S No 2848

सत्यमेवजयते

GOVERNMENT OF INDIA

MINISTRY OF RAILWAYS

INDIAN RAILWAYS TECHNICAL SPECIFICATION

FOR

THIN WALLED FLEXIBLE ELASTOMERIC CABLES WITH COPPER CONDUCTORS FOR WORKING VOLTAGES (i) UPTO 750 VOLTS AND (ii) ABOVE 750 VOLTS UPTO 1.8/3.0KV (FOR TAP CHANGER ELECTRIC LOCOMOTIVES, AC/DCEMU, BG AC EMU& MEMU/COACHING STOCK)

Specification No. ELRS/SPEC/ELC/0019, (REV- 4)

APPROVED BY	SIGNATURE
PEDSE	ओमप्रकाश 22.2.18

ELECTRICAL DIRECTORATE
RESEARCH DESIGNS & STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW – 226011

Prepared by	Checked by	Issued by
JE/ Design 22.02.2018	JE/ Design 22/02/18	EDSE 22/2/18

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Status of Revision

S. N.	Date of Revision	Clause No.	Revision	Reasons for Revision
1.	06.07.2010	Amendments made in relevant pages and the same are renumbered	1	i) Incorporation of provisions contained in the guidelines & approval of Railway Board circulated vide their letters dated 20.03.09 & 27.04.10 ii) Inclusion of all Amendments of Rev 0 of spec in the main text of Rev 1.
2.	21.02.2011	Amendments made in relevant pages and the same are renumbered	2	Incorporation of provision contained in the approval of Railway Board vide their letter dated 06.12.2010 regarding use of single layer insulation/sheath for cable upto 750V with EVA material for conventional electric locomotives and correction of dimension in Data Sheets 1A& 2A.
3	22.02.2017	1.5, 2.1 ,3.2.3 ,7.1.2,7.1.3,7.2.1(c,d), 7.2.4, 7.2.5,7.2.8, 7.2.13,7.2.15,7.2.21,7 .2.22,7.2.24,7.3.2,7.4. 1(c,d),11.4	3	Incorporation of provision contained in Railway Board 2016/ML/Misc dated 16-5-16 for using improved polymers for manufacture of cables capable of withstanding high temperature i.e. at least 150 deg C instead of 120 deg C and in turn other changes.
4	22.02.2018	1.6 (new), 3.1.1, 7.1.2, 7.1.3, 7.2.1.(a)(i),(ii),(iii), 7.2.13, 7.2.16, 7.4.1(a)(i),7.4.5, Datasheet1A,2A,&2B.	4	In specification Typical value of strands and nominal value of dia are mentioned. However these are not required as per referred IS 8130-2013. There are some Typographical mistakes. Which are to be corrected?

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TECHNICAL SPECIFICATION FOR ELECTRON BEAM IRRADIATED/CHEMICALLY CURED CROSS LINKED THIN WALLED FLEXIBLE ELASTOMERIC CABLES WITHCOPPER CONDUCTORS FOR TAP CHANGER ELECTRIC LOCOMOTIVES (WITH DC TM) AND COACHING/AC/DC EMU, BG AC EMU &MEMU STOCK.

(FOR WORKING VOLTAGE UPTO 750 VOLTS AND ABOVE 750 VOLTS UPTO 1.8/3.0KV)

1.0 SCOPE:

1.1 Specification no ELRS/SPEC/ELC/004 of June 1999 for thin walled cables for Electric Locomotive was issued specifying both Chemical Curing & Electron Beam Radiation Curing Process but only one table of dimensions of Cable/ Insulation thickness and Tolerance was indicated there. With the development of electron beam irradiated cables indigenously and to get full advantage of precise control of dimension, separate tables were given for chemical & Electron beam curing process and Specification No. ELRS/SPEC/ELC/0019 of May 2002 was issued. It is also observed that different Production Units are following different Specifications for the same type of cables. In the present version, details of Multi core cables and all four Amendments specified in earlier version of specification have been included and the specification has been made uniform for all Railway/Production units to make it complete for adoption of thin walled cables on existing Tap Changer Electric Locomotive with DC drives and Coaching/AC/DC EMU, BG AC EMU & MEMU Stock. Based on the experience gained by IR with coaches imported and manufactured now for Rajdhani / Shatabdi Express trains, in consonance with the trend being adopted worldwide for control voltage cable and also to ensure uniformity in specifications adopted by different PUs/ Railways, this specification provides for use of single/double layer of cable insulation/sheath for working voltages upto 750 volts for Tap Changer Electric Locomotives/ EMU/Coaching Stock and use of double layer of insulation/ sheath for working voltage above 750 volts for Electric Locomotives and EMU/Coaching Stock.

1.2. This specification covers the design / performance requirements of Electron Beam Irradiated/ chemically cured thin walled flexible cables with copper conductor for use in power, auxiliary as well as control circuits of conventional Tap Changer Electric Locomotives, AC/DC EMU, and BG AC EMU & MEMU/Coaching stock. The cables shall be of limited fire hazard type i.e. minimum flame spread, low smoke emission and limited toxic fume emission.

1.3 The specification is applicable to meet the requirements of cables for working voltage up to 750 volts (with single / double layer insulation) for tap changer Electric Locomotives, AC/DC EMU, BG AG EMU&MEMU/Coaching stock, and above 750 volts up to 1.8 KV /3KV grade cables (with one layer of insulation and one layer of sheath) for Tap Changer Electric Locomotive AC/DC EMU, BG AC EMU and MEMU / Coaching Stock.

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1.4 The Cables shall be suitable for continuous operation at conductor temperature of 120°C.

1.5 All the provisions contained in RDSO's ISO procedures laid down in Document No. QO-D-7.1-11 dated 05.12.2017(titled "vendor –Changes in approved status") and subsequent versions/amendments thereof shall be binding and applicable on successful vendor/vendors in the contracts floated by Railways to maintain quality of products supplied to Railway.

1.6 Due care has been taken to specify parameter, Standards and test methods. Wherever these parameters have not been specified, relevant national/International Standards can be referred. In case of Typographical error /omission relevant standard will be referred.

2.0 TEST METHOD AND REQUIREMENTS:

2.1 General:

The tests are classified as product development Tests. Type Tests, Routine test and Acceptance Tests. All thermal tests shall be carried out in oven capable of maintaining uniform heating inside.

2.1.1 Product development tests:

These tests shall be carried out on the insulation and sheath materials to establish:

(a) Safe working temperature(120°C)
(b) Life (Arrhenius Plot – 20,000 hrs as per IEC 60216 at120°C)
(c) Infrared spectrograph (Polymer identification)

2.1.2 Type Tests:

These tests shall be carried out to prove conformity with the requirement of specification and design feature of the cable. Complete type tests on two sizes, one lowest & one highest size (for control cable upto 750 volts grade for single core and multi core separately as per CL.3.2.1) and on two size, one lowest and one highest size (for cables above 750V grade and upto 1.8KV /3.0 KV and multi core cable separately as per Clause 3.2.2) shall be carried out. In case of any change in the material, manufacturing process or design of the cable by the manufacturer or as desired by the client in the interim period, complete type tests shall be repeated.

2.1.3 Routine tests:

These tests shall be carried out on all finished cable length to ensure consistency of the product. However, the purchaser may carry out these tests on sample taken at random as per the relevant specification to verify the result observed by the manufacture.

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2.1.4 Acceptance tests:

These Tests are to be carried out on the samples taken from a lot for the purpose of acceptance of the lot.

