

## SPECIFICATION No. TI/SPC/OHE/WR/1060 (Rev1)



सत्यमेव जयते

GOVERNMENT OF INDIA

MINISTRY OF RAILWAYS

SPECIFICATION No. TI/SPC/OHE/WR/1060 (Rev.1)

25 KV A.C. TRACTION OVERHEAD EQUIPMENT

SPECIFICATION FOR STAINLESS STEEL WIRE ROPES

(For official use only)

Issued by:

TRACTION INSTALLATION DIRECTORATE

RESEARCH DESIGNS &amp; STANDARDS ORGANISATION

MANAK NAGAR, LUCKNOW 226 011

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1. SCOPE:
- (i) This specification covers the requirement of stainless steel wire ropes used in auto tensioning device for 25 kv a.c. traction overhead lines and supersedes specification no. ETI/OHE/14(9/94) with A & C slip no.1 to 5.
- (ii) The "Make in India" policy of government of India shall be applicable.
2. SERVICE CONDITION
- 2.1 The stainless steel wire ropes are used in the auto-tensioning devices viz winch type or 5:1 ratio pulley block type or 3:1 ratio three pulley type, **three pulley modified grooved type ATD, Five Pulley ATD, Three Pulley Regulating Equipment with 2400 kgf** installed at both the ends of each tension length of OHE, to suspend the counter weights. With the variation in ambient temperature, the length the OHE wire changes, these variations are taken up by the wire rope moving around the drum/pulleys and a constant tension is maintained in the OHE conductors.
- 2.2 The wire ropes are intended for use through out India including marine/industrially Polluted areas and in coastal belt with heavy rains in monsoon and saline atmosphere. The maximum temperature may reach **65–70°C** and humidity 100%. The wire rope is also subjected to vibrations due to wind and passage of trains and also at times to impact loading in case of breakage of OHE conductors.
2. REFERENCES OF SPECIFICATIONS: Reference has been made to the Indian and British Standard Specification in preparation of this specification. In addition to above standards, the results of endurance test conducted by RDSO on SS wire ropes of earlier specifications have also been referred.
- (i) IS: 6528-1995 (2001): specification for stainless steel wire.
- ~~(ii) BS:970(Pt:4)-1970-Specification for wrought steels.~~  
**BS EN 10090:1998-Valve steels and alloys for internal combustion engines**
- (iii) IS 2266: **2002(R2017)** - Specification for steel wire ropes for general engineering purpose.
- (iv) IS **3973:1984(R2017)**-Specification for the selection installation and maintenance of wire ropes.
- (v) IS: 1608-2005- Specification for tensile testing of metallic materials.
- (vi) IS 6594: **2018** -Specification for technical supply conditions for steel wire ropes and strands.
- ~~(vii) BS 5884:1999:Specification for methods of test for determination of d.c magnetic properties of magnetic material.~~  
**EN 60404-15:2012+A1:2017 -Specification for Methods for the determination of the relative magnetic permeability of feebly magnetic materials**
- (viii) IS:1804-2004- Specification for fibre core for steel wire ropes.
4. MATERIAL FOR WIRE
- 4.1 The material of wire, used for stainless steel wire ropes shall be austenitic nickel chromium molybdenum stainless steel conforming to
- (a) Grade SS 316 of ~~BS: 970-Part 4-1970~~ **BS EN 10090:1998**  
Or
- (b) AISI grade 316,  
Or
- (c) Grade 04Cr17Ni12Mo2 of IS:6528-1995 (2001).

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4.2 Wires of the rope shall be drawn from wire rods of lower diameter avoiding drastic reduction in cross section. Intermediate annealing shall be adopted in the cold drawing process to relieve locked-up (residual) stresses and to minimize conversion of austenite into martensite structure.

