



Offshore Design Section  
Engineering Services  
ISO – 9001:2008

**FUNCTIONAL  
SPECIFICATION FOR  
INSTRUMENTATION CABLES**

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Discipline Instt

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# FUNCTIONAL SPECIFICATION

## FOR

### INSTRUMENTATION CABLES

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## 1.0 SCOPE OF THIS DOCUMENT:

This Specification defines the minimum requirements for design, manufacture, supply and testing of Instrumentation Cables with cable glands / accessories for installation on the offshore process / well platforms.

## 2.0 CODES & STANDARDS:

### 2.1 Reference Specifications:

- a) Instrumentation Design Criteria
- b) Basic Bid Work

### 2.2 The Contractor shall ensure that the scope of work is executed with all mandatory and statutory Indian requirements.

All cables, accessories and other components supplied, shall comply with the latest revisions of the applicable codes and standards.

- a) B I S [Bureau of Indian Standards]
- b) IEC [International Electro technical Commission].
- c) NEMA [National Electrical Manufacturers Association].
- d) NEC [National Electrical Code]
- e) IEEE [Institute of Electrical and Electronics Engineers].
- f) API [American Petroleum Institute].
- g) Any other recognized International code or standard may be used in lieu of above, subject to approval of company.

## 3.0 SCOPE OF SUPPLY:

### 3.1 Quantity of the Cables for instrumentation works shall be based on the actual requirements for cable laying, looping, terminations etc., and shall include 'spare' length for exigencies during installation / commissioning.

The Scope for supply of Cables includes the following items:

- a) Flame retardant, low smoke, zero halogen, heat and oil resistant low voltage cables. (Instrumentation Cables - Signal, Alarm, Digital, Thermocouple extension, etc., and Power Cables for Instrumentation power requirements)
- b) Flame retardant and Fire resistant, low smoke, zero halogen, mica glass tape insulated, heat and oil resistant low voltage cables. (Cables for: F&G systems, ESD systems, Safety related & for Critical Control, Power and Shut Down applications).
- c) Cable glands and Cable accessories
- d) Termination Accessories / Connectors where specified.



**3.2** Vendor shall submit detailed Specifications for Company's approvals, with type of Cables and Quantities mentioned therein.

#### **4.0 GENERAL REQUIREMENTS:**

##### **4.1 Safety**

- a) Non-metallic materials, such as conductor insulations shall be non-hygroscopic, flame retardant and / or fire resistance, self extinguishing and non toxic chaired.
- b) Materials that are toxic to the environment or are a potential Carcinogen such as asbestos, poly chlorinated bi-phenyls (PCBs), Mercury etc., shall not be used in the making of the cables.

##### **4.2 Materials, Workmanship and suitability:**

- a) All materials utilized in the construction of the cables shall be to the latest industrial standard specifications, new and in current production. Should any material prove unsatisfactory, it will be rejected notwithstanding any previous satisfactory examination or tests of similar material or of completed cables
- b) Where required the Contractor shall provide cable sheath oil resistance performance characteristics.
- c) The use of polymeric materials as alternatives to elastomeric materials shall be subject to acceptance by the company. The Contractor's proposal for such alternatives shall be supported by detailed certified evidence of continuous and complete performance in offshore locations.

##### **4.3 Design life:**

Cables and cable accessory shall be suitable for operations without periodic maintenance applied throughout the design life of the platform specified elsewhere in the bid package. The overall availability and reliability of the cables and cable accessories shall be demonstrated by the Contractor.

##### **4.4 Units and information:**

All quantities and dimensions shall be expressed in metric units. All information, manual, certificates, data and inscriptions shall be in the English language.

#### **5.0 TECHNICAL REQUIREMENTS**

##### **5.1 General**

- 5.1.1 The cable shall be new and in good condition and shall be suitable for layering and bunching in ladders, trays and ducts.
- 5.1.2 All signal, power and control cables on non critical loops shall be flame retardant, low smoke type with sunlight and oil resistant outer sheets, 'zero / low halogen' suitable for installation on offshore oil and gas processing platforms.
- 5.1.3 Cables on critical service for safety and emergency systems shall be fire resistant type in addition to the specifications at 5.1.2 above.