3.0 MATERIAL:

3.1 CONDUCTORS:

3.1.1 The conductor shall be made up with circular tinned, annealed copper wires complying with the requirement of IS: 8130 –2013 with flexibility of Class – 5. Nominal cross – sectional area, maximum single wires dia of conductor, and maximum resistance of conductor at 20 deg. C shall be as per data sheet 1A(with chemical curing process- single core cables) and 2A&2B,(With e – beam curing process – single core and 19 core cables). Bunching of wires up to 10.0 sq. mm. may be concentric /rope construction. For conductor sizes above 10.0 sq.mm. Only rope stranded bunching of wires shall be adopted.

3.1.2 A Polyester separator Tape of red or any other distinguishing color shall be applied over the conductor. However, for manufacture of cables using Electron Beam Curing process, provision of separator tape on the conductor is not mandatory.

3.2 INSULATION AND SHEATHING:

3.2.1 For cable up-to 750 volts grade (for tap changer electric locomotive and AC/DC EMU, BG AC EMU& MEMU / Coaching stock):

Insulation shall be of one layer with material being EEA/EMA/EVA. This shall serve the purpose of insulation as well as sheath for this application. Testing voltage, requirement and parameters of this type of cable have been specified in the testing Clauses separately, wherever they are different. For construction, dimension and conductor resistance, refer Table 1 of Datasheets 1A &2A.

OR

Insulation and sheath arrangement shall be of two layers with material as per CL.3.2.2 off this specification. Testing voltage requirement of this type of cable in this cable case shall also be same as for cables of CL.3.2.2.For construction, dimension and resistance, refer Table 2 of Data sheets 1A, & 2A and Table 1 of Data sheet 2B.

The compound used for insulation/sheath shall be halogen free and suitable for continuous operating temperature of conductor at 120°C. The manufacture shall establish the Infra Red Spectrograph of material and furnish the same to RDSO. In case

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of any change in the material, the manufacturer shall obtain RDSO's approval before adoption. The manufacturer will establish test facilities for Infra Red Spectrography at their works itself.

3.2.2 For cable above 750 volts and upto 1.8/3.0 KV (for tap changer electric locomotives and AC/DC EMU, BG AC &MEMU/Coaching stock):

Material to be used for insulation shall be EPDM and that for sheathing shall be EEA/EMA/EVA. The compounds used for insulation and sheath shall be halogen free and suitable for continuous operating temperature of conductor at 120°C. The manufacture shall establish the Infra Red Spectrograph of material and furnish the same to RDSO. In case of any change in the material, the manufacturer shall obtain RDSO's approval before adoption. The manufacturers will establish test facilities for Infra Red Spectrograph at their works itself. For construction, dimension and conductor resistance, refer Table 2 of Data sheets 1A, & 2A and Table 1 of Data sheet 2B.

3.2.3 The curing of the insulation/ sheath shall be by:

Chemical cross linking process presently adopted for Elastomeric Cables

OR

Electron – beam cross linking process.

Electron – beam cross linking process, the requirements shall be governed by RDSO's STR NO.–RDSO/2017/EL/STR/0087, Rev'0' or latest.

In case the curing is by chemical cross linking process, the requirements shall also be Governed by RDSO's STR NO.–RDSO/2007/EL/STR/0020, Rev'0' or latest.

4.0 CONSTRUCTION:

The conductor formation, minimum thickness of insulation/sheath and tolerance in overall diameter of the cable with chemical curing process shall be according to Data sheet 1A enclosed. Similar data for cables with electron –beam –cross linking process will be as given in Data sheets 2A& 2B enclosed.

5.0 COLOUR

Unless specifically indicated the color of the outer sheath shall be black.

6.0 IDENTIFICATION , PACKING AND MARKING

6.1 IDENTIFICATION

The following details shall be printed on the sheath of the cable at every 1meter.

(a) Manufacture Name/Trade Mark.

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(b) Rated voltage.
(c) Year of manufacture
(d) Indication of insulation material and its operating temperature.
(e) Nominal cross –sectional area of the conductor.
(f) Reference specification number.

6.2 PACKING AND MARKING

6.2.1 All cables shall have their ends sealed with non-hygroscopic sealing materials.
6.2.2 The cables shall be either wound on reels or drum or supplied in coils packed and labeled.
6.2.3 The label of the stenciling on the drum shall contain the following information:

(a) Reference specification number,
(b) Manufacture's name , brand name or trade mark,
(c) Type of cable and voltage grade,
(d) Number of cores,
(e) Nominal cross –sectional area of the conductor,
(f) Length of the cable on the drum/reel/coil,
(g) Number of lengths of the reel, drum or coil (if more than one),
(h) Direction of rotation of drum (by means of arrow),
(i) Approx. gross weight &
(j) Year of manufacture

7.0 TESTS, TEST METHODS AND REQUIREMENTS

Tests shall be made by the manufacturers at their expense to the compliance with all requirements of this specification. The tests shall be made in presence of authorized representative of RDSO/production unit /Zonal Railway. Separate test for 750 V grade single layer/double layer cable indicated in CL. 3.2.1 used for Tap Changer Electric Locomotives, AC/DC EMU, BG AC EMU&MEMU/Coaching stock and for above 750 and upto1.8/3.0 KV grades cables indicated in CL. 3.2.2 used for Tap Changer Electric Locomotives AC/DC EMU,BG AC EMU&MEMU/Coaching stock applications respectively have been indicated, wherever required.

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7.1 PRODUCT DEVELOPMENT TESTS (for all grades of cables)

CLAUSE NO.	NAME OF THE TESTS 1	REQUIREMENTS 2	TEST METHORD 3
7.1.1	Test for identification of rubber polymers used for insulation and sheathing.	-	ASTM – D -3677 -83 (or Latest version)
7.1.2	Mechanical properties of the insulation. - Tensile strength as received - Elongation at break as received - After heat ageing for 10 days at 180+_3 deg.C -Tensile strength -Elongation at break	 ≥10N/mm sq. ≥ 150% ≥7N/mm sq ≥ 105%	IS:10810- Part -7 IS: 10810 -Part – 11 Where dumb – bell specimen cannot be prepared , tubes of the combined sheath and insulation shall be used
7.1.3	Mechanical properties of the Sheath. - Tensile strength as received - Elongation at break as received - After heat ageing for 10 days at 180+_3 deg.C -Tensile strength -Elongation at break	 ≥10N/mm sq. ≥ 150% ≥7N/mm sq ≥ 105%	 IS: 10810 Part – 7 IS: 10810 Part – 11 Where dumb – bell specimen cannot be prepared , tubes of the combined sheath and insulation shall be used
7.1.4	Thermal Endurance Test & duration of usability Elongation at break absolute		IEC60 216Arrhenius plot ≥50% after 20000Hrs at 120+_2°C
7.1.5	Weatherability of sheath material	Elongation at break≥80% (exposure 14 days)	ASTM G53-1984
7.1.6	Resistance to Cleaner for 24 hours at room temp. (ordinary soap solution)	No cracks or other deterioration in Sheath and Insulation layer. No breakdown when tested according to CI.7.2.1(c)	Test arrangement according to CI.7.2.15.1 of this specification. The specimen shall be immersed in specified medium for the described test duration. The ends of the specimen shall rise above the test medium at

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			least 50 mm.

