (6) fibers.

6. 3.4.2- The loose tubes shall be dual layer design and preferably be made of polybutylene terephtalate compound (PBTP) according to ASTM D 3221 , 4507. The properties of PBTB shall be specified by supplier.

6. 3.3.3-The loose tubes stranded together around a central strength member by s-z or reverse lay techniques.

6. 3.3.4-Each buffer tube shall be filled with a non-hygroscopic, non nutritive to fungus, electrically non-conductive, homogeneous gel to prevent water and moisture penetration. The gel shall contain anti-oxidant, additives, and be readily removable with conventional solvents, the gel shall be non-toxic and safe to exposed skin. The gel chemically and mechanically compatible with all cable components. The properties of this gel shall be specified by supplier.

6. 3.3.5-The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrinkback requirements.

6. 3.3.6-Filler rods shall be used to fill all unused buffer tubes, or shall be used instead of unused buffer tubes in the cable core to lend symmetry to the cable cross-section where needed. The colour of the fillers shall be white.

6. 3.3.7-The Min. nominal outer diameter of the buffer tubes and filler rods shall be 2.3 mm.

6. 3.3.8-Two polyester yarn binders shall be in contra helix form with sufficient tension to secure each buffer tuble, filler to the dielectric central member without crushing the buffer tubes.

6. 3.3.9-The flooding compound used between the loose tubes, filler, central strength member and polyester tape shall be according to clause 3.3.4.4 of this specification.

6. 3.3.10-The buffer tubes, fillers and central strength member shall form the standard cylindrical group or cable core.

6. 3.3.11-One layer of Polyester tape with a sufficient thickness placed longitudinally over the cable core. The tape shall form a close fit around the cable core with a sealed over lap of 4 mm minimum. The properties of this tape shall be specified by supplier.

6. 3.3.12-Flooding compound shall be applied over the polyester tape.

6.3.3.13-The colour coding for individual tubes shall preferably be as given below:

1. red 2. Blue 3. Green 4.Yellow

6.3.4- First Jacket (Inner Jacket)

6.3.4.1-The inner jacket shall be Medium Density Polyethylene (MPDE).

6. 3.4.2-The MDPE jacket material shall be as defined by ASTM-D1248, Type II, class C and Grades J4, E7 and E8.

6. 3.4.3-The minimum thickness of the jacket shall be 1.5 mm.

6. 3.4.4-The minimum tensile strength and ultimate elongation of the first jacket shall be:

- Tensile strength 12 N/ mm^2 Min
- Ultimate elongation 500 % Min

6.3.5- Armoring

6.3.5.1-Corrugated steel (electrically chrome plated low carbon steel) tape both side coated with ethylene acrylic copolymer, applied longitudinally over the first jacket with a minimum overlap of 4 mm. This layer is used for adding the mechanical sterngth of fiber optic cable.

6. 3.5.2-Thickness of steel tape shall be 0.2 mm after corrugation process and thickness of the copolymer coating shall be 0.04 mm. Care should be taken that the overlapped portions of the armor type shall be in register (corrugations shall coincide at overlap) and in contact at the outer edge.

Notes:

It is preferred that the overlapped portion of the corrugation shall be connected together by adhesive or welded.

6.3.6- Aramide Yarn Layer (braid)

In the single mode duct jelly field fiber optice cable, the braid or aramid yarn layer shall be used instead of corrugated steel tapes.

6.3.6.1-The following specification and relevant test methods of aramid yarn shall be proposed in the technical proposal:

a) coeficient of thermal proposal
b) tensile properties (tenancity, tensilestrength, elongation at break, …) at room temperature.
c) Cross section or thickness.
d) Load at specified elongation (g force)
e) Twist (t/m)
f) Yield (m/Kg)
g) The thickness of total yarn

6.3.6.2-The aramid yarn should be high modulus, high flexibility good dimention stability and corrosion resistance.

6.3.6.3-In the duct cable, a single flat copolymer coated aluminum tape shall be applied longitudially with an overlap of 3 mm over the first jacket.

6.3.7- Outer Jacket

6.3.7.1-The outer jacket shall be free of holes, splits, cracking, blisters or other failures of the sheath components when examined under 5 X magnification and shall be as smooth and concentric as is consistent with the best commercial practice.

6. 3.7.2-Polyethylene for the outer jacket shall contain carbon black to provide ultraviolet light protection, and shall not promote the growth of fungus.