- 5.1.4 Conductors shall be stranded and Cables shall be flexible and suitable for easy termination using standard crimps and terminals.
- 5.1.5 All instrument signal cables shall be continuously shielded with the shield grounded at the same point / bus as the signal circuit, generally at the control instrument (panel) end.
- 5.1.6 Detailed specifications and testing requirements on “inner and outer conductor insulation and sheathing” material for low halogen / fire resistant / Flame Retardant cables, refer FS 4011 (Electrical – Functional Specifications for Electrical Cables). Fire resistant characteristics of the cables shall be as per IEC 60331 (750°C for three hours)

## 5.2 Cable Types:

- 5.2.1 The cables used shall in general be of the following types:

a) **Fire Resistant Cables:**

Cables of this type shall be used for all circuits / instrument loops that have a safety-related function, or are required to remain operational under emergency conditions. Specification shall be same as that of instrumentation cables as at 5.2.2 (b) below, however with the Primary Insulation being “Fire Resistant” inclusive of the necessary protective fire proofing insulations. In addition these shall be listed by UL/FM or equal in fire service and shall comply with the requirements of IEC 60331 and IEC 60332-3 (Category A) or better. It shall have a fire resistant layer between tinned copper conductor and extruded insulation of MICA glass tape material. This includes cables for all parts of F & G Systems (analog / digital signals), ESD systems, PA Systems, warning beacons and platform status lamps, fire control systems, and power supplies to those systems.

b) **Flame Retardant Cables:**

Cables that are not Fire Resistant shall be Flame Retardant type and shall comply with the requirements of IEC 60332-3 (Category – A). The flame retardant cables to be used for different applications shall in general be as follows:

i) **Signal Cables:**

- Twisted Single Pair / Triad cables shall be 600 V rated and shall have 1.5 sq. mm. PVC covered, 7 stranded Copper conductor, shield with aluminum backed by Mylar tape with the metallic side down helically applied with either side 25% overlap of 100% coverage. Minimum shield thickness shall be .05 mm for single pair and 0.75 mm for triads and multi pair cables.
- 18 AWG, 7 stranded tinned copper drain wire shall be provided and shall be in continuous contact with the aluminum side of the shield. The drain wire resistance including the shield shall not exceed 30 Ohms / Km.
- Cables shall have PVC Inner & Outer jacket and galvanized steel armoring. Jacket shall be light blue in color for intrinsic safe applications and Black for others.
- Ripcord shall be provided for all cables.



- All signal cables (Single or Multi-Pair), shall have individual and overall screen for the conductor pairs / triads, when used for analog 4-20mA and low level signals such as thermocouple signals, pulsed signals or similar signals. All other instrumentation cables (alarm / digital / control) cables shall have overall (collective) screen. For Cored cables there shall be no screen. Drain wire and the cable conductor screens shall be grounded at one place i.e., at the panel end where the electronics (signal circuit) in the panel is grounded.
- Pairs and triple (triad) type cables shall be uniformly twisted (at least 10 twists per meter) to form pairs/triples and shall not be dissociated by normal handling. Multi-pair / triple cables shall be laid to prevent cross-talk between pairs/triples.
- Instrument signal cable configurations shall in general be: 1 pair, 2 pair, 6 pair, 12 pair, 1 Triad, 6 Triad, 8 Triad etc.
- Multipair cables shall have following additional features:
  - Individual Pair / Triad shall be twisted.
  - Pair / Triad identification by color coding / numbering.
  - Individual pair shielding apart from overall shielding.
  - Single Pair Communication Cable, of 22 AWG 7 strand copper wire with PVC insulation.

ii) **Control / Alarm / Status Cables:**

These shall be same as signal cables except there shall be no individual pair shielding in case of multi-pair cables.

iii) **Extension and Compensating Cables for Thermocouples:**

The cables for thermocouple extension cables shall be of same material as that of thermocouple, which shall be marked as X behind the identification letter for thermocouple as per convention. Compensating cable material shall have same thermo-electric properties as that of thermocouple material. These cables generally shall be same as signal cables except conductor shall be solid 16 AWG in single pair and solid 20 AWG in case of multipair cables. Colour coding, thermoelectric characteristics and limits of errors shall be as per ANSI MC 96.1, BS, EIN, DIN etc.