7.2 TYPE TESTS ON COMPLETE CABLE (for both voltage grades)

CLAUSE NO	NAME OF THE TESTS 1	REQUIREMENTS 2	TEST METHODS 3
7.2.1	**Test on conductor/ cable**		
(a)	(i) Composition of conductor.	technical data sheet 1A, 2A &2B	As per clause – 11.7 of this specification.
	(ii) Per sulphate test.	CI.7.1.1 of IS: 8130 – 2013	Part – 4 of IS: 10810-1984 or Latest version.
	(iii) Annealing test.	CI.7.1.2 of IS: 8130 – 2013	Part – 1 of IS: 10810-1984 or Latest version.
	(iv) Resistance test.	Technical data sheet 1A,2A&2B	Part -5 of IS: 10810-1984 or Latest version.
(b)	**Test for thickness of insulation & sheath**	Technical data sheet 1A,2A&2B	Part -6 of IS: 10810-1984 or Latest version
(c)	**High voltage test (water immersion test)**	6kV,50 Hz 5 Min. (For 750V grade single layer cable of CL.3.2.1) after water immersion for 24 hour at room temperature, No break down.	Part 45 of IS: 10810 - 1984 or Latest version cable length: 3 to 5 meters
		8KV , 50 Hz , 15 Min.(For above 750 V & upto 1.8/3.0 KV grade cable of CI.3.2.2) after water immersion for 24 hours at room temperature No break down	part 45 of IS: 10810-1984 or Latest cable length: 3 to 5 meters

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(d)	**Insulation Resistance test** i) For 750 V grade single layer cable of CI.3.2.1 At room temp At 90± 3 deg.C	**(Insulation resistance constant)** K≥2000Mega ohms Km K≥30Mega ohms Km	Part 43 of IS : 10810-1984 or Latest version
	ii)For cable above 750 V and upto 1.8/ 3.0 KV grade cable of CI.3.2.2 At room temp. At 90± 3 deg.C	 K ≥12000Mega ohms Km K ≥200Mega ohms Km	Part 43 of IS : 10810-1984 or Latest version
(e)	**DC stability test**	Water immersion for 10 days No breakdown at 750 V DC (for 750 volts grade single layer cable of CI.3.2.1) and 1800 V DC (for above 750 V &upto 1.8/3.0 KV grade cable of CI.3.2.2).	clause -11.4 0f this specification
7.2.2	**Dielectric strength**	≥ 8 KV AC (for 750 v grade single layer cable of CI.3.2.1).	Clause – 11.6 of this specification
		≥15 KV AC (for above 750 V & upto 1.8/3.0 KV Grade cable of CI.3.2.2). No BD occurs at less than this voltage	
7.2.3	**Tracking resistance** Cross section <2.5 mm sq. 4-16 mm sq. 25-95 mm sq. 120-150 mm sq. Tracking Voltage Break Down voltage	current consumption after 10 sec. at 2 KV (for 750 V grade single layer cable of CI.3.2.1) ≤1.0 m A ≤1.5 m A ≤2.0 m A ≤2.5 m A ≥ 07 KV ≥ 10 KV	Clause – 11.5 of this specification

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	<2.5 mm sq. 4-16 mm sq. 25-95 mm sq. 120-300 mm sq. Tracking Voltage Break Down voltage	**(For above 750 V & upto1.8/3.0 KV grade cable of CI.3.2.2)** ≤ 1.0 m A ≤ 1.5 m A ≤ 2.0 m A ≤ 2.5 m A ≥ 20 KV ≥ 25 KV	Clause – 11.5 of this specification
7.2.4	Mechanical properties of the insulation. - Tensile strength as received - Elongation at break as received - After heat ageing for 10 days at 180±3 deg.C -Tensile strength -Elongation at break	≥10N/mm sq. ≥ 150% ≥7N/mm sq ≥ 105%	IS: 10810- part -7 IS: 10810 -part – 11 Where dumb – bell specimen cannot be prepared , tubes of the combined sheath and insulation shall be used.
7.2.5	Mechanical properties of the Sheath. - Tensile strength as received - Elongation at break as received - After heat ageing for 10 days at 180±3 deg.C -Tensile strength -Elongation at break	≥10N/mm sq. ≥ 150% ≥7N/mm sq ≥ 105%	IS: 10810 part – 7 IS: 10810 part – 11 Where dumb – bell specimen cannot be prepared , tubes of the combined sheath and insulation shall be used.
7.2.6	Tear Resistance of the Insulation & Sheath	Tearing force >2.5 N/mm	IS: 10810 part 17
7.2.7	Stripability for section 1.5 to 6mm sq.	The admissible stripping Force shall be between the min. and max. Values. The conductor shall not be damaged and shall be free or residues.	Appendix 'A' of this specification
7.2.8	Hot set test Insulation and sheath	Max. elongation - under load ≤ 100 % -after cooling ≤15%	IS: 10810 Part – 30 Test load 20N/cm. sq Test temp. (2 00±3) °C

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			Where dumb – bell specimen cannot be prepared tubes of the combined sheath and insulation shall be used.
7.2.9	Shrinking	Shrinkage ≤1.5 mm Length of specimens300mm, Test temp. 180 ±3 deg.C Exposure time 6 hours.	IS: 10810 Part- 12
7.2.10	Heat shock	No cracking in sheath or Insulation layer. Test temp. 180 ± 3 deg.C Mandrel dia according to CI.7.2.15.1 of this Specification. Exposure time 1 hour.	IS: 10810 Part 14
7.2.11	Dynamic cut through resistance	The mean value P for 4 tests, each with 90degree rotation of the specimen and 100 mm longitudinal displacement, shall not be lower than The value give in the following table.	Clause 11.3 of this specification
	Cut through force P(N)		
	Cross section (mm sq.)	23± 2deg.C	70± 2deg.C
	2.5	≥ 100N	≥30N
	35	≥300N	≥ 80 N

7.2.12	Notch sensitivity (Applicable for double layer Cable of CI 3.2.1.and 3.2.2)	No breakdown when tested according to CI .7.2.1 (c)	Appendix 'C' of this specification
7.2.13	Pliability	Recoil angle≤30 deg. No breakdown when tested according to CI.7.2.1 (c)	Appendix 'D' of this specification
7.2.14 7.2.14.1	Abrasion resistance of - sheath (Applicable for double layer Cable of CI 3.2.1.and 3.2.2)	The scrape abrasion resistance shall not be less than 1200 double stroke.	Appendix ' B ' of this specification

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7.2.14.2	-Marking (indelibility)	No continuous strip shall be visible On the marking under 150 double stroke	Appendix ' B ' of this specification
7.2.15	**Windability (deformation) of the finished cable.**		
7.2.15.1	-As received	No cracking in sheath or insulation layer. No breakdown when tested according to CI .7.2.1(c)	Clause – 11.2 of this specification. Mandrel cable Dia dia 3 x D for ≤10mm 5 x D for > 10 ≤20mm 8 x D for > 20mm
7.2.15.2	After ageing for 10 days at180 ± 3 deg.C	No cracking in sheath or insulation layer. No break down when tested according to CI 7.2.1(c)	Mandrel dia according to CI.7.2.15.1. The test specimen shall be aged for 10 days at 180±3 deg.C before winding.
7.2.15.3	At -15±2deg.C	No cracking in sheath or insulation layer. No break down when tested according to CI 7.2.1(c)	Mandrel dia according to Cl.7.2.15.1. of this specification .The test specimen shall be aged for 10days at 180±3 deg.C before deposited for 4 hours in cold box.
7.2.16	Impact at -15±2deg.C	No cracking in sheath or insulation layer. No break down when tested according to CI.7.2.1(c)	Test specimen as received and after ageing in air oven during 10 days at 180±3 deg.C. IEC 60811-506-2012.
7.2.17	Slippage test	The relevant displacement of the conductor with insulation shall not be more than 10mm for cables with 25mm dia and 15mm for cables over 25mm dia respectively	Clause-11.8 of this specification. A sample length 350±5mm is taken and bent to a radius for 150mm.