## 5.0 SIZE OF WIRE AND WIRE ROPES.

5.1 Diameter: The diameter of wire ropes shall be as follows:

SN	Diameter of	For use in winch type, 3:1 ratio three pulley type, three pulley modified grooved type ATD (3:1 ratio), Three Pulley Regulating Equipment with 2400 kgf, Five pulley Auto tensioning device.	For use with pulley block type (5:1 ratio) regulating equipment
1	Cover wires	0.41mm + 0.015 mm -0mm	-
2	Core wires	0.46 mm + 0.015 mm - 0mm	-
3	Wire rope	8.65mm+0.35mm -0mm	5.5mm + 0.22 mm - 0.055mm
4	Wire	-	0.6mm± 0.015mm

5.2 **Length:** The ropes shall be supplied in the following lengths.

i	For winch type regulating equipment	10.5+0.05m -0.0m
ii	For Pulley block type (5:1 ratio) regulating equipment	9.0+0.05m -0.0 m
iii	For three pulley type (3:1 ratio) regulating equipment as per Drawing No. ETI/OHE/P/5500-1 Sheet No.1 of 2	7.0+0.05m-0.0 m
iv	1. For three pulley modified grooved type ATD (3:1 ratio), as per drawing no. TI/DRG/OHE/ATD/RDSO/00001/99/3. 2. Three Pulley Regulating Equipment with 2400 kgf. As per drawing no. TI/DRG/OHE/ATD2400/RDSO/00001/169/1Rev1	8.0+0.05m -0.0 m
v	For Five pulley Auto tensioning device as per drawings TI/DRG/OHE/ATD/RDSO/000012/15/0 latest revision.	11.5 +0.05m/-0.0

5.3 **Ovality:** The ovality (out of roundness) shall be taken in accordance with annexure A of IS 6594:2018. The maximum variation between any four measurements of dia of the rope shall not be more than 0.51 mm.

5.4 **Bending radius for wire rope of 3-pulley modified ATD:** Minimum radius of bend for the wires in the tensioned condition in three pulley type modified ATD is 100 mm. Stainless steel wire rope should not unlay when bent on pulleys of 3-pulley modified ATD during endurance test.

## 6. CONSTRUCTION OF WIRE ROPE

6.1 The wire ropes shall be manufactured in accordance with IS: 2266-2002(R2017) and IS:3973-1984 (R2017).

6.2 The wire rope of winch type & 3:1 ratio (three pulley type), three pulley modified grooved type ATD (3:1 ratio), Three Pulley Regulating Equipment with 2400 kgf, Five pulley Auto tensioning device shall be of 34X7(6/1) construction. The details of construction of wire rope are given in TABLE-1 below:

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TABLE-1

Layer	No. of strands	Direction of laying of wires in strands	Direction of closing of strands in rope
Outer	17	Left hand	Right hand
Middle	11	Right hand	Left hand
Inner	6	Right hand	Left hand

- 6.3 The wire rope for pulley block type (5:1 ratio) regulating equipment shall be 6x7(6/1) construction as per Table -1 of IS:2266-2002(R2017).
- 6.4 **CENTRAL CORE:** The central or main core of the rope shall be of a size sufficient to give full support to the strands and shall be made of soft fibre core confirming to IS: 1804-2004.
- 6.5 **DIRECTION OF LAY AND LAY LENGTH:** The ropes for winch type and 3:1 ratio (three pulley type) regulating equipment, three pulley modified grooved type ATD (3:1 ratio), Three Pulley Regulating Equipment with 2400 kgf, Five pulley Auto tensioning device shall have direction of lay as given in TABLE-1 of page-4. The rope for pulley block type (5:1 ratio) regulating equipment shall have right hand ordinary lay. The length of lay of ropes shall be less than 8.0 times the specified diameter of the rope.
- 6.6 **Preforming:** The wires and strands in ropes shall be pre shaped to conform to helical shape which they take in the finished rope, so as to make them, "lie dead" in the rope without any tendency to unlay, while the rope is in unloaded condition.
- 6.7 **JOINTS:** No joints shall be permitted in the wires, used for manufacture of wire rope
- 6.8 **LUBRICATION:**
- 6.8.1 During manufacturing, wire rope shall be fully lubricated both during "stranding and closing" with lubricant Balmerol Rope Lube LL or any other source as advised by RDSO to reduce internal abrasion. Amount of lubrication on the finished rope after stranding shall be at least 5.0 gms/meter length of wire rope. The lubricant shall be applied immediately before formation of strands from wire and rope from strands. The excess lubricant shall be gently wiped out from the rope surface. Dust/Dirt/moisture free system shall be ensured for above mentioned lubrication.
- 6.8.2 Wire rope shall be lubricated by user Railways during service with lubricant Balmerol Rope Lube 1000 or any other lubricant as advised by RDSO. Lubricant shall be applied on the wire rope especially on the portion moving over drum and pulley either by pouring, dripping or pressure spray method and by brush over straight portion or rope at least once in a year. Frequency of application may be increased depending upon the climatic and environmental conditions.
7. **SEALING OF ENDS:** The ends of the wire rope shall be properly sealed to prevent individual wires getting loose and opening out. The ends of rope shall be welded/fused together by electric welding/fusion process. The diameter of the sealed ends shall not exceed the diameter of the rope.
8. **IDENTIFICATION MARKING:** In order to identify the manufacturer's name, the month, year of manufacture and specification number from the finished wire rope, an aluminium alloy ferrule of adequate thickness and length shall be provided at one end of