iv) **Power Cables:**

Power cables shall be 3-core, minimum 2.5 mm<sup>2</sup> copper conductors, 600V 1.0 KV grade, with PVC insulation, galvanized steel armoring. Larger sizes shall be used where required to keep cable voltage drop below 2% of the supply voltage.

c) **Special Cables:**

Cables for special instruments like analyzer, turbine meter, serial interface, Magnetic flow meters, Ultra sonic flow meters, etc. shall be as per manufacturer's recommendation.

d) **Digital Communication Cables**



- i) In addition to the technical requirements stated in the previous sections, the following requirements are specific to digital communication cables.
- ii) In general, the digital communication cables covered by this specification shall be in accordance with the recommendation of the manufacturers supplying the digital equipment.
- iii) Fiber Optic Cable shall be based on ITU-T Rec. 652. Fiber Optic Cable shall be in general fiber multimode 62.5 / 125 micro meter buffered fiber, aramid yarn central strength member and aramid yarn reinforced. Fibre optic cables shall have 50 % spare fibres or 4 spare fibres whichever is greater.
- iv) Cables for serial communication shall be foil screened twisted (4 pairs), 100 ohms impedance, 12.5 pF/ft and 24 Ohms/mile, to Beldon 9729 or equivalent.
- v) Cabling of Ethernet or fast Ethernet service shall be Category 5e or Category 5 dependant on location and digital equipment.
- vi) Both armoured and un-armoured cables shall be required as per requirement.

e) **Optical fiber cables for Sub-Sea applications:** Refer Composite Cable specifications [FS-4020 Subsea Cable] in Electrical Discipline.

### 5.3 Conductor:

Conductor shall consist of plain, annealed, high conductivity, standard, tinned copper, smoothly drawn, circular in section, free from defect, complying with the requirement of IS:8130 / IEC-60228.

### 5.4 Conductor Insulation:

5.4.1 The Insulation shall be in general extruded compound of low smoke material complying with the requirements of IEC 60502.

5.4.2 Voltage grades for insulation shall be as follows:-

Nominal System Voltage:	Up-to 240 V
Maximum System Voltage:	264
Voltage Grade:	600 / 1000 V

5.4.3 Properties of Conductor Sheath / Insulation shall meet the following requirements [refer: FS 4011 (Electrical Discipline – Functional Specifications for Electrical Cables)].

- a) Temperature Index: Min.250 °C as per ASTM. D 2863
- b) Oxygen Index: Min.30 as per ASTM D 2863
- c) Acid Gas Generation: As per IEC 60092-359



- d) Smoke Generation: Less than limit for types SW4 Compounds as per IEC 61034
- e) Dielectric strength: Min.60% of original dielectric strength tested in accordance with NEMA-WC-5 at  $75^{\circ}\pm 1^{\circ}\text{C}$ .
- f) Flammability: Flame retardant characteristics of electric cable as per IEC- 60332 Part 3 Category –A
- 5.4.4 Cables nominated as Fire resistant shall comply with the following performance characteristic in addition to the above requirements.
- Fire Performance: Fire resistant characteristic of electric cables as per IEC 60331 (750°C for 3 Hrs)

## 5.5 Bedding and Inner Sheath

- 5.5.1 The bedding shall be extruded, non-hygroscopic solid filler substantially filled to prevent any ingress of water inside the cable. The material used for the bedding and fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. The inner sheath shall be effectively filled and shall comply with thickness requirements as IEC 60502. Removal of inner sheath shall not cause adhesion or damage to the conductor insulation. Taped inner sheath shall not be accepted.

## 5.6 Braiding/Armoring

- 5.6.1 Multicore cables shall be mechanically protected with hot dipped galvanized steel wire braiding (GSWB) or galvanized steel wire armoring (GSWA) applied over the inner sheath.
- 5.6.2 Single core low voltage and high voltage cables shall be mechanically protected with tinned phosphor bronze wire braiding (PBWB) or hard drawn aluminum round wire armoring which shall be applied over the inner sheath to conform to the requirements of international standards.