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7.2.18	Ozone Resistance test	275±25 ppm 96 hours at room temperature. No cracks in sheath or insulation layer. No breakdown when tested according to 7.2.1(c)	IS:10810-Part-13
7.2.19	Resistance to fluids	No cracks or other deterioration in sheath and insulation layer. No breakdown when tested according to Cl 7.2.1 (c)	IS: 10810 Part-31 Mandrel dia according to Cl. 7.2.15.1 of this specification. The specimen shall immersed in the specified in medium for the described test duration. The ends of the specimen shall rise above the test medium at least 50mm.
7.2.19.1	Mineral oil 100±2 deg.C 24 hours	-do-	-do-
7.2.19.2	Diesel oil 70±2 deg.C 168 hour	-do-	-do-
7.2.19.3	Cleaner at Room temp. for 24 hours (ordinary Soap solution)	-do-	-do-
7.2.20	Flame Retardant (single cable)	Charred length ≤200mm Cease of burning ≤30 sec.	IS:10810 Part-61
7.2.21	Flame Propagation (Bunched Cable)	The charred or affected portion should not have reached a height exceeding 2.5 m above the bottom edge of the burner.	IEC 60332-3 (Relevant categories)
7.2.22	Corrosivety of Combustion Gases on sheath only	Ph- Index≥4.3 Electrolytic conductivity ≤100 micro Siemen/cm	IEC 60754-2
7.2.23	Toxicity of Combustion Gasses on sheath only	Toxicity index≤5	Gases as per UITP part 2E7&Test method as per NES713
7.2.24	Smoke Density on sheath only	SDR-20%max.	ASTM-D-2843 or latest Version
7.2.25	Test for identification of rubber polymers (Insulation & Sheath)	Material shall be according to Cl . 3.2.1 & 3.2.2	ASTM –D-3677-83 or Latest version

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7.3 ROUTINE TESTS:

CLAUSE NO	NAME OF THE TESTS 1	REQUIREMENTS 2	TESTS METHODS 3
7.3.1	Conductor Resistance	Technical Data sheet 1A, 2A and 2B	IS:10810 – part – 5
7.3.2	High Voltage Test (Water immersion test)	6kV, 50 Hz. 5 Min. (For 750V grade single layer cable of CI.3.2.1) after immersion in water for 24 hours at room temp. No breakdown.	IS:10810- part- 45 cable length: 3 to 5 meters
		8 kV, 50 Hz 15 min (for above 750 V and upto1.8/3 KV grade cable of CI.3.2.2after immersion in water for 24 hours at room temp. No breakdown.	IS:10810- part- 45 cable length: 3 to 5 meters
7.3.3	Spark Test	6KV (for 750V grade single layer Cable as per CI.3.2.1) 15 KV (for above 750 V and upto 1.8/3.0 KV No breakdown	IS:10810- part- 44

7.4. ACCEPTANCE TESTS:

CLAUSE NO	NAME OF THE TESTS 1	REQUIREMENTS 2	TESTS METHODS 3
7.4.1 (a)	**Test on conductor/ cable** (i) Composition of conductor	Technical data sheet 1A, 2A &2B	As per clause – 11.7 of this specification.
	(ii) Persulphate test.	CI.7.1.1 of IS: 8130 – 2013	Part – 4 of IS: 10810 – 1984or latest.
	(iii) Annealing test.	CI.7.1.2 of IS: 8130 – 2013	Part – 1 of IS: 10810-1984 or latest version.
	(iv) Resistance test.	Technical data sheet 1A,2A&2B	Part -5 of IS: 10810 - 1984 or latest version.
(b)	**Test for thickness of insulation & sheath**	Technical data sheet 1A,2A&2B	Part -6 of IS: 10810-1984 or latest version.

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(c)	**High voltage test (water immersion test)**	6kV,50 Hz 5 Min. (For 750V grade single layer cable of CL.3.2.1) after water immersion for 24 hour at room temperature, No break down.	IS:10810- Part- 45 cable length: 3 to 5 meters
		8kV , 50 Hz , 15Min. (For above 750 V & upto 1.8/3.0KV grade cable of CI.3.2.2) after water immersion for 24 hours at room temperature No break down	IS:10810- Part- 45 cable length: 3 to 5 meters
(d)	**Insulation resistance test** (i)For 750 V grade single layer cable of CI.3.2.1 At room temp At 90± 3 deg.C (ii)For cable above 750 V and upto 1.8/ 3.0 KV grade cable of CI.3.2.2 At room temp. At 90± 3 deg.C	Insulation resistance constant K≥2000 Mega ohms Km K≥30Mega ohms Km K ≥12000 Mega ohms Km K ≥200Mega ohms Km	Part 43 of IS : 10810-1984
(f)	**Tracking resistance** Cross section <2.5 mm sq. 4-16 mm sq. 25-95 mm sq. 120-150 mm sq. Tracking Voltage Break Down voltage <2.5 mm sq. 4-16 mm sq. 25-95 mm sq. 120-300 mm sq. Tracking Voltage Break Down voltage	Current consumption after 10 sec. at 2 KV (for 750 V grade single layer cable of CI.3.2.1) ≤1.0 m A ≤1.5 m A ≤2.0 m A ≤2.5 m A ≥07KV ≥10KV (For above 750 V & upto 1.8KV/3.0 KV grade cable of CI.3.2.2) ≤1.0 m A ≤1.5 m A ≤2.0 m A ≤2.5 m A ≥20KV ≥25KV	Clause – 11.5 of this specification Clause – 11.5 of this specification

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7.4.2	Strippability for section 1.5 to 6mm sq.	The admissible stripping force shall be between the min. and max. Values. The conductor shall not be damage and shall be free or residues.	Appendix 'A' of this specification
7.4.3	**Windability (deformation) of the finished cable**		
7.4.3.1	-As received	No cracking in sheath or insulation layer. No breakdown when tested according to Cl.7.2.1(c)	Clause – 11.2 of this specification. Mandrel cable Dia 3 x D for ≤10mm 5 x D for > 10 ≤20mm 8 x D for > 20mm
7.4.4	Test for identification of rubber polymers (Insulation & Sheath)	Material shall be according to Cl . 3.2.1 & 3.2.2	ASTM –D-3677-83 OR Latest version
7.4.5	Hot set test Insulation and sheath	Max. elongation - under load ≤ 100 % -after cooling ≤15% Test temp. 200±3 deg.C Test load 20N/cm. sq	IS: 10810 Part – 30
7.4.6	slippage test	The relevant displacement of the conductor with insulation shall not be more than 10mm for cable with 25mm dia and 15mm for cable over 25mm dia respectively	Clause -11.8 of this specification a sample length 350±5mm is taken and bent to a radius for 150mm.

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8.0 CORE IDENTIFICATION :

8.1 The core of 19 core cable shall be identified by numbers printed on the cores. The numerals printed on cores shall appear at intervals of not greater than 150 mm.

8.2 For 19 core cables, used in tap changer electric locomotive the core identification shall be done by numbers. The core shall be numbered sequentially, starting with number 1 for inner layer. The number shall be printed in Hindi – Arabic numerals on the outer surface of the cores. All the numbers shall be of the same color, which shall contrast with the color of insulation. The numeral shall be legible.

8.2.1 For 19 core 2.5 sq. mm. control cables and 4.0 sq. mm. jumper cables in AC /DC EMU, BG AC EMU & MEMU/Coaching Stock the core identification shall be done by sequential numbers starting with number 1 at the outer layer and end at the central core. The increasing numbers in all layers shall be in the same direction .The number shall be printed in Hindi/English numerals on the outer surface of the cores. All the numbers shall be of the same color, which shall contrast with the color of the insulation. The numerals shall be legible.

8.3 Arrangement of marking – The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other.
When the number is a single numeral, a dash shall be placed below it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral.