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the wire rope. The identification marking shall consist of the manufacturer's name code, month and year of manufacture on one side and "OHE/WR/1060" on the opposite side. The marking shall be clearly punched/etched on the ferrule.

## 9. PHYSICAL AND CHEMICAL PROPERTIES

### 9.1 Tensile Strength

SN	Properties	For winch type and three pulley type (3:1 ratio) regulating equipment—three pulley modified grooved type ATD (3:1 ratio), Three Pulley Regulating Equipment with 2400 kgf, Five pulley Auto tensioning device.	For Pulley block type (5:1 ratio) regulating equipment.
a)	Tensile strength of wire	180 kgf/mm <sup>2</sup> (Min.)	180 kgf/mm <sup>2</sup> (min)
b)	Breaking force of wire rope	4350 kgf minimum	2000 kgf minimum
c)	One minute withstand load	3650 kgf	1700 kgf

Note : The tensile strength of wire shall be calculated on actual measured area.

### 9.2 $\alpha$ - MARTENSITE AND RESIDUAL STRESS AND RELATIVE MAGNETIC

**PERMEABILITY:** The residual stresses and  $\alpha$ - martensite content shall not exceed 25 kgf/mm<sup>2</sup> and 10% respectively on the wires taken from the completed rope. The relative magnetic permeability of the wires taken from completed ropes shall not exceed 2.5.

### 9.3 CHEMICAL COMPOSITION:

The chemical composition of wires taken from complete ropes shall be as per clause 4.1.

### 10. FREEDOM FROM DEFECTS:

The complete rope shall be free from defects, like loose wires, broken wires, open strands or other irregularities. The strands shall be evenly laid and shall not unlay when unwound from the reel or coil. The wires shall be free from injurious defects i.e. cracks, pit marks, flattened surfaces, rusting, slivers and peeling etc. The surface shall be perfectly smooth.

## 11. TESTS:

11.1 All the tests specified in clause 11.4 shall normally be carried out at the manufacturer's works and the tests shall be arranged without making any claim or charges for all such tests including labour machinery/apparatus etc. However, the tests specified in clause 11.4 (x), (xi) and (xii) can be conducted with reputed and recognized testing agencies after specific approval of DG (TI), RDSO or its authorized representative. In case the facilities do not exist with the suppliers, the charges for these tests shall be borne by the **supplier-manufacturer**.

11.2 Test certificate of chemical composition shall be obtained from the **suppliers manufacturer** of the raw material procured/processed. The manufacturer shall also check the chemical composition of every lot of raw material purchased. The certificates of these shall be produced at the time of inspection.

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11.3 The manufacturer shall ensure that the fibre core comply with IS:1804-2004 and in particular meet the requirement of this standard with regard to its construction, sizes, lay length and chemical tests for acid & salt. Test certificate for the same shall be obtained from the **supplier manufacturer** and submitted at the time of testing.

11.3(a) Before giving call to RDSO/Purchaser for testing of the prototype of the wire rope, the manufacturer shall submit a detailed test schedule consisting of the details of each test and nature of the test, venue of the test and the duration of each test and the total number of days required to complete the test at one stretch. **But if not completed in one stretch, the test shall be completed in second go** , Once the test schedule is approved, the test shall invariably be done accordingly, However, during the process of type testing or even later, RDSO/Purchaser's representative reserves the right to conduct any additional test(s) besides those specified herein, on any equipment/sub-system or system so as to test the system as per requirement or for gaining additional information and knowledge.