## 5.7 Outer Sheath

- 5.7.1 The outer sheath shall be heat and oil resistant, suitable for installation in an offshore oil and gas processing platform, with uniform thickness and fit tightly over the braiding / armour to ensure no undue residual strain is left in the material.
- 5.7.2 Outer sheath marking shall be such that details of size of cable (no of cores and conductor cross section), type of insulation, manufacturers name and international standard identification shall be embossed on the outer sheath at regular intervals at maximum of 1 metre.

## 5.8 Colour Coding

- 5.8.1 Cable outer sheaths shall be permanently colour coded such that colours do not deteriorate with age or fade with exposure to direct sunlight. Cable shall be UV resistant and coded as per the requirements of IEC 60502.
- 5.8.2 Cable Colour Coding





1	Low Voltage Power and Control (Equal to or less than 1 KV)	Black
2	Earth	Green / Yellow
3	Instrument Intrinsically Safe (IS)	Light Blue
4	Instrument (Non-IS)	Black

5.8.3 Cable cores shall be coloured as follows:

- 24 V DC Digital Circuits: Positive – White, Negative – Black
- Analogue Circuits: Positive – White, Negative – Black

5.8.4 Individual cores of multi-core power, control, instrument and telecommunications cables, if identified by numbers, shall have both the number and the printed word of the number permanently marked throughout the entire length of the core, at 100 mm interval.

## 5.9 Bending Radius

5.9.1 Cables shall be suitable for installation with the minimum bending radius, appropriate for the type of cable supplied, which shall comply with the requirements of IEC 60092 – 359.

5.9.2 The Contractor shall declare the National standards or the other internationally acceptable standard specification giving minimum bending radius

## 5.10 Cable Drums

5.10.1 Cables shall be dispatched on suitable barrel diameter, securely battened, with take off ends of the cable brought to the outside of the drum and fully protected against mechanical damage.

5.10.2 The wood used for construction of the cable drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum.

5.10.3 The Contractor shall ensure all cable drum lengths supplied shall be continuous as conductor jointing shall not be acceptable. Cables shall be wound on non-returnable cable drums.

5.10.4 Each cable drum shall be fitted with a stainless steel or equivalent label. Equivalent material used for providing the label should be corrosion resistant to saline conditions. The label shall be fixed to the outside of each flange, engraved or permanently marked with the following information:

- a) Company's Drum Number
- b) Manufacturer's name
- c) Cable type number
- d) No. of cores and cable cross sectional area in mm and core construction/stranding eg. 3C+E 4mm<sup>2</sup>, (7/0.85)
- e) Voltage grade
- f) International Standard(s)



- g) Purchase order number/item number
- h) Drum length (in meters)
- i) Net and gross weights (kg)
- j) Weight per meter
- k) Date of manufacturer.

### 5.11 Cable Lengths and Tolerances

- 5.11.1 Cable drum lengths shall require approval by the Company prior to dispatch from the manufacturer.
- 5.11.2 A tolerance of 5% shall be permissible for each cable drum supplied, although a maximum tolerance of +3% and zero negative tolerance shall be permissible on the ordered quantity of each cable type.

### 5.12 Cable Glands

- 5.12.1 The Contractor shall ensure full tolerance in the dimensional details of the cable outer diameter and diameter under braiding / armouring (where applicable) is provided by the manufacturer.
- 5.12.2 The Contractor shall ensure the cable glands to suit cable sizes are supplied by the manufacturer. All cable glands (NPT) shall be double compression type dual certified Exd and deluge protected unless otherwise approved by the Company.
- 5.12.3 All cable glands and adaptors will be made of nickel-plated brass/SS and will be fitted with soft sealing nylon washers or integral nitrile washers. Fiber washers will not be used. Locknuts will be used for entry into sheet steel boxes and enclosures.
- 5.12.4 Industrial cable glands (ET type) may be used with non-certified equipment in indoor, non-hazardous locations.

### 5.13 Cable Shrouds

Material for heat shrink Cable shrouds shall be cross linked polyolefin.