6. 3.7.3-The outer jacket material to be used in this cable shall be black, High Density Polyethylene (HDPE) in accordance with ASTM D 1248, type III, class C, Category 5 and containing a suitable antioxidant system.

6. 3.7.4-The carbon black shall be a furnace-type conforming to the designation N110 in ASTM 1765. the carbon black content in the jacket when measured in accordance with ASTM D 1603 shall be 2.6 ± 0.25% by weight.

6. 3.7.5-The light absorption coefficient of the jacket will be at least 400 when measured at a wavelength of 375 nm per ASTM D 3349.

6. 3.7.6-The HDPE jacket shall be met the tensile and elongation following minimum requirements:

Min. Tensile strength	19.3 (28000) Mpa (Psa)
Min. Elongation	500 %
Thickness	2 ± 0.1 mm

6. 3.7.7-Ripcords shall be provided under the armored and both dielectric cable jackets in order to provide a means for quick jacket removal.

6. 3.7.8-The outer jacket shall be marked with manufacture's name, month and year of manufacture, sequential length markings, fiber count, fiber type, the letters NIGC and telephone handset symbol per NESC section 350 G.

6. 3.7.9-The above information shall be printed in permanent and durable white ink at intervals not more than (5) five meters. But the length of the cable shall be identified in each one meter. If remarking is required, yellow marking are used to correct the error in the original markings.

6. 3.7.10-The marking shall be insoluble in water and shall be remain legible to normal vision after the marking durability test.

6. 3.7.11-The maximum pulling tension shall be 4000N during installation, the supplier shall propose how to provide additional tensile strength related to FRP central strength member.

7. Optical fiber and cable performance

In order to check the similarity of fiber and cable design, material composition, manufacturing process the following requirements shall be applied to the fiber and finished cables.

7.1-The supplier's test certificate and test results for the following raw materials used in manufacturing of these optical fiber cables shall be submitted.

- HDPE & MDPE layers
- Corrugated steel tape
- Ripcord
- Aramid yarn
- UV ink
- Buffer tube
- FRP

- Gel-filled (filling & flooding compound)
- Filler
- Fiber

7.2-The minimum optical, geometrical and mechanical of fiber shall be in accordance with the clause of 6.2.2 , 6.2.3 and 6.2.9 of this specification.

7.3-The attenuation, chromatic dispersion & PMD of all fibers when introduced in cable form shall not exceed from values specified in clause 6.2.2 of this specification.

7.4-The cutoff wavelength, λ cc, of single-mode optical fiber cable shall be $\leq$ 1260 nm.

7.5-The minimum mechanical and environmental performance of the finished cable should be accordance with the following tables, all attenuation & PMD measurements shall be performed at 1310 & 1550 nm. .

7.6-mechanical performance table

Item	Cable Test	Test Method	Reference Standards	Minimum Requirements
1	Cable bend:	Mandrel Dia: 20 X cable Dia @-30˚C and 60˚C	EIA/TIA-455-37 IEC 194-1-E11	- Attenuation change ≤ 0.1 dB - No damage or breakage of cable
2	Impact resistance:	25 Impact cycles Impact Energy:5J	EIA/TIA-455-25 IEC60744-1-E4	- Attenuation change ≤ 0.05 dB
3	Compressive strength: (armoured & all-dielectric)	440N/Cm	IEC 60794-1-E3	- Attenuation change ≤ 0.05 dB
4	Maximum tensile load:	Load up to 4000N L ≥ 40 meter	EIA/TIA-455-33 IEC 60794-1-E1	- Attenuation change ≤ 0.05 dB
5	Cable twist (torsion test)	2 meters length rotation: ±180º 10 cycles (20 Items) Load: 10 kg	EIA/TIA-455-85 IEC 60794-1-E7	- Attenuation change ≤ 0.05 dB
6	Cable cyclic flexing	20 X cable Dia 30 cycles/min	EIA/TIA-455-104 IEC 60794-1-E8	- Attenuation change ≤ 0.05 dB - No damage or breakage of cable
7	Kink test	3 meters length Formed in to a loop Min: 20 X cable Dia	IEC 60794-1-E10	- No damage or breakage of cable, loose tube or fibers
8	Repeated bending	No: 10 cycles Rate: 2 sec/cycle Load: 10 kg L > 1.5 m Angle: ± 90 Mandrel Dia: 20 X cable Dia	IEC 60794-1-E6	- Attenuation change ≤ 0.1 dB