11.3(b) In case, any dispute or disagreement arises between the manufacturer and RDSO/Purchaser during the process of testing, as regards to the type test and /or the interpretation and acceptability of the type test results, it shall be brought to the notice of Director General (Traction Installation), Research Designs & Standards Organisation, Manak Nagar, Lucknow, whose decision shall be final and binding.

11.3(c) In the event of the tests not being carried through to completion at one stretch for any reason attributable to the successful **tenderer**/manufacturer and it is required for the representative of the purchaser/Director General (Traction Installation), Research Designs & Standards Organisation, Manak Nagar, Lucknow to go again or more number of times to the works of the successful **tenderer**/Manufacturer or other Place(s) for continuing and /or completing the tests on the prototype(s) of the equipment, the **successful tenderer**/manufacturer shall **have to provide accommodation as per RDSO ISO documents Document No: QO-D-8.1-17 Version No:1.1 Date Effective: 19.06.2020 ,Logistics provision by vendor for inspections or latest.**

#### 11.4 TYPE TESTS:

		Clause No.	Type tests	Acceptance
i	Visual examination	12.1	Yes	Yes
ii	Measurement of diameter & ovality of wire rope	12.2.2	Yes	Yes
iii	Measurement of diameter of wire	12.2.1	Yes	Yes
iv	Measurement of lay length	12.3	Yes	Yes
v	Measurement of length of rope	12.4	Yes	Yes
vi	Tensile test on wire	12.5	Yes	Yes
vii	Tensile force test, one minute withstand test and breaking force test on rope	12.6	Yes	Yes
viii	Chemical composition	12.7	Yes	Yes
ix	Microscopic surface examination of wire	12.8	Yes	Yes
x	Inter crystalline corrosion bend test on wire	12.9	Yes	No
xi	Measurement of residual stress on wire	12.10	Yes	No
xii	Determination of $\alpha$ -martensite content of wire	12.11	Yes	No
xiii	Measurement of relative magnetic permeability	12.12	Yes	Yes

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xiv	Endurance test	12.13	Yes	No
xv	Lubrication test	12.14	Yes	Yes
xvi	Winding test	12.15	Yes	Yes
xvii	Test for <b>preforming</b>	12.16	Yes	Yes
xviii	Test for <b>bending radius</b>	5.4	Yes	No

11.4.1 For the type tests except endurance test, samples shall be selected from three different lengths of wire ropes produced by the manufacturers and tested. The wire ropes produced by the manufacturers and tested. The wire rope samples shall be first subject to tests given in clause 11.4(i) and 11.4(v). One sample each from three selected wire ropes shall be subjected to tested given in clause 11.4(ii) and (iv). Then one sample from each of the three wire ropes selected shall be subjected to tests given in clause 11.4(iii),(vi),(ix),(x), (xi) (xii) and (xvi).

Thereafter one piece each from three different lengths of wire ropes shall be subjected to test given in clause (xiii). Followed by this, three samples from the selected wire ropes shall be subjected to test as per clause 11.4(vii), (xv) & (xvii). Then one cover wire and one core wire selected from each layer of one sample of wire rope shall be tested as per clause (viii). Two more length of wire rope shall be produced by the manufacturer for conducting endurance test.

## 11.5 BULK MANUFACTURE:

11.5.1 Only after clear written approval of the result of tests on the prototype is communicated by the DG/TI, RDSO to the manufacturer, he shall take up bulk manufacture of wire ropes, which shall be strictly with the same material and process as adopted for the prototype. In no circumstances, materials other than those approved in the prototype shall be used for bulk manufacture.

11.6 **CRITERIA FOR ACCEPTANCE:** Wire ropes shall be offered in batches of 300 pieces, all of which shall be made from the same production batch. All the wire rope samples shall be subjected to the tests as per Clause 11.4(i) and (v). Then three wire ropes from each batch shall be selected at random for tests.

11.6.1 Samples from three selected ropes shall be subjected to the tests according to Clause 11.4(ii) and (iv). Then one sample from each of the three wire ropes selected shall be subjected to tests as per Clause 11.4(iii), (vi) and 11.4(xii). Again one piece each from three different lengths of wire ropes shall be subjected to tests as per Clause 11.4(x). Followed by this, three samples of wire ropes shall be subjected to tests as per Clause 11.4(vii), (xi) and (xiii). Then one cover wire and one core wire selected from each layer of one sample of wire rope shall be tested as per clause 11.4(viii).