9.0 LAYING UP OF CORES:

9.1 In case of 19 core cables, the core shall be laid together with a suitable right hand lay in accordance with clause 11 of IS : 1554 (part 1) – 1988. The outer most layers shall have right hand lay and successive layers shall be laid with opposite lay. Fillers in interstices may be provided to ensure reasonable circularity of laid up cables. The filler material shall be suitable for the operating temperature of 120 deg.C.
The value of the lay for 19 core cable shall be max. 12 times the pitch circle diameter.

10.0 SAMPLING :

The sampling plan for acceptance tests shall be as follows:

10.1 LOT
In a consignment, the cable of the same size manufactured under essentially similar conditions of production shall be grouped together to constitute a lot.

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10.2 SCALE OF SAMPLING

10.2.1 Samples shall be taken be and tested from each lot for ascertaining the conformity of the lot to the requirement of the specification.

10.2.2 The number of samples to be selected shall depend on col. 1 and 2 as indicated below. These samples shall be taken at random.

No of drums/coils/Reels in the lot (N) (1)	No of drums coils/ reels to be taken as sample (n) (2)	Permissible No. of defectives. (a) (3)
Up to 25	3	0
26 to 50	5	0
51 to 100	8	0
101 to 300	13	1
301 to above	20	1

10.2.2.1 In order to ensure the randomness of selection. Procedure given in IS: 4905 – 1968 may be followed.

10.3 NUMBER OF TESTS AND CRITERION FOR CONFORMITY:

Suitable length of the test samples shall be taken from each of the drums selected. These test samples shall be subjected to each of the acceptance tests. A test sample is called defective if it fails in any one of the acceptance tests. If the number of defective is less than or equal to the corresponding permissible number given in col.3 under 10.2.2, the lot shall be declared as conforming to the requirements of acceptance tests; otherwise not.

11.0 SELECTED TEST METHODS:

11.1 Some of the test methods as specified under various clauses of this specification are given below from clauses 11.2 to 11.8.

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11.2 WINDABILITY (DEFORMATION) TESTS:

The test-pieces shall be wound round a mandrel with a dia of :-

- 3Dfor cable dia ≤ 10 mm
- 5D for cable dia> 10 ≤ 20mm
- 8D for cable dia>20 mm, being the external dia. of the cable, and in such a way as to form 10 continuous turns in a right-hand direction. This procedure shall be followed 3 times.

The test-pieces shall be unwound carefully straightened and rewound 3 times on the same mandrel, in such a way as to form 10 continuous turns in a left- hand direction side so that the external surface of the cable situated on the outside during first operation is now on the inside. No cracks visible to the naked occur.

The cable shall withstand the high voltage test after the cable has been subjected to the above bending test.

11.3 DYNAMIC CUT THROUGH RESISTANCE:

This test shall be carried out on sample of cable, using a tensile tester operating in a compression mode. The tester shall be equipped with a chart recorder which shall be suitable for recording the force necessary to force a flat tungsten carbide edge (90 deg. Included angle with a 0.127mm flat edge)through the covering of a sample cable. The tester shall also be equipped with a chamber which will allow the test to be performed at elevated temperature and a low voltage detection circuit designed to stop the tester when the cutting edge cuts through the covering and comes in contact with the conductor.

The sample of cable of suitable length shall be placed on a hard flat surface so that the cutting edge is perpendicular to the axis of the cable. The cutting edge shallbe moved through the covering at a constant rate of 5 mm/min.

Four test shall be performed on each sample and moved forward 25 mm minimum. and rotated clockwise 90deg. between each test. The average of the four tests shall be the cut through resistance which shall be greater than the minimum value as mentioned in clause 7.2.11. The cut through test shall be performance with the cable samples at Temperature indicated in clause 7.2.11.

11.4 DC STABILITY TEST :

This test is carried out on cable using direct current to ensure the characteristics. Which permit the commission of the protection sheath.

The test shall be carried out on samples 5 meters long. The samples shall be continuously immersed except for its end which shall project about 250 mm. for 240 hours in a water bath in which sodium chloride has been dissolved to a proportion of 10 gms per litre. The temperature of water shall be 65 deg.C ± 5 deg. C .the conductor of the sample shall be

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connected to the negative pole of the DC supply of 750 V DC for 750 V grade single layer cable of CI.3.2.1 and 1800 volts for double layer cable of CI.3.2.1 and CI. 3.2.2. The positive of the DC supply shall be connected to a copper electrode immersed in the water (Without galvanic connection in the container).

There shall be no breakdown of the insulation during the 240 hours test. There shall be no damage to the outer surface of insulation: discoloration shall be ignored.

11.5 TRACKING RESISTANCE :

The annular electrode shall consist of at least 3 continuous turns of copper wire of about 1.8 mm dia. Care must be taken when applying the electrode to ensure that the cable is not damaged. The sample with two annular electrodes 50.mm apart shall be bent into a single loop and placed in water for four hours at a temp. from 15 to 20 deg. C. The ends of the cable shall project at least 50mm above the surface of the water. After this immersion, the samples shall be removed and dried with non- fluffy filter paper. Immediately afterwards the leakage current shall be measured by a milli-ammeter when a voltage of 2000 V 50 Hz is applied for 10 sec. between the electrodes. The voltage shall then be raised at the rated of 100V per second until tracking occurs followed by a flashover. The value of leakage current, tracking voltage and breakdown voltage shall be as under:-

Maximum leakage current	
Cross sectional area of copper	Max. Leakage current after 10 seconds at 2 KV.

(a) (for 750 V grade single layer cable of CI.3.2.1)
- (i) Tracking voltage – surface tracking shall not occur below 07 KV
- (ii) Breakdown voltage – flashover shall not occur below 10 KV

(b) (for above 750 V& upto 1.8/ 3 KV grade cable of CI.3.2.2)
- (i) Tracking voltage – surface tracking shall not occur below 20 KV
- (ii) Breakdown voltage – flashover shall not occur below 25 KV

11.6 TEST FOR DIELECTRIC STRENGTH:

A sample of cable of 1 meter length shall be immersed in water for 24 hours and thereafter an alternating voltage of 50 Hz shall be applied between the conductor and water, commencing from 6000 V and increasing in steps of 750V every 30 seconds until puncture occurs. The voltage at which puncture occurs shall not be less than as specified in clause 7.2.2.

11.7 COMPOSION OF CONDUCTOR:

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All wires must be of the same nominal dia. The dia. of wire shall be measured by means of a ratchet micrometer or a dia micrometer, between smooth faces circular in shape. The average of the readings of a two measurements taken at right angle to each other shall be accepted as the value of the dia.

11.8 SLIPPAGE TEST:

A sample of length approximately 350mm is taken and bent to a radius of 150 mm. the relative displacement of the conductor with insulation shall not be more than 10mm for cable upto 25 mm dia. and 15 mm for cables over 25 mm dia.