7.7-Environmental performance

Item	Cable Test	Test Method	Reference Standards	Minimum Requirements
1	Temperature cycling	Temperature range: -40˚ to + 85 ˚C Transition from 0º to -40ºC : 2 hours Duration at -40º : 8 hours Transition from -40º to +85ºC: 4 hours Duration to +85ºC : 8 hours Transition from +85º to 0ºC : 2 hours Duration of each cycle :24 hours Number of cycles :10	EIA/TIA-455-37 IEC 60794-1-F1	Attenuation change ≤ 0.05 dB
2	Cable aging	168 hours @ 85 ˚C	EIA/TIA-455-3 ICE 60794-1-F1	Attenuation change ≤ 0.05 dB
3	Cable freezing	frozen in ice	EIA/TIA-455-98 IEC 60794-1-F1, 6	No attenuation change
4	Water penetration	head of water: 1 m test period: 24 hours	EIA/TIA-455-8 IEC 60794-1-E5	No either leakage at the end of length
5	Filling & flooding compound flow	24hours @ +70 ˚C	EIA/TIA-455-81 IEC 60794-1-E14	No flow
7	vibration	2 meter Amplitude ± 5mm Frequency 10 Hz Duration 15 days	None	- No mechanical damage to the cable construction - No increase over the original attenuation

7.8-The supplier shall be submit detailed test procedures & test rate for each of the above mentioned tests as is applied in manufacturing process with technical proposal.

7.9-The supplier shall specify the outer diameter (in mm) and weight (in kg/km) of the optical cable.

7.10-All routine tests according to internal quality test plan shall be performed. The test procedures, criteria and test results for each routine test shall be submitted to NIGC.

7.11-In addition, the manufacturer shall do the following minimum tests in the manufacturing process of these cables and submit the measurements and computed values to the NIGC on a suitable and easily readable from.

7.12-Test on 100 percent of completed cable:

a) The armor for each length of cable must be tested for continuity

b) Attenuation for each optical fiber in the cable

c) PMD of each optical fiber in the cable

7.13-Tests on a quality assurance basis must be made as frequently as is required for each manufacturer to determine and maintain compliance with:

a) cable cut off wavelength
b) chromatic dispersion
c) PMD
d) Zero-dispersion slope
e) Shrinkback and cold bend testing of loose tube.
f) Adhesion properties of the protective fiber coating
g) Performance requirements for the inner and outer jacketing materials.
h) Performance requirements for the filling and flooding compounds.
i) Bonding properties of the coated armoring materials.
j) Performance requirements for FRP and filler materials.
k) Sequential marking and lettering.
l) Cable bend, cable impact, repeated bending and Min. bend radius tests.
m) Water penetration, compound flow and freezing tests.
n) Cable twist, cable flex, kink and cable compression tests.
o) Tensile Strength, Temperature Cycling and Cable Aging tests.
p) Lighting damage susceptibility and current carrying capacity tests.

7-14-Any test which is part of the manufacturer's standard test procedure and not specifically requested herein, will be required.

8. End cap

For cable protection against water ingress during storage, shipping and installation, both side of each cable should be sealed by suitable heat shrinkable end cap with following parameters:

- Should be of polyethylene hot melt material.
- Should be suitable for 24-core armoured fiber optic cable.
- With at least 60 mm length and 2.2 mm thickness.
- A circular steel plate shall be used in End cap for protection of the heat shrinkable End caps.

9. Packaging

The finished cable shall be wounded evenly on specially constructed metallic drums to avoid macro bending of the optical fibers during shipment; the cable delivery length shall be 4.10 km.

Both ends of the cables shall be available for tests, and thoroughly sealed with heat shrinkable end caps and fixed to the drum sides protected by metal covering.

The cable drums shall be made in same dimension with barrel diameter, not less than 30 times the nominal diameter of the cable.

The cable in the drum shall be securely fastened to prevent the cable from coming loose during transportation and installation.

All cables shall be individually packed to avoid damage during transit end storage in accordance with best commercial practice and with the requirements of applicable specifications. The material used for packing, wrapping, sealing, moisture resistant barriers, corrosion prevents, etc. shall be of recognized brands and shall conform to the cable from impact, vibration, rough handling, radiant, fungus or mold, etc….

Each cable drum shall have a copy of factory acceptance test report enclosed in it.

The cable drum shall be covered by black sheet plast that its thickness and quality shall be agreed between end user and cable manufacturer. The covering drum shall be fastened with band to the drum.

A nameplate shall be attached on the body permanently and should include following information:

1-Manufacturet Name & Address.