11.6.1.2 If any sample fails to comply with any test(s) specified in this specification, test(s) shall be repeated on three samples, taken from the same length but limited to the test(s) in which failure occurred. If in the retest(s) any sample fails, the batch represented by the sample shall be deemed not to comply with specification and the batch shall be rejected. The lengths representing rejected batch shall be cut into 3 meter long pieces in the presence of the inspector, so that rejected wire rope cannot be used ~~on-the~~ in railways.

## 12. METHOD OF TESTS

12.1 **VISUAL EXAMINATION:** All the ropes shall be visually examined for proper lay, bird caging and freedom from defect mentioned in clause 10 and for flexibility. The end sealing shall be carefully examined to see that all the wires in the rope are properly

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fused or welded together and no air pockets formed. The diameter of sealed ends should not exceed the diameter of the rope including tolerance. All the ropes shall be examined for identification marking.

## 12.2 MEASUREMENT OF DIAMETER:

12.2.1 **Wire:** The diameter of representative wires meant for tensile test shall be measured by means of a micrometer. Before measurement the wires shall be straightened. The recorded value shall be the mean of three readings. The diameter so measured shall be within limits specified in clause 5.1.

12.2.2 **Rope:** The diameter of the rope on representative samples shall be measured by callipers on a straight portion of the rope without tension, at two points spaced at least one meter apart and at each point, two diameters at right angles shall be measured. The average of these four measurements shall be within the tolerance specified in Clause 5.1. The maximum variation between any of the four measurements shall not exceed 0.51mm. The diameter of sealed end shall not exceed the diameter of rope.

12.3 **MEASUREMENT OF LAY LENGTH:** Length of lay shall be measured on three representative samples. The measurement shall be made with the help of lay gauge. The length of lay shall be within the limits specified in clause 6.5.

12.4 **MEASUREMENT OF LENGTH OF ROPE:** Individual lengths of wire ropes shall be measured. For this purpose, the lengths shall be laid carefully between two marks representing the length of rope being inspected. Length of ropes shall be within the limits specified in clause-5.2.

12.5 **TENSILE TEST ON WIRE:** Test samples tested in accordance with IS: 1608-2005 shall conform to the tensile strength values specified in clause 9.1.

## 12.6 TENSILE FORCE TEST, ONE MINUTE WITHSTAND AND BREAKING FORCE TESTS ON ROPE:

12.6.1 **BREAKING FORCE** test shall be conducted in accordance with Appendix-B of IS: 6594-2018. The rope shall conform to the breaking load and withstand load values specified in clause 9.1.

12.6.2 **TEST PIECE:** The minimum length of the test piece between grips shall be 600mm for 8.65mm diameter rope and 300 mm for 5.5 mm diameter rope. During testing, the test piece shall be gripped in such a way that all wires in the rope share the load. It may be useful to provide the test piece with conical sockets. If such sockets are used, care has to be taken that the casting material penetrates well to ensure intimate cohesion with the untwisted wires.

12.6.3.1 **TENSILE FORCE TESTING:** Tensile force shall be applied as quickly as possible up to the 85% of the prescribed minimum breaking force value. Then force shall be increased @ max 10Mpa/second till specified breaking force. Then wires shall be looked through a 3X magnifying glass and no crack must be present.

12.6.3.2 **ONE MINUTE WITHSTAND AND BREAKING PORCE TEST:** Tensile force shall be applied as quickly as possible up to the prescribed 1 minute withstand value and maintained for a period of not less than 60 seconds. The effect of creep shall be ignored. The load shall then be increased @ not more than 10Mpa (1kg/mm<sup>2</sup>)/second till the test sample snaps. This value shall be recorded. In case, the minimum breaking force is not