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DATA SHEET – 1A

CHAMICAL CURING PROCESS – SINGLE CORE CABLE
CONSTRUCTION, DIMENSION AND CONDUCTOR RESISTANCE
TEMPERATURE RANGE:-40 TO + 120 DEG.C
MIN. BENDING RADIUS FOR OD < 10MM = 3 X D & OD > 10MM = 5 X D

Table 1

1. For control cable upto 750 volts grade with single layer insulation/ sheath for Tap changer of Electric Locomotive AC/DC EMU. BG AC EMU & MEMU/Coaching Stock as per CI.3.2.1 of specification

SL. No.	Nominal cross sectional area of core ($mm^{2)}$	Single wire dia (max) (mm)	Minimum wall thickness of insulation/ sheath (total)(mm)	Overall cable Dia (D) (mm)	Max. resistance of conductor at 20 deg. C (ohm/Km)
1	25.0	0.41	0.96	8.90 ± 0.50	0.795
2	35.0	0.41	1.10	10.20 ± 0.50	0.565
3	50 .0	0.41	1.20	11.90± 0.50	0.395
4	70.0	0.51	1.30	14.30 ± 0.50	0.277
5	95.0	0.51	1.40	15.90 ± 0.50	0.210
6	120.0	0.51	1.50	17.90± 0.50	0.164
7	150.0	0.51	1.60	20.30 ± 0.50	0.132

1. Rope stranded conductor construction shall be adopted from sizes 10. Sq. mm and above
2. As per clause no. 3.2 of IS 8130:2013 Nominal cross sectional area of conductor is the value that identifies a particular size of conductor but is not subject to direct measurement.
3. Each particular size of conductor is required to meet a maximum resistance value as per IS 8130-2013.

Table 2

2. For cable above 750 Volts and upto 1.8/3.0 KV as per CI.3.2.2 of specification for Tap changer of Electric Locomotive & AC/ DC EMU, BG AC EMU & MEMU/Coaching stock

SL. No.	Nominal cross sectional area of core ($mm^{2)}$	Single wire dia (max) (mm)	Minimum wall thickness			Overall cable Dia (D) (mm)	Max. resistance of conductor at 20 deg. C (ohm/Km)
			Insulation (mm)	Sheath (mm)	Total (mm)		
1	25.0	0.41	0.60	0.80	1.40	10.6± 0.5	0.795
2	35.0	0.41	0.65	0.85	1.50	12.1 ± 0.5	0.565
3	50 .0	0.41	0.70	0.90	1.60	14.0± 0.5	0.395
4	70.0	0.51	0.75	0.95	1.70	16.1 ± 0.5	0.277
5	95.0	0.51	0.85	1.05	1.90	17.8± 0.5	0.210
6	120.0	0.51	0.95	1.15	2.10	20.1± 0.5	0.164
7	150.0	0.51	1.00	1.20	2.20	22.4± 0.5	0.132
8	185	0.51	1.05	1.25	2.30	24.3± 0.5	O.1080
9	240	0.51	1.10	1.30	2.40	27.4 ± 0.5	0.0817
10	300	0.51	1.15	1.35	2.50	30.2 ± 0.5	0.0654

Note: 1. Rope stranded conductor construction shall be adopted from sizes 10. Sq. mm and above
2. As per clause no. 3.2 of IS 8130:2013 Nominal cross sectional area of conductor is the value that identifies a particular size of conductor but is not subject to direct measurement.
3. Each particular size of conductor is required to meet a maximum resistance value as per IS 8130-2013.

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DATA SHEET – 2A

ELECTRON – BEAM – CROSS LINKING CURING PROCESS – SINGLE CORE CONSTRUCTION, DIMENSION AND CONDUCTOR RESISTANCE TEMPERATURE RANGE : - 40 TO + 120 DEG.C MIN. BENDING RADIUS FOR OD < 10MM = 3 X D & OD > 10MM = 5 X D

Table 1

1. **For control cable upto 750 volts grade with single layer insulation/ sheath for Tap changer of Electric Locomotive AC/DC EMU. BG AC EMU & MEMU/Coaching Stock as per CI.3.2.1 of specification**

S.N.	Nominal cross sectional area of core ($mm^{2)}$	Single wire dia (max) (mm)	Minimum wall thickness of insulation/ sheath (total)(mm)	Overall cable Dia (D) (mm)	Max. resistance of conductor at 20 deg. C (ohm/Km)
1	1.5	0.26	0.55	2.70± 0.10	13.7
2	2.5	0.26	0.60	3.30± 0.15	8.21
3	4.0	0.31	0.65	3.95± 0.15	5.09
4	6.0	0.31	0.70	4.50 ± 0.20	3.39
5	10	0.41	0.80	5.60 ± 0.30	1.95
6	16	0.41	0.86	7.20 ± 0.30	1.24
7	25	0.41	0.96	8.60 ± 0.30	0.795
8	35	0.41	1.10	10.00 ± 0.30	0.565
9	50	0.41	1.20	11.90 ± 0.30	0.393
10	70	0.51	1.30	14.20 ± 0.30	0.277
11	95	0.51	1.40	15.70 ± 0.30	0.210
12	120	0.51	1.50	17.70 ± 0.30	0.164
13	150	0.51	1.60	20.30 ± 0.30	0.132

Note: 1. Rope stranded conductor construction shall be adopted from sizes 10. Sq. mm and above

2. As per clause no. 3.2 of IS 8130:2013 Nominal cross sectional area of conductor is the value that identifies a particular size of conductor but is not subject to direct measurement.
3. Each particular size of conductor is required to meet a maximum resistance value as per IS 8130 -2013.

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Table 2

2. For cable above 750 Volts and upto 1.8/3.0 KV (for Tap changer Electric Locomotive & AC/DC EMU, BG AC EMU & MEMU/Coaching Stock) as per CI.3.2.2 of specification

Note

SL. No.	Nominal cross sectional area of core ($mm^{2)}$	Single wire dia (max) (mm)	Minimum wall thickness			Overall cable Dia (D) (mm)	Max. resistance of conductor at 20 deg. C (ohm/Km)
			Insulation (mm)	Sheath (mm)	Total (mm)		
1	1.5	0.26	0.30	0.40	0.70	3.20 ± 0.10	13.7
2	2.5	0.26	0.30	0.40	0.70	3.70 ± 0.15	8.21
3	4.0	0.31	0.35	0.45	0.80	4.50 ± 0.15	5.09
4	6.0	0.31	0.35	0.45	0.80	5.10± 0.15	3.39
5	10	0.41	0.40	0.50	0.90	6.30 ± 0.20	1.95
6	16	0.41	0.50	0.70	1.20	8.30 ± 0.20	1.24
7	25	0.41	0.60	0.80	1.40	10.2 ± 0.30	0.795
8	35	0.41	0.65	0.85	1.50	11.7± 0.30	0.565
9	50	0.41	0.70	0.90	1.60	13.6± 0.30	0.393
10	70	0.51	0.75	0.95	1.70	15.6± 0.30	0.277
11	95	0.51	0.85	1.05	1.90	17.3 ± 0.30	0.210
12	120	0.51	0.95	1.15	2.10	19.6 ± 0.30	0.164
13	150	0.51	1.00	1.20	2.20	21.9 ± 0.30	0.132
14	185	0.51	1.05	1.25	2.30	23.8 ± 0.30	0.108
15	240	0.51	1.10	1.30	2.40	26.9 ± 0.30	0.0817
16	300	0.51	1.15	1.35	2.50	29.7 ± 0.30	0.0654

1. Rope stranded conductor construction shall be adopted from sizes 10. Sq. mm and above
2. As per clause no. 3.2 of IS 8130:2013 Nominal cross section area is value that identifies a particular size of conductor but is not subject to direct measurement.
3. Each particular size of conductor is required to meet a maximum resistance value as per IS 8130-2013.

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DATA SHEET – 2B

ELECTRON – BEAM – CROSS LINKING CURING PROCESS – 19 CORE CABLES CONSTRUCTION, DIMENSION AND CONDUCTOR RESISTANCE TEMPERATURE RANGE :- 40 TO + 120 DEG.C MIN. BENDING RADIUS = 4 X D

Table 1

For cable above 750 volts grade for Tap changer of electric locomotive, AC/DC EMU, BG AC EMU & MEMU/coaching stock as per CI.3.2.2 of specification.