2- Specification: IGS-M-IT(002)

3- Date of Manufacture:

4- Order No.

5- Type & Trade Name of Material.

6- Country of Origin

7- Country of Destination.

8- Terms of Delivery

9- Total Gross Weight

10- Cable Length

11- Reel or Pack No.

10. Quality assurance programmed & Factory Acceptance Test (FAT)

10.1- Quality assurance programmed

10.1.1-The supplier shall submit the details of Quality Assurance Program followed by him becoming with raw materials, fabricated components, assemblies, etc. to finished product (AS APPLICABLE). Supplier shall obtain and forward the Quality Assurance Programmed for equipment supplied by sub-contractor, if any.

10.1.2-The quality program must assure adequate quality throughout all areas of contract performance, i.e, design, development, fabrication, processing, assembly, inspection, test, maintenance, packing and associated documentation and shipping.

10.1.3-The NIGC's representatives and/or third appointed agency reserve the right to inspect and test cable at all stages of production and testing. The inspection and testing shall include but not be limited to material, sub-assemblies, prototypes, produced units, guaranteed performance specifications, etc.

10.1.4- The quality program, including performance, process and product will be submitted to NIGC.

10.1.5- The necessary information about test equipments/instruments, test gear, test bed and reasonable facilities available for Factory Acceptance Test (FAT) shall be attached to the technical proposal.

10.1.6-NIGC's representatives shall have free entry and access to any and all parts of the Supplier's facilities associated with manufacturing and testing of the system at any given time.

10.1.7-It should be explicitly understood that under no circumstances shall any approval of the NIGC or his representatives relieve the Supplier of his responsibility for marital, design, quality assurance and the guaranteed performance of the system and its constituents.

10.1.8-Supplier shall notify the NIGC's representatives at least 45 days in advance, of the date on which system shall be ready for Inspection and Testing. All relevant documents and manuals; approved engineering drawings, etc. shall be provided to the NIGC's representatives at least 30 days in advance of the start of inspection and Testing.

10.1.9-NIGC's representatives shall, after completion of inspection and testing to their satisfaction, issue factory acceptance certificates to release the cable for shipment. No cable shall be shipped under any circumstances unless a factory acceptance certificate has been issued for it, unless agreed otherwise by NIGC's representatives.

10.1.10-In addition to the qualification requirements and in order to meet the criteria of this specification, the manufacturer should have in place the following:

a)The information defining the product design and conformance to this specification.

b) The manufacturer's quality program (plan) to meet these requirements.

c) Historical data for mature products demonstrating that the requirements are consistently met.

d)Use of industry standard test procedures.

10.2-Factory Acceptance Test (FAT)

10.2.1- All fiber and fiber optic cable, shall be tested in the factory prior clearance for shipping. The fat shall include individual drums where appropriate.

10.2.2- The FAT shall demonstrate adherence of the cable to the design standards and compliance to this functional specification.

10.2.3-30 days prior to the FAT, supplier shall submit a FAT test procedure to NIGC for approval.

10.2.4-All factory acceptance tests will be carried out on sample test basis. The sample will be selected by NIGC inspections.

10.2.5-The sampling rate will be mutually agreed between NIGC and the supplier. However, it will be at least ten (10) percent of cable drums.

10.2.6-One copy of test results will be attached to the drum and package. Two additional copies of all test results shall be submitted to NIGC.

10.2.7-Supplier shall be arranged all test equipments/instruments, man power test-gear, accessories, etc… necessary for testing.

10.2.8-The NIGC will dispatch two representatives to inspect factory tests. All expenses including air-ticket shall be paid by Supplier.

10.2.9- The manufacturer shall be performed the entire necessary and pertinent factory test on the raw materials, fiber, finished cables, equipments and accessories.

10.2.10- The supplier will offer the NIGC representatives, without charge, all reasonable facilities and assistance necessary to satisfy the NIGC representatives that the work is being performed in accordance with the requirements of this specification.

10.2.11- In order to check the full integrity of fiber and finished cables the following factory acceptance tests and checks shall be realized.

10.2.12- The following transmission properties, Geometrics and mechanical tests shall be carried out for fiber optic:

A)transmission properties

Attenuation at 1310 & 1550 nm

Chromatic dispersion

Zero dispersion slope

Zero dispersion wavelength

Fiber cut-off wavelength

PMD at 1550 nm

B)Geometrical

mode field diameter at 1310 & 1550 nm

core non-circularity error

cladding diameter

cladding non-circularity error

core/cladding non-circularity error

coating diameter

coating non-circularity error

cladding/coating non-circularity error

C)Mechanical

Macrobending loss

coating strip force

tensile strength

proof test

fiber curl

E) Environmental

Temperature cycling

10.2.13-The following optical, Geometrical, Mechanical and Environmental test shall be carried for fiber optic cables.