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- attained & prior to that breaking occurs inside or adjacent to the grips, the sample shall be discarded & tests should be carried out of fresh sample.
- 12.7 **CHEMICAL COMPOSITION:** The chemical analysis when made in accordance with relevant specification shall meet the requirements of the material specified in Clause-4.
- 12.8 **MICROSCOPIC SURFACE EXAMINATION OF WIRE:** Microscopic examination of the surface shall be carried out on the wires taken from finished rope. The wire shall be examined at magnification of 100x or more. The defects such as pits and silvers shall be within 1% of the wire diameter.
- 12.9 **INTERCRYSTALLINE CORROSION BEND TEST:** The Inter-crystalline corrosion bend test shall be carried out, in accordance with ~~Clause 1.13.4 of BS: 970 Pt:1 1983 BS EN 10090:1998~~, on the wires taken from the finished ropes and the wires shall satisfy the requirements mentioned therein.
- 12.10 **MEASUREMENT OF RESIDUAL STRESS:** The residual stress shall be measured either by X-Ray diffraction method or layer removal method. The value shall not exceed as specified in clause 9.2.
- 12.11 **MEASUREMENT OF  $\alpha$ - MARTENSITE CONTENT:**  $\alpha$ - Martensite Contents shall be measured by magnetic hysteresis saturation loop method. The value shall not exceed as specified in Clause 9.2.
- 12.12 **MEASUREMENT OF RELATIVE MAGNETIC PERMEABILITY:** The relative magnetic permeability of the wires taken from finished rope shall be measured accordingly to any of the test methods given in specification ~~BS: 5884-1999 EN 60404-15:2012+A1:2017 - Specification for Methods for the determination of the relative magnetic permeability of feebly magnetic materials~~. The relative magnetic permeability of the wire/wire rope shall not exceed as specified in Clause 9.2.
- 12.13 **ENDURANCE TEST:** Endurance test on the wire rope shall be carried out for minimum 30,000 cycles of operations with test rig simulating actual working conditions. After completion of 30,000 cycles of operations, the wire rope shall be removed from test rig and checked for breaking strength. The wire rope should withstand breaking load of min. 4100 kgf. At the end of 30,000 cycles, number of broken wires shall be recorded.
- 12.14 **Lubrication test:** The lubricated sample shall be pre-weighted. Then the sample shall be digested in commercial Benzene for six hours and dried in natural condition overnight. After normal drying, sample should be re-weighted to determine the amount of lubrication used during manufacture of wire rope. The lubricant shall be at least 5.0 gms per meter length of SS wire rope by weight.
- 12.15 **Winding test:** The wire from the finished rope is winded edge to edge six times onto same type wire. After winding up, the wire shall be looked through 3X magnifying glass and no crack, no tear or no other defects must be present.
- 12.16 **Preforming Test:** A test of the performing of the ropes shall be carried out by Un laying at one end of the rope, two strands opposite to each other for approximately two ropes lay lengths. When these two strands are re-laid into the rope, the wires shall maintain their position in the strands and strands shall resume their position in rope.
13. **PACKING AND MARKING:**
- 13.1 Individual lengths of rope shall be wrapped with two layers of polythene over the entire length and shall then be coiled. Such individual coils shall then be wrapped with a layer of polythene Upto 25 such coils shall be packed in strong wooden box to avoid damage

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during transit. Each box shall contain the ropes of one production batch. The box shall carry on its outer face the following information.

- (i) Manufacturer's trade name, brand or make:
- (ii) Specification no, month and year of manufacture
- (iii) Nominal diameter of rope:
- (iv) Number of lengths
- (v) Reel number/production batch number:
- (vi) Net and gross weight:
- (vii) Contract number and consignee:
- (viii) Date of inspection:
- (ix) Inspector's stamp and seal:
- (x) Any other particulars specified by the purchaser.

14.0 **TECHNICAL LITERATURE & OTHER DETAILS:** While supplying the wire ropes, the manufacturers shall furnish the installation and maintenance instructions regarding the precaution to be under taken while handling, storage and installation of wire ropes and maintenance instructions, required to be followed after installation of wire ropes.

15.0 All the provisions contained in RDSO's ISO procedures laid down in documents no ISO9001:2015 Document No: QO-D-8.1-11 Version No: 1.3 Date Effective: 01.07.2020 (Title- "Vendor change in approved status") and subsequent versions/amendments thereof, shall be binding and applicable on the successful vendor/vendors in the contract floated by railways to maintain quality of products supplied to railways".

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