S N	Nominal cross sectional area of each core ($mm^{2)}$	single wire dia (max) (mm)	Minimum wall thickness of core (mm)			No Of cores	Thickness Of Outer Sheath (mm)	Overall cable Dia (D) (mm)	Max. resistance of conductor (ohm/Km)
			Core insulation (mm)	Core sheath (mm)	Total (mm)				
1	2.5	0.26	0.30	0.40	0.70	19	1.4	23.0±0.5	8.21
2	4	0.31	0.35	0.45	0.80	19	2.0	30.5 ± 1.0	5.09

Note: 1. As per clause no. 3.2 of IS 8130:2013nominal cross section area is value that identifies a particular size of conductor but is not subject to direct measurement.

2. Each particular size of conductor is required to meet a maximum resistance value as per 8130-2013.

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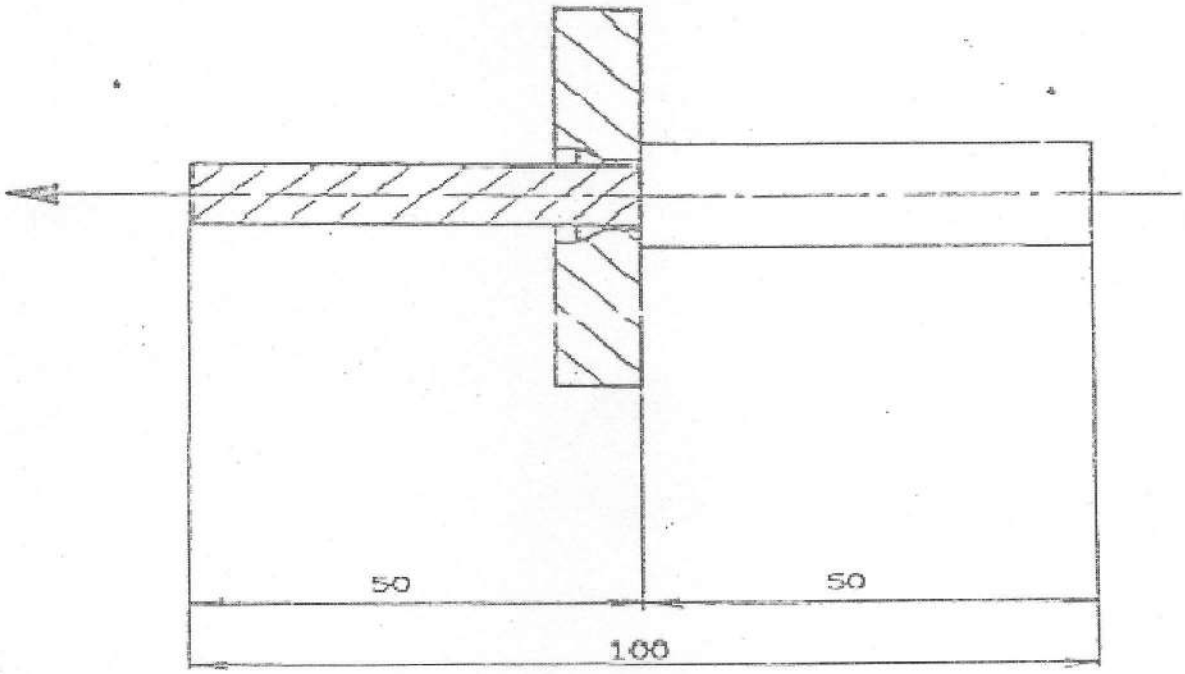
APPENDIX – A

Strippablility (Clause – 7.2.7)

Test method:

A simple of 100 mm length shall be stripped 50 mm carefully. So that the remaining portion of 50 mm is not moved or deformed.

The stripped end shall be slipped into the bush according the figure. The diameter of the bore hole shall slightly exceed the diameter of the conductor. The conductor shall be pulled out from the insulation with constant speed by means of elongation test equipment.



STRIPPABILITY TEST DEVICE

Retention force

Nominal cross- Section (mm²)	Pull force	
	Minimum in N	Maximum in N
1.5	20	60
2.5	25	80
4	30	100
6	30	100

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APPENDIX – B

Abrasion resistance (Clause – 7.2.14):
Abrasion resistance of sheath (Clause – 7.2.14.1):

Test method:

The equipment according the figure . A hardened tungsten carbide blade (detail x) will be mounted perpendicularly to the axis of the sample and rubbed over the sample with an amplitude of oscillation of 10 to 20mm.

40 and 60 double strokes per minute shall be made. Test weight shall be according to table given below. Number of cycles shall be counted with a counter.

In the movement the steel blade reamer has contact to the conductor; the equipment shall be switched of automatically by the circuit with max. DC 50 V and 0.05 A.
Sample shall be positioned straight on its support during test by a suitable fixture.
8 tests shall be performed. After each test the sample (length about 750mm) shall be moved forward by 50mm and turned by 90 deg.

Requirements :

The arithmetic mean value of the 8 results must be according to 7.2.14.1

Test weight:

Cross section (mm2)	Weight (Kg)
2.5 35	0.5 1

Abrasion resistance of marking (clause -7.2.14.2):

Test method:

Sample of suitable of length is fixed into apparatus according the figure .into such a manner that the marking is positioned under the steel wire with is loaded which a test weight of 200g.
Three tests shall be made.
Amplitude of oscillation shall be 10 and 20mm. 40 to 60 double stokes per minute shall be made
.

Requirements:
According to clause 7.2.14.2

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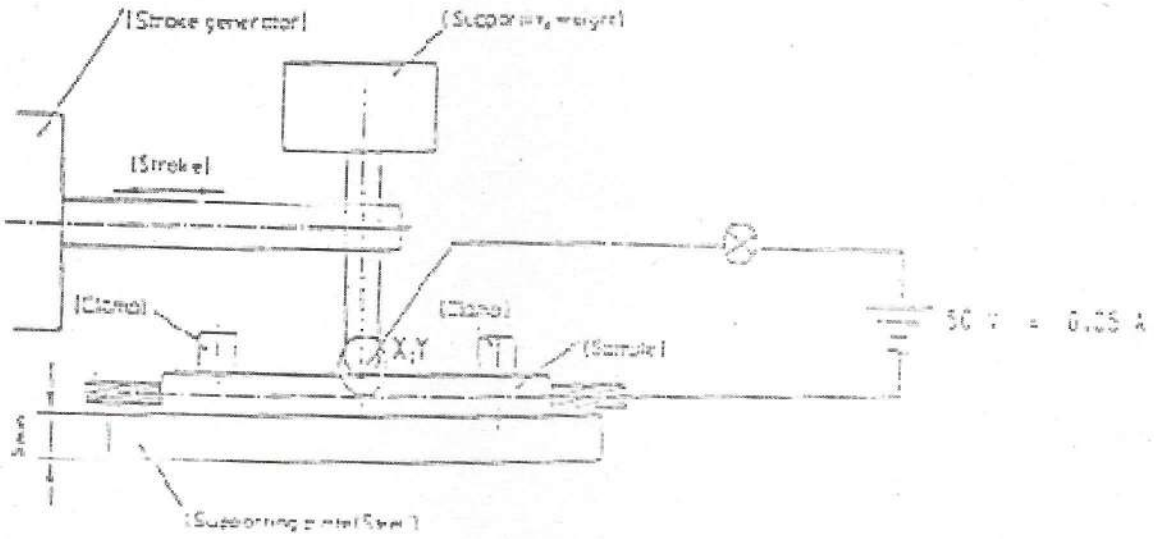
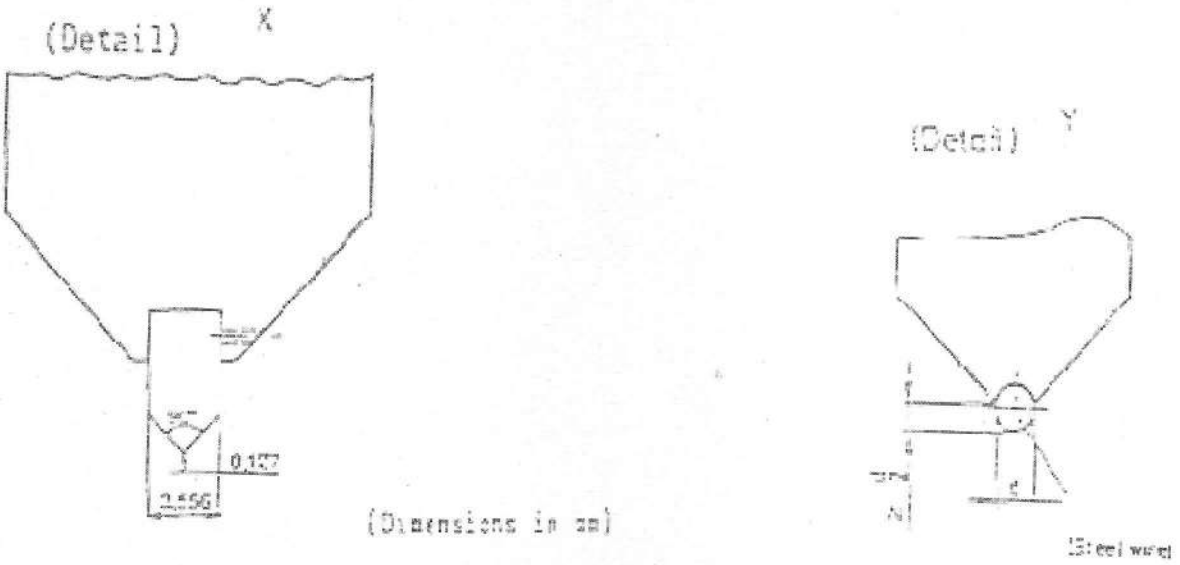
APPENDIX – B(Cont.)