A) Optical test

Optical Attenuation

PMD

Cable cut-off wave length

B) Geometrical tests

Outer diameter

Thickness of the all sheathes

Identification

C) Mechanical tests

Tensile strength (pulling or tensile load)

Repeated bending

Impact resistance

Torsion (twist)

Vibration

Kink test

Compression test

Cable bending

D) Environmental

Water penetration

Compound flow

Temperature cycling

10.2.14- NIGC reserves the right to inquire and add any other possible tests before approving the list as an official contract document.

10.2.15- In case of fiber and cable tested and inspected in accordance with this specification, fail to pass the test or comply with specification requirements, the test shall be repeated on future pieces, and if it again fails, the whole lot shall be rejected.

11. Documentation

All documentations shall be in SI units and the English language. Drawing will be metric; produced on metric size paper. Supplier will be held liable for all purchaser cost resulting from errors in Supplier's certified prints. Supplier is cautioned against submitting certified drawings and data, which have not been checked.

Supplier shall submit a document register for all drawings, technical description, calculations, work and test procedures, etc. that are to be prepared for the job. These shall include Supplier's subcontractor documents and are subject to review and approval by purchaser or his engineering subcontractor. This document register shall be used to track receipt/transmittal and shall be updated by Supplier with each submitted. The document register shall be presented by Supplier at the kick-off meeting for purchaser/engineering subcontractor approval.

Appendix A

Calculating the chromatic dispersion coefficient

The chromatic dispersion coefficient, D, is specified by putting limits on the parameters of a chromatic dispersion curve that is a function of wavelength in the 1310 nm region. The chromatic dispersion coefficient limit for any wavelength, λ, is calculated with the minimum zero-dispersion wavelength, $\lambda_{0\min}$, the maximum zero-dispersion wavelength, $\lambda_{0\max}$, and the maximum zero-dispersion slope coefficient, $S_{0\max}$, according to:

$$\frac{\lambda\ S_{0\max}}{4}\left[1-\left(\frac{\lambda_{0\max}}{\lambda}\right)^4\right] \le D(\lambda) \le \lambda\frac{S_{0\max}}{4}\left[1-\left(\frac{\lambda_{0\min}}{\lambda}\right)^4\right]$$

The values of $\lambda_{0\min}, \lambda_{0\max}$ and $S_{0\max}$ shall be within the ranges specified in above table. The above equation, when used with these values, can be used to determine upper limits of the chromatic dispersion coefficient in the 1550 nm region.

The chromatic dispersion coefficient, D, is specified within a wavelength range by stating a range of allowed absolute values of the chromatic dispersion coefficient. The chromatic dispersion coefficient shall not cross zero within the specified wavelength range. The sign of the chromatic dispersion is also specified. The form of the specification is:

$$D_{\min} \le |D(\lambda)| \le D_{\max} \qquad for \quad \lambda_{\min} \le \lambda \le \lambda_{\max}$$

Values for $D_{\min}, D_{\max}, \lambda_{\min}, \lambda_{\max}$ and sign shall be within the ranges given in above table. Extension to wavelength ranges above1565 nm and below 1530 nm are under consideration.

Appendix B

Instructions to Bidder's Tender Responses

Bidder must complete for each paragraph and sub-paragraph which is listed in the technical specification and indicate the bidder response table to each specific paragraph. The response will be given with a check (✓) in the appropriate column.

- A check (✓) in the "Comply" column means the bidder can meet completely the conditions indicated in the particular paragraph.

- Checks (✓) in the "Partially Comply" and the "Supporting Information" columns mean the bidder has met the condition of the particular paragraph and has supplied the necessary supporting information.

- Checks (✓) in " Not Comply " and " Supporting Information " columns means that the bidder cannot meet all the conditions indicated in that particular, paragraph , but has supplied information to support his position.

Response Format

PARAGRAPH REFERENCE	COMPLIED	NOT COMPLIED	PARTIALLY COMPLIED	SUPPORTING

The supplier shall state why he can not comply with the item or why NIGC should reconsider his position.

The factory test schedule and test procedures shall be submitted with technical proposal.

The manufacturer shall submit the procedures and quality test plan for routine and type test with technical proposal