## 6.0 TESTING AND INSPECTION

### 6.1 General

- 6.1.1 The cable shall be tested and inspected at the manufacturer's works, or at a recognized testing facility. The Contractor shall ensure all the test equipment necessary to test the cables is provided by the manufacturer. Test certificates for all tests shall be provided to the Company, immediately on completion of tests performed. All tests shall be witnessed by the Company or its authorized representative.
- 6.1.2 The Contractor shall ensure detailed records and log sheets regarding the results of the tests and certification that the items supplied will meet specified performance requirements, are supplied.



## **6.2 Inspection**

- 6.2.1 The Contractor shall ensure all material employed shall be available prior to and after the manufacture of cables, for inspection by the Company. The Contractor shall furnish all necessary information concerning the supply to the Company's inspector or representative. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all the stages and will have the authority to reject any material which appears to be unsuitable or of unsatisfactory quality.
- 6.2.2 In addition, the minimum inspection requirements, prior to shipment of cable shall be the following:
- Verify cable lengths
  - Verify sheath colour
  - Verify gland fit
  - Verify core configuration
  - Verify core colours
  - Check continuity of each core (and screen/drain wires where applicable) on each drum (to match manufacturer's data sheet for DC resistance)
  - Check insulation resistance between cores and armour, where applicable (test at twice working voltage, not less than 10 M Ohm)
  - Verify drum markings

## **6.3 Factory Acceptance Testing**

- 6.3.1 Electrical and instrument cables shall be tested in compliance with the standards to which they are manufactured with all optional tests included.
- 6.3.2 Company shall be advised at least (4) weeks in advance of the scheduled date of each test and again 20 days prior to the actual test.
- 6.3.3 Tests shall include but are not limited to the following:
- Cables shall be tested in accordance with IEC 60092-359 tests to include electrical resistance of conductors.
  - Verification of design limitations; cable for use in IS circuits shall have their parameters measured to ensure that these comply with the relevant standards namely L/R micro F / Km & mH /Km.
  - Instrument cables shall be tested to verify the following:
    - The maximum inductance to resistance ratio (L/R) between insulated conductors of any one pair of screened cables shall not be greater than 26 micro-henries per ohm.
    - The mutual capacitance of screened cable at a frequency of 1 KHz shall not be greater than 100 pF per meter.



- iii. The pair to pair capacitive unbalance values at a frequency of 1 KHz for unscreened pairs shall not be greater than 250 pF per meter.
- iv. Spark test: a spark test shall be carried out on all instrument cables. All cores shall be tested at 6 KV rms.
- v. Coaxial cables shall be tested for frequency response, attenuation and insertion loss.
- vi. Type tests shall be carried out in compliance with IEC 60331 and IEC 60332 (Part 3) when specified.
- vii. Type test certificates may be acceptable, subject to acceptance by the company, in lieu of the tests.

#### 6.4 Sealing

- 6.4.1 Immediately after electrical tests, the ends of the cable shall be sealed with heat shrink caps to prevent the ingress of moisture.

#### 7.0 CERTIFICATION

- 7.1 All cables and cable accessories of similar design and construction features manufactured by the same Vendor:

- a) Shall have been type tested by an authority approved by the Company.
- b) Shall have been in continuous satisfactory service in offshore for a minimum period of two years.
- c) Shall be having current certification/approval/listing by an agency approved by the Company or UL or FM.

#### 8.0 INSTALLATION REQUIREMENTS

##### 8.1 Cable Runs and Segregations:

- a) The Contractor shall ensure that there is no interference between cables having different voltage or signal types. Instrument cables shall be segregated from antenna cables and others carrying RF signals so as to avoid interference.
- b) All instrumentation cables shall be supported / laid in trays. Power cables shall not be run in trays carrying signal cables. The physical separation of power and signal cables shall be as per API-550 Part –I SECTION VII. Cables in intrinsically safe circuits shall preferably be not run in the tray for cables in non-intrinsically safe circuits. If run in the same tray a metallic earthed separator shall be provided. Conduits carrying intrinsically safe cables shall be painted with the blue color bands at each end.
- c) Where cables are run through conduit, the entry and exit shall be smooth and free from burrs. The use of conduits shall be kept to a minimum, as far as possible.
- d) Cables must be pulled into conduit in a way that ensures there is not damage to the cable.