Test Arrangement for Abrasion Resistance of Sheath of Marking

Prepared by	Checked by	Issued by
Design 22.02.2018	JE/ Design	EDSE 22/2/18

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APPENDIX - C

Notch Propagation of finished cable (Clause 7.2.12)

Test method:

The test shall be carried out on a sample of suitable length. At the midpoint the covering of the sample shall be notched with a razor blade around the whole circumference to a depth of one third of combined minimum insulation thickness according to data sheet

The notched sample shall be wrapped around a mandrel with the diameter according to clause – 7.2.15.1 of this specification. The notch touches and is parallel to the axis of the mandrel, while wrapping the cable sample for several turns on each side of the notch.

Then the sample is removed from the mandrel and the immersed in water during 1 hours at room temperature, before being subjected to the voltage test, clause 7.2.1 (c) but at 50% of the specified test voltage.

Requirements: Clause - 7.2.12

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APPENDIX-D

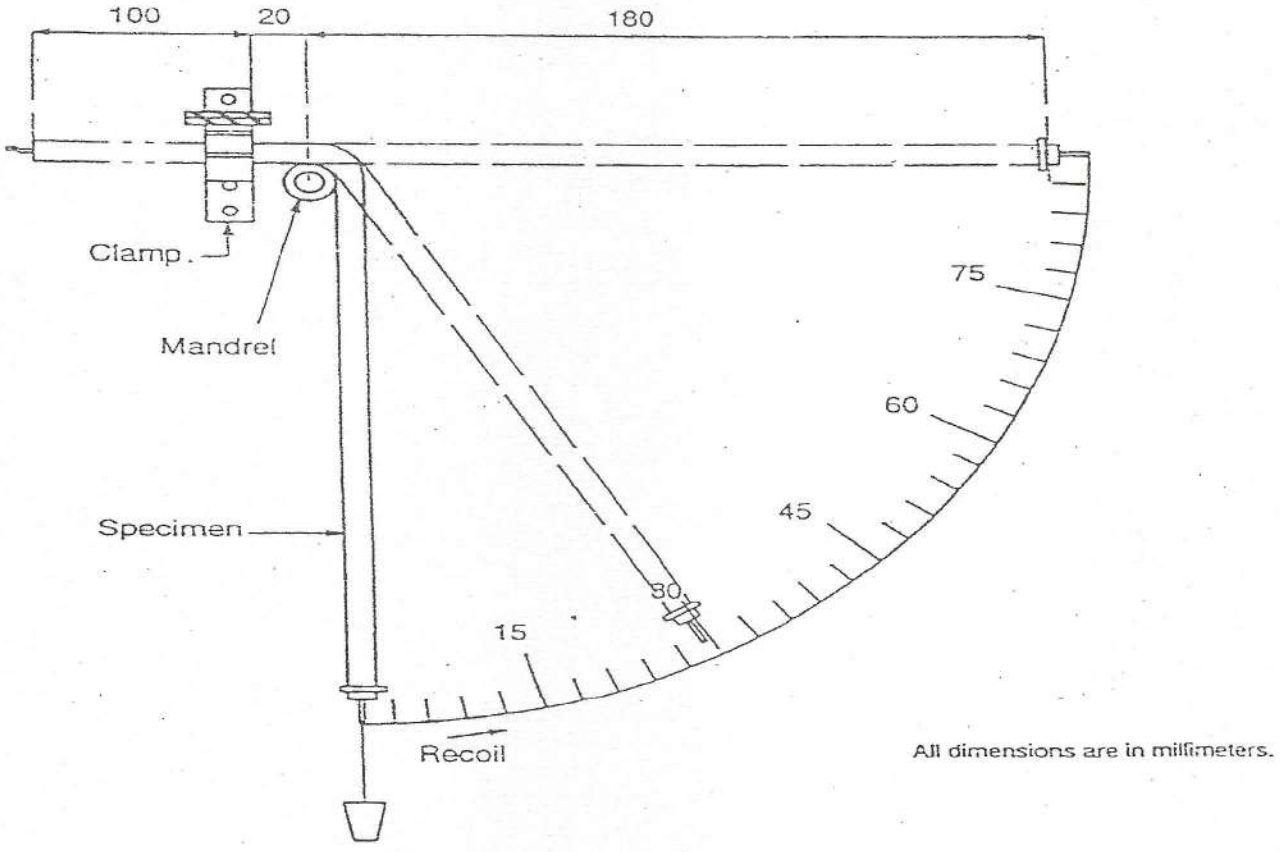
Pliability(Clause – 7.2.13):

This test measures the ease with the cable bends and accept a permanent set.

Test method :

Cut samples of cable to minimum 300 mm long, consecutively the same coil. The samples shall be straightened and stored at room temperature for at least 3 hours. Test the samples using the test rig shown in the following diagram. The diameter of the mandrel in the test rig shall be 25mm. Apply a mass of minimum 10 kg to the cable, at the position shown in the diagram, sufficient to bend the cable downwards through 90 + 0° – 1°. Ensure that the sample remains in this position for 5 minutes and record the mass. After this time, remove the mass and allow the specimen to recoil towards its original position. At a time 5, minutes after removal of the mass, record the recoil distance – Test temperature 23 ±2 °C.

On completion of the test, the cable sample should pass high voltage test according to clause 7.2.1 (c).



Prepared by	Checked by	Issued by
JE/ Design 22.02.2018	JE/ Design 22/02/18	EDSE 22/2/18

Signature Not Verified
Digitally signed by NEHA DATTARAM DHULE
Date: 2026.02.26 15:27:43 IST
Reason: IREPS-CRIS
Location: New Delhi