- e) Splices shall be made only at terminals, in instruments or approved equipment / junction boxes in any cable path.

## 8.2 Cable Marking:

- a) All cables shall be identified with stainless steel cable markers securely fixed to the cable with cable tie wraps at the following locations:
- All cable glands
  - Entering and leaving cable ladders, ducts and supports
  - Both sides of walls or bulkheads
- b) Cable markers shall be fitted during or immediately after cable installation.

## 8.3 Cable Identification:

- a) All wiring, cables, tubes, multi-tube bundles, junction boxes and auxiliary equipment shall be suitably identified as per applicable codes and practices. Plastic adhesive tapes shall not be used for identification. Identification and details of all such equipment and wiring/tubing shall also be clearly marked on appropriate drawings. All wiring shall be tagged with slip on or clip-on wire marker at both ends with the wire number specified on the drawings.
- b) Terminals for electrical connections including thermocouple extension wires shall be numbered and identified to indicate polarity, ground Connections, test connections, and any other pertinent information.

## 8.4 Cable Installation:

- a) All instrument signal cables shall be continuously screened, with screens grounded at the equipment room end only, and securely insulated at the field end. All cables exiting equipment rooms shall be protected / armoured, including serial link and data highway cables. Where armour is not possible for certain cables, same shall be protected by way of pipes (GI) along the length up-to and into the MCT.
- b) For ease of instrument disconnection, an adjustable elbow or union shall be provided between the terminating gland and the instrument.
- c) A neat loop of cable 250 mm diameter shall be left immediately adjacent to all instrument devices in the field.
- d) Cabling to locally mounted instruments shall not be routed across normal or emergency walkways nor interfere with access to equipment.
- e) Multi Cable Transits (MCT) shall be used to provide gas-tight cable penetrations through control room wall, decks or firewalls.
- f) Contractor shall size and provide MCT considering 50% spares for each cable size/Cable OD. Power, Control and signal cables shall be suitably separated within the MCT Frame.



### 8.5 Cable Termination:

- a) All cables shall be terminated using double compression type glands on explosion proof equipment. These glands shall be explosion proof, certified. All cable glands in outdoor service and on equipment subjected to salt water spray shall be weather proof to IP 67. All terminations shall be screw clamp type terminals for 2.5-mm<sup>2</sup> conductors minimum (no flying leads) and correctly certified where necessary. Insulated crimp lugs shall be used for all cable core connections, with only one conductor per terminal side.
- b) No wire shall be terminated/left with mechanical strain on it in any conduit or trunking.
- c) Cables shall be terminated in 316 SS glands, suitably certified where necessary. The inner sheath shall be left on the cable after the gland, and removed at the point of entry into wiring duct.
- d) Cable cores shall not be 'pig tail' finish.
- e) Cable screens and drain wires shall be securely fastened and insulated at the final field termination.
- f) The communications conductor of a cable shall be terminated in the bottom terminal(s) of a row of terminals.
- g) Printed sleeve-type ferrules shall be fitted to all cable cores on both sides of every core. 'C' type and adhesive type shall not be used.
- h) All cables shall be individually loomed at maximum fixing centers of 60 mm and where cores leave the loom.
- i) Only one conductor shall be used per terminal side.
- j) All cables ends terminated at each end shall be covered with heat shrink type cable shrouds for protecting them from ingress of water, and foreign particles.
- k) Cable entry to control room/other rooms shall be through listed multi-cable transits.
- l) Terminal blocks shall be non-hygroscopic, Vibration proof, stack on type and shall use captive screws for terminals. Terminals shall be tinned or Silver plated. All terminations shall be through use of wire lugs. Terminal blocks shall be flame retardant type.
- m) Cable Termination for Skid Items: Manufacturer or fabricator supplying skid mounted equipment or vessels with instrumentation which provides or utilizes off skid alarms / shutdowns / control functions, shall terminate signals on a central junction box, near skid boundary, available for hook-up by Contractor. The location of this junction box shall be noted on vendor drawings.